THE AGRONOMIC, ENVIRONMENTAL, ECONOMIC AND CO-EXISTENCE IMPACTS OF GM CANOLA

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TAKE HOME MESSAGES

- There are substantial benefits from GM herbicide tolerant canola when compared with alternate non-GM weed control systems. These include more effective weed control, reduced pesticide use, reduced use of cultivation, improved yields, reduced risk of herbicide resistance and a reduction in the environmental 'footprint'.
- The economic impacts of GM canola have been variable due to the initial lack of access to GM canola varieties, the cost of access to GM technology and grain marketing/logistic issues.
- Concerns relating to co-existence failed to materialise with the majority of GM canola respondents and non-GM canola growers reporting no impacts on their farming operations. The issue of co-existence has not influenced farmers' choice in opting to grow GM canola or to increase the area of GM canola grown.
- The major barrier to adoption of GM canola is the perceived lack of economic value derived from GM canola compared with the alternate non-GM weed control management system options.

KEY WORDS

Agronomic impact, canola, Clearfield® canola, co-existence, conventional canola, economic impact, environmental foot print, genetic modification, genetically modified canola, GM canola, herbicide resistance, InVigor® canola, non-GM canola, Roundup Ready® canola, triazine tolerant canola, weed control systems.

BACKGROUND

Australia has experienced almost two decades of genetically modified (GM) cotton production since the introduction of the first single Bt gene INGARD® varieties in 1995. GM cotton now accounts for over 95 per cent (%) of all cotton grown. The rapid adoption of GM cotton has been due to the farmer benefits including improved productivity and economic return, along with a greatly reduced environmental footprint for the industry.

Australian grain growers were the first to broadly adopt herbicide tolerant weed control systems in canola. Farmer adoption followed the release of canola varieties with tolerance to the triazine herbicides in 1993. By 2010 it was estimated that approximately 80-85% of Australia's canola crop was triazine tolerant (TT) canola.

The rapid adoption of TT canola came about in response to the agronomic and economic benefits derived from the reduced need for cultivation, more effective control of a broad range of grass and broadleaf weeds and increased management flexibility. This continued, despite a number of management challenges, including lower yield and oil content potential associated with TT canola and the use of triazine herbicides (a soil active residual herbicide which has a higher risk of soil and groundwater contamination).

In 2003 an alternate herbicide tolerant weed control management system with conventionally bred tolerance to the imidazolinone (imi) group of herbicides (Clearfield® canola) was released.

The imi-tolerant weed control system and hybrid technology delivered both an alternate weed control system and improvements in yield and oil content. However, its adoption was limited due to the presence of group B herbicide resistance in a range of weeds within the canola growing regions of Australia.

In 2004, the GM herbicide-tolerant Roundup Ready® and InVigor® varieties gained approval from the federal regulator, the Office of Gene Technology Regulator (OGTR), on human health, safety and environmental grounds. Even so, the first commercial plantings of canola did not occur until 2008. The delay in commercial release of GM canola was a result of moratoriums on growing GM canola being imposed by State Governments on the grounds of perceived uncertainties over the co-existence and management of GM and non-GM crops through the supply chain, and the potential economic impact through loss of market access and/or premiums for non-GM canola. In 2008, these moratoriums were lifted in New South Wales (NSW) and Victoria, followed by Western Australia in 2010. Moratoriums still exist in the canola growing states of South Australia and Tasmania.

AIM

A study was commissioned in 2008 by the Birchip Cropping Group (BCG) and Grains Research and Development Corporation (GRDC) to assess the impacts of the first GM canola available to farmers in NSW and Victoria.

The purpose of this study was to assess at farm level the impact of GM herbicide tolerant canola on farming operations that may or may not include non-GM canola. Adoption patterns were tracked over a three year period (2008-2010) looking at the agronomic, economic and environmental impacts and attitudinal changes in relation to the concerns relating to the co-existence of GM and non-GM canola production systems.

METHODOLOGY

An annual telephone survey of canola growers in NSW and Victoria was conducted using open, closed and partially closed questions to elicit both quantitative and qualitative information from survey participants.

The quantitative component of the study focused on identifying the on-farm impacts and differences between GM canola and non-GM canola weed control programs. The qualitative component of the

study focused on the attitudes, perceptions and behaviour of both GM and non-GM canola growers to utilising GM canola in their crop rotations. The study also tracked attitudes to adoption and issues relating to the co-existence of GM and non-GM production systems.

The survey involved a series of attitudinal benchmark questions over the three canola growing seasons. Where a quantification of farmer attitudes was required, a sliding scale (0-10) was applied to record respondent opinions. Where appropriate, survey participants' additional comments were recorded and collated.

Survey participants were canola farmers from across the major grain growing regions of NSW and Victoria. (Table 1)

Table 1: Distribution of survey participants 2008, 2009 and 2010.

2008 survey participants	NSW	Victoria	Total	(%)
Non-GM canola farmers	198	103	301	78.5
GM canola farmers	40	42	82	21.5
Total canola farmers	**238**	**145**	**383**	**100**
2009 survey participants	**NSW**	**Victoria**	**Total**	**(%)**
Non-GM canola farmers	175	102	277	61.5
GM canola farmers	50	124	174	38.5
Total canola farmers	**225**	**226**	**451**	**100**
2010 survey participants	**NSW**	**Victoria**	**Total**	**(%)**
Non-GM canola farmers	211	179	390	76.2
GM canola farmers	33	89	122	23.8
Total canola farmers	**244**	**268**	**512**	**100**

RESULTS AND INTERPRETATION

The findings from the study demonstrate that the adoption of Roundup Ready® canola in NSW and Victoria has generated a range of agronomic, environmental and economic impacts when compared with non-GM canola weed management systems, two of which are herbicide tolerant variety based systems (triazine tolerant canola and Clearfield® canola developed through the use of mutagenesis), with the third system conventional pesticide use in conventional canola.

The study demonstrated that the major farmer based benefits from growing Roundup Ready® canola were to be gained in using it as a replacement for TT canola which, during the period of the study, represented the majority (65-75%) of the total area planted to canola. The study demonstrated that when compared with TT canola, respondents growing Roundup Ready® canola identified the following benefits:

- more effective control of grass and broadleaf weeds, in particular, control of herbicide tolerant annual ryegrass (*Lolium rigidum*)
- a reduction in the number of weed control programs required to achieve effective weed control (average of 61 programs in TT canola versus 12 programs in GM canola)
- reduced use of pre-emergent soil residual herbicides (area treated 26% lower)
- reduced use of the high risk group A herbicides (down 86%) and moderate risk group C herbicides (down 100%) delaying the development of herbicide resistance in grass and broadleaf weeds

- replacement in the use of atrazine and simazine herbicides including active ingredients applied (-54%); pre-emergent soil residual herbicides (-44.6%) and post-emergent soil residual herbicides (-97.9%)
- reduced (-48%) reliance on and use of glyphosate for knockdown weed control prior to crop establishment (despite an increase in use of glyphosate for post-emergent weed control)
- enhanced adoption of conservation tillage practices:
    - reduction (-29%) in the use of cultivation for weed control
    - increase (+39%) in the use of low soil impact cultivation equipment for weed control
    - increase (+5%) use of direct drilling equipment for crop establishment
    - reduction in the consumption of diesel fuel (down 16%) and emission of compounds such as carbon dioxide, carbon monoxide and oxides of nitrogen
- increased flexibility in crop management, especially relating to 'time of sowing' and 'weed control' operations (nominated by the majority (51%) of respondents)
- lower environmental foot print (using the Environmental Impact Quotient (EIQ/ha)
    - reduced the pre-emergent herbicide environmental foot print by 56%;
    - reduced the post-emergent herbicide environmental foot print by 49%; and
    - reduced the cumulative weed control program environmental foot print by 60%.

While these benefits were demonstrated when comparing Roundup Ready® canola with TT canola, they were not necessarily of the same magnitude or present when compared with the alternate non-GM canola weed control management systems (i.e. conventional canola and Clearfield® canola).

Roundup Ready® canola, when compared with conventional canola and Clearfield® canola, delivered reductions in the:

- number of weed control programs required to achieve effective weed control
- range and use of tank mixtures for achieving effective weed control
- use of herbicides high risk (group A and group B) and moderate risk (group D and group I) to the development of herbicide resistance in grass and broadleaf weeds
- frequency of cultivation and the use of high soil impact cultivation equipment.

Following the release of GM canola, respondents identified a number of issues as barriers to the initial adoption or expanded use of GM canola. The major barriers identified included the lack of:

- access to GM canola varieties with a range of maturity types adapted for growing across the geographically large and climatically diverse states of Victoria and New South Wales
- geographic access to the Roundup Ready® canola technology
- flexibility in the Roundup Ready® canola system (e.g. use of tank mixtures).

By 2010, the majority of these barriers had been addressed and resolved. However, during the study, a range of additional 'post farm gate' issues emerged which, until the end of the study in 2010, continued to act as major barriers to the adoption and/or expansion of GM canola.

In order of importance these barriers included:

- cost of access to the 'Roundup Ready® canola technology package' (i.e. technology fee + planting seed cost + herbicide cost)
- lack of access to grain delivery sites for GM canola resulting in higher freight costs and reduced flexibility in marketing options
- the differential in 'farm gate' prices offered by grain marketers for GM grain and non-GM canola grain (-$10 - $15/t).

During the study period, the average variable cost of weed control in Roundup Ready® canola was consistently higher than that of the non-GM canola weed control management systems.

Canola type	Average variable cost* (AUD$/ha) of weed control	Range (AUD$/ha)
GM canola	58.08	37.70 - 75.76
Imidazolinone tolerant canola	46.16	9.81 – 93.06
Triazine tolerant canola	38.70	9.25 – 93.06
Conventional canola	25.12	7.62 – 44.45

* Includes the cost of herbicides applied, the cost of herbicide application and for GM canola the GM canola Technology Access Fee.

When compared with the alternate non-GM canola weed control management systems, the difference in the variable cost of weed control in Roundup Ready® canola during the study was due to the:

- imposition by Monsanto of a Technology Access Fee for the Roundup Ready® canola herbicide tolerant technology which is not applicable to alternate non-GM weed control management systems (and also affected by higher yields due to the end point royalty component)
- increased use of the pre-emergent herbicide trifluralin for complementary control of herbicide resistant annual ryegrass
- increased use of multiple applications of glyphosate for in-crop post-emergent weed control, from 16.1% in 2008 to 50.0% in 2010.

The research also confirmed that government, industry and grower concerns relating to the co-existence of GM and non-GM canola crops at the 'farm gate' prior to its introduction have failed to materialise. The majority of respondents growing GM canola (84-91%) during the study did not receive any complaints from neighbours with paddocks adjacent to their farm, nor from farmers within or without the district (i.e. farmers and general public). During the same period, the majority (93-95%) of non-GM canola respondents who were aware of a GM canola crop being either grown by a neighbour or by other farmers in the district indicated that the GM canola crops did not have an impact on their farming/business operation.

Of the complaints received by GM canola respondents, these primarily related to:

- people's predisposing beliefs (i.e. they did not support the growing of GM canola)
- concern about the impact on non-GM products (e.g. canola, honey, dairy)
- the development of weed resistance to glyphosate.

Thus, the issue of co-existence has not been a major factor influencing grower behaviour in terms of farmers living amicably with their neighbours or within the broader farming community. Nor has the issue of co-existence influenced farmers' choices in opting to grow, or not to grow, GM canola or whether to increase the area of GM canola grown. The area of GM canola is forecast to increase by both GM and non-GM canola growers.

COMMERCIAL PRACTICE

In summary, this study provided the opportunity to document the quantitative (agronomic, economic and environmental) and qualitative impacts of GM technology for canola growers and related on-farm co-existence implications across the first three years of farmers growing GM canola. The analysis shows that there have been substantial agronomic and environmental benefits at the farm level, while economic outcomes have been variable due to:

- the lack of access to GM canola varieties with a range of maturity types adapted for growing across the geographically large and climatically diverse states of Victoria and New South Wales;
- the cost of technology access;
- marketing/logistical issues.

Over the three year period, when compared to TT canola which dominates the area planted to canola in Victoria and New South Wales, the introduction of GM herbicide tolerant canola technology has resulted in more effective weed control, reduced pesticide use, reduced use of cultivation, improvement in yields, reduced risk of herbicide resistance development and a reduction in the environmental footprint associated with pesticide use.

The level of adoption of GM canola has been below stakeholder expectations when compared with the adoption after 10 years release of GM canola (95% market share) in Canada and GM cotton (98% market share) in Australia. The study suggests that neither the agronomic and environmental benefits of Roundup Ready® canola, nor the presence of co-existence issues at the farm gate are the major barriers to the broader adoption of GM canola.

Rather, the study would suggest that the major barrier to adoption is the perceived lack of economic value derived from the Roundup Ready® canola technology package (the cost of access + the cost of weed control + yield + farm gate grain price + logistics costs) when compared to the established economic value of the alternate non-GM weed control management system options.

Despite this, the overall sentiment expressed by GM and non-GM growers participating in the study was positive and indicated that they would increase adoption of GM canola. The positive sentiment expressed possibly reflects respondents' recognition of the benefits of GM canola including: effective weed control, especially the increasingly prevalent weeds that have developed herbicide tolerance; the positive environmental and agronomic impacts; and the increased flexibility in management at critical times of the year.

In addition, it may reflect respondents' expectations that as adoption, and consequently production, of GM canola increases, current barriers such as the cost of access to the technology, marketing/logistical issues will be addressed.

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