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GENETICALLY MODIFIED CROPS MORATORIUM REVIEW

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Introduction

It is with much optimism that the authors submit to the **GENETICALLY MODIFIED CROPS MORATOTIUM REVIEW** the following submission. The paper provides critical information pertaining to one of the key questions on the introduction of genetically modified (GM) canola that being:

"What benefits will a GM canola herbicide tolerant weed control management system deliver to Australia canola growers when grown within Australian farming systems and crop rotations?"

This submission and the results contained herein are based on the conduct of an independent five (5) year crop rotation experiment which focused on the efficacy, effectiveness and economic performance of a GM herbicide tolerant canola weed management system in comparison with current conventional weed management system options within a typical crop rotation system located at Wagga Wagga (NSW).

It is the authors' understanding that this project is the only long term crop system research undertaken to evaluate GM herbicide tolerant canola under field experimentation in Australia.

The project at all times was conducted under the strict protocols and in compliance with conditions applied by the Office of the Gene Technology Regulator.

Abstract

A comparison of a Roundup Ready GM canola weed management system with current conventional canola weed management system options was undertaken at Wagga Wagga over a 5 year rotation. The outcomes were that Roundup Ready canola achieved superior weed control and delivered generally higher yields and oil quality when compared to current conventional weed managements system options. There were positive flow-on impacts on the remainder of the crop rotation from the weed control achieved with Roundup Ready canola in the first year of the rotation. There were no difficulties with volunteer canola control. The Roundup Ready GM canola rotation was the most profitable in the canola years of the crop rotation and over the total crop rotation. These outcomes clearly demonstrated the potential advantages and benefits of Roundup Ready GM canola to Australian farmers.

Background

Whereas GM herbicide tolerant canola has been widely grown in Canadian farming systems since 1996, achieving 82% of the total crop in 2005 (4.3 million ha)[1], there is no experience of its incorporation into Australian conservation farming systems. In Australian farming systems glyphosate (i.e. Roundup) herbicide is currently applied as a pre-plant non-selective herbicide to remove competition to the crop at sowing time. The introduction of glyphosate herbicide tolerant crops (i.e. Roundup Ready) opens up the opportunity for glyphosate to be also used in the crop for post-emergence weed control. As such it provides an alternate mode of action herbicide for application to replace, rotate with, or complement the current use of pre and/or post emergent herbicides where the development of herbicide resistance in weeds prevents the use of current herbicides. The use of glyphosate in this manner will potentially control a broad range of both grass and broadleaf weeds. A positive outcome will be the reduction in the range and volume of herbicides currently applied for weed control in canola.

The applicability to Australian conditions however is an unknown, and an evaluation of Roundup Ready weed control technology is thus required with respect to:

- its ability to effectively replace current canola weed management system options,
- its compatibility with current canola weed management tools,
- its relative yielding capability,
- its effectiveness with in-crop weed control,
- its carryover impacts in the rotation and
- its economic performance both within the year of the canola crop and across the crop rotation.

The objectives of the project therefore were to evaluate the effect of the inclusion of Roundup Ready GM canola in a typical winter crop rotation relative to other common canola weed management system options. The weed management system focus was annual ryegrass (*Lolium rigidum*) because it is the most challenging weed of winter crop production in Australia due to its propensity to evolve herbicide resistance to a range of current herbicides applied for its control in canola. The project was conducted through 5 seasons from 1999 to 2003 at Charles Sturt University, Wagga Wagga, NSW.

Methodology

The experiment commenced in 1999 with a comparison of three different canola weed management systems for the control of annual ryegrass. The canola systems, using isogenic lines, were:

1. Conventional (non-herbicide tolerant) - cv Surpass 600

2. Triazine tolerant (non-GM herbicide tolerant) - cv Surpass 600TT

3. Glyphosate tolerant (GM herbicide tolerant) - cv N758, (Roundup Ready)

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[1] GM crop impact: the first ten years, ©PG Economics Ltd 2006

Individual plots were 10m x 1.8m with 1.2m buffers to minimise spray drift effects.

Table 1. Application rates and adjuvants used for all selective herbicides used within each canola system

Canola system	Herbicide	Timing	Rate (g a.i. /ha)	Adjuvant
Conventional cv Surpass 600	trifluralin	Pre-emergent	960	Nil
	clethodim	Post-emergent	48	DC-Trate @ 2L in 100L
Triazine tolerant cv Surpass 600TT	simazine + atrazine	Pre-emergent	1000 + 500	Nil
	atrazine	Post-emergent	500	BS1000 @ 40mL in100L
Roundup Ready® cv N758	trifluralin	Pre-emergent	960	Nil
	glyphosate	Post-emergent	405	Nil

There were three replicates in a randomised block design, with split-split plot treatments as follows:

- +/- a preseason light cultivation ('autumn tickle');
- full (wide points) or minimal (narrow points) soil disturbance at sowing;
- glyphosate preplant at either the full disturbance rate (360g a.i./ha) and direct drilling rate (495g a.i./ha); and
- selective herbicide regimes, ie pre-emergent herbicide only; post-emergent herbicide only; pre-emergent plus post-emergent herbicides; no selective herbicide control treatment. Table 1 provides detail of herbicide treatments which were those appropriate to each canola system.

Fertilisers were applied to all crops in line with regional best practice (NSW Department of Primary Industries, 1999). Flutriafol fungicide was applied at 100g a,e,/ha to minimise blackleg infestation and methidathion insecticide was applied pre-emergence at 80 g a.i./ha to the whole site post-sowing for the control of red legged earth mite.

Following the canola crop in Year 1, the experimental site was managed uniformly as a common rotation for the next three years but carryover effects from Year 1 were monitored each year. In Year 2, wheat (cv Diamondbird) was grown, followed in Year 3 by lupins (cv Wonga) and wheat (cv Diamond bird) in Year 4. Detailed treatments for these crops are given in Table 2. All crops were direct drilled with narrow points and fertilisers applied according to best district practice.

Table 2. Cropping system and herbicide application for 2000-02 seasons

Year	Sowing rate (kg/ha)	Pre-season knockdown	Pre-emergent herbicide	Post-emergent herbicide
1999 canola	4.5	Table 1	Table 1	Table 1
2000 wheat cv Diamondbird	77	Paraquat +diquat	chlorsulfuron	Diclofop methyl
2001 lupins cv Wonga	80	Paraquat + diquat	simazine	Haloxyfop Diflufenican
2002 wheat cv Diamondbird	80	glyphosate	triasulfuron	Diclofop methyl
2003-canola	4.5	Table 1	Table1	Table1

In Year 5, canola systems were again compared. The four systems involved were:

- conventional canola (cv Surpass 600)
- triazine tolerant canola (cv Surpass 600TT)
- imidizolinone-tolerant canola (cv Surpass 603CL) and
- glyphosate-tolerant GM canola (cv N758)

Each canola system was superimposed on each of the Year 1 canola systems. However as there had been no effect of pre-sowing cultivation or of soil disturbance at sowing in Year 1, the Year 5 treatments were confined to the selective herbicide treatments of Year 1. The site was treated with 612 g a.i./ha glyphosate for non-selective knockdown weed control one week prior to sowing. As Year 1 herbicide treatments were still yielding differences in annual ryegrass populations, 144 plots were used comprising equal numbers of plots from each previous herbicide and canola system regime to allow three replicates of each previous system. Each canola weed management system was managed using the appropriate herbicides. Initially, two post-emergent applications of glyphosate were planned for the glyphosate tolerant system however, due to unsuitable conditions for herbicide application, only one post-emergent application of glyphosate was possible.

Gross margins calculations were based on the farm enterprise budgets available from the New South Wales Department of Primary Industries for the years in question. Pesticide costs per hectare were calculated using average retail prices (Mullen and Dellow, 1999; Mullen *et al*., 2000; 2001; 2002) and actual application rates. Machinery costs were based on the New South Wales Department of Primary Industries guide to tractor and implement costs for the appropriate years. Fertiliser costs were calculated using actual price paid and the application rate used each season. Other typical costs that could be incurred for a commercial crop (eg., windrowing, harvesting, cartage, insurance and industry levies) were included in all

calculations based on information from the farm enterprise budgets available from the New South Wales Department of Primary Industries for each season.
For canola in 1999, a base price of $300 per tonne was assumed. An oil premium/discount of 1.5% per 1% variation from 42% oil content was calculated based on oil tests conducted by AgSeeds, Horsham, Victoria for each plot. A technology fee for the Roundup Ready® canola was not included in the calculations. Income from the following three years of the rotation of wheat, lupin and wheat crops was based on market price at the time (ie $180, $264 and $219 per tonne respectively).

Statistical analysis

- Grain yields were obtained for each plot using a plot harvester and sub-samples of canola seed were taken for oil analyses.
- Weed count means for each plot were obtained by averaging quadrat counts per plot. Data were transformed using ln(count + 1) to normalise variances prior to the analyses of variance.
- Initial annual ryegrass density was included as a covariate in the analysis of subsequent annual ryegrass data to address some variations in initial annual ryegrass densities.
- *Post hoc* Fisher's protected LSD tests were used to separate significantly different means. Data were back-transformed into counts for presentation and significantly different treatments are indicated by superscripting.

Results

Canola crop yields in Year 1 largely reflected the herbicide regime used in the production of that crop. Highest yields were obtained where both pre-emergent and post-emergent herbicides were used and lowest yields where no selective herbicides were involved due to the associated weed burden (Table 3). Conventional canola (CC) yielded better than both Triazine Tolerant (TT) and Roundup Ready (RR) canola in this latter situation, suggesting that both these lines are not as competitive as conventional lines and less likely to be successful under higher weed burdens in the absence of herbicides.

Table 3. Canola yields (t ha^{-1}) in Year 1 for three canola weed management systems under different management regimes

Treatment	Canola Weed Management System		
	Conventional	Roundup Ready®	Triazine tolerant
Herbicide			
Control	0.36	0.17	0.16
Pre-emergent	0.95	0.96	1.81
Post-emergent	1.34	2.02	0.58
Pre- & Post	1.64	2.20	2.17
s.e.d.	0.05	0.05	0.08
Cultivation			
Full cut + pre-season cultivation	0.19	1.11	0.80
Direct Drill + 0.8 L ha^{-1} glyphosate	1.09	1.33	1.19
Direct Drill + 1.1 L ha^{-1} glyphosate	1.26	1.51	1.32
Full cut + 0.8 L ha^{-1} glyphosate	1.33	1.32	1.37
Full cut + 1.1 L ha^{-1} glyphosate	1.49	1.41	1.22
s.e.d.	0.14	0.07	0.08

Post-emergent-only treatments were superior in yield to pre-emergent-only in conventional canola and in RR but inferior in TT canola. The better performance of the pre-emergent-only in TT canola is likely to be due to the activity of the triazines in that system as they are more efficacious through root absorption in seedlings and less effective on established plants through foliar absorption.

Overall, the RR system was the most successful when selective herbicides were used post-emergent or both pre and post-emergent. These outcomes reflected the weed populations recorded (Table 4) and the ability of RR canola to provide broadleaf weed control as well as ryegrass control.

The impact of other treatments, relating to autumn tickle, degree of disturbance at sowing and rate of knockdown herbicide pre-sowing, was largely inconclusive. Only the RR canola derived benefit from the autumn tickle and full soil disturbance. There was a trend towards higher yields where the higher rate of glyphosate was used as a knockdown (Table 5) but is not explained solely by ryegrass populations. The impact of other weed species may have played a role in this response.

Wheat yields in Year 2 were influenced by the weed management herbicide regimes imposed in the Year 1 canola crops (Table 5) but cultivation practices in the canola had no significant impact on wheat yield. Where TT canola had been grown, highest wheat yields were obtained where triazines had been used in a pre-emergent application. In CC canola plots, wheat yields were significantly better where both pre-emergent and post-emergent herbicides had been used.

Following RR canola, wheat yields were significantly increased where glyphosate had been used post-emergent, either with or without a pre-emergent herbicide. Interestingly, wheat yield of the control treatment in the RR system was greater than, or similar to, yields from any treatment in the CC or TT systems.

Table 4. August 1999 (Year 1) weed densities (plants m^{-2}) as affected by canola system

Treatment Cultivation	Herbicide	Weed category: Annual ryegrass	Broadleaf	Other grasses
Conventional				
	Control	312.9 ^{a}	2.4 ^{a}	0.8 ^{a}
	Pre-emergent	94.9 ^{b}	12.3 ^{b}	3.5 ^{b}
	Post-emergent	35.2 ^{c}	43.4 ^{c}	3.5 ^{b}
	Pre- & Post	20.7 ^{d}	15.6 ^{b}	2.5 ^{b}
FD + AT		74.4 ^{a}	8.0 ^{a}	4.8 ^{a}
DD + 360 g a.i. ha^{-1} glyphosate		74.2 ^{a}	13.6 ^{b}	1.4 ^{a}
DD + 495 g a.i. ha^{-1} glyphosate		62.3 ^{a}	10.9 ^{a,b}	1.9 ^{a}
FD + 360 g a.i. ha^{-1} glyphosate		71.6 ^{a}	16.3 ^{b}	2.6 ^{a}
FD + 495 g a.i. ha^{-1} glyphosate		62.4 ^{a}	15.9 ^{b}	2.0 ^{a}
Roundup Ready				
	Control	447.1 ^{a}	10.8 ^{a}	1.5 ^{a}
	Pre-emergent	163.4 ^{b}	4.1 ^{b}	3.1 ^{b}
	Post-emergent	29.9 ^{c}	0.7 ^{c}	0.1 ^{c}
	Pre- & Post	11.5 ^{d}	0.2 ^{c}	0.1 ^{c}
FD + AT		37.7 ^{a}	1.3 ^{a}	1.6 ^{a}
DD + 360 g a.i. ha^{-1} glyphosate		85.3 ^{b}	3.3 ^{a}	1.1 ^{a}
DD + 495 g a.i. ha^{-1} glyphosate		87.1 ^{b}	2.8 ^{a}	0.6 ^{a}
FD + 360 g a.i. ha^{-1} glyphosate		83.6 ^{b}	2.6 ^{a}	0.9 ^{a}
FD + 495 g a.i. ha^{-1} glyphosate		82.2 ^{b}	2.1 ^{a}	0.4 ^{a}
Triazine tolerant				
	Control	221.1 ^{a}	32.1 ^{a}	2.3 ^{a}
	Pre-emergent	28.3 ^{b}	10.7 ^{b}	0.5 ^{b}
	Post-emergent	176.5 ^{a}	7.7 ^{b}	1.2 ^{a,b}
	Pre- & Post	8.1 ^{c}	3.7 ^{c}	0.0 ^{b}
FD + AT		87.7 ^{a}	17.1 ^{a}	5.6 ^{a}
DD + 360 g a.i. ha^{-1} glyphosate		44.8 ^{b}	7.5 ^{a}	0.3 ^{b}
DD + 495 g a.i. ha^{-1} glyphosate		56.8 ^{b}	7.6 ^{a}	0.0 ^{b}
FD + 360 g a.i. ha^{-1} glyphosate		46.8 ^{b}	11.1 ^{a}	0.6 ^{b}
FD + 495 g a.i. ha^{-1} glyphosate		52.6 ^{b}	10.2 ^{a}	0.4 ^{b}

Means within each weed and treatment category with the same superscript are not significantly different at the 5% level as determined by Fisher's protected LSD test on transformed data.

AT = autumn tickle; FD = full disturbance at sowing; MD = minimal disturbance at sowing

Table 5. Yields (t ha^{-1}) of wheat (2000), lupins (2001) and wheat (2002) in rotation as affected by the herbicide regime of canola in 1999

	Prior canola weed management system		
Treatment	**Conventional**	**Roundup Ready®**	**Triazine tolerant**
2000 – wheat			
Control	6.34	6.95	6.11
Pre-emergent	6.32	7.05	6.87
Post-emergent	6.42	7.21	6.33
Pre- & Post	6.93	7.38	6.91
s.e.d.	0.07	0.11	0.08
2001 - lupins			
Control	0.68	0.56	1.07
Pre-emergent	0.70	0.90	0.97
Post-emergent	0.85	0.92	1.05
Pre- & Post	0.83	0.88	1.02
s.e.d.	0.05	0.07	n.s.
2002 – wheat			
Control	2.11	2.09	1.90
Pre-emergent	2.10	2.10	2.38
Post-emergent	1.95	2.07	2.60
Pre- & Post	2.09	2.21	2.66
s.e.d.	0.06	n.s.	0.07

In the lupin crop in Year 3 (Table 5), there was still evident a response to use of selective herbicide from Year 1 in the RR treatment ($p<0.001$) but there were no detectable effects of canola system treatments following the triazine tolerant canola. Differences in the yields from the conventional plots were most likely attributable to grazing of the young lupins by wild ducks rather than to carry over effects resulting from previous treatments.

Wheat yields in Year 4 were limited by low seasonal rainfall, with average yields being marginally above 2 t/ha across all systems. There were differences still evident between original herbicide treatments within the triazine tolerant and conventional systems (Table 5). The CC post-emergent herbicide treatment produced lower yields than other treatments, as did the TT pre-emergent treatment from Year 1. There were no significant yield differences in the RR canola plots from Year 1.

Table 5. Annual ryegrass density (plants m^{-2}) in September of Years 2, 3 and 4 in crops following the different canola management systems in Year 1

.

Treatment		Crop		
Cultivation	**Herbicide**	**2000 Wheat**	**2001 lupins**	**2002 wheat**
conventional				
	Control	116.8 [b]	2.7 [a]	44.2 [b]
	Pre-emergent	114.8 [b]	2.6 [a]	45.9 [b,c]
	Post-emergent	175.4 [a]	4.1 [a]	58.1 [c]
	Pre- & Post	93.3 [c]	1.4 [b]	28.5 [a]
FD + AT		88.3 [a]	1.9 [a]	32.0 [a]
DD + 360 g a.i. ha^{-1} glyphosate		122.8 [b]	2.5 [a]	35.7 [a]
DD + 495 g a.i. ha^{-1} glyphosate		135.0 [b]	2.0 [a]	49.6 [a]
FD + 360 g a.i. ha^{-1} glyphosate		140.2 [b]	3.3 [a]	44.6 [a]
FD + 495 g a.i. ha^{-1} glyphosate		130.2 [b]	3.5 [a]	57.3 [a]
Roundup Ready				
	Control	110.8 [a]	2.1 [a]	45.2 [a]
	Pre-emergent	56.1 [b]	1.0 [a]	16.7 [b]
	Post-emergent	37.2 [c]	1.7 [a]	24.3 [b,c]
	Pre- & Post	17.6 [d]	0.8 [a]	26.7 [c]
FD + AT		37.8 [a]	0.5 [a]	20.3 [a]
DD + 360 g a.i. ha^{-1} glyphosate		49.6 [b]	1.5 [a]	23.7 [a]
DD + 495 g a.i. ha^{-1} glyphosate		51.2 [b]	1.9 [a]	35.9 [a]
FD + 360 g a.i. ha^{-1} glyphosate		53.5 [b]	1.7 [a]	23.7 [a]
FD + 495 g a.i. ha^{-1} glyphosate		36.3 [a]	1.7 [a]	32.0 [a]
Triazine tolerant				
	Control	175.1 [a]	8.2 [a]	75.7 [a]
	Pre-emergent	58.3 [b]	2.3 [b]	45.6 [b]
	Post-emergent	195.0 [a]	9.8 [a]	93.9 [a]
	Pre- & Post	34.6 [c]	0.8 [c]	22.4 [c]
FD + AT		88.0 [a]	3.1 [a]	52.3 [a]
DD + 360 g a.i. ha^{-1} glyphosate		98.5 [a]	4.1 [a]	49.3 [a]
DD + 495 g a.i. ha^{-1} glyphosate		125.1 [a]	4.1 [a]	57.6 [a]
FD + 360 g a.i. ha^{-1} glyphosate		74.3 [a]	4.2 [a]	46.6 [a]
FD + 495 g a.i. ha^{-1} glyphosate		79.1 [a]	4.4 [a]	55.4 [a]

Means within each canola system and year with the same superscript are not significantly different at the 5% level as determined by Fisher's protected LSD test on transformed data.

There were no carryover effects of cultivation or glyphosate rate on annual ryegrass populations (Table 5) with the exception that the autumn tickle plus full soil disturbance at sowing reduced ryegrass number in the CC and RR plots of wheat in Year 2.

In terms of selective herbicide effects ryegrass was more plentiful in the post emergent treatments in both wheat years in CC and least plentiful in the pre + post-emergent plots. In TT plots there was a lower population of ryegrass in the pre-emergent and the pre + post-emergent treatments whilst there was no consistent trend over years for RR except that the overall weed population was much lower than for the other canola systems.

In 2003, four canola systems were compared and differences in yield were recorded (Table 6). Both the imidazolinone (IT) and RR systems provided higher yields than the CC system across the Year 1 systems. TT canola yields were a further 15% lower except for the Year 1 RR plots where TT yields exceeded those of CC.

Table 6. Canola yields (t/ha) in Year 5 following wheat as affected by the initial canola weed management system of Year 1

	Prior canola weed management system		
Canola system	**Conventional**	**Roundup Ready®**	**Triazine tolerant**
Conventional	1.46	1.68	1.71
Imi tolerant	2.59	2.44	2.65
Roundup Ready	2.10	2.40	2.27
Triazine tolerant	1.01	1.89	1.63
s.e.d.	0.09	0.14	0.12

Annual ryegrass populations in Year 5 (Table 7) were at a low level in all plots although numbers were significantly higher in the CC after CC and the TT after TT plots. Any plots where RR was used had minimal levels of ryegrass.

Table 7. Annual ryegrass density (plants /m) in August 2003 (Year 4) within four canola systems imposed on the three canola weed management systems in Year 1 of the rotation.

	1999 canola weed management system		
2003 canola system	**Conventional**	**Roundup Ready ®**	**Triazine tolerant**
Conventional	32.1 ^{a}	3.3 ^{a,b}	8.4 ^{b}
Imidazolinone tolerant	1.7 ^{c}	1.7 ^{b,c}	1.1 ^{c}
Roundup Ready®	0.4 ^{c}	0.5 ^{c}	0.6 ^{c}
Triazine tolerant	5.9 ^{b}	7.1 ^{a}	36.0 ^{a}

Means within each column with the same superscript are not significantly different at the 5% level as determined by Fischer's protected lsd test on transformed data

Gross margin analysis for Year 1 showed clearly that failure to use selective herbicides with any canola system resulted in economic loss due to the competitive effect of weeds preventing high yields (Table 8). In Year 1, average oil content of harvested grain was 44.0%, 45.5% and 42.9% for conventional, Roundup Ready® and triazine tolerant varieties respectively.

The use of a pre-emergent herbicide only yielded similar gross margins for both CC and RR canola where trifluralin was used. Use of triazine herbicides enhanced the gross margin in the comparable triazine tolerant treatment. Use of glyphosate as a post-emergent selective herbicide within the RR system provided consistently high gross margins (Table 8).

Table 8. Annual gross margins per hectare in Year 1 for different selective herbicide treatments imposed over three canola weed management systems.

Treatment	Canola variety		
	Conventional	Triazine tolerant	Roundup Ready®
No herbicide	-$111	-$179	-$174
Pre-emergent herbicide only	$65	$323	$65
Post-emergent herbicide only	$175	-$53	$423
Pre- and post-emergent herbicides	$252	$430	$461
Average (all treatments)	$95	$130	$194

Conventional canola produced a lower yield and gross margin than would be expected based on annual ryegrass control. This was due in part to Paterson's curse (*Echium plantagineum*) and capeweed (*Arctotheca calendula* L. Levyns.) being present on the site and the lack of effective weed control. These species were only suppressed by the post-emergent herbicides available for use in the conventional canola, whereas they were controlled by the herbicides used in both the triazine tolerant and Roundup Ready canola. After the full four year crop rotation, the disparity in gross margins between herbicide treatments in the first year had declined, but was still present (Table 9). The performance of glyphosate as a post emergent herbicide in the RR system was reflected positively in delivering the highest gross margins over the first 4 year cycle of the rotation.

Table 9. Average annual gross margins per hectare over a four-year rotation for different selective herbicide treatments imposed during the first year of canola.

Treatment	Canola weed management system		
	Conventional	Triazine tolerant	Roundup Ready
No herbicide	$206	$194	$219
Pre-emergent herbicide only	$248	$370	$311
Post-emergent herbicide only	$289	$271	$397
Pre- and post-emergent herbicides	$321	$420	$427
Average (all treatments)	$267	$314	$338

Discussion

The production of canola is dependant on the capability of farmers to provide effective weed control in order to achieve an economic yield. The availability of triazine tolerant varieties enabled the development of the canola industry in Western Australia because it facilitated the control of wild radish in that crop. Although yields were often inferior to conventional varieties, due to the genetic deficiency of the TT varieties, the overall benefit gained from the superior weed control both within the canola crop and the following crop rotation provided an overall significant benefit to the farmer.

The rapid adoption of TT canola by growers has, in the short to mid term, provided a significant advance in weed control and improved yields. The long term downside is the potential environmental impact due to the residual nature of the triazine herbicides applied for weed control in TT canola. Roundup Ready canola provides another agronomic option for farmers and will likely replace the TT canola weed management systems because of its superior weed control, the genetically improved varieties within which the Roundup Ready technology will be provided and the overall improvement in the “bottom line” gross margin it is likely to deliver to farmers. In addition, due to the environmentally friendly profile of the herbicide glyphosate applied to Roundup Ready canola, its application will not attract the same long term environmental issues that face TT canola.

Canola production is also under challenge from annual ryegrass, particularly because of its ability to evolve resistance to herbicides used for its control. The Group A chemicals in particular are now extensively compromised by this resistance and this has a significant impact on canola production which depends heavily on the Group A options. The availability of glyphosate as a post-emergent herbicide in Roundup Ready varieties provides new options for resistant weed control.

The Roundup Ready system provides a new significant option for farmers for control of both broadleaf and grass weeds by an alternate mode of action to other selective herbicides. Of course, glyphosate is a fundamental part of the conservation farming system that operates in Australia and thus its potential new use as a post-emergent selective herbicide will need to be well managed to preserve its effectiveness for its traditional role.

This project considered GM Roundup Ready canola in comparison with current weed control management system options in canola using annual ryegrass as the target weed for control as it is the major grass weed competitor in Australia’s cropping systems. The experiment demonstrated that the Roundup Ready GM canola weed management system option was at least as productive as, and was generally more productive than, the current canola weed management options. The control of ryegrass was more effective with glyphosate when applied in a Roundup Ready canola system and the effects, both agronomic (i.e. improved weed control) and economic, carried over into later seasons of the crop rotation. In addition to the control of annual ryegrass,l the superior control of broadleaf weeds seemed also to contribute significantly to improved yields. Using real costs and product prices for the years in question, the Roundup Ready GM canola was superior in gross margins, due to cost savings, better weed control and improved product quality.

There has been concern expressed about the threat of volunteers in the next crop and concerns about eradication difficulties. Within the trial, the alternative herbicide Spray.Seed (paraquat/diquat mix) was used as a knockdown in Years 2 and 3. In each year total control of volunteers was achieved without difficulty.

The research undertaken clearly demonstrated that a Roundup Ready GM canola weed management system, when compared to current conventional weed management system options:

- delivered better control of both annual grass and broadleaf weeds;
- produced positive carryover effects into other parts of the rotation;
- provided a better financial outcome;
- delivered improved product quality; and
- readily achieved control of canola volunteers.

In the view of the authors there is much to be gained by the Australian grains industry in general and by canola growers specifically by allowing the commercial production of GM canola, in particular Roundup Ready canola.

For state governments to continue the current moratoriums and to not allow the introduction of GM canola will significantly disadvantage canola growers and make it increasingly difficult for them to capture the efficiency and economic benefits of technology that their competitors in Canada have been capturing and exploiting for more than ten years.

Perhaps of more significance is that if the current moratoriums on growing GM canola are allowed to continue it will deny canola growers the opportunity to address the two major threats to the sustainable future of the Australian canola industry that being:

- the evolution of herbicide resistance and the resulting loss of current weed management system options, and

- the environmental challenge of current weed management systems in canola based on the use and application of triazine herbicides.

In summary, the authors recommend, based on the outcomes of the research reported in this submission, that the State Government repeal the current legislation that empowers the current moratorium on the growing of GM canola. This be undertaken as a matter of priority, given the current threats to the sustainability of growing canola and the potential benefits to the Australian canola industry of adopting GM canola.