16-2-2000

Crop Updates 2000 - Weeds

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Recommended Citation

Stewart, V, Minkey, D, Hashem, A, Riethmuller, G, Harries, M, Newman, P, Weeks, C, Dhammu, H S, Cheam, A, Bowran, D, Piper, T, Wallace, A, Roy, B, Devenish, K L, Leaver, L J, Rayner, B, Collins, M, Monardino, M, Pannell, D, Powles, S, Peltzer, S, Walsh, M, Boyle, C, Neve, P, Lorraine-Colwill, D, Preston, C, Diggle, A, LLewellyn, R, Duane, R, Lee, S, Nicholson, D, Carlton, P, Smith, S, Crabtree, B, Cumming, G, Cameron, D, Jackson, M, Paton, S, Peirce, J R, and Shea, G. (2000), *Crop Updates 2000 - Weeds.* Agriculture Western Australia, Perth. Conference Proceeding.

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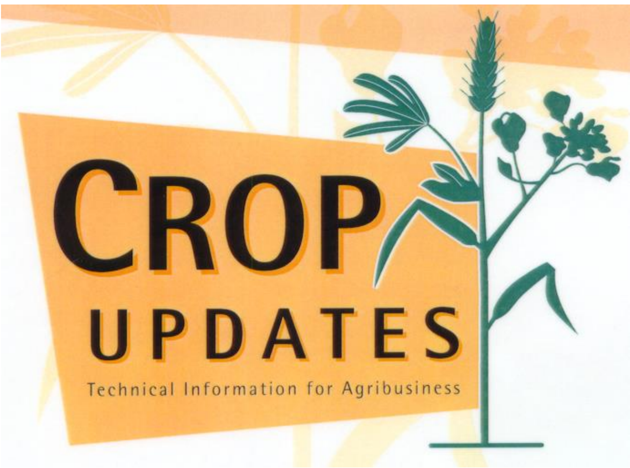

2000

WEED UPDATES

- Western Australia

PRESENTED AT RENDEZVOUS OBSERVATION CITY,
WESTERN AUSTRALIA, 16-17 FEBRUARY 2000

Compiled and edited by Vanessa Stewart

Unregistered pesticides and uses: This document reports the results of some research where the product, or the use reported for that product, is not currently registered. Any discussion of these uses does not constitute a recommendation for that use. All pesticide use must be in accord with the registered uses for that product.

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Introduction

1999 Crop Updates - Weed Update

1999 was a busy year for those involved in weed research, extension and advice.

Of note the following occurred during 1999:

- Resistance of radish to both triazines and diflufenican was confirmed.
- Summer and autumn rain created the need for summer weed spraying.
- Low knockdown rates and/or failure to adjust rates for stressed weeds resulted in poor pre-seeding control in many areas for some growers.
- Marshmallow created control problems for many growers.
- Heavy rains early in the season and at seeding resulted in extensive crop damage.
- The debate on the benefits of genetically modified herbicide tolerant crops to our farming systems continued in forums, workshops and the media.
- A number of individual growers included a significant area of green/brown manuring into their program.
- WAHRI published results from their surveys on the resistance status of ryegrass and radish in the wheatbelt.

Already in 2000 people are being inundated with queries on summer weed control. Coupled with this has been an increase in requests to identify less common weeds that are thriving in the wet conditions prevalent throughout most the State.

This year we have received contributions from Agribusiness, Private Research Groups, Agriculture Western Australia and WAHRI. We would like to take this opportunity to thank everyone for their contributions. We appreciate the effort to which people have gone to deliver their papers. We understand that there are many conflicting commitments at this time of year.

2000 Weed presentations have been incorporated into both the Cereal and Pulse and Oilseeds days. Papers included in the booklet will be presented as either oral presentations or posters over the two days. There are a number of additional papers that have been included in the book only. The contributing authors were unavailable to present the information due to alternative commitments.

There are a large number of products containing the same or different concentrations of the same active ingredient. The use of trade or proprietary names in this book does not constitute a preferred recommendation. Alternative manufacturer's products containing the same active ingredient may perform as well or better than those specifically referred to.

It is important to remember that this document contains results from research where the reported product or the use reported for that product is not currently registered. Any discussion of these uses does not constitute a recommendation for that use.

Finally I would like to thank Shelly Ford for her assistance in compiling this book.

Vanessa Stewart
CONVENOR - WEEDS
AGRICULTURE WESTERN AUSTRALIA, MERREDIN

Effect of seeding density, row spacing and Trifluralin on the competitive ability of Annual Ryegrass in a minimum tillage system

David Minkey, Abul Hashem, Glen Riethmuller and Martin Harries,
Agriculture Western Australia, Merredin Dryland Research Institute, Merredin

KEY MESSAGE

Narrow row spacing and high seeding rates of wheat led to decreased emergence, competitive ability and seed production of annual ryegrass. Optimal yields were found at higher seeding rates under a high weed burden than a low weed burden, particularly at narrow row spacing. There was no effect of row spacing or seeding rate on screenings. Wide row spacing, low weed burden and lower seeding rates led to less frost affected grain.

Herbicides had the biggest effect on weed burden; however, by using high seeding rates and narrow row spacing in conjunction with trifluralin weed numbers were reduced to very low levels.

BACKGROUND

There has been a trend towards wider row spacing of crops due to the ease of stubble handling, improved yield of lupin, lower machinery capital cost, improved soil health and reduced germination of weeds. The effect of row spacing and seeding rate on weed competition and seed quality of wheat has not been adequately examined in the wheatbelt of Western Australia. There is also little information on these effects over several seasons and the interaction with herbicides. This study addresses these issues under a no-tillage seeding system.

METHODS

Design

Four seeding rates (50, 100, 200 and 400 kg/ha) and three row spacing (90, 180 and 270 mm) was organised in a full randomised design with four replicates. In 1998 wheat (var. Arrino) was seeded on 11 June with 100 kg/ha Agras No. 1 using Harrington knife-points. Plots were 20 m by 3.24 m in size. In 1999 treatments were imposed on the same plots using barley (var. Stirling) sown on 1 June with 100 kg/ha Agras No. 1 and 80 kg/ha urea applied on 1 July. A split plot design was included in 1999 with half of every plot receiving 4 L/ha Trifluralin 400.

RESULTS

Weed competition

In the absence of herbicides (with the exception of a knockdown at seeding) total head number was reduced further by reducing row spacing and increasing seeding rate (Figure 1a). In the presence of Trifluralin annual ryegrass head numbers were reduced to very low levels (Figure 1b).

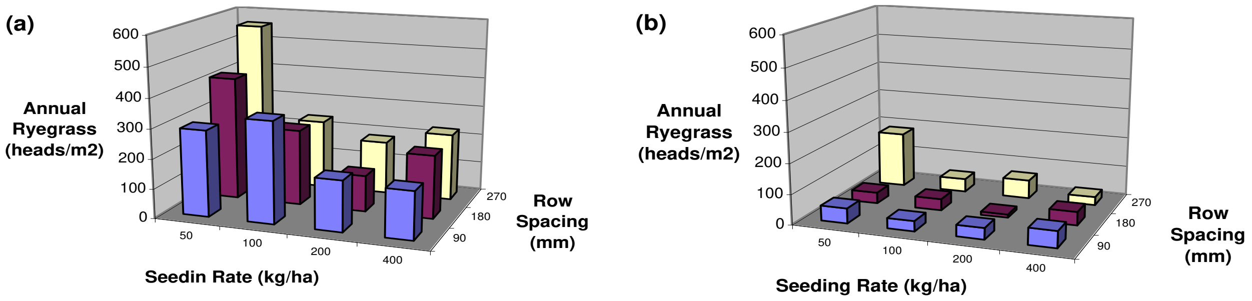

Figure 1. **Effect of row spacing and seeding rate of barley following wheat on the ryegrass head production with (Figure 1b) and without (Figure 1a) Trifluralin.**

Yield

Row spacing and seeding rate did not affect grain yield of barley when Trifluralin was applied (Figure 2a). In the absence of Trifluralin yield decreased with decreasing seeding rate (Figure 2b), presumably due to increased annual ryegrass competition.

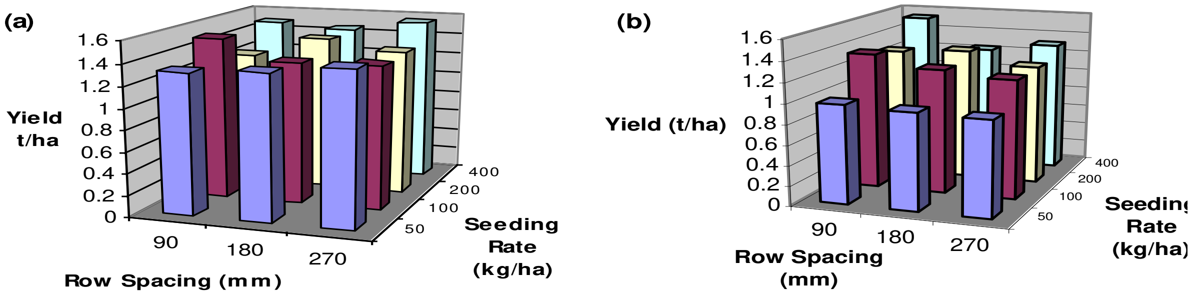

Figure 2. **Effect of row spacing and seeding rate on the yield of barley following wheat with (Figure 2b) and without (Figure 2a) Trifluralin.**

Grain quality

There was no effect of row spacing and seeding rate on the grain protein and screenings of barley. However, there was a decrease in screenings with the addition of trifluralin and hence lower weed burden. There was also an interaction between seeding rate and trifluralin application, where screenings decreased with increasing seeding rate where no trifluralin and hence higher weed burdens, was applied.

CONCLUSIONS

Higher seeding rates can be an effective tool in reducing annual ryegrass seed set. This is particularly the case when using narrow row spacing. However a small benefit can still be gained at wide row spacing. Concern over screenings due to higher seeding rates was unfounded and should not deter its use, particularly in conjunction with other control strategies. Other studies from around the State have also shown that increased seeding rate does not influence screenings. There are benefits for frost prone areas to increase row spacing without increasing seeding rates, but the penalties are high with increasing weed burden.

A strong interaction exists between seeding rate, row spacing and herbicide use. Ryegrass numbers and hence seed head production, can be reduced to very low levels when Trifluralin is used in conjunction with high seeding rates and/or narrow row spacing. Care must be taken when using narrow row spacing with Trifluralin due to potential crop damage, speed being the critical factor. At wider row spacing good control of annual ryegrass was achieved through the use of trifluralin and higher seeding rates indicating that, with its other benefits, wide row spacing may in the long term lead to a more sustainable cropping system. However, what this study shows is that for good weed control to occur under wide row spacing, herbicides must be effective. In the advent of herbicide failure increased crop competition through seeding rates and row spacing can prevent a blow out of weed populations.

The trial will be taken into a third year to see if weed burdens can be further reduced using these methods.

ACKNOWLEDGEMENTS

We would like to acknowledge GRDC for providing funding.

REFERENCES

Minkey, D., Riethmuller, G. and Hashem, A. (1999). Effect of row spacing and seeding rate on the emergence and competitive ability of annual ryegrass in a no-tillage seeding system. In proceedings 1999 Weed Updates pp. 33-34.

GRDC Project No.: Daw 492

Paper reviewed by: Mr Glen Riethmuller

High wheat seeding rates coupled with narrow row spacing increases yield and suppresses grass

Peter Newman[1] **and Cameron Weeks**[2]

[1] Agronomist, Elders Limited
[2] Mingenew/Irwin Group

INTRODUCTION

Recent trial work conducted by Minkey (1999) in Merredin has demonstrated the benefits of high cereal seeding rates and narrow row spacing on grass weed suppression and cereal yield. The aim of this trial was to demonstrate this effect with realistic seeding rates for the Mingenew area. Growing more competitive crops will have increasing importance with the onset of herbicide resistant weeds.

TRIAL DETAILS

Site: Non wetting sandplain site approximately 20 km west of Mingenew
Seeding date: 19 May 1999
Wheat variety: Carnamah
Seeding machinery: Agriculture Western Australia cone seeder. 1.44 m x 25 m plots
Seeding rates: 30, 60, 90 and 120 kg/ha
Row spacing: 7” (18 cm) and 14” (36 cm)

The site did not have a uniform grass weed burden, however, there were header rows running across all plots that had high brome grass and ryegrass weed burdens. Grass weed tiller counts were taken from within these header rows to demonstrate how the seeding rate affected the grass weed burden. Seedling density measurements were not taken but emergence was very even and rated as being excellent.

RESULTS

Wheat Yield /ha

Wheat sown at narrow row spacing was significantly higher yielding than wheat sown at wide row spacing. Wheat sown at 60kg/ha was higher yielding than wheat sown at 30 kg/ha and wheat sown at 120 kg/ha was significantly higher yielding than wheat sown at 30 kg/ha or 60 kg/ha.

	30 kg seed /ha	60 kg seed /ha	90 kg seed /ha	120 kg seed /ha	Average
7” Row spacing	2729	2934	3009	3189	2965a
14” Row spacing	2654	2802	2790	2788	2759b
Average	2692a	2868b	2900bc	2988c	

Seeding rate LSD	117
Row Spacing LSD	83
Seeding rate x row spacing	166

Screenings %

There was a trend of decreasing screenings with increasing seeding rate. Wheat sown at 90 kg/ha had significantly less screenings than wheat sown at 30 kg/ha or 60 kg/ha. There was no difference in screenings between narrow or wide row spacing.

	30 kg seed /ha	60 kg seed /ha	90 kg seed /ha	120 kg seed /ha	Average

7” Row Spacing	1.53	1.37	1.13	1.1	1.28a
14” Row Spacing	1.34	1.58	1.13	1.45	1.37a
Average	1.43bc	1.47c	1.13a	1.27ab	

Seeding rate LSD	0.17
Row Spacing LSD	ns
Seeding rate x row spacing	0.25

Brome + Ryegrass Tillers/m^2 in header row

There was a trend of decreasing grass weed tillers per square metre with increasing seeding rate. Where wheat was sown at 30 kg/ha there were significantly higher grass weed tiller numbers than all other seeding rates. There was no difference in grass tiller numbers between narrow and wide row spacing. For narrow row spacing the trend of decreasing grass tiller numbers with increasing seeding rates was linear (i.e. doubling seeding rate resulted in halving the grass tiller numbers).

	30 kg seed /ha	**60 kg seed /ha**	**90 kg seed /ha**	**120 kg seed /ha**	**Average**
7” Row spacing	210	107	61	52	107a
14” Row spacing	297	128	102	116	161a
Average	253b	117a	81a	84a	

Seeding rate LSD	109
Row Spacing LSD	ns
Seeding rate x row spacing	ns

HECTOLITRE WEIGHT

There was no effect of seeding rate or row spacing on Hectolitre Weight.

DISCUSSION

The narrow (7”) row spacing/120 kg/ha seeding rate treatment produced the highest yield, lowest screenings and lowest grass tiller numbers per square metre. Conversely, the wide (14”) row spacing/30 kg/ha seeding rate treatment produced the lowest yield and highest grass tiller numbers per square metre. While all of these results were not significant there is a convincing trend to suggest that high seeding rates coupled with narrow row spacing is a much better alternative to wide row spacing and/or low seeding rates.

It is interesting that for wide row spacing there was no yield response to increasing seeding rate. Whereas for narrow row spacing there was a significant (i.e. 460 kg/ha) increase in yield as seeding rate increased from 30 kg/ha to 120 kg/ha. This highlights the importance of both narrow row spacing and high seeding rates being adopted together to maximise the benefits.

The decrease in screenings with an increase in seeding rates that was observed is contrary to many farmers beliefs but has been supported by numerous trials in the past. The theory is that a high seeding rate produces fewer tillers per plant and these tillers are more likely to produce a higher percentage of plump grain. It is likely that this is the reason for the result seen in this trial.

ACKNOWLEDGEMENTS

We would like to thank Tony Bake for allowing us to conduct the trial on his property.

REFERENCES

Minkey, D., Riethmuller, G., and Hashem, A. (1999). Effect of row spacing and seeding rate on the emergence and competitive ability of annual ryegrass in a no-tillage seeding system. In proceedings 1999 Weed Updates pp. 33-34.

Resistant ryegrass management in a wheat - lupin rotation

Abul Hashem, Harmohinder S. Dhammu, Aik Cheam, David Bowran and Terry Piper, Agriculture Western Australia

KEY MESSAGE

Competition from Fop-resistant ryegrass reduced wheat yield up to 73% in 1999. High seeding rate (120 kg/ha) combined with autumn tickle and trifluralin gave higher yields of wheat than plots treated with Logran® + Hoegrass® or trifluralin + Glean® and seeded at 60 kg/ha without tickling.

In the absence of herbicides, non-chemical options such as high seeding rate and autumn tickle increased wheat yield by 50% as compared to untreated control. However, alternative herbicides must be combined with autumn tickle and high seeding rate to reduce the resistant ryegrass burden in wheat and prevent population build up over time.

AIM

This trial was conducted to develop chemical and non-chemical options to manage Fop-resistant ryegrass for sustaining crop productivity in wheat-lupin rotation.

METHODS

This trial was conducted on deep sandy loam soil at Wongan Hills Research Station from 1997 to 1999. Intensified chemical and non-chemical treatments (Table 1) were imposed in 1997 wheat with rotation of some herbicides in 1998 lupin and 1999 wheat.

The plots that were sown at normal seeding time in 1997 were sown at late seeding time in 1999 and vice versa. Eight management practices involving non-chemical and chemical options to control Fop-resistant ryegrass were imposed in 1999.

The treatments were laid out in a split-plot design with time of seeding in the main plots and management levels in the sub-plots. This population of ryegrass was 70% resistant to Fop but susceptible to Dims.

Autumn tickling was done on 23 April 1999 at a depth of 2-3 cm by 10 cm scarifier points. Wheat cv. Westonia was sown on 3 and 21 June 1999. Pre-seeding ryegrass emergence was recorded on 22 April, 25 May and 18 June 1999. Heads of ryegrass/m^2 were recorded at anthesis of wheat in 1999.

Table 1. Description of treatments used in 1997 and 1999 wheat. In 1998 lupin, all plots were uniformly treated with 2.0 L simazine followed by Select® in Treatment 8 and paraquat as crop topping in Treatment 4*

	1997 Treatments		1999 Treatments
1.	Untreated control/SSR	1.	Untreated control/SSR
2.	Hoegrass®, 1.0 L/SSR	2.	Hoegrass®, 1.0 L/SSR
3.	Logran®, 35 g/Hoegrass®, 1.0 L/SSR	3.	Logran®, 35 g/Hoegrass®, 1.0 L/SSR
4.	Trifluralin 2.0 L/diuron 1.0 L/Hoegrass® 1.0 L/SSR	4.	Trifluralin 2.0 L/Glean® 20 g/SSR
5.	Autumn tickle/HSR/seed catching	5.	Autumn tickle/HSR/seed catching
6.	Autumn tickle/Logran® 35 g/HSR/seed catching	6.	Autumn tickle/diuron 1.0 L/HSR
7.	Autumn tickle/trifluralin 2.0 L/HSR/seed catching	7.	Autumn tickle/trifluralin 2.0L/HSR/seed catching
8.	Autumn tickle/trifluralin 2.0 L/diuron 1.0 L/HSR/seed catching	8.	Autumn tickle/trifluralin 2.0 L IBS/diuron 1.0L PSPE/HSR/Seed catching

* SSR Standard seed rate (60 kg/ha)
HSR High seed rate (120 kg/ha)

RESULTS

Year 1 (1997 wheat) and Year 2 (Lupin 1998)

In 1997, alternative herbicides such as trifluralin and Logran® reduced ryegrass head by 92-99% while non-chemical treatments such as autumn tickle and high seed rate of wheat reduced ryegrass head by 28% as compared to untreated control (Table 2). Control of ryegrass in 1997 wheat using alternative herbicides reduced ryegrass emergence in 1998 season by 88-95% before seeding lupin and by 90-94% after seeding lupin. Residual effect of only non-chemical options such as autumn tickle and high seed rate imposed in 1997 wheat reduced ryegrass density by 39% before seeding lupin and by 52% after seeding lupin.

Ryegrass density as counted at seven weeks after emergence of 1998 lupin varied from 133/m^2 in plots treated with trifluralin followed by diuron and Hoegrass to 2457/m^2 in plots treated with Hoegrass in 1997. Regardless of initial ryegrass plant density in lupin, ryegrass head density in lupin was reduced to 40-72/m^2 except in Treatment 8 where ryegrass was controlled by Select®. These results indicate that ryegrass was heavily suppressed by highly competitive lupin crop. At the onset of bolting stage, lupin plants had completely closed canopy and shaded ryegrass. Ryegrass plant mortality occurred in lupin crop probably due to severe reduction in available light.

Year 3 (Wheat 1999)

Residual effect of treatments with alternative herbicides in 1997 and 1998 reduced pre-seeding emergence of ryegrass by 73-75% in untickled plots (Treatments 3 and 4) and by 40-67% in the tickled plots (Treatments 5-8) in 1999 as compared to untreated control (Table 2). Higher pre-seeding emergence in Treatments 5-8 in 1999 could partly be attributed to autumn tickling. In the untickled plots treated with Logran® + Hoegrass® or trifluralin + Glean® (Treatment 3 and 4) in 1999 reduced ryegrass heads by 66-81% with 248-257% increases in wheat yield as compared to untreated control. In plots that were tickled, seeded at 120 kg/ha and treated with trifluralin or trifluralin + diuron (Treatment 7 and 8), heads of ryegrass were reduced by 76-99% and yield of wheat increased by 248-276%. In treatment 8, wheat yield increase was same as in Treatment 3 although ryegrass head density was reduced by 99%. This could partly be attributed to 25% damage of wheat plants in Treatment 8 under first seeding time as compared to 4.2% plant damage in Treatment 3.

Table 2. Effect of management practices on the density and head production of resistant ryegrass and yield of wheat in wheat - lupin rotation

1997 wheat		1998 lupin			1999 wheat			
Treat-ments	**RG head/m^2**	**RG PS plants/m^2**	**RG PO plant/m^2**	**RG Head/m^2**	**1999 Treat-ments**	**RG PS plants/m^2**	**RG head/m^2**	**Wheat yield (t/ha)**
1	588	3740	2360	54	1	2548	968	0.42
2	401	1752	2457	72	2	2248	927	0.39 (-7)*
3	8	216	224	46	3	677	329	1.46 (248)
4	7	300	133	37	4	642	182	1.50 (257)
5	421	2277	1129	68	5	2780	888	0.63 (50)
6	33	291	207	61	6	1514	452	0.63 (50)
7	47	459	244	40	7	1539	230	1.58 (276)
8	28	184	236	6	8	836	10	1.46 (248)
P value	<0.001	<.001	<.001	.018			<0.001	<0.001)
LSD	232.0	511.8	485.0	35.7			157.9	0.221

*	Figures in brackets are percentage increase over untreated control
RG	Ryegrass
PS	Pre-seeding
PO	Post-emergent.

In the non-chemical treatment (Testament 5), ryegrass head density was reduced by 8% but yield was increased by 50% as compared to untreated control. The higher ryegrass density in Treatment 5 could be attributed to higher number of heads in 1997 and 1998 as compared to best control treatment. These results indicate that resistant ryegrass has been slowly building up in year 3 in absence of alternative herbicides although 50% yield increases in 1999 clearly indicate that high seed rate of wheat is a beneficial option.

CONCLUSIONS

Resistant ryegrass reduces wheat yield by up to 73%. Non-chemical weed control options should be combined or rotated with alternative herbicides to control Fop-resistant ryegrass.

ACKNOWLEDGEMENTS

We thankfully acknowledge Grain Research and Development Corporation for funding the project and Steve Bell for his technical assistance.

GRDC Project No.: DAW 535 WR

Paper reviewed by: H.S. Dhammu and Terry Piper

Integrated weed management – Will it work with my rotation?

Alexandra Wallace, Agriculture Western Australia, Katanning

KEY MESSAGES

- RIM is a useful tool for predicting ryegrass population behaviour in rotations.
- IWM can be incorporated into existing rotations.
- Inclusion of pasture in rotations may aid with weed control by increasing options.

AIMS

Integrated Weed Management (IWM) combines multiple weed management techniques to reduce weed density. The idea is to manage the weeds using a variety of control measures, in this way the weed is less likely to develop an evasion strategy (e.g. resistance to herbicides).

This paper presents results on test runs of a range of rotations, using the RIM model, for their compatibility with IWM strategies. Gross margin data after a period of ten years is presented generated from two ryegrass starting densities, 100 and 500 plants/m^2.

METHODS

A variety of crop rotations covering pasture:crop to continuous crop (Table 1) scenarios were planned. Strategies of intensive annual ryegrass management were designed for each rotation. These strategies detailed when IWM techniques were used and which development phase they targeted. RIM (Ryegrass Integrated Management model) was then utilised to determine the effectiveness of each strategic plan.

Starting densities of 100 and 500 ryegrass seeds in the soil/m^2 were used to test each rotation.

The model assumed the following long-term average weed free crop yields for; wheat (1.9 t/ha), barley (2.1 t/ha), canola (1 t/ha) and lupins (1.3 t/ha). Pool prices were based on 1999/2000 season delivered to Fremantle; wheat ($175/t), barley ($190/t), canola ($300/t), lupins ($143/t). Herbicide usage, over a 20 year period, was limited to the following; Group A (2 applications), Group B (2), Group C (6), Group D (6), Group L (15), Group M (15).

RESULTS

After 10 years of the rotation, strategy 5, the continuous cereal (with one legume green manure each 10 years) had the best results in terms of both the annual ryegrass and profit aspects (Table 2). There are obvious disadvantages to running continuous cereal for 10 years, serious disease build-up the highest risk.

The two rotations that included pasture were the easiest to run and this rotation could probably be 'tweaked' to perform better than the numbers above indicate. One big disadvantage to these rotations is the increased soil seed bank present after the 10 year cycle. While plants setting seed are very low and annual profit is reasonable the large seed bank threat is concerning.

In Strategies 3 and 4, the relatively large numbers of ryegrass plants setting seed in November indicate that these rotations are about to collapse. However, after 20 years strategy 3 improves, while strategy 4 does collapse with a very high soil seed bank and large numbers of plants in November.

CONCLUSION

IWM tools will fit into some of our existing rotations, at least in the short term (10 years). Two of the strategies, 3 and 4, showed signs of collapse after 10 years of the rotation, while one was able to recover given a longer running phase the other failed. After a cycle or two of any particular rotation it may be necessary to change the rotation to a new one. The RIM model is very effective for assessing the future of a rotation with regard to potential ryegrass population shifts.

Apart from strategy 5, continuous cereal, two of the better scenarios were those that contained a pasture component. Pasture gives more options than a continuous crop rotation as livestock provide another non-herbicide weed control method. Combining a pasture phase with longer crop phases than those explored here would be worthy of investigation.

Table 1. The rotations used and the management practices imposed for the RIM analysis, based on a rotation running for 20 years

Strategy	Rotation	Management practices
1	P:P:W	Sub-clover pasture – spraytop and graze in both pasture years, paraquat yr 1, glyphosate yr 2. High intensity winter/spring grazing. Delay seeding wheat (10 days) to enable tickle cultivation and use of knockdowns. High seeding rate (150 kg/ha). Apply trifluralin.
2	P:P:C:W	Sub-clover pasture – spraytop and graze in both pasture years, paraquat yr 1, glyphosate yr 2. High intensity winter/spring grazing. TT canola, apply trifluralin pre-em, atrazine post-em, swathe, windrow, burn stubble. Delay seeding wheat, tickle cultivation + knockdowns. High seeding rate. Apply Glean® in yr 4 and 12 and trifluralin in yr 8, 16 and 20.
3	B(sil):C: W:L:W	Barley silage – plant following tickle cultivations with high seeding rate, cut early, spray out regrowth (glyphosate). TT canola in yr 2, 7 and 12, nonTT in yr 17. Atrazine (or trifluralin pre-em), high seeding rate (7 kg/ha), swathe windrow stubble then total burn. Delay seeding wheat, tickle cultivation + knockdowns. High seeding rate. Apply trifluralin. Seed catch at harvest, burn dumps. Lupins, simazine in yr 4, 9 and 19, Select® in yr 14, crop top, burn stubble. Wheat seeded early, high seeding rate, seed catch at harvest, burn dumps.
4	L(gm):W: C:B	Lupin green manured in yr 1, 9 and 17. Simazine applied in yr 13, Select® applied in yr 5 and 13. Crop top in yr 5 and 13. Burn crop stubble in yr 5 and 13. Wheat, seeded early, high seeding rate, apply trifluralin, Glean® in yr 6 and 10, seed catch at harvest, total burn. TT Canola, atrazine post-em, swathe, windrow stubble, burn windrows. Barley, high seeding rate, delay seeding, apply trifluralin, swathe.
5	P:W:W: W:O:W: W:W:W: P	Cadiz serradella green manured in yr 1 and 10. Delay seeding, high seeding rate, apply trifluralin or Glean® (2 applications), seed catch and total burn (13 years, not consecutive), or burn stubble (4 years). Oats – hay crop, delay seeding, high seeding rate and no herbicides.

Table 2. **Annual ryegrass seeds in the soil in April (/m²), the number of plants setting seed in November (/m²) and average annual profit ($) following 10 years of each rotation. Commencement densities of 100 and 500 seeds in the soil/m² were assumed**

Strategy	100 seeds/m² in year 1			500 seeds/m² in year 1		
	Seeds/m² (April)	Plants/m² (November)	Gross margin $	Seeds/m² (April)	Plants/m² (November)	Gross margin $
1	199	3	86	680	10	86
2	144	1	95	380	4	98
3	69	27	109	257	99	101
4	305	74	122	477	116	110
5	1	0	120	152	25	119

KEY WORDS

integrated, weed, management, ryegrass

GRDC Project No.: DAW 587W

Paper reviewed by: Dr David Bowran

Long term herbicide resistance trial - Mingenew

Peter Newman Elders, Mingenew **and Cameron Weeks** Mingenew-Irwin Group

INTRODUCTION

Conclusions from trials in the central region suggest that it takes at least two years of non selective control of ryegrass to run a seed bank down to an acceptable level for cropping to continue without the use of grass selective herbicides. The primary aim of this trial is to determine how many years it takes to run down a ryegrass seed bank. Anecdotal evidence suggests that it is likely to take three years rather than two years to run down a ryegrass seed bank on non wetting sands. The trial also aims to determine what is the best way to achieve two to three years of non selective weed control while maximising profit.

TRIAL DETAILS

This trial is on the property of Tony and Shirley Blake, Strawberry (west of Mingenew). The soil type is a non-wetting sand. In September 1998 the site was selected and an area of lupins (A blocks) were sacrificed with Glyphosate. The rest of the trial site (B Blocks) was conventionally harvested. Consequently two ryegrass populations have resulted. The two blocks were sown as shown in the trial layout. Each block comprises 0.2 hectares. The cropped blocks have since been harvested using an International header towing a chaff collection cart. The pasture block was sacrificed with glyphosate in September and then sprayed two weeks later with Spray Seed to ensure 100% ryegrass and brome grass seed set control.

TRIAL LAYOUT

Lupins harvested in 1998	**4B** 1999 Canola (Treflan + Atrazine + Select) Wheat in 2000	**3B** 1999 Late sown Unicorn Barley Lupins in 2000	**2B** 1999 Pasture Cadiz Seradella Wheat in 2000	*1B* 1999 Pasture Cadiz Seradella 2000 Pasture
Lupins sacrificed in 1998 before ryegrass seed set	**4A** 1999 Canola (Treflan + Atrazine) Wheat in 2000	**3A** 1999 Late sown wheat Lupins in 2000	**2A** 1999 Pasture Cadiz Seradella Wheat in 2000	**1A** 1999 Pasture Cadiz Seradella 2000 Pasture
		Fence		

RESULTS

Table 1. Yield summary of cropped blocks

Block	Crop	Yield (kg/ha)
3A	Wheat	1000
4A	Canola	250
3B	Unicorn Barley	960
4B	Canola	580

Table 2. Summary of Ryegrass counts (plants/m²) 1999

Date	Ryegrass per square metre								Comments
	1a	2a	3a	4a	1b	2b	3b	4b	
26/3/1999	10	27	9	29	202	313	195	68	Before first knockdown
14/5/99				8				38	Canola sown
23/6/99	43	73	78	3	975	525	825	240	Barley, wheat and Cadiz sown
21/7/99	14	63	48	7	314	595	357	127	Post em counts
Total	67	163	135	47	1491	1433	1377	473	

Average of A blocks 103

Average of B blocks 1193

Table 3. Summary of Brome grass counts (plants/m²) 1999

Date	Brome Grass per square metre							
	1a	2a	3a	4a	1b	2b	3b	4b
23/6/99	230	400	313	13	100	0	18	0
21/7/99	40	101	58	0	19	1	0	0
Total	270	501	371	13	119	1	18	0

Average of A blocks 289

Average of B blocks 34

RESISTANCE STATUS OF SITE

The paddock has been in a wheat: lupin rotation for 17 years with one pasture break in that time. Grass selective herbicides have been used extensively in the lupin phase of the rotation and SUs have been used for several years in the wheat phase. The site was sampled in 1998 to determine the resistance status with the following results.

Chemical Group	Resistance Status
Group A (Fops)	Resistant
Group A (Sertin)	Resistant
Group A (Select)	20% Resistant
Group B (i.e. SUs)	Resistant
Group C (Atrazine)	10% Resistant
Group D (Trifluralin)	Susceptible

CONCLUSIONS TO DATE

- Sacrificing lupins in 1998 resulted in roughly a ten-fold reduction in ryegrass numbers.
- The rest of the paddock was crop topped in October and ryegrass counts have shown this practice to be equally effective, as sacrificing the crop providing the timing is correct.
- Removing ryegrass from A Blocks in 1998 has resulted in roughly a 10 fold increase in brome grass germination in 1999. Brome grass hates competition.
- Using trifluralin and atrazine in canola in 1999 has reduced ryegrass numbers from roughly 1400 plants per square meter to roughly 500 ryegrass plants per square meter in block 4B.

- Delayed sowing is not the answer to ryegrass management given the high numbers of ryegrass that continue to germinate after crops were sown late. Early sowing of a competitive crop may be better.
- Crop yields at the site were very disappointing due to the site being nutrient deficient and the canola suffering from knockdown spray drift. More attention will be paid to the nutrition of the site in the future.

Paper reviewed by: Dr David Bowran

Is two years enough?

Bill Roy, Agricultural Consulting and Research Services

Within project ACR2, supported by GRDC, interesting changes in ryegrass numbers are being observed where no seed has been allowed to set for zero to two years under various rotational regimes.

The key questions now are:

- Is a two-year break sufficient and if so for how long?
- How can the 'cost' of a two-year break be minimised and so optimise crop returns over time?

Data from site 1a – non wetting sand at Dowerin

		AR*	GM**	3 yr AR	Cumulative GM
Case 1					
1997	Amery wheat cut for hay/re-growth sprayed	322	-53		
1998	Machete wheat	140	146		
1999	Westonia wheat– too poor to harvest	918	-110	1380	-17
Case 2					
1997	Machete wheat	150	148		
1998	Oats/Vetch for hay – re-growth sprayed	712	110		
1999	Brookton wheat	108	124	970	382
Case 3					
1997	Amery wheat cut for hay/re-growth sprayed	126	-71		
1998	Brown manure (wheat)	84	-89		
1999	Westonia wheat	35	217	245	57

Data from site 2 – red loam at York

	Taken to grain in 1996	AR*	GM**	3 yr AR	Cumulative GM
Case 1					
1997	Stirling barley – brown manured	3310	-173		
1998	Karoo canola	424	6		
1999	Dundale field peas– spray topped	179	7	3913	-160
Case 2	Cut early for silage in 1996				
1997	Stirling barley	110	450		
1998	Hyola canola	84	-56		
1999	Amery wheat (CCN affected)	124	7	318	401
Case 3	Cut later for hay in 1996				
1997	Re-seed to pasture – spray topped	860	-79		
1998	Pasture – spray topped	24	64		
1999	Westonia wheat	8	496	892	481

* Aggregated ryegrass count m^{-2} yr^{-1}.
** Gross Margin \$ ha^{-1}.

Further data to be generated in the project in 2000 will go some way to answer the key questions but already data has been generated which provides an insight into the differences to be expected as a result of management decisions.

There are indications that decision takers must take account of different responses in varying soil types e.g. the cultivation effect on ryegrass in non-wetting sands is much more difficult to discern than on a good loam. Managers should also note the evidence of Case 2/Site 2 where an advantage resulting from seed set control in 1996 can start to be lost within two cropping years if tight control on the overall program is not maintained and other influences do not come into play e.g. CCN.

The fate of ryegrass seed when sheep graze chaff cart heaps

Keith L. Devenish[1] **and Lisa J. Leaver**[2]

[1] Agriculture Western Australia, Northam
[2] Curtin University of Technology, Muresk Institute of Agriculture, Northam

KEY MESSAGE

The grazing of sheep on chaff cart heaps in wheat stubbles has little impact on the spread of ryegrass seed back into the paddock. Sheep were selective in what they ate and spread out the chaff cart heaps considerably while foraging for grain and other fine material. Grazing can speed up the burning process and reduce the risks associated with burning. Grazing allowed seeding machinery to pass through the unburned heaps easily but the concentrated area of ryegrass seed will still be an issue and require burning at a later stage. Burning can be postponed for paddocks with fragile soils until after a cultivation when it is safer to burn.

BACKGROUND

Catching weed seeds by towing chaff carts behind grain harvesters can collect up to 80% of ryegrass seed from wheat crops and concentrate them in chaff cart heaps. These seeds can then be destroyed when a hot fire burns the heaps. Farmers are concerned that grazing will spread the ryegrass seed back into the paddock via the faeces and a hot burn may not be possible where sheep spread the heaps out too far. The problem is that chaff cart heaps burn for up to four days creating a major risk of fire getting out of control as well as smoke being emitted from smouldering heaps creating a social impact on rural communities. The burning operation is time consuming and there is always the threat of litigation if fire spreads to neighbouring farms or communities.

Spread of ryegrass through the faeces

A literature search was conducted to answer the question about how much ryegrass seed may be passed back into the paddock through the sheep faeces. Gramshaw and Stern (1977) found that less than 1% of ingested ryegrass seed was viable when voided in the faeces. Unpublished work of Stanton (1998) shows this amount was about 3%. On-farm observations indicate that only small numbers of ryegrass seeds germinate in sheep camps where faeces are concentrated. Further literature also found that larger proportions of viable ryegrass seed pass through cattle. Some farmers have noticed that cattle spread the heaps more than sheep and soil them with urine and faeces. Grazing cattle on chaff cart heaps is not recommended where the spread of ryegrass is an issue.

AIMS

To measure the impact on the spread of ryegrass seed when sheep are grazed on chaff cart heaps in paddocks of wheat stubble and to develop a method to reduce the risks associated with burning chaff cart heaps on fragile soils.

METHODS

A trial was conducted at Mingenew on a 120 ha paddock of wheat stubble on sandplain soil. The trial focused on measuring the spread of ryegrass seed from chaff cart heaps to the surrounding areas as a consequence of grazing, and a possible effect of prevailing winds. At harvest time the chaff cart heaps were dropped in a row at right angles to the direction of harvest. The first treatment was grazed and left unburnt to observe what happened at seeding time. The second treatment was grazed and burnt and the third was fenced to exclude stock as an ungrazed treatment. After grazing, the germinated ryegrass plants were counted at 1, 2, 4 and 8 metre distances in each direction from the heaps after it rained. The first count was after March rain before ryegrass was sprayed with glyphosate. The second count was in June after winter opening rains when canola was sown. Three block treatments were applied to 15 chaff cart heaps with five heaps in each treatment. A similar trial was conducted at Yerecoin as part of an Honours project using germination counts as well as collecting soil samples before and after grazing to measure the number of ryegrass seeds.

TRIAL RESULTS

Grazing had no significant effect on the number of ryegrass plants that germinated at the measured distances from the chaff cart heaps at both the Mingenew and Yerecoin trials (see Table 1). There was also no significant difference for ryegrass seed numbers where soil samples were collected before and after grazing at the Yerecoin trial. In addition, there was no direction effect on the spread of ryegrass from prevailing winds at either trial.

Table 1. The effect of sheep grazed on chaff cart heaps on germinated ryegrass numbers at Mingenew and Yerecoin

Distance from heaps	Mingenew	Mingenew	Mingenew	Yerecoin	Yerecoin
	Grazed and not burnt	Grazed and burnt	Ungrazed and burnt	Grazed and burnt	Ungrazed and burnt
1 m	345	380	395	219	278
2 m	309	291	352	259	242
4 m	288	282	358	207	208
8 m	270	297	334	156	199

Spread of the heaps

Grazing with sheep reduced the volume of chaff cart heaps by about a third (10.5 v 6.3 m^3) but increased three fold the area of the heaps. This suggests that sheep spread out the material while foraging for grain and other fine residues (fines). Weaners were grazed at the Mingenew trial initially but they did not target the heaps so were replaced by 600 adult ewes grazed at 5 hd/ha for 25 days. In both trials the adult ewes tended to graze the heaps intensively yet there was only minimal contamination from faeces and urine. The heaps were spread out significantly after 2-3 weeks of grazing.

Sheep feed value

There was no change in dry matter digestibility or crude protein for grazed versus ungrazed chaff cart heaps at Mingenew. The average DDM was 47% and CP 5.6%, which is not considered sufficient to maintain liveweight of grown sheep. The hectolitre weight was reduced from 74 to 50 g/HL from grazing but remained the same for ungrazed heaps. This supports the finding that sheep were foraging though the chaff cart heaps searching for higher value material such as grain and fine residues. Therefore any feed value of chaff cart heaps will depend upon the amount and value of these components. Our measurements were not intense enough to identify these differences. Liveweight was not recorded but the ewes appeared to maintain weight.

Burning the grazed heaps

Grazing reduced the height of the heaps from almost one metre to 10-15 cm. Importantly, the edge of each heap remained well defined and there was no difficulty in obtaining a hot burn to destroy ryegrass seeds. Grazing the heaps could be used by growers as a tool because the heaps will burn quicker once they are spread by sheep.

Cropping over unburnt heaps

After grazing, the no-till seeding equipment passed easily through all the unburnt heaps. Seeding did not distort the heaps excessively meaning that burning after a cultivation was still possible. This could be an advantage for fragile soils to reduce the fire risk but the heaps will still require burning at some stage, otherwise there is no point in using chaff carts.

ACKNOWLEDGMENTS

Piers and Robin Blake for their generous support for the Mingenew trial. Tom, Beth and Richard Field for their tremendous support at the Yerecoin trial. D. Roberts from Agriculture Western Australia for his valuable advice on chaff cart heaps. Dr Gaye Krebs who supervised the Honours project and WANTFA who provided a scholarship for Ms Leaver.

Paper reviewed by: **Dr Terry Piper**

Can blanket wiping and crop topping prevent seed set of resistant wild radish and mustard?

Abul Hashem, Harmohinder Dhammu, Vanessa Stewart, Brad Rayner and Mike Collins, Agriculture Western Australia

KEY MESSAGE

Effective prevention of radish seed production during barley phase reduced emergence of wild radish plants by 50-96% in the subsequent pulses. Blanket wiping on radish in pulses following barley crop, reduced radish pod production by 92% in chickpea and 98% in field pea although crop yields were reduced 15-50% at Avondale.

Among the seven herbicides used in blanket wiping, glufosinate controlled 81% of the mustard with 21% damage to chickpeas in Mukinbudin and glyphosate controlled 73% radish with 4% damage to chickpeas at Nokaning. Although more works need to be done with regard to herbicide rate, output volume, time of blanket wiping and herbicide residues in crop, results show that this technique appear potential in reducing radish and mustard seed production.

AIM

Wild radish has evolved widespread resistance to Group B herbicides and to lesser degree to Group C and E herbicides. Any control failure during early stages of crop due to resistance is likely to result in huge seed production of resistant radish or mustard. Majority of these seeds is likely to be a great burden in the subsequent crops, particularly pulses.

Three trials were conducted in 1999 to examine if seed set of radish and mustard could be prevented by crop topping and blanket wiping.

METHODS

In Trial 1 conducted at the Avondale Research Station following 1998 barley (cv O'Connor and Unicorn), chickpea (cv Heera) was sown in O'Connor plots and field pea (cv King) was sown in Unicorn plots on 31 May 1999. Blanket wiping (2,4-D amine 2.0 L/ha + Chlorsulfuron 10 g/ha) was done in both crops on 16 September 1999. Crop topping (glyphosate 1.0 L/ha or 2,4-D ester 1.0L/ha) was done on 3 November in field pea and 8 November in chickpea. At the time of blanket wiping radish was at flowering to early pod bearing stages while at crop topping time 30-60% pods were well established. Viable seed production of radish was determined in 1998 and radish seedling emergence was recorded six weeks after emergence (WAE) of crops in 1999. This radish population was partially resistant to Group B herbicides. Number of flowering plants and pods of radish and crop yields were recorded in pulses.

In Trial 2 at Mukinbudin, blanket wiping was performed on Group B-resistant wild mustard growing in a chickpea crop with seven herbicides at label rates (Table 2). In Trial 3 at Nokaning, blanket wiping was performed on wild radish growing in a chickpea crop with the same seven herbicides at label rates (Table 2). Weed control and crop damage were assessed visually on a scale of 0 (no weed control or no crop damage) to 100% (complete weed control or total crop damage). Yield of chickpeas was recorded in both the trials.

RESULTS

Radish seed set prevention in Trial 1

Radish seed set prevention options in 1998 barley resulted in 56-100% reduction of viable seed production of radish as compared to untreated control (Figure 1). While swathing and blanket wiping were more effective than crop topping in reducing radish seed production, Unicorn being an early maturing one provided better window to reduce radish seed production than O'Connor variety. This reduction in radish seed production in 1998 barley resulted in 50-96% reduction in the emergence of wild radish in subsequent chickpea and field pea as compared to untreated control (Figure 1).

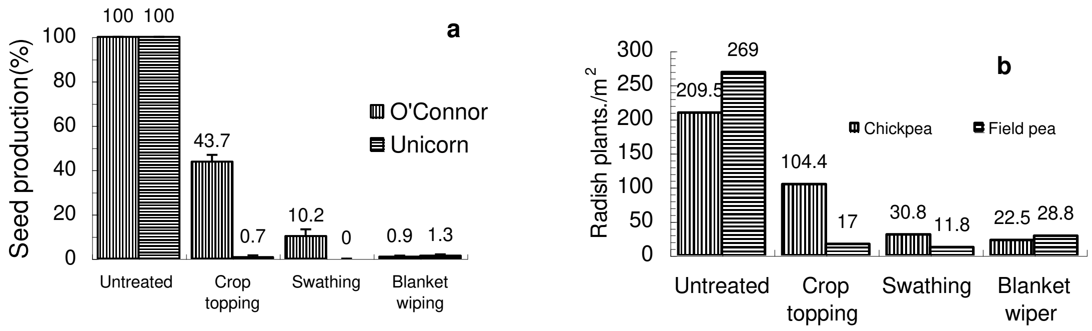

Figure 1. **Effect of seed set prevention treatments on the (a) viable seed production of radish in 1998 barley and (b) on radish density in 1999 pulses. O'Connor 100% = 32,913/m^2 and Unicorn 100% = 24,658/m^2 viable seed of radish.**

Combination of residual effect of 1998 treatments in barley, crop competition and blanket wiping in 1999 pulses reduced number of flowering radish plants by 90-95% and radish pod production by 92-98% as compared to untreated control (Table 1). Crop topping or swathing in barley followed by crop topping in pulses reduced radish pod production by 14-73% in chickpea and 83-89% in field pea. On the average, number of flowering plants in field pea was 36% lower than chickpea indicating that field pea was probably more competitive to radish than chickpea. Crop topping reduced yields by 3-7% in chickpea and 13-15% in field pea. Blanket wiping reduced yield by 15% in chickpea and 52% in field pea. These results indicate that the blanket wiping technique used to control radish was not as safe in field peas as in chickpeas.

Table 1. **Effect of seed set prevention treatments in 1998 barley and in 1999 pulses on radish pod production and crop yields[1]**

Treatments		Flowering radish plants/m^2		Radish pods/m^2		Yield (% untreated control)	
Barley 1998	**Pulses 1999**	**Chick-pea**	**Field pea**	**Chick-pea**	**Field pea**	**Chick-pea**	**Field pea**
Untreated	Untreated	71.5	68.2	8819	10581	100	100
Crop topping	Crop topping	45.5	9.5	7594	1791	93	87
Swathing	Crop topping	13.0	6.7	2387	1155	97	85
Blanket wiping	Blanket wiping	7.5	3.2	684	242	85	48
P-value		<.001		0.006			
LSD		1.53		1440.6			

[1] CTG = Crop topping with glyphosate 1.0 L/ha, CTE = Crop topping with 2,4-D Ester 1.0 L/ha, BW = Blanket wiping with 2,4-D amine 2.0 L/ha + chlorsulfuron 10 g/ha. Yields of untreated chickpea and field pea are 902 and 1459 kg/ha respectively.

Blanket wiping effect on radish and mustard in Trial 2 and 3

At Mukinbuddin, blanket wiping with 7 herbicides controlled mustard by 15-91% with 6-43% crop damage to chickpea (Table 2). Glufosinate controlled 81% mustard with 21% damage to chickpea. At Nokaning, 13-86% radish control was achieved with 1-45% crop damage by the same 7 herbicides (Table 2). Glyphosate controlled 73% radish with 4% damage to chickpea. Chickpea yield as obtained from these two trials varied form 20 to 87% of untreated control.

CONCLUSIONS

Effective prevention of radish seed set by blanket wiping, swathing and crop topping during barley phase greatly reduces the radish burden in subsequent pulses. Blanket wiping and crop topping during pulses phase appear potential as tool to prevent radish seed production.

Table 2. Effect of blanket wiping with various herbicides on radish and mustard control, crop damage and chickpea yield[1]

Treatments	Mustard at Mukinbudin (% of untreated control)			Wild radish at Nokaning (% of untreated control)		
	Mustard control	Crop damage	Chickpea yield	Radish control	Crop damage	Chickpea yield
Glyphosate	91	43	44	73	4	38
Glufosinate	81	21	73	17	1	56
Diquat	61	10	81	56	3	56
Oxyfluorfen	30	6	87	13	1	62
Chlorsulfuron	15	23	23	84	45	20
2,4-D amine + Glean Glean 10101 0gchlorsulfuron	76	38	21	86	39	24
Tigrex®	74	13	58	74	27	34

[1] Glyphosate 1.5 L/ha, Glufosinate 2.0 L/ha, Diquat (Reglone) 1.5 L/ha, Oxyfluorfen 3.0 L/ha, chlorsulfuron 20 g/ha, 2,4-D amine 2.0 L/ha + Glean 10 g/ha and Tigrex® 1.0 L/ha. Yield of untreated chickpea was 1200 kg/ha at Mukinbuddin and 1370/ha at Nokaning.

ACKNOWLEDGEMENTS

We thankfully acknowledge Grain Research and Development Corporation (GRDC) for funding the project. Special thanks are also due to McGinniss and Maddock families for providing trial sites and all cooperation.

GRDC Project No.: DAW 535 WR

Paper reviewed by: Vanessa Stewart

The value of green manuring in the integrated management of ryegrass

Marta Monjardino[1,2]**, David Pannell**[2]**, Stephen Powles**[1]

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KEY MESSAGE

The economic value of green manuring in the integrated management of herbicide-resistant annual ryegrass is not high (perhaps neutral), but nevertheless, green manuring can be a valuable tool in the case of total resistance to selective herbicides and with increasing weed numbers in the system.

AIMS

Farmers are addressing the problem of herbicide-resistant ryegrass in dryland agriculture by adopting a system of integrated weed management (IWM) that allows weed control with a range of chemical and non-chemical methods. One of the non-chemical practices being considered is green manuring, which provides highly effective weed control, increased nutrient availability in the following year and improved soil organic matter. On the other hand, the loss of a year's production involves a short-term economic sacrifice. In this study, the trade-offs between the effective weed control and biological benefits provided by green manuring as well as the large short-term economic losses associated with this practice are investigated for various rotations and patterns of herbicide use.

METHOD

This analysis is conducted using RIM (Ryegrass Integrated Management), a bio-economic management model that simulates the dynamics of a ryegrass population over a period of up to 20 years. The model includes a detailed representation of the biology of weed, crops and pasture as well as of the economics of agricultural production and management.

The value of green manuring was investigated for several scenarios of rotations:

1. wheat/wheat/lupins (WWL)
2. wheat/lupins/wheat/canola (WLWC)
3. wheat/wheat/lupins with a cadiz serradella pasture phase in years 14-16

In addition, three scenarios of herbicide use were defined:

1. Full resistance to Group A and B selective herbicides.
2. Two uses of herbicides of Group A and 2 of Group B available before complete herbicide resistance developed.
3. Six applications of each chemical of Group A and B available.

In all three scenarios it was assumed that there were four applications left of Group C herbicides, 4 of Group D, 15 of Group M and 15 of Group L.

Complementing these strategies of herbicide application and green manuring (all scenarios were tested with and without green manuring of lupins in the second year of the rotation), many combinations of other control methods (non-chemical and non-selective herbicides) were investigated in order to find the most profitable integrated strategies of weed management.

Finally, series of sensitivity analyses were run for a whole range of parameters, including the initial ryegrass seed bank numbers, the level of weed control in the year prior to green manuring, the effectiveness of green manuring, the seed bank decline due to germination and the weed-free yield.

RESULTS

The results in Table 1 show that green manuring is a more valuable tool in situations of higher ryegrass infestations, higher total germination of ryegrass or the use of higher performing wheat crops. In contrast, effective control provided by selective herbicides (Group A and B) or the inclusion of a pasture phase in the rotation reduces the value of green manuring.

Table 1. Effect of several factors on the net value of green manuring ($/ha/year). The last four columns are for a WWL rotation. An example of the effect of herbicide use is given for the scenario with 1600 seeds m^{-2}.

No. applic. group A&B	Initial ryegrass seeds m^{-2}	WWL (std 80% germ, std yield)	WLWC (std 80% germ, std yield)	Pasture Phase	Ryegrass germination		Higher wheat weed-free
					70%	90%	yield
0	100	-1	0	-4	-4	2	0
0	200	1	1	-2	-1	3	1
0	400	2	2	0	0	4	2
0	800	3	4	2	2	4	3
0	1600	3	4	2	2	5	4
2	1600	2	0				
6	1600	1	-5				

Results also show that green manuring has a positive value when combined with more than 90% weed kill in the year prior to this practice (Figure 1) as the seed bank is reduced to very low levels and is likely to remain so for a much longer period of time.

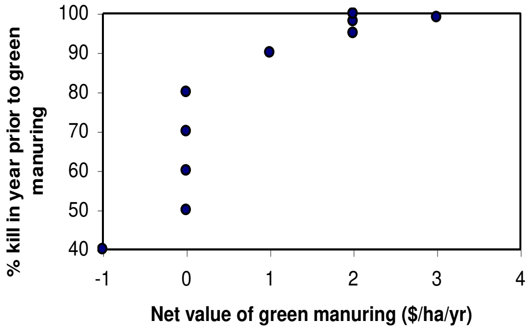


Figure 1. Effect of the per cent weed kill in the year prior to green manuring on the net value of green manuring.

CONCLUSIONS

The investigation into the value of green manuring as part of the integrated management of herbicide-resistant ryegrass shows that green manuring is not a highly economic option, due to the large costs associated with it. However, the obvious benefits of green manuring outweigh its costs in a situation of full resistance to selective herbicides and when weed numbers are extremely high in the system. Green manuring is even more effective when combined with excellent weed control in that year and the year prior to this practice.

KEYWORDS

green-manuring, IWM, ryegrass, resistance

GRDC Project No.: UWA275WR

Some ways of increasing wheat competitiveness against ryegrass

Mike Collins, Centre for Cropping Systems, Agriculture Western Australia, Northam

KEY MESSAGE

1. A splitter boot, when used with trifluralin (1 L/ha) and a narrow row spacing (19 cm), significantly increased wheat yield in a 1999 Wongan Hills trial.
2. When seeding and post seeding herbicides were not used, high seed rate (125 kg/ha) plus narrow row spacing (19 cm) plus additional nitrogen (50 kg/ha urea) was the best combination.

AIM

To increase the competitiveness of wheat against ryegrass, without reliance on post seeding selective herbicides.

METHOD

Two trials were sown in early June with Westonia seed using Agmaster® knife points.

Treatments

1. 19 and 38 cm row spacings.
2. 50 and 125 kg/ha seed rates.
3. Additional N as 50 kg/ha urea (basic fertiliser was 100 kg/ha Agras 1) in treatments:
   - Broadcast immediately before seeding (IBS).
   - Mixed with the Agras and banded (band).
   - Broadcast at the three leaf stage (3lfBC).
   - 'Directed' into the crop rows at the three leaf stage (3lfD).
4. 'Splitter' boots ('spl'), which placed the seed in two rows 4 cm apart.
5. A 'scalper' device ('scal'), which moved the upper soil layer (1-2 cm) into the inter-row zone, was used in some 38 cm row plots.
6. The treatments were spread over two adjacent trials:
   - 99WH79 having paired treatments of 1 L/ha trifluralin plus 35 g/ha Logran® ('Herb'), or not ('NH'), row spacing and the splitter and scalper options, all at 50 kg/ha of seed.
   - 99WH80 had nitrogen, seed rate, row spacing options, but without hebicides after pre-seeding 'knockdowns' and without splitter and scalper options.

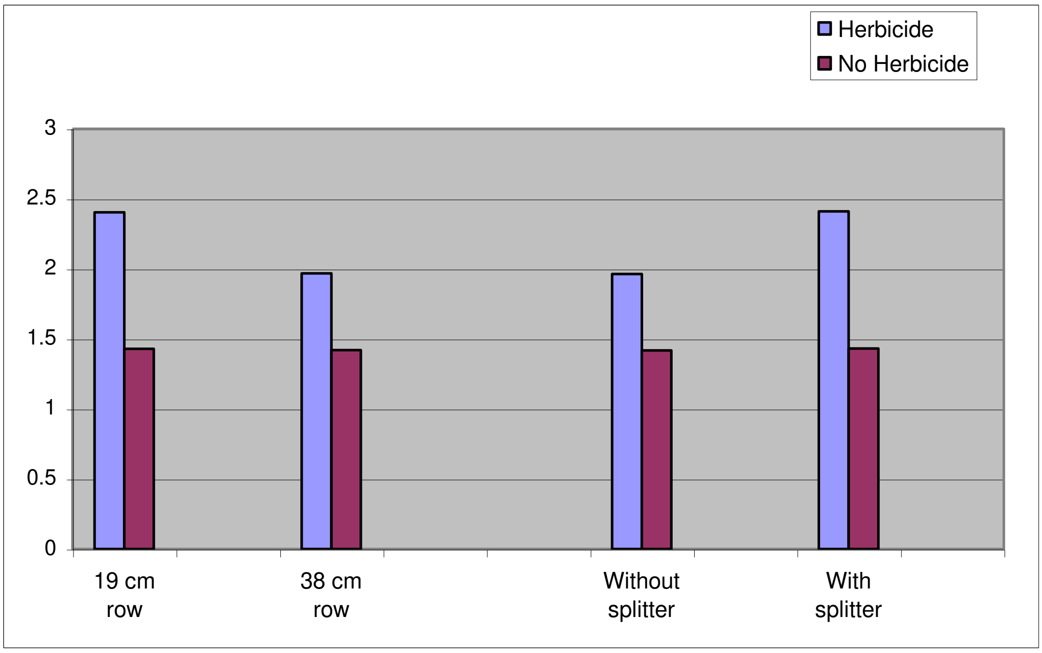
Wheat and ryegrass establishment, biomass through the season, and seed production were measured. At this stage ryegrass seed and wheat quality data are not yet available.

RESULTS

Scalper

This device worked well in removing the top 1-2 cm of soil and residue, resulting in a 'scalped' zone 11 cm wide. This did not reduce ryegrass emergence compared to untreated soil, obviously due to a well-stocked seed bank below the surface. [A trial in 1998 had shown promise with this idea, but that scalper was quite large, dragged back on the tine and produced a deep groove. Ryegrass seedling numbers in the row were similar to the trifluralin + diuron treatment (98WH77).]

Splitter and Row Spacing (at 50 kg/ha seed rate)



Good weed control was necessary for narrow row spacing and splitter benefits, but the other trial found that the additional N boosted the 19 cm row spacing treatment yield more than the 38 cm row treatment.

Additional N, row spacing and seed rate

	99WH80 Treatment	Ryegrass DM Oct	*	Wheat yield	*	Relative yield
1	50/19	1579	abc	1.774	c	100
2	125/19	1223	d	2.300	ab	130
3	50/19/IBS	1810	a	2.269	ab	128
4	50/19/3lfBC	1726	ab	2.095	abc	118
5	50/38/band	1600	abc	1.984	bc	112
6	50/38/3lfD	1612	abc	1.789	c	101
7	125/38/3lfD	1448	bcd	1.968	bc	111
8	125/19/3lfBC	1401	cd	2.421	a	136
	Mean	1550		2.075		117
	F prob	0.012		0.038		
	lsd	293		0.4298		

* Treatments with similar letters are not significantly different at the 5% probability level.

CONCLUSIONS

- The splitter made a greater improvement at the narrow row spacing, but only with good weed control.
- The higher seed rate improved yield more at the narrow row spacing, and without the herbicide treatment.
- The higher seed rate could not compensate for yield decline at the wider row spacing.
- Additional N made a greater yield improvement at the narrower row spacing.
- Additional N, narrow row spacing, and higher seed rates could compensate for lack of trifluralin.

GRDC Project No.: DAW 617

Paper reviewed by: Dr Terry Piper

Understanding and driving weed seed banks to very low levels

Sally Peltzer, Agriculture Western Australia, Albany

With the advent of herbicide resistance there is potential for extremely large weed seed banks to develop.

The size of the weed seed bank depends on:

1. the seed rain at the end of the season; and
2. the extent to which seed from previous years can survive in the soil without germinating with subsequent crops.

How quickly will these seed banks decline in the **absence** of weed seed input?

Will the decline rate vary between Western Australia's range of soil types and moisture regimes?

For example, a heavy red clay soil may have a different moisture status, differing temperatures at depth due to the darker colour and associated moisture gradients and a distinct fertility from a light sand. Consequently the seed banks from the 2 soils may decline at different rates.

Will the wetting of non-wetting soils substantially reduce the seed bank decline of ryegrass?

Are there genetic differences between the wild radish seed banks in Geraldton compared to the south coast?

A 5-year GRDC-funded project began recently to address these issues.

The main aims of the project are:

- To understand the persistence of five annual weeds (annual ryegrass, barley grass, wild radish, doublegee and wild oat under different climatic conditions and different soil characteristics.

- To evaluate the success of various strategies, such as tillage or green manuring, designed to accelerate seed bank decline for these weeds.

Cross-resistance of chlorsulfuron-resistant wild radish to imidazolinones

Abul Hashem, Harmohinder Dhammu and David Bowran, Agriculture Western Australia

KEY MESSAGE

Chlorsulfuron-resistant wild radish populations appear to have low level of cross-resistance to imidazolinones (OnDuty®) although this product was highly effective on most of the chlorsulfuron-resistant radish populations. Therefore, Imidazolinone herbicides should be used carefully to sustain productivity of crops particularly Imi-tolerant canola and wheat.

AIM

Wild radish has evolved widespread resistance to Group B herbicides within the Western Australian wheatbelt. Imidazolinone -tolerant crops such as canola and wheat are being introduced in Australia. Existence of cross-resistance between sulfonylureas and imidazolinones in wild radish may reduce the productivity of these crops. Information on such cross-resistance in wild radish is not yet available. This trial was therefore conducted to investigate existence of cross-resistance in chlorsulfuron-resistant wild radish populations to imidazolinones viz., OnDuty®.

METHODS

A total of 46 wild radish populations including known susceptible biotypes were tested with three replications. Radish plants were grown in 1.0-L pots under glasshouse conditions. Chlorsulfuron (20 g/ha + MW 0.1%) and OnDuty (55 g/ha + Hasten 1%) were sprayed at 2-3 leaf stages of radish plants. Plant mortality was assessed 4 weeks after spraying (early flowering stage). Surviving plants were monitored up to full flowering stage or early pod formation stage. Resistance level (plant survival) percentage was calculated on the basis of number of plants before spraying within each replication. The plants that survived with no visible effect of herbicide and flowered about the same time as the untreated plants, were regarded as resistant.

RESULTS

Out of 46 populations of wild radish populations tested in this trial, 32 (70%) were resistant to chlorsulfuron and four (9%) were resistant to OnDuty® (Table 1). These four populations that were resistant to OnDuty® were also resistant to chlorsulfuron. In other words, out of 32 chlorsulfuron-resistant populations, only four were resistant to OnDuty® and remaining 28 were susceptible to OnDuty®.

None of the 46 populations was resistant to OnDuty® only. While 14 (30%) of the 46 populations were susceptible to chlorsulfuron, as many as 42 (91%) were susceptible to OnDuty®. The range of resistance level to OnDuty® was 3-7% while range of resistance level to chlorsulfuron varied from 4 to 100%.

Table 1. Number of wild radish populations with a given resistance and cross-resistance status to chlorsulfuron and OnDuty®*

Chlorsulfuron status		OnDuty® status	
	Total populations	Resistant	Susceptible
Resistant	32 (70)	4 (9)	28 (61)
Susceptible	14 (30)	–	14 (30)
Total populations	46 (100)	4 (9)	42 (91)

* Figures in brackets are percentage of 46 populations.

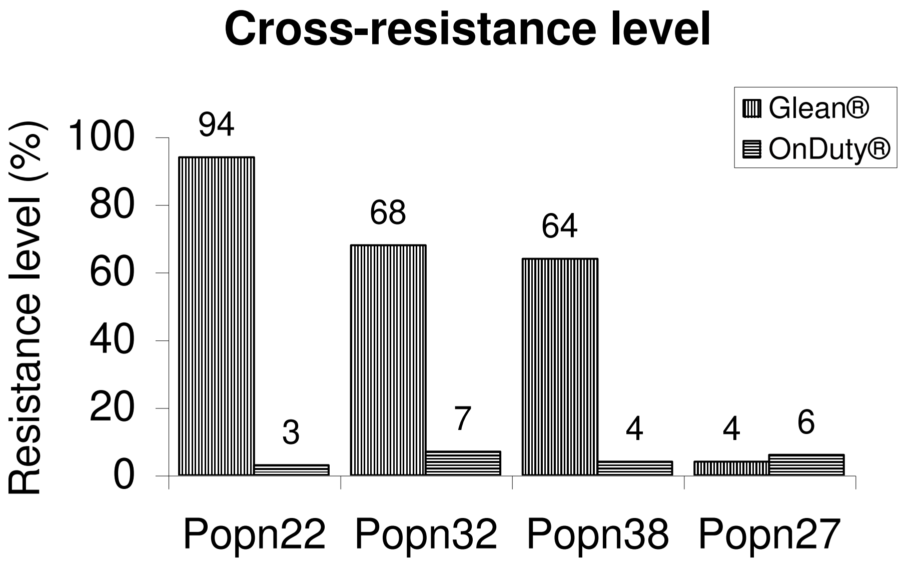


Figure 1. **Resistance levels in the four wild radish populations that showed cross-resistance between chlorsulfuron and OnDuty®.**

A close examination at the resistance level of the 9% populations that had cross-resistance to chlorsulfuron and OnDuty®, revealed that most of these populations were highly resistant (64-94%) to chlorsulfuron but only slightly resistant (3-7%) to OnDuty® (Figure 1). In one (population 27) of these populations, resistance level to both herbicides was at initial stage.

These results clearly show that genes that may endow resistance to OnDuty® are present in chlorsulfuron-resistant wild radish populations. However, the frequency of population with OnDuty®-resistant gene and the percentage of plants with such resistant gene within a given resistant population is much lower than chlorsulfuron resistance.

OnDuty® was highly effective on most chlorsulfuron resistant radish populations indicating that OnDuty® is still an option to manage chlorsulfuron-resistant radish populations. However, this herbicide must be rotated with other groups of herbicides to prevent evolution of such resistance. For example, in a canola-cereal-legumes-Imi-wheat rotation, if OnDuty® is used in canola, radish in Imi-wheat should be controlled by herbicides with different mode of action, such as Phenoxys and OnDuty® should not be repeated in cereals or pulses.

CONCLUSIONS

Presence of cross-resistance in chlorsulfuron-resistant wild radish to OnDuty® indicates that Imi herbicides must be used judiciously to sustain the Imi-tolerant crop productivity.

ACKNOWLEDGMENTS

We are thankful to Grain Research and Development Corporation (GRDC) for funding the project and Cyanamid Agriculture Pty Limited for supplying the OnDuty® herbicide.

GRDC Project No.: DAW 535 WR

Paper reviewed by: Terry Piper and David Bowran

Investigation of suspected triazine resistant ryegrass populations for cross-resistance and multiple resistance to herbicides

Michael Walsh, Charles Boyle and Stephen Powles, Western Australian Herbicide Resistance Initiative, University of Western Australia

KEY MESSAGE

The three populations of annual ryegrass selected from canola crops on suspicion of being resistant to Atrazine were identified as resistant populations. Screening subsequently identified all three of these populations as being multi-resistant with the ability to survive herbicides from many different groups.

AIM

To confirm the resistance status of three populations of annual ryegrass suspected of being resistant to atrazine. Also the extent of resistance of these populations to a number of other herbicide groups was characterised.

METHODS

Seed collected from each of the three suspected atrazine resistant populations were germinated on agar trays in an incubator. Seedlings were removed from the agar and planted to 2 cm depth, at a density of 12 seedlings per pot. All pots were placed outside in a screened area following two days acclimatisation in a glass-house, pots were watered and fertilised as necessary. Herbicide treatments were applied at the two-leaf stage using a dual nozzle cabinet sprayer delivering 110 L/ha. Mortality assessments were conducted 10-14 days after treatment.

RESULTS

All three populations were found to be resistant to atrazine with significant plant survival at the recommended rate of this herbicide (Figure 1). The relatively low level of resistance indicates that the mechanism involved is not target-site based.

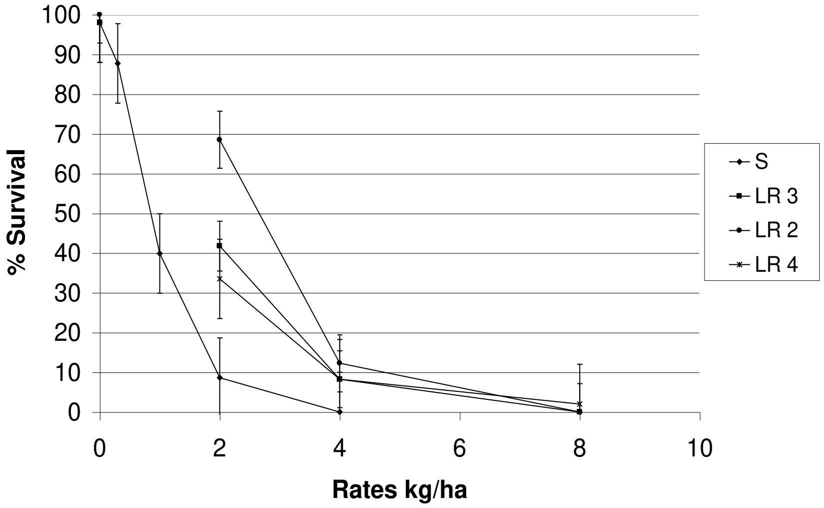
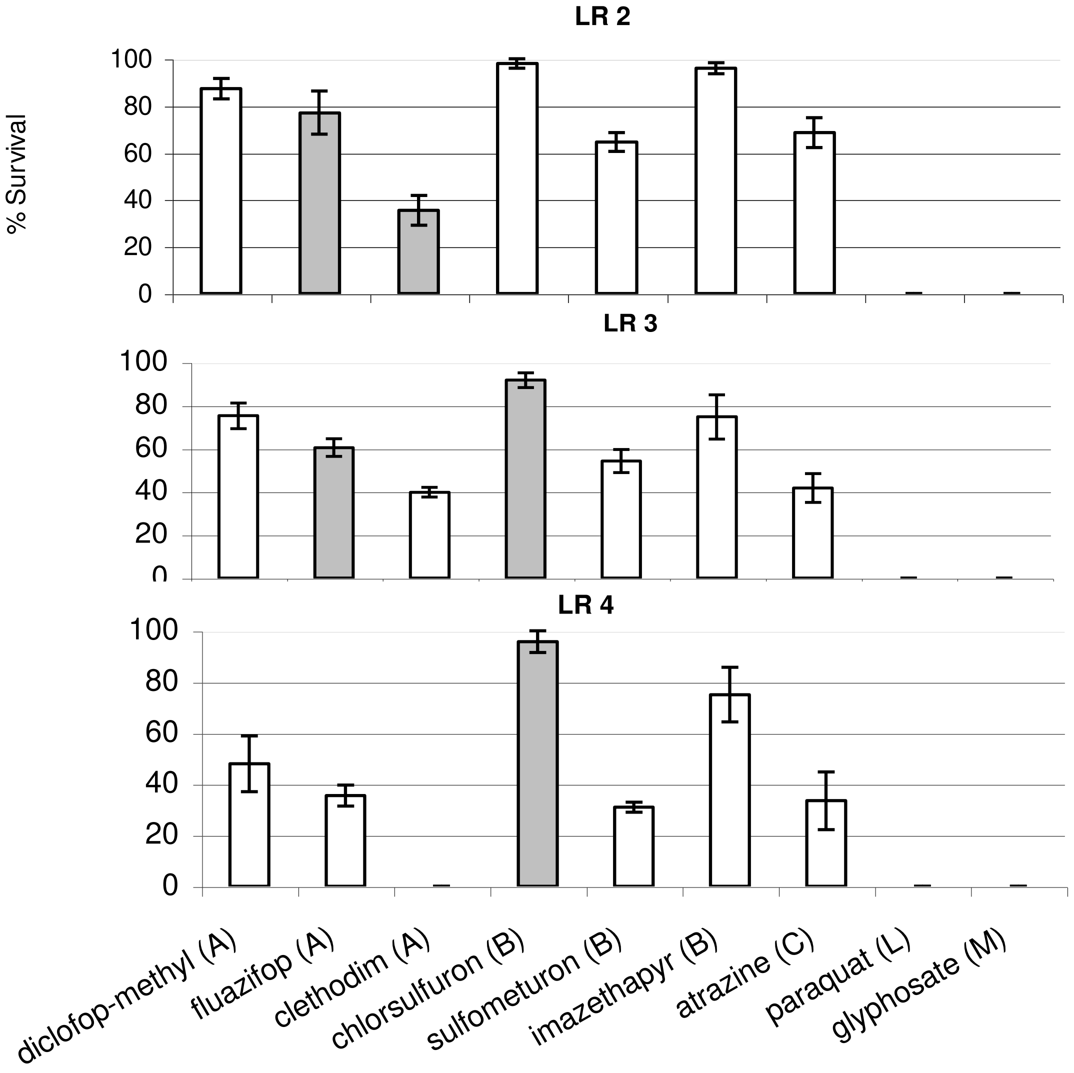


Figure 1. Atrazine dose response of four populations of annual ryegrass.

It was also revealed that the three ryegrass populations had multiple and possible cross-resistance to seven herbicides across three herbicide groups (Figure 2). In many instances resistance to a particular herbicide developed without previous applications. Assuming the three populations are a representation of the type and extent of herbicide resistance evolving in Western Australia, failure to prevent further development of herbicide resistance will severely reduce production from extensive cropping systems in this State.



▨ Indicates herbicides that have previously been applied.

Figure 2. Response (% Survival) of three annual ryegrass populations to the recommended rate of nine herbicides.

CONCLUSIONS

Three populations of annual ryegrass selected on the suspicion of resistance to atrazine were subsequently identified as being multi-resistant populations. It is believed that the mechanism of resistance involved (herbicide metabolism) has endowed these populations with the ability to survive herbicides with diverse modes of action. It is likely that these types of multi-resistant populations will become more common where herbicides from a number of different groups are being used for the control of annual ryegrass.

KEYWORDS

herbicide resistance, Annual ryegrass, multiple resistance

GRDC Project No.: UWA 275 WR

Paper reviewed by: Prof. Steve Powles

Genetics and fitness of glyphosate resistant ryegrass

S. Powles[1], P. Neve[1], D. Lorraine-Colwill[2], C. Preston[2]

[1] WAHRI, University of Western Australia
[2] CRC Weed Management Systems, University of Adelaide

KEY MESSAGE

Glyphosate resistance in the Orange, NSW resistant biotype is endowed by a single major nuclear gene. There appears to be a fitness penalty associated with resistance.

AIMS

To identify the genetic control of glyphosate resistance in ryegrass and the fitness of the resistant plants.

RESULTS

Resistance to the knockdown herbicide glyphosate has now occurred in Australia and Malaysia, following persistent usage of this herbicide. Populations of annual ryegrass (*Lolium rigidum*) from Orange, NSW (Powles *et al*. 1998) and Echuca, Victoria (Pratley *et al.* 1999) are glyphosate resistant after 10-15 years annual exposure to glyphosate. In Malaysia, several populations of the annual grass weed *Eleusine indica* exhibit glyphosate resistance (Lee and Ngim, 1999, Tran *et al.* 1999). These are the first weed species, worldwide, to display glyphosate resistance. Considerable research is underway to identify the biochemical, genetic and molecular basis of glyphosate resistance in these weeds.

Very recent results identify that resistance in one of the Malaysian *Eleusine* populations is target site based. Glyphosate is a potent inhibitor of the plastid enzyme EPSP synthase and Tran *et al.* (1999) have identified that this enzyme is less inhibited by glyphosate in the resistant biotype.

This work establishes that target site EPSP synthase changes can result in glyphosate resistance. In both the Orange and the Echuca ryegrass, the glyphosate resistance is not due to any changes in EPSP synthase. Thus, glyphosate resistance in these two ryegrass populations is non target site based (Lorraine-Colwill *et al.* 1999, Feng *et al.* 1999). The details of the mechanism remain to be discovered.

Genetics of glyphosate resistance in ryegrass

Given the importance of glyphosate to Australian and world agriculture it is very important to establish the genetic basis of glyphosate resistance. We have this work underway with the Orange, NSW glyphosate resistant biotype by crossing these plants with known glyphosate susceptible plants. We first established that resistance is conferred via pollen and therefore the resistance is due to a nuclear gene. We have produced F1 progeny between glyphosate resistant and susceptible ryegrass, and have back-crossed the F1 to the susceptible parent. We have treated the F1 and back-cross populations with glyphosate and our results show that glyphosate resistance is endowed by a single, major nuclear gene.

Ecological fitness of glyphosate resistant ryegrass

Resistance to the Group C triazine herbicides is usually associated with reduced fitness of the resistant plants. Conversely, resistance to Group A or B herbicides is not associated with fitness penalties. It is important to establish whether or not glyphosate resistance is associated with any fitness penalties. We have this work underway with the Orange glyphosate resistant biotype. We are working with a F_2 population of crosses between the resistant and susceptible plants. We have preliminary evidence that the Orange resistant ryegrass biotype exhibits a fitness penalty. This will be further investigated in 2000 in both glasshouse and field studies.

CONCLUSION

Glyphosate resistance in the Orange, NSW biotype is endowed by a single major nuclear gene. This glyphosate resistance may be associated with a fitness penalty.

KEY WORDS

glyphosate, herbicide resistance, genetics

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Managing herbicide resistance - the effect of local extinction of resistance genes

Art Diggle[1], **Paul B. Neve**[2], **Stephen B. Powles**[2]

[1] Agriculture Western Australia, South Perth
[2] WAHRI, Faculty of Agriculture, University of Western Australia

KEY MESSAGE

If cropping can be managed in relatively small areas with limited movement of weed seeds between areas, modelling studies indicate that it is possible to delay herbicide resistance through local extinction of resistance genes.

BACKGROUND

Herbicide resistant weeds have become a problem that no farmer can ignore. In recent years, there has been widespread occurrence of resistance to selective herbicides and the problem is continuing to worsen. However, many weed populations are still susceptible to existing herbicides, and new herbicide tolerant crops are being developed, giving farmers more weed control options. In some cases herbicides from new chemical groups, e.g. glufosinate, may become available for in crop use and in such cases there is no history of selection for resistance. Can resistance to these herbicides be controlled in weeds, or is history doomed to repeat itself?

Herbicide resistance occurs because a small fraction of weeds have genes that make them resistant to the herbicide. When the herbicide is used the susceptible plants die but the few resistant ones grow, set seed and multiply. In a few years, the resistant type dominates the paddock. To begin with though, the herbicide resistance genes are rare and plants that are resistant to more than one herbicide are very rare. If it happens that none of the resistance genes is present in a population of weeds in a restricted area, then no selection can occur. If no resistant weeds come into the area, the herbicides will remain effective indefinitely.

THE MODEL

A model has been produced that simulates development of resistance to two separate herbicide groups in a single weed population. The model considers a set area, such as 1 hectare or 100 hectares and calculates the probability that weeds that are resistant to either or both herbicides will exist in that area. The model allows herbicides to be used in any pattern and it calculates the buildup of resistant weeds through time.

The model has been set to simulate a weed similar to ryegrass which is initially susceptible to 2 highly effective types of herbicide with different modes of action, which we will call X and Y. The model is based on probabilities. Consequently, when genes reach low numbers they may or may not become extinct. Therefore, as in reality, the model produces different results on different runs, but by running it several times, the range of possible results and their probabilities can be worked out.

The model has been run 10 times for each of two patterns of herbicide use in both 1 hectare and 100 hectare areas. The two patterns of use were ‘rotation’ and ‘combination’. When used in rotation, herbicides X and Y were used in alternate years. When used in combination, both herbicides were used in all years but applied in separate operations rather than as a mixture. This is the same pattern as used for the ‘double knock’ of paraquat and glyphosate, but it can also be used for other combinations of herbicides. The initial frequencies of the genes for both types of resistance were 1 in 1 million and the initial weed population was 100 seeds per square metre for all runs.

RESULTS

In a 1 hectare area where herbicides X and Y were rotated, resistance developed after 10 years in four runs out of 10 and did not develop in the other 6 runs. Where the herbicides were used in combination each year, herbicide resistance did not develop in any runs (Figure 1).

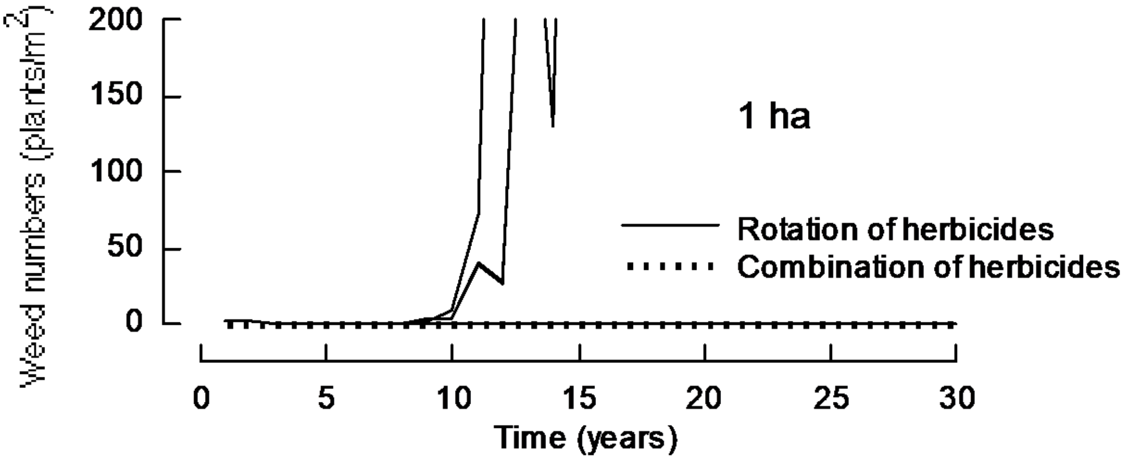

Figure 1. Twenty runs of the model for a 1 hectare area, with 10 runs for herbicides X and Y used in rotation and 10 runs with herbicides X and Y used in combination in all years.

In a 100 hectare area resistance developed in all runs where the herbicides were rotated and in 2 out of 10 runs where they were used in combination (Figure 2).

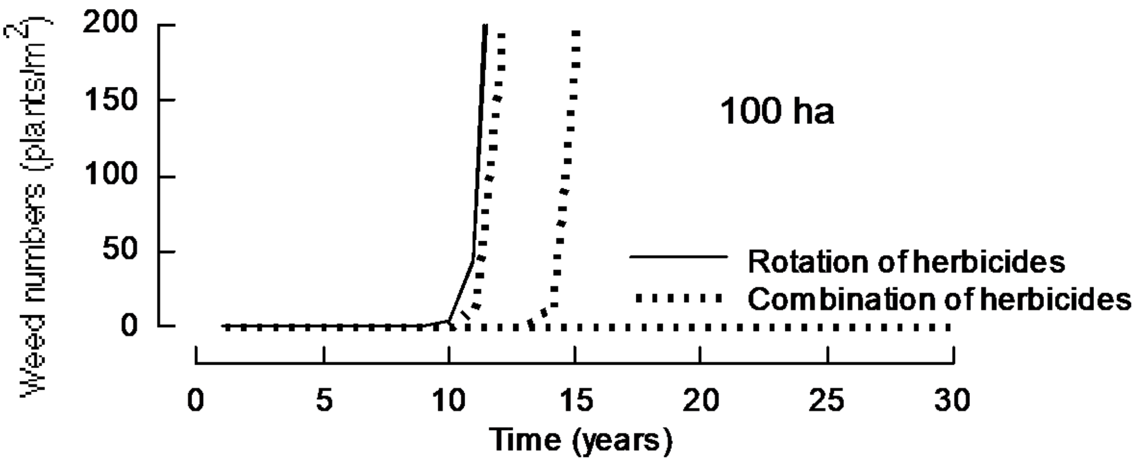

Figure 2. Twenty runs of the model for a 100 hectare area, with 10 runs for herbicides X and Y used in rotation and 10 runs with herbicides X and Y used in combination in all years.

CONCLUSION

Herbicide resistance can be controlled in small areas if resistant types can be prevented from moving in. This can be accomplished in larger areas if highly effective herbicides are used in combination, as both types of resistance can be driven extinct by the other herbicide. It may be that this type of control will be achievable in practice in the future for some weed species through a combination of precision seeding, accurate mapping of weed populations (for early detection of resistant individuals), use of very clean seed (to prevent movement of resistant seed between paddocks) and the double knock strategy.

KEY WORDS

herbicide resistance, model, extinction, crop hygiene

Paper reviewed by: Professor Stephen Powles

The double knock – the best strategy for conserving glyphosate susceptibility?

Paul B. Neve[1], Art Diggle[2], Stephen B. Powles[1]

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KEY MESSAGE

A simulation model demonstrates potential benefits of the double knock (sequential pre-seeding application of glyphosate and paraquat) for conserving glyphosate susceptibility in annual ryegrass.

BACKGROUND

Until recently the broad spectrum, knockdown herbicide, glyphosate, was assumed to be nearly infallible to resistance evolution. However, in Australia, glyphosate resistance has now been documented in two annual ryegrass (*Lolium rigidum*) populations (Powles *et al.* 1998; Pratley *et al.* 1999).

The expected introduction of glyphosate-resistant crops and the increasing move towards zero and minimum tillage systems, with their reliance on knockdown herbicides for pre-seeding weed control, will increase the selection pressure for evolution of glyphosate resistance in weed populations. Clearly, any loss of glyphosate susceptibility would severely compromise current practices. However, this need not occur. Mutation to glyphosate resistance is uncommon and the opportunity exists for judicious, proactive management to prevent its possible widespread evolution.

A MODELLING APPROACH

A simulation model of the population genetics and dynamics of glyphosate and paraquat resistance in annual ryegrass has been developed. The model assumes that resistance to both herbicides is conferred by mutations at single, but discrete gene loci. Simulations run over a 30 year period. Life cycle parameters (i.e. germination fraction, seedbank longevity), cultural and chemical control strategies and crop rotations can be varied to enable comparisons of different strategies and scenarios on the predicted evolution of glyphosate and paraquat resistance.

In particular, this paper compares long-term strategies for the use of glyphosate and paraquat for pre-seeding, knockdown weed control. As such, all other life-cycle parameters and control strategies will be kept constant. A glyphosate resistant crop is included one year in every three of the rotation. During these years glyphosate is used for in-crop post-emergent weed control, in all other years an alternative selective herbicide is applied.

Four strategies will be compared:

Strategy 1	Glyphosate applied every year for pre-seeding weed control.
Strategy 2	Glyphosate and paraquat applied in alternate years.
Strategy 3	Paraquat used in years following glyphosate resistant crop, glyphosate in other years.
Strategy 4	The double knock – glyphosate and paraquat used sequentially every year.

RESULTS

Probabilities and mean rates of resistance evolution for each strategy, calculated from 100 thirty-year runs of the model are presented in Table 1 and Figure 1, respectively.

Table 1. Probabilities of glyphosate resistance evolution under four knockdown management strategies

Strategy	Probability of glyphosate resistance evolution
1. Glyphosate every year	0.64
2. Alternate glyphosate and paraquat	0.35
3. Paraquat following in-crop glyphosate	0.46
4. Double knock	0.00

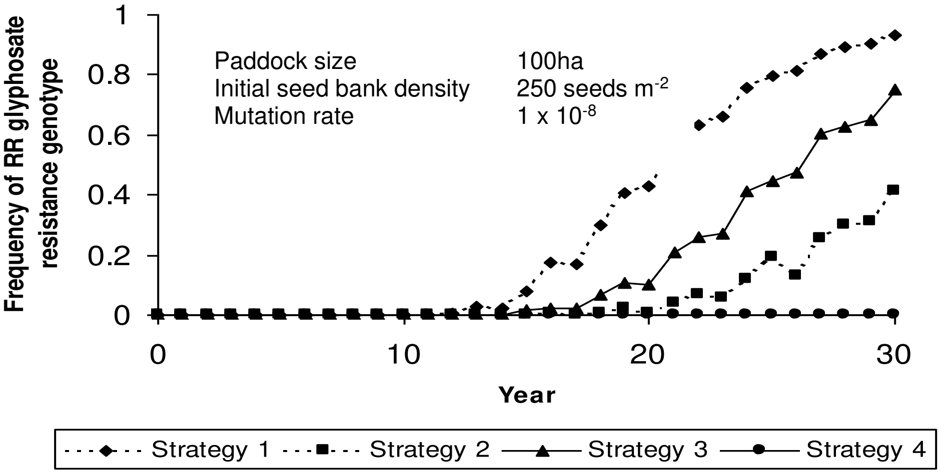

Figure 1. Predicted rates of glyphosate resistance evolution under a range of knockdown herbicide strategies and rotations.

Clearly, the double knock strategy (strategy 4) is the most effective for preventing the evolution of glyphosate resistance. Indeed, this strategy maintains complete susceptibility to glyphosate within the ryegrass population for the entire 30 year simulation period in 100% of simulation runs. Conversely, as we might expect, yearly reliance on glyphosate alone for pre-seeding ryegrass control, results in a predicted probability of resistance evolution of 64%, resistance evolving in approximately 15 years.

Paraquat resistance has never been reported in ryegrass, but has evolved in other weedy species (Purba *et al.* 1993). Resistance to paraquat did not evolve under any of the strategies investigated. This does not, however, mean that annual ryegrass will never develop resistance to paraquat.

CONCLUSION

A simulation model predicts that a pre-seeding double knock with glyphosate and paraquat will considerably reduce the rate and probability of glyphosate resistance evolution in annual ryegrass.

KEYWORDS

model, resistance, glyphosate, double-knock

LITERATURE

Evolved resistance to glyphosate in rigid ryegrass (Lolium rigidum) in Australia. S.B. Powles, D.F. Lorraine-Colwill, J.J. Dellow, C. Preston. Weed Science 46, 1998.

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GRDC Project No.: UWA 257

Paper reviewed by: Dr Frank Forcella

Wild radish has evolved resistance to triazines

Abul Hashem, Harmohinder S. Dhammu, David Bowran and Aik Cheam,
Agriculture Western Australia

KEY MESSAGE

A wild radish population in northern wheatbelt of Western Australia has evolved 176-fold resistance to simazine and atrazine. About 90 to 98% of the progeny plants of this population survived up to 4.0 kg a.i./ha of simazine and 57% survived at 8.0 kg a.i./ha atrazine. However, this population was effectively controlled by other herbicides with different mode of action.

AIM

Control failure in wild radish was observed in a TT canola paddock after 13 applications of triazines at Mingenew. Three trials were undertaken to investigate if wild radish population in this paddock has evolved resistance to triazines.

METHODS

Mature pods of a wild radish population (PW98) suspected to be resistant to triazines were collected in 1998 from Mingenew, the Northern wheatbelt of Western Australia. The pods were dried at room temperature, crushed to overcome dormancy, and seeds were cleaned.

In trial 1, 20 seeds of PW98 (R biotype) along with a population 970105 (S biotype) known to be susceptible to triazines were sown in 1.0 L pots in 3 replications. Pots were filled with commercial potting mix covered with a 2.5 cm layer of sandy loam soil at the top. Plants were grown in a glasshouse under natural light. Five days after emergence (DAE), plants were thinned to 12 plants/pot. At 2-3 leaf stages, plants were sprayed with atrazine and plant survival was recorded 4 weeks after spraying (WAS). The surviving plants of the R biotype were transplanted to 5.0 L pots and were kept outdoors at close proximity to allow free cross-pollination. Mature pods were collected from these surviving plants.

In Trial 2, the progeny seeds collected from the R biotype plants that survived variable rates of atrazine in Trial 1 were sown in 1.0 L pots along with the S biotype in four replications as in Trial 1. Simazine was sprayed on the surface of soil and incorporated into top 1 cm layer of soil before planting. Plant survival was recorded five weeks after emergence. The plants to be sprayed with atrazine as post-emergent were thinned to 12 plants/pot 5 DAE. Atrazine was sprayed at 2-3 leaf stages of plants. Plant survival in all the pots was recorded 4 WAS.

In Trial 3, using the original collections of seeds, plants of R and S biotypes were grown in pots as in Trial 1. At 2-3 leaf stages, plants were sprayed with chlorsulfuron 15.0 g, metosulam 5.0 g, diflufenican 50.0 g, 2,4-D 500.0 g, glyphosate 460.0 g and paraquat 250.0 g a.i./ha. Plant survival was recorded 4 WAS.

All herbicides were applied as commercial formulations with adjuvants as recommended by the herbicide manufacturers. Percent plant survival was calculated based on the untreated control. In Trial 2, LD_{50} ratio was computed by regression analysis.

RESULTS

In Trial 1, all the plants of S biotype were completely killed at 0.5 kg a.i./ha or higher rates of atrazine. About 25% of the R biotype plants survived at 0.5 kg a.i./ha of atrazine while 10% survived up to 6.0 kg a.i./ha of atrazine (Figure 1). These preliminary results indicated that the suspected R biotype radish was resistant to atrazine although the population was highly heterogeneous.

In Trial 2, 90-98% of the R biotype progeny plants survived up to 4.0 kg a.i./ha of simazine applied as pre-seeding incorporated and 57% survived up to 8.0 kg a.i./ha atrazine applied as post-emergence (Figure 1). The high heterogeneity as observed in Trial 1 was greatly improved in the progeny plants in Trial 2. All the plants of the S biotype were completely killed at 0.25 kg a.i./ha of simazine or 0.50 kg a.i./ha of atrazine. These results clearly confirmed that the suspected R biotype was resistant to triazines. Based on LD_{50} ratio, the R biotype progeny plants were 176 times more resistant to triazines than the S biotype.

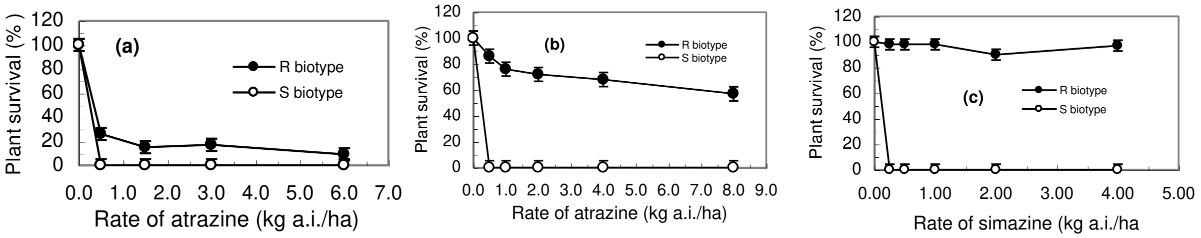

Figure 1. **Plant survival of triazine resistant (R) and susceptible (S) biotypes of wild radish at variable rates of atrazine and simazine. (a) Survival of plants from original collection in Trial 1, (b) and (c) survival of progeny plants in Trial 2.**

In Trial 3, all the plants of the R biotype were completely killed by herbicides such as 2,4-D amine, glyphosate and paraquat at label rates. Chlorsulfuron controlled 86%, metosulam controlled 85% and diflufenican controlled 97% of the treated plants of R biotype. All the treated plants of the S biotype were completely killed by each of these herbicides.

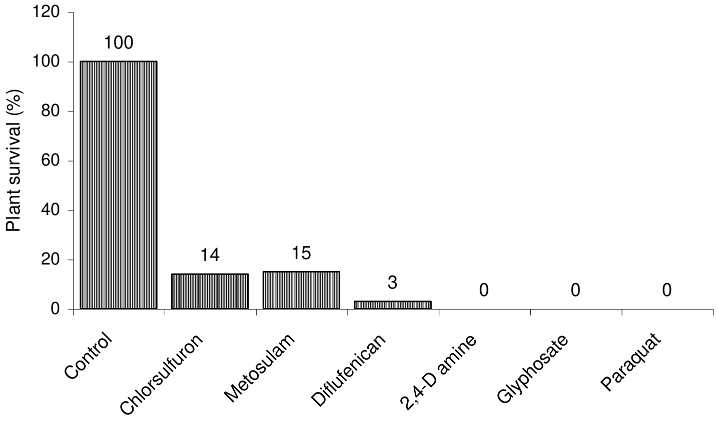

Figure 2. **Response of triazine-resistant wild radish plants from original collection to herbicides with different mode of action than triazines. Plant survival percentage was calculated based on the untreated control.**

Wild radish is one of the most important weeds of the field crops in Western Australian Wheatbelt. It is the main target weed species of atrazine used in TT canola as post- emergent. Evolution of resistance to triazines by this weed species is a serious threat to the pulse, lupin and canola industries of Australia.

The results of Trial 3 suggest that there is opportunity to control the triazine-resistant biotype of wild radish by herbicides such as 2,4-D, paraquat, glyphosate, diflufenican, metosulam and chlorsulfuron. However, this weed can not selectively be controlled by these herbicides in canola and pulses as easily as in cereals beside the fact that it has evolved widespread resistance to ALS-inhibiting herbicides. Therefore, alternative weed management strategies need to be developed to manage triazines resistant populations of wild radish and to prevent or delay the evolution of such resistance.

CONCLUSION

Wild radish has evolved resistance to triazines within the wheatbelt of Western Australia. However, this population is effectively controlled by other herbicides with different mode of action.

ACKNOWLEDGMENTS

We are thankful to Grain Research and Development Corporation (GRDC) for funding the project and to David Nicholson and Shoela Mukhtari for their technical assistance in the study.

GRDC Project No. DAW 535 WR

Paper reviewed by: Harmohinder Dhammu

Ryegrass resistance in Western Australia - where and how much?

Rick Llewellyn and Stephen Powles, Western Australian Herbicide Resistance Initiative, Faculty of Agriculture, University of Western Australia

KEY MESSAGE

The proportion of cropping paddocks containing a ryegrass population resistant to diclofop and chlorsulfuron has reached very high levels in several Western Australian cropping areas, although large differences between areas exist and clethodim resistance remains low across all areas.

AIMS

Although Western Australia has gained a reputation for having one of the most serious herbicide resistant problems in Australia, if not the world, the actual extent of resistance has not previously been determined. The aim of this study is to provide a measure of what proportion of paddocks contain Group A and Group B resistant ryegrass and determine what susceptibility remains to key herbicides used for selective ryegrass control across several cropping areas.

METHODS

Prior to harvest in 1998, a total of 264 in-crop paddocks were randomly selected within eight Agriculture Western Australia crop variety testing areas (see Table 1). Ryegrass seed was collected in each paddock where more than 10 seed producing ryegrass plants were found within a 100 m x 100 m sampling area. During sampling the ryegrass density within the sampling area was visually scored. From May-August 1999, sets of approximately 25 plants from each of 185 populations were grown outdoors for testing with Group A and B herbicides. Initial Group A testing was performed using diclofop (1.0 L/ha Hoegrass). Populations with greater than 20% of ryegrass plants surviving were classified as Resistant. Where there were less than 20% of plants surviving the populations were classified as Developing Resistance and where all plants were killed they were classified as Susceptible. Resistant populations were later tested for resistance to clethodim (200 mL/ha Select). Initial Group B testing was performed using chlorsulfuron (40 g/ha Glean), with populations being classified as Resistant, Developing Resistance or Susceptible. Resistant populations were later tested with sulfometuron (40 g/ha Oust).

RESULTS

Ryegrass was found in 87% of paddocks surveyed at generally low-moderate densities (Figure 1).

The proportion of populations resistant to diclofop varied greatly between agronomic areas (Table 1). As expected, it was very high in the Wongan Hills-Coorow (M2) area, with 73% being Resistant. In contrast, no diclofop Resistant populations were found in the Williams-Darkan area (H4). Overall, of the 185 populations tested, 46% were classified as Resistant or Developing Resistance to diclofop. No Select resistant populations were found.

The overall percentage of tested paddocks classified as Resistant or Developing Resistance to chlorsulfuron was 64%. All populations classified as Resistant to chlorsulfuron were resistant to Oust, indicating that target site mechanisms were responsible for Resistant classification under the testing conditions. Enhanced metabolic resistance mechanisms are likely to have resulted in populations being classified as Developing Resistance.

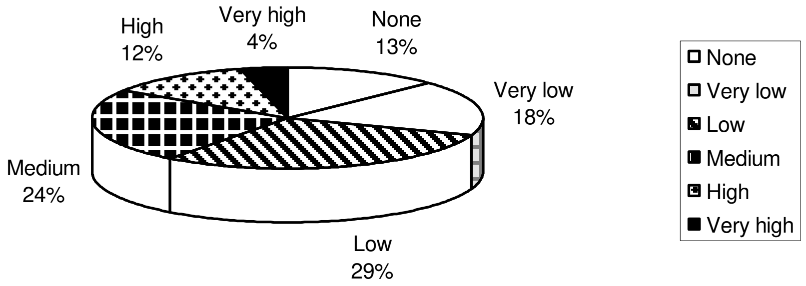

Figure 1. **Ryegrass density in surveyed areas as a percentage of 264 paddocks, October-November 1998. Approximate densities: None - none found in survey area; Very low and Low - less than 1 plant/m^2; Medium - 1-10 plants/m^2; High and Very High - greater than 10 plants/m^2.**

Nearly half of all paddocks tested contained a ryegrass population classified as Resistant to diclofop and/or chlorsulfuron and only 28% of populations were Susceptible to both herbicides.

Table 1. **Diclofop and chlorsulfuron resistance as a per cent of populations tested in each area**

	Diclofop			Chlorsulfuron		
Area*	**Resistant**	**Developing**	**Susceptible**	**Resistant**	**Developing**	**Susceptible**
H2	12	12	76	9	27	64
H4	0	4	96	0	21	79
M2	73	23	4	62	26	12
M3	24	38	38	18	46	36
M4	13	26	61	58	17	25
L2	40	40	20	67	11	22
L3	15	15	70	50	30	20
L4	7	30	63	44	26	30
All (ave.)	23	23	54	38	26	36

Rainfall regions: H - high, M - medium, L - low
Zones: 2 - north central, 3 - central, 4 - south central

* Refer to Agriculture Western Australia Crop Variety Testing areas

CONCLUSION

The results highlight both the seriousness of the resistance problem in Western Australia and also the opportunity to take action. Whilst some areas already have very high levels of diclofop and chlorsulfuron resistance, grain growers in other areas still have high herbicide efficacy and the option of avoiding the path to rapid and widespread resistance. The low level of resistance to Select across all cropping areas is encouraging for future ryegrass control, however, it also suggests that the issue of conserving the effectiveness of ryegrass herbicides remains important for all Western Australian farmers.

Results of this study showing the extent of diclofop and chlorsulfuron resistant populations in map form are available from the WAHRI website: http://wahri.agric.uwa.edu.au.

KEYWORDS

Herbicide resistance ryegrass

GRDC Project No.: UWA275WR
Paper reviewed by: Stephen Powles

Wild radish herbicide resistance survey

Michael Walsh, Ryan Duane and Stephen Powles, Western Australian Herbicide Resistance Initiative, University of Western Australia

KEY MESSAGE

There is currently an exceedingly high frequency of chlorsulfuron resistant wild radish populations across the Western Australian wheatbelt. Over 20 percent of wild radish populations randomly selected from wheat crops were found to be resistant to chlorsulfuron.

AIM

A survey was conducted to determine the current frequency of wild radish populations resistant to chlorsulfuron and atrazine.

METHODS

Random surveying of wild radish populations for herbicide resistance was conducted across the Northern, Central and Eastern regions of the Western Australian wheatbelt. The survey was conducted throughout the growing season months of June and July 1999, so as to coincide with the application of post-emergence herbicide treatments.

Wild radish plants were collected by randomly selecting a cropping paddock and searching an area of approximately 500 m^{-2} in each paddock. Within these areas, wild radish seedlings were exhumed and placed in paper bags for transplanting the following day. Wild radish plant growth stages at the time of collection ranged from 2 to 8 leaves. At each survey site, a handheld GPS unit determined the latitude and longitude coordinates.

Collected seedlings were screened using the Novartis Quick-test where plants were trimmed and allowed to re-establish in pots in the glasshouse for approximately ten days before being treated with herbicides. Wild radish plants collected from canola crops were treated with 2.0 L/ha of Atrazine and plants from wheat crops were sprayed with 20 g/ha of chlorsulfuron. After three weeks wild radish plants that had survived the respective herbicide treatments were trimmed back allowed to re-establish and treated again with the same herbicide. Any plants that survived the second treatment were declared herbicide resistant.

RESULTS

A massive 21% of the Wild radish populations randomly collected from wheat crops throughout the survey region of the Western Australian wheatbelt were found to be resistant to chlorsulfuron (Table 1). Although it has previously been established that chlorsulfuron resistant populations of *R. raphanistrum* were present in Western Australia (Hashem *et al.* 1999) the extent of resistance is far greater than expected.

There is currently an extremely high frequency of wild radish populations already present in copping paddocks in Western Australia. In the Northern survey region 40% of the Wild radish populations were found to be resistant to chlorsulfuron (Table 1). This was more than double the frequency of resistant populations in the central region and almost four times the frequency of populations in the eastern region. This result corresponds with a similarly high proportion of chlorsulfuron resistant annual ryegrass populations recently recorded for this region (Llewellyn and Powles unpublished). This suggests that growers in this area have imposed a high selection pressure for chlorsulfuron resistant weed populations in this particular region.

It has also been suggested that seed dormancy is less in Wild radish populations from the warmer northern region than in populations from cooler southern districts. A weed species that exhibits low dormancy will develop resistance more rapidly than a species with increased seed dormancy. Additionally, population densities were higher in this region and may also be a contributing factor. A combination of high selection intensity, increased populations and the dormancy traits of Wild radish potentially explain the increased frequency of resistant populations found in the northern regions.

Table 1. **Summary of wild radish survey results**

Crop	Paddocks		Resistant populations	
	No. surveyed	**WR collected**	**Total**	**%**
Wheat	206	133	28	21
Canola	75	34	2	6
Total	**281**	**167**		

Of the 34 populations collected two were found to be Atrazine resistant. However, although resistance was identified no conclusions on the frequency of resistant populations can be made due to the reduced number of populations screened.

Table 2. **Wheat paddocks surveyed, wild radish populations collected and number and proportion of resistant populations for the individual regions**

Region	Paddocks		Resistant populations	
	# Surveyed	**WR collected**	**Total**	**%**
Northern	64	50	19	38
Central	74	51	5	9.8
Eastern	67	34	5	14.7
Total	**205**	**135**	**29**	**21.5**

CONCLUSION

There are currently extensive levels of chlorsulfuron resistance in wild radish populations randomly selected from across the Western Australian wheatbelt. This result is a major concern to farmers who are already trying to manage extensive levels of resistance in annual ryegrass populations. There were higher frequencies of resistance identified for the northern survey region, which is similar to results recorded for ryegrass by Llewellyn and Powles (unpublished).

KEYWORDS

wild radish, herbicide resistance, chlorsulfuron

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GRDC Project No.: UWA 270

Paper reviewed by: Prof. Steve Powles

Knockdown resistance in the Western Australian wheat belt – a proposed survey

Paul B. Neve[1], Abul Hashem[2], Stephen B. Powles[1]

[1] WAHRI, Faculty of Agriculture, University of Western Australia
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KEY MESSAGE

During the 2000 growing season WAHRI and Agriculture Western Australia will test weed populations for suspected resistance to glyphosate and paraquat. This will establish whether and to what extent resistance to these knockdown herbicides is present in the Western Australian wheat belt.

BACKGROUND

To date, resistance to the knockdown herbicides, glyphosate and paraquat has not been reported from the Western Australian wheat belt. Nevertheless, the characterisation of a glyphosate resistant population of annual ryegrass (*Lolium rigidum*) from New South Wales (Powles *et al.* 1998) and Victoria (Pratley *et al.* 1999) has demonstrated the potential for resistance evolution. Glyphosate and paraquat have been crucial to the continued increase in productivity in the Western Australian wheat belt. Clearly, evolved resistance to these weed control options will severely compromise current farming practices, particularly when the imminent introduction of glyphosate resistant crop varieties is considered.

METHODOLOGY

A survey is being planned which will establish the presence and extent of glyphosate and paraquat resistance in Western Australia. Glyphosate and paraquat resistance are uncommon and as such random sampling methods such as those employed in recent surveys to quantify the level of resistance to selective herbicides in the Western Australian wheat belt (Walsh *et al.* 2000; Llewellyn and Powles, this volume) are not feasible or practical.

Instead, this survey will be publicised in the rural media, on the internet and at relevant meetings, workshops and conferences in March and April this year. Farmers, agronomists and consultants will be invited to send ryegrass and other weed seedlings which have not been controlled by pre-seeding knockdown herbicide applications to WAHRI at UWA or Agriculture Western Australia in Merredin. These seedlings will be trimmed and transplanted into trays where they will be grown under standard conditions for a period of 7-10 days. On resumption of healthy growth, seedlings will be sprayed with paraquat or glyphosate at recommended field rates to test their resistance status. This technique is a modification of the Novartis Quick-test (Boutsalis, 2000). These tests will provide a means for early detection of knockdown resistance and provide an opportunity for alternative control strategies in the current year to prevent seed set by resistant weeds where these are identified.

It is envisaged that pre-addressed kits will be made available to district agronomists and at Agriculture Western Australia District Offices. These will comprise Express Post envelopes to ensure rapid transfer of samples and a short questionnaire to give details of herbicide applied, rate and timing of application and herbicide and cropping history.

We are hoping to foster cooperation between WAHRI, Agriculture Western Australia, agronomists, growers and chemical manufacturers and believe that this can be beneficial to all. Growers and agronomists can benefit from free resistance testing of suspected populations. The application of knockdown herbicides to millions of hectares across the wheat belt can act as a mass screening for resistance to these chemicals. We seek the help of growers and agronomists to locate suspect populations. This ‘mass screening’ will be more efficient than costly and time consuming random screening techniques.

KEYWORDS

glyphosate, paraquat, resistance, survey

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GRDC Project No.: UWA 257

Paper reviewed by: Professor Stephen Powles

Diflufenican resistant wild radish

Aik Cheam, Siew Lee, David Bowran, David Nicholson and Abul Hashem,
Agriculture Western Australia

KEY MESSAGE

A population of wild radish collected from the northern wheatbelt of Western Australia proved to be resistant to diflufenican in dose-response experiments conducted in the field and glasshouse.

Subsequent experimentation demonstrated that the population could be successfully controlled with triazines and phenoxys.

The history of herbicide use on the affected property revealed the population had been exposed to only four applications of diflufenican and five applications of ALS inhibitors herbicides.

AIMS

Diflufenican (Group F herbicide) is widely used by growers in Western Australia to control wild radish in lupin crops. A Northern wheatbelt lupin grower observed that wild radish in his farm was not killed by applications of diflufenican during the 1998 season. A study was therefore initiated in the 1999 season with the following main objectives:

1. To evaluate the susceptibility to diflufenican in the wild radish collection.
2. To establish effective alternative herbicides against the resistant biotype.
3. To understand the dynamics of the resistant biotype so effective management strategies can be developed.

METHODS

Dose-response studies

Dose-response experiments, in the glasshouse and field, were carried out to confirm the resistance status of the suspected diflufenican-resistant biotype. A known susceptible wild radish population was used as a control in all experiments.

Diflufenican was applied at a range of rates to wild radish seedlings at the two-three-leaf stage of development.

For each herbicide rate, three replicate pots were used in the glasshouse. Each pot was large enough to support 50 seedlings without any over-lapping of leaves at the time of spraying and the experiment was repeated two to three times.

In the field, the diflufenican dose-response experiment was carried out in 1 m x 2 m plots seeded with 200 wild radish seeds for each herbicide rate.

Response to herbicides was recorded at various time intervals, starting 21 days after spraying in both the glass-house and field experiments. Plants were recorded as alive if majority of their leaves remained green and their growing points remained alive or they strongly recovered after application of the herbicide. The surviving plants were allowed to flower and set seed.

Field management studies

A field management trial under various cropping rotations was established at the original site with the suspected diflufenican-resistant biotype. Triazine-tolerant canola, wheat and lupins were grown in this first year of the rotation to allow the use of alternative herbicides for the control of the suspected resistant biotype. A randomised complete-block design with four replications was adopted and plot size was 25 m x 6 m.

Herbicides applied to control wild radish were atrazine (50%) at pre-emergence and 2 L post-emergence in canola crop; bromoxynil + MCPA (Buctril MA at 1.4 L/ha) in wheat crop (Z15); diflufenican (Brodal at 200 mL) in the first lupin crop and diflufenican (Brodal at 100 mL) mixed with metribuzin (Lexone at 100 g/ha) in the second lupin crop. All post-emergent herbicides were applied to wild radish at the 2 to 6 leaf stage. Pre-emergent application of simazine at 2 L/ha was the standard basic treatment in the lupin plots. However, pre-emergent simazine application was purposely left out in some of the buffer strips seeded with lupins that received only diflufenican at 200 mL/ha. These strips were used for comparing with the response of wild radish in diflufenican-treated plots that received pre-emergent simazine.

Cohorts of wild radish seedlings that survived and produced seeds were recorded in all treatments. This method of assessment is the only reliable method of determining whether wild radish survivors were late germinations or survivors from early sprays.

RESULTS AND DISCUSSION

Resistance to diflufenican was confirmed in both the glasshouse and field studies (Figures 1). This is the first reported case of diflufenican resistance in wild radish selected under field conditions and is also the first reported case of diflufenican resistance in any plant in the world. In all cases, the plants that survived showed herbicide symptoms and their growth was retarded, the severity of the retardation increased at higher rates. At the highest recommended rate of 200 mL/ha, the percentage of plants that survived ranged from about 70 to 80% when recorded four weeks after spraying. The survivors flowered and set seed successfully in the field.

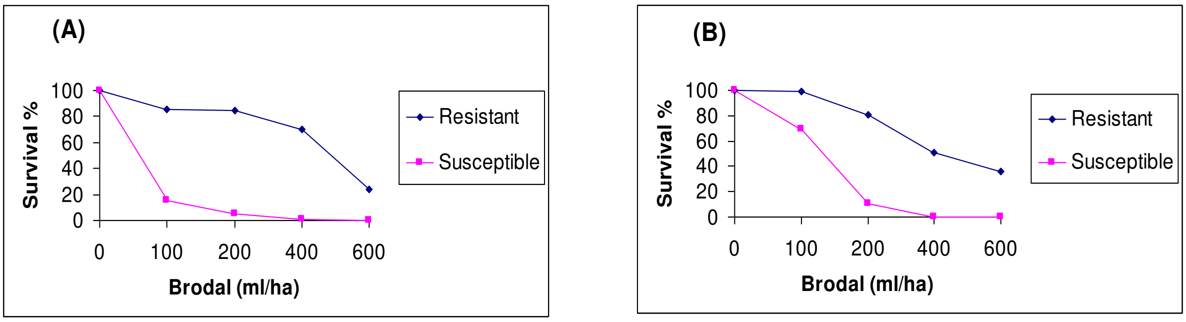

Figure 1. Glasshouse (A) and field responses (B) of a known susceptible and diflufenican-resistant populations of wild radish at a range of Brodal rates.

The diflufenican-resistant population also was resistant to the Group B herbicides, chlorsulfuron and metosulam, but was susceptible to simazine and 2,4-D. An examination of the history of herbicide use on the affected farm revealed the wild radish population had been exposed to five applications of Group B herbicides and to only four applications of diflufenican when the grower first observed diflufenican to be less effective than expected on wild radish in his 1998 lupin crops.

A mixture of diflufenican and metribuzin used as a follow-up treatment proved to be effective on most of the survivors. The wet 1999 season has resulted in exceptionally good control of the resistant population in our lupin plots pre-treated with simazine that were subsequently treated with diflufenican or a mixture of diflufenican + metribuzin. In contrast, there was poor control of wild radish in the lupin crop of the buffer strips that were not pre-treated with simazine despite the high rate of dilufenican (200 mL Brodal) applied. It is therefore argued that the population has evolved resistance to diflufenican, as confirmed in the dose-response experiments. The reason for the high mortality of wild radish in plots pre-treated with simazine could be due to the synergistic interaction between simazine and diflufenican. The moist soil condition maintained the activity of simazine, which was still visible at the time of diflufenican application.

Triazine compounds have been shown to widen the window of application of diflufenican and increase the level of efficacy. Therefore, following the application of diflufenican in a season when simazine is quite active in the soil it may be difficult to detect the survival of a wild radish population that has already evolved resistance to diflufenican.

As expected, the control of wild radish was effective following the application of atrazine in canola and also following the application of bromoxynil + MCPA in the wheat crop. The overall results of this trial are shown in Figure 2. Monitoring the dynamics of the population in subsequent years would be difficult because of the overall low density of the seedbank at the field site. A cleaner paddock is expected this season because of the effective kill of the good germinations last season. This is despite the input of fresh seeds by the small numbers of wild radish survivors which on average produced 340 seeds/plant in canola, 290 seeds/plant in wheat and 230 seeds/plant in lupins.

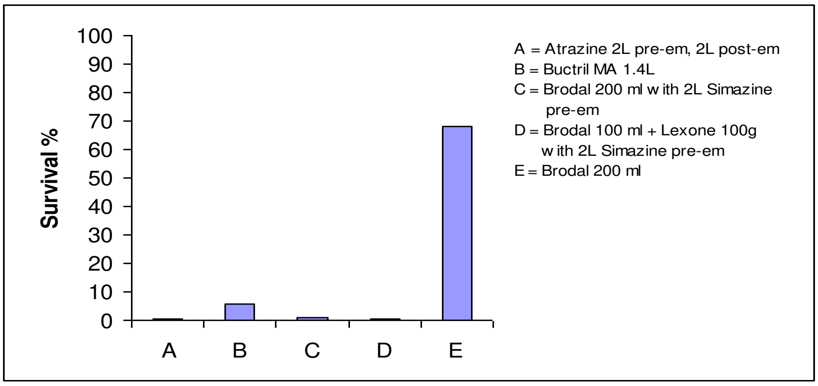

Figure 2. Wild radish survivors following different herbicide treatments as assessed in late spring of 1999.

CONCLUSION

This study has shown that a rotational farming system can be implemented to deal with the challenges of herbicide resistance. Following the confirmation of a population of wild radish multiple-resistant to diflufenican and ALS inhibitors herbicides, the use of alternative herbicides with a different mode of action, on their own or in mixtures, has resulted in very effective control of the resistant biotype in three major crops, namely, wheat, lupins and canola. However, it is suggested that no single herbicide group should be relied upon and high priority should be given to the adoption of integrated weed management.

ACKNOWLEDGMENTS

This work is partly funded by the CRC for Weed Management Systems. Bruce Roberts and Fonda Piesse provided technical assistance. Professor Steve Powles provided helpful suggestions and unfailing encouragement.

KEY WORDS

wild radish, diflufenican resistance, multiple-resistant

Multiple resistance to triazines and diflufenican further complicates wild radish control

Aik Cheam, Siew Lee, David Bowran, David Nicholson and Abul Hashem,
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KEY MESSAGE

Given the importance of triazines and diflufenican in Australian agriculture, especially in Western Australia, the evolution of resistance to both herbicide groups is a significant development that should be closely watched. It is important that weed scientists and extension workers become more aware of herbicide recommendations that minimise the evolution of resistance.

AIMS

Wild radish is rapidly evolving resistance to several herbicide groups in Western Australia. The number of herbicide-resistant populations continues to increase and the presence of multiple resistance within a population is becoming a common phenomenon. This study aimed:

1. To determine whether a suspected population was resistant to triazines and diflufenican.
2. Establish whether there are alternative selective alternative herbicides that can be used on the population in both glasshouse and field situations.
3. To monitor the dynamics of the resistant population in a rotational farming system.
4. Measure the response of commonly used wild radish herbicides on the suspected population in the wheat, lupin and canola crops.

METHODS

Glasshouse studies

Dose-response experiments, using at least 50 plants per replicate per herbicide rate to give statistically significant results, were performed in the glasshouse to confirm resistance of the population to the triazines (atrazine and simazine) and diflufenican. A known susceptible population was used as a control in all experiments. In the post-emergent application, atrazine or diflufenican was applied at a range of rates to the wild radish seedlings at the two- to three- leaf stage of development. Atrazine, diflufenican and simazine as pre-emergent treatments were also applied in separate trials to further confirm resistance. Other herbicides used included chlorsulfuron (Group B), metosulam (Group B) and 2,4-D (Group I) applied at the standard recommended use rate to wild radish at the two- to three-leaf stage. In all experiments, three replicates per herbicide rate were used and the experiments were repeated at least once. Seedling survival scores were obtained at various time intervals, three weeks after spraying.

Field studies

Three separate field experiments were carried out last season.

Two of the experiments were dose-response experiments to confirm resistance of the wild radish population to triazines and diflufenican. The third was a long-term trial to monitor the population dynamics of the suspected resistant population in a rotational cropping system.

Since the suspected resistant population was in canola crop in 1998, wheat and lupins were grown in the first year of the 1999 rotation trial so that alternative herbicides could be used for its control. Triazine-tolerant canola was also included to allow the application of atrazine to confirm triazine resistance in the suspected population.

A randomised complete-block design with four replications was used with plot size 25 m x 6 m. Herbicides applied to control wild radish were atrazine (50%) at 2 L pre-emergence and 2 L post-emergence in canola crop; bromoxynil + MCPA (Butril MA at 1.4 L) in wheat crop at Z15, diflufenican (Brodal at 200 mL) in one lupin crop and diflufenican (Brodal at 100 mL) + metribuzin (Lexone at

100 g/ha) in the second lupin crop. All post-emergent herbicides were applied to wild radish at the two- to three-leaf stage. Pre-emergent application of simazine at 2 L/ha was the basic treatment in all the lupin plots. Cohorts of wild radish seedlings that survived and produced seeds were monitored in all treatments.

RESULTS AND DISCUSSION

Resistance to triazines (atrazine and simazine) and diflufenican was confirmed under glasshouse and field conditions in a population of wild radish collected from the northern grainbelt of Western Australia (Figure 1 and 2).

In the case of atrazine resistance, in the glasshouse the number of surviving plants remaining was approximately constant, between 30–40% within the range of rates tested. This was not the case under field conditions where a much higher survival rate within the recommended herbicide range of 1 to 4 L/hawas observed. The glasshouse conditions account for better herbicide activity than in the field due to the more controlled environment.

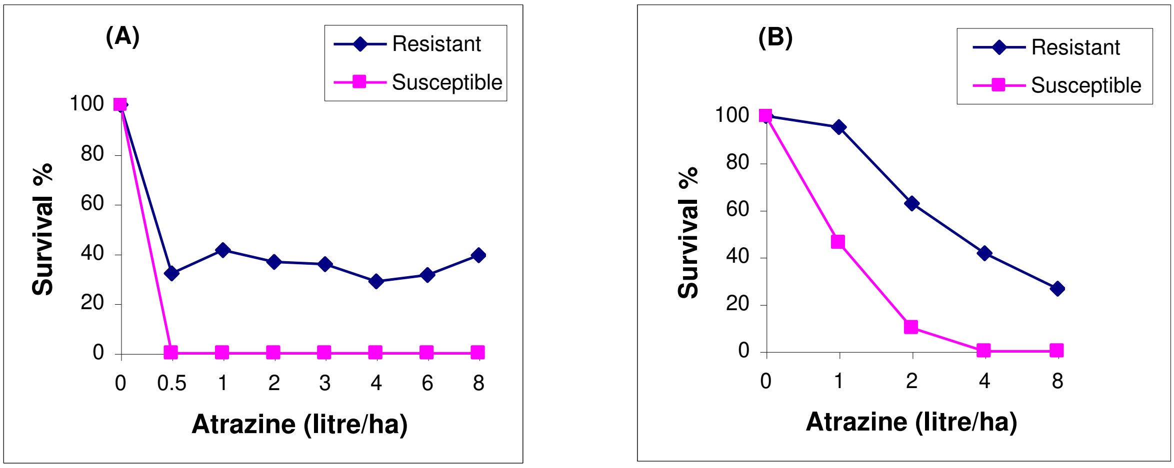


Figure 1. **Glasshouse (A) and field (B) confirmation of triazine resistance in wild radish.**

The response to diflufenican at the 0.1 L/ha recommended rate was poorer in the field than in the glasshouse. However at the highest recommended rate of 0.2 L/ha, a similar survival rate of around 50% was noted in both environments. The history of diflufenican use on the affected farm revealed the wild radish population had been exposed to only four applications. This is considered a relatively short number of applications in contrast to the number of triazine applications involving simazine use in the lupin phase of the wheat-lupin rotations over the last 20 years or so.

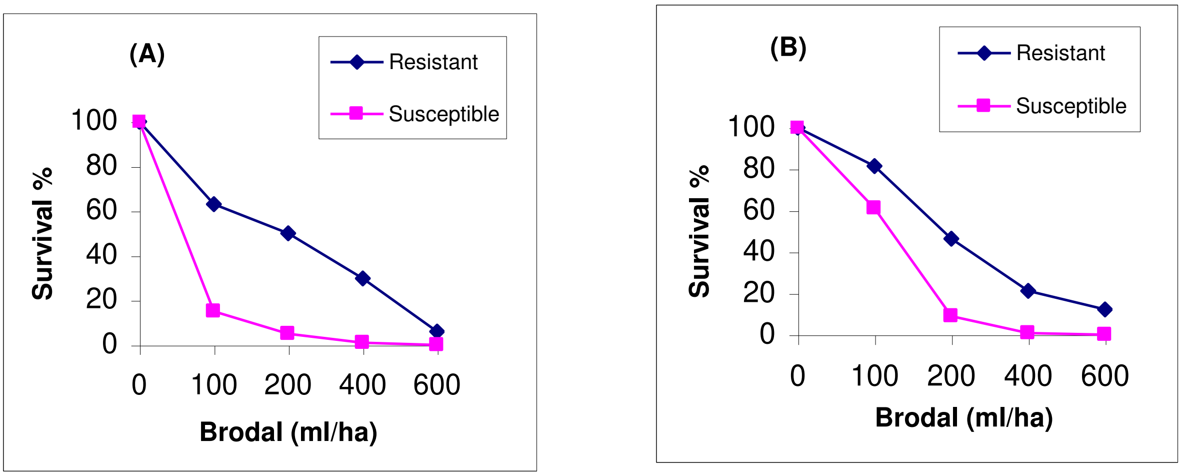


Figure 2. **Glasshouse (A) and field (B) confirmation of diflufenican resistance in wild radish.**

Results of the rotation trial further confirmed the resistance status of the wild radish population under study. Wild radish survival was high in the canola crop due to the failure of atrazine. Diflufenican on its own or even in combination with metribuzin gave unsatisfactory control of the wild radish in the lupin crop. The diflufenican + metribuzin mix did not give better control of wild radish than diflufenican on its own. This was probably because the diflufenican rate in the mixture was only half that of the diflufenican applied on its own. Since the wild radish population was already resistant to triazines (Group C), the addition of metribuzin (Group C) probably did not matter much.

This failure means that we are losing a very important option for the control of wild radish in lupin crops. The best control was achieved in the wheat crop treated with bromoxynil + MCPA (Buctril MA) which resulted in an exceptionally clean crop. The yield data of each herbicide-treated crop with its corresponding control in the absence of wild radish clearly reflected the efficacy of the different herbicide treatments on the resistant population (Table 1).

Table 1. Yields of herbicide-treated crops with radish versus yields of corresponding crops without radish (t/ha). Data within brackets is mean survival (%) of wild radish

Treatment	With radish	Without radish
Canola (Atrazine)	0.62 (76)	1.35
Wheat (Buctril MA)	5.08 (0)	5.40
Lupins (Brodal only)	1.70 (49)	2.57
Lupins (Brodal + Lexone)	1.36 (60)	2.62

Wild radish plants that survived the treatments belonged mainly to the first cohort of emergence (first three weeks after crop seeding). On average they produced 755 seeds per plant in canola crop and 688 seeds per plant in lupin crop. Plants that emerged during third to fifth week after crop seeding produced 16 seeds per plant in canola and 75 seeds per plant in lupins. Any radish that emerged later than the fifth week after crop seeding failed to survive in all crops.

CONCLUSION

The evolution of wild radish populations with multiple resistance to different groups of herbicides is of great concern. The resistance to triazines and diflufenican but not the ALS inhibitors herbicides in this particular population means that in the lupin crop there is only one herbicide option left, i.e. the use of metosulam. In this situation the use of group B herbicides must be carefully planned to avoid development of resistance to this Group. Use of a combination of weed control practices is advisable.

ACKNOWLEDGMENTS

This work is partly funded by the CRC for Weed Management Systems. Bruce Roberts and Fonda Piesse provided technical assistance. Professor Steve Powles provided helpful suggestions and unfailing encouragement.

KEY WORDS

wild radish, multiple resistance, triazine resistance, diflufenican resistance

Herbicide tolerance of lupins

Terry Piper, Weed Science Group, Agriculture Western Australia, Northam

KEY MESSAGE

Herbicide tolerance in lupins continues to be somewhat unpredictable. Tolerance is related to site characteristics, with disease levels probably being the most important. Growers should continue to use minimum rates of herbicides, especially in tank mixes.

THE TRIALS

99MW35 was on a red sand. The lupins grew well, with no signs of diseases until late in the season when anthracnose was detected in Kiev.

99WH72 was on acid sandplain. Moisture stress occurred at times but there was little disease. Aphids badly affected the Tallerack at flowering. They made a remarkable recovery but the results should not be relied upon.

99WH74 was on a grey sand, ex pasture, which had a heavy capeweed burden. Those treatments able to control this have thus been favoured and the results have been given as a per cent of the Brodal treatment. This gave good control and is known to be a safe treatment in its own right.

This trial was sown with knife points and the IPP treatments caused considerable damage when washed into the seeding slots. Their true effect has been masked because they were also the most effective capeweed treatments. There was also a low level of Brown Leaf Spot.

RESULTS

Statistical analysis has not been completed and I have only given sed figures. Double this number is about the lsd.

Brodal/Lexone/simazine continues to be the most unpredictable treatment. It was safe at Mullewa, but was the most damaging treatment at Kalannie and would have been so at Buntine except for the anomolous result with Myallie. In past trials, this treatment has been safe at Katanning and becomes more damaging further north. It was again safe at Katanning, seemed to be more damaging at Wongan (data analysis from these sites is not yet complete), damaging at Kalannie and Buntine, and safe again at Mullewa.

Lexone was tolerated well by all varieties at Mullewa but affected Tanjil at Buntine and Kalannie, and Belara at Buntine. Merrit is also suspect at both sites.

Brodal/Lexone and Brodal/Eclipse were also safe at Mullewa and Kalannie, but not at Buntine. Brodal/Lexone still seems the safer of the two.

These relative safeties are consistent with the observed levels of plant stress at each site. Katanning and Mullewa were stress free, Kalannie had moisture stress at times, while Wongan and Buntine both had slight leaf disease. At Buntine, Merrit was especially affected early and was visibly the most damaged by herbicides. It did recover considerably by harvest.

Eclipse was observed to cause a paling of all varieties for two weeks after spraying at Kalannie, but there has been no effect on yield.

Quilinock had been affected by a range of herbicides in previous years but not this year, except for Eclipse at Kalannie. Tanjil had good tolerance at Mullewa, but was more sensitive at Buntine. This may well be a response to growing season, with the variety unable to recover in the shorter season at Buntine.

GRDC Project No.: **DAW 618**

Paper reviewed by: **Vanessa Stewart**

Herbicide effects on yields of lupin varieties at Mullewa (99MW37), Kalannie (99WH72) and Buntine (99WH74)

Herbicides	**Belara**			**Kalya**			**Merrit**			**Myallie**			**Quilinock**		**Tallerack**			**Tanjil**		
	MW	**KL**	**BN**	**MW**	**KL**	**BN**	**MW**	**KL**	**BN**	**MW**	**KL**	**BN**	**MW**	**KL**	**MW**	**KL**	**BN**	**MW**	**KL**	**BN**
Yield kg/ha	1477	1403	928	1854	1237	764	1472	1071	607	1161	1125	414	1593	1372	1340	551	513	1795	1237	494
Simazine 2l (*)	100	100	92	100	100	87	100	100	84	100	100	91	100	100	100	100	79	100	100	82
Simazine 4l	106	99	81	93	95	81	105	94	91	105	100	95	104	95	94	101	101	98	98	94
Simazine/Atrazine 2/1 L	109	95	83	98	101	97	93	96	96	101	98	105	103	92	98	102	99	94	97	88
Atrazine 2 L		94	83		95	91		94	97		95	103		97		103	75		96	**77**
(*) Diuron 1 L	112	92	**61**	99	89	**63**	101	86	**75**	105	90	88	107	92	106	93	91	100	83	80
(*) Diuron/Lexone 1 L/133 g	110	103	**65**	101	96	85	108	97	**75**	108	95	103	103	95	102	101	96	100	88	**73**
(*) Brodal 200 mL	102	103	100	94	93	100	98	103	100	104	105	100	100	89	103	94	100	94	87	100
(*) Lexone 150 g	108	97	78	93	88	93	96	88	88	99	96	97	98	87	101	110	94	96	84	**62**
(*) Brodal/Lexone 100 mL/100 g	102	107	85	101	103	88	97	94	95	103	104	108	101	90	103	107	88	96	90	98
(*) Brodal/Eclipse 60 mL/6 g	98	96	**74**	96	90	79	85	102	**64**	89	99	82	98	87	95	83	**76**	92	93	**65**
(*) Brodal/Lexone/simazine 100 mL/100 g/1 L	96	88	**66**	97	96	91	87	93	89	98	86	140	92	**65**	103	91	102	89	67	89
(*) Eclipse 10 g	104	104	88	89	98	85	**82**	91	83	96	99	96	96	97	103	112	90	101	92	**77**
Sed	4.7	8.6	11.9	4.4	6.5	10.9	6.5	8.0	10.5	7.3	6.7	16.8	5.6	13.2	6.7	19.6	12.7	5.4	7.8	10.5

Treatments 1-4 were applied immediately before seeding (IBS).

Treatments 5-6 were applied immediately after seeding (IPP).

Treatments 7-11 were applied to 4 leaf lupins.

Treatment 12 was applied to 8-10 leaf lupins.

Treatments 5-12 had a basal simazine treatment IBS.

Tanjil lupins will tolerate metribuzin under the right conditions

Peter Newman, Agronomist Elders Limited and Cameron Weeks,
Mingenew/Irwin Group

INTRODUCTION

Lupin herbicide tolerance trials conducted in Mingenew in 1998 suggested that the varieties Wonga and Tanjil were highly susceptible to the herbicide Metribuzin and the variety Belara suffered significant leaf scorch from Metribuzin but recovered to show no yield decline. No rain fell for five days after this trial was sprayed. Metribuzin affects lupins by scorching the leaves and causing significant defoliation. Observations by Elders agronomists in the field have been that if rain falls within 24 hours of spraying Metribuzin this leaf scorch is significantly reduced.

TRIAL DETAILS

Site:	Weed free. Good yellow sand approximately 15 km west of Mingenew.
Seeding Machinery:	Airseeder with knifepoints and presswheels.
Pre emergent herbicides:	Knockdown + Simazine 1 L/ha + Atrazine 0.5 L/ha + Diuron 0.5 L/ha
Post emergent herbicides:	Broadleaf treatments applied on 11 June 1999 when lupins were just at the 8 leaf stage. Approximately 25 mm rain fell commencing about 7 hours after spraying was completed. Spraying conditions were excellent. No grass selective herbicide was applied.

RESULTS

Table 1. Grain yield of control (Kg/ha) and grain yield percent of control for twelve herbicide treatments applied to five Lupin varieties

Treatment	Tanjil	Belara	Kalya	Gungurru	Moonah
1. Simazine 500 mL (Yield kg/ha)	3323	3191	3165	3067	2953
2. Simazine 500 mL	100	100	100	100	100
3. Simazine 2 L	101	95	95	93	**87**
4. Brodal 120 mL	9	99	97	96	99
5. Brodal 200 mL	102	99	94	96	101
6. Brodal 120 mL + Lexone 100 g	101	100	96	98	102
7. Brodal 120 mL + Lexone 150 g	100	100	95	99	102
8. Brodal 120 mL + Simazine 500 mL + Lexone 70 g	102	101	99	99	103
9. Brodal 120 mL + Simazine 500 mL + Lexone 100 g	103	99	95	97	100
10. Brodal 120 mL + Dimethoate 100 mL	101	101	104	89	107
11. Brodal 120 mL + Verdict 300 mL	102	101	95	94	102
12. Eclipse 14 g	105	102	100	96	102
13. Eclipse 14 g + Brodal 20 mL	103	101	98	97	103
LSD	NS	NS	NS	NS	7.5

Note: Lexone contains 750 g/kg Metribuzin.

The only significant result in the trial is that Moonah suffered from Simazine. This site is in a high Anthracnose risk area and some disease was present in the trial but it did very little damage.

OBSERVATIONS

Tanjil suffered more leaf scorch symptoms than any other variety when assessed 14 days after spraying. The most significant leaf damage was where treatment 8 was applied to Tanjil. The visual damage observed for this treatment was grey to brown leaf scorch on the top four leaves of the lupin plant causing roughly a 30% defoliation of these leaves. Moonah suffered more leaf scorch from Metribuzin than the varieties Belara, Kalya and Gungurru but less leaf scorch than Tanjil. Negligible leaf scorch was observed for all rates of Metribuzin for the varieties Belara, Kalya and Gungurru. The addition of Dimethoate or Verdict to Brodal resulted in more Brodal flecking than for Brodal alone but not to the point where it would be a concern. No visual effects of Eclipse were observed.

DISCUSSION

This trial demonstrates that Metribuzin can be used safely across a range of lupin varieties when applied in the right conditions (i.e. rain fell more than 4 hours after spraying but within 24 hours). Last year where it didn't rain for five days after spraying, Tanjil and Wonga suffered significant defoliation and 30% yield loss at the same rate (i.e. high rate). Several lupin herbicide tolerance trials have shown that Tanjil and Wonga have similar tolerance to Metribuzin.

The guidelines for spraying Metribuzin onto Tanjil or Wonga Lupins based on two years of trial results are as follows:

- Spray when rain (i.e. enough to form a droplet on the leaf) is due to fall more than four hours after spraying but within 24 hours of spraying.
- Do not spray before the 6 leaf stage of the lupin. 8 to 10 leaf is preferable.
- Use moderate rates of Metribuzin and expect to see some leaf scorch.
- Do not spray Metribuzin if Brown Leaf Spot has had a history of damaging crops in your area. Metribuzin has proven to be safer in the northern wheatbelt than other areas of Western Australia.
- Avoid spraying Metribuzin in a post emergent mix if the crop is suffering from Simazine, Atrazine or Diuron damage from pre emergent herbicides as this may pre-dispose the crop to leaf scorch from Metribuzin.
- Consult and agronomist, the rates will vary greatly from paddock to paddock.

ACKNOWLEDGEMENTS

Thanks to Clancy Michael of Mingenew on whose property the trial was

Herbicide damage does not mean lower yield in Lupins

Peter Carlton, Trials Coordinator, Elders Limited

KEY MESSAGE

In 1999 metribuzin was used with relative safety on lupins in the central wheatbelt, but these results must be interpreted with caution. Crop damage was evident in all lupin varieties tested, especially at the higher rates, but was most severe in Tanjil and Wonga. However this did not translate into reduced grain yield. Metribuzin was found to be safe for Belara, Gungurru, Kalya and Myallie and Wonga. That yield was not affected, except for Tanjil, was perhaps fortuitous and a similar result cannot be guaranteed next season. Metribuzin can be sprayed at high rates but specific guidelines are difficult to develop and it is important that farmers consult with their local agronomist, especially when spraying Tanjil or Wonga. This trial also highlighted the comparable yields of Wonga and Tanjil.

INTRODUCTION

Crop tolerance to herbicides has become an important issue to farmers in the management of new Lupin varieties in Western Australia. Evidence from lupin herbicide tolerance trials conducted in Western Australia suggests that some of the newer varieties are susceptible to the herbicide Metribuzin that is used to control broadleaf weeds in lupins. Visual symptoms of leaf scorch and general plant thriftiness have occurred in Tanjil and Wonga Lupins and, on occasion, have translated into significant yield reductions. Atmospheric conditions following herbicide application, especially rainfall events have been implicated. To date the evidence for susceptibility of some of the newer varieties to herbicide damage, especially Metribuzin, has been anecdotal or subjective. To help quantify the herbicide tolerance of the newer lupin varieties this paper reports the results of a herbicide tolerance trial conducted at Bolgart in 1999.

METHOD

Lupins were seeded on May 12 at 100 kgha^{-1} with 100 kgha^{-1} superphosphate using Superseeder knife points and presswheels at 9 inch row spacing. Roundup (800 mL) was applied 3 weeks prior to seeding and Sprayseed (750 mL) and Simazine (2 L) were applied the day before seeding. Twelve herbicide mixes utilising combinations of Brodal, Eclipse, Simazine and Lexone (see Table 1) were applied to six varieties of lupins; Belara, Gungurru, Kalya, Myallie, Tanjil and Wonga in a modified RCB design. Varieties were sown alongside each other in plots measuring 16 m * 100 m. Spray treatments 4 m wide were then sprayed across varieties, giving a plot size of 3 m * 16 m. Post emergent herbicide treatments were applied July 8 and visual assessment of crop damage was made at 18 and 28 days. Plots were machine harvested and grain yield measured on 13.2 m^2.

RESULTS

At 18 days after spraying visual symptoms were apparent in all Lupin varieties for mixes that contained Lexone and for Brodal 200 mL. Symptoms were most severe on Tanjil, followed by Wonga. Most leaf damage occurred at the highest rate of Lexone. Belara, Gungurru and Kalya had generally recovered and were growing vigorously at 28 days after spraying (Table 1). However, Tanjil and to a lesser extent Wonga followed by Myallie, were still showing signs of leaf damage and stunted growth at the higher rates of Lexone. Phyto-toxicity effects were also measured for Eclipse and Brodal mixes but the symptoms were slight compared to the effect of Lexone and plants recovered quickly.

Herbicide application did not reduce yield of Belara, Gungurru, Kalya, Myallie or Wonga (Table 2). Tanjil was the only lupin to suffer a significant yield reduction and then only at the highest rate of Lexone when yield was reduced by 33%. Rainfall 4 days after spraying (13 mL) did not reduce foliar symptoms but, combined with a soft finish, may have contributed to the better than expected yield results.

Table 1 **Crop tolerance of Lupin varieties assessed over 12 herbicide treatments. Scored on a visual rating that encompassed plant mortality, growth, leaf damage (key: 1 = no effect, 9 = major effect**

Herbicide treatments	Lupin varieties					
	Belara	Gungurru	Kalya	Myallie	Tanjil	Wonga
Simazine 500	1	1	1	1	1	2
Simazine 500, Brodal 120	1	1.5	1.5	1.5	1.5	1.5
Simazine 500, Brodal 120, Lexone 75 g	1	1	2	1	4	3
Simazine 500, Brodal 100, Lexone 100 g	1	1.5	1	3	3.5	3
Simazine 500, Brodal 120, Lexone 125 g	1	1	2	2.5	5.5	4.5
Brodal 120, Lexone 75g	1	1.5	1	1.5	2	2
Brodal 100, Lexone 100g	1	1	1.5	1.5	3	2
Brodal 120, Lexone 125g	1	1.5	1.5	2.5	1.5	2
Brodal 200	1	1	1.5	1.5	2	2
Eclipse 14 g	1	1	2	1	2	1
Eclipse 7 g, Brodal 120	1	2	1	2	1.5	1.5
Eclipse 14 g, Brodal 120	1	1.5	2	2	2	1

Table 2. **Grain yield of newer lupin varieties assessed over 12 herbicide treatments. Yield is given as percentages of the grain yield of the Simazine treatment. LSD's presented as percentages**

Herbicide treatments	Lupin varieties					
	Belara	Gungurru	Kalya	Myallie	Tanjil	Wonga
Simazine 500, Brodal 120	108	105	103	92	101	104
Simazine 500, Brodal 120, Lexone 75 g	-	96	101	90	86	98
Simazine 500, Brodal 100, Lexone 100 g	97	108	93	85	84	93
Simazine 500, Brodal 120, Lexone 125 g	-	105	87	83	67	85
Brodal 120, Lexone 75 g	105	102	88	85	93	108
Brodal 100, Lexone 100 g	92	103	78	75	88	95
Brodal 120, Lexone 125 g	99	95	96	93	91	95
Brodal 200	100	107	100	99	104	113
Eclipse 14 g	112	96	84	92	85	88
Eclipse 7 g, Brodal 120	110	112	92	84	99	99
Eclipse 14 g, Brodal 120	99	105	103	107	106	111
Simazine 500	2394	2288	2565	2174	2695	2548
Lsd	*ns*	*7*	*ns*	*Ns*	*17*	*16*
P	*0.051*	*0.007*	*0.08*	*0.12*	*0.01*	*0.045*

CONCLUSION

This trial demonstrates that metribuzin can be used with relatively safety across a range of lupin varieties but these results must be interpreted with caution. The susceptibility of Tanjil and Wonga Lupins to high rates of metribuzin in the two and three way mixes was evident in this trial. That yield was not affected, except for Tanjil, was perhaps fortuitous and a similar result cannot be guaranteed next season. Very little metribuzin is used in the central compared to the northern wheatbelt and trial work with lupins has demonstrated an inconsistent response across varieties, with generally more plant damage than is found in trials in the north. Typically, more yield damage would be expected for the central area than was found in this trial. Metribuzin can be sprayed with safety but specific guidelines are difficult to develop and it is important that farmers consult with their local agronomist for advice. As a general rule Belara, Gungurru, Kalya and Myallie are tolerant of medium rates of metribuzin. Tanjil and Wonga may be sprayed with metribuzin provided certain guidelines are followed, e.g. see the paper by Peter Newman, 'Herbicide tolerance of new lupin varieties'.

KEY WORDS

lupin varieties, herbicide tolerance, crop damage, yield

Paper reviewed by: Bevan Addison, Elders Limited

Herbicide tolerance of new pea varieties

Dr Terry Piper, Agriculture Western Australia, Northam

KEY MESSAGES

Most combinations of metribuzin, diuron and Spinnaker can be safely used IPP in field peas. The Brodal/Lexone mix used for radish control in lupins can also be used.

However Helena and WAPEA2039 may be sensitive to metribuzin, diuron and Spinnaker.

THE TRIALS

Both trials (99MW34 and 99ME93) were on red loamy clays and the Merredin trial was very wet around seeding. The herbicides mixes tested were aimed at achieving best practice weed management by using a range of herbicide groups. Also tested was a Bladex/simazine mix, aimed at possibly lowering the cost of the pre-sowing treatment.

RESULTS

Statistical analysis is not yet finished. It may be possible to reduce the variance with more detailed analysis and I have just reported sed figures. They are quite high, although the trials looked to be more uniform than most pea trials and were essentially weed free.

Substituting some simazine for Bladex in the basal treatment appeared safe in most cases, but did reduce yields in apparently random cases. The practice cannot be recommended, as it is not registered anyway.

King, Magnet and Cooke seem tolerant of most of the herbicides tested, except for two unexplicable results. The data will be reassessed to see if there is some explanation for this. Comparing the Magnet results from Merredin and Mullewa does raise one point of concern. There was no damage at Mullewa, but some significant reductions at Merredin. This suggests that perhaps there is a low level of crop retardation which could be grown away from at Mullewa, but not at Merredin due to either the shorter and/or colder season.

Helena is sensitive to Spinnaker and metribuzin and the potential variety WAPEA2039 even more so.

The use of a Brodal/metribuzin mix for post-emergent radish control seems justified. It has never reduced the tolerance of any variety to any pre-emergence herbicide. Both products are registered, but not as a mix. Growers would therefore have to take responsibility for any results, but given the greater efficacy of the mix on brassica weeds, this would seem worthwhile.

Trials 99MW34 (10 LH columns) and 99ME93 (two RH columns) Herbicide tolerance of pea varieties

	Herbicides	King	King!	Magnet	Magnet!	Cooke	Cooke!	Helena	Helena!	2039	2039!	King	Magnet
1.	Bladex 2 L IBS (*) kg/ha	2248	2300	2594	2384	2534	2167	2841	2638	1946	2109	1782	1766
2.	Bladex/simazine 1/1 L IBS	108.4	100.8	97.7	106.1	100.2	110.5	**74.3**	108.0	93.7	**75.5**	131.4	**67.6**
3.	Diuron 2 L	87.5	98.9	106.2	111.2	93.3	111.1	82.1	100.9	117.7	88.8	129.2	**69.9**
4.	Spinnaker 200 mL	98.3	97.0	107.4	106.0	90.4	117.7	**71.6**	103.6	85.3	83.6	100.6	72.2
5.	Lexone 300 g	99.2	104.3	99.2	93.3	85.8	104.7	**78.6**	93.3	**78.3**	**70.3**	92.4	70.8
6.	Lexone/Diuron 200 g/1.5 L	101.3	100.7	108.9	123.7	112.5	108.0	99.5	124.0	114.1	108.5	106.3	70.5
7.	Spinnaker/Diuron 150 mL/1.5L	95.9	99.9	95.6	100.5	89.2	91.9	**69.6**	84.8	**69.8**	**78.9**	116.6	82.7
8.	Spinnaker/Lexone 150 mL/200 g	103.9	98.9	92.3	101.0	75.1	108.1	84.2	108.0	93.9	92.2	80.1	**66.6**
9.	Spinnaker/Lexone/Diuron 100 mL/150 g/1 L	105.9	100.1	100.0	104.8	81.8	113.4	**76.4**	73.0	88.8	80.7	107.9	72.4
10.	(*) Diuron 1.5 L	109.5	98.5	112.6	111.1	95.5	113.8	82.8	103.7	**77.1**	**73.9**	117.2	68.2
11.	(*) Spinnaker 150 mL	98.4	99.8	99.9	102.1	108.7	120.7	92.1	108.9	89.6	96.0	99.7	81.9
12.	(*) Lexone 200 g	**74.6**	99.7	111.9	109.7	91.2	106.4	79.9	106.5	**75.5**	**72.5**	102.9	95.4
13.	(*) Lexone/Diuron 150 g/1 L	82.8	98.3	98.2	89.6	**70.3**	86.1	**65.2**	78.0	**57.0**	**76.8**	101.6	68.6
14.	(*) Spinnaker/Diuron 100 mL/1 L	95.0	100.5	109.7	100.5	89.3	107.9	96.3	110.6	104.1	80.5	93.5	75.3
15.	(*) Spinnaker/Lexone 100 mL/150 g	81.7	97.1	109.8	114.3	93.6	96.1	**79.1**	94.8	81.8	61.0	117.3	**64.5**
16.	(*) Spinnaker/Lexone/Diuron 75 mL/100 g/1 L	104.7	99.9	106.7	109.9	95.8	108.5	**75.3**	99.7	100.4	100.1	83.5	76.8
	Sed	16.1	3.4	11.4	10.4	13.0	15.4	11.1	17.4	20.9	17.7	18.2	16.5

Treatments 1-2 are IBS, Other treatments are IPP.

Treatments (*) have basal Bladex @ 2 L/ha.

! At Mullewa, Brodal/Lexone @ 60 mL/60 g was applied along half of each variety at 4-6 leaves.

Herbicide tolerance of (waterlogged) wheat

Dr Terry Piper, Agriculture Western Australia, Northam

KEY MESSAGE

Under waterlogged conditions, herbicide tolerances can be lost. Group B and D herbicides especially can cause high yield reductions in wheat.

THE TRIALS

99ME89 was a standard herbicide tolerance trial at Merredin Research Station, in a red loamy clay. The trial was sown with a full cut combine with covering harrows. The site was wet before seeding and became wetter soon after.

99ME91 was a similar trial, but testing a range of 'farmer favourite' herbicide mixtures. It was located near 99ME89, but on a slightly lighter soil type.

RESULTS

Statistical analysis has not been completed and I have only given sed figures. Double this number is about the lsd.

99ME89

The most dramatic visual effect early was the crop retardation by trifluralin. Emergence was 1-2 weeks behind the other treatments and the crop never caught up. Yields reflect this, with a 20% loss on average and only Westonia being at all tolerant.

Stomp® caused similar problems, although it was usually a little safer.

These results are in stark contrast to similar trials at Mullewa and Newdegate, where neither herbicide caused any problems. These sites however where moist rather than wet at sowing and emergence. In a smaller trial at Buntine, trifluralin and Stomp® both delayed emergence of all varieties, but here the trial was sown with knife points and there was soil wash into the furrows just after seeding. Stomp® had a noticeably greater effect than trifluralin in this trial. Although emergence was delayed by about a week, the plants were not subsequently affected and final yields were not reduced.

The SU herbicides have also caused considerable damage. Chlorsulfuron has reduced yields of all varieties by 20-30% and was just as bad when used IPP with diuron. Metsulfuron was severe on some varieties and even triasulfuron had a significant effect on Camm. This may be due to Camm being a long season variety, as early visual assessments were that all varieties were reduced in height, but the others seem to have recovered.

The effects of Achieve® and Barrel® on Camm might also be due to this, the variety being unable to recover in time from early effects.

Again, the SU effects were not evident at either Newdegate or Mullewa.

99ME91

The gross herbicide effects have given high deviances, but some significant effects will still emerge. Varieties are Amery, Arrino, Brookton, Calingiri, Carnamah, Cunderdin, Westonia, Fitzgerald, Stirling.

Metribuzin/trifluralin is sometimes used by farmers desperate for control of brome or barley grass in-crop. We have recorded yield losses of 25% at Mullewa from this mix, but this year sets new records. To be fair, the mix often shows little or no loss, but I believe it to be too risky. Especially in a wet year, these grasses can be well controlled by delayed seeding.

Trifluralin plus either chlorsulfuron or diuron looked to be very damaging early but the crops have recovered to the point there is little yield penalty. This is likely to be due to the abundance of moisture this year, and may not apply to a dry finish year, or to a late variety.

Previous trials suggested that Brookton was sensitive to Group B herbicides but later trials have not shown this. Its reaction to MCPA/Glean®/Ally® here again suggests that the initial observation was real. My initial advice still holds, be careful of SU's with Brookton.

The most disturbing result of this trial is the performance of Westonia. Past trials have always shown Westonia to be very tolerant of all herbicides, but it has reacted badly to most of the mixtures here.

99ME91 Effects of herbicide tank mixes on cereal yields, Merredin Research Station

Herbicides	**Am**	**Ar**	**Br**	**Cal**	**Car**	**Cun**	**We**	**Fit**	**St**
Untreated	1339	1348	1684	1660	1784	1874	2256	2110	2293
Glean®®/Treflan 15 g/1.0 L	94.0	95.5	98.6	92.8	96.1	89.2	**79.1**	**78.1**	93.5
Lexone®/Treflan 150 g/0.75 L	**48.6**	**56.4**	**47.7**	**40.1**	**64.7**	**29.8**	**55.7**	94.9	86.7
Diuron/Treflan 1.0 L/1.0 L	108.4	96.7	99.2	108.1	111.9	101.4	**86.7**	95.0	105.5
Diuron/Dual®® 1.0 L/1.0 L	101.1	106.8	105.9	110.5	107.4	101.9	**84.2**	98.3	106.6
Logran®/Diuron/Dua®l 30 g/1.0 L/0.5 L	97.8	103.5	99.8	102.4	112.3	101.7	89.1	86.5	94.2
Hoegrass®/Jaguar® 0.75 L/0.5 L	119.5	105.7	106.5	110.8	114.0	105.5	93.7	95.0	108.4
Jaguar®/Tigrex® 0.2 L/0.2 L	96.8	101.8	96.3	97.3	97.0	94.7	**88.3**	94.3	85.6
Lexone®/Jaguar® 65 g/0.2 L	123.4	108.5	101.7	107.2	109.0	105.8	**88.1**	91.2	97.6
Ally®/Tigrex® 4 g/0.5 L	119.2	99.0	107.9	100.3	103.9	105.2	90.1	94.8	103.4
MCPA/Glean®/Ally® 300 mL/ 3 g/3 g	110.1	97.8	**78.0**	105.1	106.7	105.7	**86.3**	98.2	96.2
	12.0	9.0	16.2	6.7	10.9	6.9	5.6	9.2	8.9

GRDC Project No.: DAW 618

Trial 99ME89 Herbicide effects on wheat yields at Merredin Research Station

	Herbicides	Ajana	Amery	Arrino	Brookton	Calingiri	Camm	Carnamah	Kalannie	Nyabing	Perenjori	Westonia	Karlgarin	Average
1	Untreated kg/ha	3182	2003	2215	2653	2591	2795	2526	2404	2464	2662	2404	2294	
2	Glean® 12.5 g	**68.0**	**72.7**	**73.9**	**76.7**	**86.3**	**75.1**	**86.2**	**78.6**	**82.5**	**80.4**	**73.7**	**80.2**	77.9
3	Glean® 20 g	**71.9**	**73.2**	**72.7**	**79.0**	**74.1**	**73.2**	**80.2**	**68.6**	**67.9**	**79.0**	**72.4**	**65.1**	73.1
4	Logran® 35 g	92.3	92.6	88.6	92.5	98.8	**86.9**	96.0	89.4	97.2	86.1	88.8	94.1	91.9
5	Avadex® 2.0 L	91.5	97.9	85.9	107.1	98.5	90.5	100.7	93.3	104.1	101.1	91.2	95.4	96.4
6	Stomp® 1.8 L	**82.0**	93.3	91.7	**86.5**	**85.9**	**78.8**	**84.4**	**75.9**	84.8	**72.4**	92.5	**86.7**	84.6
7	Treflan® 2.0 L	**65.5**	**73.7**	**72.9**	**76.2**	**78.6**	**74.2**	**86.0**	**81.9**	89.6	**85.2**	96.6	**88.8**	80.8
8	Yield® 2.3 L	90.6	91.8	86.7	94.7	95.7	94.0	91.3	81.3	108.1	101.0	106.4	109.0	95.9
9	Lexone® 150 g	94.5	94.4	98.8	96.8	99.0	92.6	92.6	82.5	97.1	93.8	96.2	97.4	94.6
10	Diuron + Dual® 1.0 L + 0.5 L	95.8	102.2	97.7	97.7	97.0	90.0	88.0	89.5	94.6	87.6	85.8	95.1	93.4
11	Diuron + Glean® 1.0 L + 15 g	**73.4**	**70.0**	**77.1**	**75.0**	**79.0**	**74.5**	**80.0**	**61.6**	**69.4**	**74.7**	84.3	**64.1**	73.6
12	Hoegrass® 1.5 L	89.8	95.2	90.7	89.4	93.1	**85.2**	89.6	88.0	92.8	89.4	100.4	**86.7**	90.9
13	Wildcat® 0.5 L	96.4	97.0	102.8	97.1	94.6	95.2	97.6	91.3	100.3	91.3	94.3	96.3	96.2
15	Topik® 140 mL	91.9	97.8	94.2	100.5	92.6	93.6	100.4	92.1	92.0	84.7	105.1	96.7	95.1
16	Ally® 5 g	**84.5**	87.5	**84.0**	**83.7**	91.4	**77.7**	91.2	92.4	96.2	93.6	98.0	92.2	89.4
17	Jaguar® 1.0 L	90.2	100.4	104.3	99.5	95.1	95.8	102.7	97.5	99.4	93.4	103.0	98.3	98.3
18	Achieve® 0.25 kg	95.6	92.1	87.9	93.2	92.7	**83.9**	98.7	95.3	95.3	88.2	99.9	102.0	93.8
19	Barrel® 1.0 L	97.3	107.5	103.8	96.8	105.3	**84.9**	93.1	92.1	97.4	90.4	104.7	102.6	98.0
21	Tigrex® 1.0 L	93.9	97.7	98.8	95.8	93.7	92.1	96.8	90.1	100.2	95.9	93.1	95.4	95.3
22	Diuron + MCPA 0.35 L+0.4 L	92.7	99.2	93.5	95.0	97.1	92.9	102.3	90.6	99.8	94.8	98.8	96.9	96.1
23	2,4-D amine 1.0 L	82.9	89.9	87.5	91.6	90.8	86.9	92.7	89.6	98.2	91.6	103.0	96.1	91.7
	sed	5.1	8.0	7.5	7.3	5.6	6.2	5.7	6.0	9.1	9.4	8.9	6.0	

Treatments 2-8 were incorporated by sowing, 9-12 were applied immediately post-plant, 12-18 at Z12-13, 19-22 at Z14-15 and 23 at Z15-16.

Treatments 12-17 and 21 were applied with 0.25% wetter and Tr 18 with 0.75% Supercharge.

Wheat herbicide tolerance trials – Mingenew 1999

Peter Newman[1]**, Cameron Weeks**[2] **and Stewart Smith**[3]

[1] Elders, Mingenew
[2] Mingenew-Irwin Group
[3] Agriculture Western Australia

INTRODUCTION

Two wheat herbicide tolerance trials were conducted in the Mingenew area on contrasting soil types to gather local information on the herbicide tolerance of recently released wheat varieties. A Sandplain site (pH 5) and an Alkaline Clay site (pH 8) were chosen to compare the effect that soil type can have on herbicide tolerance, in particular the Sulphonyl Urea (SU) Herbicides. SU herbicides are typically more active on alkaline soils and can be more damaging to sensitive wheat crops as a result.

TRIAL DETAILS

Seven Wheat varieties were sown along side each other using the farmers air seeders. Herbicide treatments were sprayed across all seven varieties. Pre emergent treatments were sprayed immediately before seeding. Post emergent treatments were sprayed at the 4 to 4.5 leaf stage of the wheat. Bromoxynil was sprayed over the entire of both sites at a rate of 2 L/ha when the wheat was at the 2 to 3 leaf stage to ensure a weed free site.

Sandplain site

Property of Clancy and Jan Michael, 15 km West of Mingenew.

Soil type:	Good Yellow Sand, pH 5.0
Seeding date:	19 May 1999
Post emergent herbicide application date:	21 June 1999

Heavy land site

Property of Vic and Beryl Elsegood, 15 km North East of Mingenew

Soil type:	Red Crumble Clay, pH 7.5
Seeding date:	17 June 1999
Post emergent herbicide application date:	23 July 1999

OBSERVATIONS

It is difficult to make too many conclusions from the data due to the variability of the sites. However, given trends within the data and observations made in the field, the following observations are of interest.

- No phytotoxicity was seen from any pre emergent herbicide applications at both sites except for Logran + Diuron which caused some white leaf tipping (i.e. Diuron damage) in some plots. The lack of yield suppression from high rates of Logran was surprising given that it was a particularly wet season. Both sites were sown with knife points which may have contributed to the safety of all pre-emergent herbicides.

- Ally caused crop yellowing across all varieties at both sites but this rarely contributed to yield suppression. This highlights the fact Ally regularly causes entire crops to 'lose their colour' but this is very difficult to observe where there is no unsprayed area to compare to.

- MCPA appeared to 'saften' Ally i.e. MCPA + Ally plots exhibited less crop yellowing than Ally alone and there was a trend of MCPA + Ally yielding slightly higher than Ally alone although this result was not significant. Past work by company representatives and Agriculture Western Australia staff suggests that this may be as a result of mild antagonism between the two products. It may be worth trialing further to determine if the antagonism can be reduced e.g. by mixing Ally with MCPA LVE for example.

- Monza caused very minor crop yellowing i.e. less crop yellowing than Ally treatments. Arrino showed some sensitivity to Monza at the Heavy Land Site but otherwise all varieties appeared to have good tolerance to Monza.
- Cadence caused transient flacidity across all varieties at both sites. All varieties recovered within 10 days and there was no effect of Cadence on Yield.
- Tigrex caused some minor crop yellowing across all varieties at both sites. All varieties recovered within one week and there was no effect of Tigrex on yield.
- Ajana appears to be sensitive to a range of herbicides at the light land site. There was a problem with the spray equipment that resulted in the pre emergent treatments being applied at rates higher than was intended.
- On the heavy land site Kalgarin appears to be sensitive to a range of herbicides. Arrino appears to be sensitive to Diuron.

Table 1. Wheat yield expressed as percentage of control treatment for seven wheat varieties sprayed with 13 herbicide treatments at the Sanplain Site

Treatment	Westonia	Ajana	Arrino	Kalgarin	Cunderdin	Carnamah	Brookton
1. Control (Yield kg/ha)	3519	2772	3442	2651	3337	3462	3682
2. Glean 27 g/ha	91	97	88	87	94	103	101
3. Logran 47 g/ha	102	94	95	87	100	104	107
4. Logran 94 g/ha	104	**90**	92	88	96	104	105
5. Logran 47 g/ha + Diuron 650 mL/ha	97	**88**	92	85	98	99	101
6. Lexone 260 g/ha	106	**92**	93	88	103	102	103
7. Ally 5 g/ha	96	77	88	78	98	97	98
8. MCPA 400 mL + Ally 5 g/ha	109	**92**	90	82	99	103	100
9. Diuron 350 mL/ha + MCPA 400 mL/ha	106	94	86	86	97	99	101
10. Monza 25 g/ha 2% DC Trate	105	**89**	93	84	106	110	106
11. Cadence 115 g/ha	107	96	93	83	104	104	105
12. Tigrex 1 L/ha	101	**90**	88	86	102	104	103
13. Cadence 115 g/ha + MCPA 400 mL/ha	101	**91**	89	82	102	107	106
LSD	11*	7.5	NS	NS	NS	NS	NS

* Significant at 90% confidence interval.
NS Not Significant.

Table 2. Wheat yield expressed as percentage of control treatment for seven wheat varieties sprayed with 13 herbicide treatments at the Heavy Land Site

Treatment	Westonia	Ajana	Arrino	Kalgarin	Cunderdin	Carnamah	Brookton
1. Control	3232	2741	2604	2243	2910	2824	3337
2. Glean 20 g/ha	105	93	95	99	110	96	93
3. Logran 35 g/ha	101	97	95	97	108	100	103
4. Logran 70 g/ha	102	104	97	105	115	105	99
5. Logran 35 g/ha + Diuron 500 mL/ha	95	92	**80**	**94**	102	96	99
6. Lexone 200 g/ha	107	98	102	95	105	97	89
7. Ally 5 g/ha	92	81	100	**88**	97	93	100
8. MCPA 400 mL + Ally 5 g/ha	98	87	96	**93**	109	95	100
9. Diuron 350 mL/ha + MCPA 400 mL/ha	97	85	**86**	**80**	98	86	96
10. Monza 25 g/ha 2% DC Trate	103	87	94	**88**	102	99	97
11. Cadence 115 g/ha	92	88	103	**94**	94	95	87
12. Tigrex 1 L/ha	103	92	93	**91**	92	87	97
13. Cadence 115 g/ha + MCPA 400 mL/ha	107	97	96	99	92	88	94
LSD	10	NS	13.5*	6	NS	NS	NS

* Significant at 90% confidence interval.
NS Not Significant.

Trifluralin works better on ryegrass when no-tilling into thick wheat stubble as granules, or mixed with limesand

Bill Crabtree, WANTFA Scientific Officer, Northam

KEY MESSAGE

This innovative trial demonstrates that ryegrass control with trifluralin can be improved with the addition of a solid carrier, especially in no-till and with stubble retention. This improvement comes from good penetration of the trifluralin through the stubble layer to where the weed seeds are located. In contrast, much of the liquid trifluralin becomes locked onto the stubble and does not reach the target weeds. Increasing the water volumes from 30 to 90 L/ha did not improve trifluralin efficacy. The solid carriers improved herbicide efficacy with the lower label rate (1.0 L/ha) giving good ryegrass control in the inter-row and the furrow. While higher rates, with the solid carriers, thinned the wheat plants and gave increased ryegrass control in the furrow.

AIM

To improve the efficacy of trifluralin in no-till and in stubble retained cropping systems. Canadian farmers have been effectively using trifluralin and applying it to thick wheat residues with success for many years. Some scientists have reported that it is only effective for Canadians because they apply it before the snow falls and the snow layer ensures even movement of the trifluralin on the soil's surface. My discussions with leading Canadian farmers in 1996 revealed that many farmers use granules in the spring, a week before seeding, and with good success. Also Winston Broun, a farmer from Coorow, demonstrated successful ryegrass control by mixing limesand with trifluralin and applying it before seeding. This trial will compare these approaches with the conventional liquid formulations at various water rates.

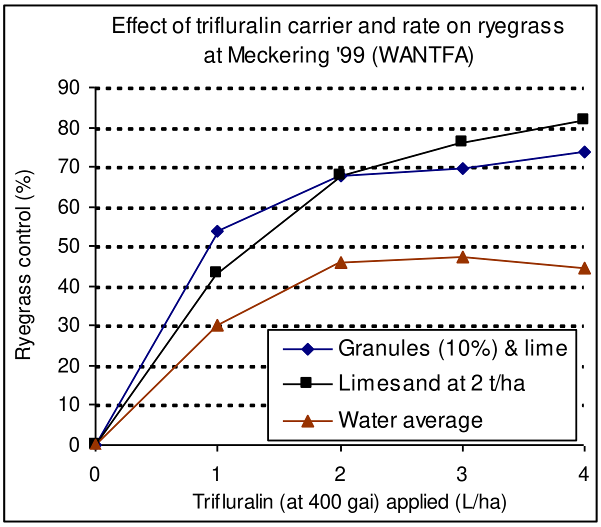
METHOD

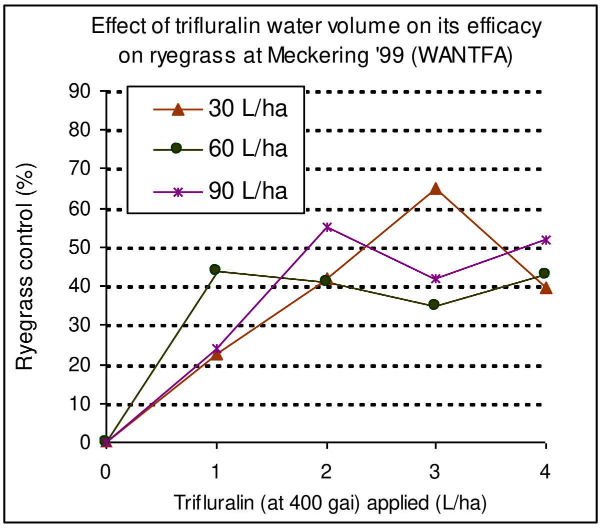
A randomised complete block factorial design was used, with three replicates. Three trifluralin carriers were used (limesand at 2 t/ha, granules with limesand at 2 t/ha and three water rates {30, 60 and 90 L/ha}) at five rates of trifluralin (0, 1, 2, 3 and 4 L/ha of 400 gai). There were two nil herbicide treatments, one with limesand and one without limesand. A Meckering wheat crop that yielded 3.2 t/ha in 1998 that had high levels of stubble (70% ground cover) which was standing (undisturbed) was used for the trial. The topsoil pH was estimated to be 4.8 ($CaCl_2$) and the site had 2 t/ha of lime applied in 1996.

The herbicide treatments were applied immediately before sowing with knife points and press wheels on 262 mm (10.5") row spacings on 21 June. Westonia wheat was sown at 80 kg/ha with 80 kg/ha of DAPSZC (17.3:18.6:0:8.5), while 80 kg/ha of urea was applied immediately before sowing and 100 kg/ha was applied 4 weeks after sowing. Wheat and ryegrass counts were taken four weeks after sowing. Visual ratings of ryegrass and wheat tiller numbers were taken on 18 October and ryegrass control in the furrow versus ridges was rated on the 16th November. Harvest was with a small plot harvester on 21 December.

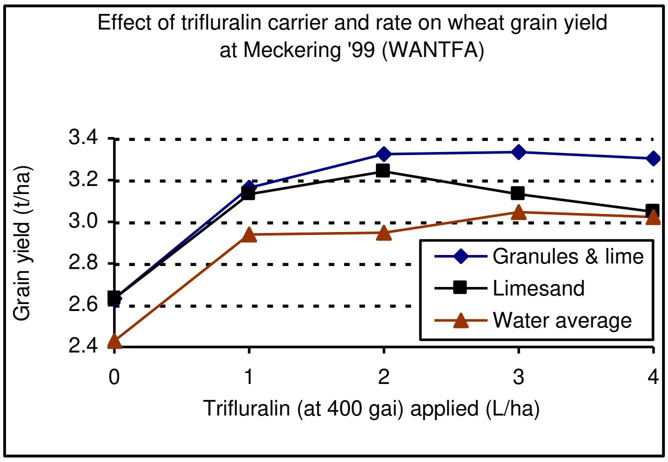
RESULTS

The site had a uniform ryegrass density, with 325 pl/m^2 counted in the two control treatments. Both of the solid carriers of trifluralin, with granules (with limesand as a carrier) or with the trifluralin liquid - mixed with limesand gave effective ryegrass control of up to 80% compared to the liquid formulation which did not exceed 50% control. In fact, the 1 L/ha rate of the granules gave better ryegrass control than the 2, 3 or 4 L/ha rate of trifluralin as a liquid. With the solid carriers, ryegrass control occurred both in the furrows and in the inter-row and with greater efficacy than with the liquid carrier. Water volume had no effect on trifluralin efficacy for ryegrass control and this continued into grain yield.


Effect of trifluralin carrier and rate on ryegrass at Meckering '99 (WANTFA)


Effect of trifluralin water volume on its efficacy on ryegrass at Meckering '99 (WANTFA)

Ryegrass control was not affected by limesand without trifluralin. However, limesand did improve wheat grain yields and the trifluralin water carriers (averaged) response curve probably should be shifted up 200 kg/ha to equate for this. Regardless, improved grain yields occurred by using solid trifluralin carriers, as opposed to liquid formulations. Limesand gave slightly better ryegrass control than the granular formulation with the higher rates (3-4 L/ha) but the limesand-only carrier did not improved grain yields like the granules did. In fact crop damage with the limesand increased at rates higher than 2 L/ha and this reduced subsequent grain yields.


Effect of trifluralin carrier and rate on wheat grain yield at Meckering '99 (WANTFA)

CONCLUSION

Trifluralin activity can be greatly improved with no-till seeding into standing thick wheat stubble by applying it immediately before seeding with a solid carrier such as granules or limesand. This is an exciting finding and has broad ranging implications for no-till and stubble retention cropping systems. Other herbicides particularly those that are more active in alkaline conditions (caution will need to be exercised with some of these) will need to looked at. In contrast to trial work last year, increasing water volumes did not significantly improve trifluralin efficacy. An extra 750 kg/ha of grain yield was achieved, and this was of significant economic benefit.

ACKNOWLEDGMENTS

Thanks to GRDC and Nufarm for both half funding this work through the Meckering R&D WANTFA sub-committee. AgriTech Crop Research managed the site and the chair of this committee is Mr Geoff Fosbery. Ray Fulwood was kind enough to assist with the trial and provided the land. Many thanks to the Canadians, particularly Stan Rampton and Dr Doug Derksen and Winston Broun who inspired the research!

Paper Reviewed by: David Sermon and Ashley Bacon

A SIMILAR TRIAL AT EAST MAYA

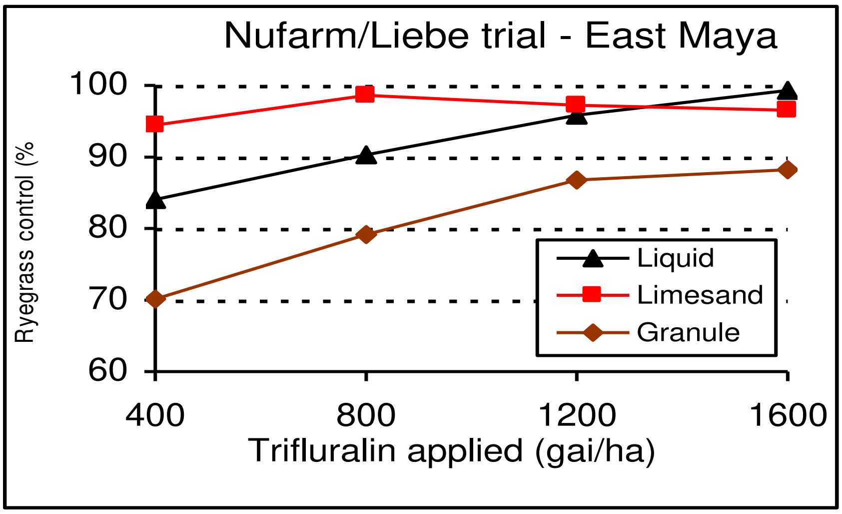
A trial conducted by David Sermon of Nufarm and the Liebe Group showed similar trends. Although stubble levels were half that of the Meckering trial.

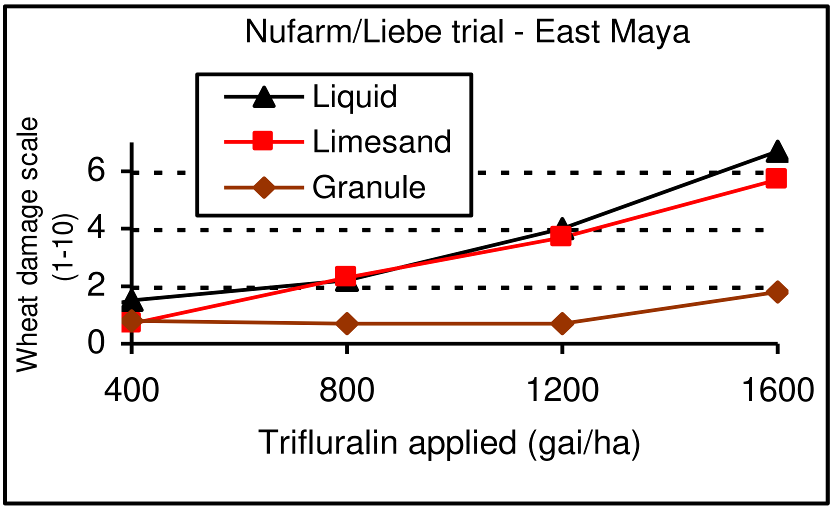
TRIAL DETAILS

Completely randomised full factorial design, with 3 reps. An acidic loamy sand with 30% stubble cover. The trial was sown on 23 June with a Flexicoil Bar with Agmor Seeding Boots and Press wheels. Arrino wheat was sown at 80 kg/ha and with DAPZC at 80 kg/ha. Urea was applied at 80 kg/ha on 3 August. Glyphosate was applied in May and 5 June. This was the third successive wheat crop after lupins in 1996.

RESULTS

Unfortunately the 1.5 t/ha wheat crop was hailed and grain yield data was lost. Water applied trifluralin was effective in this low stubble level trial. Granules and limesand carriers gave effective weed control, particularly at the 2 L/ha rate (800 gai/ha). Both these solid carriers give poorer efficacy than the liquid – the reasons for this contrast with the Meckering result are undefined. The granular formulation gave much less crop damage.





Increasing trifluralin rate did not compensate for delaying incorporation

Bill Crabtree, WANTFA Scientific Officer, Northam

KEY MESSAGE

In contrast to last year's comments from a similar trial, this more comprehensive work suggests that, if possible, farmers should begin seeding with no-tillage immediately the trifluralin is applied. A wheat yield loss of 200-300 kg/ha (10%) has occurred, in this trial, with high levels of ryegrass when trifluralin incorporation was delayed by 24-48 hours. For all 4 rates of trifluralin used there was no extra loss in trifluralin efficacy on ryegrass, or loss of wheat yield, with a further 24 hour delay to 48 hours. This work encourages farmers to consider placing herbicide sprayers on the front of their seeders or using the granular application method (which is cleaner). The adjacent paper shows how effective trifluralin granules can be at controlling ryegrass in thick stubble.

AIM

To determine if any grain yield penalty exists when farmers delay the incorporation of trifluralin with no-till seeding in paddocks with high levels of ryegrass. Trials in 1997 and 1998 showed that good ryegrass control was possible when trifluralin incorporation was delayed by 24 hours provided the trifluralin rate was increased by about 0.5 L/ha. However, in this trial, seeding was done at the same time and the herbicide treatments were applied 0, 24 and 48 hours before seeding. While, with previous trials, all herbicide treatments were applied on the same day and seeding was done 0, 24 and 48 hours after applying herbicide application. This resulted in enigmatic grain yield results.

METHOD

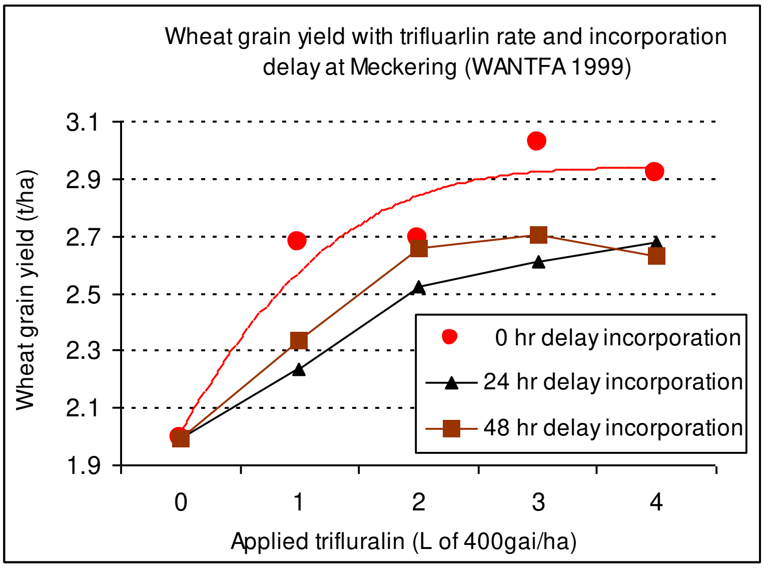
A randomised complete block factorial design was used, with three replicates. Five trifluralin rates were used (0, 1, 2, 3 and 4 L/ha of 400 gai) as the main plots and three timings of incorporation (0, 24 and 48 hours after spraying) were sub-plots. A Meckering lupin crop with high levels of ryegrass in 1998 was selected for the trial.

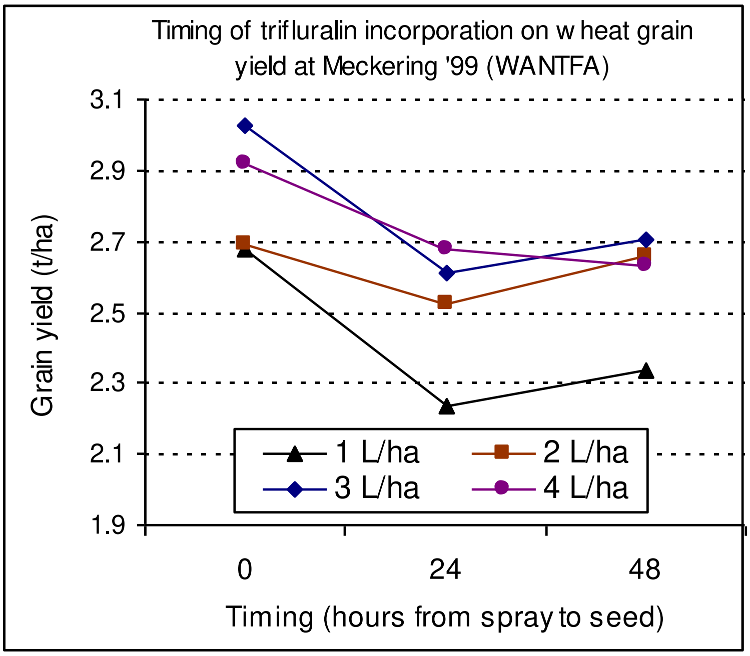
The herbicide treatments were applied and seeded across with knife points and press wheels on 225 mm (9") row spacings on 31 May. At spraying, the conditions were similar for each of the three timings with temperatures being 19-20ºC, relative humidity at 51-58%, sunny conditions and moist soil. Arrino wheat was sown at 80 kg/ha with 100 kg/ha of Agrich (12:11.4:0:12:5). Urea was topdressed immediately before sowing at 60 kg/ha and 100 and 40 kg/ha of urea was applied 4 and 8 weeks after sowing (sandy site with lots of leaching rain). Trial was treated for leaf disease with 1.0 L/ha on 2 September. Wheat and ryegrass counts were taken four weeks after sowing. Visual ratings of ryegrass and wheat tiller numbers were taken on 18 October (not presented). Harvest was with a small plot harvester on 21 December.

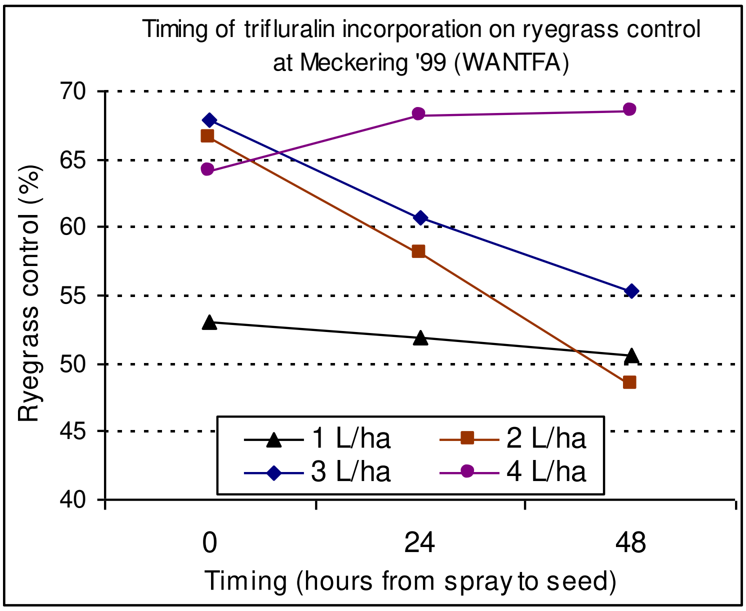
RESULTS

The site had a uniform ryegrass density, with 777 pl/m^2 counted in the control treatment. Delaying the timing of trifluralin incorporation generally decreased its efficacy and decreased wheat grain yields. Delaying seeding from 24 to 48 hours further decreased trifluralin efficacy for 1-3 L/ha rates, but had no impact on grain yield.

Ryegrass control was significantly less than in previous years, with 68% contol being the highest. However, the remaining weeds competed poorly with the crop. The grain yield with no herbicide applied was 1.99 t/ha and the best treatment obtained a 1.0 t/ha grain yield response.


Wheat grain yield with trifluarlin rate and incorporation delay at Meckering (WANTFA 1999)
Wheat grain yield (t/ha)
3.1
2.9
2.7
2.5
2.3
2.1
1.9
0
1
2
3
4
Applied trifluralin (L of 400gai/ha)
0 hr delay incorporation
24 hr delay incorporation
48 hr delay incorporation


Timing of trifluralin incorporation on wheat grain yield at Meckering '99 (WANTFA)
Grain yield (t/ha)
3.1
2.9
2.7
2.5
2.3
2.1
1.9
0
24
48
Timing (hours from spray to seed)
1 L/ha
2 L/ha
3 L/ha
4 L/ha


Timing of trifluralin incorporation on ryegrass control at Meckering '99 (WANTFA)
Ryegrass control (%)
70
65
60
55
50
45
40
0
24
48
Timing (hours from spray to seed)
1 L/ha
2 L/ha
3 L/ha
4 L/ha

CONCLUSION

This work shows that for best grain yield it is not wise to delay trifluralin incorporation, even if trifluralin efficacy on ryegrass can be improved by increasing the herbicide rate. In fact, 1.0 L/ha of trifluralin applied immediately before sowing gave grain yields equal to high trifluralin rates when used with delayed incorporation either 24 or 48 hours before seeding. This is surprising as the amount of ryegrass that 1 L/ha controlled was only 53% and it gave yields equal to 2-4 L/ha applied 24-48 hours before incorporation. Further work may be needed to assess ryegrass control and yields below incorporation timings of 24 hours. An extra 1 t/ha of grain yield was achieved and was of significant economic benefit.

ACKNOWLEDGMENTS

Thanks to GRDC and Nufarm for each half funding this work through the Meckering R&D WANTFA sub-committee. AgriTech Crop Research managed the site and the chair of this committee is Mr Geoff Fosbery. Colin and Ross Pearse kindly assisted with the trial and provided the land. Many thanks!

Paper reviewed by: David Sermon and Ashley Bacon

Poor emergence survey, 1999

Terry Piper, Weed Science Group, Agriculture Western Australia, Northam

MESSAGE

When soils are waterlogged, or might become so before cereals emerge, avoid using trifluralin or pendimethalin herbicides. Be especially careful if sowing with knife points, as soil wash into furrows can exacerbate problems.

RATIONALE

At the beginning of the 1999 growing season, there were a number of reports of poor cereal crop emergence. The crops were reported to be either slow in emerging and/or the emergence was substantially reduced. A survey form was inserted into local Ag Memos in the hope that the responses might reveal any potential causes that might be common factors.

Farmers were asked the following questions:

- Location?
- Crop Variety?
- Soil type?
- Herbicides used pre-emergence?
- Seeding machine? Seeding depth?
- Pre-sowing rainfall?
- Rainfall around emergence?
- Any soil wash into furrows after sowing?
- Area affected?
- How much delay in emergence time?
- How much reduction in emergence %?
- Has the crop caught up?

The questions were prompted (in part) by observations from our own tolerance trials, where the worst emergence seemed to be associated with high soil water levels and where soil wash and Group D were seen to be contributing factors.

CONCLUSIONS

There were 25 replies, from most areas of the wheatbelt:

Bruce Rock, Coorow, Cranbrook, Dalwallinu, Goomalling, Irwin, Kent, Kojonup, Kondinin, Lake Grace, Morowa, Mullewa, Perenjori, Pingelly, Three Springs, Trayning, Wickepin, Wongan and Wyalkatchem.

Crop variety was probably not significant, with Amery (3), Arrino (5), Brookton (3), Calingiri (4), Carnamah (2), Cascades, Cunderdin, Dagger, Datatine (2), Eradu, Machete, Spear, Stiletto (2), Stirling, Tincurrin (2), Westonia and Wilgoyne being sown.

Soils were described as Sandy; Grey sand; Sand, yellow – white; Sand, yellow; Sand, yellow – gravelly; Sand, yellow – grey; Sandy loam; Sand over clay; Loam to Gravel sand; Loam; Medium Loam; Heavy Loam; Clay loam; Wodjil clay; Gravel; Yellow gravel; and Red/grey clay. This would seem to suggest that soil type was not critical either.

A wide range of seeding machines: 511 combine (2); Agmaster no-till (3); Combine, min-till, harrows; DBS; Flexicoil; Flexicoil, press wheels; Forward 746; Forward, Harrows; Great Plains NT; Harrington points (3); Harrington points, harrows; JD bar; JD bar, 50 mm point; JD bar, speed boot, harrows; Knife points, press wheels; Morris bar, speed boots; Multi-vator; Superseeder points, harrows; Sweeps, harrows; Weston air seeder – were used.

Seeding depth was from 2 to 7 cm, with 2.5 to 4.5 the most common and 13 respondents reported furrow fill while 12 said this did not happen. Emergence reduction ranged from 0-100%, while crop development delay was estimated at being from 0-28 days. Affected areas ranged from 1 to 1100 ha, with most being 1-200 ha.

The two constant factors were rainfall at sowing/emergence (50 mm to 200+ mm) and Group D herbicide use, either trifluralin and/or pendimethalin. These were sometimes mixed with diuron or an SU and rates ranged from 0.75 to 2.5 recommended rates. There does not seem to be any correlation between damage level and rates or tank mixes. The one crop that was resown had the lowest rate of Stomp®, but it did have the highest rainfall (400 mm)

Some respondents offered extra comments:

- "Another area sown earlier and emerged before the big rain has shown no problems with similar rates applied" (1.5 L each Stomp® and trifluralin, acid wodgil clay).
- "A paddock that should be a 2.5-3.0 tonne crop will be lucky to go 1.5 tonne. Only unaffected crop is on surface gravel country" (30 g Logran + 1.8 L Stomp®, yellow to deep white sands).
- "It all emerged but has always struggled. We believe it was a combination of the Stomp®/diuron rather than the Stomp® on its own" (1.8 L Stomp® + 800 mL diuron, sand and sandy loam).
- "On heavier red loam in the same paddock there was no reduction in germination" (1.6 L Stomp®, medium loam).
- "In waterlogged areas – total loss of wheat but the ryegrass flourished, either from not being affected or from a subsequent germination" (2 L trifluralin, grey sand).
- "Problems may be insect related, still assessing" (1 L trifluralin + 385 g diuron, medium to heavy loams).

My own observations of our trials gave a similar mixed message.

On a loamy sand at Buntine where furrows were filled by soil wash, both trifluralin and Stomp® delayed the emergence of wheat (six varieties) by about a week. The crop subsequently caught up with little effect on yield.

On Esperance sandplain, Newdegate gravelly sand and Mullewa red clay loam we did not see any adverse effects. The sites were not especially wet in the sowing emergence period. There was some damage from Achieve in two reps of two varieties at Mullewa, when waterlogged at spraying.

On a Merredin clay loam, that was very wet, emergence was badly affected, especially by trifluralin. Emergence was reduced by about 40% and delayed by 10-14 days. Final yields are down by 10-35%. Chlorsulfuron has also caused severe damage in this trial.

LESSONS

Trifluralin has been seen to cause similar problems in the past, although reduced emergence was most often associated with crusting. There has certainly been no crusting in these cases. Past experience also has been that Stomp® was softer on the crop (and weeds) than trifluralin. This again was the case in our Merredin trial, but not at Buntine and not in the experience of many farmers.

An observation from Buntine, where knife points were used in patchy stubble, was that emergence was affected more where the stubble was thinnest. Soil wash into furrows was more there and so the wheat had both an extra depth from which to emerge and more herbicide to emerge through.

Unfortunately, knowing that problems are likely only tells us to be cautious with Group D's in very wet soils. It does not suggest an obvious alternative. Group B herbicides are not an alternative, as they can be very damaging under waterlogging. Nor are post-emergents always an alternative, as soil that is waterlogged at seeding is likely to be untrafficable in another 3-5 weeks.

A possible scenario is to make use of the early rains (and germinations) to ensure good knockdowns (alternating glyphosate and bipyridyls) and then seeding with knife points to minimise stimulation of weed seeds. The crop might then remain weed free long enough for it to become its own herbicide (keep seeding rates up!).

Paper reviewed by: Vanessa Stewart

AFFINITY 400DF – A new herbicide with a new mode of action (Group G) for Broadleaf Weed Control in Cereals

Gordon Cumming, Technical Officer, Crop Care Australasia

INTRODUCTION

Affinity 400 DF is a new herbicide expected to be available for the 2000 winter broadacre cropping season, distributed in Australia by Crop Care Australasia. It is a novel, fast acting herbicide with a new mode of action Group (G), for the post emergent control of a range of important broadleaf weeds in cereals.

Affinity 400 DF is available as a convenient to use WG formulation containing 400 g/kg carfentrazone-ethyl which is a contact herbicide effective at very low rates. To broaden the weed spectrum it is recommended to be used with MCPA amine.

MODE OF ACTION

Carfentrazone-ethyl is unique and offers a new mode of action (Group G) for broadleaf weed control in Western Australia. This has significant implications for the control of SU, diflufenican and triazine resistant populations of wild radish as well as other weed pests such as double gee.

Carfentrazone-ethyl is a member of the aryl triazolinone group (Group G) of herbicides, the active is rapidly absorbed through leaves and controls weeds through the process of membrane disruption, which is initiated by the inhibition of the enzyme protoporphyrinogen oxidase. This inhibition interferes with the chlorophyll biosynthetic pathway. At the recommended rates, Affinity does not have any soil activity and there are no crop rotation restrictions on the label.

EFFICACY

Affinity 400 DF is labelled for the post–emergent control of five broadleaf weeds with bedstraw the most sensitive. The addition of 500 mL/ha of MCPA (500 g/L as amine) increases the weed spectrum to include 20 weeds over a wider range of growth stages. Of these the most significant to Western Australia are wild radish, turnip, Indian hedge mustard, spiny emex (Doublegee), wireweed, white ironweed, prickly lettuce and volunteer lupins and canola.

Affinity is **not** suitable for application with crop oil concentrates or blended oil/surfactant adjuvants, due to unacceptable levels of crop phyto toxicity. For this reason, Affinity is not suitable for mixing with Grass Selective Herbicides.

1999 TRIAL PROGRAM

A serries of five trials were conducted in Western Australia last season to evaluate the effectiveness of Affinity 400 DF on populations of wild radish that were suspected of being SU (Group B) resistant and to further evaluate rate ranges of Affinity compared to some common standards.

METHODS

All five trials were conducted in the same manner. Treatments were applied at two timings, with the same product rate for each timing, to evaluate the robustness of rate with weed growth stage.

Locations:	Geraldton, Wongan Hills, Bruce Rock, Pingelly and Dumbleyung. The northern 3 sites were known or suspected to be SU resistant.
Timing 1 (T1):	The majority of the crop was at the 3 leaf stage (Z13). The majority of wild radish plants were at the 2 to 3 Leaf.
Timing 2 (T2):	This was made 14 days after T1. The majority of the crop was first to second tiller (Z21-Z22). The majority of wild radish plants were 6 to 8 leaf.

RESULTS AND DISCUSSION

For the purpose of this discussion reference shall be made to Figure 1 as an average of all five sites. The results from each site are set out in Table 1 for the reader to review at their leisure.

The Group B herbicides failed to provide adequate levels of control at four of the five sites. Even though levels of approx. 70% were achieved, this left between 2 and 8 plants/m^2 depending on the size of the initial population. This is indicative of Group B resistant radish populations, due to the variability in the age and hence resistance status of the germinating seed in any one season.

At the first timing of 2–3 leaf radish, all products performed well (95% or greater) with no significant differences (P = 0.05) between treatments at any site.

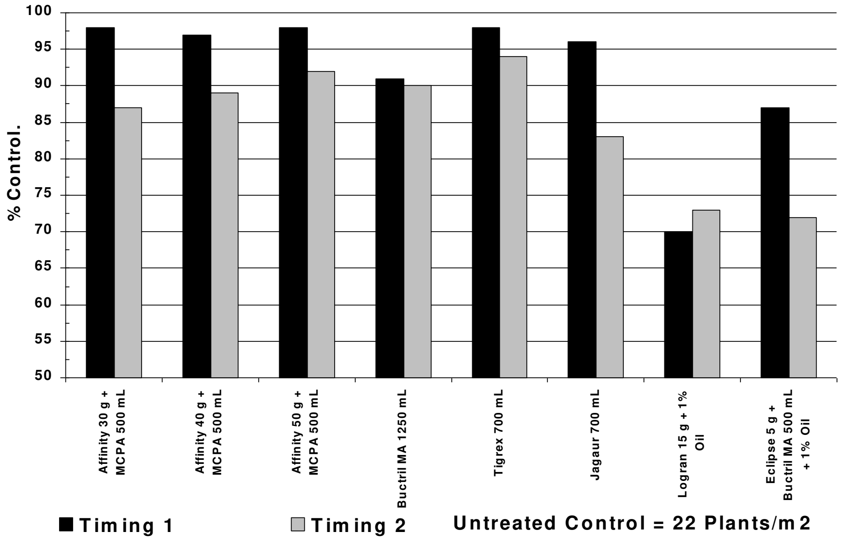
There would appear to be some scope for future refinement of the Affinity 400 DF label at the lower rates of 30 and 40 g/ha on small weeds of cotyledon to 2 leaf.

At the second timing (14 days later) on 4 to 6 Leaf radish, there was clear product separation. Jaguar was clearly inferior to all other treatments. Tigrex, Buctril MA and Affinity @ 50 g/ha all provided 90% or greater levels of control.

Affinity @ 40 g/ha provided 89% control although the variation across the sites for this rate at the later timing was greater than for 50 g (92%) suggesting that the 40 g rate was not as reliable.

Affinity @ 30 g/ha, whilst performing well at T1, provided significantly (P = 0.05) lower levels of control at T2 giving clear evidence of a sub-lethal rate on larger plants.

It needs to be remembered that at this early stage of development wild radish grows very rapidly, the time difference between T1 and T2 was only 14 days at each site. In this time the radish plants doubled in size and presented quite a challenge to some of the treatments. Products and rates should always be selected to provide robust levels of control - a couple of weeks delay can greatly alter the outcome.



For the purpose of this graph the Logran and Eclipse treatments have been averaged from the 4 SU Resistant sites only.

Figure 1. Wild radish *(Raphanus raphanistrum)* control averaged over all five sites.

CONCLUSION

Affinity 400 DF has demonstrated robust and reliable control of SU resistant wild radish populations when used at the recommended label rate of 50 g/ha. There is also some scope for a future reduction in label rates on wild radish at the cotyledon to 2 leaf growth stage.

Affinity 400 DF will provide farmers with a useful alterative to SU (Group B) products and can be used in a properly planned rotation to alleviate some of the selection pressure being placed on diflufenican (Group F) based products such as Tigrex and Brodal.

Paper reviewed by: Richard Warner ‘Technical Manager, Herbicides’ Crop Care Australasia.

	Treatment	Rate/ha Prod. (g or L)	Tim-ing	Geraldton (AU12-99-H655)				Wongan Hills (AU12-99-H657)				Bruce Rock (AU12-99-H659)				Dumbleyung (AU12-99-H638)				Pingelly (AU12-99-H637)			
				Radish plants		Grain yield		Radish plants		Grain yield		Radish plants		Grain yield		Radish plants		Grain yield		Radish plants		Grain yield	
				% control ***		% of control **		% control ***		% of control **		% control ***		% of control **		% control ***		% of control **		% control ***		% of control **	
1.	AFFINITY + MCPA	30 + 500	T1	100	G*	281	A*	94	DEF*	151	AC	99	FG*	163	AD*	98	E*	111		100	C*	126	
2.	AFFINITY + MCPA	40 + 500	T1	99	FG	277	A	96	DEF	156	AC	100	G	172	AB	88	CDE	119		100	C	121	
3.	AFFINITY + MCPA	50 + 500	T1	100	G	280	A	98	F	164	A	100	G	172	AB	93	DE	124		100	C	114	
5.	BUCTRIL MA	1250	T1	99	FG	276	A	96	EF	150	AC	100	G	174	A	58	AC	122		100	C	98	
6.	TIGREX	700	T1	100	G	260	AC	95	DEF	154	AC	100	G	165	AC	97	E	118		100	C	135	
7.	JAGUAR	700	T1	100	G	259	AC	95	DEF	145	BCD	99	EFG	164	AD	88	BCDE	131		100	C	115	
8.	LOGRAN + Oil 1% v/v	15	T1	93	CE	218	CD	90	BCD	131	DE	92	B	143	BCDE	41	A	115		100	C	135	
9.	ECLIPSE + BUCTRIL MA + 1% v/v	5 + 750	T1	97	EF	253	AC	95	DEF	142	CE	98	DF	161	AD	55	AB	127		100	C	109	
10.	AFFINITY + MCPA	30 + 500	T2	92	CD	260	AC	92	CE	155	AC	92	B	136	DF	78	AE	118		80	A	111	
11.	AFFINITY + MCPA	40 + 500	T2	95	DE	260	AC	93	CE	159	AB	95	BD	156	AD	73	AD	127		91	B	98	
12.	AFFINITY + MCPA	50 + 500	T2	96	DE	285	A	94	DEF	163	A	99	EFG	166	AC	71	AD	127		99	C	90	
14.	BUCTRIL MA	1250	T2	92	CD	272	AB	95	DEF	150	AC	93	BC	148	AD	69	AD	136		99	C	95	
15.	TIGREX	700	T2	89	BC	254	AC	94	DEF	157	AC	97	CDE	160	AD	89	CDE	125		100	C	98	
16.	JAGUAR	700	T2	91	CD	227	BCD	83	AB	127	E	93	B	142	CDE	49	A	120		99	C	98	
17.	LOGRAN + Oil 1% v/v	15	T2	80	A	202	D	81	A	106	F	85	A	112	FG	67	AD	123		100	C	95	
18.	ECLIPSE + BUCTRIL MA + 1% v/v	5 + 750	T2	82	AB	217	CD	86	AC	125	E	85	A	116	EFG	60	AC	122		100	C	119	
19.	CONTROL (Plants/m^2 or Yield t/ha)			S 37		0.30	E	S 21		1.64	F	S 30		1.30	G	S 6		1.28		S 10		2.93	
	Standard Deviation																						
	F-test probability			0.00%		0.00%		0.01%		0.00%		0.00%		0.23%		0.68%		66.13%		0.03%		11.03%	
	Coefficient of Variation					11.50%				8.63%				12.03%				15.49%				17.89%	
	5% LSD																						

S Treatment simple mean and omitted from statistical analysis.

* Treatments flanked by same letter are not significantly different at P = 0.05; ** Data Untransformed; *** Data Detransformed following Y = sqrt(x + 0.375).

NB: The sites at Geraldton, Wongan Hills and Bruce Rock were known to be SU resistant.
The sites at Dumbleyung and Pingelly were believed to be SU susceptible although the results from Dumbleyung strong suggest a high level of SU resistance.

The 3 northern sites produced a clear and significant (P = 0.05) correlation between the level of radish control and the final grain yield.
The 2 southern sites did not produce significantly (P = 0.05) different yields although there was again a numerical correlation between the level of radish control and the final grain yield.
The lack of statistical difference can be largely accounted for by the lower radish population numbers at these two sites.

Herbicide screening for Marshmallow

[1] Agriculture Western Australia, Merredin
[2] Elders Ltd, Merredin

BACKGROUND

Marshmallow is a weed of no-tillage farming systems which has few herbicides registered for its control. Glyphosate and oxyflourfen (Goal®, Goal CT® and Spark®) gives excellent knockdown control as well as glyphosate and Logran® followed by Spray.Seed®. There are few post emergent options registered for its control. This paper will summarise the results of three herbicide screening trials investigating both pre and post emergent herbicide options.

RESULTS

Screenings one and two assessed by visual assessment on growth. Screening three assessed by plant counts.

Screening 1

(Agriculture Western Australia). 15 herbicides and mixes were applied at various doses to assess efficacy on small sized marshmallow (height, 10-20 cm) that had previously been exposed to 10 g/ha Glean® and 1 L/ha Roundup CT® and survived. Plots were 5 m by 20 m arranged in a fully randomised block design with three replications. Sprayed on 12 May 1999 at Nukarni, applied at 60 L/ha water volume.

Herbicide	Dose/ha	% Control
Glyphosate 450	0.5 L	52
	1.0 L	45
	2.0 L	75
Sprayseed	0.5 L	70
	1.0 L	77
	2.0 L	93
Glyphosate 450+Goal	1.0+0.1 L	100
Glyphosate 450+Logran	1.0+10 g	63
Logran	10 g	37
Goal	0.1 L	100
Atrazine+Oil	2 L+2%	63
Lexone+Brodal	0.1+.05	98
Atrazine+Brodal	1 L+.05 L	95
Tigrex	1.0 L	98
Jaguar	1.0 L	85
Broadstrike	25 g	70
Lexone+oil	0.15 L+2%	88
Basta	1 L	45
	2 L	63
Amitrole	0.5 L	60

Screening 2

(Agriculture Western Australia) Ten herbicides and mixes were applied at various doses as a demonstration trial on large sized marshmallow (height, up to 0.75 m). Plots were 5 m by 10 m arranged in a fully randomised design with two replications. Sprayed on the 2 August 1999 at Merredin Research Station, applied at 60 L/ha water volume.

Herbicide	Dose/ha	% control

Atrazine + Oil	2 L + 1%	40
Glyphosate 450	2 L	20
Jaguar	1 L	70
Goal	150 mL	75
Glyphosate 450 + NH4SO4	2 L + 1%	95
Atrazine + Brodal	2 L + 50 mL	85
Broadstrike	25 g	95
Tigrex	1 L	85
Lexone + Brodal	100 mL + 50 mL	50

Screening 3

The 3rd screening is taken from an Elders Ltd trial conducted by David Cameron, entitled, 'Post emergent marshmallow control in no till'. Ten herbicides and mixes were applied at various doses on 1 to 10 leaf marshmallow plants. Plots were 1 m by 10 m arranged in a fully randomised design with three replications. Crop stage (Moondah barley) Z14–Z22, paddock received 500 mL/ha Roundup Extra® and 1.25 L/ha Trifluralin. Sprayed on 5 June 1998, applied at 40 L/ha water volume.

Herbicide	Dose/ha	% Control	Comments
Tigrex	400 mL	94	Very Good Control
Jaguar	500 mL	100	Excellent Control
Broadstrike	25 g	0	Chlorosis. Poor suppression
Logran + Oil	15 g + 1%	0	Minor suppression
Logran + Oil	30 g + 1%	0	Suppression. Stunted, some chlorosis
Brodal	50 mL	53	Good activity. Stunted, some necrosis
Brodal + Logran	50 mL + 5g	0	Minor Chlorisis
Brodal + Logran	50 mL + 10g	1	Good Suppression
Tigrex + Logran	400 mL + 5g	61	Good Suppression
Tigrex + Logran	400 mL + 10g	24	Suppression slow

CONCLUSIONS

There appears to be synergy between the group 'C' herbicides (atrazine and lexone) and Brodal, achieving nearly 100% control when in combination (Screening 1 and 2). Goal gives excellent control with or without glyphosate (screening 1). Tigrex and Jaguar, in general, gives good control albeit slow acting (screening 1, 2 and 3). Antagonism was observed between Tigrex + Logran and Brodal + Logran (screening 3). The addition of ammonium sulphate appears to increase the activity of glyphosate (Screening 2). Broadstrike was variable in its activity (screening 2 and 3). In screening two, Broadstrike gave excellent control, although taking up to 6 weeks to achieve this result.

Emphasis should be placed on the treatment of marshmallow when plants are young and small.

ACKNOWLEDGEMENTS

We would like to acknowledge GRDC for providing funding for the trials carried out for screening 1 and 2 and Elders LTD for supplying the data for screening 3.

GRDC Project No.: Daw 492
Paper reviewed by: Vanessa Stewart

The control of Capeweed in Clearfield Production System for canola

Mike Jackson and Scott Paton, Cyanamid Agriculture Pty Ltd

KEY MESSAGE

ONDUTY herbicide applied at 40 g/ha provides satisfactory control of Capeweed (*Arctotheca calendula*) when population densities are light and applications are made early. In high-density situations a mixture of ONDUTY at 40 g/ha and Lontrel at 150 mL/ha provides an additive level of control.

AIMS

The Clearfield Production System for Imidazolinone tolerant canola incorporates ONDUTY herbicide, Pioneer Imidazolinone tolerant canola seed and a Best Management Practice Program. The National Regulatory Authority registered ONDUTY in December 1999, with specific support for the concepts of the Clearfield Production System. This initial registration allows the post emergence use of ONDUTY on canola with the Clearfield trait, limited this winter season to two Pioneer Hi-Bred varieties. The system provides an exciting, alternative opportunity to farm managers growing canola.

ONDUTY provides reliable knockdown and residual weed control of most key broadleaf and grass weeds occurring in the Western Australian wheat belt. An exception is Capeweed, which is not on the current use label. Capeweed is widespread in sheep/crop rotations where it multiplies in the pasture phase. The absence of Capeweed from the ONDUTY label may be a matter of concern to some growers wanting to use the CLEARFIELD Production System.

Cyanamid conducted a number of field trials in 1999 for control of Capeweed with ONDUTY. The primary aim was the use of Lontrel with ONDUTY, however useful data were also obtained from other trials sites where Capeweed occurred.

METHOD

Four trial sites were undertaken in the southern wheat belt, where Capeweed were present. The trials were sown to Canola with the CLEARFIELD trait using commercial equipment. The sowing rate of 4 kg/ha seeding was used following the guidelines of the Best Management Practice Program. The sites were in the vicinity of Dumbleyung, Gnowangerup, Arthur River and Narrogin in Western Australia.

Another site with two trials was sown at Congelin. The canola was seeded at 4 kg/ha using a 12 row, small plot airseeder with narrow points pulled by a 4WD utility vehicle. The site was sown no-till following weed knockdown. Agras fertiliser at 120 kg/ha was side banded and a Lorsban + Talstar mix was sprayed immediately after sowing, for insect and mite protection.

Post emergence herbicide treatments were applied by Cyanamid R&D personnel using LPG pressurised, back pack sprayers and hand held booms equipped with four 11001 LP flat fan nozzles spaced 50 cm apart. The treatments were sprayed at 175 kP and at 100 L/ha of spray mix.

Treated plots were each 2 m x 9 m, separated from adjacent plots by a 1 meter wide buffer. All trials were replicated four times with replicates separated by a 1 meter wide corridor. The trials had 14-18 treatments, including an untreated check.

ONDUTY effects on Capeweed were assessed 6-8 weeks after application. Four of the five trials were harvested at crop maturity.

RESULTS

The level of Capeweed control achieved using ONDUTY* (at 40 g/ha rate), was largely dependant on the age of the weed population at application. ONDUTY* provided adequate control of Capeweed when applied to plants between 2-5 leaf, however product performance on plants older than 6 leaf decreased significantly. Figure 1 depicts data from three trials, each with a Capeweed population averaging 5-10 plants/square metre.

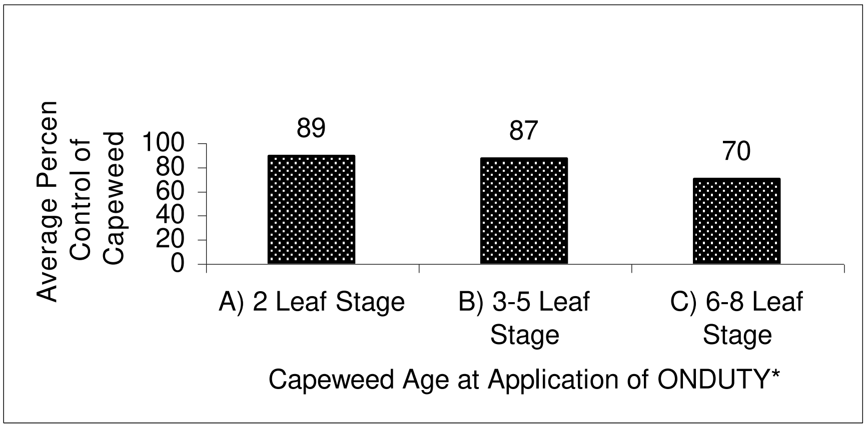


Figure 1. The impact of capeweed age at application of ONDUTY* (40 g/ha) on weed efficacy levels.

Older populations of Capeweed were generally not well controlled by the registered rate of the ONDUTY* (40 g/ha). The performance of ONDUTY* on Capeweed was reduced in situations where weed densities were high and the Capeweed population had advanced past the 6 leaf stage of development.

Figure 2 depicts the average percent Capeweed control levels recorded from application of ONDUTY* (40 g/ha), Lontrel (300 mL/ha) and a tank mix combination of ONDUTY* (40 g/ha) + Lontrel (150 mL/ha). The tank mix combination provided better control of Capeweed than the highest rate of Lontrel (300 mL/ha). Trial data was taken from two locations where treatments were applied at the 6-8 leaf stage of development and population densities ranged between 10-30 plants/square meter.

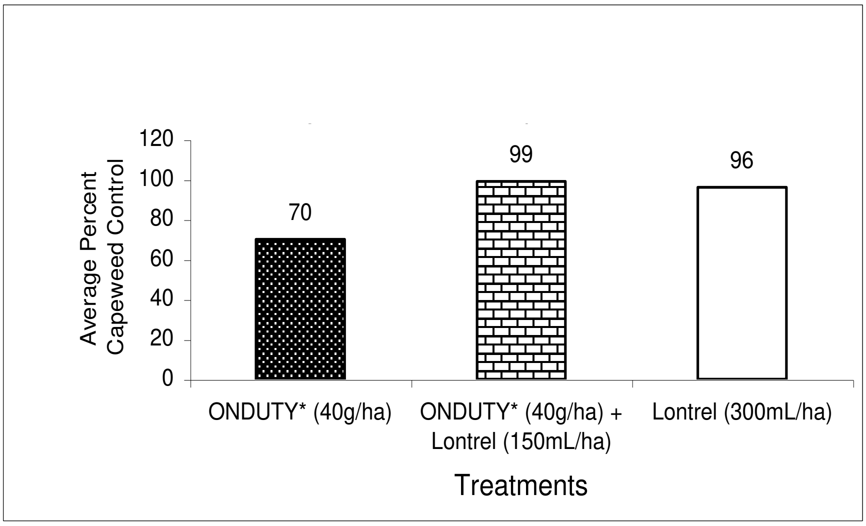


Figure 2. The average per cent capeweed control achieved when treatments are applied at the 608 leaf stage of weed development.

Table 1 compares the average yields, taken from four trials, for each of the respective treatments and the untreated control. The highest yields were recorded in plots treated with ONDUTY* (40 g/ha) in tank mix with Lontrel (150 mL/Ha), where weed competition was at it's lowest.

Table 1. Average yield of canola with the CLEARFIELD trait (kg/ha)

Treatment	Average yield (kg/ha)
Untreated Control	1173
ONDUTY* (40 g/ha)	1297
ONDUTY* (40 g/ha) + Lontrel (150 mL)	1483
Lontrel (300 mL)	1248

CONCLUSION

Five trials undertaken by Cyanamid during the 1999 Winter cropping season for the control of Capeweed in the Clearfield Production System for canola. The trials focused on the weed efficacy provided by ONDUTY*, Lontrel* and tank mix combinations of these products for control of Capeweed in crop. Several key observations can be made from these trial results.

The performance of ONDUTY* (40 g/ha) for control of Capeweed is dependant on the age of weeds and population densities at application. Where Capeweed populations are light (5-10 plants/m^2) ONDUTY* can provide upto 90% control, however as population densities increase the weed control can be significantly reduced.

Figure 1 demonstrates the importance of application timing for the performance of ONDUTY* in controlling Capeweed. ONDUTY* can provide adequate control when applied between the 2-4 leaf stage of Capeweed development. Application of the herbicide after the 6 leaf stage of weed development did not provide acceptable levels of control. Addition of Lontrel in a tank mix with ONDUTY* substantially improves control of Capeweed (Figure 2). Where weed age exceeds 6 leaf at application, Capeweed control can be improved using a tank mix combination of ONDUTY* (40 g/ha) and Lontrel (150 mL/ha).

Minimising weed competition during crop development can have a significant impact on crop yields. The average yield results taken from the five trials (Table 1). The average canola yield was highest in plots treated with the tank mix combination of ONDUTY* (40 g/ha) and Lontrel (150 mL/ha), due to the improved weed control.

Cyanamid remains committed to continue trial program covering various aspects of the Clearfield Production System, aiming to maximise the benefits to growers.

KEY WORDS

clearfield, ONDUTY, lontrel, capeweed

Effect of herbicides Tordon™ 75D and Lontrel™, used for eradication of Skeleton Weed, on production of Lupins in following seasons

John R. Peirce and Brad J. Rayner, Agriculture Western Australia

AIMS

To determine if lupins can be retained in a rotation where Tordon™ 75D and Lontrel™ have been applied at rates of 1, 2, 4 and 8 L/ha to eradicate skeleton weed.

INTRODUCTION

Skeleton weed *Chondrilla juncea* L. is currently under an eradication campaign in Western Australia. Treatment involves an initial dose of 7 L/ha of Tordon™ 75D (picloram + 2,4-D amine) and depending on regrowth in the following three years, additional amounts may be required before the infested paddock can be released from quaranteen. While safe on cereals and canola Tordon™ (pictoram) is known to have residual activity on many legume species. An investigation into the long-term effect of both Tordon™ and Lontrel™ (also effective on skeleton weed), was commenced at Lake Varley in October 1995 to examine the effect of rates of 1, 2, 4 and 8 L/ha of both chemicals on the growth of lupins over several seasons. Yields taken in 1997, 1998 and 1999 suggested that 18 months after treatment with up to 8 L/ha Lontrel™ lupins can be included in a rotation. Lupins only tolerated up to 4 L/ha of Tordon™ 75D after the same period but it was safe to plant lupins three years after treatment in areas receiving up to 8 L/ha. Retreatment four years later in the February of 1999, lupins would only tolerate 1 L/ha of Tordon™ 75 D compared to 8 L/ha of Lontrel™.

On this soil type at Lake Varley, which is known to support skeleton weed, the current treatments used to eradicate the weed will not cause any major gaps in cropping rotations, particularly if Canola is included. Further testing is required in other regions where skeleton weed is found.

METHODS

Tordon™ and Lontrel™ were applied in August 1995 at 1,2,4 and 8 L/ha in a randomised block design experiment at Lake Varley. After the break of the season in 1996 14 crops and pasture species including Myallie lupins, Amery wheat, Narendra canola, oats and barley were established. There was no incrop herbicides used and cultivation following the knock down herbicide glyphosate was the only weed control

In 1997 the cropping was altered and only wheat, lupins, canola and pasture was used. The same varieties were retained for wheat and lupins, canola being changed to Karoo, a triazine tolerant variety and the pasture being arrowleaf clover. In addition from 1996, following the knockdown herbicides the following incrop herbicides were used:

	Pre	Post
Wheat	Trifluralin + logran	Diuron + MCPA Hoegrass
Lupins	Simazine	Simazine Brodal Hoegrass
Canola	Simazine and Atrazine	Hoegrass

The crop rotation from 1997 was as follows:

1997	1998	1999
Wheat	Pasture	Canola
Lupins	Canola	Pasture
Canola	Lupin	Wheat
Pasture	Wheat	Lupins

RESULTS

Because of the lack of in-crop weed control, yields from 1996 are not presented.

With the exception of Tordon™ 75D at 8 L/ha, yield reductions 18 months after treatment were less than 20% (Table 1). Lontrel™ was considerably safer than Tordon™ 75D, with yield losses at the 4 and 8 L/ha being only 5 and 8% respectively, compared with 10 and 41% using Tordon™ 75D. Some 30 months after the treatment, with the exception of 1 and 8 L/ha of Tordon™ 75D all treatments out yielded the unsprayed. No explanation can be given for the result from the 1 L/ha rate. By 42 months even 8 L/ha of Tordon™ 75D did not show any yield suppression on lupins. However, retreating in February 1999 with the same rates applied in August 1995 caused severe damage (34% reduction) with as little as 2 L/ha of Tordon™ 75D and total yield loss at 8 L/ha. The equivalent rate (8 L/ha) of Lontrel™ only depressed yields by some 20%.

The effect on lupin yield of four rates of Lontrel™ and Tordon™ 75D applied in August 1995

Treatments	Rate L/ha	% Yield compared to untreated			
		1997	1998	1999	1999*
Lontrel™	1	90	110	114	95
Tordon™	1	84	79	106	119
Lontrel™	2	86	102	89	93
Tordon™	2	80	102	128	66
Lontrel™	4	95	128	120	103
Tordon™	4	90	112	82	38
Lontrel™	8	92	113	99	81
Tordon™	8	59	95	113	0

CONCLUSIONS

Careful planning of crop stations in areas where skeleton weed has been found is required, so that there is at least a 30 months break following the application of 7 L/ha of Tordon™ 75D will still allow lupins to be retained in a rotation. Cropping through areas infested with skeleton weed is not permitted until twelve months after the Tordon™ 75D treatment has been applied, however, there is no restriction on cropping outside these areas. This gives the option of growing wheat, barley, oats or canola as the first crop following treatment.

One of the benefits of these two chemicals is the control of capeweed for several seasons where the higher rates are used. In addition some suppression of summer weeds such as mintweed and melons was also noted.

In the areas adjacent to the Tordon™ 75D treated skeleton weed there is also an opportunity to use the incrop herbicides Lontrel™ or Tordon™ 242. Tordon™ 242 contains, in addition to picloram, MCPA, instead of 24-D which is present in Tordon™ 75D. These products are active on a range of broad leaved plants including capeweed and thistles but at present are not registered for the use on skeleton weed in Western Australia. With the herbicide resistance problems in radish, these products may find a new niche.

*** Retreated in February 1999 with the same rate of chemical.**

ACKNOWLEDGEMENT

This work was funded from the skeleton weed eradication trust fund.

GrainGuard - Opportunities for agribusiness to help protect the West Australian grains industry

Greg Shea, Executive Officer, GrainGuard

The grains industry is highly exposed to a number of biological threats including incursions of exotic pests, the spread of endemic pests, the development of pesticide resistance and problems associated with grain contamination.

The unique feature of the *GrainGuard* initiative is the development of a total management program for industry and government which identifies and assesses threats to the grains industry along with the development of active responses to these threats. There is a role for grain industry members and especially agribusiness to assist in this initiative. Good communication networks are required between sectors of the Industry when there is an emergency response at the time of an incursion. This has already borne fruit with the Emergency Response for Ascochyta blight in Chickpeas last year where agribusiness played a major role in providing information on disease traceback.

The foundation of *GrainGuard* is the maintenance of a high level of bio-security beginning at the farm level. Growers, agribusiness and others throughout the grain handling chain are encouraged to be vigilant and report any unusual pest observations and seek identification of these pests or disorders by Agriculture Western Australia specialists.

Grain handlers, marketers, millers and processors are very aware of the potential impact of exotic pests on the quality and marketing of grain. All industry members face substantial risks from the damage that may flow from a major exotic pest incursion or a significant grain contamination incident. In-house sampling and inspection procedures by this group make it well placed to maintain surveillance for grain pests and contaminants.

Independent consultant agronomists, crop monitors and commercial agronomists provide a major resource, which could be harnessed to enhance pest surveillance through the farm sector of the industry. This paper provides details of two examples of potential threats to the grain industry and the associated surveillance activities industry members might assist with.

KHAPRA BEETLE

This insect has not been recorded as established in Australia. Currently, almost all countries have an import restriction on the importation of Khapra beetle. Based on current trade this represents all trading partners for wheat. There is an expectation from our markets that we provide proof of freedom from the pest, hence there is a level of surveillance carried out by AQIS inspectors and Agriculture Western Australia agriculture protection program surveillance staff. Khapra beetle is the most important pest of stored products in the world, attacking principally cereals and oil seeds. The insect is difficult to detect, secretive in nature and tolerant to phosphine. The impact of insect is not just the damage to grain, as the insect is difficult and costly to control once established.

The Khapra beetle is oval, dark brown and 2-3 mm long. The larvae are the most commonly occurring stage and are yellow-brown, covered in thick brown hair and reach a length of 5 mm.

Aims of surveillance

An incursion of Khapra beetle in the US in the 1950s was eradicated at a cost of US$50 million. Due to the slow movement and development of the pest once established, eradication is achievable. However, the secretive nature of the pest means that it is difficult to detect in the early stages of an incursion and the earlier the detection is made, the easier (and less expensive) this eradication will be.

It is in everyone's best interest to minimise the effect of an incursion should it occur. Quarantine has a particular focus on where material might enter at the border along with procedures for maximising detections. One or two detections of Khapra beetle occur each year, usually in ship’s stores.

Agriculture Western Australia surveys for Khapra beetle by using sticky pheromone traps that attract both Khapra and Warehouse beetles. Visually distinguishing between pest and native beetles belonging to the same family as Khapra and warehouse beetle is very difficult therefore a preliminary molecular procedure is used. Any grain samples with insect infestation sent in using the GrainGuard kits, particularly hairy larvae, will be examined for Khapra beetle. Should Khapra beetle be detected, there is a well-established protocol for eradication using fumigation. As a serious quarantine pest, there is a strong Australia wide commitment to effectively deal with an incursion. Agriculture Western Australia currently carries out surveillance for Khapra beetle. Any assistance that you can give would be useful to complement this activity.

What you can do

Keep on the lookout for hairy larvae, they could be the Khapra beetle; only a trained entomologist can tell the difference between them and native or warehouse beetles. Set up some traps during the warm months - adults are strongly attracted to pheromone traps.

For taking grain samples, target high-risk areas, such as warehouses, grain and seed storage areas, wasp nests, spider webs, rat baits and dead birds are all likely locations.

BROOMRAPE

Broomrape (*Orobanche* sp) are serious weeds of pulse, oilseed and vegetable crops worldwide. They are parasites and can only survive by attacking the root system of a suitable host. Broomrape contamination is a prohibited import for many of Australia's key export markets.

Two species of broomrape are found in Australia but neither is a weed of crops. Common broomrape is very prevalent in Western Australia and is found in pastures and gardens. The other is a native broomrape that is rare. There is no need to report these broomrapes unless you see them attacking crops. It is imperative that detections of any other species of broomrape exotic to Western Australia are reported. Branched broomrape *(O. ramosa)* has been found in South Australia and measures are currently in place for its eradication. Grain crops that could be affected include canola, lupins, chickpeas and lentils. There are requirements from many markets for all grain exported to be free of Broomrape seed contamination.

What you can do

If you come across this weed in your fieldwork, take a sample and use the GrainGuard kit to send it away thereby ensuring that it arrives at the lab in good condition. The sample will be identified and you will be informed of the plant's identity. Determine which plant is the host by digging up the broomrape and examining the root system. Any Broomrape parasitising a crop plant should be treated with caution. Avoid spreading any soil, as this is the most common method of spreading the minute, dust like, seeds. Eradication is by fumigation and is very difficult to achieve over large areas of infestation so therefore discovery shortly after establishment is important.

Can you help?

If you can assist with any part of the GrainGuard initiative, contact me at the Dryland Research Institute Merredin Ph: (08) 90 813 111, e-mail gshea@agric.wa.gov.au.

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