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# Canola and Australian Farming Systems

2003–2007

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# Why GM Canola?

Canola is the third most important winter grain crop grown in Australia and has a four-year average farm gate gross value of \$596 million (1). In Canada, Genetically Modified (GM) canola has been commercially available since 1996. Two GM canola types (Roundup Ready® and InVigor® hybrids) make up around 85% of the market valued at \$2,119 million at the farm gate (2).

The figures presented in 2003 were review using the same methods described (3) taking account of the changes in the industry since then. If half of the current canola types grown were replaced with GM canola, the impact in Australia would be:

- 640 t less triazine herbicide would be used each year
- An extra 225,000 ha of canola could be grown by direct drilling or minimum tillage.
- Average national canola yields would increase from 1.17 to 1.28 t/ha (8%).

- An additional 200,000 ha of canola could be grown in low rainfall regions.
- Wheat production (in rotation) would increase by 80,000 tonnes on the additional canola area.

Canola is grown in rotation with wheat and pastures. It is important in Australian cropping systems because as well as producing oil and protein meal, the wheat crops following canola can show up to a 20% increase in yield because it acts to suppress diseases and pathogens of the other crops in the rotation (3).

Table 1 shows the state by state breakdown of these benefits. The data shows that if half of the Triazine Tolerant (TT) canola was replaced with GM canola, there would be an estimated national benefit of nearly \$160 million annually, plus additional significant environmental benefits as a result of reducing triazine use and facilitating direct drilling.

**Table 1** Summary of the effect of replacing 50% of TT canola and 40% of conventional canola with GM canola.

Factor	NSW	VIC	SA	WA	Total
Reduced triazine use - tonnes	100 t	92 t	80 t	360 t	632 t
Increased proportion of canola of DD (%)	9%	7%	9%	2%	6%
Increased canola area ('000 ha)	40	30	30	100	200
Increased yield	8%	6%	4%	8%	7%
Increased canola production	19%	19%	20%	32%	23%
Increase wheat production ('000 t)	16	12	12	40	80
Increased value of production	\$34 million	\$26 million	\$23 million	\$74 million	\$157 million

## Environmental benefits

In modern cropping systems, herbicides have replaced cultivation which helps reduce the loss of topsoil and improve health of the soil. In Australia, over 60% of canola cultivars planted are tolerant to triazine herbicide and these cultivars are known as TT canola (short for "Triazine Tolerant" canola) (3).

However, triazines are residual herbicides and stay active in the soil for considerable periods of time. There have been environmental concerns around their use (4). The GM varieties that have been developed are tolerant to the post emergent broad spectrum herbicides glyphosate and glufosinate-ammonium, respectively (5, 6) which have a lower environmental impact than the triazines.

## Human and Environmental Safety

In 2003, InVigor® hybrid canola and Roundup Ready® canola were approved for use by Australia's independent regulators, Food Standards Australia New Zealand (FSANZ) and the Office of the Gene Technology Regulator (OGTR). Their examination of the scientific evidence showed that the GM varieties were just as safe as conventional canola (5, 6).

## Trade/Economic benefits

The adoption of GM canola could provide significant economic advantages now worth an estimated \$157 million annually at the farm, which is 16% higher than the 2003 estimate (3).

Current GM producing countries have no difficulties gaining access for GM grains (7, 8, 9).

The GM crops corn, cotton, soybean and canola are now grown on over 100 Mha worldwide (10). These crops are traded throughout the world with the majority of global soybeans, corn and canola exports now coming from countries that produce GM varieties. In 2006, as a result of drought, Australia imported approximately 60,000t of Canadian GM canola. InVigor® and Roundup Ready® canola are now approved for import to Europe (7).

Canada has grown improved GM canola varieties since 1995 and has maintained its large market share into Japan, whilst developing new markets such as China, Mexico and Pakistan (11).

Using available infrastructure and know how, the Australian grains supply chain already has protocols, processes and practices in place to deliver market choice with GM canola varieties (12, 13), similar to Canada (14).

# Canola in Australia

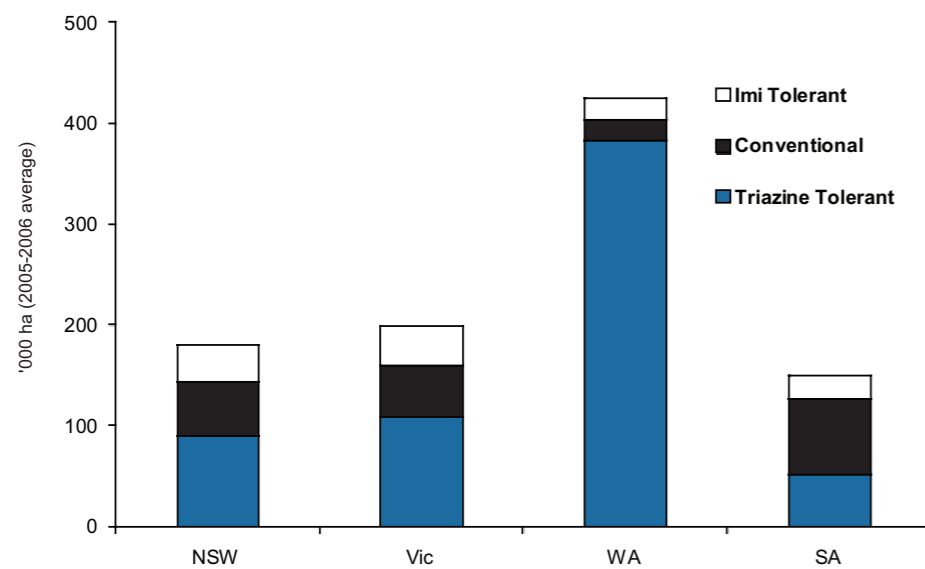
By area sown, canola is now the third largest winter crop grown in Australia (1).

Canola was first grown in Australia in the 1970's. It was the release of herbicide tolerant (HT) types in 1993 that saw a rapid rise in domestic production, which peaked at about 2.2 Mt from 1.85 Mha in 1999. Since then, a combination of poor seasonal conditions and changing terms of trade has seen canola areas reduce to less than 1.0 Mha, and the 5 year average yield decline to 1.18 t/ha (1, 9). Much of the canola produced is HT, with triazine tolerant (TT) and imidiazolinone tolerant (IT) making up about 75% of the Australian crop (3) (Figure 1).

Indeed, most of the decline in canola area sown has been conventional types, as the area of TT canola is similar to the 2001/2002 period.

HT canola is particularly important to grain growers as there are no herbicides available to effectively control weeds such as wild radish and wild mustard in conventional canola (15). These weeds compete with canola crops, can contaminate canola seed and build up and infest subsequent wheat crops. TT canola has been the most popular canola grown, especially in Western Australia, but because of the nature of its herbicide tolerance, it has an inherent yield penalty, estimated at 25% compared to conventional varieties (16).

Figure 1 Areas of canola, 2 year average of 2005-06, and estimated proportions of different herbicide tolerance types (1, 3).



In 2003, a comprehensive review (3) of the implications of adopting GM canola on half the current canola area in Australia concluded that the introduction of two types of GM canola with tolerance to either Roundup® or Liberty® herbicides would provide farmers with other additional important weed control options. Based on their impact in Canadian farming systems, these HT GM crops will give another set of vital herbicide management options

for Australian growers (14, 17) and deliver substantial environmental and economic benefits.

Most importantly, GM canola will allow farmers to sow earlier, achieve better weed control when compared to current canola weed control systems and avoid the inherent yield and oil penalties associated with TT canola (3).

# Trade and Economics

One of the major issues investigated since the OGTR approval of GM canola varieties in 2003 has been the possible effect GM canola in Australia could have on trade. An early report identified that GM crops have the potential to influence Australian and global trade as well as improving crop productivity, making agricultural production more sustainable and expanding the range of agricultural products (18).

Victorian State Government-commissioned reports (19, 20) concluded that while there was some sensitivity in particular markets to GM crops, there was little or no evidence of any general price discrimination or market access problems.

Large quantities of GM canola, mainly from Canada, are regularly traded internationally, including into Australia's current canola markets of Japan, China, Bangladesh and Pakistan (21) (Table 2). The Lloyd Report (19) and later ABARE reports (7, 9) concluded that it is expected that Australian GM canola would continue to access the same markets, and that there is no evidence that current GM producing countries have difficulties gaining access for their non-GM grains (21).

Table 2 Australian and Canadian trade of canola in three markets (21)

Country	Year	Total Imports ('000 t)	Canada ('000 t)	Australia ('000 t)	% Canada	% Australia
Japan	2004	2,261	1,662	599	74%	26%
	2005	1,946	1,611	336	83%	17%
	2006	2,274	1,941	333	85%	15%
China	2004	424	420	2	99%	>1%
	2005	296	255	40	86%	13%
	2006	738	728	0	99%	0%
EU	2004	226	3	94	>1%	41%
	2005	153	4	>1	2%	>1%
	2006	647	3	261	>1%	39%

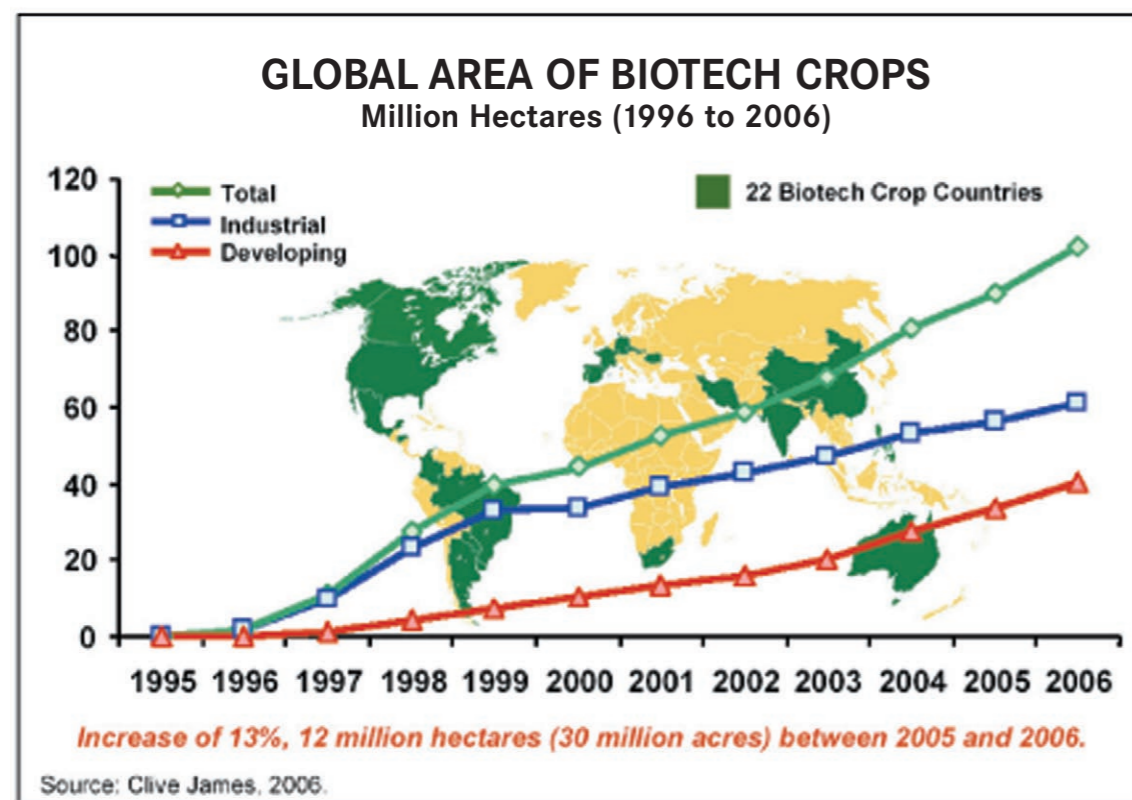
The European Union (EU) has trade restrictions on the importation of some types of GM canola, but over the past five years it has been a net exporter of canola, and is only a small and opportunistic market for Australia (8, 21). For example, Western Australia exported 99.6% of their product to markets that do not discriminate against GM canola varieties (22). More recently, the rapid expansion of biodiesel from canola oil in the EU has created new opportunities for canola oil imports. In addition, GM canola grain and oil imports are now approved for entry into the EU (7).

Earlier reports on market acceptance of GM canola indicated that there were no price premiums for non-GM canola (8, 9, 20, 21). Those suggestions have been supported by the most recent ABARE report (7) which concluded that the great bulk of GM canola is sold at

similar prices to conventional canola in most major canola markets throughout the world. Australia is not realising any price premium for producing non-GM canola and is missing significant agronomic and environmental benefits from growing non-GM canola varieties under Australian conditions.

The approved GM canola herbicide tolerance traits are the same as those used in approximately 85% of the canola grown in Canada, as well as in soybean, cotton and corn grown in 22 regions, including the EU, North and South America (10, 23) (Figure 2). These traits, alongside insect protection traits, were introduced to commercial production systems in 1996. By 2005 they were sown on over 100 Mha and had produced \$27 billion (US) in extra farm income over those 10 years (24).

Figure 2 Global areas of biotech crops since 1995 (10).



ABARE (25) indicated in 2003 that there are substantial economic benefits to adopting agricultural biotechnology, and developing countries stand to benefit the most. They estimated that if Australia does not access new GM crop varieties, the economic loss will be equivalent to up to \$5.8 billion in lost GNP over a ten year period (25).

A Western Australian study indicated that growing glyphosate-tolerant canola would provide consistently higher on-farm returns than growing TT canola (26).

These benefits have not been realised as the Australian canola industry has been unable to access the technologies available to growers in countries against which Australia competes for export markets because of the impact of State moratorium legislation (27). Australia is also missing out on access to new developments in biotechnology such as drought tolerance and more efficient use of nitrogen, that could keep Australia competitive in a challenging environment (27, 28, 29, 59, 60).

## Canada's success story

Australia has now watched Canada grow commercial GM HT canola for more than 10 years, with documented reports of substantial benefits to growers and the environment (30, 31). Since 1996, canola production has increased by 40% and average yields have increased by 27%. Over the same period, Australian yields have declined by 10%.

In Canada, more than 90% of canola grown is herbicide tolerant (HT) and 85% are GM varieties (30). The most widely grown varieties are Roundup Ready® canola. There are also InVigor® hybrids which are Liberty® tolerant. About 50% of all canola plantings are now hybrids, including InVigor®, and Roundup Ready® hybrids. The yield of hybrids, irrespective of HT profile, has consistently been higher than conventional open-pollinated types (32). Farmers' demand is clearly for HT canola types and the few varieties released without specific herbicide tolerances are not widely grown. There are now no non-HT canola lines entered into the Canadian canola registration trials. Specialty oil canola varieties have also shown accelerated adoption in Canada (from 9% market share in 2004 to 12% in 2005) and the hybrid GM types are adding further gains in this market. This is being driven by health conscious food customers including those wanting to avoid trans-fatty acids – the GM moratoria have hindered the same advances in the Australian oilseed market.

The Canola Council of Canada is planning for a 70% increase in production to over 16 Mt from now until 2015, with key markets identified in the North American crush, and uses as biodiesel in Europe and North America. New functional and production traits are planned for inclusion in canola to increase its adaptation and use, with many traits introduced using biotechnology (33).



Figure 3 The author (RMN left) in a crop of hybrid GM canola in western Manitoba, July 2006.

# Safety and Regulation

## Environmental benefits

In the scenario where GM canola replaces 50% of TT canola and 40% of conventional canola, and with an additional 200,000 ha of canola planted because of the new technology, almost all of this would be grown under direct drilling or minimum tillage (3). As well, the move to GM HT canola from conventional would allow minimum tillage to be used.

The swing away from TT canola would reduce the use of the herbicide atrazine which has been identified as an aquatic pollutant (4). A reduction in its use is a significant environmental benefit.

The IT canola herbicides are more environmentally benign than the triazines, but residues can carry over under certain environmental conditions reducing subsequent crop options for growers. However, the major problem with herbicides used on IT canola is that there is already widespread resistance to this type of herbicide (Group B), because the genes for resistance are already at relatively high frequencies in some common Australian crop weeds (3, 61).

A study reported in 2006 that the worldwide use of GM HT canola, soybean, cotton and corn changed the chemical profile used which led to a 14% reduction in the “environmental footprint”. The reduction in tillage, fuel and chemicals that goes with GM crops was estimated to have saved 73 Mt of carbon dioxide since GM crops were introduced (24).

## History of GM canola in Australia

In 2003, the Office of the Gene Technology Regulator (34) gave approval for the general release of two types of genetically modified canola. They were:

Roundup Ready® canola which contains genes that confer tolerance to the broad spectrum herbicide Roundup® or any other formulation of glyphosate registered for use on Roundup Ready® canola (5).

InVigor® hybrid canola contains novel genes for pollination control and tolerance to the herbicide glufosinate-ammonium (tradename Liberty®) (6).

Following the Federal approval of GM canola, the governments of the canola-producing states imposed moratoria on the cultivation of these types of canola.

# Supply Chain Management

## Good On-Farm Management Practice

Canola production requires growers to practise industry best management farm practices. For example, as with most crops, a small amount of seed from canola plants can carryover to subsequent crops. This common phenomenon is managed by adopting an integrated approach to weed management (3). For example by not using the GM-linked herbicide in the next year, but using an alternative knockdown prior to planting, (17).

## Pollen flow

### *Can a HT trait move into a non-HT canola through cross pollination?*

Termed ‘gene-flow’, this occurs among different canola cultivars. Extensive studies have been conducted to carefully track pollen flow in canola. Those authors concluded that pollination between commercial fields occurs only at very low frequencies (37, 38, 39). Even when multiple transgenic fields are adjacent to conventional fields, levels of pollen flow are likely to be below the current internationally-accepted adventitious presence thresholds for our most sensitive markets (40).

On-farm best management practices can be used to effectively manage pollen flow. For example, where canola crops are adjacent, a five-metre buffer “pollen trap” can be placed between GM canola fields and non-GM canola. If necessary, where such fields abut, the first five metres can be sown with conventional canola around the GM crop, which can be harvested as GM canola (13, 41).

### *Can HT genes move into related Brassica weeds?*

Research has shown that in the field, the barriers to inter-specific hybridisation and then gene introgression are so great that the likelihood of transfer is effectively nil (37, 39, 42).

## Resistance management

The introduction of HT GM canola highlights the importance of effective weed resistance management strategies. Glyphosate is the most widely used herbicide in Australian cropping systems, where it is used for knockdown, pre-sowing weed management (3). It has been shown that sustained use of glyphosate, or virtually any herbicide, when used intensively can select for weeds resistant to the chemical (43). There are some populations of annual ryegrass with glyphosate resistance already (44). However, this can be managed and the level of resistance in weed populations contained to acceptable levels (43, 45) by using a range of techniques such as the use of the herbicide trifluralin pre-sowing and avoiding the use of glyphosate for some years in the crop rotation. Sustaining the long-term use of glyphosate is an important issue for agriculture in general, and guidelines have been developed for glyphosate management in all systems (17, 46).

## Co-existence

Co-existence is the term given to the ability of different production systems to maintain the integrity of the product, as well as trace it through the agrifood supply chain. It is not a product or crop safety issue, but relates solely to the production and marketing of crops approved for use and their ability to meet agreed industry standards.

In Australian canola, levels of adventitious presence of GM canola less than 0.9% meet State legislative standards and identification of grain as non-GM for the most sensitive trading partners (47). Suitable testing procedures have been identified for detecting GM presence in grain samples (48).

In countries currently producing GM crops, speciality crops (eg organic), non-GM and GM production systems are able to co-exist. For example, in North America, where more than 70% of the plantings of soybean, corn and canola are GM, the evidence shows that GM crops have co-existed with non-GM and organic crops without significant economic or commercial problems (49).

## OGTR and FSANZ

*Australia has a transparent, independent, thorough and scientifically-based assessment procedure for the management of genetically-modified organisms, including crops (34, 35) considered on a case-by-case basis. In 2003 OGTR's assessment concluded that the risks to human health and safety, or to the Australian environment, from the commercial release of these two types of canola, were no greater than those posed by non-GM canola. That is, they are as safe as conventional canola (5, 6). Further, the review of food safety standards by FSANZ showed that the GM products evaluated were essentially the same as existing non-GM products (36).*

Similar conclusions were drawn from corn production systems in Spain (50). The EU has released a series of case studies on co-existence (51).

The conclusion from the EU study on corn, sugar beet and cotton was that with few or no changes in current practices, seed production is technically feasible to meet a threshold of 0.5%. ABARE also reported recently that the release of GM canola would have negligible impact on organic canola (52).

Little organic canola is produced. Organic bees, honey and livestock are unaffected by GM canola products, with co-existence issues adequately addressed using existing management standards.

Australia has a detailed understanding of the agronomic and environmental issues concerning GM canola production systems (3, 37). Co-existence guidelines released in Australia (12, 13) and Canada (14) emphasise common points about enabling growers to access and use the technologies they choose. The principles are:

- plant seed of known quality from reputable sources
- communicate with buyers and agents about the market requirements so acceptable specifications are known
- select paddocks that can be protected from spray or pollen drift or use buffer zones
- consult with neighbours about crop intentions to enable coordination of neighbouring crops
- clean seeding, harvest, transport and storage equipment at crop or variety changes

For growers who elect to grow GM canola, stewardship programs will highlight co-existence requirements as well as weed resistance management practices.

## Supply chain management post-farm gate

In Australia the grain industry is ready to move ahead with the commercialisation of approved GM canola. The grains supply chain already has protocols, processes and practices in place to deliver market choice for growers (12, 13).

Currently, these processes are applied in the growing, transporting, marketing and processing of special malting barley, noodle wheat, canola, sunflower and maize

varieties in Australia. An industry wide set of standards to specify quality characteristics is applied along the supply chain as the basis of trade (12).

ACIL Tasman (18) and Lloyd (19) both produced detailed reports on these supply chain issues. They concluded that there were suitable protocols available to manage GM and non-GM canola using existing resources. Appropriate sampling and testing protocols are available (54).

The preservation of the identity of GM or non-GM grains could add additional costs of compliance, (54, 55, 56), but GM market access restrictions are insufficient to offset the agronomic benefits to Australian production. This is the case even if costs are incurred in keeping GM and non-GM canola separate in the production and marketing process (18).

### Liability

A 2005 report by ACIL Tasman concluded that current common law provisions would adequately cover any liability issues (18). Independent analysis, both in Australia and the United States, has concluded that there is ample capacity under common law actions of trespass, nuisance and negligence to deal with any possible adverse consequences of the commercial release of GM crops (18). The NZ Royal Commission also reported in 2001 that there was no need for a special liability regime for GM crops (53).

## GM Cotton

*Since 1996, the Australian cotton industry has been growing GM crops with in-built naturally occurring Bt insecticides. In 2000, Roundup Ready® cotton was approved for use and combined with the Bt trait, now 90% of cotton grown contains GM traits (57). Liberty® tolerant cotton was released in 2006. Growers have chosen these traits because of the productivity gains, as well as a large reduction in pesticide use – on average from 11 to 3 sprays per season (58). GM cotton has now become a cornerstone of the Integrated Pest Management strategies used in the cotton industry.*

# About the authors

## Dr Rob Norton

Dr Robert Norton is a Principal Lecturer (Agronomy) with the School of Agriculture and Food Systems, The University of Melbourne. He has a degree in Agricultural Science from The University of Melbourne and in 1993 completed a PhD in canola agronomy.

Dr Norton has taught agronomy and crop protection to undergraduate and post-graduate students since 1981.

He is based at Grains Innovation Park at Horsham, where he supervises research projects and post-graduate students in the areas of nutrient management and crop adaptation, as well as teaching at the main undergraduate centre's of The University of Melbourne.

He published "*Conservation farming systems and canola*" in 2003 and has published more than forty refereed conference and journal papers since 1999.

## References

The references used to develop this report are indicated by number and these can be accessed at: <http://www.jcci.unimelb.edu.au/GMCanola2007.html>

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## Professor Rick Roush

Prof. Rick Roush joined the University of Melbourne in late 2006 after spending three years as Director, Statewide Integrated Pest Management Program at the University of California. He holds degrees in entomology from the University of California, Davis and Berkeley, and has been well exposed to teaching, research and research management in Australian agriculture and higher education. From 1995 he spent eight years in Australia, first as an Associate Professor in the Department of Crop Protection at the University of Adelaide, and later as Chief Executive Officer of the Cooperative Research Centre for Weed Management.

Prof. Roush's research draws on experience in agricultural crops and natural ecosystems in various part of the world including the USA and Australia. His work contributes to a range of areas including practical pest management, basic biology and toxicology of insects, molecular biology of insect neuroreceptors, biological control of insects and weeds and conservation biology.



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