

GM Canola: An Information Package

Prepared for the Department of Agriculture, Fisheries and Forestry by ACIL Tasman, with the assistance of Innovation Dynamics

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Australian Government

Department of Agriculture, Fisheries and Forestry

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Executive summary

Key points

- Canola is an important crop in Australian winter crop rotations.
- Canola has benefits for farming enterprises beyond the direct returns the crop generates, other crops in the rotation benefit from the weed control and disease management options canola provides.
- Weed resistance to conventional canola chemicals and diseases pressures is threatening canola's contribution to farming systems in Australia.
- Australia's main competitor, Canada, has been using genetically modified (GM) canola for 10 years with no appreciable loss of market share or price and enjoys significant agronomic benefits from the technology.
- Consumers do appear to be concerned about GM crops in general but these concerns do not appear to be translating into significant or sustained price increases being paid for non-GM canola products.
- Where there are economic advantages to be gained from producing non-GM canola, the Australian grain supply chain appears capable of separating GM canola from non-GM canola and other crops at a relatively low cost.
- GM canola offers some solutions to the current problems conventional canola faces in Australia and is likely to make an important contribution to farming systems, once farmers have access to the technology and adapt it to their individual business needs.
- GM is a plant breeding technology that can be applied to canola varieties and the technology should be considered as such. GM technology should not be confused with the agronomic performance of the particular canola variety it has been applied to.
- GM crops are one aspect of a dynamic global food and grain industry. An assessment of the impact of the commercial release of GM canola in Australia should not confuse general industry trends toward increased segregation and traceability with the impact of GM grains and canola in particular. In many instances GM grains represent a small contribution to the changes underway in the Australian grains industry.
- GM canola is not a panacea for the problems facing crop producers, processors and consumers. To be effective the technology needs to be used in conjunction with other industry innovations.
- It is important to ensure that GM technology is assessed on the merits or otherwise of this plant breeding technique and , in this context, it can be seen as part of wider industry changes.

Over the last 20 years canola has become an important crop in most grain growing regions of Australia. Since the first commercial planting of canola in Australia in 1969, the area sown has increased to an annual average of 1.0 million ha producing up to 2.4 million tonnes of seed.

Canola seed is grown to produce canola oil and canola meal. Canola oil is a useful vegetable oil used in a range of cooking and manufacturing applications. Canola meal is the dry matter left after the oil is extracted and is a valuable high protein livestock feed supplement. In a well managed crop rotation, canola provides important weed management options and disease breaks for cereal crops. Other advantages of canola in crop rotations are increased machinery efficiency, as it is generally sown and harvested at different times to cereals, and revenue diversification.

However, canola production is under pressure in Australia as weeds commonly found in canola become resistant to conventional management practices, and fungal disease and insect pests appear to be becoming more prevalent. Canola is also less drought tolerant than wheat and barley. All of these factors are contributing to canola becoming an increasingly risky crop in the rotation.

There are currently two GM canola traits that have been licensed for commercial release by the Gene Technology Regulator (GTR) as they have been assessed as not posing any risks to human health and safety or to the environment that cannot be managed. The two GM traits confer herbicide tolerance and have been bred into canola varieties to provide a wide range of agronomic characteristics suitable for a number of production situations.

The two GM canola varieties approved for commercial release in Australia are InVigor® and Roundup Ready®. InVigor® is a registered variety of GM canola owned by Bayer CropScience (previously known as Aventis CropScience Pty Ltd), which also owns the earlier developed variety known as LibertyLink®.

LibertyLink® confers resistance to the active ingredient in the Aventis herbicide Liberty, glufosinate-ammonium. The LibertyLink® modification was incorporated into the cultivar “Innovator”, the first genetically modified canola commercialised in Canada in 1994 by AgrEvo, Aventis’ predecessor. By 1997, three years after release, Canadian plantings of LibertyLink® had already reached 800,000 ha, representing some 20 percent of total plantings.

Monsanto’s GM canola is branded Roundup Ready®, and is tolerant to the active ingredient in Monsanto’s Roundup® herbicides, glyphosate (Monsanto Australia 2006). This genetic modification enables glyphosate to be sprayed on weeds that are growing in Roundup Ready® canola crops, to kill the weeds without destroying the canola. Roundup Ready® is the only canola variety that is tolerant to the herbicide glyphosate.

It is estimated that over 80 per cent of the canola grown in Canada is now GM.

The GM canola varieties currently licensed in Australia provide some relief to weed resistance by providing new weed management options. The next generation of canola varieties are likely to have increased disease resistance and may even have improved drought tolerance.

While the currently licensed GM canola varieties have been assessed as safe for human consumption and release into the environment, there appears to remain consumer resistance

to GM crops in general. However, at this stage, there is no evidence that consumer concerns have translated into a significant and sustained price difference between GM and non-GM canola.

In response to consumer concerns most of Australia's major agricultural trading partners have introduced limits on the amount of accidental mixing (adventitious presence (AP)) of GM crops with conventional crops. The European Union, an opportunistic market for Australian canola seed, is the only importer to have banned GM canola seed importation. However, in the face of increasing demand for industrial use of GM canola the European Union is now allowing certain GM canola varieties to be imported for industrial use.

In Australia there are a range of state and territory government moratoria on the commercial release of GM canola. These moratoria were introduced in part due to concerns about negative market impacts from the commercial release of GM crops, and potential negative spill overs to producers wishing to grow non-GM crops. Victoria and South Australia have recently announced reviews of the moratoria, which are due to lapse in 2008.

Most of this concern stems from a lack of confidence that the GM and non-GM crops can be segregated sufficiently through the entire supply chain to meet market specifications.

Numerous independent studies have shown that, if there is an economic incentive to segregate GM and non-GM canola, the Australian grain supply chain is capable of achieving current market specifications at low cost. In fact segregations within the tolerances specified by most international standards are routinely achieved and exceeded by the Australian grain supply chain for most other grain types.

The Australian grain industry is well placed to manage the introduction of GM canola and has done a considerable amount of planning through bodies such as the Gene Technology Grains Committee (GTGC) and the National Agricultural Commodity Marketing Association (NACMA). These bodies are voluntary industry associations which have developed common terms, management protocols and standards for GM crops.

Where the supply chain fails, those economically disadvantaged have the opportunity to seek redress from those responsible through informal mechanisms and dispute resolution services currently offered by NACMA. When these options fail to resolve the dispute, common law remedies appear capable of providing recourse as they do for all other grain industry issues.

Therefore as the state and territory moratoria come up for review, growers should consider how GM technology could be used in their own production system based on the merits of the technology separate from the broader agronomic performance of the canola varieties to which it is applied.

GM crops are one aspect of a dynamic global food and grain industry. An assessment of the impact of the commercial release of GM canola in Australia should not confuse general industry trends toward increased segregation and traceability with the impact of GM grains and canola in particular. In many instances GM grains represent a small contribution to the changes underway in the Australian grains industry.

1 Introduction

This report has been commissioned by the Department of Agriculture, Fisheries and Forestry to collate and analyse the most recent information on genetically modified (GM) canola. The purpose of this report is to present a comprehensive synthesis of the plethora of information on GM canola that is currently available. The report will be a valuable resource for all of those involved in the debate about commercialisation of the technology.

The report presents some of the principles of the main arguments for and against the commercial release of GM canola and investigates what the best available published information says on the subject. In addition, views were collected through consultation with a range of stakeholders including those with an interest in the production, marketing, processing and consumption of GM canola in Australia.

The development of GM canola and other crops comes at a time of considerable change in the Australian and global grains industry. There is increasing concentration in farm input supplies; environmental pressures on farmers are building; some claim the position of the family farm as the dominant agricultural economic unit is under threat; there is considerable uncertainty as to the effects of climate change on agriculture; and agricultural markets appear to some to be becoming more globalised.

Disentangling information on GM canola from the broader commentary on the main issues facing agriculture has been an important challenge for the authors of this paper. For example, contracts and user agreements between the farmers and the technology owner are likely to be an important feature of the commercialisation of GM canola in Australia. This is seen by some as a threat to the continuation of the family farm and a loss of control by farmers. Yet, contracting is increasing in a number of industries and is completely independent of the type of technology used by either party in the transaction.

It is important to consider the question of the commercial release of GM canola on the merits of the technology, and in the context of the other issues facing agriculture. However, there are a range of other issues beyond GM that are affecting the sector. The eventual success or otherwise of canola in Australia depends on all these factors, not GM alone.

This report was prepared between June 2006 and July 2007, with the assistance of Innovation Dynamics.

1.1 Report structure

This report has nine chapters. The remainder of this chapter presents a snapshot of the current state of play with GM Canola in Australia. Chapter 2 presents background information on the production and market for canola seed, oils meals and its substitutes globally and in Australia. Chapter 3 explains some of the technical aspects of GM technology and its application in canola. Chapter 4 discusses the regulatory environment for canola in Australia and internationally in more detail. Chapter 5 considers issues associated with the market acceptance of GM products in Australia and internationally, from the perspective of consumers and other users. Chapter 6 considers the role of canola in the Australian cropping system and the likely impacts, including benefits and costs, of introducing GM canola in Australia for the nation's grain growers. Chapter 7 discusses issues pertaining to the growing of GM and non-GM canola and other grains. Chapter 8 considers the likely implications of the introduction of GM canola for other Australian agricultural and food products. Chapter 9 considers GM canola and legal liability issues.

1.2 GM Canola in Australia – a snapshot of the current state of play

Since 2001, the Office of the Gene Technology Regulator (OGTR) has had responsibility for licensing field trials and the commercial release of GM organisms. OGTR approval is only provided if the Regulator is satisfied that the trials or commercial release will not pose any risks to human health and safety or the environment that can not be managed.¹

In 2003, the Gene Technology Regulator (OGTR) gave approval for the commercial release of certain InVigor® and Roundup Ready® GM canola varieties. In respect of the InVigor® license the Regulator found that 'InVigor® canola as safe to humans and the environment as conventional (non-GM) canola' (OGTR 2003a). The Regulator, when announcing the license for the Roundup Ready® Canola stated that 'The comprehensive risk assessment has demonstrated to me that the commercial scale release of Roundup Ready, canola will not pose a risk to human health and safety or the environment' (OGTR 2003b).

As at 3 July 2007, licenses for the commercial release of GM food, feed and fibre crops have been only issued for various types of GM cotton and GM canola (Table 1).² However, licenses for experimental field trials have covered numerous other crops, as shown in Appendix A

Despite the OGTR's rigorous assessments many stakeholders remain concerned about the release of GM crop varieties, including canola (it should be noted that a discussion of concerns held by stakeholders in respect of canola forms an important part of this report). Largely as a result of stakeholder concerns, and before any commercial GM canola crops were planted, all States and Territories, with the exception of Queensland and the Northern Territory, put in place moratoria on the commercial release of GM food crops and in some states all GM crops. In some instances the sunset on the moratoria have been extended and at the time of writing all jurisdictions moratoria were (or were preparing to be) in place until 2008 (Table 2).

¹ A detailed discussion of the regulation of GM crops may be found in chapter 4.

Table 1 Summary of commercial approvals of GM crops by OGTR

Species	Trait	Owner	Approval date
Cotton	Insect resistant	Monsanto	26 October 2006
Cotton	Herbicide tolerant	Bayer Crop Science	8 August 2006
Cotton	Herbicide tolerant	Monsanto	16 February 2006
Cotton	Insect resistant/herbicide tolerant	Monsanto	26 October 2006
Cotton	Herbicide tolerant/insect resistant	Monsanto	26 October 2006
Cotton	Herbicide tolerant	Monsanto	20 June 2003
Cotton	Insect resistant	Monsanto	12 June 2003
Canola	Various herbicide tolerant and hybrid breeding systems	Bayer CropScience	25 July 2003
Canola	Herbicide tolerant	Monsanto	19 December 2003
Cotton	Insect resistant	Monsanto	23 September 2002

Data source: Office of the Gene Technology regulator www.ogtr.gov.au

Table 2 Gene technology moratoria legislation

State (scope)	Legislation title	Commencement	Sunset
ACT (food)	Gene Technology (GM Crop Moratorium) Act 2004	10 July 2004	No earlier than 17 June 2006 ^a
NSW (food)	Gene Technology (GM Crop Moratorium) Act 2003	25 June 2003	March 2006; then to March 2008
WA (all)	Genetically Modified Crops Free Areas Act 2003	21 December 2003	2008
SA (all incl trials)	Genetically Modified Crops Management Act 2004	29 April 2004	2007 ^b
Tasmania (all)	Genetically Modified Organisms Control Act 2004	16 November 2004	16 November 2009
Victoria (all)	Control of Genetically Modified Crops Act 2004	12 May 2004	2008 ^c

a. The Act expires on a date (not earlier than 17 June 2006) fixed by the Minister by written notice presented to the presented to the Legislative Assembly. At the time of writing the moratorium remained in place. b. HAL 2006 reports that the South Australian Minister for Agriculture stated that legislation to extend the moratoria to 2008 was in preparation. c. The Victorian moratorium on GM canola is expected to end on February 29, 2008 unless a new moratorium order is introduced following a review of the moratorium by an independent panel chaired by Prof. Sir Gustav Nossal (announced 22 May 2007).

Data source: Issues Paper No. 4, Review of the Gene Technology Act 2000, Department of Health and Ageing (2006), Tasmanian Department of Primary Industries, Water and Environment (2003) and www.thelaw.tas.gov.au, Agriculture and Food Policy Reference Group (2006) and HAL (2006), personal communication with ACT Government Department of Health representative. Victorian Department of the Premier and Cabinet (2007).

² OGTR Licenses have also been issued for the commercial release of GM carnations in 2001

The moratoria differ between jurisdictions - while some prohibit the commercial production of GM food crops, others prohibit the commercial production of all GM crops. However, some moratoria include provisions for limited and controlled trials of declared GM food crops for research purposes. GM cotton which was already in commercial production prior to the moratoria's introduction is unaffected by the moratorium in NSW.

In February 2006 the Agriculture and Food Policy Reference Group submitted its report to the Minister for Agriculture, Fisheries and Forestry. This report, amongst other things, recommended the lifting of state Government moratoria on the commercial use of GM crops. The report made the following recommendations in respect of GM crops:

In view of the potentially significant human health, environmental and economic benefits from using biotechnology in agriculture and food production, and the costs to Australians of failing to capture them:

- governments must give higher priority to communicating the benefits of current and emerging agrifood biotechnology, and to publicising the robustness of the regulatory regime for the safety of research and the resulting products;
- agriculture and food businesses should work with governments to facilitate the rapid uptake of agrifood biotechnologies that will contribute to better health, a cleaner environment and more globally competitive industries;
- state governments should lift their moratoriums on the commercial use of GM crops immediately, and work with the Australian Government, industry and researchers to achieve nationally consistent traceability and tolerance protocols, and to clarify legal liability issues surrounding the use of GM organisms in agriculture and food products (Agriculture and Food Policy Reference Group 2006, p. 101).

In May 2007, the Victorian Premier announced that an independent panel, chaired by Professor Sir Gustav Nossal would review Victoria's moratorium on the commercial planting of GM canola (Bracks, 2007). The Premier stated that:

The Government will use the recommendations to assist it in making a decision before the moratorium sunset date about whether or not to allow the commercialisation of GM canola (Bracks, 2007).

Following the Victorian announcement, New South Wales, South Australia and Tasmania have subsequently initiated reviews of their respective GM crop moratoria

2 What is canola?

This chapter presents information on the production and market for canola seed, oils and meals and its substitutes globally and in Australia.

2.1 Canola - a rapeseed cultivar

Canola was originally the trademark name of a Canadian rapeseed cultivar with special characteristics, which was developed using natural plant breeding methods. Rapeseed has been grown by humans for thousands of years and is one of the few edible oilseeds that can be cultivated in cool temperate climates (Gunstone 2004). Rapeseed is in the Brassica family and is therefore sometimes referred to as a brassica oilseed. In its agronomy Canola is closely related to the condiment mustards used for flavouring and for their medicinal properties (Gunstone 2004). It is less closely related to broccoli, cabbage and cauliflower (Johnson & Croissant 1992). Brassica crops may in fact be among the oldest cultivated plants known to man (Sovero 1993):

‘In India, *B. rapa* is mentioned in ancient Sanskrit literature from ca. 1500 BC and seed of *B. juncea* have been found in archaeological sites dating back to ca. 2300 BC (Prakash 1980). Rapeseed production has a long history in China. The Chinese word for rapeseed was first recorded ca. 2500 years ago, and the oldest archaeological discoveries may date back as far as to ca. 5000 BC...’

The main difference between traditional rapeseed and canola is that traditional rapeseed varieties are high in erucic acid (up to 55 per cent by volume) and in sharp-tasting compounds known as glucosinolates. The oil derived from traditional varieties has a pungency that became sought after within some regional cuisines, e.g., in Bengal (India and Bangladesh). But this flavour, as well as the colouring of traditional rapeseed oil, proved to be of limited appeal to European and North American tastes. Similarly, the meal obtained from the traditional cultivars had certain undesirable properties, described by Sovero (1993) as follows:

“In traditional rapeseed cultivars the seed solids contained over 100 µmol/g of glucosinolates. The hydrolysis products of glucosinolates give cruciferous vegetables their characteristic flavor and mustard its [sic] pungency. Some of these hydrolysis products, however, are toxic or at least anti-nutritional. Also, many of the glucosinolate derivatives decrease the palatability of the meal and, consequently, the voluntary uptake of the feed by animals. For these reasons, the use of conventional rapeseed meal was limited mainly to cattle supplementary protein formulas and had relatively low value.”

In order to improve the flavour and palatability, and therefore acceptability of rapeseed products both for human and animal consumption, it was important to improve on traditional varieties by producing a cultivar low in erucic acid as well as in glucosinolates. This was first achieved in Canada in the 1970s through traditional breeding and cultivars that exhibited these traits became known as ‘double-low’ or ‘double-zero’ varieties. The Western Canadian Oilseed Crushers Association originally registered the trademarked name canola, but this trademark was later transferred to the Canola Council of Canada. As mentioned above, the use of the term canola for rapeseed cultivars that are of “canola quality” has since then become standard industry practice. Canola quality varieties have an erucic acid content of less than 2 per cent and also have less than 30 micromoles of glucosinolates per gram of seed (see, for example, the Canola Council website for full details on the definition of canola characteristics).

Canola plants grow 2 to 4 feet tall with branching from the central stem. Canola's yellow flowers have four petals. Seed pods are 1 to 1.5 inches long and approximately 1/8 inch wide. From these pods, the oil-bearing seeds – similar to mustard seeds in appearance – are harvested and the vegetable oil is extracted either mechanically or using solvent (see, for example, Chapter 2 in Gunstone 2004); the 'leftovers' are referred to as rapeseed or canola meal, i.e., an 'oil meal' which is high in protein, and this is routinely fed to animals as a component of livestock feed (see, for example, Chapter 9 in Weiss 2000).

2.2 Canola in Australia ³

Rapeseed was first trialled in Australia in the early 1960s and was first grown commercially in 1969, following the introduction of wheat delivery quotas. However, but it took over twenty years until canola really became a significant Australian crop.

The slow emergence of the crop was due to a variety of reasons, including the absence of prior on-farm experience with the crop, and problems with blackleg fungal disease. The early varieties were of relatively low quality by today's standards. Furthermore, the early varieties were all of Canadian origin, and had not been bred for Australian conditions.

The need to develop improved Australian varieties quickly became obvious, particularly due to the Blackleg outbreak in the 1970s. The first Australian varieties were the low erucic acid, blackleg resistant varieties from Western Australia, Wesreo (1978) and Wesway (1979). The first 'canola quality' *B. napus* varieties to be released were Wesroona (Western Australia, 1980) and Marnoo (Victoria, 1980). Marnoo was popular, particularly in Victoria; however, its limited blackleg resistance was a handicap in New South Wales. As such, New South Wales growers had been mainly growing Span at the time they quickly adopted Jumbuck (also *B. rapa* variety, released in 1982) because of its better yield, quality and disease resistance.

In 1987, the first really high quality canola varieties became available (Maluka and Shiralee). These combined canola quality with blackleg resistance and high yields. Another significant development was the release of the first hybrid canola in 1988 (Hyola 30).

The availability of much better varieties and crop agronomy packages, and good prices through the 1990s, made the crop increasingly attractive to growers and led to rapid expansion in the acreage planted to the crop. As a result the area sown to canola in Australia rose from 0.1 million hectares in the early 1990s to 1.3 million hectares 2000-01. Production increased from around 0.1 million tonnes to a peak of 2.4 million tonnes in 2000-01.

The area planted in recent years has appeared to stabilise at around 1.0 million hectares in Australia. The Grains Research and Development Corporation (GRDC) has noted that:

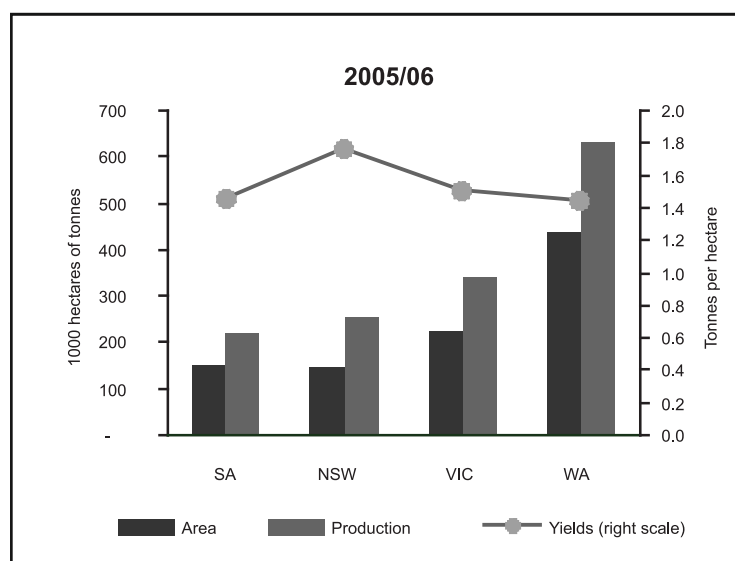
'[T]he area in southern Australia sown to canola has declined substantially and many growers are missing the rotation benefits it can provide. In 2006 it will be a priority of the GRDC to identify the causes behind canola not achieving its potential, and retain canola as a break crop for Australian growers... The commercial release of *B. juncea*, which is anticipated for 2007, will be an important step in addressing the general decline of canola in southern Australian grain production.' (GRDC Crop Doctor online report, 24 March 2006).

³ This section draws heavily on Colton and Potter's chapter in Salisbury et al. (1999).

The distribution of plantings and crop volumes for the 2005-06 year shows that the total area planted to canola and the total output produced was highest in Western Australia. At the same time, Western Australia has the lowest yields of all states (see Figure 1).

The Australian Bureau of Agricultural and Resource Economics (ABARE) forecasts reported in its October 2006 drought update indicate that canola production in 2006-07 will be down by around 69 per cent on the previous year (see Table 4). These forecasts represent a significant reduction on those reported by ABARE in its June and September crop reports (ABARE 2006). The October 2006 Australian Oilseed Federation (AOF) crop report also revised down previous 2006-07 state-wide canola production forecasts by almost 30 per cent. The AOF predicts that the east coast will see a shortfall of canola for its domestic market (except for some tonnage from WA).

Figure 1 Australian canola production by state, 2005-06



Data source: ABARE crop report Feb 06 & ABARE crop and livestock report Oct 2006

Table 3 ABARE canola production estimates and forecasts (October 2006)

	1994-95	2002-03	2005-06 ^a	Forecast 2006-07
	kt	kt	kt	kt
Australia	264	871	1441	440
New South Wales	73	184	254	20
Victoria	57	177	338	90
Queensland	0	0	0	0
Western Australia	108	299	630	260
South Australia	26	210	218	70

^a Preliminary estimate.

Note: Total includes Tasmania – there is no total

Data source: ABARE 2006b

2.3 Global oilseed and vegetable oil production and trade

Canola is one of several oilseeds that compete in international markets. Canola products, the oil and the meal, also compete against other oils and meals, including those from certain vegetables. Significant competing oilseeds include soybeans, cottonseed, peanuts and sunflower seed. Soybeans are low in oil and therefore are a significant source of meal, and soybean meal has proved particularly useful in some animal feed rations.

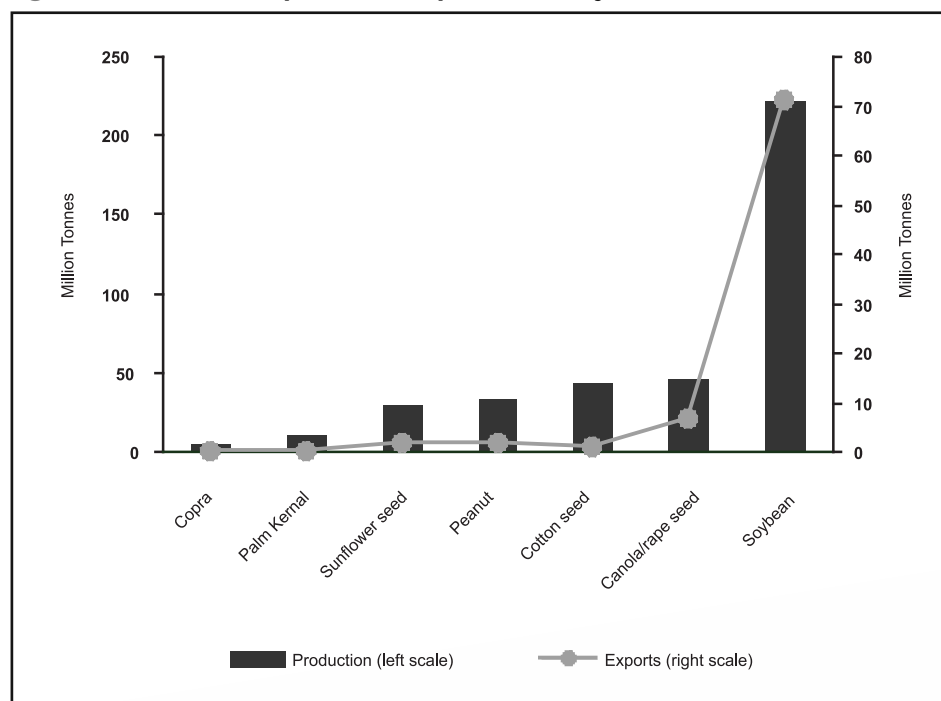
Another important world market competitor that needs to be noted is palm oil. This competes in certain end uses with canola oil. Palm oil supplies are very different from the annual oilseeds in that they are driven by the economics of large oil palm plantations mainly in Malaysia and Indonesia, which can offer year round supply.

2.3.1 World oilseeds production and trade

Canola, as well as canola oil and meal are traded in significant volumes as undifferentiated commodities in global markets.

Figure 2 puts world canola production and trade into context. Canola is ranked second amongst the major oilseeds in terms of total output (48.55 million tonnes or about 13 per cent of total oilseed production in 2005/06) and export volumes (about 7.08 million tonnes in 2005/06). It is behind soy, which dominates the global production picture at output levels above 220 million tonnes.

Figure 2 World output and exports of major oilseeds in 2005-06



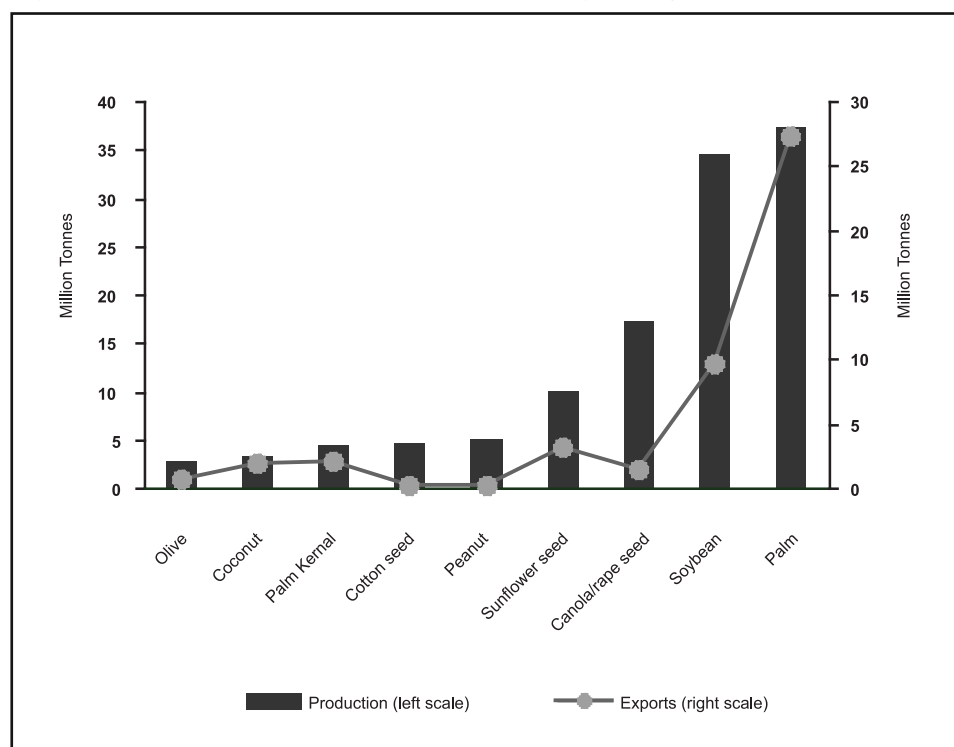
Data source: USDA FAS World Markets and Trade, June 2006

A global canola harvest of some 46.4 million tonnes is forecast for 2006-07. Of this, it is anticipated that approximately 6.97 million tonnes will be exported for crushing in other countries (USDA FAS World Markets and Trade forecasts). The lower forecast in canola production for 2006-07 is attributed to lower canola production in Canada (ABARE Australian Commodities June 2006). In 2005-06, the United States was the largest producer and exporter of oil seeds worldwide (95.5 million tonnes and 26.83 million tonnes respectively). The other significant oilseed producing and exporting country in the southern hemisphere is Brazil, which exports large volumes of soybeans (USDA FAS World Markets and Trade forecasts).

2.3.2 World vegetable oil production and export

Canola has a much higher oil content than soybeans (roughly 42 per cent vis-à-vis 19 per cent) and, as a consequence, crushing a ton of canola produces over twice as much vegetable oil than crushing a tonne of soybeans. Nevertheless, in aggregate, compared to canola oil, more than twice as much soybean oil is produced globally (see Figure 3).

Figure 3 World output and exports of major vegetable oils in 2005-06



Data source: USDA FAS World Markets and Trade, June 2006.

Palm oil is the major global source of output as well as trade in the edible oils.⁴ Canola oil is in third place behind soybean oil and palm oil in terms of production, and in fourth place behind sunflower oil in terms of exports (see Figure 3). These oils are canola's major global competitors.

⁴ Note that palm oil differs from palm kernel oil (palm kernel output was included in Figure 2). Palm oil is obtained from the flesh of the oil palm fruit. The kernels contained in the fruit are processed separately.

⁵ See Canola Council of Canada website, <http://www.canola-council.org/portal.html>

2.4 World canola/rapeseed production and trade

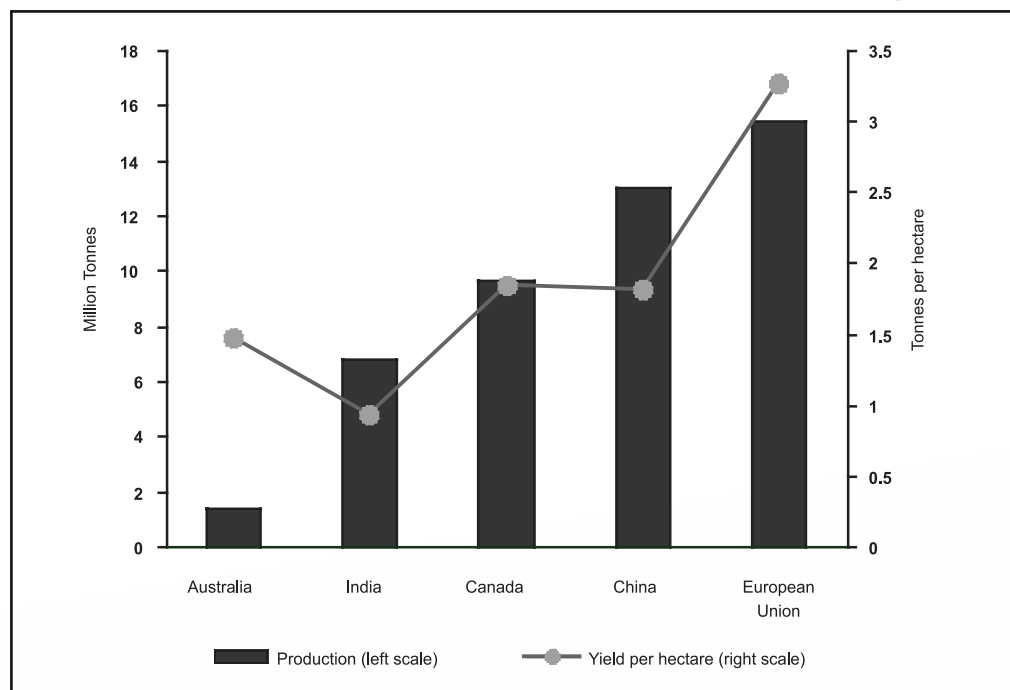
Europe is the global leader in the production of canola (see Figure 4). Despite this, the European Union remains a major importer of canola. China, which is also a large producer, is another net importer and Australia has sold successfully into both markets. Whilst there is also a general shortfall of production in India, domestic markets are protected in that country, via the imposition of tariffs on imported canola and canola oil. Canada is the third largest producer of canola. The majority (about 80 per cent) of Canada's canola production is GM.⁵

Australia produced an estimated 1.4 million tonnes of canola in 2005-06 (Figure 4). As a result of the drought, production is expected to reduce to about 0.8 million tonnes (or less) in 2006-07. Before the drought the forecast production for 2006-07 was about 1.25 million tonnes.

On average, Australian canola yields stood at just below 1.5 tonnes per hectare in 2005-06. This is quite high when compared with the preceding five years, during which yields came on average to just over 1.1 tonnes of canola per hectare planted (whilst Australian output over that period averaged 1.5 million tonnes).

Figure 4 also illustrates that Australian yields are not particularly high by international standards. In terms of the major international producers, Australian canola yields were on average higher only than those seen in India. Output and yields were highest in Europe where an estimated 15.4 million tonnes of canola were produced in 2005-06 at an average yield per hectare of 3.0 tonnes. The difference in yield between Australia and other countries is largely due to the planting of canola in lower rainfall zones and more marginal land types in Australia. Some areas of Australia, particularly high rainfall zones produce similar yields to those in Europe and Canada.

Figure 4 Canola/rapeseed production and yields, by country (2005-06)



Data source: USDA FAS World Markets and Trade, June 2006

While Australia is still a relatively small producer of canola by international standards, Australia is a significant player in export of canola seed, with Australia's exports historically accounting for between 12 and 26 per cent of canola seed export trade (see Table 6).

Canada is Australia's major competitor in terms of global canola markets. In 2005-06, Canada's canola seed exports increased in volume terms and its share of world exports increased to 77 per cent. Canada also dominates the canola oil export market. In 2005-06, Canada exported 1.09 million tonnes of canola oil, which equates to around 65 per cent of total world canola oil exports (see Table 6).

The European Union import market for canola is expected to rise from around 70 kt in 2002-03 to 800 kt in 2006-07 (see Table 4).

Table 4 European Union (25 jurisdictions) canola imports

Year	2002-03	2003-04	2004-05	2005-06	2006-07 (estimate)
(000's Mts)	70	220	120	500	800

Note: Figures exclude European Union intra trade.

Data source: Oil World Flash July 7, 2006 page 2

Table 5 International trade in canola seed and oil

	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
	Mt	Mt	Mt	Mt	Mt	Mt	Mt	Mt
Seed imports								
China	2.20	3.68	2.36	0.78	0.05	0.42	0.32	0.70
European Union ^a	0.96	0.09	0.54	0.20	0.06	0.17	0.11	0.45
Japan	2.17	2.23	2.18	2.08	2.11	2.28	2.23	2.35
Other importing countries	1.71	2.2	1.94	1.92	1.82	2.38	2.4	3.43
Total seed imports	7.04	8.20	7.02	4.98	4.04	5.25	5.06	6.93
Oil imports								
European Union	0.01	0.00	0.00	0.00	0.01	0.03	0.04	0.34
India	0.24	0.16	0.05	0.01	0.05	0.00	0.00	0.00
Other importing countries	1.37	1.58	1.18	1.1	0.85	1.32	1.13	1.17
Total oil imports	1.62	1.74	1.23	1.11	0.91	1.35	1.17	1.51
Seed exports								
Australia	1.32	1.89	1.48	1.30	0.61	1.05	1.02	0.88
Canada	3.88	3.90	4.84	2.67	2.42	3.76	3.49	5.43
Other exporting countries	1.64	2.42	0.89	0.96	1.1	0.71	0.58	0.77
Total seed exports	6.84	8.21	7.21	4.93	4.13	5.52	5.09	7.08
Oil exports								
Canada	0.76	0.78	0.74	0.54	0.54	0.82	0.84	1.09
European Union ^a	0.77	0.71	0.21	0.28	0.25	0.14	0.13	0.08
Other exporting countries	0.25	0.25	0.21	0.19	0.12	0.19	0.17	0.51
Total oil exports	1.78	1.74	1.16	1.01	0.91	1.15	1.14	1.68

^a Excludes intra-European Union trade

Note: Imports may not equal exports in any given period as a result of lags in shipping time.

Data source: ABARE 2006a, Australian Commodity Statistics 2006, Canberra

Due to the high meal content of soybeans, demand for soybeans is ultimately driven by the demand for meal. In this sense, canola and soy compete in different market segments – canola is driven by household and industrial demand for the high value oil, and soy is driven by demand from the livestock industry for its high value meal component.

2.4.1 Australian canola exports

Traditionally, Australia consumes about 500,000 tonnes of canola domestically, with the remainder of the crop being exported. Japan and Pakistan have been Australia's most important and consistent overseas markets to date. Prior to the 2002-03 drought, Australia was regularly exporting over 1 million tonnes of canola. However, exports decreased to 880,000 tonnes in 2005-06 (Table 6). There is a strong chance that Australia could become a regular importer of canola seed and meal given the recent run of dry seasons and anticipated increases in demand, particularly for meal.

Table 6 Australia's exports of canola seed and canola oil by destination

	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
	kt	kt	kt	kt	kt	kt	kt	kt
Canola seed								
Bangladesh	126.33	99.36	148.22	151.75	70.12	100.57	67.95	41.30
China	393.79	1,212.02	294.81	335.77	50.08	2.19	39.62	0.00
Japan	293.19	369.96	375.94	395.43	444.40	545.84	495.23	370.27
Pakistan	42.83	56.21	224.32	306.66	38.50	284.28	387.24	97.46
Other	463.69	155.06	435.82	113.48	9.20	115.90	28.53	375.24
Total	1 319.83	1,892.61	1,479.11	1,303.09	612.30	1,048.78	1,018.56	884.27
Canola oil								
China	4.50	0.00	0.00	5.03	5.30	12.58	0.26	0.29
Japan	0.04	5.18	13.84	9.66	10.00	10.02	18.42	9.34
New Zealand	5.21	10.26	9.67	14.51	13.11	12.29	14.19	15.73
Other	46.43	23.56	4.54	2.11	2.96	12.02	14.33	9.07
Total	56.18	39.00	28.05	31.31	31.38	46.91	47.19	34.42

Data source: ABARE 2006a

2.5 GM canola production and trade

GM crops were first commercialised in the mid-1990s and the global area planted to these crops has been expanding rapidly. From a near-zero base in the mid-1990s, the total area planted to all GM crops – including GM soybeans, cotton and maize/corn – has quickly risen to an estimated 102 million hectares in 2006. The United States, Argentina, Brazil, Canada, India and China are primary adopters of GM crops and account for 95.6 per cent of all plantings; however at least 16 other countries have smaller plantings of GM crops (James, 2006). More importantly, it should be noted that:

With the exception of some specialty crops, GM varieties are not routinely segregated from conventional varieties and therefore make up a considerable proportion of all exports. (AOE, 2003)

James (2005) estimates that worldwide some 4.7 million hectares were planted to GM canola, equivalent to some 18 per cent of the total area planted. Most of this area is planted in Canada, one of Australia's key competitors.

In 1998 the European Union put in place an across the board moratorium on the approval of GM product applications. Consequently, GM canola seed could not be grown in or imported into the European Union. Despite its loss of access to the European Union, Canadian canola seed exports continued to rise in response to demand from other countries. China and Japan account for the majority of Canada's canola seed exports, with the United States and Mexico being the country's other major buyers.

As a result the European Union canola seed import market was exclusively supplied by Australia and some Eastern European countries. While Canada took to supplying some markets that Australia traditionally supplied, such as Pakistan, Bangladesh and Japan.

Although Canada could not sell its canola seed into the European Union, under the European Union guidelines Canada was able to continue selling canola oil into the European market (i.e., the value added products). This is because the oil extracted from the GM plant is chemically exactly the same as canola oil from conventional non-GM canola plants.

The equivalence of canola oil produced from GM and non-GM varieties and the acceptance of both sources of oil in the European Union appears to have been a contributing factor to the recent acceleration in investments in Canadian canola processing capacity. For example, an announcement coming from Cargill on 17 July 2006 states that it will expand its canola processing plant at Clavet, Saskatchewan, from 2,200 tonnes per day to 3,000 tonnes per day. As such, it would thus appear that Canada has not suffered any major commercial setback, at least in international markets, due to its adoption of GM canola.

However, there have been some recent developments in regards to the European Union moratorium. The United States, Canada and Argentina in 2003 challenged the moratorium through the World Trade Organization (WTO). Put simply these countries, amongst other things, claimed that the European Union had breached the WTO Sanitary and Phytosanitary (SPS) agreement's rules by creating undue delay in the biotechnology licensing approvals process. In September 2006 the WTO released its findings on the challenge and concluded, amongst other things, that, as at August 2003, there was undue delay in the approval of 24 of the 27 products. The WTO Panel's full findings may be found at: http://www.wto.org/english/news_e/news06_e/291r_e.htm. In March 2007 the European Union lifted the moratoria on the approval of GM seed for animal feed and industrial purposes, allowing Canada to once again compete with Australia in this market after an absence of 10 years.

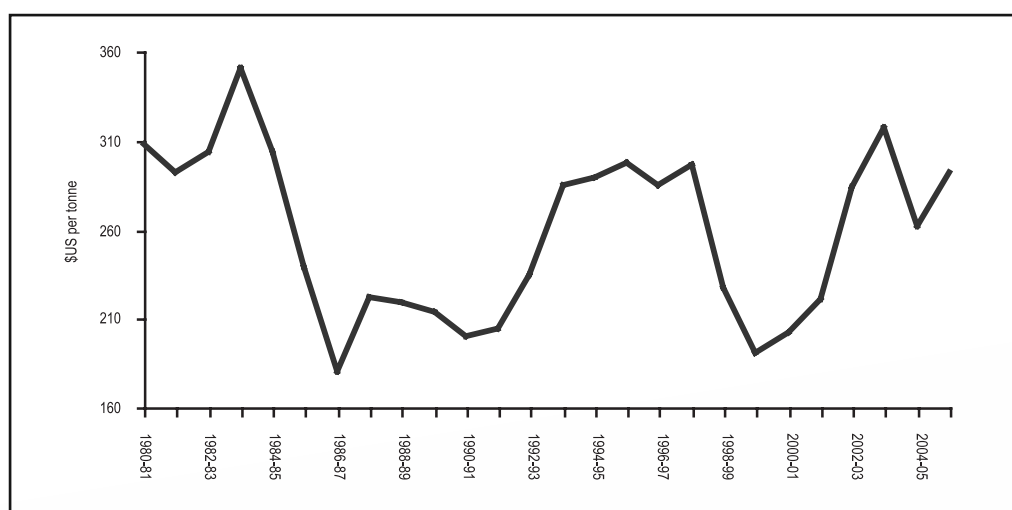
As explained above, Australia is normally a net exporter of canola. However, as a result of the pressures of drought Australia took delivery of its first shipment of Canadian GM Canola seed at the Port of Newcastle in December 2006. It is understood that the seed was processed in Newcastle and sold to unnamed buyers in the oilseed and biodiesel industries (ABC 2006a).

The regulation of GM crops in Australia and internationally is discussed in chapter 4. .

2.6 Global oil seed and edible oil prices

An examination of the detailed mechanics of global edible oil market interactions is beyond the scope of the present paper. Figure 5 presents time series of canola seed prices, which highlights that the seed's value. While relatively volatile, it has tended to be sold in the range \$US180 per tonne to \$US351 per tonne, with the average price in 2005-06 being \$US292 per tonne (see Figure 5). The USDA Foreign Agricultural Service indicates that prices are currently on the increase with average prices reported for October 2006 and preliminary prices for November 2006, reaching \$337 per tonne and \$351 per tonne, respectively (USDA 2006, Table 33).

Figure 5 Canola seed average annual import price



Note: Cif Rotterdam.

Data source: ABARE 2006a, Australian Commodity Statistics 2006, Canberra

Edible oils compete in differing end uses for a variety of reasons. For example, due to its relatively high saturated fat content palm oil hardens at a higher temperature than the other vegetable oils – palm stearin can in fact be used to substitute for tallow in soaps – and as a consequence palm oil is often preferred by margarine manufacturers. By using palm oil, these manufacturers can avoid some of the costs of hardening the end product. Possible unwanted consumer concern associated with trans-fatty acids that are the result of conventional hydrogenation methods can thus also be sidestepped through the use of palm. Palm oil is produced in abundance by Malaysia, so that it represents a cheap source of raw material.

By contrast, sunflower oil and canola oil are low in saturated fats and have to differing degrees built up reputations as 'healthy' oils. Canola and sunflower oil production costs are significantly above those of oil palm. Sunflower yields rarely exceed 1.5 tonnes per hectare (i.e., 0.6 tonnes of oil per hectare). At the other end of the spectrum, Malaysian oil palm plantations on average produce over 4.0 tonnes of oil per hectare.

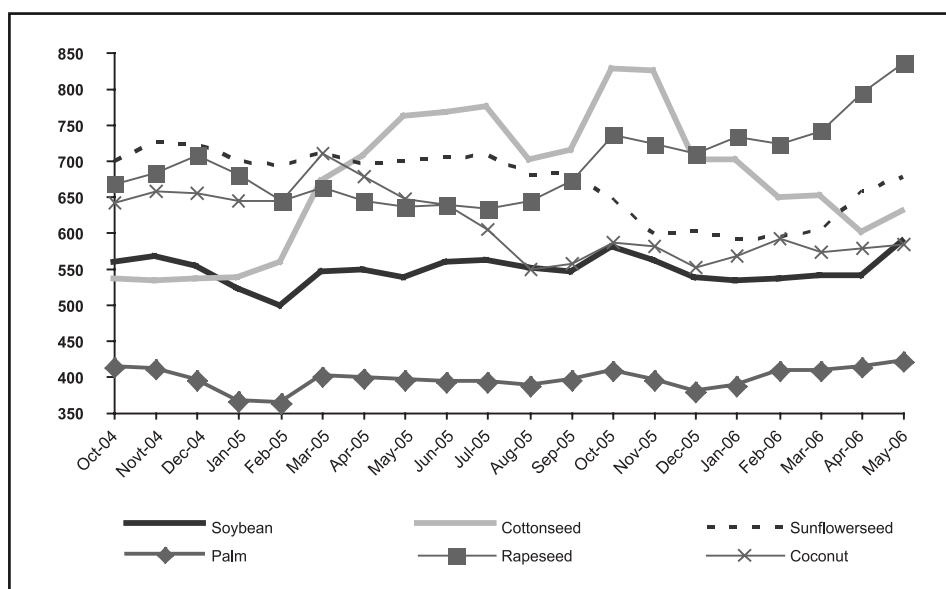
The premium paid for canola and sunflower oil over the price of palm oil, evident in Figure 5, to some degree reflects household consumer demand for oils that are low in saturated fats.

During most of 2005 and 2006, for example, palm oil traded at a fairly stable price of around \$400 per tonne at Malaysian ports, whilst sunflower oil prices fluctuated between \$600 and \$700 per tonne at Rotterdam.

Canola oil prices on the other hand varied more significantly over the two year period with prices ranging from \$640 to \$840 per tonne (see Figure 5).

Even if \$30-50 per tonne transportation cost from Malaysia to Rotterdam for palm oil was allowed – which would give us a 'Rotterdam' palm oil price that was closer to the other oils – a significant price differential would persist. Indeed, as implied by the price series shown in Figure 5, differentials are sometimes so high that this must at least partly reflect consumer or industrial user preferences for the different oils. Increased demand for bio-diesel, particularly in the European Union, is one explanation for the increased prices being observed for canola oil.

Figure 6 Monthly world prices of major traded vegetable oils, US\$/tonne (May 2004 to June 2006)

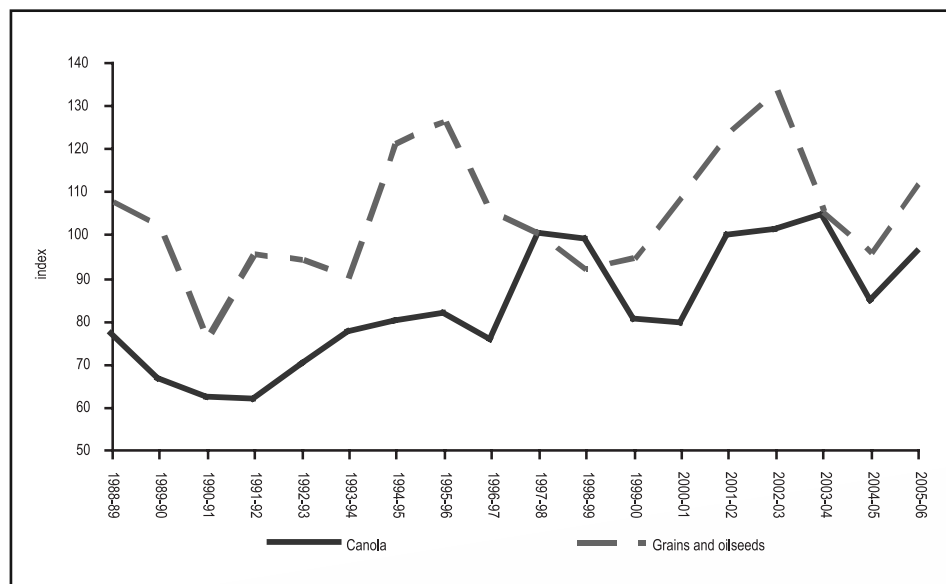


Note: All prices are Rotterdam prices with the exception of palm oil, which is the Malaysian free-on-board price for refined, bleached and deodorised palm oil.

Data source: USDA FAS World Markets and Trade report, Table 22, June 2006.

Returns to Australian farmers for canola have also been volatile (see Figure 7). ABARE estimates that real canola prices received by farmers have fallen in recent years. Canola prices received by farmers have in the main been more volatile than the average price received for all grains and oilseeds (Figure 7).

Figure 7 Index of prices received by farmers in Australia for canola and average price received for grains and oilseeds (1997-98 = 100)



Note: ABARE revised the method for calculating these indexes in October 1999. The indexes for commodity groups are now calculated on a chained weight basis using Fishers' ideal index with a reference year of 1997-98=100. Indexes for most individual commodities are based on annual gross unit value of production.

Data source: ABARE 2006, Australian Commodity Statistics, Table 22.

Analysis conducted by ABARE in 2003 found no clear evidence that Australia was at that time receiving a market premium for non-GM canola (Foster, Berry and Hogan. July 2003). However, ABARE's more recent analysis reports that there is some anecdotal evidence of price premiums being earned on canola exported to the European Union. However, a comparison of returns from canola exports to Japan and the European Union over a four month period in 2006 did not show unequivocal evidence. ABARE suggested that any price premium which might be obtained is more likely due to the European Union's restrictions on Canadian canola seed imports:

It is difficult to confirm the anecdotal evidence that the canola exported to the European Union is earning price premiums. A comparison of Australian export returns for the Japanese and EU markets over the four months in 2006 when large shipments to the European Union were made does not show unequivocal evidence of price premiums. The ability to import Canadian canola oil is a factor limiting the extent of import price premiums for canola in the European Union. Any price premium with the EU rapeseed market is mainly an artefact of the restrictions on imports of Canadian canola and would probably largely disappear when the restrictions are lifted (ABARE 2007a).

2.7 Canola Usage

Canola is a versatile plant – the oil and meal derived from the seed have a number of applications and are found in a great variety of end products, ranging from margarine and other spreads to spray oils, as well as soaps, plastics and bio-diesel. For some industrial applications (such as lubricants and slipping agents), it is the high erucic acid content of traditional canola cultivars that is valued. In this case, industrial users usually offer farmers a premium to plant and harvest small volumes of high-yielding erucic acid canola cultivars under contract.

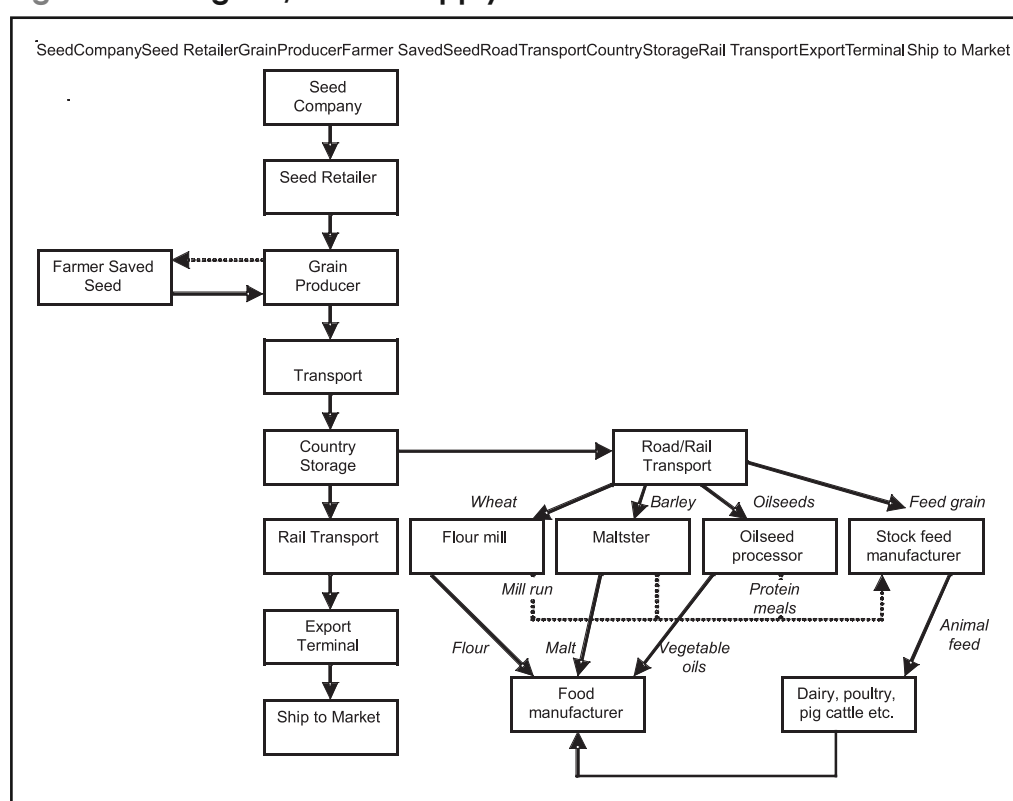
Canola reaches the final consumer via at least three distinct supply chains:

1. Human consumption: canola oil used directly for human consumption and in foodstuffs that are consumed by humans (cooking oil, margarine, etc). This comparatively 'short' supply chain extends from seed producer, to farm gate, to seed crushing plants (chemical or physical extraction), to oil refineries, and then through to food processors and ultimately final consumers. Modern vegetable oil refining and bleaching techniques mean that refined canola oil is almost completely odourless and of neutral colouring. The oil is also very low in saturated fatty acids, which has given it a marketing advantage in recent years. This has ensured that since the introduction of 'double-zero' varieties, refined canola oil has found a steadily increased level of acceptance as a cooking oil by consumers in OECD countries.
2. Animal consumption: canola meal used in livestock feed, which in turn produces food products (meat, eggs, milk, etc.) that are ultimately consumed by humans. This relatively 'long' supply chain again begins with the seed producer and the farmer, and after crushing of the seed the meal obtained is shipped to feed formulators. The combined or formulated feed then returns to the farm gate, and in the 'second iteration' the end product moves from farm gate through abattoir, etc, to food processors, and finally to human consumers in the form of meat, eggs or dairy goods or processed foods containing these products; and

- Industrial consumption: canola used in applications where the supply chain links farmers to industrial processors that utilise chemical or other processes to transform the seed, oil or meal (e.g., through inter-esterification, fractionation, extrusion, etc). Once canola has been transformed in this way it can be utilised in a great number of applications (including cosmetics, food additives, emollients, lubricants, slipping agents, plastics, etc.).

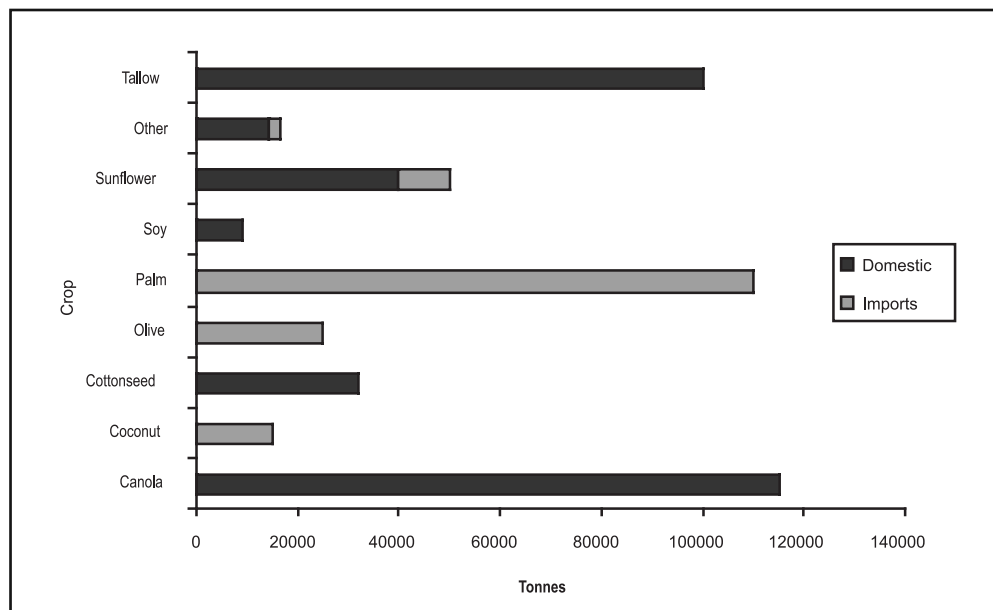
The first two supply chains are captured in Figure 8. One of the issues relating to the introduction of GM canola concerns the potential for co-mingling of GM canola with other crops along the supply chain shown in Figure 8. Much of the on-farm and off-farm equipment involved along this supply chain is the same for canola and other crops. For this reason, the Australian Grain Harvesters Association has, for example, developed a clean down protocol for all harvesters designed to minimise contamination of GM seeds between different crops.

Figure 8 The grain/oilseed supply chain



2.7.1 The Australian demand for oils and fats

The Australian market for oils and fats utilises around 550,000 tonnes annually. Of this, soft oils (canola, sunflower, cottonseed and soybean) at 225,000 tonnes account for almost half. Canola represents around half of all soft oil consumed. Imported palm oil and tallow continue to be significant, accounting for around 200,000 tonnes in total. The retail sector remains significant using 185,000 tonnes; however, the major growth is in the commercial and food service segments accounting for the balance of usage.

Figure 9 Indicative Australian edible oil usage, tonnes per year

Data source: based on a diagram previously available from the Australian Oilseeds Federation's website: <http://australianoilseeds.com/>.

Prior to their use in the food industry oils and fats are refined to improve the stability and appearance. This process involves the degumming, bleaching, neutralising and deodorising of the oil. The major refiners in Australia are Goodman Fielder, Unilever and Peerless. All of these companies are retailers and wholesalers of vegetable oil and vegetable oil based products. Australia also sources some canola oil from imports.

Oil usage in Australia can be separated into three major markets:

- **Commercial** – This sector comprises approximately 40 per cent of annual fats and oil consumption in Australia, and comprises commercial foods such as biscuits, bakeries, salad dressings, snacks and frozen foods. Canola oil is used in some of these products.
- **Retail** – relates to the oils and fats used in margarines and cooking oils, and makes up 35 per cent of domestic demand. Margarine comprises half of retail usage although this has been steadily declining. Canola oil is widely used in this segment.
- **Food services** – Hard oils, such as tallow and palm, which are best suited for deep frying, dominate this sector largely driven by price and flavour. Canola oil is not as well suited to frying so little is used in this sector in Australia. The oil can, however, be hydrogenated or inter-esterified to produce a hard fat suitable for frying (e.g., in Germany a well known fast food chain uses a specially formulated canola oil product for frying).

2.7.2 The Australian market for oilmeals

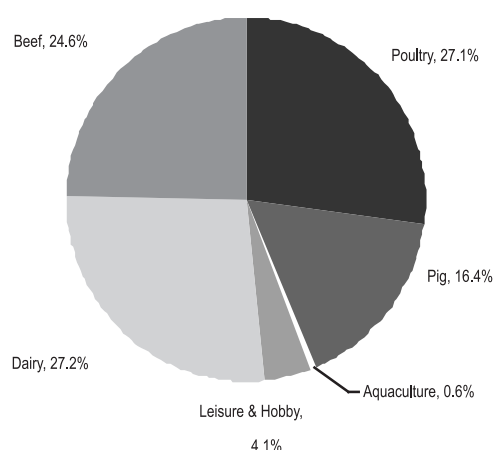
Livestock feedstuffs vary in composition but are primarily composed of cereal grains as a source of protein and energy. Protein meal (vegetable and animal) in conjunction with other dietary additives is included to meet the nutritional and dietary requirements of the animal. Rapid expansion of intensive livestock feeding in Australia over the past two decades has resulted in significantly increased demand for protein meals, including canola meal, of which around 0.2 million tonnes is consumed annually (see Table 7).

Table 7 Australian Vegetable Protein Meal Consumption (000's tonnes)

	2002-03	2001-02	2000-01	1999-00	1998-99
Canola	192	203	192	183	183
Soy	376	273	198	75	103
Sunflower	13	42	43	75	114
Cotton meal	144	144	144	252	234
Cotton seed whole	14	104	242	212	325
Total	739	766	819	797	959

Data source: SFMA website June 2006

The dairy, poultry and beef feedlot industries are the largest feed consumers accounting for over 75 per cent of feed intake. The pig industry is the other significant consumer (see Figure 10).

Figure 10 Stock feed usage by sector

Data source: SFMCA website, June 2006.

Ridley AgriProducts is the major commercial manufacturer of stockfeed in Australia producing around 1.5 million tonnes annually although integrated manufacturers, such as Ingham and Barthers. QAF Meat Industries (a wholly owned subsidiary of QAF Limited of Singapore) – a leading vertically integrated producer of pigs and pig meat in Australia - also produce significant quantities of feed for consumption within their enterprises.

Feeds for use in aquaculture are also a fast growing sector of the animal feed industry worldwide, and canola meal is suitable for inclusion in aqua feeds. Recent research on canola in aqua feeds carried out in Western Australia concluded that canola oil can successfully replace fish oil in diets for marine fish, and that possibly up to 60 per cent of the diet can be made up of canola meal (Glencross, 2003). It is therefore likely that canola will in due course play an increased role in aquaculture feed rations, i.e., including fish (e.g. salmon and tuna), molluscs (oysters and abalone), crustaceans (prawns and crabs) and aquatic plants.

2.8 Summing up

Canola is a hybrid form of rapeseed. Canola was originally the trademark name of a Canadian rapeseed cultivar which had special characteristics. Over time the characteristics of the Canadian rapeseed cultivar have become increasingly common in rapeseed varieties bred elsewhere across the globe. As a result the term canola has come to be applied more broadly. In practice, the term canola and rapeseed are often used interchangeably.

Australian farmers have been commercially growing some form of canola since the late 1960s. However, the crop importance increased in the last decade. For example, in the early 1990s the area sown to canola in Australia was only around 0.1 million hectares. By 2001 the area sown to canola had risen to approximately 1.3 million hectares. The area planted in recent years has declined to around 1.0 million hectares, with the decline most obvious in the southern parts of Australia.

ABARE forecasts that as a result of the drought canola production in 2006-07 will be down by around 69 per cent on the previous year. In response to the dramatic decline in production volumes at least one Australian firm has imported GM canola seed, which has been processed in Australia for unnamed customers.

In global terms, Australia is a relatively small producer of canola, with the largest producers being the European Union, China and Canada. Notwithstanding this, Australia is a significant player in the export of canola seed and to a lesser extent in canola oil. Australia's exports historically account for between 12 and 26 per cent of canola seed export trade.

Canada is Australia's major competitor, either directly or indirectly, in terms of global canola markets. Around 80 per cent of Canada's canola production is sourced from GM canola seed. In 2005-06 Canada's canola seed exports increased in volume terms and its share of world exports increased to 77 per cent. Canada also dominates the canola oil export market.

Canola seed and its products, the oil and the meal, compete against other oils, including those processed from other oilseeds and certain vegetables, such as palm oil and soybean. Canola and its products tend to be traded as undifferentiated commodities in global markets. Between 1998 and 2007 the European Union had restricted the importation of GM canola seed forcing Canada out of this market. However, in March 2007 the European Union lifted the moratoria on the use of GM seed for animal feed and industrial purposes, allowing Canada to once again compete with Australia in this market after an absence of 10 years.

Despite its loss of access to the European Union during the 1990s, Canadian canola seed exports continued to rise in response to demand from other countries less sensitive to GM canola seed.

Canola (and sunflower) oil tend to obtain a price premium over the prices obtained for some other oils, such as palm oil. To some extent this premium reflects household consumer demand for oils that are low in saturated fats. Global prices for canola oil tend to be relatively volatile, with prices increasing significantly in recent years. However, ABARE data suggests that prices earned by Australian farmers for canola production have fallen over the same period suggesting that the higher prices for canola oil are being enjoyed by processors rather than farmers.

Canola is a versatile plant – the oil and meal derived from the seed have a number of applications and are found in a great variety of end products, ranging from margarine and other spreads to spray oils, as well as soaps, plastics and bio-diesel. Canola meal is also used as a livestock feedstock.

The following chapter provides some background on GM technology and its application

3 GM technology and its application to canola

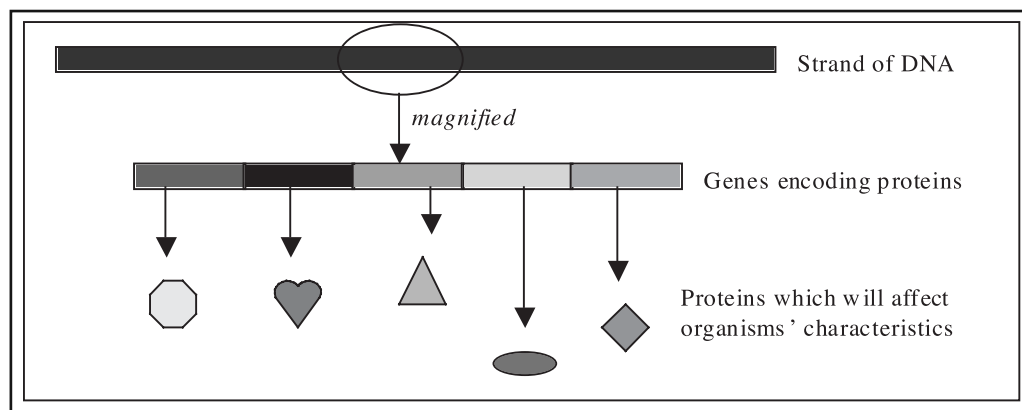
This chapter aims to explain GM technology and its application to canola seed breeding. The discussion is intended to allow the non-scientist to better understand the GM process and its use. The chapter goes on to compare GM techniques and the more traditional methods of crop breeding. The chapter also explains the differences between GM canola varieties and the varieties currently grown in Australia which have been produced using more traditional biotechnology techniques.

3.1 What is GM technology?

What is GM technology?

Genetically modified (GM) technologies introduce new characteristics, or traits, to living organisms (CSIRO, 2006, p.3). The new characteristics are achieved by altering the genetic make up of the organism using DNA manipulation techniques.

Every cell in an organism contains DNA. Strands of DNA are made up of a chain of segments called genes. Each gene encodes the instructions for how to make a particular protein, and it is the production of different combinations of these proteins that defines the attributes and traits of an organism. By changing the underlying DNA in a gene, it is possible to modify the production of certain proteins, or produce new proteins altogether, that can alter the traits of the organism. This modification can be accomplished by either deleting a section of DNA altogether, or by taking a desired gene from one organism and placing it into the DNA of another.



To produce such a modification, GM technologies isolate the particular piece of DNA containing the gene responsible for the desired attribute (from organism A), precisely cut the gene out, and then introduce the gene (and its related trait) into the DNA of organism B. To ensure the gene functions properly in the new host, it is necessary to also introduce other DNA sequences called promoters, to control when and how frequently the protein is expressed (CSIRO, 2006, p.4).

BRS (2007) points out that developments in GM plants can be characterised as falling within 3 generations. The subject of this report GM canola fits within the 1st generation of GM plants, ie a GM plant with traits that aim to reduce the inputs required for growing Canola.

In many instances it is possible to introduce similar physiological and physical changes into plants, by conventional breeding techniques. However, the process is slower and more “hit and miss” than gene transfer and is limited to genes from the same or closely related species (DAFF, 2003).

3.1.1 What are transgenic plants?

A transgenic plant contains a gene or genes which have been artificially inserted (Colorado State University, 2004). The inserted gene sequence is called a “transgene” and usually comes from an unrelated plant or from an entirely unrelated species.

The main purpose behind the production of transgenic crops is to try to assemble a combination of genes in the plants that will enhance the productivity of the crop as far as possible. For example, it is possible to introduce genes into plants so that they then produce proteins that kill certain pests, thereby allowing growers to use less insecticide on their crops. Other attributes which have been transferred between plant species include longer shelf life, disease tolerance (UKAEBC, 2002), and physical attributes such as texture and colour. A crop of cultivated plants which are clearly distinguishable from others by one or more characteristics, and which retain these characteristics when it reproduces, is called a cultivar.

3.1.2 How are transgenic plants made?

Once a specific gene has been identified, isolated and manipulated it must be reintroduced to the target organism. This is not a simple process. There are three techniques currently being employed for the transfer of a gene into the target crop:

1. The DNA encoding the desired gene is inserted into a bacterium that has the ability to infect the target plant and transfer a piece of DNA.
2. The wall of the target plant's cell is physically removed, and the stripped cell is jolted with electricity to disrupt the cell membrane and allow the new DNA to pass into the cell.
3. The new DNA is coated onto tiny gold pellets and a gene gun is used to “shoot” the gene into the target crop cells.

For cells that successfully receive the new gene, standard tissue culture techniques are applied to induce the cells to grow into adult plants (Voiland and McCandless, 1999).

3.1.3 Comparing breeding techniques and alternatives

GM technologies are used to modify the characteristics of selected crops. These modifications may result in changes to the agricultural requirements for growing the crop. For example, different pesticides may be applied; pesticide application regimes may change; and tilling and crop rotation cycles may also be altered (ACIL Tasman and Innovation Dynamics, 2005).

3.2 Differences between GM canola and traditional varieties

The OGTR has approved herbicide tolerant GM canola varieties for commercial release in Australia (see Chapter 4). This section discusses the approved GM varieties and the conventional canola varieties traditionally grown in Australia.

The benefits of herbicide tolerant (HT) canola include the potential for increased crop yields and crop value, increased weed management options, and more environmentally friendly herbicide use. All of these benefits are related to the simplified weed control afforded by the herbicide tolerance.

HT crops are relatively new to Australia, having been introduced into commercial production as recently as 1994 through conventional breeding techniques. The uptake of HT crops was rapid, and a decade later it was estimated that 80-90 per cent of canola crops in Western Australia, and 30-40 per cent of canola crops in other Australian states were comprised of HT canola (Biotechnology Australia. BioFacts: Factsheet Number 29, August 2004). About 60 per cent of non-GM canola is tolerant to the herbicide atrazine.⁶

Currently the leading non-GM herbicide tolerant canola in Australia and Canada is the Clearfield System. Clearfield is a non-GM herbicide tolerant cropping system that was developed using traditional plant breeding techniques. It combines canola varieties that are specially developed to be tolerant to the herbicide ONDUTY, an imidazolinone (Group B) herbicide

The new breed offers control of problem weeds when used in conjunction with ONDUTY herbicide in accordance with a Best Management Practice program. The breeding technique has also improved the crop in other ways, including crop yield, oil content and high levels of blackleg resistance.

There have been other successful examples of herbicide tolerant canola being developed through conventional breeding techniques. Triazine-tolerant (TT) canola, developed from a naturally occurring mutation, is the main variety (Foster, 2003).

The two herbicide tolerant GM canola varieties approved for commercial release in Australia are InVigor® and Roundup Ready®. InVigor® is a registered variety of GM canola owned by Bayer CropScience (previously known as Aventis CropScience Pty Ltd),⁷ which also owns the earlier developed variety known as LibertyLink®.

⁶ OGTR, Questions and Answers on Bayer CropScience Genetically Modified InVigor® Hybrid Canola Decision (DIR21), July 2003/February 2004

⁷ Bayer CropScience Website address is www.bayercropscience.com.au

LibertyLink® confers resistance to the active ingredient in the Aventis herbicide Liberty, glufosinate-ammonium (Genetic Manipulation Advisory Council 1999). The LibertyLink® modification was incorporated into the cultivar “Innovator”, the first genetically modified canola commercialised in Canada in 1994 by AgrEvo, Aventis’ predecessor (OGTR, 2000). By 1997, three years after release, Canadian plantings of LibertyLink® had already reached 800,000 Ha, representing some 20 per cent of total plantings (ibid).

hybrid improves yield, because of the greater genetic potential of the hybrid and the improved weed control associated with tolerance, at all stages of plant growth, to the herbicide glufosinate ammonium. It is claimed that the hybrid also has the potential to reduce soil erosion because the farmer does not need to till as much to remove weeds (OGTR, 2002a).

With the exception of its use with InVigor®, glufosinate ammonium is not registered for use in broad-acre cropping in Australia OGTR (2002a). However, the herbicide is registered for use in horticulture and some non-agriculture uses.

In 2002, Bayer CropScience applied to OGTR for approval to release seven similar types of genetically modified canola (Table 8), although the company only intended to release two of these varieties (Ms8 and Rf3) under the InVigor® brand. Bayer applied for approval for all seven lines in order to maintain consistency between regulatory approvals, as these varieties were already approved in the USA and Canada (OGTR, 2002b).

Table 8 Genetic modifications in the seven InVigor®, GM canola lines

Line	T45	Topas 19/2	MS1	RF1 & RF2	MS8	RF3
Traits	Glufosinate ammonium tolerant	Glufosinate ammonium tolerant, antibiotic tolerant, sterile	Glufosinate ammonium tolerant, antibiotic tolerant, male sterile	Glufosinate ammonium tolerant, antibiotic tolerant, fertility restorer	Glufosinate ammonium tolerant, male sterile	Glufosinate ammonium tolerant, male sterile
Genes	pat gene	pat gene; nptII gene	bar gene; bamase gene; nptII gene	bar gene; barstar gene; nptII gene	bar gene; bamase gene	bar gene; barstar gene

Data source: OGTR 2002b

In 2003, OGTR approved the commercial release of InVigor® variety of hybrid canola. OGTR approved release because it found that:

- InVigor® is no more toxic or allergenic than non-GM canola;
- InVigor® is not likely to be any more weedy than non-GM canola and can be effectively managed with a wide range of herbicides already used to control non-GM plants and weeds; and
- InVigor® will only cross-pollinate with a small group of related plant species at a very low level, which means the gene will not be transferred into weeds (which would potentially induce resistance in the weeds also, and hence cause a significant weed problem) (OGTR, 2003).

Monsanto's GM canola is branded Roundup Ready®, and is tolerant to the active ingredient in Monsanto's Roundup® herbicides, glyphosate (Monsanto Australia 2006). This genetic modification enables glyphosate to be sprayed on weeds that are growing in Roundup Ready® canola crops, to kill the weeds without destroying the canola. Roundup Ready® is the only canola variety that is tolerant to the herbicide glyphosate.

In sharp contrast to the herbicide glufosinate ammonium (tolerated by InVigor®), glyphosate is registered for use in many applications in broad-acre agriculture by the Australian Pesticides and Veterinary Medicines Authority (APVMA).

Roundup Ready canola was developed through the introduction of two new genes into an Australian canola variety (OGTR, 2002c). One gene produces an enzyme which is essential to the survival of the plant in the presence of glyphosate herbicide. The other gene expresses a protein used by the plant to break down the glyphosate into harmless compounds. Both genes are derived from conventional soil bacteria.

Roundup Ready® canola was approved for commercial release in Japan in 1996 (Agriculture, Forestry and Fisheries Research Council, 2000), Canada in 1994 (OGTR, 2003) and the USA in 2003 (OGTR, 2003). Oil from Roundup Ready® canola is approved for good use in these three countries as well as Europe and Australia. The Australian approval for the use of the oil was provided by Food Standards Australia New Zealand (OGTR, 2002c).

Following rigorous evaluation and extensive public consultations, the Australian Gene Technology Regulator issued a licence for the commercial release of Roundup Ready® canola in December 2003 (OGTR, 2003c). In reporting her decision the Gene Technology Regulator, Dr Meek stated:

The comprehensive risk assessment has demonstrated to me that the commercial scale release of Roundup Ready, canola will not pose a risk to human health and safety or the environment.

..... the APVMA [Australian Pesticides and Veterinary Medicines Authority] has applied a number of conditions on the registration of Roundup Ready® herbicide to ensure responsible management of Roundup Ready® herbicide use on Roundup Ready® canola, and to minimise the risk of development of herbicide resistance.

.... I am advised that unwanted Roundup Ready® canola plants can be effectively removed with a range of approved herbicides and mechanical weed control methods.

Using a mixture of weed control options is consistent with integrated weed management practice,....

I also understand that a number of industry initiatives have also been developed to facilitate segregation of GM from non-GM canola. Industry and State governments are also consulting on the marketability and trade issues, as distinct from health, safety and environmental issues (OGTR 2003c).

Monsanto stopped its Australian canola R&D program in 2004 (Monsanto, 2006). In September of 2006, Monsanto Australia announced that it would licence Roundup Ready® canola technology to Nufarm Ltd, an Australian agricultural chemical company. Nufarm had an agreement with Monsanto dating back to 1999 to sell glyphosate and Roundup Ready® products in Australia (Monsanto Inc, 1999). The new agreement provides Nufarm with a licence to develop and commercialise Roundup Ready® canola in Australia, along with acquisition of Monsanto's Roundup Ready® canola germ plasm and a licence to the Roundup Ready® canola trait to Nufarm Ltd (Nufarm, 2006).

The major difference between the Monsanto's Roundup Ready®, Bayer's InVigor® and the non-GM varieties is the herbicide to which they show resistance. Of the HT GM canola varieties, InVigor® has been designed to tolerate only the herbicide glufosinate ammonium, while Roundup Ready® is able to tolerate glyphosate which is more widely used.

3.3 Summing up

GM technologies alter the genetic make up of living organisms to introduce traits that cannot be acquired through the process of natural (traditional) reproduction. GM technologies involve the isolation, manipulation and reintroduction of foreign genes into organisms. The new gene usually produces a protein that creates a new characteristic or trait in the organism.

By carefully choosing a gene that expresses a known protein, it is possible to control which new trait is introduced. This is done by isolating the piece of DNA containing the desired gene, precisely cutting the gene out and then introducing the gene into the DNA of another organism. It is also necessary to introduce additional DNA sequences called promoters, which control the amount of protein expressed and hence the strength and depth of the new trait.

GM technology allows physiological and physical attributes to be transferred between species. Some examples of potential attributes include longer shelf life, disease tolerance, herbicide tolerance, or changes in texture or colour. Similar changes can be bred into plants by conventional (non-GM) means, such as in the case of TT canola, which is resistant to the herbicide Triazine, and was developed using traditional breeding techniques. However, the traditional breeding process can be much slower and more “hit and miss” than genetic modification. Importantly, traditional non-GM techniques are limited to genes from the same or closely related species.

The development of a GM plant crop differs markedly from conventional approaches to breeding. There is an extended research and development phase required to generate the new variety. Biotechnology tools and techniques can be used as part of the R&D process in these early stages. The resulting progeny may be genetically modified through insertion of new genes into their DNA, or they may be unmodified but still have been developed with the assistance of biotechnology.

Two herbicide tolerant GM canola varieties, InVigor® and Roundup Ready®, have been approved for commercial release in Australia. The InVigor® hybrid contains a gene from the earlier LibertyLink® variety, and two other introduced genes that are used to facilitate the production of hybrids. This combination is claimed to improve yield because of the greater genetic potential of the hybrid and the improved weed control associated with tolerance of the herbicide glufosinate ammonium. It is claimed that the hybrid also has the potential to reduce soil erosion because the farmer does not need to till as much to remove weeds.

Roundup Ready® is tolerant to a different herbicide called glyphosate, which is the active ingredient in Monsanto's Roundup. Roundup Ready® canola was developed from an Australian canola variety that had two new genes derived from soil bacteria introduced into its DNA. These genes produce an enzyme which allows the plant to survive in the presence of glyphosate, and a protein that breaks down the glyphosate into harmless compounds.

In 2003 these two GM canola varieties were approved for commercial use in Australia after the OGTR assessed that 'the commercial release of Roundup Ready® canola will not pose a risk to human health and safety or the environment, which cannot be managed. Chapter 4 explains the regulatory environment under which this assessment was made.

4 The regulatory environment

This chapter discusses approaches to the regulation of commodities such as canola and GM canola. Section 4.1 discusses the self regulation put in place by the grains industry for the marketing of agricultural commodities, including canola. Section 4.2 explains Australia's approach to the regulation of gene technology and its application to GM canola. Approaches used in other countries to regulate the use of GM technology are discussed in section 4.3. Finally, section 4.4 sums up the chapter's findings.

4.1 Grains industry self regulation of segregation

The Australian grains industry, through the National Agricultural Commodities Marketing Association (NACMA), has put in place a system of national standards and industry protocols for the marketing of agricultural commodities.

NACMA was initially formed in 1991 by state based merchant organisations in response to the need for common terms of trade and grain specifications. As a result of structural changes in the grains industry NACMA's role and functions were reviewed in 2002. After amendments to its constitution in 2003, NACMA's role, membership and functions have been broadened with the body now having a greater focus on commercial issues throughout the grains industry value chain. NACMA now has a membership which represents all sectors of the grain supply chain, from grain producers to domestic end-users and grain export trading companies.

NACMA's amended constitution states that the company was formed with the object of:

- (a) promoting the interests of those involved in the Grain Industry on a national basis;
- (b) promoting harmony and good relations in the Grain Industry and safeguarding the interests of persons and firms engaged in the Grain Industry;
- (c) guarding and maintaining a high reputation for the Grain Industry in commercial life and to promote the ethical and financial accountability of the membership of the Company;
- (d) co-operating with persons in promoting matters beneficial to the Grain Industry and its participants;
- (e) assisting Government at all levels to formulate policy to permit the more efficient operation of the Grain Industry;
- (f) providing an apolitical and unbiased forum for discussion and debate of issues relevant to the Grain Industry;
- (g) encouraging marketing between recognised and reputable organisations;
- (h) providing all participants in the Grain Industry with the most efficient trading tools and dispute resolution mechanisms.⁸

Reflecting these objects, NACMA undertakes a number of activities including:

- developing and publishing grain Trade Rules for grain contracts;
- developing (in conjunction with various industry bodies) and publishing grain standards. These standards are updated yearly and are accepted as the industry's standard reference;
- releasing Codes of Practice relating to the storage and transport of basic commodities and basic value added products. These Codes are published in conjunction with Australian Oilseeds Federation;
- conducting an arbitration system for members (NACMA website).⁹

NACMA is a member of the following Australian Committees/organisations:

- Pulse Australia
- Grains Council of Australia – Grain Trade Working Group
- Gene Technology Grains Committee
- Australian Quarantine and Inspection Service - Grains Industry Consultative Group
- National Standards Commission Committee on Grain Quality Measurements.

After consultations with its members, NACMA has agreed that it needs to play a proactive role in the development of protocols to manage the potential introduction of GM crops into the Australia grain supply chain. NACMA in its Commercialisation of GM crops position paper recognises the need to work with stakeholders to ensure adequate segregation in the event of GM crops being commercially released. The paper states that the organisation:

...will work with members and industry to facilitate the development of the necessary tools and mechanisms to ensure that trade in GM crops continues to operate smoothly and effectively with the commercial release GM crops.

In assuming this responsibility, NACMA recognises that in the event of the commercial release of GM crops in Australia, many non-GM markets would need to be satisfied that mechanisms exist to ensure grain supplies are adequately separated from other grains.

Sensitivities surrounding the use of GM varieties mean that a range of integrated industry processes and systems would need to be developed and implemented to ensure the separation of GM and non- GM varieties to satisfy market requirements where required (NACMA 2006).

NACMA's GM position paper states that its approach is to work with members through its Grain Standards, Commerce and Transport, Storage and Handling committees and with other sectors of the industry in order to assist in the development of processes and systems that would allow commercial activities to continue to operate efficiently in a coexistence environment.

⁸ Constitution of National Agricultural Commodities Marketing Association Limited, http://www.nacma.com.au/__data/page/111/NACMA_Constitution-Final_Amended.pdf

⁹ NACMA's involvement in the grains industry, http://www.nacma.com.au/about_nacma/nacmas_role_today

4.2 Australia's gene technology regulation

Prior to 2001, the release of genetically modified organisms (GMO) was subject to a voluntary program, run by the federally funded Genetic Manipulation Advisory Committee (GMAC), which had been established in 1987. The GMAC approved the release for field trials of a GM *Agrobacterium* in 1998 (O'Neill, 2004). The second GMO approved by the committee was INGARD cotton, in 1996.

Although GMAC had no statutory authority or enforcement powers, its advice was consistently sought and complied with by Australian researchers, most probably because compliance with its recommendations was a condition of research and development funding from the Australian Government (Gene Technology Review 2006). However, with significant advances in gene technology, with increased involvement of private sector commercial interests and growing community concerns about genetically modified organisms, the Australian, state and territory governments saw a need for a more formal regulatory regime. In 1998 the Australian Government, together with the states and territories, initiated a cooperative and consultative process to develop Australia's current approach to the regulation of gene technology (Gene Technology Review 2006).¹⁰

As a result of this process Australia has a uniform, national approach to the regulation of gene technology, which is underpinned by an inter-governmental agreement known as the Gene Technology Agreement, the Gene Technology Act 2000 and related regulations.

4.2.1 Inter-governmental agreement

The Gene Technology Agreement (2001) sets out the understanding between Commonwealth, state and territory governments regarding the establishment of a nationally consistent regulatory system for gene technology. The agreement has been signed by the Commonwealth and all state and territory governments. The agreement's effective commencement date was 11 September 2001, when the Commonwealth and Victoria, Australian Capital Territory, South Australia and Queensland signed the agreement. Western Australia, New South Wales, Tasmania and the Northern Territory signed the agreement at later dates. The decision to enter into such an agreement reflected all of these Governments acknowledgement that there was a need for a co-operative national legislative scheme to protect the health and safety of people and to protect the environment, by identifying risks posed by, or as a result of, gene technology and by managing those risks through regulating certain dealings with genetically modified organisms.

¹⁰ Chapter 2 of The Gene Technology Review (2006) report provides detail on the background to the development of the current arrangements

It was also acknowledged and agreed that the co-operative national scheme should, amongst other things:

- provide an efficient and effective regulatory system;
- operate in a seamless manner in conjunction with existing Commonwealth and State regulatory schemes;
- be nationally consistent;
- be based on a scientific assessment of risks undertaken by an independent regulator,
- ensure that the regulatory burden is commensurate with the risks;
- be characterised by decision-making that is transparent, and that incorporates extensive stakeholder and community involvement;
- be able to be amended to respond to the development of gene technologies and their uses; and
- be consistent with Australia's international treaty obligations.

It was agreed that the Commonwealth Gene Technology Act 2000, which became effective in June 2001, would form the basis of the co-operative national scheme and that each state and territory would submit to its Parliament a Bill (or Bills) to ensure that the scheme applies consistently to all persons, things and activities within Australia.

The agreement also established the Gene Technology Ministerial Council, which comprises a Minister from each jurisdiction. The Council, which is discussed further below, is charged with the implementation of the legislation and the oversight of the role of the Regulator.

4.2.2 Gene Technology Act and regulations

The Gene Technology Act 2000 and its related regulations, Gene Technology Regulations 2001, came into effect in June 2001, setting in place Australia's national legislative scheme for the regulation of gene technology. The object of the Act is to:

...protect the health and safety of people, and to protect the environment, by identifying risks posed by or as a result of gene technology, and by managing those risks through regulating certain dealings with GMOs.

As the focus of the legislation is the protection of the health and safety of people and the protection of the environment, considerations such as economics and marketing are excluded from the regulatory framework.

The regulatory framework established under the Act is designed to operate in conjunction with other Commonwealth and State regulatory schemes relevant to GMOs and GM products.

The Act established the Office of the Gene Technology Regulator and specified the Gene Technology Regulator's functions and powers (discussed below).

The Act also gives the Gene Technology Ministerial Council, which was established under the inter-governmental Gene Technology Agreement, the authority to issue policy principles in relation to:

- ethical issues relating to dealings with GMOs; recognising areas, if any, designated under State law for the purpose of preserving the identity of GM and/or non-GM crops for marketing purposes;
- matters relating to dealings with GMOs prescribed by regulation. These regulations may relate to matters other than the health and safety of people or the environment, but must not derogate from the health and safety of people or the environment.

4.2.3 The Gene Technology Regulator and the relationship with and other regulatory agencies

The Gene Technology Regulator established by the Gene Technology Act 2000 is charged with the responsibility for assessing applications for a licence to intentionally release a genetically modified organism into the environment. Under the Act and regulations the Regulator will only issue a licence after being satisfied that the release will not pose any risks to human health and safety or the environment that cannot be managed.

The Act requires that the Regulator must prepare a risk assessment and risk management plan (RARMP) for each licence application for Dealing Involving Intentional Release (DIR) for both field trials and commercial release. This plan then forms the basis of the Regulator's decision whether or not to issue a licence. The RARMP must be developed in consultation with a wide range of expert groups and stakeholders including the public. The Act requires that the Regulator, during the preparation of the RARMP, must seek input from:

- Food Standards Australia New Zealand (FSANZ), which sets the standards for safety and labelling of foods for human consumption;
- the Agricultural Pesticides and Veterinary Medicines Authority (APVMA), which is responsible for assessing the safety and ensuring the efficacy of all agricultural chemicals and veterinary medicines;
- the Therapeutic Goods Administration (TGA), which regulate pharmaceuticals; and
- the National Industrial Chemicals Notification and Assessment Scheme (NICNAS), which regulates the use of industrial chemicals.

The regulator is currently required to make a decision to license or not license within 170 days.

In addition to providing a license for the release of a genetically modified organism into the environment, the Gene Technology Regulator is also required to maintain a public record on the OGTR website of all dealings undertaken with GMOs in Australia. To assist in this task, the FSANZ, APVMA, TGA and NICNAS are required to advise the Gene Technology Regulator if they approve a product that is, or was produced by, a GMO.

The Gene Technology Regulator is responsible for the evaluation of all applications for contained research and early stage trial work with GMOs in Australia. However, once a GMO reaches later stage development or commercial application, other product approval authorities also have a role in the framework (see Table 9). The Statutory Review of the Gene Technology Act and the Gene Technology Agreement explained the situation in respect of herbicide tolerant plants as follows:

....the [Gene Technology] Regulator must approve the environmental release of GM insecticidal or herbicide-tolerant plants into the environment, the Australian Pesticides and Veterinary Medicines Authority (APVMA), which is responsible for the regulation of all agricultural chemicals, must register the insecticidal gene or approve the application of the herbicide to which the GM plants are tolerant (Statutory Review Panel, 2006, p25).

The process and the considerations undertaken by these other approval bodies in respect of the approval of a GM product is no different to the approval processes required for non-GM products. The only differences between these bodies activities for the approval of GM and non-GM products is that:

- if an imported gene technology product is approved they are required to advise the Gene Technology Regulator of the approval; and
- if the GMO is to be commercially made or grown in Australia these other bodies have a policy of working closely with the Gene Technology Regulator and coinciding where possible with the respective decisions.

The Statutory Review Panel's report explains as follows:

Although the focus and responsibility of other agencies which regulate products that are, or are derived from, GMOs are distinct from those of the Regulator, all the agencies have a policy of aligning the decision making processes so far as is practicable. They work closely together to ensure thorough coordinated assessments of parallel applications are undertaken and, wherever possible, that the timing of decisions by both agencies coincide (Statutory Review Panel, 2006, p25).

Table 9 Commonwealth Government Agencies with a role in regulating gene technology

GM products	Agency	Portfolio	Scope	Relevant Legislation
GMO dealings	OGTR - Gene Technology Regulator and Office	Health and Ageing	OGTR administers a national scheme for the regulation of GMOs in Australia, in order to protect human health and safety and the environment by identifying risks posed by or as a result of gene technology, and to manage those risks by regulating certain dealings with GMOs	Gene Technology Act 2000
Medicines, medical devices, blood and tissues	TGA - Therapeutic Goods Administration	Health and Ageing	GA administers legislation that provides a national framework for the regulation of therapeutic products in Australia and ensures their quality, safety and efficacy.	Therapeutic Goods Act 1989
Health and Medical Research	NHMRC ¹ -National Health and Medical Research Council	Health and Ageing	While not strictly a regulator, NHMRC provides funding for health and medical research, and advises the community and governments on a range of health and health-related ethical issues. Through its oversight of the Gene and Related Therapies Research Advisory Panel (GTRAP), the NHMRC has a specific advisory role in relation to human clinical research using gene therapy or GM cells and tissues.	
Food	SANZ - Food Standards Australia and New Zealand	Health and Ageing	FSANZ is responsible for food standards, including mandatory approvals for the safety and labelling of food produced using gene technology before it can be sold.	Food Standards Australia New Zealand Act 1991
Agricultural and Veterinary Chemicals	APVMA - Australian Pesticides and Veterinary Medicines Authority	Agriculture, Fisheries and Forestry		Agricultural and Veterinary Chemicals (Code) Act 1994; Agricultural and Veterinary Chemicals Administration Act 1994
Industrial chemicals	NICNAS/OCS - National Industrial Chemicals Notification and Assessment Scheme; Office of Chemical Safety	Health and Ageing	NICNAS administers a national notification and assessment scheme to protect the health of the public, workers and the environment from the harmful effects of industrial chemicals.	Industrial Chemicals (Notification and Assessment) Act 1989
Quarantine	AQIS Australian Quarantine and Inspection Service	Agriculture, Fisheries and Forestry	AQIS regulates the importation into Australia of all animal, plant and biological products that may pose a quarantine pest and/or disease risk	Quarantine Act 1908; Imported Food Control Act 1992

¹ NHMRC administers the Research Involving Human Embryos Act 2002; however, research with human embryos is excluded from the scope of the Act.

Data source: Statutory Review Panel (2006).

4.2.4 Gene Technology Ministerial Council (GTMC) and policy principles

The GTMC provides policy input into the implementation and operation of the scheme including providing advice on the appointment of the Gene Technology Regulator and the members of the Gene Technology Committees (see below). The GTMC is supported by the Gene Technology Standing Committee comprising senior Commonwealth and state department officials.

As noted above, the GTMC has legislative authority to issue policy principles dealing with ethical issues relating to GMOs and the recognition of areas designated under state law for the purpose of preserving the identity of GM and/or non-GM crops for marketing purposes.

The GTMC has at this stage issued one policy principle, known as the Gene Technology (Recognition of Designated Areas) Principle 2003. This principle, which came into effect on 5 September 2003, allows the States and Territories to preserve the identity of GM or non-GM crops (or both) for marketing purposes.

The Regulation Impact Statement (RIS) for the Gene Technology (Recognition of Designated Areas) Principle also explained that this principle is intended to overcome a Constitutional requirement in respect of Australia's national approach to gene technology regulation:

While the issuing of a policy principle by the Ministerial Council is not a precondition or directive to the introduction, or operation of State laws, a question was raised early on whether such a law would be consistent with the Act.

If a State law designating GM crop areas or non-GM crop areas were proved to be inconsistent with the Commonwealth law, it would, to the extent of the inconsistency, be prevented from operating.

The draft policy principle for designated areas is designed to reduce potential that such an inconsistency might arise (Department of Health and Ageing, 2003).

Under Australia's Constitution, any state law found to be inconsistent with Commonwealth law, would be prevented from operating to the extent of that inconsistency. The inclusion of this policy principle mechanism in the Act provides certainty to those states or territories that might otherwise be concerned that the Gene Technology Regulator's findings might override its jurisdiction's legislation, for example, legislation establishing non-GM designated areas (see Department of Health and Ageing 2003).

The RIS also explained that the policy principle does not create any GM or non-GM areas. Rather, the policy recognises these areas if they are designated by state or territory law. The policy principle only has an effect when a state or territory creates designated areas under its own law.

However, the introduction of this policy principle does affect the Gene Technology Regulator's consideration of licence applications. Under the The Act, the Gene Technology Regulator is prevented from issuing a GMO licence if he or she is satisfied that to do so would be inconsistent with the principle.

4.2.5 State government moratoria

As explained in chapter 1, the Gene Technology Regulator in 2003 licensed the commercial release of certain GM herbicide resistant canola on the basis that it would pose little risk to either human health or the environment. However, before any commercial GM canola crops could be planted, all States except Queensland (and the Australian Capital Territory) made use of the Gene Technology (Recognition of Designated Areas) Principle and put in place moratoria that effectively prohibited their commercial release. At the time of writing, most moratoria were expected to be in place until at least 2008 in NSW, Victoria, South Australia and Western Australia, 2009 in Tasmania and in place until the Minister's notice is given in the ACT (see Table 2 in section 1.2).

The question of why the moratoria were put in place is a complex one. In Victoria, the decision was justified on the basis that:

...there were still deep divisions and uncertainty within industry, the farming sector and regional communities about the impact of GM crops on market... The OGTR has determined GM canola is safe for human health and the environment but the State Government has a responsibility to consider market implications for our exporters.”¹¹

In the Victorian Legislative Assembly, the Agriculture Minister the Hon Bob Cameron noted high levels of community and industry concern about the release of GM-canola, with particular respect to its possible impact on markets for grains and dairy products, and suggested that it was only prudent to retain a moratorium on the commercial release of GM canola for four years, after which market trends should become more clear.¹²

Very similar justifications for the moratoria were made by Governments in most of the other states. Following are quotes drawn from the second reading speeches relating to the various moratorium bills as they were being passed through the other state parliaments:

NSW – ‘This legislation has been introduced to allow more time for the New South Wales farming and the broader community to be assured that the introduction of GM canola will not adversely impact on the marketing, both domestically, but more importantly, overseas, of non-GM canola.’ (The Parliamentary Secretary to the Minister for Rural Affairs, Local Govt., Emergency Services, and Lands Mr Neville Newell).¹³

South Australia – ‘The bill will give effect to the Government's commitment to ensure that genetically modified crops are regulated in South Australia. This is necessary to protect existing and future markets for farm produce until supply systems are developed to provide the necessary segregation and identify preservation of crops.’ (The Minister for Agriculture, Food and Fisheries the Hon Rory McEwan).¹⁴

Western Australia – ‘[The minister] stated that the moratorium would allow issues associated with market impacts, identity preservation and feasibility and the risks and benefits of establishing GM and GM free zones to be fully debated in the community’ (Parliamentary Secretary to the Minister for Agriculture, Forestry and Fisheries; the Midwest, Wheatbelt and Great Southern; Parliamentary Secretary to Minister for the Environment and Heritage and Water Resources Mr Francis Logan).¹⁵

¹¹ Media Release, Department of Premier and Cabinet, March 25, 2004.

¹² Victorian Parliamentary Hansard, Legislative Assembly, 1 April 2004, Assembly, pg 527.

¹³ New South Wales Hansard Articles, Legislative Assembly, 30 May 2003.

Tasmania – ‘The bill is based on the present situation in relation to markets for GM and non-GM products. Given that this is an area where markets are still determining their position, and demand for GM versus non-GM has not yet been identified, the act will be reviewed if a change in market forces and attitudes warrants a different approach to GMOs in Tasmania’ (The Minister for Primary Industries and Water The Hon Steven Kons)¹⁶

The report by the Agriculture and Food Policy Reference Group (2006,) suggested that the state moratoria were inconsistent with the national approach to gene technology regulation (see chapter 1). Furthermore, it noted that the moratoria were imposing a heavy cost on Australian farmers and the economy, as well as causing the withdrawal of research expertise and investment in biotechnology, particularly with regard to GM crops, in Australia.

State governments were sensitive to a lack of unity in the views of agricultural producers in addition to the campaigns mounted by anti-GM activist groups. In response, the state and territory governments imposed moratoria on the grounds of market acceptance concerns.

In considering the moratoria, the Statutory Review of the Gene Technology Act 2000 and the Gene Technology Agreement found it was unusual for the states and the ACT to intervene in such a way, given the lack of evidence of a market failure:

The Review noted that it was most unusual for States to intervene in the agricultural market in this manner and this type of intervention would usually only be taken when there is strong and compelling evidence of a market failure. However, after examining a number of reports identified during consultations, the Review could not find documentary support for a market failure. The Review noted that choice of variety was usually left to the farmer who would consider market signals, customer preferences, production costs and yield among other influences (Statutory Review Panel, 2006, p.96).

The implementation of the moratoria by most state and territory governments has brought into question whether the current Inter-Governmental Agreement on Gene Technology is operating in an effective and nationally consistent manner. The Review concluded that:

...the moratoria were causing detrimental rather than beneficial impacts and were counterproductive as they were preventing the collection of information that would otherwise assist farmers in making a choice on whether to grow GM crops. The Review also concluded that the moratoria were having negative effects on the agricultural and research sectors (Statutory Review Panel, 2006, p.96)

The Review also noted that:

.....there was no evidence of adverse impacts on markets, and concluded that the moratoria were having detrimental rather than beneficial impacts. It recommended that all jurisdictions should reaffirm their commitment to a nationally consistent scheme, including a nationally consistent approach to market considerations, and work together to develop a national co-existence framework (Gene Technology Ministerial Council, 2006, p.4).

¹⁴ Parliament of South Australia, House of Assembly Hansard, 29 March 2004

¹⁵ Parliament of Western Australia, Hansard, House of Legislative Assembly, 7 May 2003.

¹⁶ Parliament of Tasmania, House of Assembly Hansard, 21 April 2004

Thus, while the actions of the government's in introducing the GM moratoria are legally legitimate; they have created an inconsistent policy outcome. As implied by the Statutory Review's recommendation there would be benefits from all jurisdictions reaffirming their commitment to a nationally consistent scheme, including a nationally consistent approach to market considerations and the development of a national co-existence framework.

4.2.6 Review of the Gene Technology Act

As noted above, the first Statutory Review of the Gene Technology Act and the Gene Technology Agreement was completed in 2006. While the review found that, overall, the Act and the national scheme were working well, it recommended changes to improve the operation at the margin. The Review's recommendations have been considered by the Australian, state and territory governments and with only a few exceptions the recommendations were agreed to or agreed to in-principle.¹⁷ Legislation to reflect this decision was passed by the Commonwealth Parliament in June 2007 and received Royal Assent on 28 June 2007. The state and territory governments will use their best endeavours to introduce corresponding amending legislation into their Parliaments before 31 December 2007.

One of the outcomes of the Australian, state and territory governments' response, is that all governments have reconfirmed their commitment to a nationally consistent scheme for gene technology. However, Queensland, Tasmania, Western Australia and South Australia do not agree with the Statutory Review Panels' recommendation to commit to a nationally consistent transparent approach to market considerations. Further, the Tasmanian and Western Australian Governments, did not accept the recommendation for the Commonwealth and states to work together to develop a national framework for co-existence of non-GM and GM crops to address market considerations. However, on 27 April 2006, the GTMC agreed to refer these issues to the Primary Industries Ministerial Council for consideration and advice on a consistent transparent framework for the co-existence of both non-GM and GM crops by the end of 2007. This framework can then be assessed for adoption by the States, who wish to do so, as each jurisdiction's moratorium ends or is, reviewed (National Gene Technology Ministerial Council, 2006, p.21).

Another of the outcomes of the statutory review and the Governments' response has been a change in the Gene Technology Regulator's evaluation process for the DIR. The evaluation process has been split to distinguish between field trials and commercial release. The new timeframes are:

- 150 days for a limited and controlled release for which the Regulator has not identified a significant risk
- 170 days for a limited and controlled release for which the Regulator has identified a significant risk
- 255 working days for other releases (OGTR website <http://www.ogtr.gov.au/ir/process.htm>, accessed 2 July 2007).

The Governments' in their response to the Review's recommendations on this matter state that:

...different timeframes for each category reflect the different intensity of the evaluations to assess the health and safety of people and the environment, which is dependent on the features of the two types of releases (Gene Technology Ministerial Council, 2006, p.11).

¹⁷ The Governments' full response to the Review may be found at [http://www.health.gov.au/internet/wcms/publishing.nsf/content/CE28398A33AF02E6CA25707400080A57/\\$File/Governments%20Response%2027%20Oct%2006%20Final.pdf](http://www.health.gov.au/internet/wcms/publishing.nsf/content/CE28398A33AF02E6CA25707400080A57/$File/Governments%20Response%2027%20Oct%2006%20Final.pdf)

4.3 International regulatory approaches

International approaches to the regulation of gene technology were reviewed by the Statutory Review of the Gene Technology Act 2000 and the Gene Technology Agreement 2001. The Statutory Review Panel (2006) examined the gene technology frameworks of the European Union, New Zealand, Japan, the United States of America, Canada, Argentina and China.

The Statutory Review Panel found that with the exception of New Zealand, most countries had used their existing product regulatory authorities to approve GMOs. As a result, most of the countries do not have a single overarching piece of legislation governing gene technology regulation. Thus, of the countries reviewed, New Zealand at the one extreme has worked to centralise and consolidate its gene technology regulation, while at the other extreme Japan has a system of voluntary guidelines with respect to GMOs rather than a legislative framework.

Reflecting the decentralised approach in most countries, the Statutory Review Panel found that applications for approval to use GMOs often require more than one agency's or authority's approval. The Review Panel gave the following examples:

.. in Canada, approval may be needed from three agencies to approve the GMO plant for release into the environment, for use as livestock feed and for use as human food; whereas in the US, approval may be needed from both the US Department of Agriculture and the Food and Drug Administration if a plant GMO is intended for general release for the purpose of being used for human food. However, in most countries there are different application processes depending on the intended use of the GMO (Statutory Review Panel, 2006, p.91).

As part of the approval process, all countries reviewed by the Panel require that safety assessments of the potential risks to the environment and to human health must be undertaken. These assessments are undertaken by either the applicant or a relevant authority or both. The information required for submission in the assessment is generally set down in the legislation. The Statutory Review Panel noted that Canada and the European Union set down particularly detailed guidelines as to the requirements. Public consultation is a feature of the assessment and approval process in most of the countries reviewed by the Panel.

Table 10 reproduces the Statutory Review Panel's summary of findings for each of the country's gene technology regulatory framework. The Panel after reviewing the alternative regulatory frameworks considered that it had found no innovative approaches to regulating GMOs that would improve Australia's gene technology legislative arrangements. The Panel considered that Australia's approach to regulating GMOs was rigorous, transparent and accessible. The Review noted:

...from the community's perspective, the Australian system is one of the most rigorous, transparent and accessible. It is also flexible enough to deal with rapidly changing technology for the near future (Statutory Review Panel, 2006, p. 92).

Table 10 Summary of Gene Technology Regulation in selected countries

Country	
European Community	The EC has issued a number of directives that relate to different uses with GMOs and GM products. • In relation to the use of GMOs, there are three relevant directives: – contained use of GM micro-organisms; – deliberate release of GMOs into the environment and placing on the market; and – protection of workers from the risks of exposure to biological agents. • In relation to GM products, there are also a number of relevant directives: additives in feeding stuffs; medicinal products; and novel food.
New Zealand	One primary piece of legislation covers research with GMOs and release of GMOs into the environment in New Zealand — the Hazardous Substances and New Organisms Act 1996 (HSNO Act). • The Agricultural Compounds and Veterinary Medicines Act 1997 (ACVM) contains additional provisions that relate to approvals for Agricultural Compounds and Veterinary Medicines that are or contain genetically modified new organisms, while the Medicines Act 1981 contains provisions relating to approvals required in relation to human medicines that are or contain genetically modified new organisms. Foods and food products that are, or contain genetically modified new organisms, or produced using gene technology, must also be assessed for safety for human consumption in accordance with the Australia New Zealand Food Standards Code. • There is no single statutory link (or one-stop shop) between legislation to regulate GMOs and GM products (such as GM therapeutics and agricultural and veterinary chemicals). However, in 2003, the HSNO Act and Medicines Act together were amended to improve the overall effectiveness of the operation of the HSNO Act and reduce compliance costs (while not increasing risk to the public health or the environment), and provide a fast-track process for low-risk organisms, including low-risk GMOs, used in both human and animal medicines, and for use in emergencies. • Exports of genetically modified organisms that constitute living modified organisms as defined under the Cartagena protocol on biosafety to the Convention on Biological Diversity are regulated under the Imports and Exports (Living Modified Organisms) Prohibition Regulations 2005 to the Imports and Exports (Restrictions) Act 1988.
Japan	Controls on gene technology are essentially voluntary and different aspects of gene technology are overseen by different portfolios: Ministry of Agriculture, Forestry and Fisheries oversee GMOs for use in agriculture; Science and Research Agency oversees experimentation in all research facilities other than University research facilities; Ministry of Education, Culture, Sports and Science Technology oversees experimentation in University research facilities; and in relation to GM products, the Ministry for Health, Labour and Welfare approves GM products such as pharmaceuticals, medical treatments and foods.

Country	
The United States	Several pieces of legislation regulate GMOs: Federal Plant Pest Act—7 USC 7B; Federal Insecticide, Fungicide, and Rodenticide Act—7 USC 136; Federal Food, Drug and Cosmetic Act—21 USC 9; Toxic Substances Control Act — 15 USC 53. • The system requires permits to be issued by the relevant regulatory authority. Depending on the nature of the GMO, permits may be required from more than one authority. In general: the US Department of Agriculture Animal and Plant Health Inspection Service (APHIS) has the broadest authority over transgenic plants and has responsibility for determining whether such a plant poses a threat directly or indirectly as a plant pest; the US Environmental Protection Agency (EPA) regulates microbial and plant pesticides, new uses of existing pesticides and novel micro-organisms; and the US Food and Drug Administration (FDA) is responsible for ensuring the safety of all food (by enforcing tolerances in food set by EPA), feed, and human and veterinary drugs. • There is no statutory link between each of the regulators. There are a number of agencies under the US Department of Agriculture involved in the regulation of GMO-related matters: • APHIS has responsibility for determining whether a genetically engineered organism is as safe for the environment as its traditionally bred counterpart and can be freely used in agriculture, and regulates field-testing, interstate movement, and importation of genetically engineered organisms through the Biotechnology Regulatory Services (BRS). • The Agricultural Marketing Service (AMS) is responsible for administering plant variety and seed laws in the U.S., which also cover biotechnology-derived seeds, and for government activities regarding certification and labelling of agricultural seed for varietal purity for international trade. • The Agricultural Research Service (ARS) is USDA's in house science agency. The agency's biotechnology research includes introducing new traits and improving existing traits in livestock, crops, and micro-organisms; safeguarding the environment; and assessing and enhancing the safety of biotechnology products. • The Cooperative State Research, Education, and Extension Service (CSREES) administer the Biotechnology Risk Assessment Research Grants Program (BRAG) which supports the development of science-based information regarding the safety of introducing into the environment genetically-modified plants, animals, and micro-organisms. • The Economic Research Service (ERS) conducts research on the economic aspects of the use of genetically engineered organisms, including the rate of and reasons for adoption of biotechnology by farmers. • The Food Safety and Inspection Service (FSIS) is the public health agency in the U.S. Department of Agriculture responsible for ensuring that the nation's commercial supply of meat, poultry, and egg products is safe, wholesome, and correctly labelled and packaged including animals involved in biotechnology. The National Agricultural Statistics Service (NASS), as the fact finder for agriculture, provides information on the adoption of biotechnology crops (specifically corn, cotton, and soybeans).

Country	
Canada	Canada does not have a single piece of legislation that regulates GMOs. Most of the legislation applicable to biotechnology addresses specific product categories, and pertains both to biological and non-biological processes and products. - The main agencies involved in the regulation of GMOs are Agriculture and Agri-Food Canada, Environment Canada and Health and Welfare Canada. The relevant legislation includes: Canadian Environment Protection Act 1999 (CEPA) (covers those uses not covered by other legislation); Feeds Act (feeds); Fertilisers Act (supplements); Health of Animals Act (veterinary biologics); Seeds Act (plants with novel traits); Pest Control Products Act (microbial pest control agents); and Food and Drugs Act (drugs, cosmetics, medical devices, and novel foods from both plant and animal sources); Plant Protection Act (importation of unapproved plants with novel traits). - The release of novel substances (this includes GMOs) into the environment is governed by the above-mentioned Acts. There are also directives that provide guidelines for applying for the release of novel substances into the environment. In addition, there are directives for the release of novel plant and animal organisms for both confined and unconfined releases. The Canadian Food Inspection Agency, under the Agriculture and Agri-Food Portfolio, is the main agency responsible for the release of novel substance into the environment and is divided into Sections. One of the sections, the Plant Biosafety Office has carriage of assessing applications for the confined and unconfined release of novel substances (plant) into the environment. If the novel plants could be used as a feed (for livestock or laboratory animals), then the Feed Section of the Canadian Food Inspection Agency assesses the application for release. Applications for release of novel substances that could be used as food for humans are assessed by the Department of Health. Where necessary, approval for release of a novel substance may require approval from more than one authority/agency.
Argentina	The Secretaria de Agricultura, Ganaderia, Pesca y Alimentos (SAGPyA)/Secretary of Agriculture, Livestock, Fisheries and Food is responsible for granting licences to dealings with GMOs. SAGPyA bases its decisions on the recommendation of an expert committee: Comisión Nacional Asesora de Biotecnología Agropecuaria (CONABIA)/The National Advisory Committee on Agricultural Biosafety. These rules are part of the general regulatory system governing the agricultural existing regulations in Argentina related to plant protection (Decree-Law of Agricultural Production Health Defense. N° 6704/66 and its amendments), seeds and phytogenetic creations (Seed and Phytogenetic Creations Law, N° 20.247/73 and its regulatory Decree), and animal health (Law of Veterinarian Products. Supervision of the creation and commercialisation. N° 13.636/49).
China	The Ministry of Agriculture appears to be mainly responsible for the formulation and implementation of regulations in relation to biotechnology and biosafety. - Other interested government agencies include the State Environmental Protection Agency, the Ministry of Public Health, the Inspection and Quarantine Agency, the Ministry of Foreign Economy and Trade and the Ministry of Sciences and Technologies. - All these agencies' views are represented on State Ministerial Council. - Day-to-day regulation of GMOs is administered by the Office of Agricultural Genetic Engineering Biosafety Administration. However, in late 2005, the Chinese Government formed a new body to administer GMO regulation. - The Ministry of Public Health is responsible for food safety in relation to GMOs intended for that purpose. - The Ministry for Sciences and Technologies is responsible for biotechnology research. - Genetic engineering work is classified into four classes of risk to human health and ecological environment: none; low; intermediate; and high. - The risk classification is determined by the relevant agencies on the State Ministerial Council.

Box 1 Global GM regulation

Cartagena Protocol on Biosafety

On 29 January 2000, the Conference of the Parties to the Convention on Biological Diversity adopted the Cartagena Protocol on Biosafety.

The Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. It establishes an advance informed agreement (AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory. The Protocol contains reference to a precautionary approach. The Protocol also establishes a Biosafety Clearing-House to facilitate the exchange of information on living modified organisms and to assist countries in the implementation of the Protocol. There are two main decision making procedures in the Protocol:

- A procedure enabling countries to obtain necessary information to take decisions about the import of GM agricultural commodities for use as food or feed, or for processing, produced from crops grown in another country. The basis for this procedure is the Biosafety Clearing House (BCH) containing risk assessment information submitted on specific GMOs. The aim is to facilitate the exchange of scientific, technical, environmental and legal information on GMOs.
- An Advanced Informed Agreement (AIA) procedure for GM products (such as seeds and plants for growing) that are intended to be deliberately introduced into the environment of the importing country. The procedure requires the exporter of the product actively to notify the potential importer in advance before proceeding with the export, and to wait for the decision of the importing country based on risk assessment information provided in the notification. Information about the operation of this procedure will also be posted to the BCH.

In 2006 there are 132 member countries of the Protocol.

World Trade Organization

The WTO is relevant to trade in GMOs in three ways:

- non discrimination: in the event that a country imposes a trade barrier against a certain product, this barrier must be equally enforced across all similar or like products, both domestic and foreign;
- 'like' or substantially equivalent' products: these must be subject to the same regulations in a particular regulatory jurisdiction, regardless of their origin or the production and processing methods [PPMs] used in their production; and
- general exemptions: for example, food safety and environmental protection regulations.

There are two main agreements under the WTO which are relevant to consideration of GMOs:

- the agreement on sanitary and phytosanitary measures (SPS); and
- the agreement on Technical Barriers to Trade (TBT) which deals with technical, non-safety, food and quality issues such as nutrition analysis, grading and packaging (including labelling).

It is worth noting that until now, in the 9 years since the first commercial release of GM crops there have only been two disputes examined under WTO rules. One was raised by Argentina, the US and Canada against the EU (faulting “undue delay” in approving GM products) and one raised by Thailand against Egypt (on import prohibition on canned tuna with soybean meal).

Codex Alimentarius Commission

Another source of potential international standards and guidelines on GM crops is the Codex Alimentarius Commission (Codex). This is a joint agency of the Food and Agriculture Organisation and World Health Organisation (both agencies of the United Nations), established in the 1960s with a current membership of 165 countries.

Codex is responsible for determining harmonised global food standards including codes of practice, guidelines and recommendation pertaining to food safety and quality. Once a standard is developed, which can take several years, member countries are expected to adopt the standard into national food regulations.

Codex has guiding principles, including:

- to protect the health of consumers and to ensure fair practices in food trade;
- to promote the international co-ordination of all food standards among international governmental and non-governmental organisations;
- to establish priorities for food standards and to initiate and guide the development of draft standards along with appropriate organisations.

There is a Codex ad hoc Intergovernmental Task Force on Foods Derived from Biotechnology which is expected to report this year. It is developing guidelines for the conduct of food consisting of, or derived from, animals that have been modified by modern biotechnology. These guidelines will be based on scientific evidence, risk analysis and having regard, where appropriate, to other legitimate factors relevant to the health of consumers and the promotion of fair trade practices. These guidelines will support the Principles for Risk Analysis of Foods Derived from Modern Biotechnology, which only covers plants and micro-organisms, which were adopted by Codex in 2003.

4.4 Summing up

The Australian canola industry, as part of the wider Australia grains industry, is subject to industry self-regulation which includes complying with standards and protocols designed to ensure the industry operates efficiently and effectively, and therefore continues to be internationally competitive. The industry's self-regulation body, NACMA, after consultation with its members, has acknowledged that it has an important role to play in the development of processes and systems that would allow commercial activities to continue to operate efficiently in an environment where GM and non-GM crops coexist.

Since 2001, Australia has had a uniform, national approach to the regulation of gene technology, which is underpinned by the Gene Technology Act and the Gene Technology Agreement between Commonwealth, state and territory governments. The regulation is designed to protect environment and the health and safety of humans by identifying and if necessary managing any risks posed by or as a result of gene technology. Considerations such as economics and marketing have been intentionally excluded from the regulatory framework. The intention of the Act was that these issues should not detract from human health and environmental safety issues.

The first Statutory Review of the Gene Technology Act and the Gene Technology Agreement was completed in 2006. The Review found that overall the Act and the national scheme were working well. However, concern was expressed that the moratoria were causing detrimental rather than beneficial impacts and were counterproductive as they were preventing the collection of information that would otherwise assist farmers in making a choice on whether to grow GM crops.

While the review considered that the national system was working well overall, some changes to the arrangements were recommended at the margin. With only a few exceptions these recommendations were agreed to or agreed to in-principle by the Commonwealth, state and territory governments. The Commonwealth Parliament's Gene Technology Amendment Act 2007, which reflects these decisions, received Royal Assent in June 2007. However, a major issue of concern for some of the parties was the need for a consistent transparent framework for the co-existence of both non-GM and GM crops. This matter has been referred to the Primary Industries Ministerial Council for consideration and advice. The Council's findings on the most appropriate framework are expected by the end of 2007.

Other countries approach to the regulation of GM technology and genetically modified organisms vary considerably. While there are numerous differences, all countries require safety assessments of the potential risks to the environment and to human health. In most countries, other than Australia and New Zealand, the regulatory approach does not involve an overarching piece of legislation governing gene technology regulation, and as a result applications for approval to use GMOs often require more than one agency's or authority's approval. The Statutory Review of the Gene Technology Act and the Gene Technology Agreement considered that from 'the community's perspective, the Australian system is one of the most rigorous, transparent and accessible'.

5 Market acceptance of GM Canola

This chapter considers market acceptance of GM canola. Section 5.1 considers arguments for and against GM canola and/or GM crops, which have been put forward by consumers and a number of organisations with strong views one way or the other. Section 5.2 presents evidence on consumer attitudes to GM crops in Australia and internationally, while section 5.3 considers food producers and industrial users attitudes to GM crops, including GM canola.

5.1 Who wants GM Canola and who doesn't?

5.1.1 Consumer representatives

From a consumer point of view there are arguments for and against GM canola. Choice Magazine (2003) included the following arguments for GM foods which are representative of the information reported in the Australian media:

- Improving on nature - increasing the nutritional value, aesthetic appeal, shelf life and processing potential of foods
- Feeding a hungry world - pests or disease resistant crops could result in less wastage, greater yields, more economical production and ultimately lower-cost food. Crops modified for drought-resistance or larger yields could also benefit people in some developing countries
- Environmental benefits - pests or disease resistant crops could reduce the need for chemical sprays
- Medical benefits - Foods could be modified to provide edible vaccines.

Arguments against GM canola and GM food in general centre on the concern that there is little information about the potential effects of genetic modification and the risk that a new technology might have, particularly on the health of the population, given that GM food is consumed. Choice Magazine summarises the arguments against GM food as:

- Health concerns
- Environmental concerns
- Ethical concerns.

These concerns are explored in greater detail in Box 2.

Box 2 Typical consumer arguments against GM foods

- Health concerns
 - The effectiveness of antibiotics could be reduced
 - New allergens could be created inadvertently, and known allergens could be transferred from traditional foods into genetically modified variants
 - Science can't actually prove that GM foods are safe.
- Environmental concerns
 - GM crops could accidentally cross-pollinate non-GM crops
 - Genes that code for resistance to chemical herbicides could be transferred from GM plants to weeds
 - genetic modification of some crops to permanently produce the 'natural biopesticide'

Bacillus thuringiensis (Bt) could encourage the evolution of Bt-resistant insects, rendering the spray ineffective

- Growing GM crops on a large scale may have implications for biodiversity, the balance of nature, wildlife and the environment.
- Ethical concerns
 - Using genes from animals in plant foods, poses ethical, philosophical and religious problems for many people.
 - Animal welfare can be compromised due to health problems.
 - When new GM organisms are 'created', the company takes out a patent on them to protect their commercial interests
 - The consequences of concentrating the ownership of food resources into the hands of a small number of multinational corporations
 - We are producing more than enough food to feed the world, and it's often the politics and economics of access and distribution that leads to food shortages and hunger.

Data source: Choice Magazine (2003)

5.1.2 Growers and other organisations

In Australia there are a number of organisations that support the introduction of GM canola while others do not. Organisations and a summary of their official stance on GM canola are listed in Box 3. Arguments against the introduction of GM canola to Australia are primarily focussed on the need to protect farmers and consumers from modified crops given that little is known about their potential impact. Proponents of GM canola argue that GM crops will benefit Australia's canola supply chain.

Box 3 Examples of organisations for and against GM canola

Opponents of GM canola

- Biological Farmers of Australia –

‘GMOs are expressly prohibited within the organic production chain in Australia. Much uncertainty remains about GMOs, foods and the environment. Organics takes a precautionary approach to GMOs. The vigilant work of BFA has been aimed, in concert with other concerned groups, at protecting the interests of industry members and broader consumer concern regarding GMOs in foods.’ (Organic Annual Report 2004 Ed 2 , p 14)
- Network of Concerned Farmers - an Australia wide network of conventional and organic farmers who are concerned about the economic, environmental and social impacts of genetically modified crops. The concerns about GM canola relate to:
 - impact on the non-GM growers
 - costs and liability
 - contamination and loss of markets for all agricultural produce
 - herbicide resistance
 - environmental impacts
 - patents
 - corporate control of farms (www.non-gm-farmers.com/about.asp).
- Greenpeace – produces the True Food Guide which rates food brands by their policy on genetically engineered ingredients. Greenpeace claims that Australians are increasingly refusing GM and that companies are responding by improving their rating. Greenpeace provides a list of companies that have improved their rating (www.truefood.org.au/guide2.html).

Proponents of GM canola

- Australian Oilseeds Federation – provided there are realistic market specifications and production procedures established to manage crop and environmental impacts, issues regarding GM gene flow should not be a barrier for co-existence. The Australian Oilseeds Federation encourages the ongoing debate over the introduction of GM canola. The Australian Oilseeds Federation believes that the provision of sound, scientifically based and accurate information is critical to ensuring that the industry makes the best decision about its future (2004, p2).
- Producers Forum for Biotechnology Access – members include grain and oilseed growers from Western Australia, dried fruit, dairy, grain and beef producers from Victoria, and cotton, grain, cattle, sheep and oilseed growers from New South Wales and Queensland. The Forum is driven by ‘frustration at the attitude towards GM crops of some of the major commodity companies and State Governments in Australia, and feel that Australia is missing out on possibly the most beneficial technical advance the world has ever seen’. The Forum is concerned that Australian farmers are being ‘forced to abstain from possibly the most important technology in our lifetimes’ (www.producersforum.net.au).

- Western Australian Farmers Federation - revised its policy in February 2007 to support the lifting of the moratoria:
‘WAFarmers - supports the lifting of the current State Government moratorium on the commercial release of GMOs. WAFarmers supports new Australian and State Government tolerance levels of 0.9 per cent in crops and 0.5 per cent in seeds. WAFarmers supports the OGTR and its charter to protect the health and safety of Australians and the Australian environment.’
- National Farmers’ Federation –
‘National Farmers’ Federation recognises the potential of biotechnology (including gene technology) as a valuable tool within agricultural production systems. The responsible and strategic application of biotechnology within Australia’s production systems will result in significant benefits for Australian farmers, the environment, consumers and the Australian economy as a whole’ (www.nff.org.au/pages/sub/biotechnology_position.pdf)
- Grain Growers Association – ‘GGA champions the application of technology to all farming systems in the quest to make grain growing more sustainable and profitable. Australian cotton farmers have been able to successfully integrate GM crop technology into their farming operations and GGA believes grain growers should be given the opportunity to trial similar technology’ (www.graingrowers.com.au/gga_activities/advocacy/gm_technology).
- Grains Council of Australia – ‘Agricultural biotechnology is critical to the future of Australian plant industries, as it will allow greater freedom for the development of more efficient, environmentally and socially sustainable food, fibre and industrial product value chains...’ (www.grainscouncil.com/).
- The NSW Farmers Association supports the immediate removal of the NSW moratorium for GM crops and supports further investigation into market implications, legal liability and receipt of independent data in the meantime (www.nswfarmers.org.au)

5.2 Consumer attitudes

Consumer attitudes toward GM food in Australia and around the world are generally negative. ABARE (Foster, 2001, p 29) cited a number of studies that all pointed toward a negative consumer attitude to GM food. For example, the Angus Reid Group (2000) found that:

- Half of all consumers in all but one of the countries surveyed had a negative attitude toward the adoption of GM foods. Between 44 and 58 per cent of these consumers say they understand little about GM foods. The understanding is greatest in Germany, Australia and the UK, and the least in the United States and Brazil;
- United States consumers with negative views grew from 45 per cent of the population in 1998 to 51 per cent in 2000. This trend was more pronounced in Canada with 45 per cent of consumers having a negative view in 1998 and 59 per cent in 2000.

However, some surveys indicate that attitudes appear to be changing as the information regarding GM foods becomes more widespread. The impact of information regarding GM foods on consumer preferences has been the subject of a number of studies in Australia and overseas.

5.2.1 Attitudes in Australia

The Productivity Commission (Stone, Matysek and Dolling. 2002, p 23) found that amongst other things, consumer attitudes to genetically modified food are dependent on several factors including 'the information available to consumers about GM food, which is likely to vary with health and environmental safety concerns, and community understanding of the technology'.

This study was confirmed by ABARE (Foster, 2001, p 30) who researched consumer willingness to accept GM products and suggested that a cycle may exist where consumers' concerns grow as they 'become aware of the prevalence of GM products in the food chain, but then concerns diminish as knowledge about gene technology increases'.

A report by Biotechnology Australia (Cormick, 2003, p 1) supports a different conclusion. From three surveys in 1999, 2001 and 2003 to investigate consumer attitudes towards GM foods and crops, Biotechnology Australia concluded that consumer attitudes were becoming more negative particularly as they relate to GM food:

'the moral acceptability of GM crops that were modified to be pest-resistant fluctuated from 66 per cent in 1999 to 72 per cent in 2001 and 69 per cent in 2003, while the moral acceptability of using gene technology in food and drinks has dropped from 62 per cent in 1999 to 59 per cent in 2001 and further still to 53 per cent in 2003.'

The report noted, however, that 'a comparative analysis of four major environmental concerns in 2003 showed that GM foods was a lesser concern (11 per cent) than pollution (35 per cent), nuclear waste (26 per cent) and greenhouse issues (17 per cent)' (Cormick, 2003, p 2), suggesting that whilst consumers have concerns regarding GMOs they have a greater concern regarding other community issues.

This finding was supported in later research by Biotechnology Australia:

When compared to other current societal issues (e.g. pollution of the environment), the largest proportion of people rated GM foods and cloning as the least concerning issues (Eureka Research 2005, p 8).

The same report found:

'...that most people believed GM food crops to be unnecessary and unnatural, and to pose unknown health risks' (Eureka Research, 2005, p 13).

Despite this negative opinion of GM crops:

'It was clear from the qualitative research that GM food is not an issue to which most people give much thought in making everyday purchasing decisions, despite beliefs about the widespread availability [and consumption] of GM food [in Australian supermarkets]' (Eureka Research, 2005, p 24).

Biotechnology Australia (2005, p 17) also reported that Australian consumers were accepting of GM foods if they provided a consumer benefit:

‘The highest value for the broad population is perceived consumer benefit, and the presence or absence of a perceived benefit will alter support or rejection of a GM food, with the impact being greater the larger the personal impact of the benefit.’

And furthermore, if general attitudes for and against GM foods were graphed, the graph would show a broad spread, with strong numbers at the extreme opposition and support, but the majority of Australians would be located in the middle (2005, p 17).

Biotechnology Australia's latest survey of public attitudes to GM foods found that attitudes tend to vary with the type of food being considered (Biotechnology Australia 2006). For example, in respect of a generic question about eating any GM foods, only 37 per cent of respondents indicated they were likely or very likely to do so. Whereas in response to the question “Are you likely to eat GM cooking oils that contain less cholesterol?” 48 per cent of respondents indicated they were likely or very likely to do so (see Table 11).

Table 11 Australian's attitudes to eating GM foods in 2006

Are you likely to eat	Very Likely	Likely	Neither	Unlikely	Very Unlikely
Any GM food?	9per cent	28per cent	9per cent	28per cent	26per cent
Packaged food containing one GM ingredient, such as GM soy or GM canola oil?	11per cent	37per cent	8per cent	25per cent	19per cent
GM cooking oils that contain less cholesterol?	14per cent	34per cent	8per cent	24per cent	20per cent
Vegetables modified with plant genes for drought resistance?	11per cent	29per cent	10per cent	29per cent	21per cent

*Note: The survey was conducted by ACNielsen and involved a sample of 1,410 persons
Data source: Biotechnology Australia, <http://www.biotechnology.gov.au/index.cfm?event=object.showContent&objectID=E6F3DEA2-960B-38D5-E1BADCE724181C1B>*

The Biotechnology Australia survey also found that there is strong support amongst Australians for government regulation of GM crops and the labelling of GM foods for choice. Similarly there was considerable support amongst those surveyed for segregation and for GM crops to be trialled in Australia to assess suitability to Australian climatic conditions (see Table 12).

Table 12 Australian's support for regulation, research, segregation and trialling GM crops in 2006

Do you support.....	Strongly support	Support	Neither	Oppose	Strongly oppose
Regulation of GM crops by the Government?	34per cent	33per cent	11per cent	13per cent	9per cent
Labelling of GM foods for choice?	67per cent	23per cent	4per cent	4per cent	3per cent
Research into what GM crops suit Australian climates? Growing	34per cent	35per cent	9per cent	11per cent	11per cent
GM crops separately to non-GM crops?	30per cent	33per cent	11per cent	13per cent	12per cent
Trialling GM crops to see if they are suitable to Australian climates?	27per cent	43per cent	7per cent	13per cent	11per cent

*Note: The survey was conducted by ACNielsen and involved a sample of 1,410 persons
Data source: Biotechnology Australia, <http://www.biotechnology.gov.au/index.cfm?event=object.showContent&objectID=E6F3DEA2-960B-38D5-E1BADCE724181C1B>*

The recent research by Biotechnology Australia and others suggests that Australian consumers do have concerns regarding GM foods. Some consumers are aware and accepting that they are likely to consume GM modified foods, and acceptability of GM foods appears to depend on the type of food or specific benefits attributed to biotechnology.

5.2.2 Attitudes in other countries

Consumer preferences seem to be dependent on the country of residence, with consumers in countries that have adopted GM crops being more accepting of GM foods than consumers in other countries. For example, the United States, Argentina, Canada and China adopted GM technology and in 2002 accounted for 99 per cent of all GM crop production, whilst there have been far less plantings of GM crops in Australia, the European Union and Brazil. Correspondingly, Biotechnology Australia notes that United States consumers are more willing to accept GM foods and crops than consumers in Europe (Cormick, 2003, p 2).

Their findings are based on a comparison of a 2001 Eurobarometer study and a 2002 study by the United States Food Policy Institute. These studies found that:

‘70 per cent of Europeans did not want GM foods, with 59.4 per cent believing they had adverse effects on the environment. By comparison, 74 per cent of people in the US approved of GM foods which were less expensive or tasted better’ (Cormick, 2003, p 2).

These findings are supported by the Danish Institute of Agricultural and Fisheries Economics (Nielsen, Thierfelder and Robinson. 2001, p 3) who report that farmers in North America, Argentina, Mexico and China are rapidly adopting the new GM crop varieties as they become available, and citizens in these countries are generally accepting this development. A New Zealand study also found that GM is more acceptable in North America than within Europe (Saunders and Catagay, 2001, p 3).

However, the USDA's (2006) report titled *The First Decade of Genetically Engineered Crops in the United States*, found several United States surveys which indicate that some United States consumers are concerned about GM food (Table 13). However, it was noted that these concerns had not had a large impact on the market for foods containing genetically modified ingredients in the United States. The USDA report also reviewed a number of studies into consumers' willingness to pay for foods which were GM free or to avoid foods with GM ingredients. Overall most consumers were found to be willing to pay more for non-GM food. However, an important exception was GM “golden rice” which may help combat dietary shortages of Vitamin A (see Table 14). On the other hand the USDA concluded that at least some consumers did not require a discount to buy foods containing GM. It was also noted that willingness to pay studies does not necessarily reflect what consumers actually do when they are purchasing food:

While surveys and willingness-to-pay studies provide some insight into consumer opinion, they often do not reflect how consumers will behave in a real market situation when purchasing goods and services. Each food product has many characteristics, such as taste, color, and ripeness. The presence of a biotech-derived component is only one attribute. Empirically, it is difficult to determine what percentage of the price a consumer is paying for a specific characteristic. There are no published studies that indicate how many consumers have actually paid a premium to purchase non-GE [non-GM] goods, but there is some empirical evidence of the types of goods that are currently offered for sale to consumers. In the United States, many products contain GE ingredients, and the demands for these products apparently have been unaffected by negative opinions about biotechnology expressed in surveys. A few specialty brands are marketed as “GE free,” but they represent a small percentage of supermarket sales. In some other countries, however, strong consumer demand for non-GE products has limited the availability of GE items (USDA 2006).

Saunders and Catagay (2001) confirmed the trend in Australia that attitudes toward GM foods are changing and that this change depended on the amount of available information regarding GM foods and the perceived reliability of the source of that information.

Table 13 Surveys on consumer perceptions of foods containing GM ingredients^d

Country/ Population	Surveyed by	Details
The United States	Pew Initiative/Mellman Group, 2003, 2004	27 per cent favour introduction of GM foods; 47 per cent oppose. However, 64 per cent disagree with the statement, "genetically modified foods should not be allowed to be sold even if the Food and Drug Administration believes they are safe," and 28 per cent feel that those foods should not be allowed, even if the FDA feels they are safe.
The United States	Gallup, 2001	52 per cent support the application of biotechnology; 38 per cent oppose the use of biotechnology in food production.
The United States	Hallman, 2004	47 per cent approved or leaned toward approval of the use of GM to make plant-based foods, 41 per cent disapproved or leaned toward disapproval, and 12 per cent were unsure.
United States	IFIC, 2005	50 per cent said likely to buy and 45 per cent said not likely to buy GM produce modified to taste better or fresher; 64 per cent said likely to buy and 32 per cent said not likely to buy GM produce modified to require fewer pesticide applications.
Beijing, China	Hu and Chen, 2004	67 per cent were concerned about biotechnology.
Nanjing, China	Zhong et al., 2002	40 per cent would buy GM foods; 17 per cent would not; 34 per cent don't know.
Beijing, China, Shijiazhuang, China	Ho and Vermeer, 2004	40 per cent were willing or rather willing to consume foods containing GM-based ingredients, 51 per cent were neutral, and 9 per cent were rather unwilling or very unwilling to consume the foods.
Flemish speakers in Belgium	Verdurme and Viaene, 2003	15 per cent opposed to GM foods; 34 per cent perceived small risks and small benefits; 26 per cent perceived moderate risks and moderate benefits; and 23 per cent perceived large benefits.
United Kingdom	2003 GM Public Debate Steering board	86 per cent preferred not to eat GM foods; 8 per cent happy to eat GM foods.

^dData source: USDA 2006, Compiled by USDA's Economic Research Service.

Table 14 Willingness to pay for foods that do not contain GM ingredients¹

Country	Food	Study	Willingness-to-pay premium
The United States	Vegetable oil	Tegene et al., 2003	In experimental auctions, consumers willing to pay 14 per cent more for non-GM food.
The United States	Potatoes	Loureiro and Hine, 2002	Customers willing to pay 5 per cent more for non-GM food.
The United States	Golden rice	Lusk, 2003	Customers willing to pay 93 cents for GM "golden rice" with added vitamin C, 65-75 cents for regular rice.
United Kingdom	All foods	Burton et al., 2001	Customers indicated willingness to increase food budgets by 26-129 per cent to avoid GM foods.
Italy	*	Bocaletti and Moro, 2000	Consumers' willing to pay a positive amount for GM attributes; 66 per cent did not require a premium to consume GM foods.
United States, France, Germany, and United Kingdom	Beef fed with GM feed	Lusk et al., 2003	U.S. consumers willing to pay \$2.83 and \$3.31 per lb. to avoid GM; European consumers \$4.86 to \$11.01.
United States, United Kingdom	Breakfast cereal	Moon and Balasubramanian, 2001	Survey found 56 per cent of UK consumers willing to pay a premium to avoid GM compared with 37 per cent of U.S. consumers.
Norway, United States, Japan, Taiwan	Vegetable oil	Chern et al., 2002	Norwegian students were willing to pay \$1.51 (55-69 per cent premium) per litre for non-GM vegetable oil, U.S. students were willing to pay \$1.13 (50-62 per cent premium), Japanese students were willing to pay \$0.88 (33-40 per cent premium), and Taiwanese students were willing to pay \$0.45 cents (17-21 per cent premium).
China	Rice	Li et al., 2002	80 per cent of consumers did not require a premium to purchase GM rice and on average were willing to pay a 38-per cent premium on GM rice and a 16-per cent premium for GM soy oil.
Norway	Bread	Grimsrud, et al., 2004	Consumers required discounts of 37-63 per cent to buy GM bread; One-fourth willing to buy with no discount.
Australia	Beer	Burton and Pearse, 2002	Younger consumers would pay \$A 0.72 less and older consumers \$A 0.40 less for beer made with GM barley.
Canada	*	West et al., 2002	83 per cent of consumers ascribed a lower value to several GM foods.
France	*	Noussair et al., 2004	35 per cent of consumers were unwilling to purchase GM foods, and 42 per cent were willing to purchase them if they were less expensive.
United States	Oil, chips, and potatoes	Rousu et al., 2004	Consumers reduced their demand by an average of 7-13 per cent for each food product having 1 per cent and 5 per cent tolerance levels for GM material relative to GM-free food.

¹ See also Lusk et al. (2005), who summarize a set of 25 studies including 57 GM valuation studies and report that, on average, consumers are willing to pay a positive premium for GM-free foods.

*This study did not focus on a specific food item.

Data source: USDA 2006, Compiled by USDA's Economic Research Service

5.2.3 Impacts of consumer preferences

The attitudes of consumers towards GM foods can have an impact on public policy that impacts on all segments of the supply chain from commercialisation of new crops to food labelling regulation. A model (Nielsen, Thierfelder and Robinson, 2001, p 34) of global trade flows found that changing consumer attitudes toward GM foods will have substantial effects on trade, production and prices not only for the crop sectors that benefit directly from the new technology, but also for the sectors that use these crops as inputs in production.

ABARE noted that even in the countries that have adopted GM there has been consumer resistance which has slowed down commercialisation of new GM varieties (see Foster, Berry and Hogan, 2003, p 3). ABARE reports that commercialisation of GM wheat and rice has been held back as a result of uncertainty about consumer acceptance:

Uncertainty about consumer acceptance throughout the world has also meant that GM wheat and rice varieties that have been developed in North America and Asia have not been commercialised (ABARE 2007a, p.2).

Furthermore, ABARE reported it is noticeable that while countries like China and Australia have adopted GM cotton, there has not been the same adoption of GM food crops (Foster, Berry and Hogan, 2003)

The University of Nebraska (2005, p 13) noted that in response to the negative consumer attitude towards GM foods, that the European Union imposed stringent approval processes for new genetically modified products and required labelling on all products containing more than 0.9 per cent of genetically modified ingredients. Imports of GM products into Europe have been severely restricted and as a result United States exports to Europe have been limited.

Labelling of GM products is now mandatory in a number of countries as illustrated in Table 15 which shows the level as a percentage of GM content at which labelling is required. There is evidence that the introduction of labelling laws has encouraged markets to source GM free food (Saunders and Catagay, 2001, p 3). Prior to labelling laws being introduced in Japan, GM-free sources were being targeted for future supply in anticipation of these laws. Presently there are 31 Japanese foods subject to labelling requirements.

Table 15 GM food labelling: level of GM content

Country	Level of GM content (per cent)
United States	Not required
Japan	5
South Korea	2
Australia	1
New Zealand	1
European Union	0.9

Data source: University of Nebraska

There is additional evidence that consumer preferences have resulted in marketing efforts designed to elicit higher prices for GM free foods. Several studies have noted that price premiums for GM-free products are beginning to appear with two tiered pricing structures developing in some markets such as Japan, Korea, and Europe.

The Australian Oilseeds Federation reports that Australia is well positioned to capture any market premiums for non-GM canola. However, there is little indication of market premiums for Australia's non-GM status in Japan or China nor the increasingly important markets of Pakistan and Bangladesh (2003, p2). Furthermore, despite losing access to the European Union market because of its GM status, Canadian canola exports have increased following the commercial release of GM varieties reaching record levels in 2000- 01.

As noted in chapter 2, ABARE (2007) found some evidence of price premiums being earned on canola exported to the European Union

5.3 Potential Australian users of GM - canola current attitudes

5.3.1 Growers

As reported in Box 3 above, grain growers and their representative bodies have mixed views on the acceptance of GM canola and GM crops more generally. There is some evidence that better information on GM canola could turn around the views of some detractors. For example, GM information forums organised in 2005 by Crabtree agricultural consulting in Western Australia suggest that once farmers have been provided with information on GM canola their attitudes change. Crabtree agricultural consulting advised ACIL Tasman that 49 per cent of the 146 people (88 per cent being farmers) who attended the five events and completed a survey questionnaire did not support the use of the technology prior to the information forum. At the end of the information forum only 6 per cent of these people did not support the technology (information provided by Bill Crabtree and also reported by Criddle 2005).

5.3.2 Edible oil processors

Oil refiners have been exposed to GM vegetable oils for some time, as approximately 40 per cent of the Australia cotton crop is currently planted to GM varieties. GM cottonseed is not segregated from conventional varieties when the seed is ginned.

Cottonseed oil is not widely used in the retail sector because of its quality characteristics. Its main use is in the food service industry as frying oil. However, refiners advised that some margarines have been reformulated to avoid the use of cotton seed oil, where it was previously included in blends. Although Food Standard 1.5.2 does not require the labelling of highly refined foods, where novel DNA and/or protein has been removed (vegetable oils produced from an expeller/solvent extraction process) the major oil refiners have indicated a preference to purchase canola oil produced from non-GM canola.

5.3.3 Industries dependent on livestock feed rations (dairy, meat and eggs)

A number of industries depend to some degree on the use of edible oils or oilmeals as part of the production process. The main sectors identified by the consultants in this context are dairy, meat and eggs. The Australian dairy industry produced output worth \$3.34 billion at the farm gate in 2005-06 (ABARE, 2006a). Similarly, the value of cattle slaughtered for beef during 2005-06 exceeded \$7.2 billion, with sales of live cattle to foreign markets raising a further \$358 million in 2005-06 (DAFF, Australian Food Statistics, 2006). It should be noted that approximately 50 per cent of all cattle bred and slaughter for beef production are finished in feedlots (ALFA, 2006), implying the significant dependence of the cattle industry on livestock feed rations. Clearly, these industries have an interest in the implications of the potential introduction of GM canola insofar as they perceive that this may affect their production processes or consumer demand (including overseas markets).

Canola oil and meal are often included in the feed rations of cows, although inclusion rates differ slightly if the aim is to increase milk production (dairy cows) rather than fattening (beef cows). Manufacturers and exporters have indicated to the consultants that there is no regulatory requirement for labelling for the use of GM animal feeds either in Australia or in countries that have important export markets for our dairy products, such as Japan and European Union.

Whilst there is no regulatory requirement in these markets some overseas buyers have sought assurance that GM animal feeds are not used and dairy manufacturers have introduced restrictions on the use of GM animal feeds by dairy farmers. The level of tolerance demanded by the dairy processor is determined by the market they are selling to and the status of competitors. These market requirements are achieved through an integrated systems approach based on supplier contracts, on-farm quality assurance programs and stock feed vendor declarations.

Submissions from stock feed manufacturers presented to the ACIL Tasman for its study on GM canola in Victoria make it clear that protein meals are a small proportion of a cow's total diet if incorporated with grazing pastures. It is also clear (from a submission made by a prominent stock feed manufacturer to the aforementioned report prepared by the consultants) that unsegregated, and therefore nominally GM, imported soybean meal and domestically produced cotton seed meal is currently utilised in some dairy rations, with no apparent market impacts.

Table 16 details the breakdown of a typical dairy cow diet. Table 17 outlines the resultant percentage of the cow's diet that would be GM based on the level of GM in the protein concentrate source at varying levels.

Table 16 Dairy cow intake breakdown

	per cent
Total dairy feed intake	100per cent
Grass proportion of feed	75per cent
Concentrated feed proportion	25per cent
Protein in concentrate feed (15-18per cent)	17per cent
Protein proportion of total feed	4.25per cent

Source: Farm Horizons 2003

Table 17 GM dairy cow supplement scenarios

	GM per cent in total feed
GM per cent in total feed	
Protein is 100 per cent GM	4.25per cent
Protein is 50 per cent GM	2.13per cent
Protein is 10 per cent GM	0.43per cent
Protein is 5 per cent GM	0.21per cent
Protein is 1 per cent GM	0.0043per cent

Source: Farm Horizons 2003

The United Dairy Farmers Ltd submission to a previous ACIL Tasman study on GM canola in Victoria (ACIL Tasman, 2005) contained the following statement:

The Australian Dairy Council's policy recognises the significant potential benefits from the use of Gene Technology in varying forms along the whole supply chain and the need for its development and application, in an integrated systems approach. The industry recognises the rights of consumers and customers' choice in product selection based on sound information being available. The industry also recognises the rights of producers, processors and retailers to have choice in the application or otherwise of Gene Technology for their business needs.¹⁸

Milk processors (Bonlac, Murray Goulburn and National Foods), while generally supporting GM technology, have in the past expressed three major areas of concern:

- maintenance of the ability to source non-GM feed from credible suppliers who will provide certification and substantiated assurances;
- ensuring that the introduction of the technology does not reduce their competitiveness in international markets; and
- maintenance of choice between GM and non-GM so that the dairy industry can realise market opportunities if identified.

In 2006 the Australian Dairy Industry Council (ADIC) announced that it was reviewing its GM policy (Robert Poole, Dairy Farmers, Policy Director, ABC 2006). The Australian Dairyfarmers Limited's magazine, the Australian Dairyfarmer, also reported that a review of GM use by the industry is underway and that it will be completed before the end of state governments GM moratoria in 2008:

The Australian Dairy Industry Council (ADIC) formed a sub-committee that has begun the process of a review. This includes gathering the best information about the science, the market and the view of other stakeholders.

The work of the ADIC sub-committee is ongoing and recommendations will be ready for consideration before the review of State moratoria (The Australian Dairyfarmer, 2006, reported on the ADF website)

Perhaps as a result of the expected benefits of GM crops for the sector a resolution to reverse the Victorian Dairy industry's anti-GM policy was proposed from the floor at the United Dairyfarmers of Victoria (UDV) annual conference in 2006. At the June 2007 Annual conference an amendment to that 2006 motion was put and the motion 'that the UDV adopt the draft ADIC GM technology policy as its official policy whilst recognising the marketing requirements of the dairy industry' was carried. The Victorian Farmers Federation reported that the members debated the motion for almost an hour, and that the motion 'was carried by an overwhelming majority' (Victorian Farmers Federation 2007).¹⁹

¹⁸ From the written submission to the Independent Canola Review Committee September 2003.

It is our understanding that Japanese domestic milk producers feed a substantial amount of soybean meal to their herds. This meal is sourced from the United States and is not considered to be GM-free. The NZ Government's decision to allow the test and possible eventual use of GM crops and pastures (subject to health and environmental assessments). It is not clear if this testing will likely lead to some adoption of GM crops and pastures in that country.

Our analysis is that a segregated and identity preserved grain handling system will provide the dairy industry with the assurances and flexibility it needs. The Stock Feeds Manufacturing Association is working to develop identity preservation and quality assurance systems and strongly recommends that industry standards be set for identity preservation systems in the whole grain supply chain.

Genetically modified feed ingredients

The stockfeed industry already uses significant quantities of GM protein meals in their rations, with around 60 per cent currently coming from GM sources, notably soybean meal. The bulk of Australia's soybean meal is assumed (by the industry and users) to be GM, as the bulk is imported from the U.S. All of the cottonseed meal is also considered to be GM, as over 80 per cent of Australian cotton (Glover et al 2005) is planted to Bt varieties which are not segregated due to lack of demand for non-GM cottonseed meal or oil.

Dairy industry – Milk processors (liquid and manufacturing) currently limit the inclusion of genetically modified feed ingredients to 5 per cent in lactating dairy cow feeds. The primary reason given by the dairy industry to stock feed manufacturers for GM feed ingredient constraints are the requirements of export markets.

Pig Industry - The Australian pig industry has flagged the inclusion of GM feed ingredients in pig feed as an area requiring review. Australian Pork Limited has stated its position on GM food, specifically that support for the endorsement of GMO crops should be withheld until issues such as consumer resistance, market concerns, segregation, costs, farmers rights and co-existence have been addressed (APL, 2005).

Poultry Industry – At this stage the Australian Poultry Industry Association, which represents the chicken meat industry, has shown no objection to the use of GM feed ingredients. Similarly the egg layer industry has not expressed concern over the use of GM feed material in chicken rations.

Conversely niche poultry markets (including turkeys and ducks) have expressed concern over the use of GM feed ingredients. In some cases turkey and duck producers have requested diets to be GM ingredient free (tolerances have not been specified).

¹⁹ Victorian Farmers Federation, '2007, UDV members cast their vote on GM', Media Release, 20 June 2007, http://www.vff.org.au/main/index.php?option=com_content&task=view&id=334&Itemid=49

Box 4 AFLA – Food safety a bigger issue

The position of the Australian Feed Lotters Association is one of ambivalence to GM feed rations.

While there is no price differential they will choose non-GM feed. If or when it costs more to source non-GM, then they will use GM feed.

They see no market advantage in utilising non-GM feed, particularly in Japan.

Several reasons are put forward to explain this situation. GM is not high on the list of issues for beef purchasers - BSE and substitution are more important

Major competitors in the Japanese market, including domestic producers, use GM in rations. The Japanese do not want to preclude any significant supplier from their market — similar to the situation for wheat.

5.3.4 Honey

There are no known detrimental effects on honey bees from the pollen or the management practices associated with the currently licensed varieties of GM canola.

Pollen, which commonly occurs in honey at concentrations ranging from 20,000 to 100,000 grains per 10 g (and rarely to a maximum of 5 million grains per 10 g), is thought to represent the most likely source of GM material in bee products. If we assume that an “average” pollen grain weighs 0.03 mg, these values are equivalent to honey containing 0.0006 per cent to 0.03 per cent by weight, with a maximum value of 1.5 per cent (Malone, 2002).²⁰

GM food labelling legislation in most markets allows for the adventitious presence of GM material without requiring GM labelling. At present the tolerances for labelling are:

- 0.9 per cent in the European Union;
- 1 per cent w:w in New Zealand and Saudi Arabia;
- 3 per cent w:w in South Korea; and
- 5 per cent w:w in Japan (Malone 2002).

The honey bee association has a comprehensive quality assurance program that is being extended to all members.²¹ Under Australian labelling standards honey is allowed 1 per cent of GM material if that presence is unintentional as is stated in the user guide to food standard A18/1.5.2 (Food Standards Australia 2002).

For the honey bee industry, some strategies to reduce adventitious presence in honey products suggested by New Zealand studies which are applicable to GM canola may include:

- separating GM and non-GM crops (effectiveness will depend on bee flight distances);
- targeting GM plants where the transgene is not expressed in pollen, or the transgene occurs only in chloroplasts, or where pollen or flower formation is blocked; and
- removing pollen grains from honey by filtering after harvest.

²⁰ Ministry of Agriculture and Forestry NZ, Literature review of Genetically modified plants and bee products.

The New Zealand Ministry of Agriculture and Forestry (2002) reported that:

Some shipments of honey from Canada, where bees can forage on GM canola and GM food labelling is not required, were rejected by Germany in 1999. This event has received considerable publicity, but the Canadian Honey Council reports that this market has now recovered. Reports of difficulties with honey exports from Argentina, the United States or Australia could not be found.

5.3.5 Industrial usage – biodiesel, oleochemicals, etc.

As indicated above, canola oil can be modified by chemical or other processes to produce a range of novel end products. In terms of the history of the Australian chemical industry, the use of agricultural by-products as raw materials progressed from the use of slaughter yard bone material for the manufacture of fertiliser, to animal-fat derived chemicals. Processed animal fat was reacted with caustic soda to produce soap, glycerine and crude fatty acids (stearin and olein).

Vegetable oils (notably olive oil) are used in the production of a number of branded soaps. Canola oil can also be used in the production of soap, but in the continued presence of cheap tallow (and the possibility to import cheap oil and coconut palm products supplied by the Malaysian and Indonesian oleochemicals industries) it is usually uneconomical to do so, and there is little marketing advantage associated with including canola oil in the formulation (unlike olive oil).

Some of the more specific traditional niche markets of rapeseed oil are related to the high erucic acid content of rapeseed (not canola). These include lubricants and slipping agents. Canola (as defined as being low in erucic acid and glucosinolates) will therefore be unlikely to be used in these products.

One potentially major application of canola oil in the future is that of biodiesel. The world's largest user of biodiesel, France, already stipulates that diesel must contain a 5 per cent component of biodiesel (which is often referred to as rapeseed methyl ester or RME – the term canola is not used in Europe). At present, however, the use of canola oil in biodiesel is still negligible in Australia.

The issue of segregation and identity preservation has not really arisen in relation to industrial uses of canola. This may be because canola oil is seen as a more green or sustainable substitute for traditional chemical feed stocks such as petroleum and tallow. In terms of biodiesel, the 90 per cent life-cycle reduction in carbon emissions, and other benefits, certainly appear to have outweighed negative associations that customers may have had in relation to genetic modification.

²¹ Information provided in discussions with the Australian honey bee industry representative.

5.4 Organics

As explained in Box 3 the Biological Farmers of Australia expressly prohibited GMOs within the organic production chain in Australia. Organic producers tend to take a precautionary approach to GMOs.

ABARE's report *Potential Impacts from the Introduction of GM Canola on Organic Farming in Australia* (2007) suggests that the coexistence of GM and organic canola was likely to have a very limited impact on the related organic industries, largely due to standards but also due to the availability of sufficient organic resources.

ABARE points out that in the first instance, consumers and farmers are protected by organic farming standards that prohibit the intentional and non-intentional use of GM products in organically certified products. With respect to specific industries, standards also protect the organic canola industry as it is a requirement that organically grown canola is isolated from non-organic canola. Organic honey producers are also protected as conventional canola is not even a suitable for organic honey production. This coupled with general the general prohibition outlined above compounds low impact. With respect to the livestock sector, the impact is expected to quite low as organic livestock have sufficient non-GM meal for feed. Additional protection is provided in that GM crops and animals and organic crops are animals are not permitted in parallel farming systems (i.e. farming systems with certified organic and conventional products).

Given Australia's stringency in organic certification relative to its major organic trading partners, Australian organic farmers can generally satisfy export organic requirements at the same time as satisfying domestic requirements.

5.5 Summing up

Market acceptance of GM canola is currently mixed. A number of groups and organisations support GM canola, whilst others do not. Broadly speaking, consumers as a group would appear to be more sceptical of GM canola than producers, although there are exceptions to this rule. There also appears to be a large segment of opinion, both amongst producers and consumers, which is currently neither strongly supportive nor strongly opposed to GM canola. For this group, it is likely that more information on GM canola, for example on specific health or environmental benefits, could sway opinion.

6 Canola and Australian farm businesses

The chapter considers the role of canola in Australian farm businesses. The chapter firstly considers how canola crop agronomy has impacted on yields and other factors such as crop rotation. The chapter also discusses some challenges to the production of canola, particularly weeds, and the role of the non-GM triazine tolerant (TT) canola variety. The agronomic benefits and risks of GM canola including yields and gross margins achieved are considered in sections 6.2 and 6.3. Results of economic modelling which has examined the impact of adopting or not adopting GM crops from an economy wide perspective are discussed in section 6.4. The last section sums up the chapter's findings.

6.1.1 Agronomic factors and canola's role in Australian crop rotation

Several important developments in canola crop agronomy that occurred mainly through the 1990s can be identified as having had a major impact on yield and profitability of the crop for farmers. These were important factors behind the rapid expansion of canola in Australia, and are further discussed in the sections below. Colton and Potter (1999) identify an impact on other crops in the rotation via an associated increase in liming, and give this account of the emergence of canola in Australia:

The crop monitoring program Canola Check was introduced in New South Wales in the late 1980s and was taken up in other states in the early 1990s. It played a major role in giving new growers the confidence to take on a crop that had the reputation of being hard to grow. It also brought their crop agronomy and marketing skills up to speed quickly and had them achieving high yields and practicing price risk management at an early stage. The growth of the canola industry provided a major impetus to the use of lime to ameliorate acid soils. This is particularly so along the central and southern slopes of New South Wales where aluminium and manganese toxicity were becoming more common. Canola proved to be a crop which was adversely affected by soil acidity but was profitable enough to provide good returns, even after the cost of applying lime. Most longer-term canola growers on these soils have now limed their whole farm and are enjoying increased productivity from all their crops and pastures.

Rotation and canola

There are a number of elements in addition to the simple value of the oil and meal derived from the crop that underpin the use of canola as a rotation crop. For example, the crop has been associated with benefits related to soil management, pest control and yield increases in crops that follow it in the rotation.

Gunstone (2004) summarizes the role and value of canola in the cropping system as follows:

Oilseed rape provides a convenient alternative for cereal-based agricultural systems as it is broad leaved and can be grown as a break crop for a continuous run of cereals. Minimal investment in new machinery is required as the bulk of oilseed cultivation operations can be conducted with existing cereal equipment. The timing of work required for oilseed rape throughout the season allows arable work peaks to be spread throughout the year... Oilseed rape has beneficial effects for following crops in rotation. Its deep rooting tap root opens up the soil and can improve soil structure, particularly of clay soil, and break up of compacted subsurface layers of soil. Nutrient residues left after the crop has been harvested improve the fertility of the soil with subsequent benefits for the following crops. Yields of wheat crops following oilseed rape can typically yield around 35% more than in a continuous cereal sequence... The breakdown of glucosinolates from Brassica residues left in the soil may also have a biocidal effect and aid control of pests and soil diseases (pp. 2-3).

In its 1999 advice sheet on the risks of growing wheat on wheat rather than with a rotation break crop (pulses, legumes or canola), the GRDC highlighted that agronomists were divided on the subject. The GRDC pointed to trials that had shown a yield disadvantage of wheat on wheat. Nevertheless, the GRDC pointed out that some agronomists have had a lot of success with wheat on wheat and some agronomists considered a wheat on wheat crop sequence could be a viable short term option if there was a good understanding of the risks and adequate preparation.

More recently, GRDC's Ground Cover (2006) reported that in recent years there has been a reduction in the plantings of Canola in lower-rainfall farming areas and some of the traditional NSW canola heartland, but not in the west or in southern Victoria where canola is used as a rotation crop had taken off. There was an expectation that many of the growers that had moved away from canola were going to return canola to their rotations because of the benefits it brings for weed control and carry-over nitrogen. It appears that

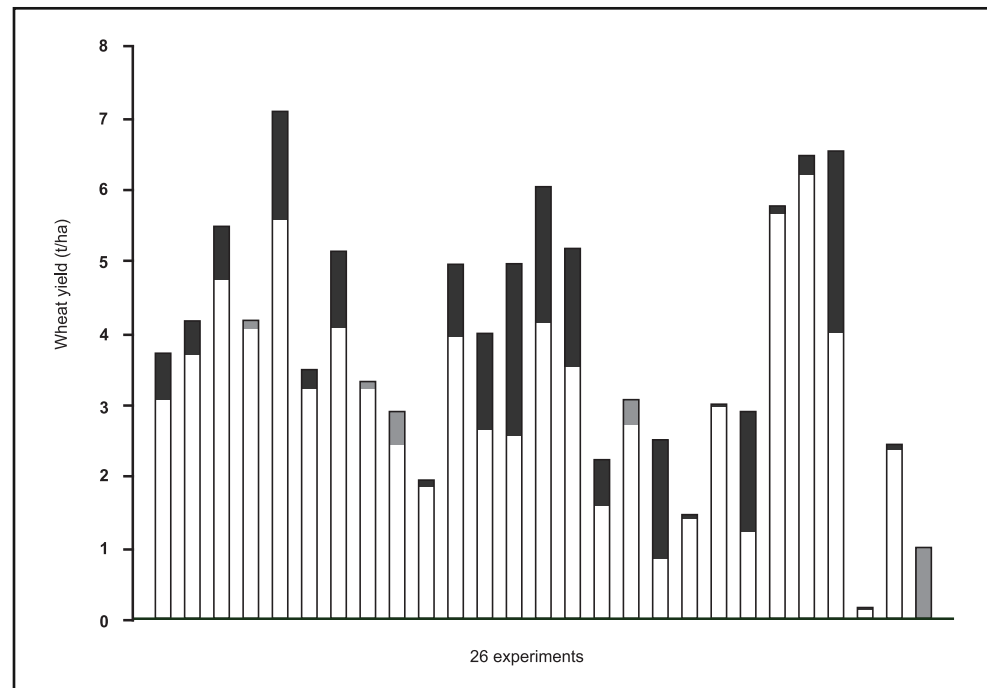
...many growers are starting to feel the impact of decreasing or removing canola from their rotation, through lesser wheat yields in a continuous cereal program and in weed-management problems (GRDC 2006).

Canola break crop trials have continued since those reported by GRDC in 1999. Dr John Kirkegaard, a CSIRO Plant Industry expert, was reported in the Ground Cover article as saying that trials from 1988 to 2003 in southern NSW indicated that wheat gross margins and yields tended to be higher with a canola wheat crop rotation compared to wheat on wheat crops.

In 35 field experiments from 1988 to 2003 in southern NSW, wheat planted after canola yielded an average of 20 per cent more than wheat planted after wheat," he says. "Significant yield benefits were seen in 90 per cent of cases. The gross margin for canola-wheat was 25 per cent higher than for wheat-wheat and 70 per cent of the increased gross margin came from the better wheat after canola" (GRDC 2006).

Reflecting Dr Kirkegaard's recently reported views; Angus, Kirkegaard and Peoples (2001) report the results of 26 experiments where wheat was grown after a canola break crop. In a majority of cases, the wheat yield was higher after growing a canola break crop than after growing a wheat crop (see Figure 11). It was found that the average yield benefit following canola in the 26 experiments reviewed was 20 per cent. However, the benefit varied from minus 16 per cent to a high of 197 per cent.

Figure 11 Yield of wheat growing after wheat (open bars) and the increase (blue bars) or decrease (grey bars) of yield for wheat growing after canola in 26 experiments in southern Australia (26)



Data source: Angus, Kirkegaard and Peoples (2001).

Importantly, Angus, Kirkegaard and Peoples found that legume break crops can often result in a higher wheat yield than the canola break crop. However, the attractiveness of canola as a break crop is the relatively high margins available:

Despite the lower yields of wheat after canola than after legumes in experiments, there has been more recent adoption of canola than grain legumes (except in the northern sand plain of WA, where lupin is well adapted) presumably because the gross margin for canola is greater than for the grain legumes used for feed grains. Even though returns for canola are relatively high, the economic value of substituting canola for wheat was made up of 27 % from the canola itself and 73% for the following wheat. Another benefit of canola is the more reliable response to fertiliser N by the following wheat crop (Angus, Kirkegaard and Peoples, 2001).

Walton et al. (1999) make the following observations regarding canola production in Australia:

Canola in Australia is rather different to crops in most other countries. Here, the crop is usually sown in autumn, but with spring type varieties which do not need vernalisation (winter chilling) to flower although vernalisation speeds up flowering. Crops ripen in late spring or early summer, after a 5-7 month growing season. This compares to the situation in Europe, where most of the crop is of winter varieties which require vernalisation, are sown in early autumn, and harvested late in the following summer, nearly 12 months after sowing. In Canada, by contrast, early maturing varieties are sown in spring, and develop rapidly in the long days to be harvested before the onset of winter, with less than a 4 month growing season. Perhaps the nearest equivalent to the Australian crop is that in the Indian subcontinent, where early maturing varieties are grown over the cooler winter period. The early rapeseed crops in Australia (1960s and 1970s) were Canadian varieties, which were poorly adapted to the short days of our winter-spring season. Australian researchers have therefore been at the forefront of work to understand flowering responses, and in tailoring the new varieties to our environment. The aim of breeders has been to retain just enough of the responses to delay the onset of flowering to produce a satisfactory leaf canopy. This interception of most incoming solar radiation gives a yield potential to match the environmental resources available. The growth of canola and its seed yield in Australia is almost always limited by the amount of water available to the crop, at least during maturation. The development of ways to measure and improve water use efficiency has therefore been critical in making the most of our environment (p. 1).

Walton et al. (1999) summarised some of the key agronomic features of canola in Australia as follows:

- Canola in Australia is mostly grown in winter-dominant rainfall environments with spring type varieties which do not need vernalisation (winter chilling) to flower although vernalisation speeds up flowering.
- The aim of breeders has been to retain just enough of the responses delaying the onset of flowering to produce a leaf canopy intercepting most of the incoming solar radiation to give a yield potential to match the environmental resources.
- Rain-fed crops are sown usually after the first significant rains in April or May, the growth and yield is then determined by the amount of water available.
- The water use efficiency for potential seed yield is usually between 10-12 kg/ha/mm.
- The key agronomic factors in canola production are linked with increasing whole-farm profitability and sustainability using canola in rotations with cereals and pulses.

Recently the impact on hydrological factors, particularly drainage, of planting continuous canola and other crops was investigated by a CSIRO team based at the Black Mountain Laboratory in Canberra (Wang et al., 2004). This investigation found that:

'Although continuous wheat leads to slightly greater mean annual water uptake and deep drainage (69 mm/yr), wheat, canola and rotation perform similarly in terms of water use, and the results are sensitive to management.'

In other words, canola would not appear to confer either an advantage or disadvantage vis-à-vis other annual and perennial crops in regard to water use. Finally, in commenting specifically on the role of canola in rotations, Norton Kirkegaard, Angus and Potter (1999) note the following key points:

‘Canola is one of the most profitable crops available to grain growers in southern and western Australia and rotations have been adapted to accommodate it. Canola provides large yield benefits to subsequent cereal crops by providing an effective disease break.

Canola was often grown as the first crop after pasture but now canola is often used more intensively in rotations, posing problems of herbicide use, disease carryover and increasing potential of blackleg in existing cultivars.

The sulfur, gypsum and lime required to grow canola in many regions are providing a benefit to crops and pastures grown in rotation.’

6.1.2 Weeds and triazine tolerant canola

More intensive use of canola in the rotation has in some regions led to new challenges, including disease carryover. In Western Australia, wild radish has begun to pose a significant challenge for the cultivation of canola. It is a weed that is closely related to canola, thus precluding some traditional chemical treatment options – the herbicides which could be used to eliminate the radish would similarly affect the canola.

In recent years, triazine tolerant (TT) canola has provided an option to growers. TT canola has been widely adopted by growers despite penalties associated with lower grain yield and oil content, as well as lower resistance to blackleg and persistence of triazine herbicides in the soil. In 1999, TT canola accounted for almost 50 per cent of the Australian crop (OGTR, 2002):

In the majority of cases, TT canola is chosen because the weeds (particularly Brassicaceae species) present cannot be controlled in the conventional varieties. In 1998, it was estimated that the areas of TT canola grown were 90% in Western Australia because *R. raphanistrum* is a major problem, and 25 – 30% in South Australia, Victoria and New South Wales ... TT canola represents a challenge to integrated weed control, especially in Western Australia, where there are concerns about widespread use of triazine (Group C) herbicides. Parts of Western Australia have a long history of triazine herbicide use, particularly in lupins and there is already evidence of atrazine resistant annual ryegrass (*Lolium rigidum*) and triazine resistance in wild radish.

The emergence of triazine resistance in wild radish and ryegrass is therefore likely to present a significant future challenge to canola growers. One option would be to introduce canola varieties that are resistant to Roundup, but as these are GM varieties that option cannot currently be exercised as a result of the State and ACT Governments’ moratoria.

6.2 Agronomic benefits and risks of GM canola

6.2.1 Break crop benefits

Breakcrop benefits likely to be unchanged

In section 6.1.1 the agronomic benefits of growing traditional canola crops were identified. It can be expected that the two GM canola varieties approved by the OGTR would have similar agronomic benefits as a break crop for wheat. However, at this stage no break crop trials have been conducted using the GM canola varieties. Canola yield result from the GM canola trials are discussed in section 6.3.

6.2.2 Weed control benefits

An important benefit for farmers from the introduction of the two GM canola varieties is better control of weeds. Weeds can be a major problem for canola crops. As discussed previously, Triazine-tolerant canola cultivars have been developed through traditional breeding approaches. This canola cultivar has been widely adopted in those areas of Australia where *Raphanus raphanistrum*, *Fumaria* spp. (fumitory) and *Capsella bursa-pastoris* (shepherd's purse) are a major problem, as the herbicide is particularly effective against these weeds. However, the evidence is mounting that weeds are becoming resistant to Triazine.

Further, a random survey has shown that while Triazine-tolerant canola reduces the problem in some species, the cultivars are not completely removing weed problems in canola (see Table 18). The survey found that:

Some weeds such as *Lolium rigidum*, *Hordeum* spp. and *Raphanus raphanistrum* were present in a large proportion of the TT crops In contrast, other species (eg *Capsella bursa-pastoris* and *Fumaria* spp) were less prevalent in the TT crops. It is surprising that densities of some weed species were similar or even greater (eg *Sisymbrium orientale* and *Polygonum aviculare*) in the TT crops, compared with the conventional cultivars. In contrast, *Arctotheca calendula*, *Vulpia* and *Capsella bursa-pastoris* had lower [prevalence] in the TT crops (Lemerle, Blackshaw, Potter, Marcroft and Barrett-Lennard, 1999).

Table 18 The percentage incidence of the most widespread weed species recorded at 62 sites and the average weed density (plants per m²) in TT and conventional canola

Weed species	Incidence at field sites (per cent)	Proportion of TT canola (as a per cent of total sites where the weed occurred)	Average weed density in TT canola (plants per m ²)	Average weed density in conventional canola (plants per m ²)
<i>Lolium rigidum</i> (annual ryegrass)	86	40	26	20
<i>Arctotheca calendula</i> (capeweed)	66	27	2	7
<i>Polygonum aviculare</i> (wireweed)	53	24	31	4
<i>Avena</i> spp. (wild oats)	47	21	6	2
<i>Fumaria</i> spp. (fumitory)	42	11	5	7
<i>Vulpia</i> spp. (silver grass)	32	30	11	29
<i>Hordeum</i> spp. (barley grass)	21	46	1	2
<i>Sisymbrium orientale</i> (Indian hedge mustard)	21	23	15	5
<i>Capsella bursa-pastoris</i> (shepherd's purse)	21	8	0	12
<i>Raphanus raphanistrum</i> (wild radish)	16	60	4	2

Data source: Lemerle, Blackshaw, Potter, Marcroft and Barrett-Lennard (1999).

The authors noted that TT canola is not the magic bullet some have imagined:

There is a perception that TT-canola will provide a “magic bullet” weed control solution for growers. However, this evidence shows that weeds survive even with the TT canola weed control practices, thus producing seed and replenishing the seedbank in the soil, and exacerbating subsequent weed infestations. The survival of such large numbers of weeds will facilitate the development of herbicide resistance in these weed species. This is of particular concern given the suspected discovery of a population of *Raphanus raphanistrum* in WA resistant to triazine herbicides in 1998, with a further 53 populations with confirmed resistance to Group B herbicides (A Cheam, personal communication).

The commercial introduction of Invigor and Roundup Ready GM canola could be expected to address this weed problem effectively.

6.2.3 Risks

The risks to the environment (including farming practices) have been a key concern of many stakeholders. In assessing the two GM canola varieties, the OGTR examined if there were any risks to the environment if these varieties were licensed for commercial use. In addition, as these two GM varieties are herbicide tolerant varieties, the risks of the associated herbicide use were also assessed by the APVMA.

As explained in chapter 4, in Australia the Gene Technology Regulator must prepare a risk assessment and risk management plan (RARMP) for each GM licence application. RARMPs were prepared for the Invigor® and Roundup Ready® GM canola varieties using the OGTR’s Risk Analysis Framework. The following potential hazards were identified through the RARMP process (see OGTR 2002b and 2002c):

Table 19 Potential hazards identified

Invigor	Roundup ReadyUnited States
• Toxicity and allergenicity for humans • Toxicity and allergenicity for other organisms • Weediness • Transfer of introduced genes to other organisms • Herbicide resistance	• Toxicity or allergenicity to humans • Toxicity to other organisms: • Weediness • Gene transfer • Herbicide Resistance • Change in herbicide use patterns

While the precise wording of the potential hazards varied slightly in the two RARMPs, the potential concerns raised for Invigor were very similar to those identified for Roundup Ready. However, in the case of Roundup Ready, a sixth potential hazard, ‘change in herbicide pattern use’, was identified due to the importance of glyphosate in weed control in broadacre agriculture and in other agricultural and non-agriculture applications.

After assessing the risks and the characteristics of the two GM canola varieties the Gene Technology Regulator came to the conclusion that, for all potential hazards identified, the risks to human health and safety and the environment were negligible (or in the case of gene transfer, very low and decreasing significantly at distances of over 5-10 metres). The only specific conditions imposed on the Invigor and Roundup Ready OGTR licenses related to the management of the risk of gene transfer – it was a condition of the license that the applicants provide the Gene Technology Regulator with a testing methodology that is capable of reliably detecting the presence of the GMO and any transferred genetically modified material that might be present in a recipient organism.

Note that in respect of Roundup Ready canola, the Regulator states that, while the risks to human health and safety and the environment are negligible, there could be a need to change some farm practices, including the use of alternative herbicides. This change could lead to increased complexity and potentially costs. In respect of weediness the OGTR (2002c) stated:

The adoption of Roundup Ready® canola will mean that farmers will need to make choices and potentially modify their farming practices. This may result in increased complexity in implementing alternative weed management strategies, as well as other economic considerations.

In respect of gene transfer the OGTR stated:

The emergence of glyphosate tolerant volunteers where Roundup Ready® canola has not previously been sown will mean that farmers must make choices about methods of weed control, after considering farm practice and economic issues.

...While transfer of the glyphosate tolerance trait to related species would not result in an adverse impact on the environment, it would have implications for the choice of herbicide(s) in situations where glyphosate is the principal strategy for control of these plants.

Comments of a similar nature were not made in respect of the Invigor®, as the Liberty herbicide to which the hybrid is resistant does not have as many applications in the agricultural and non-agricultural environments as does glyphosate.

Both Bayer CropScience and Monsanto have developed stewardship principles to address resistance concerns of stakeholders and these principles are reflected in the registration provided by APVMA.

The Gene Technology Regulator did not impose a condition in relation to herbicide resistance, as this issue had been assessed by the APVMA and had been addressed by conditions of registration for the use of Liberty herbicide on Invigor® canola and Roundup® herbicide on Roundup Ready® canola. However, the registered owner's obligation to comply with conditions imposed by the APVMA was noted in the OGTR licences. The APVMA conditions include:

- implementation of a Resistance Management Plan developed by the licensee;
- reporting of resistance incidents to the APVMA; and
- establishment of an industry/expert/government Herbicide Resistance Consultation Group (OGTR 2002c).

The risk of resistance to glyphosate, one of the most important chemicals used in farming, is not restricted to its use with Roundup Ready® canola. Glyphosate resistance is a concern for traditional agriculture. A national Glyphosate Sustainability Working Group, which is a collaborative initiative involving research, industry and extension representatives, is working to promote the sustainable use of the glyphosate in Australian agriculture.²³ Monsanto, Nufarm and Syngenta have representatives on the Working Group. The priority goals of the Working Group are to:

- Increase the sustainability of glyphosate usage through the development and delivery of clear and consistent information, based on industry consensus;
- Increase collaborations and consistency among the glyphosate research and extension activities of key research, extension and industry groups; and
- Contribute to the development of research, development and extension initiatives aimed at improving the management of glyphosate.

The CRC for Weed Management reports that as at October 2005, there were 44 confirmed glyphosate resistant annual ryegrass (*Lolium rigidum*) populations in Australia. Of these populations, 24 have been confirmed in broadacre cropping. Glyphosate resistance has not been confirmed in other weed species in Australia.

Chemical companies which supply glyphosate have a strong commercial interest in ensuring the resistance issue is managed. For example, the Crop Management Plan for InVigor hybrid canola includes:

- Grower involvement in:
 - Planning and preparation prior to planting
 - Record keeping
 - Use of appropriate crop rotations
 - Use of certified seed
 - Strategies to minimise adventitious presence
 - Control of volunteer canola;
- An industry proposal for coexistence of GM canola and conventional canola in Australia to minimise the unintended presence of GM canola in conventional canola seed, including separation distances;
- Information on weed and resistance management to minimise gene flow between canola and close relatives (canola, brassica vegetables and weedy relatives) is to be included on the Liberty Herbicide label, as well as in current weed resistance management strategies that are managed and communicated by the industry;
- Recommendations for planting, harvesting and postharvest management, including consideration of good agricultural practices in seed production, effective cleaning and hygiene practices, optimising harvesting efficiency and appropriate handling with correct information provision to identify the GM crop; and
- Training and accreditation for retailers and agronomists handling InVigor hybrid canola during the introductory period (Bayer CropScience 2002).

²² See <http://www.weeds.crc.org.au/glyphosate/index.html>

Monsanto and Nufarm (who has purchased a license to sell Monsanto's Roundup Ready canola in Australia) also have in place stewardship principles for the use of glyphosate. They have also invested in research to understand the proper uses and stewardship of the glyphosate, including some of the factors that can contribute to the development of weed resistance. However, Monsanto has previously pointed out that, as a result of the herbicide's characteristics, the development of weed resistance to glyphosate is rare because:

1. Most weeds and crops are inherently susceptible to glyphosate, and the long history of extensive use of glyphosate over the past 28 years has resulted in few instances of resistant weeds;
2. Selection for glyphosate resistance using whole plant and cell/tissue culture techniques was unsuccessful; therefore, it is expected to occur rarely in nature under normal field conditions.
3. Glyphosate has many unique chemical properties, such as its mode of action, small biomimetic chemical structure, limited metabolism in plants and lack of residual activity in soil, which makes the development of resistance less likely (Monsanto 2004).

Nevertheless, given some weeds in Australia are showing resistance to glyphosate, it seems clear that the glyphosate resistance needs to be managed closely by farmers with or without the introduction of Roundup Ready® canola into commercial use. If Roundup Ready® canola is introduced; it may require replacing the chemical at other stages of the rotation.

The risk of a build up of resistance more generally might be reduced if farmers have the opportunity to rotate between the various GM and non-GM herbicide tolerant varieties, as this might give them the opportunity of also alternating herbicides throughout their rotation. Further, as farmers' knowledge and implementation of the stewardship management principles, which are a key requirement of APVMA's license to use glyphosate and glufosinate-ammonium in conjunction with Roundup Ready® and Invigor canola respectively, are realized, the risks of herbicide tolerance being a problem in these GM varieties should be reduced.

6.3 GM canola yield and gross margins

6.3.1 International findings

Much of the information on GM canola yields and gross margins comes from experience in the United States and Canada, where the crops are grown commercially. For example, Sankula and Blumenthal (2004) in a study for the National Center for Food and Agricultural Policy found that North Dakota growers of herbicide tolerant GM canola varieties had cost effective weed control compared to conventional varieties. These lower costs were achieved despite growers of GM crops paying a seed premium and technology fee (see Table 20):

Both glyphosate- and glufosinate-tolerant canola varieties provide weed control equivalent to that achieved with conventional herbicides but with the use of one or two herbicides only and at a reduced rate and cheaper cost (Sankula and Blumenthal, 2004, p.20).

Table 20 Comparison of weed management costs in various canola systems in North Dakota in 2003

	US\$ per acre
Conventional canola using Clopyralid post planting	
Ethafluralin (pre)	\$8.77
Quizalofop (pre)	\$8.75
Clopyralid (post)	\$15.22
Cost of two applications	\$8.00
Total weed management cost	\$40.52
Conventional canola using Ethametsulfuron post planting	
Ethafluralin (pre)	\$8.77
Quizalofop (pre)	\$8.75
Ethametsulfuron (post)	\$9.25
Cost of two applications	\$8.00
Total weed management cost	\$37.65
Average weed control costs in conventional canola	\$37.65
Glyphosate-tolerant canola	
Seed premium	\$5.00
Technology fee plus one pound of ai/A glyphosate	\$15.00
Cost of one application	\$4.00
Total cost	\$24.00
Glufosinate-tolerant canola	
Seed premium	\$7.00
Technology fee	\$0.00
0.37 of a pound of ai/Aglufosinate	\$14.35
0.023 of a pound of ai/A quizalofop	\$3.59
Cost of one application	\$4.00
Total cost	\$28.94
Average weed control cost in transgenic (GM) canola	\$26.47

Data source: Sankula and Blumenthal (2004).

Sankula and Blumenthal also found that since 2001, there had been an increase in the adoption of glufosinate-tolerant LibertyLink canola and a significant reduction in the planting of glyphosate-tolerant Roundup Ready canola. This switch occurred despite the higher cost of glufosinate as a weed control measure. Higher yields and greater variety underpinned this change:

Higher adoption of glufosinate-tolerant canola is due to the awareness and increased knowledge about the trait, availability of the trait in high yielding varieties, and also due to a greater choice of varieties (Sankula and Blumenthal, 2004, p 18).

The Canola Council of Canada (2001) commissioned Serecon Management Consulting and Koch Paul Associates to undertake an agronomic and economic assessment of GM canola. The methodology for this study included a survey of western Canadian canola growers. The survey was designed to compare transgenic (GM) canola and conventional canola.²³ A considerable amount of effort was undertaken to ensure a balanced sample of GM and non-GM canola by Canadian province and ecozone and, in the case of non-GM canola, by variety grown. The survey considered:

- variety grown, seeding rates, pedigree vs. common seed and seed costs;
- yield, dockage and grade, as well as self-reported net returns per acre;
- summer fallow practices, including herbicide use on the canola field in 1999;
- fertilizer use;
- mechanical and cultural weed control; and
- the history of transgenic use, and the impact on practice change since adopting a transgenic variety, and benefits or disadvantages to growing transgenics.

The survey findings found that compared to non-GM conventional canola, GM (transgenic) varieties had higher:

- yields - ... transgenic systems result in a 10 per cent yield advantage over conventionals, thus contributing to an overall increase in canola production. This 10 per cent is significant both economically and agronomically in that it speaks to the overall production efficiency of transgenic over conventional systems (Canola Council of Canada 2001, see chapter 2); and
- gross margins with the computed average return (see Table 21) being higher than the actual grower reported return of \$Can5.80.

Table 21 Calculated cost of conventional and GM canola per acre in Canada in 2000 (\$Can)

	GM n=321	Conventional n=316
Revenue	53.95	138.55
Less costs		
Seed	19.17	12.53
Herbicides	13.68	22.53
Fertilizer	28.15	26.43
Operations	36.90	41.75
Scouting	1.03	1.11
Other	0.30	0.82
TUA (Roundup)	10.76	NA
Subtotal	109.99	105.17
Return	43.96	33.38

Data source: Canola Council of Canada 2001

²³ SMART trait varieties, which are now known as CLEARFIELD were excluded from the survey where they were the only canola grown. The decision to exclude SMART trait varieties was made on the grounds that they 'are neither transgenic nor conventional'.

6.3.2 Australian findings

There is relatively limited publicly available information on Australia's experience with GM canola yields and gross margins. The following review of field trial results of the OGTR licensed GM canola varieties and other publicly available information highlights that while Monsanto and Bayer CropScience, the producers of GM Canola in Australia, report trial results pointing to higher yields, there are some detractors such as the Twynam Agricultural Group which doubt the GM varieties' economic viability.

A key message from this data and from the varieties of views about GM canola performance is that they are likely to perform differently dependent on the circumstances, seasonal conditions, management ability and the characteristics of the variety carrying the GM trait. This has led to considerable debate about the performance of GM canola technology, which often confuses the performance of the technology and the circumstances in which it is used.

Monsanto Roundup Ready field trials

Monsanto's Roundup Ready GM Canola trials were conducted side-by-side with trials of alternative non-GM canola varieties and alternative weed management practice. Foster (2003) reports that Monsanto Australia (2001) claimed its Roundup Ready variety compared with a number of non-GM varieties grown in the trial had the following benefits:

- higher yields than most non-GM varieties (see Table 22);
- higher gross margins; and
- environmental benefits.

Monsanto has claimed that Roundup Ready canola brings many benefits to Australian farming systems including:

- Superior weed control
- Broad-spectrum weed control
- Increased gross margins.

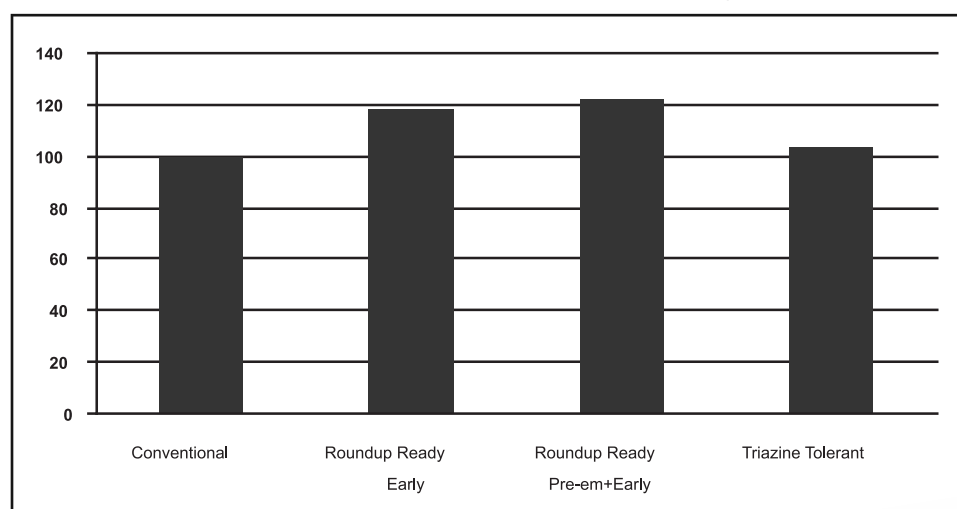
Despite Monsanto's claims, Foster (2003) reports that one non-GM variety (Clearfield) had a much higher yield rate than the three Roundup Ready varieties as well as the other non-GM varieties in the Monsanto trials (see Table 22).

Table 22 Field trial performance of Monsanto's Roundup Ready canola, 2001^a

System	Herbicide treatment	Yield	Oil content
		kg/ha	per cent
Untreated control	No herbicide	695	41.71
Conventional	Trifluralin + Select® + D-C Trate + Lontrel®	922	43.52
IT/Clearfield	Trifluralin + OnDuty® + Hasten® + Lontrel®	1,144	41.09
Triazine Tolerant	Simazine (pre-plant) + Gesaprim® (pre-plant) + Gesaprim (post emergent)	800	42.14
Roundup Ready			
-A	Two applications of Roundup	1,055	43.00
-B	One application of Roundup	977	43.04
-C	Trifluralin + Two Applications of Roundup	966	43.52

*a All systems received the same fertiliser and insecticide treatments. All varieties of canola sown had similar maturity types and black leg resistance ratings.
Data source: Foster, 2003, reporting Monsanto (2001) and Clearfield data reported on the Monsanto website in 2003 which was excluded from Monsanto (2001).*

Monsanto has reported that its Roundup Ready variety enjoy gross margins around 20 per cent higher than conventional canola varieties grown using alternative weed management systems (see Figure 12). However, Foster (2003) reports that the gross margin analysis reported in Monsanto Australia (2001) did not appear to include a "technology fee" which has been paid by Canadian farmers. It was pointed out that in 1998 this fee was around US\$9 per hectare. It is not clear whether the results reported by Monsanto in an undated presentation and reproduced in Figure 12 factor in a "technology fee".

Figure 12 Australian trials 2000 and 2001 - Two year gross margin comparisons for alternative weed management systems

*Note: This figure has been reproduced from a Monsanto PowerPoint presentation.
Data source: Monsanto (undated) "Roundup Ready canola "When your weed control is extraordinary so are your yields" PowerPoint presentation.*

Monsanto Australia's Ralph and Kruithoff (2004) have stated that high yields for Roundup Ready in conjunction with lower input costs have contributed to higher gross margins in trials throughout Australia:

The effectiveness of Roundup Ready canola as a weed control system enables farmers to benefit from increased crop productivity. Farming systems trials throughout Australia have consistently demonstrated increased gross margins with Roundup Ready canola relative to other canola technologies. This increased gross margin is generated from lower input costs and increased yields (Ralph and Kruithoff, (2004, p9).

Ralph and Kruithoff (2004) also claimed that the benefits of using Roundup Ready extend into following phases of crop rotation as trials indicated potential higher wheat yields in fields which grew Roundup Ready in the previous rotation:

The yield advantages stemming from better weed control can spill over into the following phases of the rotation. Continuation of the Farming Systems trial work has shown the potential for increased wheat yields following Roundup Ready canola. This is largely due to superior grass weed control in the canola phase resulting in less competition for the wheat crop. Additionally, with respect to triazine tolerant canola, in a dry season with little or no spring and/or summer rainfall, triazine carryover can be common. Triazine residues at the time of sowing wheat can decrease germination, cause poor vigour and potentially decrease final wheat yield (p9).

Bayer CropScience InVigor field trials

Bayer CropScience trials of the InVigor hybrid canola also demonstrated yield advantages compared to non-GM varieties in the trials. Bayer CropScience reports yield increases for its InVigor varieties ranging from a low of 9 per cent for midseason varieties to a high of 38 per cent for late season winter hybrid varieties. Average oil content for the two InVigor varieties trialed and now licensed by the OGTR also varied and, with the exception of the InVigor 40 variety, was similar or slightly lower than the non-GM varieties trialed (see Table 23).

Bayer CropScience's website summaries the findings of these trials as follows:

InVigor 40 is a mid season canola variety showing yield increases of 9-22% compared with standard open pollinated varieties in the two seasons it has been tested. InVigor 40 is strong, uniform hybrid variety with very good seedling vigour that stands slightly taller than rainbow. A provisional blackleg rating of 6.5 will be improved with the addition of Jockey seed treatment on all seed in 2004. InVigor 40 oil content averaged 46% in the two years it has been tested.

InVigor 70 is a mid to long season canola variety showing yield increases of 15 to 29% over the standard in the three years it has been tested. It flowers three days later than Dunkeld and Ripper, and stands slightly taller. It is a robust, vigorous hybrid variety with good seedling vigour. A blackleg rating of 6 will be improved with the addition of Jockey seed treatment on all seed in 2004. InVigor 70 oil content averaged 47% in the two years it has been tested (Bayer CropScience website).

InVigor 90 is a winter hybrid canola based on high yielding European types. InVigor 90 has been specifically bred for the long season canola growing districts of southern Victoria and demonstrated a yield increase of 38% compared with standard open pollinated varieties. InVigor 90 is later, taller and significantly more vigorous than Dunkeld. InVigor 90 has a provisional blackleg rating of 7.5 and an oil content of 44% (Bayer CropScience website).

Table 23 InVigor 40 — mid-season areas trials^a, New South Wales, Victoria and South Australia, 2001 and 2002

Variety	Yield ^a		Oil	Blackleg	Days to flower
	2001	2002			
InVigor 40 (GM)	109	122	46	6.5P ^b	100
InVigor Exp 833 (GM)	101	125	43	6P ^b	100
Rainbow (Conventional)	100	100	42	6.0	97
Hyola 60 (Conventional)	120	112	45	9.0	95
Pinnacle (Conventional)	61	74	40	5.5	100

a Trials were conducted at Horsham, Wagga and Beulah in 2001 and Hamilton and Naracoorte in 2002. Trials in 2002 were seeded after typical canola seeding time because of delays in obtaining regulatory approvals.

b Yield is expressed as a percentage of the yield of Rainbow.

c Blackleg ratings are provisional ratings produced by the Canola Association of Australia in 2003 from data supplied by Bayer CropScience.

Data source: Bayer CropScience website <http://www.invigor.com.au/products/invigor40.asp>

Table 24 InVigor 70 — mid-to late season areas trials^a, New South Wales, Victoria and South Australia, 2000, 2001 and 2002

Variety	2000	Yield ^a		Oil	Blackleg	Days to flower
		2001	2002			
InVigor 70 (GM)	115	117	129	47	6.0P ^b	103
Dunkeld (Conventional)	100	100	100	46	6.0	100
Ripper (Conventional)		94		47	6.5	100
ATR-Grace (Conventional Triazine tolerant)			81		66.6	100

a Trials were conducted at 13 sites over three years in NSW, Victoria and South Australia. Trials in 2002 were seeded after typical canola seeding time because of delays in obtaining regulatory approvals.

b Yield is expressed as a percentage of the yield of Dunkeld.

c Blackleg ratings are provisional ratings produced by the Canola Association of Australia in 2003 from data supplied by Bayer CropScience.

Data source: Bayer CropScience website <http://www.invigor.com.au/products/invigor40.asp>

Table 25 InVigor 90 — Late season areas trials^a, New South Wales and Victoria 2000 and 2001

Variety	Yield ^a	Oil	Blackleg	Height
InVigor 90 (GM)	138	44	7.5P ^b	155
InVigor Exp 039 (GM)	139	46	7.0	152
Hyola 60 (Conventional)	119	48	9.0	155
Dunkeld (Conventional)	100	45	6	140

a Trials were conducted at Mangoplah, Hamilton and Lake Bolac. Note results were not reported by each year.

b Yield is indicative only, and is based on the result of four trials over two years.

c Blackleg data is Bayer CropScience visual scores only.

Data source: Bayer CropScience website <http://www.invigor.com.au/products/invigor90.asp>

Pike and Clarke (2004) report that Western Australian trials of three InVigor varieties and three non-GM varieties (conventional and two triazine tolerant varieties) found that the InVigor early to mid maturity varieties produced higher yields, and in one instance higher oil content, than the non-GM varieties in the trial. InVigor 40, a mid to late maturity seed was found to have relatively lower yields, but a relatively high oil content, than the other two InVigor varieties trialed (see Table 26).

Table 26 Yield, maturity, blackleg and oil results in Calingiri WA 2003

Variety	Yield*	Maturity**	Blackleg***	Oil per cent
InVigor 40 (GM)	110	Mid-Late	6.5P	50
InVigor Experimental ARHY0306 (GM)	128	Early-Mid	6.0	50
InVigor Experimental ARHY0307 (GM)	130	Early-Mid	5.5	47
Rainbow*** (Conventional)	100	Early-Mid	6.0	46
Surpass 501 TT (Conventional Triazine tolerant)	110	Early-Mid	8.5P	51
Grace TT (Conventional Triazine tolerant)	88	Late	6.5	46

* Yield is expressed as a percentage of the yield of Rainbow, Rainbow yield was 1291 kg/ha.

** Based on maturity guidelines from Western Australia Crop Variety Sowing Guide 2003.

*** Blackleg rating for InVigor 40 is based on provisional survival ratings published by the Canola Association of Australia in 2003, from data supplied by Bayer CropScience. Blackleg rating for InVigor experimentals are estimates only, data has been submitted to the national system. Results were not available at the time of writing.

Data source: Pike and Clarke (2004)

A 2003 report for Avcare by Dr Robert Norton of Melbourne University, considered the benefits of introducing herbicide tolerant GM canola. The report argued that there were many benefits to the grains industry including:

- earlier planting;
- lower canola oil penalties compared to triazine tolerant canola;
- higher yields for both the GM canola and wheat grown after the canola rotation;
- lower herbicide costs; and
- a more sustainable canola industry via better integrated weed management and soil conservation practices.

Based on a scenario where GM canola replaced 50 per cent of the triazine-resistant canola and 40 per cent of conventional canola, and the area planted to canola increased by about 50 per cent, Norton (2003) estimated that:

- an extra 200,000 hectares of canola would be grown under direct drilling or minimum tillage;
- average Australian canola yields would increase from 1.27t/ha to 1.38 t/ha, with an increase in canola production estimated at 295,000 tonnes annually;
- wheat production would increase by 64,000 tonnes on the additional canola area planted; and
- this increase in canola and wheat production would be worth \$135 million to the Australian grains industry.

Norton also provided an example of how costs and returns for conventional and GM canola might compare. Factoring in a technology access fee and a higher yield for the GM variety, found canola gross margins per hectare would be significantly higher for the GM variety (see Table 27). It should be noted however, that the higher gross margin estimated was in large part driven by the estimated higher yield of the GM variety rather than cost savings.

Table 27 An example of how costs and returns for conventional and GM canola could compare

	Conventional	GM Canola
Expected Yield	1.8 t/ha	2.2 t/ha
Net Price \$/t on farm	\$400	\$400
Gross Return	\$720/ha	\$880/ha
Seedbed preparation & Sowing	\$14/ha	\$14/ha
Seed costs	\$15/ha	\$40/ha a
Fertilizer Costs	\$72/ha	\$72/ha
Herbicide costs	\$57/ha	\$22/ha
Insecticides	\$6/ha	\$6/ha
Windrowing & Harvesting	\$38/ha	\$38/ha
Insurance	\$10/ha	\$10/ha
Local cartage	\$10/ha	\$10/ha
TOTAL COSTS	\$222/ha	\$212/ha
GROSS MARGIN	\$498/ha	\$668/ha

Data source: Norton (2003)

An alternative view on yields and gross margin for dryland canola

In 2003, Twynam Agricultural Group's Bruce Finney reported his assessment of the likely gross margins available for dryland canola production of alternative canola varieties. While acknowledging that the assessment was based on limited information and assumptions, Mr Finney claims the analysis indicates that the current "conventional" ²⁴ canola production system generated a higher gross margin and a higher return on costs than Roundup Ready[®] and InVigor[®] canola as well as the conventional canola once identity preservation costs are taken into account.

Table 28 Twynam Agricultural Group's 2003 estimates of alternative canola gross margins and return on costs incurred (per ha)

Canola Gross Margin Analysis	Conventional	"GM free"	Roundup Ready	InVigor
Income	\$666.00	\$666.00	\$712.62	\$837.33
Growing Costs	-\$360.00	-\$360.00	-\$349.20	-\$442.00
Identity preservation costs		-\$83.25	-\$89.08	-\$104.67
Total Costs	-\$360.00	-\$443.25	-\$438.28	-\$546.67
Gross Margin	\$306.00	\$222.75	\$274.34	\$290.66
Cost/Benefit Over Conventional		-\$83.25	-\$31.66	-\$15.34
Return on Costs	85 per cent	50 per cent	63 per cent	53 per cent

Data source: Finney (2003).

²⁴ Note that the precise variety of conventional canola used in the assessment was not stated.

The assumptions underpinning Finney's estimates were:

- Non-GM canola is canola with GM presence within market access limits and this will be the future basis for marketing conventional canola;
- A yield of 1.8 tonne per ha for conventional varieties. Roundup Ready™ having a yield advantage of 7 per cent with a yield advantage of 17.5 per cent for InVigor™;
- The growing costs for Roundup Ready™ based on reports indicating they are 97 per cent of conventional crop costs once technology costs are included. It was noted that the technology cost for Australia has not been publicly released;
- The growing costs for InVigor™ based on reports indicated additional costs of \$28 per ha for seed and \$54 per Ha if a grower chooses to use Liberty™ herbicide.
- Identity preservation costs of 12.5 per cent of the grain value, reportedly based on ABARE (2003).

Identity preservation costs were an important driver of Finney's findings. The identity preservation costs assumed in Finney's analysis were 2.5 percentage points higher than those estimated by Buckwell, Brookes and Bradley (1998) and Economic Research Service (2000) and reported in Foster (2003). In later study Foster (2006) found that identity preservation costs ranged between \$331 and \$1,119 per farm from increased seed costs, cleaning and additional delivery costs. Reducing the identity preservation costs to 10 per cent (all other assumptions remaining constant would see the InVigor variety enjoying a higher gross margin than all other varieties considered by Finney.

6.4 Wider economic and cost benefit considerations

Economic and cost-benefit considerations were expressly excluded from the scope of the assessments conducted under the Gene Technology Act 2000. As explained by the Gene Technology Regulator:

Feedback from extensive stakeholder consultation during the development of the Gene Technology Act 2000 made it clear that the community wanted the regulatory system to focus exclusively on the evaluation of risks to human health and safety and the environment. This was to prevent the possibility of economic considerations, such as cost-benefit analyses, market access and agricultural trade implications, from compromising the regulatory system's focus upon the scientific evaluation of risks and the protection of human health and safety and the environment (OGTR 2003c).

This section reviews some of the economic modelling which has examined the impact of adopting or not adopting GM crops from an economy wide perspective. This analysis has typically used computable general equilibrium models.

Anderson and Jackson (2004) used a general equilibrium model to assess the impact on Australia and the rest of the world of alternative GM adoption scenarios. The modelling scenarios of interest to the GM canola debate examined:

- the implications of the adoption of GM coarse grains and oilseeds by the United States, Canada and Argentina with and without Australia and New Zealand also adopting, and with and without a European Union ban on GM crops;
- the implications of adoption of GM coarse grains and oilseeds by the United States, Canada and Argentina with and without Australia and New Zealand also adopting, and with and without the European Union and Japan, Korea and China banning GM crops.

The study modelled the potential economic impact of the productivity gains from GM crop adoption in the context of potential trade gains or losses which could arise because of other countries' decisions to accept or not accept GM crops. The analysis found that Australia and New Zealand could potentially achieve improvements in economic welfare from adopting GM crops even if the European Unions de facto moratorium on imports was maintained. However, while there is nothing to suggest this would occur, the study found that if Japan, Korea and China introduced similar bans on GM crop imports, the adoption of GM crops would have a detrimental impact on Australia's economic welfare.

Table 29 Change in Australia's economic welfare as a result of GM coarse grain and oilseed adoption by various countries

Adopting countries	Import ban	Change in economic welfare \$US million per year
United States, Canada and Argentina	No	-9
United States, Canada and Argentina	Yes in European Union	-4
United States, Canada, Argentina, Australia and New Zealand	No	7
United States, Canada, Argentina, Australia and New Zealand	Yes in European Union	10
All countries	No	2
United States, Canada and Argentina,	Yes European Union and Asia ^a	96
United States, Canada, Argentina, Australia and New Zealand	Yes European Union and Asia ^a	-13

^a Asia in this modelling was Japan, Korea and China

Data source: Anderson and Jackson 2003.

More recently ABARE (2005) used its global trade and environment model (GTEM) to quantify the implications of the debate concerning whether Australia should commercialise GM food and feed crops. This work updates earlier modeling undertaken by ABARE and used recent estimates of productivity gains, levels and rates of adoption, and indicators of likely future developments. The analysis focused on two scenarios:

- Australian states prohibit commercial plantings of transgenic grain and oilseed crops, while there is further GM crop adoption in other countries where the productivity improvements of GM crop adoption are phased in over the five years from 2006 to 2010;
- Australia adopts GM varieties of wheat, barley and canola, and as a result of the adoption achieves productivity improvements of five per cent for canola and wheat, and 10 per cent for barley which are achieved over the five years from 2006 to 2010.

Table 30 presents the estimated difference in gross national product (GNP) arising from the two scenarios. That is, the results presented are the difference in national economic welfare (measured as GNP) of Australia either adopting or not adopting transgenic grain and oilseed crops, given that other countries continue to take up the GM crop technology. Sensitivity analysis demonstrates that if the expected productivity gains were halved, the gains from adoption would be considerable and would be in the order of \$1,500 million.

Table 30 Gross National Product gains for Australia from transgenic crop adoption^a (2004 dollars)

	Gain
	\$m
Assumed productivity gains	2,952
Sensitivity analysis	
Productivity gains halved	1,492
Productivity gains doubled	5,770

^a Net present value in 2005 of gains in gross national product over the period 2006 to 2015.

Data source: ABARE Australian commodities, vol 12 no.3, (September quarter 2005) Transgenic Crops, Welfare Implications for Australia, Stephen Apted, Daniel McDonald and Heidi Rodgers.

6.4.1 Summing up

Canola became an important crop in Australia during the 1990s, and it now plays a significant role for many Australian farm businesses. Canola generally yields good farm returns even after paying for additional applications of lime to soil. Agronomic benefits traditionally associated with canola relate to soil management, pest control, and yield increases in crops that follow canola in the rotation. However, Triazine resistance is now becoming an increasing problem for growers and one option to manage this would be to introduce canola varieties that are resistant to Roundup.

Australian and international evidence, including the increasing uptake of GM canola by growers, does suggest that GM canola confers some cost, yield and gross margin advantages to growers. In short, whether or not GM canola could provide additional benefits to Australian farm businesses will depend on specific agronomic and economic circumstances faced by each business.

Economic modeling suggests that whether or not Australia will reap economic benefits from the adoption of GM crops will in part depend on the actions of other countries. ABARE has estimated that the cost to the Australian economy of not adopting GM canola could be significant – in the order of \$1.5 to \$5.8 billion over the period 2006 to 2015. On the other hand economic modelling of an unlikely scenario which would see China, the European Union, Japan and Korea all imposing bans on importing GM crops, suggests that the adoption of GM canola could have a detrimental impact on Australia's economic welfare.

7 GM, non-GM canola and other grains

A critical question for farmers, Australian grain customers and the rest of the grains industry is: 'Can GM canola be kept separate from conventional canola and other grains, if required?'. The answer to this question lies in the technical capacity of the supply chain to meet the needs of buyers and sellers and the cost of providing these services, and whether GM canola represents any unique challenges to the grains industry that will affect its ability to be segregated.²⁵

Segregation is only possible if small amounts of mixing between grains types are tolerated and can be identified. This is a fundamental principle of segregation and is well understood by buyers and sellers of all grain types. All Australian grain contracts, at every level of the supply chain specify tolerances for mixing between grains.

Tolerances are a trade off between the reduced performance of the grain due to the presence of other grain types and the cost of meeting the level of tolerance preferred. The cost of segregation increases exponentially as the tolerance level decreases.

Virtually all of the contract specifications and the common tolerance levels used in the Australian grains industry are negotiated between the buyers and the sellers. They are commercial arrangements and once agreed on bind the buyer and seller to the agreement. Many contracts use standard industry developed specifications so that transaction costs are reduced.

To formulate contract standards that include tolerance levels of one grain type mixing with another, the Australian grains industry formed the National Agricultural Commodity Marketing Association (NACMA). NACMA has over 300 members across the entire Australian grain supply chain and publishes standard contracts and grain standards for industry to use on a voluntary basis (see section 4.1 and www.nacma.com.au for more information). There is no compulsion to use NACMA standards and buyers and sellers can freely modify the standard NACMA contract or draw up their own.

The main benefit to industry of the development of NACMA contracts and standards is a substantial reduction in transaction costs. Having industry recognised standard contracts and quality standards eliminates the need for individual companies to formulate their own and allows grain parcels to be traded more widely as the specifications, if NACMA standards are used, are widely recognised and accepted. A company will only move away from using a standard NACMA contract if the costs of doing so are outweighed by the benefits of buying or selling a parcel of grain with non-NACMA standard specifications.

An example of industry self regulation similar to NACMA is the various organic certification schemes available to organic farmers. The main difference between NACMA and organic standards is that the organics standards are promoted through to the final consumer.

²⁵ This section of the study draws mainly from two grain segregation studies. The first one was completed by ACIL Tasman in 2005 which was prepared for the Victorian Government entitled, *Genetically Modified Canola: Market issues, industry preparedness and capacity for segregation in Victoria* (ACIL Tasman and Farm Horizons 2005). The second study was undertaken by ABARE and is titled, *GM grains in Australia: identity preservation* (Foster 2006). Both these studies look closely at the capacity of industry to segregate GM and non-GM grains and the likely costs of doing so.

Apart from a very small quantity of speciality canola varieties which are usually handled outside the main stream bulk handling system, there are no segregations of the vast majority of canola produced in Australia. GM canola, if it were to be segregated from conventional canola would represent the first time a segregation for canola would exist in the Australian bulk handling system. However, while there is no canola segregations, wheat, barley and most other crops are routinely segregated based on a large range of quality characteristics.

The following sections of this chapter discuss the various segments of the grain supply chain and examine their capacity to segregate GM canola from other canola types and other grains.

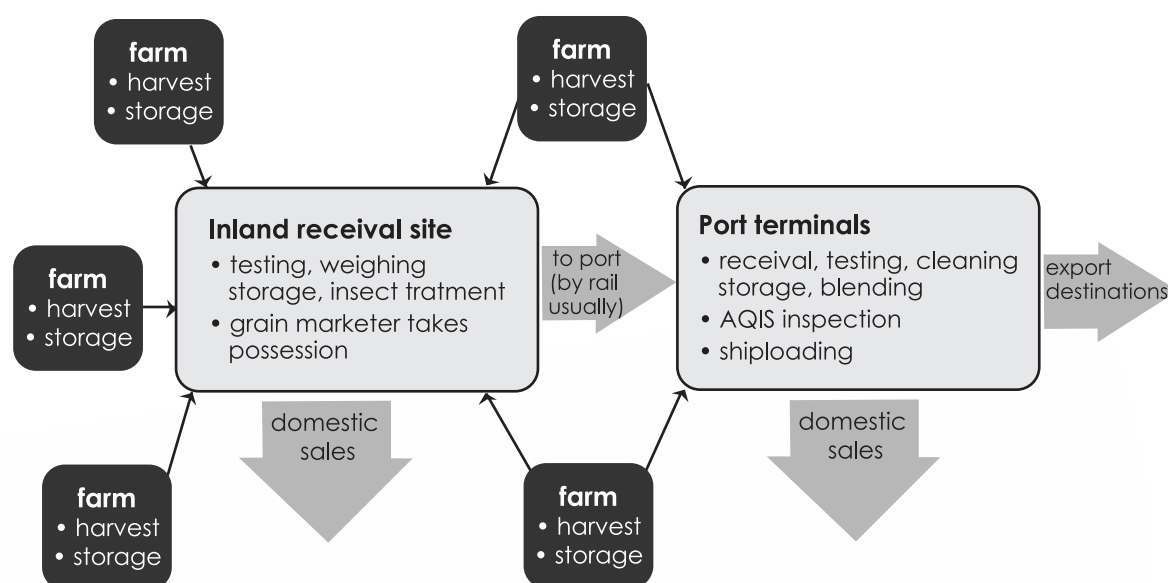
7.1 Characteristic of Australia's grain handling system

The Australian grain handling system is characterised by a series of regional (local) grain storage sites handling a large range of grain types and segregations that accumulate and prepare parcels of grain, which are distributed to domestic users or funnelled through to port terminals that assemble export cargoes.

Schematically the Australian grain handling system is illustrated in Figure 13. The key aspects of the grain handling system that are of relevance to this study are:

- There are a large number of small to medium sized farm business that deliver to a much smaller number of local storage and handling facilities;
- In turn these local and regional facilities feed into 15 to 20 major ports dotted around the Australian coast;
- The range of grain types and grain qualities managed by the bulk storage and handling system means that there is limited grain type or quality specific handling systems or infrastructure;
- The storage and handling system prepares parcels of grain for a limited number of domestic users and a small number of export terminals.

Figure 13 Farm to port handling and storage system



Foster 2006

7.1.1 Farm level segregation

Canola sown each year is typically a combination of purchased seed and stored seed from previous crops. However, even when canola is stored by the farmer for use in the following years at some point new varieties need to be purchased from commercial seed producers.

7.1.2 Seed production

The integrity of any commercial grain segregation begins with the capacity of the farmer to procure seed of sufficient purity that will allow them to meet segregation specifications once the crop has been harvested and delivered.

In Australia the peak seed industry body is the Australian Seed Federation (ASF). Following consultation with industry and its members, the SFA has established a GM canola in non-GM canola tolerance of 0.5 per cent in its code of seed production practice (www.asf.asn.au). This protocol has been established to be consistent with the OECD seeds purity framework and to allow farmers to meet likely market tolerances once the crop has been grown, harvested, transported and stored.

The following table provides some information on how the 0.5 per cent seed tolerance level has been arrived at by the seed industry.

Table 31 SIAA (now the ASF) management procedures

Stage	Estimated Additional AP	Management Procedures
Cross Pollination	0.10 per cent	Scientific Committee on Plants , European Commission 2001
Volunteers	0.20 per cent	Scientific Committee on Plants , European Commission 2001 ²
Harvesting	0.01 per cent	Scientific Committee on Plants , European Commission 2001 ²
Transport	0.05 per cent	Scientific Committee on Plants , European Commission 2001 ²
Storage	0.05 per cent	Scientific Committee on Plants , European Commission 2001 ²
Manufacturing	0.05 per cent	Food Industry TGM / HACCP Analysis.

Data source: Reiger et al 2002; Salisbury 2003

Conclusions about maintaining seed purity

Evidence suggests the seed industry is well advanced in its readiness for the introduction of GM varieties with the development of the ASF Guidelines for Managing the Adventitious Presence, and Seed Testing Protocols for Adventitious Presence in canola seed. However, the ASF has prepared these protocols based on experience that low levels of mixing of one seed type with another cannot be avoided, even with the level of management applied by the seed industry. The protocol of 0.5 per cent also recognises the seed can be produced at lower levels of tolerance but the costs of doing so becomes prohibitive, unless there is a substantial market premium for non-GM canola.

7.1.3 Commercial production of canola

If a farmer chooses to produce a non-GM canola crop to meet a specific market specification, and is confident that the seed to be used is suitable, the on farm production system must be capable of ensuring market specifications can be met.

A farmer aiming to meet a non-GM market specification will also need to consider if the additional returns from a non-GM contract exceed any additional costs incurred. Likewise GM canola producers will need to take into account the potential of commingling of any GM canola produced with other grains produced on the farm, and consider whether the advantages of GM canola are adequate compensation for taking on the additional risks.

As discussed in section 6.2.3, in addition to a farmer's own incentives to manage GM crops, the licensing agreements with the GM technology providers are to be accompanied by stewardship strategies and agreements developed by the technology companies. These strategies are consistent with the requirements imposed by the Commonwealth and State Governments through the Primary Industries Ministerial Council (PIMC) and its Plant Industry Committee (PIC) while it was active. The specific requirements for growing GM crops outlined by PIC included:

- on-farm crop management plan which forms the foundation of the stewardship program;
- communication and education;
- compliance, auditing and enforcement;
- reporting and assessment of agricultural and environmental impacts; and
- contingency plans.

The stewardship strategies developed by both the companies that produce GM canola which has been licensed for commercial release by the OGTR, (Bayer and Monsanto) are underpinned by detailed Crop Management Plans (CMP). To be able to obtain access to GM seed, growers will need to agree to implement these stewardship strategies. In addition to this growers and/or agronomists will also be required to attend education and accreditation programs to ensure these strategies are understood.

Maintaining purity at planting

Purity at planting is a function of not only seed purity but also of the cleanliness of planting equipment. Modern seeding equipment is designed to be cleaned out relatively quickly as most farmers plant a variety of seed types each year.

Seeding for most farming operations usually involves planting different crop types at different times of the seeding period. For instance canola is usually planted mid to late April in southern cropping regions while most wheats are either sown in mid to late May (grain only varieties) or early March (winter grazing wheat varieties). This means that the time to taken to clean machinery between different types of crop seeding is required regardless of the crops GM status.

An additional cost to the farmer could be occurred if non-GM canola and GM canola are to be sown concurrently. A farmer may avoid repeated cleaning of equipment if the non-GM canola is sown prior to the GM variety.

Two studies conducted in the United States, Hanna (2000) and Hanna and Greenless (2000), assessed the time it would take to clean down typical planting equipment used in the United States Midwest to effectively segregate GM and non-GM soybeans. These studies showed that high levels of purity could be readily achieved with good planter hygiene. It concluded that it would take approximately 25 minutes to obtain 99 per cent purity in a 12 row planter and 55 minutes for 99.9 per cent purity. While Australian planting equipment can vary from that used in the United States it does provide an indication of capacity to achieve sensitive thresholds for planter hygiene. The study also provides an indication of time requirements to achieve a satisfactory clean down.

Minimising cross pollination

As canola is predominantly a self-pollinating species (Salisbury 2002) there remains a risk of cross-pollination between GM and non-GM canola varieties leading to a potential source of adventitious presence in non-GM crops.

Cross pollination between canola varieties has been the subject of numerous studies. Differences in outcrossing rates in scientific literature is likely to be attributed to differences in cultivars, experimental design, differences in the size of pollen source and recipient crops and spatial arrangements, local topography and environmental conditions (Eastham and Sweet 2002 (OGTR Bayer RARMP)). A review of the major studies conducted by Salisbury (2002) showed that:

- Levels of outcrossing decrease with increased distance from the pollen source, with most outcrossing occurring in the first few metres.
- Low levels of outcrossing have been reported up to 400 metres with some irregular outcrossing seen at distances of up to 2.5 km, presumably due to insect transfer.
- An Australian field scale study (Rieger 2002),²⁶ which assessed outcrossing between an imidazolinone tolerant canola variety and traditional canola, recorded a maximum outcrossing rate of 0.225 per cent in sites which were immediately adjacent. However, no outcrossing was detected at 69 per cent of the sites.
 - The results from this Australian study showed that in the great majority of cases, even in adjacent canola fields, pollen flow is low – in a range of 0 per cent to 0.07 per cent.

Salisbury's (2002) review of the international and Australian scientific reports regarding canola pollen flow and volunteer management, found that no system of commercial field production could guarantee 100 per cent purity because of pollen flow and seed movement. Salisbury's study concluded that good management practices including the use of separation distances between GM and non-GM crops would be adequate to meet current industry standard purity levels.

In their respective CMPs, Bayer and Monsanto recommended a separation distance of at least five metres, combined with other nominated good agricultural practices to comply with a 1 per cent adventitious presence threshold. A distance of 400 meters is recommended for foundation seed canola or farmer saved seed.

²⁶ Conducted by Rieger 2002 in Salisbury 2002; Genetically Modified Canola in Australia- agronomic and environmental considerations

The technology user agreements to be introduced by the technology companies, if GM canola were commercially grown in Australia, will require that farmers growing GM varieties advise adjacent neighbours of where they will be planting these varieties.

Managing volunteers

Although not considered a persistent or 'hard seeded' species, canola has the ability to persist in the soil 'seedbank' for several years. This means that canola planted earlier in the rotation can emerge in subsequent crops (OGTRA Bayer, Monsanto RARMP). Overseas studies have shown that seed losses at harvest can range from 1.5 per cent to 9.9 per cent (CETIOM 2000 France (1.5-8.5 per cent) and Gulden et al. 2003 Canada (3.3-9.9 per cent)). The majority of seed loss occurs at windrowing and harvest and can vary depending on conditions at the time of these operations and the maturity of the crop. Improper harvester settings and excessive harvester speed are seen as contributing factor (Gulden et al. 2003).

Monitoring of trial sites following GM canola trials, conducted under OGTR licence conditions, have shown that the vast majority of germination occurred in the first year.

The monitoring reports for GM herbicide tolerant trials during 1996-2001 indicated that volunteer populations following the trials were generally adequately controlled by broadacre cultivation and herbicide application.²⁷

The CMPs recommend that a combination of thorough planning for volunteer management and good agricultural practice will provide an effective control of GM canola in cropping systems.

7.1.4 Harvesting and transport

As with sowing, harvesting machinery plays an important part in minimising adventitious presence. Harvest machinery hygiene extends to windrowers, harvesting equipment, storage facilities, transport equipment as well as items such as augers and chaser bins.

Many Australian farms have their own harvesters, field bins and other equipment but there appears to be an increasing use of contract machinery to ensure timeliness of operations and to reduce the risks of delayed harvests.

Foster (2006) estimates that a 20-30 minute clean down is necessary with a harvester moving from a GM to non-GM crop, to comply with a total unintended presence of 0.1 per cent at the end of the supply chain (Australian Grain harvesters Association 2003a,b). However, Foster notes that United States experiences suggest that cleaning times of an hour are more realistic.

Transporting grain to local silos is either done by contractors (most common in small to medium sized farms) or in trucks owned by the farmer. Increasingly bulk handlers and other traders are buying grain off the farm and providing the transport to do so. This practice is increasing the use of contract transport services from the farm to the local silo or buyer.

²⁷ Salisbury 2002 p 34

Grain bins on trucks are generally easy to clean. However, other areas of the truck also require cleaning to ensure that grain does not fall off the truck during transport on and off the farm.

The study conducted by ACIL Tasman in 2004 concluded that the approximate cost per tonne on an average canola farm to maintain machinery hygiene was approximately 23 cents per tonne of canola (see Table 32).

**Table 32 Indicative costs to maintain machinery hygiene on farm
(based on 200 hectare canola crops at 1.5 tonnes/ha)**

Activity	Labour	Assumed Wage	Labour Cost	Quantity Flushed	Premium for non-GM	Flushing Costs	Labour + Flushing Costs	Total production	Labour + flushing costs/tonne
Clean planter	1 hour	\$40/hr	\$40.00	n.a.	n.a.	n.a.	\$40.00	300 tonnes	\$0.13
Clean harvester	0.5 hours	\$40/hr	\$20.00	2 tonnes	\$5/tonne	\$10.00	\$30.00	300 tonnes	\$0.10

Data source: ACIL Tasman 2004.

7.1.5 Grain storage and handling – Country Elevators

Grain storage and handling throughout Australia has seen significant rationalisation over the past decade with three bulk handling companies (BHCs) now dominating grain storage in Australia. GrainCorp, CBH and Ausbulk are the major BHCs, with GrainCorp being the dominate grain handler to east coast Australia. More recently, a number of new participants including AWB and the Australian Bulk Alliance (ABA) have built over 1.5 million tonnes of storage capacity in eastern Australia, with most of this storage capacity being of bunker type construction. Increasing efficiency and safety demands have resulted in the traditional BHCs closing a number of the smaller and country receival facilities in favour of a lesser number of larger, more efficient country storage facilities—a trend that is likely continue.

There is also increasing levels of on farm storage as larger farms begin to see opportunities to: service the domestic feed grain and milling wheat markets; and avoid bottlenecks at regional bulk handling centres.

Types of storage and handling facilities

There is a range of different types of storage facilities used in Australia that can be broadly categorised into four types (see Table 33).

Table 33 Handling equipment used in Australia

Type	Handling equipment
Vertical silo	Receival hopper with elevator to vertical storage cells. Provides greater segregation capacity but is more expensive to build and maintain
Horizontal shed	Receival hopper with elevator to large horizontal storage sheds. Less expensive to build than vertical but reduced segregation capacity
Bunker	Receival hopper into a thrower or auger then locates grain on large storage pads that are covered with heavy plastic. Least expensive to build but limited segregation capacity.
Export terminal	Receival hoppers for rail and road. Multiple grain storage structures that could be a combination of all of the above.

The bulk handling system was developed to provide a cost-effective system to handle large quantities of bulk grain crops with limited segregations from farm to export ports or to domestic markets on the seaboard. However, changing customer demands and increasing food safety standards have resulted in a far greater use of grade and varietal segregations within the bulk handling system.

Handling procedures

Upon receival at a country receival location, all grains are weighed, sampled and assessed for a range of quality parameters that vary depending upon grain type. In the case of canola, the load is assessed for weight, oil content, impurities, moisture and broken seeds. If the grain meets the minimum receival quality for its specific grain type it is then segregated accordingly.

The grain receival docket records all of the weight and quality information as well as providing the legal transfer of ownership from the grower to the marketer. When the grower or his authorised delivery agent signs the grain receival docket, they are also verifying several aspects regarding the grain quality that can not be readily analysed upon delivery. This verification includes confirmation of the variety (which is important in wheat and malt barley classifications) and confirmation that all pesticide applications meet regulatory requirements. The grain receival docket also had a provision for a GM declaration which asks whether the grain is a genetically modified variety.

The level of complexity to achieve non-GM segregation would increase as the production of GM canola increased. For example, it is likely to become necessary to have storages that receive either GM or non-GM canola as well as mixed delivery sites which handle GM and non-GM canola as well as other grains. In this scenario, miss-representation of canola loads as well as possible adventitious presence through the grain handling process is an issue. This may occur at each of the different stages of the storage process including receival, during storage, during out loading or through the sampling process. However, as highlighted by the discussion in Box 5, sensitive segregation is not new in the Australian grain supply chain.

Box 5 Examples of sensitive segregations in the Australian grain supply chain

A number of grain products already have tight segregation requirements, such as malting barley and milling wheats, where handling companies are required to maintain segregations through the supply chain to meet specific customer requirements. In addition to these general segregation requirements, there are several examples where BHCs are routinely handling grains that have higher levels of sensitivity for specific market requirements.

Pesticide Residue Free (PRF) grain is required by some of Australia's major wheat markets including Japan and Korea. PRF grain has less than 0.1 mg/kg for organophosphates. PRF is kept in designated storages by the BHCs and identity preserved through to the export terminal where it is tested to ensure the grain is within allowable tolerances. Approximately 60 per cent of wheat stored in the BHC system in eastern Australia is PRF.

Bulk shipments of polished white rice are transported via rail from southern NSW for shipment through the Geelong export terminal. Special procedures have been developed to ensure the rice is free from impurities in order to meet sensitive market requirements. These include an agreed cleaning procedure of the entire grain path including rail wagons and export terminal prior to the movement of rice.

Organic grains are handled by GrainCorp in Southern NSW where two, eight thousand tonne storages are permanently assigned to organic wheat.

Approximately 50,000 tonnes of high oleic sunflowers from Queensland and Northern NSW are identity preserved for domestic crushing requirements each year. This involves the issuance of specific identification dockets to growers that are presented to the BHC receival location upon delivery and an agreed testing regime to ensure product quality.

These demands are likely to grow with QA requirements increasing, including IP.

Data source: ACIL Tasman 2004

7.1.6 Transport from country silos

Grain is typically transported from the country receival location to the export terminal or domestic market by a mix of rail and road transport. However, in most instances the majority of the grain is moved by rail. Specialised grain wagons are used to transport grain consignments. The wagons are of a self-emptying design and each has a capacity of approximately 50 tonnes. The number of wagons per train varies between ten and thirty wagons. The reduction in the number of small country silos has meant that rail shipments are usually from a single silo rather than a 'milk run' where grain is picked up from a number of smaller sites.

Prior to loading, trains are given rudimentary inspection for cleanliness by the loading attendant at the silo. Information obtained from Freight Australia during a previous study suggested that residual in the wagons after dumping was less than 5 kg which is mainly caught on the construction seams in the wagon. After loading each wagon²⁸ is accompanied by a wagon certificate stating its weight and quality details.

²⁸ Unit wagons only have certificates for the first and last wagon

The introduction of GM canola is not likely to impose any additional costs onto the rail industry to achieve a less than one per cent tolerance. However, lower tolerances than one per cent may incur additional cleaning and inspection costs.

7.1.7 Export terminals

Further consolidation of the grain parcels occur at the export terminal. Export terminals are designed as high throughput facilities and are constantly receiving and shipping grains, stored in the regional aggregation centres throughout the year. Some farmers and grain merchants choose to deliver grain to the export terminal by road, if it is either cheaper or more convenient. Road delivery can be particularly attractive if the trucks back load other farm inputs such as fertiliser from the port zone.

While regional silos receive a multiple of grain types and qualities that require segregation, the physical capacity of these aggregation centres often means that a limited number of grain types can be handled at any one facility. This reduces the number grains likely to cross paths at this stage of the supply chain and allows a greater level of specialisation at each cite to occur.

However, there are far fewer port terminals than regional aggregation centres in Australian and port terminals are more geographically dispersed making switching between ports more costly due to higher freight costs. As a result port terminal storage is usually more complex than country receival facilities with multiple grains and multiple grain paths. The capacity to segregate grain varies considerably at each terminal but all have a degree on segregation, allowing them to store multiple grain types and more efficiently receive and ship grain.

Also, given the higher volumes of grain managed at the port zone, economies of scale can be achieved in cleaning and segregation offsetting some of the costs associated with segregation.

Procedures

Upon receival at the export terminal grain is sampled, assessed and checked against wagon quality certificates and then segregated according to a quality segregation plan.

7.1.8 Likely levels of unintended presence and estimated costs

Table 34 below summarises the likely levels of adventitious presence (AP) described above and compares them to potential rates of adventitious presence for self pollinating oilseed rape identified in a European study conducted by the European Commission Scientific Committee on Plants in 2001. The European findings were based on farmers using good agricultural practice and segregation systems.

Table 34 Estimated average potential rates of adventitious presence at various stages of the supply chain

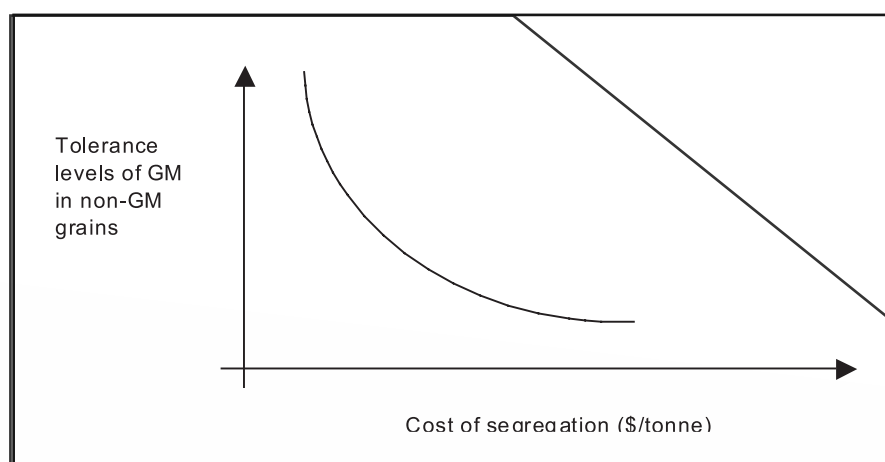
	Likely Australian AP based on evidence	EU findings
Seed	<0.5 per cent	0.3 per cent
Planting	0 per cent	0 per cent
Cross Pollination	0.1 per cent	0.2 per cent
Volunteers	0.2 per cent	0.2 per cent
Harvesting	0.01 per cent	0.01 per cent
Transport	0.01 per cent	0.05 per cent
Storage	0.01 per cent	0.05 per cent
Total	0.83 per cent	0.81 per cent

Based on the use of good agricultural practice and following systems outlined in the CMP's
Source: ACIL Tasman / Farm Horizons 2005

As a general rule, the cost of complying with tolerances levels increases exponentially with the level of tolerance required. Therefore, as tolerances decline toward zero the cost of segregation increases. The relationship between tolerances and segregation therefore is represented in Figure 14.

Foster (2006) reports that Klaitzandonakes and Magnier (2004) looked at the costs in the United States planting industry associated with achieving a range of adventitious presence thresholds. On average, they estimated compliance costs in corn increase by 9 per cent for a 1 per cent threshold; 27 per cent for a 0.5 per cent threshold and 35 per cent for a 0.3 per cent threshold.

This relationship is not unique to GM and non-GM segregations. A decrease in the tolerance of a wide variety of grain characteristics will result in a rise in the costs of delivering them. This principle underpins the development of industry standards developed by NACMA and similar self regulatory organisations world wide.

Figure 14 A representation of the relationship between market specified levels of tolerance of GM in non-GM crops and the cost of achieving them

By developing a common tolerance standard across industry, the costs of meeting these standards fall as transaction costs associated with drawing up, executing and enforcing standard contracts fall.

There have been numerous studies of the cost of achieving various levels of tolerance for a range of grains around the world, a summary of some of these studies appeared in Foster (2006) and is reproduced in Table 35.

Table 35 Previous studies: summary of estimated costs per tonne to achieve specific threshold levels of unintended presence

	Huygen et al (2003)		Carter et al (2004)	Canada Grains Council (2003)				
	5% C\$/t	1% C\$/t	0.50% C\$/t	0.50% C\$/t	5%l C\$/t	5%h C\$/t	2%l C\$/t	2%h C\$/t
tolerance								
farm to elevator	2.55	4.06	6.51	0.50	0.50	1.20	1.00	5.22
primary elevator	0.26	0.43	0.72	0.14	2.00	5.00	4.00	14.86
rail/truck	0.00	0.00	0.00	0.02	0.00	0.65	1.00	3.26
export elevator	0.26	0.33	0.38	2.09	2.00	5.00	4.00	12.17
vessel loading	0.00	0.00	0.00	0.25	0.00	0.50	0.00	0.50
management	3.75	3.75	3.75	0.00	0.00	1.00	0.12	2.00
commercial risk	0.00	0.00	0.00	1.00	0.00	2.00	4.16	10.00
Total	6.82	8.57	11.36	4.00	4.50	15.35	14.28	48.01

Data source: JRG Consulting (2004)

Foster (2006) estimated that the cost of segregation of non-GM canola range from \$331 to \$1,119 per farm, depending on the characteristics of the port zone to which the farmer is likely to deliver the grain to. The majority of these costs (85 per cent) are incurred on farm mainly in the form of higher costs for certified seed, additional cleaning costs, and waiting in queues at local silos.

These costs are based on a likely adventitious presence of between 0.31 to 0.35 per cent and assuming a seed purity level of 0.3 per cent (Foster 2006). These levels of adventitious presence are well within current food labelling and general industry standards. This level of segregation was also examined as to the likely effect on other grains in the supply chain likely to come into contact with canola. It was found that the level of adventitious presence in other grains was almost negligible.

7.2 Testing

GMO testing can occur at any stage of crop development, from seeds to harvest to food end-product. However the further a product is processed, the more difficult it is to obtain reliable results this is because of the absence of detectable DNA or protein.²⁹ There are numerous test options available and all current GMO testing methodologies detect either the DNA sequence inserted into the host genome or the protein these modifications produce.

There is no single test that can screen for all GMOs. Each case must be assessed individually to determine the best method to use, as the level of detail required can vary and the not all tests are suitable for all applications. Sampling techniques are of critical importance to the reliability of results.³⁰

Genetic modifications produce a novel trait, e.g. herbicide tolerance in field crops. At the most basic level of GMO testing, a sample of plants can be sprayed with herbicide whilst still growing, and those that survive can be identified as GM. But this is often not practical and would take weeks or months to obtain a result. Hence, more stringent tests have been developed. One of the major concerns for international trade of GM crops is the harmonisation of GMO testing results across laboratories around the world.³¹

More recent developments in both protein and DNA detection methods provide a great benefit to GMO testing both in terms of speed and cost. The first tests developed required the samples to be sent to a laboratory, and results could take up to two weeks to be returned. More recently, these have been sped up but most laboratory-based tests still take up to 2 days to return a result. Now, on-site tests have also been developed and allow breeders to perform their own testing and get results within twenty minutes.³²

Appendix B presents detail on testing methods which are currently used as well as some new technologies being developed to identify the presence of genetic modification in plants.

7.3 How are other GM products managed?

On a global basis, the management of GM foods is becoming more widespread as consumers demand greater product information. Nevertheless, as discussed in chapter 5, it is clear that consumers in some countries are not aware they are purchasing and consuming products containing GM foods.

In Australia, foods sold in supermarkets may contain GM ingredients. According to Food Standards Australia New Zealand, some packaged food, available in supermarkets, contains GM ingredients derived from GM commodity crops such as soybean, canola, corn, potato, sugar beet and cotton. Some foods containing these products have been on the Australian supermarket shelf for more than 10 years, and often longer in other countries such as the US and Canada (FSANZ, 2001).

²⁹ Summary of Ceres International Roundtable proceedings, February 25, 2003. Detecting Genetically Modified Organisms: Confronting the Limits of Testing to Resolve a Biotech Food Fight.

³⁰ *ibid*

³¹ Girffiths, K et. al. (2002). Review of Technologies for Detecting Genetically Modified Materials in Commodities and Food. Australian Government Analytical Laboratories.

³² Summary of Ceres International Roundtable proceedings, *op cit*

The most common method of managing GM foods is more detailed labelling of products particularly as they relate to imported products from GM producing countries. Most developed countries are now implementing some system of mandatory labelling or import requirement regarding approved GM foods (see Table 38).

Some companies are also taking a role in the management of GM foods by implementing tracking and testing systems in order to provide guarantees that their product is GM free. For Example, the New Zealand Ministry for the Environment (Christey and Woodfield. 2001, p 32) noted that So Good® (Sanitarium Health Food Company) products now carry a label to indicate that they are made from non-GM soy. A process was implemented to track the soy used at each stage, from seed through to final manufacturing. This also involved audited certification at each stage to maintain segregation and to minimise the possibility of mixing GM and non-GM produce. In addition, Primary Industry Bank of Australia (2001, p 5) reported that multinationals such as Tesco, Asda and Sainsbury were all seeking alternative supply channels to ensure their products are GM free.

7.3.1 Labelling

In Australia, mandatory labelling of approved GM foods was introduced in 2001 for those foods where DNA and/or protein are present and where the food has altered characteristics.

Labelling is only required where GM content is in excess of 1 per cent, to allow for the possibility that GM ingredients are unintentionally present in the food.

These standards are regulated under the Food Standards Australia New Zealand (FSANZ). A list of GM food crops and potential food uses permitted in Australia and New Zealand as at February 2006 is presented in Table 36.

Table 36 GM foods and their approval status (as at February 2006)

	Product	Proponent	Year Approved
Soybean	Glyphosate tolerant soybean	Monsanto	2000
	High oleic acid soybeans	Du Pont	2000
	Glufosinate ammonium tolerant soy	Bayer CropScience	2004
Canola	Glyphosate tolerant canola	Monsanto	2000
	Glufosinate ammonium tolerant canola	Aventis CropScience	2002
	Canola resistant to bromoxynil	Aventis CropScience	2002
Corn	Insect resistant corn	Aventis CropScience	2000
	Glyphosate resistant corn	Monsanto	2000
	Glyphosate tolerant corn	Monsanto	2000
	Insect resistant corn	Syngenta Seeds	2001
	Insect resistant glufosinate ammonium tolerant corn	Syngenta Seeds	2001
	Glufosinate ammonium tolerant corn	Aventis CropScience	2002
	Insect resistant glufosinate ammonium corn	Monsanto	2002
	Glyphosate tolerant corn	Monsanto	2002
	Insect resistant glufosinate ammonium corn	Dow AgroSciences	2003
	Insect resistant corn	Monsanto	2003
	Insect protected glufosinate ammonium tolerant corn	Dow AgroSciences	2005
	Corn rootworm and glyphosate tolerant corn	Monsanto	Assessment in progress
	High lysine corn	Monsanto	Assessment in progress
	Insect protected corn	Syngenta	Assessment in progress
Potato	Beetle resistant Colorado potato	Monsanto	2001
	Beetle resistant and potato leaf roll virus resistant Colorado potato	Monsanto	2001
	Beetle resistant with resistance to potato virus Y Colorado potato Sugarbeet	Monsanto	2001
	Glyphosate tolerant sugarbeet	Monsanto	2002
	Glyphosate tolerant sugarbeet	Monsanto	2005
Cotton	Insect resistant cotton	Monsanto	2000
	Glyphosate tolerant cotton	Monsanto	2000
	Cotton resistant to bromoxynil	Stoneville Pedigreed Seed Company and Aventis CropScience	2002
	Insect resistant cotton	Monsanto	2002
	Insect protected cotton	Syngenta	2005
	Insect protected glufosinate ammonium tolerant cotton	Dow AgroSciences	2005
	Glyphosate tolerant cotton	Bayer CropScience	2006
	Glyphosate tolerant cotton	Monsanto	2006

Data source: FSANZ, *Genetically modified foods and their approval status*. Available at www.foodstandards.gov.au. Accessed 21/6/2007.

Table 37 lists the GM foods currently permitted for sale or use in Australia as set down in Standard 1.5.2 of the Australia New Zealand Food Standards Code.

Table 37 Food produced using gene technology which is currently permitted for sale or use in Australia (2007)

Food produced using gene technology	Special conditions
Food derived from glufosinate ammonium-tolerant corn line T25 Food derived from glufosinate ammonium tolerant cotton line LL25 Food derived from glufosinate ammonium tolerant soybean lines A2704-12 and A5547-127 Food derived from glyphosate-tolerant corn line GA21 Food derived from glyphosate-tolerant corn line NK603 Food derived from glyphosate-tolerant cotton line MON 88913 Food derived from glyphosate-tolerant lucerne J101 and J163 Food derived from glyphosate-tolerant soybean line 40-3-2 Food derived from glyphosate-tolerant sugarbeet line 77 Food derived from high oleic acid soybean lines G94-1, G94-19 and G168 Food derived from insect- and potato leafroll virus-protected potato lines RBMT21-129, RBMT21-350, and RBMT22-82. Food derived from insect- and potato virus Y-protected potato lines RBMT15-101, SEM15-02 and SEM15-15. Food derived from insect-protected and glufosinate-ammonium tolerant corn line 1507 Food derived from insect-protected and glufosinate ammonium-tolerant DBT418 corn Food derived from insect-protected and glyphosate-tolerant corn line MON88017 Food derived from insect-protected Bt-176 corn. Food derived from insect-protected corn event MON863 Food derived from insect-protected corn line MIR604 Food derived from insect-protected corn line MON 810 Food derived from insect-protected, glufosinate ammonium-tolerant Bt-11 corn. Food derived from insect-protected, glufosinate ammonium-tolerant corn line DAS-59122-7 Food derived from insect-protected potato lines BT-06, ATBT04-06, ATBT04-31, ATBT04-36, and SPBT02-05 Food derived from sugar beet line H7-1 Oil and linters derived from bromoxynil-tolerant cotton containing transformation events 10211 and 10222 Oil and linters derived from glyphosate-tolerant cotton line 1445 Oil and linters derived from insect-protected cotton line COT102 Oil and linters derived from insect-protected cotton lines containing event 15985 Oil and linters derived from insect-protected cotton lines 531, 757 and 1076 Oil and linters derived from insect-protected, glufosinate ammonium-tolerant cotton line MXB-13 Oil derived from bromoxynil-tolerant canola line Westar-Oxy-235 Oil derived from glufosinate-ammonium tolerant canola lines Topas 19/2 and T45 and glufosinate-ammonium tolerant and pollination controlled canola lines Ms1, Ms8, Rf1, Rf2 and Rf3 Oil derived from glyphosate-tolerant canola line GT73	The label on or attached to a G168 package of a food derived from high oleic acid soy bean lines G94-1, G94-19 and G168 must include a statement to the effect that the food has been genetically modified to contain high levels of oleic acid

Note: A food produced using gene technology, other than a substance regulated as a food additive or processing aid, must not be sold or used as an ingredient or component of any food unless it is listed in Column 1 of the Table and complies with the conditions, if any, specified in Column 2. Food Standards Australia advised that the last edition to this permitted GM food list was made in February 2007

Data source: Australia New Zealand Food Standards Code Standard 1.5.2 Food Produced Using Gene Technology, http://www.foodstandards.gov.au/_srcfiles/FSC_Amend_Standard_1_5_2_GM_v91.doc.

The labelling rules focus on the end food product, and not the plant or process involved in its production. For example, Agrifood Awareness (Paper 14, unknown date, p 4) notes that highly refined oils such as canola and cotton oil do not require a label because refined oils contain no genetic material, and are identical to oils from a non-GM crop. Cold pressed or unrefined canola oil may require labelling if testing reveals that the new gene is routinely found in the product.

The labelling and import requirements of countries other than Australia are presented in Table 38.

Table 38 Import and labelling requirements for major Australian export destinations

Country	Import Requirements	Labelling Requirements
Japan	All GM materials must be approved by the Japanese authorities since April 2001. So far 44 GM materials for food have been approved (mainly varieties of maize, canola, potato and cottonseed)	Mandatory labelling of approved GM foods with detectable content above 5 per cent for 44 specified foods. Oils and other highly processed foods are excluded because they contain no detectable DNA or protein
China	Since 2004 all processed and unprocessed agricultural GM material requires a safety certificate and approval before import approval can proceed	Ministry of Health requires all food containing GMOs to be labelled although this has not been enforced so far
Korea	Mandatory safety assessment for all GM crops and materials since 2003	Mandatory labelling applies to specified GM foods ingredients (mainly soybean, maize and potato & products) where DNA is detectable in final product. Threshold of 3 per cent
Taiwan	From January 2003 all GM materials and products are required to be approved by Taiwan authorities prior to import	Mandatory labelling has been progressively introduced since Jan 2003 for soybean and maize products with detectable GM ingredients above 5 per cent of total
Malaysia	As of April 2004 imports require a risk assessment and approval	Mandatory labelling is being introduced where GM material is above 3 per cent by volume
Thailand	No restrictions apply	Mandatory labelling was introduced in May 2003 where foods products with over 5 per cent GM content in any of main 3 ingredients
Indonesia	All imports of GM materials require government approval	General legislation is in place requiring GM labelling but specific labelling requirements not yet established
Philippines	All GM plants and plant products have required approval for import since 2002	GM labelling is currently voluntary but the Government says its in the process of developing GM labelling regulations
India	All GM foods require Government approval with only one product – GM soybean oil –currently approved. Some undeclared and unapproved materials have been entering illegally	The Indian Government introduced compulsory labelling for foods containing GM products in August 2006. These also extend to imported food – the label must specify that the product has been cleared for marketing and use in its country of origin.
Pakistan	No regulations on imports although the Government is in the process of developing a framework legislation	None
Bangladesh	No regulations on imports although the Government is in the process of developing a framework legislation	None
Sri Lanka	None	Sri Lankan Government is developing a GM labelling system
European Union	All imports of GM products must gain approval Novel Foods Regulations where there has been effective moratorium on the granting on new approvals. Some varieties of GM maize and soybeans were authorised under previous legislation (Directive 90/220/EEC)	Legislation extends previous requirements to include all GM food and feed irrespective of the detectability of GM protein or DNA with a 0.9 per cent threshold.
Saudi Arabia	All shipments of GM products must be accompanied by a health certificate stating the GM ingredient has been approved in the country of origin for consumption. Imports of GM animals, birds and their products are banned	All GM products require mandatory labelling. There appears to be a 1 per cent threshold for unintended presence of GM material

Data source: Farm Horizons, ABARE, 2007.

7.3.2 Certification

Some producers and food manufacturers are now implementing audited certification processes which track the ingredients used in their products from seed to manufacturing. This system is essentially an extension of the quality assurance programs that many producers already have in place and involve standards to minimise the possibility of mixing GM and non-GM produce.

The New Zealand Ministry for the Environment (Christey and Woodfield. 2001, p 32) noted that similar systems are already in place in the apple, kiwifruit and meat industries in New Zealand that enable detailed tracking of produce. These systems could be further developed for use for GM produce.

Other examples of these systems include the:

- Value Enhanced Grains system developed by the U.S. Grains Council
- Canadian Soybean Export Association's identity preservation standard
- Supply Chain Initiative on Modified Agricultural Crops (SCIMAC) that was developed as a means of maintaining segregation of GM trials in the United Kingdom.

Industry within Australia has also embarked on a similar system under the Gene Technology Grains Committee, developing the Canola Industry Stewardship Principles (discussed above) which outline the operating practices required to ensure effective segregation of GM canola in Australia.

7.3.3 GM food in Australia

GM soy meal and cotton seed is currently used in the production of food in Australia. Whilst Australia has strict labelling laws regarding GM foods it is possible that highly refined oils that have been produced using GM ingredients become exempt from these standards as their GM content is undetectable. It is therefore likely that consumers in Australia are purchasing products containing GM cotton seed and soya oil without their knowledge.

Imported soy meal

In 2006, soybean was the principle biotech crop occupying 57 per cent of global biotech crop area.³³ Soya is currently one of the main sources of genetically-modified ingredients in food, and can found in a number of foods including chocolate, potato chips, margarine, mayonnaise, biscuits and bread. Soybeans are also present in animal fodder. GM soybeans have been imported from the United States into Australia since 1996, and were the first GM food approved by FSANZ according to Choice Magazine (2003). There are no genetically modified (GM) soybeans grown in Australia.

The Australian Bureau of Rural Sciences (Lamb and Cunningham. 2003, p vi) reported that there are several GM inputs to stockfeed used in Australia including imported soybeans and imported maize. The report concluded that:

- ‘ Given the wide range of supply chain arrangements potentially used by any one feedlot, it would currently be difficult for Australian producers to assure customers that their feed did not contain GM material if their rations contained cottonseed, imported soybeans or imported maize.’

³³ Soybean was followed by maize (25 per cent), cotton (13 per cent) and canola (5 per cent) (James, 2006).

Domestically produced cotton seed oil and meal

Cottonseed oil is a by product of processing cotton lint. It is mainly used for frying, in mayonnaise and salad dressings. The meal that results from the process is used as a high protein animal fodder.

The key importing countries for cotton seed tend to be developing countries such as Egypt and India however Russia is also a major importer. GM cotton is grown in the United States, Australia, China, India and Mexico.

AgriFood Awareness (2003, p 2) notes that many Australian consumers are unaware that 'cotton seed oil from commercially approved GM cotton varieties has been approved for use in the [Australian] food chain' with the primary use as oil for frying by the fast food and take away industry. Landline (2004) reported similar findings and went further to claim that consumers were unaware that vegetable oils sold in supermarkets also contained GM ingredients and were not labelled as Australian labelling laws only require labelling of foods that were derived from genetically modified crops if there is no detectable GM DNA in the final product. They also reported that meat from animals who have eaten GM cotton seed meal are consumed in Australia.

Landline (2004) also reported that vegetable oil sold in the supermarket was also likely to contain GM cotton seed oil. Consumers would be unaware of this GM content, as labelling laws allow the marketing of foods that were derived from genetically modified crops to go unlabelled if there is no detectable GM DNA in the final product.

7.4 Summing up

A number of independent studies have shown that the Australian grain supply chain has the capacity to segregate GM and non-GM canola and GM canola from a range of other grain types if there is an economic incentive to do so. Segregation is a routine function of the grain supply chain, which is dealing with demands for increased segregation.

A number of studies have concluded that the area of greatest potential for adventitious presence to occur is during commercial production. Commercial production of canola seed relies on good management practices and the maintenance of machinery and crop hygiene to ensure market specifications are met. It is likely that additional costs of segregation are likely to be incurred by those wishing to grow non-GM crops. However, they are likely to be small if current international trade and market specifications are to be met. While the costs of growing GM canola are likely to be met by those wishing to grow non-GM canola, they will only incur these costs if there is an economic incentive to do so i.e. there is a market premium for non-GM canola that exceeds the costs of segregation.

The current labelling regulations for food products establish minimum requirements that the grain supply chain and food manufacturers will have to meet for domestic and international markets. Much of the voluntary protocols and industry standards that have been established are based on meeting minimum food labelling standards. However, there are likely to be, at least in the early stages of the commercial release of GM canola, additional processor and manufacturer demands for lower tolerances of adventitious presence that will create opportunities for some growers to market non-GM canola.

Testing for the presence of novel DNA can be done in a number of ways. It appears that depending on the situation there are a number of current and emerging technologies available to test for the presence and level of GM canola in non-GM grains across the entire supply

8 Implications for other Australian industry/activity

8.1 Key issues in Australia

As explained previously, while separation and gene flow, as they relate to human health and the environment, fall within the purview of the Gene Technology Regulator, the market impact of GM canola is not considered. The key issues in Australia are centred on separation of GM and non-GM varieties in the supply chain, which was discussed in chapter 7; and the impact of growing GM canola on gene flow between species and markets and trade, which are the subject of this chapter.

8.1.1 Gene flow between species

The Bureau of Rural Sciences published a major report on gene flow in 2002 (Glover 2002). This report concluded that some gene flow is inevitable between related species, whether or not they are GM. Glover outlined that the degree to which a plant outcrosses depends primarily on its mating systems, however the degree of outcrossing can vary greatly among varieties of the same crop, including between regions and seasons. The likelihood and potential impact of gene flow from outcrossing is influenced by the crop and the environment it is to be released in. Glover also notes that while gene flow is a natural phenomenon, it is not common to have gene flow between species. Several studies are reported to support Glover's claim, and it was concluded that the gene flow rates on the same crops reported by these studies differed widely as the result of a complex array of variables that influence the rate of outcrossing.

The actual risk of gene flow in GM varieties is case-specific and is influenced not only by the crop and the environment, but also the gene, the trait, and the management practices. Glover's report classified canola as medium risk with significant potential for impact on the farm or local environment. This compares with oats, which were classified as low risk with significant potential for impact; and cotton, which is medium risk but low potential impact.

Glover concludes that low maximum thresholds of cross-contamination by cross-pollination should be attainable with the introduction of appropriate crop management plans.

8.1.2 Post-harvest

Post-harvest issues are closely related to trade and the acceptability of GM crops by our major trading partners. This has been a major focus of discussion by both government and industry.

As explained in the previous chapter, proposed guidelines for industry stewardship programs have been developed and presented to the Primary Industries Ministerial Council (PIMC 2003).

The Gene Technology Grains Committee under AVCARE (now renamed CropLife) represents the grains industry along the supply chain from researchers to food processors. It has published the Canola Industry Stewardship Principles for Coexistence of Production Systems and Supply Chains (GTGC 2003) as a set of protocols to manage the co-existence of GM and non-GM crops to ensure monitoring and traceability throughout the supply chain.

The GTGC Principles define the outcome required at each point in the supply chain (pre-farm, on-farm and post-farm handling), identify who has responsibility to act at each point, provides established standards for management, defines the relevant documentation and defines what to manage to ensure the desired outcome. The principles also:

- define the relationship that one step in the supply chain has with the previous step and with the next step in the supply chain;
- define the outcome (that is, product and associated verification) that exists as it moves from one step in the supply chain process to the next; and
- define the processes that exist within each step of the supply chain.

8.1.3 Market implications and trade

Since initial commercialisation in 1996, the global area planted to GM crops has risen more than 50 fold from 4.2 million acres in six countries to 222 million acres in 21 countries in 2005 (ISAAA, 2006).

Australian farmers and agribusinesses are operating in this global market. The restrictions placed on GM crops have caused significant concerns. For example, Ausbiotech has noted that restrictions will contribute to reduced investment in biotechnology and reduced capacity to undertake R&D in Australia. Ausbiotech has also stated that the restrictions will reduce the competitiveness of Australian farmers, while allowing other countries to gain access to Australian markets. Finally it states that the restrictions will divert research resources away from agricultural breakthroughs (Ausbiotech, 2004b).

Similar fears were also expressed in 2006 by many the Agriculture and Food Policy reference Group (see chapter 1). Further, industry commentators have stated that the moratoria currently in place are impeding Australia's access to biotechnology when, in the past, Australian growers have been known as "early adopters" of new plant varieties (Lovett 2005).

Several studies have attempted to model the impact on Australia's agricultural trade of the adoption of GM crops.

Scientists from the University of Adelaide fear that there is a false impression among farmers that there is a large GM-free market, even though surveys and analyses conducted in Australia and overseas dispute this impression. The scientists feel that the moratorium could cause producers to chase illusory non GM markets while precluding them from reaping the gains from an emerging technology (University of Adelaide, Press Release, 2002).

Similarly, these scientists have pointed out that the application of new technology is a slow and meticulous process. New varieties need to go through extensive field testing and analysis. There is a likelihood that as a result of the moratorium Australia could be turning its back on valuable technology. Thus any attempt to reintroduce the technology will have to be tested for at least a further five years before commercial release. This will give Australia a tremendous disadvantage compared to many of our competitors (University of Adelaide, Press Release, 2002).

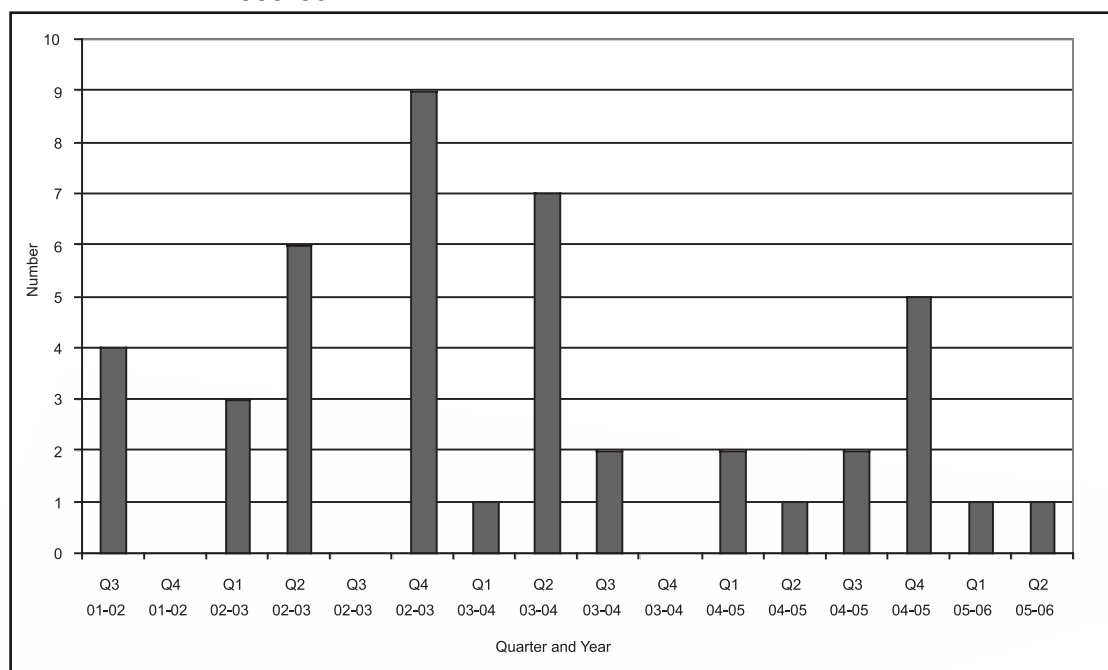
8.2 Research and Development

The impact of the events in Australia since 2001 (the operational date for OGTR) on R&D has been complex and relates both to the establishment of the OGTR regulatory system and the moratoria.

Research into genetically modified crops in Australia has been underway for many years. All the major research institutions, State agriculture departments and many co-operative research centres have programs in biotechnology, and many of these have involved GM crops. Appendix A provides a comprehensive list of licences issued by the Gene Technology Regulator (as at 3 July 2007) that involve the intentional release of GMOs into the environment, including experimental field trials. The organisations undertaking the field trials reported in the appendix include multinationals, state government departments, public sector R&D institutions and smaller biotech companies. As at 30 June 2007, three licences for intentional release crops had been issued in 2007. These licences included drought tolerant GM wheat trials by the Victorian Department of Primary Industries, sugarcane by BSES Ltd and GM canola and Indian mustard trials by Bayer CropScience.

While there have been claims that the State GM crop moratoria have negatively affected R&D in Australia, hard evidence to back this claim is scarce. There is some evidence that field trials have been reduced in number since late 2003-early 2004, according to OGTR approvals (Figure 15). This decline could be a result of other factors, such as the drought.

Figure 15 OGTR Approvals for Intentional Release of GMOs, 2001-02 to 2005-06



Data source: compiled from OGTR GMO Record in 2006.

We have identified one example of a research group moving to Queensland as a result of the moratoria in the other states: the Co-Operative Research Centre for Pest Animal Control (CRC-PAC) announced that it would be shifting its research team from Canberra to Queensland because of the moratorium. The CRC is developing genetically self-sterilising GM mice to try to prevent mouse plagues, and daughterless carp to try to remove feral carp from Australia's waterways. Because of the moratorium in Victoria, the CRC also announced it had abandoned plans to conduct the world's first field trial of its technique to sterilise mammalian pests with GM viruses in Victoria (AusBiotech, 2004).

The Victorian state moratorium was introduced just after approval for commercial release of canola was granted by OGTR to BayerCropscience (Khoo, 2004). While Bayer CropScience has indicated it will continue to do trial work in Australia, Monsanto Australia suspended development of its Roundup Ready canola in Australia due to the moratoria (Monsanto Australia, Newsletter Issue 1 08/05, p3). However, Monsanto announced on 8 September 2006 that it had sold its rights to GM canola to Nufarm for \$10 million in anticipation of the states lifting of the GM moratoria in 2008.³⁴ Nufarm has stated that it intends to recommence field trials.

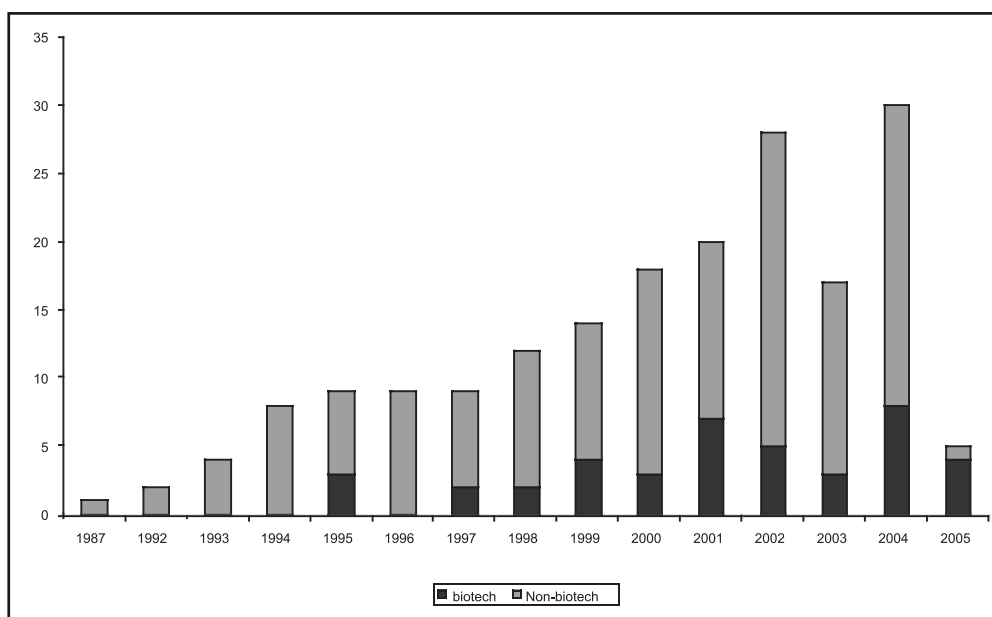
The NSW Farmers Association has expressed fears that the moratoria could pose a credible threat to Australia's ability to attract research investment and retain research personnel. The Association believes that this could, in the long term, erode Australia's agbiotechnology capability as investors will want to take their investments to markets that could yield them better returns (NSW Farmers Association, 2005).

The Australian Agricultural and Natural Resources Online (www.aanro.net) contains information on past and current canola R&D projects. The database collates information from Australian academic journals in agriculture. About 1,500 new research projects and 5,000 documents are added to the knowledge base each year. As the database collates and indexes reports and Australia-related agricultural articles in Australian and international journals, the information reported has a time lag. The database does not cover other non-published activities, such as field trial approvals by OGTR. The latest complete year for which data are available is 2005.

The database included 206 canola research projects dated from 1992 onwards, of which end dates of 2005 or earlier are available for 186. Of these 186 projects, 41 used biotechnology techniques (Figure 1) and 13 were GM, with the remainder addressing pathogen resistance and genomics, marker assisted breeding and field trials of non-GM lines. It can be seen that GM work still contributed a significant percentage of total projects in 2005.

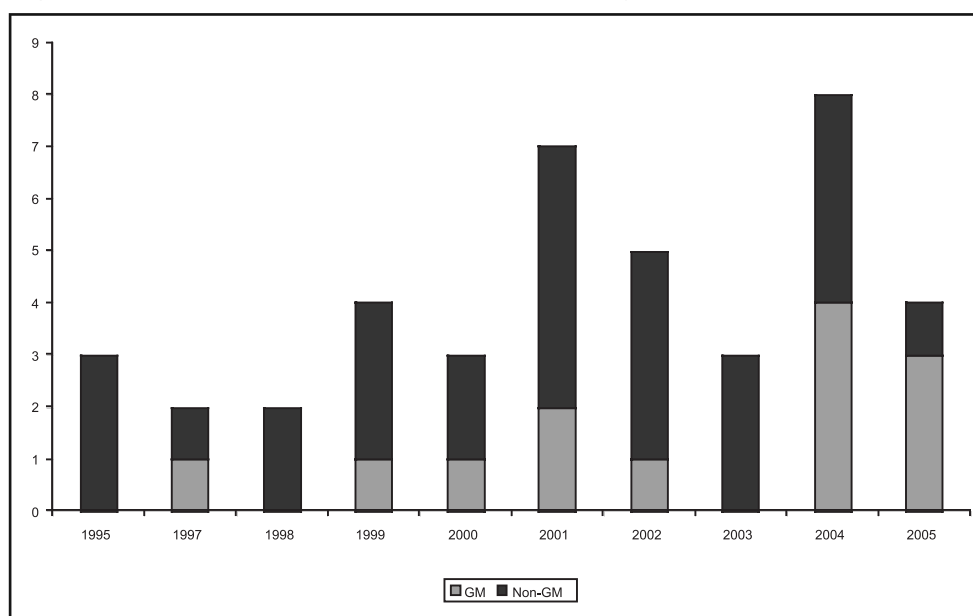
³⁴ See <http://www.abc.net.au/rural/tas/content/2006/s1736578.htm>

Figure 16 Balance of biotechnology and other R&D projects involving canola



Data source: Australian Agricultural and Natural Resources Online

Figure 17 Incidence of GM R&D canola projects 1995 - current



Data source: Australian Agricultural and Natural Resources Online

The 13 GM projects focused on developing varieties with resistance to particular pathogens (mainly blackleg and *Sclerotinia*), abiotic stress, herbicide tolerance, and health characteristics (see table). The dates reported in the Australian Agricultural and Natural Resources Online indicated that all of these GM projects have been completed.

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Table 39 Details of GM Canola R&D

Organisation	No. Projects	Coverage of projects	Latest date
CSIRO Plant Industry	6	Aluminium resistance, phosphorus uptake, high oleic varieties (3), pathogen resistance	2005
La Trobe University	3	Regulatory expression of flowering (2), pollen development	2005
Vic DNRE	2	Pathogen resistance, herbicide tolerance	2004
VIC DPI	1	Pathogen resistance	2004
Total	13		

Data source: Australian Agricultural and Natural Resources Online

Researchers for the 13 organisations involved in GM were contacted by phone to seek information about the reasons for cessation of the work. However, only seven researchers were contactable. The results were as follows:

- 3 projects completed, no further work planned;
- 1 project complete and new follow on research project commenced;
- 2 projects completed and outcomes now awaiting commercialisation;
- 1 project to be completed in 2007, organisation plans to seek further funding after this time.

Hence, five of the seven stated that the projects had met their objectives and that they had no further work planned on GM canola at present. One of these organisations did say that the moratoria had influenced this decision. The others maintained that the end of the research was a natural closure and that they had moved on to other projects.

Of the 6 project leaders that could not be contacted, two projects related to work by the CRC for Tropical Plant Protection, which has now closed. The CRC's annual report in 2004-05 states that the end product of this work has been licensed to a French company, BioGemma.

It appears that the virtual moratorium in the European Union until 2004 has affected R&D programs in the EU: a 2002 European Commission survey of the European Union biotech industry indicated that about 40 per cent of the surveyed research organisations had cancelled projects in GM related areas as a result of the moratorium imposed there. A number of scientists were also reported to have left the UK as a result of criticisms of GM crops (Farrar et al 2003). The effect of the moratorium was further highlighted in the private sector only where well over half the organisations had to cancel GM related projects (Gaskell et al. 2003; European Commission 2003, quoted in A Coulepis 2004). In June 2004, Syngenta announced closure of its UK GM crop research operation as a result of pressure from GM activists (Robinson, 2004). By that time, Monsanto, Dupont and BayerCropscience had already withdrawn from the UK (Mettler 2004).

A submission for the review of the Gene Technology Act 2000 by the NSW Farmers Association stated that any sustained moratorium on research into, trialling or release of GM crops could critically damage Australia's domestic gene technology capability and consequently adversely impact on its long term ability to exploit any technological applications in agriculture in the future (NSWFA 2005)

8.3 Summary

As with most agricultural activities, canola is produced in an open environment where the potential to impact on other agricultural activities, is possible. However, canola is largely a self-fertile plant with some potential for outcrossing. The potential for impact of GM canola on other farming activities from gene flow is limited to only close relatives of canola growing in very close proximity to the GM crop. Low maximum thresholds of cross-contamination by cross-pollination should be attainable with the introduction of appropriate crop management plans. The small potential for gene flow has been recognised and addressed in the stewardship principles developed by the grains industry.

Post farm impact of canola will depend on the capacity of the grain supply chain to manage the segregation of GM canola from conventional canola and other grains, which is covered in detail in the previous chapter. By all accounts the supply chain in Australia appears capable of managing commercial quantities of canola to meet current market requirements if there is an economic incentive to do so.

The impact of the introduction of the moratoria on GM R&D in Australia is difficult to determine. The limited data available suggests there have been instances of a reduction in GM related R&D in agriculture in Australia. The best evidence of a slow down in GM activity is a dramatic fall in the approvals granted by the OGTR between 2003 and 2005. However, interpreting this as a slow down in GM R&D is difficult.

It appears that the virtual moratorium in the European Union until 2004 has affected R&D programs in the EU: a 2002 European Commission survey of the European Union biotech industry indicated that about 40 per cent of the surveyed research organisations had cancelled projects in GM related areas as a result of the moratorium imposed there.

9 Legal and liability issues

This chapter considers the legal and liability issues which might arise as a result of the growing and use of GM canola. The question of liability arises essentially because:

- some farmers want to grow GM crops and others want to be GM free; and
- there is potential for misdescription of traded canola because of inadvertent co-mingling in storage and transport.

Possible grounds for dispute exist because of concern that the use of GM technology may impose costs a GM free business for which it may not be compensated. Disputes that may arise which are not resolved by negotiation between the affected parties can become the subject of civil actions.

However, history suggests that GM canola does not present any new or unusual legal problems. Other technology in the form of new crop varieties, hybrid plants, new animal species and new chemicals (with the potential, say, to affect an existing adjacent crop) has been introduced successfully into Australian agriculture. Typically the introduction of these new technologies has involved careful management by farmers, to ensure appropriate segregation, safety and respect for the rights of others. As noted by Ellickson (1991), farmers regularly and effectively establish and manage property rights on an informal basis, with virtually no formal legal actions. He outlined four main approaches by which farmers manage actual or potential disputes affecting each others' rights:

- recognition of norms, not legal rules, as the basic source of entitlements – most farming business are consciously committed to an overarching norm of cooperation among neighbours, irrespective of the law;
- 'what goes round comes round' or 'live and let live' philosophy – landholders generally recognise that everyone causes and experiences 'externalities' and that, provided the costs incurred in managing them are seen as roughly equivalent, the ledger is regarded as square;
- mental noting of inter-neighbour debts – when the actions of one landholder is imposing more costs on neighbours than the others, the other neighbours will take note and settle at a later date; and
- control of deviants – using a hierarchy of influences from peer pressure to intervention by local authorities.

These approaches observed by Ellickson are also reflected in more formalised approaches such as the GM crop stewardship protocols, licensing and education programs which have been developed by GM canola seed suppliers.

Any problems arising from growing and trading GM crops which cannot be resolved through the processes such as those outlined by Ellickson may become the basis of legal liability.

9.1.1 What sort of problems could arise?

Negligence – causing loss through failure to take care

A farmer growing a GM crop could be sued for negligence if he/she allowed pollen or seed from the property to 'contaminate' another property which the owner wanted to keep GM free, and thereby cause proven loss to the other (GM free) farmer (ACIPA, 2006 p.3). For a successful prosecution it would have to be shown that:

- i the GM farmer knew of the risks of contamination but did little or nothing to prevent it; and
- ii the alleged contamination caused demonstrable financial loss to the GM free farmer.

These conditions also apply in the case of negligence with conventional crops, for example, where untreated stripe rust in one paddock infests the neighbour's wheat crop.

Creating a nuisance

A farmer growing a GM crop could be sued if it could be shown that the presence of the GM crop interfered with the right of a neighbouring GM free farmer from using his/her land as they chose. For example, did the presence of a GM crop prevent the growing of organic products next door and, if so, how much loss was sustained? In the event that liability was proven, the penalty could include remediation costs (ACIPA, 2006 p.17). Again, the same applies to conventional crops, for example, where the presence of grape vines in one paddock denies the farmer next door the option of growing crops that may require the application of hormone weed sprays, but the interference with the use of the property next door would have to be shown to be unreasonable and to cause financial loss.

Trespass

A person would be guilty of trespass in this context if he/she deliberately and directly interfered with the possession of another person's land and hindered that person's right to use that land as intended. For example, if it was obvious that the residue from harvesting a GM crop was blowing into a neighbour's GM free paddock and corrective action were not taken; the owner of the GM crop could be liable for trespass. In practice, a case of trespass is likely also to be covered by nuisance (ACIPA, 2006, p.29).

Infringement of intellectual property rights

A farmer may be held liable for infringing another person's intellectual property rights if, in the case of crops, patented seed is deliberately used for commercial gain without payment of the fee for use of the technology. A similar problem can occur with stock, for example where a woolgrower 'borrows' a neighbour's prize-winning stud ram to improve his genetic base. In a much publicised case in Canada, a farmer was sued by Monsanto for patent infringement for growing its GM Roundup Ready canola without paying the required fee for using Monsanto's technology.

The farmer, Mr Schmeiser, said the original plants had entered his farm without his intervention (potentially a case of trespass and creating a nuisance on the part of Monsanto), but he failed to explain why he had isolated the Roundup Ready plants by spraying them with glyphosate, why he had harvested the plants, segregated the seeds, planted them and grew a 417 hectare crop of canola which tests showed was 95-98 per cent Roundup (glyphosate) resistant. After a prolonged legal battle, two lower courts found that Mr Schmeiser had knowingly and deliberately infringed Monsanto's exclusive rights over its Roundup Ready technology. However, on appeal the Canadian Supreme Court subsequently ruled that since Mr Schmeiser had not sold the crop at a premium and had not profited from the use of the Roundup Ready gene, the case against him did not stand, but ordered that both sides absorb their own costs (The Land, 2004) From that case it can be concluded that, in order to establish liability, proof is required of both a GM patent being wilfully infringed and commercial benefit being achieved as a consequence.

Licence requirements

As discussed in chapter 4, the commercial growing of GM crops requires a licence issued by the OGTR. Penalties apply to any breaches of the licence conditions.

Contract requirements

In cases where a GM free crop is sold to traders or consumers on the basis that it is GM free, the producer may be liable to pay compensation for loss if a breach of the sales description occurs.

Trade practices

Claims of GM free status must be accurate under Commonwealth and state legislation. Misleading and deceptive conduct in trade and commerce is expressly prohibited.

9.1.2 Legal remedies

The legal issues are not specific to GM crops. There have been potential – and some actual – problems with contamination, nuisance, trespass and theft of intellectual rights in the cropping and livestock industries for hundreds of years. Some examples include:

- pea weevil from one crop of field peas can (and does) infect the neighbour's field pea crop;
- spores from an untreated faba bean crop can contaminate the neighbour's faba bean crop, causing dramatic economic loss;
- seeds from uncontrolled weeds establish in adjoining paddocks and impose costs on the 'recipient' farmer;
- light seeds from a new and superior pasture variety may blow into neighbours' paddocks, thus giving the 'recipients' a free ride; should they be required to pay the 'donor'?
- a prize stud bull finds his way through the fence to visit a neighbouring commercial line of cows. Is the owner of the bull liable for creating a nuisance or trespass, or should he be compensated to the extent of the gain to the owner of the cows from the theft of genetic property rights?

Generally these matters are resolved amicably by farmer-to-farmer negotiation, taking account of local practice, commonsense such as give-and-take fencing over creeks and the role of peers. In the event that an issue is not resolved directly by the affected parties, long established legal remedies in common law and statute law are already in place to resolve the questions. They come down to firstly, reasonable people being careful, competent, responsible and complying with current government regulations and industry standards and, secondly, economic loss being established. Although GM crops in Australia are mainly limited to cotton at present, we are not aware of any cases in which action has been brought against a grower of GM crops on grounds of negligence, failing to take care or creating a nuisance. Recourse to the law has not been called upon because the demands of the market, commercial imperatives and long-established norms and practices resolve issues as they arise

The common law

Under common law everyone has a responsibility to manage their activities so as to minimise any externalities which may impact adversely on others. Dalton (2003) describes how the common law is able to deal with externalities associated with GM crops, both in the case of farmers and businesses further along the supply chain where there may be disputes over contractual warranties, seed manufacturers' intellectual property rights, fair trading and the Australia-New Zealand Food Standards Code.

Under a common law approach to managing GM crops, courts are likely to assess whether 'reasonable' claims are being made by both parties and whether both parties are conducting their activities in a 'reasonable' fashion. For example:

- under trespass, a farmer will only be held liable if the trespass is intentional, reckless or negligent;
- to establish that an interference constitutes a nuisance, the plaintiff must show that it was unreasonable in the light of all the circumstances – courts typically apply the principle of 'give and take' between neighbours, as noted by Ellickson (1991); and
- a negligent action requires that the GM farmer owes a third party a duty of care, that there was a breach of that duty and that damage was sustained as a consequence of that breach. This will be judged according to the standards of a reasonable person and may take into account factors such as the size of the risk, the probability of its occurrence, along with the expense, difficulty and inconvenience of taking alleviating action. [Dalton 2003.]

Basically, if a farmer can demonstrate that he has followed industry protocols, adhered to licence conditions and implemented good farming practices, any damages are less likely to be considered unreasonable. Moreover, measurable economic damage needs to be established for compensation to be awarded.

Under common law in the United States, the courts are recognising their social-utility balancing function in relation to the treatment of GM crops (Kershen 2002). For example, courts are playing a role in the allocation of scarce resources by taking account of the affect on market access where a GM crop is approved by domestic regulators but is not permitted in some export markets. The courts do not want to make decisions which may have the effect of overruling any regulatory determination to approve a GM crop for commercial release within the United States. Furthermore, the courts do not want to make decisions which may have the effect of transferring the authority to grow – or prohibit – crops to importing markets such as the European Union. The second case would effectively hand to European Union (in this example) a veto power over plant breeding technology in the United States.

Australian courts could be faced with a similar dilemma in the event that GM crops are more widely grown but are not approved by other potential importing countries.

Liability for not adopting GM technology

The increasing availability of GM technology for producing crops raises the possibility of governments, agribusiness and farmers being liable for not taking action to reduce existing adverse externalities when the means of doing so were at hand. Kershen (2001) identifies two areas where companies and governments could be held liable by the courts or by the general community for not approving GM technology. They are:

- the risk of legal liability for damages; and
- the risk of not complying with environmental regulations.

Kershen (2001) points out that liability for damages occurs when a company could face action stemming from product liability for not using a GM product when a safer GM equivalent product is available. For example, if a person becomes ill from food contaminated with a compound that is not present in a GM crop, the affected person may be able to sue the company for not using the GM product.

Kershen's environmental compliance example is particularly relevant to Australian intensive animal industries. Under United States law farmers must comply with Environmental Protection Agency (EPA) regulations relating to phosphorous loads in run-off water. If a GM feed grain became available that reduced phosphorous loads in the effluent but the farmer was contractually obliged not to use it, the company supplying the grain may be liable for breaches of EPA regulations.

9.1.3 Market demands and values

The real driver of practices leading to the avoidance of the need for prescriptive legislation is market pressure. In the grains (and meat and wool) industries, marketing requirements have forced the adoption of protocols and practices to maintain the integrity of specific varieties and lines. Consumers want greater choice and guaranteed safety, and are increasingly demanding to know that they are receiving what they have paid for. Processors are demanding greater adherence to precision in product identification, tolerance of foreign matter and performance specifications. There are higher standards and tighter rules for sampling, testing and segregation. In order to improve product integrity and raise consumer confidence, trace-back systems are in place so that problems which may adversely affect the market can quickly be identified and remedied.

Market pressure is forcing crop growers to improve their farming practices by more precise selection of varieties, use of certified or quality assured seed, reduced off-type seed, improved on-farm segregation, better weed control, improved management of farm equipment and contractors to ensure minimum contamination of the target crop and more comprehensive farm records. These improved practices include organising rotations to minimise disease and contamination, as well as sharing information and plans with neighbours so that both (all) parties can modify their activities to achieve the best outcome.

On questions of special relevance to GM crops such as product identification, segregation and traceability to source, the wider availability of DNA technology has the capacity to enable farmers, processors and retailers to meet market demands and, in doing so, avoid the need for special rules governing GM crops (see discussion of available tests in chapter 7.2).

9.1.4 GM specific legal regimes

Notwithstanding the diminishing need for legal resolutions of GM issues as the cropping industries move to more exacting market demands (see section 9.1.3), and the demonstrated capacity of the common law to apply to GM crops as it has successfully done for other crops, there is political pressure from some quarters for a specialised legal regime and the introduction of strict liability.

Specialised legal regime

The proponents of a specialised legal regime believe that a comprehensive raft of laws and regulations will prevent contamination of conventional or organic crops by GM crops. However, notwithstanding prohibitions against the commercial cultivation of canola in most states and territories in Australia, a low level presence (around 0.01 per cent) of a GM canola variety (Topas 19/2) was detected in conventional canola in Victoria in 2005. After the event, the occurrence was approved by the Australian regulators (the Gene Technology Regulator and Food Standards Australia New Zealand) and is also approved for import in Australia's major export markets, including the European Union (ABARE, 2007, p.19). Taking into account the difficulty of ensuring absolute freedom from GM grains, the Australian, state and territory governments agreed in 2005 to allow threshold levels of 0.9 per cent of GM canola in conventional canola, thereby implicitly acknowledging that the moratorium was not effective.

At face value the objective of specialised laws for GM crops is to protect the price premium of conventional and organic crops, preserve market access, and ensure that crops are safe for human consumption and will not harm the environment. However, experience with specialised laws to date preventing the commercial cultivation of canola indicates that:

- they are ineffective because there is little or no price premium to protect;
- market access is not materially affected (see ABARE 2007a);
- crops are already used safely in human consumption; and
- the environment is either unaffected or improved through reduced use of synthetic chemicals – for example the adoption of GM cotton has resulted in an 80 per cent reduction in insecticide use (Knox et al, 2006).

Moreover, the prohibition of commercial cultivation of GM crops is costly in terms of forgone agronomic benefits (such as higher yields and reduced inputs) and forgone environmental benefits (such a reduced use of insecticides and fungicides) (ABARE, 2007a p.6). As discussed above, the forgoing of these benefits could result in liability for damages. For example, if adverse externalities were not reduced when the means of doing so were available.

Costs arising from a specialised legal regime also include the uncertainty of decision-making, confused accountability and, accordingly, reduced investment. Already the various forms of moratoria on some GM crops introduced by the governments of Victoria, New South Wales, Western Australia, South Australia, Tasmania and the Australian Capital Territory have given those governments effective power to overrule the OGTR approval process and control farming practices in much of Australia. The report by the Agriculture and Food Policy Reference Group (2006) expressed concerns that the moratorium on GM crops has imposed costs on Australian farmers and the economy. Similarly the Statutory Review of the Gene Technology Act 2000 and the Gene Technology Agreement in 2006 found that the moratoria were causing detrimental rather than beneficial impacts (see chapter 4).

Most countries have decided that specialised laws for GM products are not necessary or appropriate for GM crops and that the common law is adequate. The Governments of the United Kingdom, New Zealand, United States, Canada and Australia have all declined to introduce substantive new legal regimes for GM crops. (Kershen 2002, Dalton et al 2003). The reasons for their decisions are, broadly, that:

- the common law is sufficiently adaptable to apply to new technologies;
- there are no grounds for assuming that there is anything sufficiently different about GM crops to warrant a special damages regime; and
- institutional intervention could have costly side effects.

Additional costs arising from a more complex and onerous regulatory environment could include:

- reduced incentive to innovate;
- increased transaction costs (compliance, monitoring and policing); and
- specific legislation formulated today is likely to be inappropriate for evolving products and conditions in the future.

Strict liability regime

Some of the more extreme opponents of GM crops advocate strict liability in order to make the contingent liability of using GM technology impossibly high. Strict liability is a surrogate for banning GM technology outright.

Strict liability imposes liability on a third person for the actions of another, regardless of fault. It applies in some industrial cases, for example, where the owner of a business can be held liable for an accident to an employee even though that owner had no contributing role in the accident and knew nothing about it. If the concept of strict liability were to apply in the plant breeding industry, the greatly increased risk would add enormous costs and, accordingly, reduce investment.

The intention of the concept of strict liability is to provide a safety net for compensation of employees whose activities are considered to be hazardous and inherently dangerous. However, it would be most unlikely that GM crops could be found to be hazardous or dangerous, especially as they would conform to standards and tolerances required by the market place and as approved by the office of the Gene Technology Regulator.

In the United States there is no strict liability for harm caused by an abnormally dangerous activity if the harm would not have resulted but for the abnormally sensitive character of the plaintiff's activity (Kershen 2002). It seems reasonable to conclude that this view would also be considered by the courts in Australia

It is significant that a former Chief Justice of the High Court of Australia, after discussing a range of case law, concluded that the doctrine of strict liability has no place in Australian law (Mason 1986).

9.2 Summary

The growing and use of GM canola can lead to disputes arising from adverse externalities. That is, the activity of growing, harvesting and trading canola by one person may result in diminished property rights and reduced commercial opportunities of another which are not reflected on the first person's costs. There are well established non-legal norms for resolving disputes over property rights. However, in the event that these do not lead to a mutually agreed outcome, the common law has evolved over hundreds of years to deal with disputes over property rights and the basis for payment of compensation if found to be justified. There is nothing new or different about GM canola. Which would mean that disputes over adverse externalities could not be resolved by negotiation or recourse to common law? Accordingly there is no need for special laws and regulations solely for GM crops. Moreover, increasing demands of the market being driven by commercial pressures, including tighter product description, product specification, segregation, product safety, accountability and disclosure, are reducing the likelihood of adverse externalities arising from the cultivation of, and trade in, GM crops.

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Organisation	Title of Project	Parent Organism Common Name	Parent Organism Scientific Name	Modified Trait	Issue Date	Status
Department of Primary Industries - Victoria	Limited and Controlled Release of GM drought tolerant wheat	Bread wheat	Triticum aestivum L.	Drought tolerance	13 June 2007	Current
BSES Limited	Limited and Controlled Release of GM Sugarcane with altered plant architecture, enhanced water or improved nitrogen use efficiency	Sugarcane	Saccharum spp.	Altered plant architecture, enhanced water or improved nitrogen use efficiency	13 February 2007	Current
Bayer CropScience Pty Ltd	Limited and controlled release of GM herbicide tolerant hybrid Brassica napus and hybrid Brassica juncea	Canola and Indian Mustard	Brassica napus and Brassica juncea	Herbicide tolerance and hybrid breeding system	28 March 2007	Current
Florigene Pty Ltd	Limited and Controlled Release of Genetically Modified (GM) Torenia with altered flower colour	Torenia cv. Summerwave®	Torenia X hybrida	Altered flower colour (flavonoid biosynthesis)	20 December 2006	Current
CSIRO	Limited and Controlled Release of Waterlogging Tolerant (GM) Cotton	Cotton	Gossypium hirsutum L.	Waterlogging tolerance	12 December 2006	Current
Monsanto Australia Pty Ltd	Commercial Release of GM herbicide tolerant and/or insect resistant cotton lines north of latitude 22° South	Cotton	Gossypium hirsutum L.	herbicide tolerant and/or insect resistant	26 October 2006	Current
Deltapine Australia Pty Ltd	Limited and Controlled Release of Insect Resistant Genetically Modified Cotton	Cotton	Gossypium hirsutum L.	Insect resistance	13 October 2006	Post-harvest monitoring
Monsanto Australia Ltd	Limited and Controlled Release of Water-Efficient Genetically Modified Cotton	Cotton	Gossypium hirsutum L.	Water-use efficiency	11 October 2006	Current
Hexima Ltd	Field trial of GM cotton expressing natural plant genes for fungal control	Cotton	Gossypium hirsutum L.	Fungal resistance	29 August 2006	Post-harvest monitoring
Bayer CropScience Pty Ltd	Commercial release of herbicide tolerant Liberty Link® Cotton	Cotton	Gossypium hirsutum L.	Herbicide tolerance	8 August 2006	Current

Grain Biotech Australia Pty Ltd	Field trial of genetically modified salt tolerant wheat on saline land	Bread wheat	Triticum aestivum L.	Salt tolerance, herbicide tolerance	Withdrawn
Florigene Limited	Limited and controlled release of GM rose lines	Rose	Rosa X hybrida L.	Altered flower colour, selectable marker	Current
Monsanto Australia Pty Ltd	Commercial release of herbicide tolerant (Roundup Ready Flex® MON 88913) and herbicide tolerant/insect resistant (Roundup Ready Flex® MON 88913/Bollgard II®) cotton south of latitude 22° South in Australia	Cotton	Gossypium hirsutum L.	Prolonged herbicide tolerance and/or insect resistance, reporter antibiotic resistance, reporter gene expression	Current
Deltapine Australia Pty Ltd	Limited and controlled release of insect resistant (VIP) GM cotton	Cotton	Gossypium hirsutum L.	Insect resistance, antibiotic resistance	Surrendered 13 February 2007
Bayer CropScience Pty Ltd	Field trials of genetically modified herbicide tolerant, hybrid Brassica juncea	Indian mustard (includes Brown and Oriental mustard)	Brassica juncea L. Czern and Coss.	Herbicide tolerance and hybrid breeding system	Post-harvest monitoring Current/
Bayer CropScience Pty Ltd	Field trial of herbicide tolerant (LLCotton25) and herbicide tolerant/insect resistant (LLCotton25/Bollgard II®) cottons	Cotton	Gossypium hirsutum L.	Herbicide tolerance, insecticidal action, antibiotic resistance, reporter gene expression	Post-harvest monitoring
Monsanto Australia Ltd	Field trial of herbicide tolerant (Roundup Ready® Flex MON 88913) and herbicide tolerant/insect resistant (Roundup Ready® Flex MON 88913/Bollgard II®) cottons	cotton	Gossypium hirsutum L.	Prolonged herbicide tolerance, insecticidal action, antibiotic resistance, reporter gene expression	Surrendered 10 January 2007
CSIRO	Field trial of genetically modified wheat with altered grain starch	Bread wheat	Triticum aestivum L.	Altered grain starch and Antibiotic resistance	Post-harvest monitoring
Grain Biotech Australia Pty Ltd	Field trial of genetically modified salt tolerant wheat on saline land	Bread wheat	Triticum aestivum L.	Salt tolerance, herbicide tolerance	Surrendered 30 March 2007
CSIRO	Field trial of genetically modified rice (Oryza sativa L.) functional characterisation of the rice genome	Cultivated rice	Oryza sativa L. cv Nipponbare	Herbicide tolerance, antibiotic resistance and reporter genes have been randomly inserted into rice plants. Some plant growth traits may be modified by gene knockouts.	Post-harvest monitoring

The University of Queensland	Field trial of genetically modified (GM) sugarcane expressing sucrose isomerase	Sugarcane	Saccharum officinarum L. x S. spontaneum L.	Altered sugar production and Antibiotic resistance	11 February 2005	Current
Queensland Department of Primary Industries & Fisheries	Vaccination of cattle with recombinant bovine herpesvirus vaccines	Bovine herpesvirus 1 (BoHV-1)	Bovine herpesvirus 1 subtype 1.2b strain V155	• expression of green fluorescent protein (GFP) • expression of envelope glycoprotein E2 • expression of a truncated E0 glycoprotein fused to GFP or to the E2 glycoprotein • localisation of introduced proteins on the surface of the GMOs or host cells • deletion or disruption of endogenous BoHV-1 genes	26 April 2005	Current
CSIRO	GM cotton field trial - Evaluation under field conditions of the cotton rubisco small subunit promoter driving a reporter gene	Cotton	Gossypium hirsutum L	One reporter gene (enables detection and quantification of gene expression) linked to one of two promoters, and either one or two selectable marker genes (antibiotic resistance)	21 October 2004	Surrendered 5 April 2007
Hexima Limited Ltd	Field trial to assess transgenic cotton expressing natural plant genes for insect control	Cotton	Gossypium hirsutum L	Insecticidal action, antibiotic resistance	30 July 2004	Post-harvest monitoring
Department of Primary Industries (Victoria)	Field Evaluation of Genetically Modified White Clover Resistant to Infection by Alfalfa Mosaic Virus	White Clover	Trifolium repens L	Viral Disease Resistance, Antibiotic resistance	30 July 2004	Current/ Post-harvest monitoring
Imugene Limited	Limited and controlled release of GM fowl adenovirus (FAV)	Fowl adenovirus	Fowl adenovirus, serotype 8, isolate CFA44	Immunomodulatory protein expression, Attenuation	25 January 2006	Current
Dow AgroSciences Australia Pty Ltd	Agronomic assessment and seed increase of transgenic cottons expressing insecticidal genes (cry1Ac and cry1Fq) from Bacillus thuringiensis	Cotton	Gossypium hirsutum L	Insecticidal and herbicide tolerance	28 May 2004	Current/ Post-harvest monitoring

The University of Western Australia	Preliminary agronomic assessment of high sulphur lupin	Narrow Leafed Lupin	Lupinus angustifolius cv Kayla	Increased levels of sulphur in seed	Withdrawn
CSIRO	Field Evaluation of Genetically-Modified White Clover Resistant to Infection by Alfalfa Mosaic Virus and Clover Yellow Vein Virus	White Clover	Trifolium repens	Virus resistance	Withdrawn
Department of Primary Industries	Field Evaluation of White Clover Resistant to Infection by Alfalfa Mosaic Virus and Clover Yellow Vein Virus	White Clover	Trifolium repens	Virus resistance	Withdrawn
Dow AgroSciences Australia Pty Ltd	Agronomic assessment and seed increase of transgenic cotton expressing insect tolerance genes from <i>Bacillus thuringiensis</i>	Cotton	Gossypium hirsutum	Insect resistance, herbicide tolerance	Surrendered 29 January 2007
CSIRO	Field Evaluation of Genetically Modified High Oleic (HO) Cotton	Cotton	Gossypium hirsutum	Modified fatty acid content in cottonseed oil	Post-harvest monitoring
CSIRO	Field trial for breeding and pre-commercial evaluation of GM cotton expressing tolerance to the herbicide glufosinate ammonium	Cotton	Gossypium hirsutum	Herbicide tolerance	Surrendered 5 April 2007
CSIRO	Breeding and pre-commercial evaluation of transgenic cotton expressing a vegetative insecticidal protein (VIP) gene and a herbicide tolerance gene	Cotton	Gossypium hirsutum	Insect resistance, herbicide tolerance, antibiotic resistance	Surrendered 5 April 2007
Monsanto Australia Ltd	Field trials of herbicide tolerant (Roundup Ready® MON 88913) and herbicide tolerant/insect resistant (Roundup Ready® MON 88913/Bollgard II®) cotton	Cotton	Gossypium hirsutum	Enhanced herbicide tolerance, insect resistance, antibiotic resistance, reporter gene expression	Surrendered 23 June 2006
Syngenta Seeds Pty Ltd	The Evaluation of Transgenic Cotton Plants Expressing the VIP Gene	Cotton	Gossypium hirsutum	Insect resistance, antibiotic resistance	Current
CSL Ltd	Commercial release of recombinant live oral cholera vaccine (Orchol® vaccine)	Cholera vaccine	Vibrio cholerae	Attenuation by removal of cholera toxin subunit A and inclusion of a mercury resistance marker	Current

TBayer CropScience Pty Ltd	Field Trial - Seed increase and field evaluation of herbicide tolerant hybrid canola	Canola	Brassica napus	herbicide tolerant hybrid canola	10 March 2004	Current/ Post-harvest monitoring
CSIRO	Field trial of GM grapevines - Evaluation of berry colour, sugar composition, flower and fruit development and gene flow study	Grapevines	Vitis vinifera L.	Expression of modified colour, sugar composition, flowering and fruit development, expression of green fluorescence protein, antibiotic resistance	18 June 2003	Current Ceased (moved to GMO Register) - 27 March 2007
Florigene Ltd	Ongoing commercial release of colour modified carnations	Carnation	Dianthus caryophyllus	Modified flower colour	17 June 2003	Withdrawn
Department of Primary Industries	Field trial of pineapple plants modified for blackheart reduction and to delay flowering	Pineapple	Ananas comosus	Reduction of blackheart, delayed flowering, reporter gene expression, antibiotic resistance	19 June 2003	Current
The University of Queensland	Field trial of pineapple plants modified to control flowering	Pineapple	Ananas comosus	Delayed flowering, herbicide resistance, reporter gene expression	19 June 2003	Surrendered 12 June 2007
The University of Queensland	Field trial for evaluation of GM papaya to delay fruit ripening and to test the expression of the introduced genes	Papaya	Carica papaya	Delayed fruit ripening, reporter gene expression and antibiotic resistance	17 June 2003	Post-harvest monitoring
CSIRO	Seed increase and efficacy studies in Northern Australia of transgenic cotton expressing a new insecticidal protein gene (VIP3A)	Cotton	Gossypium hirsutum	Insecticidal cotton	6 May 2003	Surrendered 22 September 2004
Monsanto Australia Ltd	Commercial release of herbicide tolerant (Roundup Ready®) and herbicide tolerant/insect resistant (Roundup Ready®/INGARD®) cotton	Cotton	Gossypium hirsutum	Herbicide tolerant, insecticidal cotton	20 June 2003	Current
Monsanto Australia Ltd	Commercial release of insecticidal (INGARD®) cotton	Cotton	Gossypium hirsutum	Insecticidal cotton	12 June 2003	Current
Bayer CropScience Pty Ltd	Commercial release of InVigor® hybrid canola (Brassica napus) for use in the Australian cropping system	Canola	Brassica napus	Herbicide tolerance, Hybrid Breeding System	25 July 2003	Current
Monsanto Australia Ltd	General release of Roundup Ready® canola (Brassica napus) in Australia	Canola	Brassica napus	Herbicide tolerance	19 December 2003	Current

Bureau of Sugar Experiment Stations	Agronomic assessment of transgenic sugarcane engineered with reporter genes	Sugarcane	Saccharum interspecific hybrid	Green fluorescent reporter gene	18 December 2002	Post-harvest monitoring
CSIRO	Field trial of oilseed poppy in Tasmania to evaluate alkaloid production	Poppy	Papaver somniferum	Altered alkaloid production pathway	6 November 2002	Signed-off 13 March 2007
CSIRO	Field trials of insect resistant cotton	Cotton	Gossypium hirsutum	Insect resistance	14 October 2002	Post-harvest monitoring
CSIRO	Field trials of insect resistant and glufosinate tolerant cotton	Cotton	Gossypium hirsutum	Insect resistance and herbicide tolerance	14 October 2002	Surrendered 22 September 2004
CSIRO	Field trials of glufosinate ammonium tolerant cotton	Cotton	Gossypium hirsutum	Herbicide tolerance	14 October 2002	Surrendered 22 September 2004
Monsanto Australia Ltd	Commercial release of BollgardII and BollgardII/Roundup Ready® cotton	Cotton	Gossypium hirsutum	Insect resistance and herbicide tolerance	23 September 2002	Current/Post-harvest monitoring
Monsanto Australia Ltd	Field trials of Roundup Ready® canola (Brassica napus) in Australia in 2002	Canola	Brassica napus	Herbicide tolerance	22 August 2002	Surrendered 2 June 2004
Aventis CropScience Pty Ltd	Small and large scale trialing of InVigor® canola (Brassica napus) for development for the Australian cropping system	Canola	Brassica napus	Hybrid breeding system and herbicide tolerance	30 July 2002	Post-harvest monitoring
Department of Agriculture (WA)	Preliminary field evaluation of Bollgard II® cotton in the Kimberley region of WA	Cotton	Gossypium hirsutum	Insect resistance	28 March 2002	Surrendered 17 October 2006
Department of Agriculture (WA)	Integrated pest management systems for INGARD® cotton	Cotton	Gossypium hirsutum	Insect resistance	28 March 2002	Surrendered 17 October 2006
Department of Agriculture (WA)	Improved alkaloid production in oilseed poppy (Papaver somniferum)	Oilseed Poppy	Papaver somniferum subsp somniferum	Altered alkaloid production pathway	30 July 2002	Surrendered 23 July 2004
CSIRO	Agronomic assessment and seed increase in northern Australia of transgenic cotton expressing Cry1Ac or Cry1Ac and Cry2Ab from Bacillus thuringiensis	Cotton	Gossypium hirsutum	Insect resistance and herbicide tolerance	28 March 2002	Surrendered 4 November 2004
Cotton Seed Distributors Ltd	Agronomic assessments and seed increase in Eastern Australia of transgenic cotton expressing Cry1Ac and Cry2Ab from Bacillus thuringiensis	Cotton	Gossypium hirsutum	Insect resistance and herbicide tolerance	18 January 2002	Surrendered 1 November 2002

B Testing plants for Genetic modification

The genetic modification of a crop or food requires the insertion of a novel piece of DNA into the plant's natural genomic DNA. This process is called a transformation 'event'. The novel DNA contains the information needed to create a new characteristic or 'trait' in the plant. In most instances, the novel DNA provides the code to produce a novel protein that affects this trait. Therefore, current methods for identifying GM plants and foods involve detection of either the novel protein or the novel DNA.

Protein Detection Methods

In most instances a genetic modification to an organism leads to production of a novel protein. The presence of this novel protein provides a means to differentiate between GM and non-GM crops. There are many protein detection methods, but all are trait-specific. Trait-specific methods can detect the presence of a particular trait or characteristic, but cannot differentiate between different transformation events which produce the same trait. The majority of trait-specific methods are immunoassays or ELISAs.

ELISA

Enzyme Linked Immunosorbent Assays (ELISAs) determine the presence and amount of a protein or antigen in a sample using an antibody-linked enzyme³⁵ which induces a colour change (or fluorescence) when the antibody binds to the antigen. A colour change indicates a positive result for the protein and its related GM trait. The depth of the colour indicates the amount of target protein present.

There are many types of ELISA available, including cheap on-site kits that provide a visual confirmation of the presence/absence of the target protein in strip test format (e.g. Strategic Diagnostics Inc.'s "TraitPLL Test Kits"), and semi-quantitative tests such as the "GMOChek™ ELISA Tests" manufactured by Strategic Diagnostics Inc and distributed by GeneScan. On-site ELISA tests take 10 minutes to 4 hours to complete, and ELISA testing service providers produce results in 1 to 2 days.³⁶

Lateral Flow Strips

Lateral flow strips are simply another form of ELISA, in which the antibodies are fixed in specific locations on a test strip, and provide a positive/negative visual result similar to a home pregnancy test. The sample is crushed and mixed with the sample protein solution. The test strip is then dipped into the sample. These tests are rapid (test results within ten minutes) and simple and can be conducted on-site but are a lot less sensitive.³⁷

³⁵ Antibodies and antigens fit together much like a lock and it's key. Enzymes are molecules which trigger a chemical reaction. By attaching an enzyme which causes a colour change to an antibody, analysts can visualise when an antigen-antibody reaction has occurred because the sample changes colour.

Magnetic Particle Immunoassays

Magnetic particle immunoassays use antibodies fixed to magnetic particles in solution to bind the target protein. Bound protein is separated from unbound protein with a magnet. This is not a common test format, and is only suitable for laboratory testing.³⁸

Protein Profiling

Protein profiling uses mass spectrometry³⁹ to create a profile of the proteins present in a sample. This profile can be compared to a database which describes how the protein mix in different varieties of crops varies, to identify the sample. Protein profiles for all the main varieties of canola are available, and the database is continually updated as new varieties emerge. This is a high throughput, high speed test, with results available in just 24 hours. The test is also relatively low cost and highly accurate.⁴⁰

Advantages & limitations of protein methods^{41,42}

The advantages of trait-specific or protein detection methods include:

- minimal to moderate sample preparation,
- relatively simple formats;
- rapid results; and
- low cost.

Many of these tests can be carried out on-site with minimal training. However, immunoassays are currently limited by:

- their sensitivity (0.5 to 1 per cent GMO);
- their ineffectiveness as a general screening tool (as a single antibody only recognises one specific protein);
- inability to differentiate between specific transformation events; and
- unsuitability for cooked foods or commodities due to breakdown of the proteins by heat or exposure to strong acids/alkalis.

Of the immunoassays, only ELISA provides any quantification, and this is of limited use because protein levels can vary from one plant to another; from season to season; between different parts of the plant; and from one stage of the cell's life cycle to another. Further, any results from quantification using ELISA produce an absolute value which cannot be used for Australian labelling, as Australian standards require relative values.

³⁶ Griffiths (2002) op cit -

³⁷ Summary of Ceres International Roundtable proceedings op cit

³⁸ Griffiths (2002) op cit. -

³⁹ Mass spectrometry is an analytical technique used to measure the mass-to-charge ratio of ions. It is most generally used to find the composition of a physical sample by generating a mass spectrum representing the masses of sample components.

⁴⁰ Department of Agriculture and Food, Western Australia (DAFW) <http://www.agric.wa.gov.au>

Sampling is very important in protein detection methods, because in some cases only certain plant tissues express the novel protein, so inefficient sampling could result in a false negative result. False positives can also occur due to cross-reactions with other components of the sample analysed.

There are only a limited number of GMOs for which commercial kits are available, because the development of suitable test antibodies for new GM traits takes several months.

DNA Detection Methods

Genetically modifying a plant involves inserting a novel piece of DNA into the plant's genetic code. The presence or absence of these novel sections of DNA provide a means to differentiate between GM and non-GM crops and foods. DNA detection methods can be used for screening, and to provide both qualitative and quantitative data. The success of all these methods relies on the quantity, quality and purity of the DNA extracted from samples in the initial purification step.

Amplification

There are many types of DNA detection methods available, but all begin with DNA isolation, followed by an amplification step. DNA amplification is the process by which a sequence of DNA is copied many times to produce a larger quantity of the target DNA sequence. This is necessary because the DNA code in the GM crop may be present in very small amounts and may not be detectable at these levels. Amplification creates more copies of the DNA so that it can be detected using standard techniques. The process by which DNA is amplified is known as PCR, or the 'polymerase chain reaction'.

PCR Screening Methods

As most GMOs contain one of a small number of common genetic elements, their presence can be used to screen samples for genetic modification. PCR screening involves the use of specifically targeted DNA primers⁴³ which amplify only the targeted genetic element. DNA primers are short strands of nucleic acids (the building blocks of DNA) which attach to strands of DNA to act as a starting point for DNA replication. Primers are designed to match the nucleic acid sequences of their intended target, so they amplify the correct DNA sequence. DNA cannot be replicated and amplified without a starting point provided by a primer.

PCR screens can be used to eliminate samples with negative results from suspicion. However, there are some unique instances in which a common genetic element indicative of GMOs may appear naturally in non-GM plants, often due to infections or the presence of soil micro-organisms in samples. Therefore further tests are required to confirm any positive results. Screening results are usually available in 1 to 2 days.⁴⁴

⁴¹ Summary of Ceres International Roundtable proceedings op cit

⁴² Griffiths (2002) op cit.

⁴³ Primers are short segments of DNA or RNA that are required to initiate DNA replication, by attaching to a complementary DNA sequence and providing a point of attachment for the replication catalyst, DNA polymerase.

⁴⁴ Griffiths (2002) op cit.

Qualitative PCR Methods

PCR screening can also be used to find novel DNA sequences which are not found in nature. For example, the *Bacillus thuringiensis* gene inserted by Monsanto into its GM cotton varieties was constructed so that the bacterial protein for which it coded would be expressed properly in plants.⁴⁵

The presence of a novel sequence can definitively identify a genetic modification, but will not provide information on where the novel sequence was inserted into the host plant's DNA. Identifying the location of a DNA sequence can be important for checking regulatory compliance, as some GM crops contain the same novel genetic sequence inserted in different places – for regulatory purposes, each of these is designated as a separate event and requires separate approval.

Event-specific PCR methods use primers which attach to junctions between the plant's natural genetic code and the point where the novel DNA was inserted into the plant DNA. This allows each specific event to be detected.

Qualitative PCR methods generally take 1 to 2 days to produce results,⁴⁶ compares the primer targets of these different PCR methods.

Quantitative PCR Methods

It is possible to use PCR methods to calculate a relative amount of the level of GMO present in a sample by amplifying two DNA sequences in parallel, one sequence from the novel DNA and one sequence from a gene that occurs naturally in the plant. The test determines the ratio between the two amounts of amplified product obtained. Quantitative PCR methods can take from 3 to 10 days to produce results, and are very sensitive.⁴⁷

⁴⁵ Monsanto Company, http://www.monsanto.com/monsanto/content/sci_tech/prod_safety/bollgard_ii/pss.pdf

⁴⁶ *ibid*

⁴⁷ Summary of Ceres International Roundtable proceedings *op cit*

⁴⁸ Griffiths (2002) *op cit*

Detection following PCR ⁴⁸

Real-time PCR using a range of fluorescing dyes or probes can be used to monitor the amplified products during the PCR process utilising high-throughput screening and automation. They are a single strand of DNA with a known sequence that is complementary to the DNA target strand. They carry a fluorescent or radioactive marker so that they can be easily identified/located. Probes provide the most specific and sensitive detection. A single PCR reaction can be used to amplify up to five different targets, with a different colour marker used to monitor each one.

After PCR is complete, the results can be analysed using a range of methods including gel electrophoresis, membrane blotting, and selective immobilisation followed by PCR-ELISA. All of these provide some type of visual result. Nested PCR⁴⁹ can also be used, and highly increases specificity and sensitivity (up to 1000 times more sensitive than PCR) by using a second set of primers that amplify a secondary target within the first PCR product to reduce unintended primer binding. However the most reliable method for unequivocally identifying a PCR product is sequencing – this is the process by which the order of nucleotides in a DNA sequence, or genetic make-up, is determined.

PCR techniques have been miniaturised and are now available on a chip format that can be read by a machine. The chips contain all the required PCR systems for rapid detection of PCR products within twenty minutes. Some of these systems are available commercially, for example the BioMark system from Fluidigm (<http://www.fluidigm.com/biomark.htm>), but research and development in this area is ongoing.

Genome Profiling

This novel sequencing method uses an array of hybridised markers⁵⁰ to rapidly identify the genetic make-up of particular crop varieties. The presence or absence of each marker can be analysed using any standard genetic analysis software, and a “whole genome” profile can be produced in two days.⁵¹ The benefit of this method is that the analyst requires no prior knowledge of the sample’s genome sequence. Before this method became available an analyst would have to spend months sequencing a plant’s genome before a DNA test could be developed. However, for crops like canola which have a known genetic sequence, this method does not provide any time saving benefit over other methods. In the case of canola, genome profiling is more likely to be useful if investigating a sample which is suspected of containing an unauthorised genetic modification with novel DNA of an unknown sequence.

⁴⁹ Nested PCR uses two sets of primers in two successive runs of PCR. The second set of primers amplifies a secondary target within the first run product to reduce contaminations in PCR products due to unintended primer binding.

⁵⁰ Markers are fragments of DNA that are associated with specific parts of specific genomes. The same marker may be present in more than one genome; so many markers are required to identify a specific crop variety. For this reason, multiple markers can be hybridised (joined to) a plate with multiple test wells to create an array.

⁵¹ Triticarte Pty Ltd, <http://www.triticarte.com.au>

Advantages and Limitations ^{52,53}

DNA detection methods are more versatile than protein detection methods. Advantages include:

- the ability to provide both qualitative and quantitative information;
- the ability to provide information on both raw and processed samples from any part of a plant (because DNA composition is the same in all cells);
- the ability to provide general or specific information by varying the DNA sequence targeted;
- the generic nature of DNA testing methods allows tests for new GM traits and even unapproved GMOs to be developed relatively quickly, however, validation of the testing method can take time;
- DNA detection methods are very sensitive, which in some instances can be a disadvantage;
- DNA methods can detect multiple GMOs at a time; and

Disadvantages of DNA detection methods include:

- the PCR used in DNA methods can be prone to contamination, so careful handling and positive and negative controls are required for reliable results; ⁵⁴ and
- to develop the primers that are used in all PCR detection techniques, information about the sequence of the suspected novel DNA and the plant genome must be known (although this is not a requirement for genome profiling).

There are also a number of commercial test kits available for detecting GMOs via DNA methods. However, careful sample preparation is required to extract DNA from samples, and the tests require a relatively high skill level and expensive equipment, and generally have to be performed in a laboratory.

⁵² Summary of Ceres International Roundtable proceedings op cit

⁵³ Griffiths (2002) op cit

⁵⁴ Positive controls are samples that are known to produce a positive result if the test is working as expected. Negative controls are samples where a negative result is expected, to help correlate a positive result with the variable being tested.

Recent Developments and Future Technologies⁵⁵

Immunoassays for GM testing are being developed using existing technologies, but with extended applications. For instance:

- lateral flow strips that can detect multiple proteins with one test;
- immunoassays for processed foods. These can bind antibodies to DNA fragments and can recognise proteins even after heating and other processing;
- incorporating ELISA into fully automated instruments which can run more samples faster;
- using immunoassays in combination with other methods such as spectrometry or biosensors for real-time antibody binding; and
- improvements in antibody specificity and binding strength to increase sensitivity and reduce sample preparation for existing test methods.

High-throughput protein micro-chip technology is being developed using micromosaic immunoassays, such as the recently developed 'soft lithography'. The silicon chips consist of networks of perpendicular narrow channels coated with antigen, through which the diluted protein solution flows. Bound protein produces a 'mosaic' pattern of tiny squares on the chip that can be analysed with a fluorescence microscope.

Gene-chip technology is relatively new and shows great potential for GMO testing. Improved DNA amplification methods have been developed recently, which do not require expensive equipment to run. These methods include rolling-circle amplification (or the related isothermal ramification amplification), tyramide signal amplification, and the hybridisation signal amplification method. None of these methods require heating to denature the DNA and begin amplification like in PCR, so there is no need for an expansive thermal cyclor. All provide highly sensitive results and are capable of amplifying DNA in situ, so therefore have the potential for development with microarray technology to provide analysis of multiple targets in a simple on-site test. This technology is not currently used for quantification and may be prohibitive due to costs.

⁵⁵ Griffiths (2002) op cit

