GM canola: pollen bees and honey

The issues surrounding pollen flow in relation to genetically modified (GM) canola remain topical following the commercial release of GM canola in Australia in 2008. This paper looks at the two canola varieties developed in Australia, the research undertaken in relation to pollen flow, and the potential management implications for these new varieties.

Pollen transfer can occur between crops and plants and is not an issue specific to GM crops. Canola is in the spotlight in relation to pollen transfer because canola pollen has the potential to travel long distances.

Two GM varieties of herbicide tolerant canola have been approved for commercial release in Australia by the Federal Office of the Gene Technology Regulator (OGTR) after seven years of field trials. One herbicide tolerant GM canola variety, Roundup Ready®, is now being commercially produced in some states of Australia.

Herbicide tolerant crops

Non-GM herbicide tolerant canola varieties are already commercially available in Australia — they are triazine tolerant (TT) and imidazolinone tolerant (IMI) canola. It is widely acknowledged by the industry that TT canola does not yield as well as non-herbicide tolerant conventional varieties, however growers accept this yield penalty because of TT's weed management capabilities.

Herbicide tolerant crops are not harmed by the herbicides applied to the weeds around them, so they provide growers with greater flexibility in weed control options. The use of the GM herbicide tolerant varieties can allow the use of herbicides that are less toxic or less persistent in the environment than those currently used, and they also reduce the level of mechanical weed removal required — which helps reduce erosion and increase retention of organic matter in the soil.

Herbicide tolerant GM canola was introduced in Western Canada in 1995 and the subsequent adoption was relatively rapid, with 26 per cent in the initial year, 78 per cent by 2002 and 95 per cent by 2007.

In 2007, a producer survey was undertaken to learn more about the producer level impacts that were being observed one decade after commercialisation. The survey was undertaken by researchers from the University of Saskatchewan and the University of Ottawa and involved 571 producers. It found that lower input costs; better weed control; and the environmental benefits, such as no-till practices were key components of the technology's success.

Pollen from GM crops

There are three main concerns about pollen from GM crops.

1. They might cross-pollinate with non-GM crops and therefore prevent them from achieving a non-GM crop status in the marketplace.
2. The new trait in a GM crop, for example herbicide tolerance, may transfer via pollen into the crop's wild or weedy relatives growing nearby. In this case, it is suggested that weeds with resistance to the particular herbicide would develop.
3. The effects of GM crops on bees and honey, where the honey is destined for a non-GM market.

Canola pollen

Pollen contains a plant's genetic material. Pollen is generally carried from plant to plant by the wind or insects. Pollination or fertilisation occurs when pollen moves from the male to the female parts of the flower. Canola is predominantly self-pollinating (70 per cent) because it produces a large amount of its own pollen that usually outcompetes the pollen from nearby flowers.

Pollen from another canola crop also has difficulty competing with pollen from within the crop. Pollen exchange is possible, however, only if the two crops are within a few metres of each other. Canola pollen is quite heavy and sticky, and as a result most of it remains airborne for only a few metres. Canola pollen dries out quickly, and dried out pollen loses its ability to pollinate, so even if it managed to travel a long distance, it may not be viable. The high temperatures and low humidity during the canola flowering period in Australia also act to dry the pollen out faster.

Pollen movement studies

Numerous studies have been undertaken to investigate the extent of canola pollen movement. The potential for pollen drift ranges from almost 100 per cent containment within metres of the crop, to several kilometres. Most studies indicate that pollen movement does occur but at very low levels:

- A Scottish study found that 90 per cent of canola pollen did not travel beyond 360 metres. However, small amounts travelled up to 2.5 kilometres.
- French data suggest 99.8 per cent of pollen falls within 25 metres of the edge of the field.
- Canadian research conducted in 1998 on large-scale field trials of canola found that 98.5 per cent of the pollen stayed in the field.

Australian research

Australian researchers published their research results on this topic in the prestigious Science journal in 2002. The work looked at pollen movement from fields of non-GM herbicide resistant canola to nearby canola crops across southern Australia.

The study involved collecting and testing 48 million seeds from 63 canola fields up to five kilometres from the herbicide resistant canola to see if they contained the herbicide resistance gene. The findings include — the furthest detected pollen was 2.6 kilometres from the source, 23 fields contained no resistance, and most of those which did contain resistance had levels lower than 0.03 per cent, with the highest level being seven seeds in 10,000 (0.07 per cent).

From these results, the researchers concluded that:

- Pollen was carried to other fields in amounts well below internationally recognised levels (0.1 per cent) for unwanted genetic transfer.
- Non-GM canola is not in any danger of being excluded from markets because it contains GM content because even without segregation, the cross-pollination levels were so low (less than 0.07 per cent) that any practicable tests would not be able to detect pollen from GM canola in non-GM crops.

The European Union accepts 0.9 per cent as the practical limit for detection of GM ingredients in foodstuffs, while the Australian threshold is one per cent.

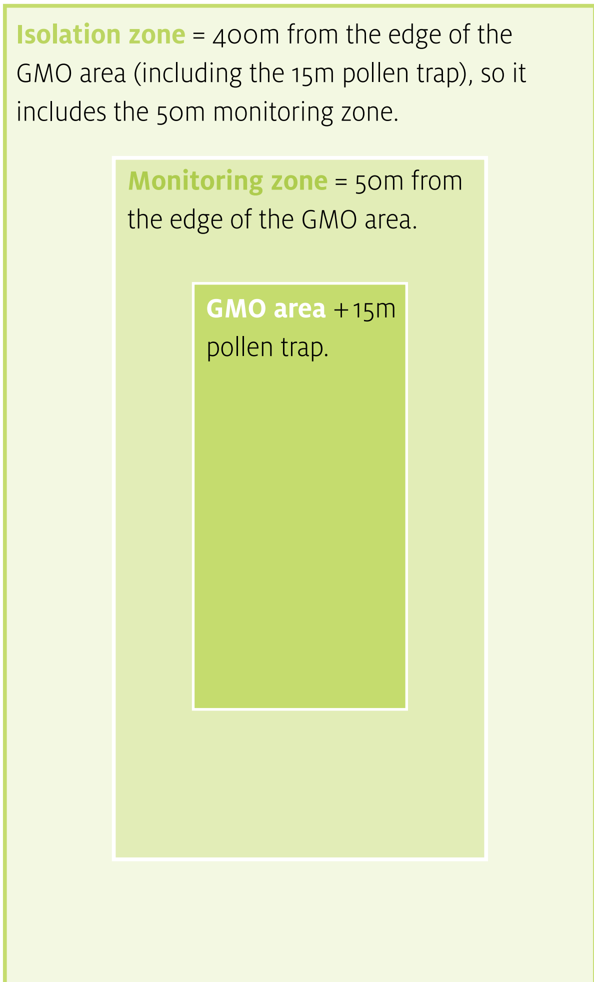
Management implications — during research

These international studies confirm that the 400 metre isolation zone required by the OGTR between GM canola and other related (brassica) crops during the field trial assessments of GM canola varieties is adequate to manage pollen movement.

Field trials of GM canola in Australia may also require:

- an additional insect-trap or buffer area of 15 metres consisting of non-GM canola planted around the GM canola
- a monitoring zone of 50 metres immediately surrounding the trial buffer zone and within the 400 metre isolation zone. This zone must be kept free of any plants related to canola during the trial period, and free of canola plants for three years after the trial.

Example of GM canola field trial management



Source: OGTR

All gene technology research is assessed on a case-by-case basis, and management guidelines are developed accordingly. For example, cotton pollen rarely moves far from the plant, and, as a result, pollen transfer is not a key issue in GM cotton.

Once a crop has been approved for commercial release it does not usually require the management conditions to be as strict, however the OGTR may in some cases still require some management guidelines, in the form of licence conditions, to be in place. No licence conditions have been set by the OGTR for the commercial use of GM canola in Australia.

Approved GM canola field trial applications

In Australia, there are currently five GM canola field trial applications licenced. Herbicide tolerance is the key modification being tested, however one applicant is looking at enhanced yield and delayed leaf senescence. Leaf senescence is broadly described as the process that occurs in a leaf near the end of its active life that is associated with the breakdown of cell components, membranes, and chloroplasts, and an overall decline in metabolism.

Management implications: on farm

Even though regulatory agencies might not require particular conditions or management guidelines for GM crops on farm, industry may decide to implement certain practices which consider market requirements. For example protocols may be developed for the coexistence of GM and non-GM canola in the grain supply chain, and include guidelines for pre-, on-, and post-farm management.

Such protocols would consider existing stewardship programs such as, in the grains industry, the Australian Seed Federation Code of Practice, Great Grain, Grain Care and other best practice programs. The protocols cover aspects such as:

- **Seed**: origin; quality; variety; regulation; technology provider terms; and, treatments.
- **Crop production area**: location; paddock history — rotation, herbicide use, fertilizer; pre-sowing machinery inspections; paddock identification; and, identification of neighbouring crops.
- **Paddock inspection**: weed species, disease and insect identification and control; fence line buffers; and, weedy species and volunteer canola identification and control.
- **Harvest**: machinery inspections; clean, secure, leak-proof transport; on-farm grain storage container inspections; and identity tags for harvested grain.

Coexistence overseas

Two reports released in 2004 by PG Economics in the United Kingdom suggest that segregation between GM and non-GM production is not only possible, but is already occurring in Europe and North America.

Spain is one of the few European Union Member Countries growing commercial GM crops. Since 1998, an insect resistant GM corn variety has been grown in some parts of Spain, and according to the report, it is successfully segregated from organic and non-GM corn in the country without any economic or commercial problems.

The experience in North America in relation to the coexistence of GM crops through the supply chain has also been successful according to the report. Of the organic growers surveyed, 92 per cent have not incurred any "direct, additional costs or incurred losses due to GM crops having been grown near their crops". Four per cent lost organic sales or had their crops downgraded because of the presence of GM material, and four per cent incurred extra costs in relation to testing for the presence of GM in their produce.

Weed management

Some people are concerned that uncontrollable weeds (sometimes referred to as 'superweeds') will develop if GM crops modified for herbicide tolerance cross-breed with their weedy relatives and pass on the herbicide tolerant characteristic.

Both Australian and international research has concluded that canola can cross-breed with relatives such as Chinese mustard (*Brassica juncea*), wild turnip (*Brassica rapa*), and wild radish (*Raphanus raphanistrum*). However, the numbers of offspring of any such crosses are very low, with reduced fertility and fitness.

Wild radish is the most severe broadleaf crop weed in Australia. As a result, further research was undertaken into the likelihood of this weed crossbreeding with herbicide tolerant canola during the products development. A three-year Australian study at the Cooperative Research Centre for Weed Management Systems found that the outcrossing rate from canola to wild radish is very low, one in 26 million.

In the event that outcrossing did occur, the environmental impact is considered to be minimal because the new gene only gives the weed resistance to the one herbicide that is applied to the herbicide tolerant crop. It would still be able to be managed by other herbicides, and it would not have any competitive advantage in the wild.

Busy bees

Bees collect nectar and pollen from native vegetation, and flowering crops, including canola, and they may travel several kilometres to tap into a good pollen source.

Bees usually collect pollen from a small area and once they have a full load they return to the hive without stopping at another crop. Bees can get a full load of pollen from just four to six canola plants.

Bees are, therefore, more likely to transfer pollen between different canola varieties when they are close together or where small plots make it less likely they will get a full load from a single plot. Canola breeders already take this into account when evaluating and growing canola to produce planting seed.

It is possible for bees to cross-pollinate non-GM and GM canola, however:

- in field trials, they would need to fly beyond the 400 metre isolation zone
- canola is 70 per cent self-pollinating, so they would also have to land on flowers that were not already fertilised
- the pollen they were carrying would have to be still viable enough for fertilisation. Canola pollen degrades very rapidly, and loses its viability within hours of leaving the flower.

Adelaide researchers investigating the potential for the honeybee to contribute to gene movement between canola varieties suggested that:

- honeybees tended to return to the same field when resources were abundant, but they tended to forage over larger distances when resources were scarce
- the honeybee has the potential to contribute to gene movement over large distances but at a very low frequency.

Honey

Honey is made from the nectar collected by bees from flowers. It generally contains 75 per cent sugar, 20 per cent water and the remaining five per cent consists of gums, ash, vitamins, enzymes, traces of plant pigments and other substances.

Honey also usually contains some pollen grains. The percentage of pollen grains depends on whether the honey has been sieved. If sieved the average pollen content is normally less than 0.1 per cent. The gene/s added to GM canola may be found in pollen and honey if fresh pollen is mixed directly into the honey. However, the presence of these genes is likely to be very low.

Organic honey in Australia

Organic honey production in Australia is co-regulated by the seven certifying bodies within the organic industry and the Australian Quarantine Inspection Service (AQIS) in relation to the export market. Accordingly, it must meet the standards as specified in National Standard for Organic and Bio-Dynamic Produce. As part of this standard, "Operators must demonstrate that hive locations are in foraging areas more than five kilometres distant from any prohibited substances which may be derived from, but not limited to genetically engineered and/or modified organisms or their products…".

GM Canola and Organic Honey

In 2007, a study was released by ABARE which concluded that the impact of GM canola on organic honey production is expected to be minimal because GM canola is most likely to be planted as an alternative to conventional canola, which for residue reasons cannot usually be grown in the vicinity of organic hives.

The report also concludes:

- Under current standards, avoiding the unintentional presence of GM material in organic honey is not likely to cause organic beekeepers to face additional production costs.
- It is possible that bees from an organic hive could come into contact with GM canola pollen, however, even in the case of the highest pollen counts in honey, unless the hive foraged mainly on GM plants, the level of GM material in honey would likely be below 0.9 per cent (the threshold for adventitious presence in the European Union).
- If reasonable measures to avoid bees foraging on GM crops were implemented the levels of unintentional presence of GM material in organic honey are likely to be very low.

Food labelling

In Australia, GM food labelling is required where introduced DNA or protein is present in the final food under Food Standards Australia New Zealand's (FSANZ) GM food labelling laws. Food or ingredients labelled 'genetically modified' either contain new genetic material or protein as a result of genetic modification or they have altered characteristics — for example, changed nutritive values — compared to the conventional food.

A one per cent threshold, where labelling is not required, exists for the unintended presence of GM material in non GM foods. This threshold applies to the presence of pollen from an approved GM food commodity. Therefore, honey containing traces of pollen that includes the modified genes does not require labelling because honey is not defined by FSANZ as a food produced using gene technology.

The same rules apply to highly refined oils, which do not contain any genetic material. Canola oil, made from GM canola, is, therefore exempt from labelling under FSANZ's food labelling regime. Cold pressed or unrefined canola oil may require labelling if testing reveals that the new gene is routinely found in the product according to the FSANZ guidelines.

Pollen content in honey

A study undertaken in 2004, investigated the percentage of canola pollen content in a range of canola honey samples from Australia (non-GM canola) and Canada (GM canola). It concluded:

- The pollen content was significantly less than the one per cent threshold by weight above which honey derived from GM canola would need to be labelled as a GM food.
- There is no evidence to suggest that the pollen content of non-GM canola honey is any different from GM canola honey. This was confirmed with the two GM canola honey samples which contained 0.2 and 0.24 per cent pollen which were within the range (0.15 to 0.443 per cent) of the pollen content for the 32 Australian canola pollen samples.
- This work indicates that honey produced from GM canola crops does not need to be labelled as a GM food.

EU honey and GM pollen development

In September 2011, the European Court of Justice ruled that permission must be sought before honey with traces of GM pollen can be sold. The ruling came after several Bavarian beekeepers demanded compensation from their government for honey and food supplements that contained traces of pollen from GM corn. The beekeepers had their hives close to fields where the Bavarian Government was growing GM corn for research purposes.

The court ruled that the pollen in question cannot itself be classified as a GMO because it has lost its ability to reproduce and is totally incapable of transferring the genetic material which it contains, however it finds that the pollen in issue is 'produced from GMOs' and that it constitutes an 'ingredient' of the honey and pollen-based food supplements. The court observes that pollen is not a foreign substance or an impurity, but rather a normal component of honey, and as a result it must be classified as an 'ingredient'. The pollen in question consequently comes within the scope of the regulation and must be subject to the authorisation scheme before being placed on the market.

The court observes that that authorisation scheme for foodstuffs containing ingredients produced from GMOs applies irrespective of whether the pollen is introduced intentionally or unintentionally into the honey. Lastly, the court holds that the authorisation obligation exists irrespective of the proportion of GM material contained in the product in question.

According to German lawyer Tobias Teufer, there are grounds for appeal of this decision. He states, 'the ECJ ruling is based on a false factual foundation and its judges ruled erroneously due to not being correctly informed about the production and harvesting of honey'.

Colony Collapse Disorder

Colony Collapse Disorder (CCD) is a phenomenon noticed particularly in the USA and Europe whereby bees suddenly disappear from their hives. Despite many theories and much research, no single cause or definitive answer has yet been identified.

To-date, research supports the view that CCD may be the culmination of a wide variety of factors and stresses that include parasites, viruses, climate change, nutrition and bee health, lack of genetic diversity and migratory bee keeping.

The assumption that GM crops could be the cause of CCD is not substantiated in scientific documentation.

Further information

Apted, S and Mazur, K (2007), 'Potential Economic Impacts from the Introduction of GM Canola on Organic Farming in Australia', ABARE Research Report 07.11 Prepared for the Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

Aventis CropScience UK Limited (2000), *Crop biotechnology and genetic improvement: the facts*. www.defra.gov.uk/environment.

Baker, J and Preston, P (2004), *The Potential For the Honeybee to Contribute to Gene Flow Between Canola Varieties*, Cooperative Research Centre for Australian Weed Management.

Brookes, G and Barfoot, P (2004), *Co-existence in North American agriculture: can GM crops be grown with conventional and organic crops?* PG Economics Ltd. www.pgeconomics.co.uk/pdf/CoexistencereportNAmericafinalJune2004.pdf

Brookes, G and Barfoot, P (2004), *Co-existence of GM and non GM arable crops: the non GM and organic context in the EU*, PG Economics Ltd. www.pgeconomics.co.uk/pdf/Co-existencestudyEU_PG_Economicsmay2004.pdf

Byrne, J (2012), 'GM honey ruling can be challenged claims legal expert'. www.foodnavigator.com/Legislation/GMO-honey-ruling-can-be-challenged-claims-legal-expert

Canola Council of Canada (2005), Impact of Transgenic Canola on Growers, Industry and Environment. www.canola-council.org/manual/GMO/gmo_main.htm

Court of Justice of the European Union (2011), Press Release 79/11. Judgment in Case C-442/09. http://curia.europa.eu/jcms/upload/docs/application/pdf/2011-09/cp110079en.pdf

Hornitzky, M (2004), How much pollen is in canola (Brassica napus) honey?, Rural Industries Research and Development Corporation, Publication No. W04/189 Project No. DAN-218A. https://rirdc.infoservices.com.au/downloads/04-189

National Standard for Organic and Bio-Dynamic Produce (2009), Australian Quarantine and Inspection Service. www.daff.gov.au/aqis/export/organic-bio-dynamic

NSW Agriculture (2002), 'Honey Bees on Canola'. www.dpi.nsw.gov.au/__data/assets/pdf_file/0013/117112/bee-on-canoloa.pdf

Department of Natural Resources and Environment, Victorian Government (1998), 'Cold pressed oils', Agriculture Notes.

Gene Technology Grains Committee (2003), 'Canola Industry Stewardship Principles For coexistence of production systems and supply chains'. www.croplifeaustralia.org.au

Gene technology regulation in Australia. www.ogtr.gov.au

Jones et al (2000), 'The Distribution, Density and Economic Impact of Weeds in the Australian Annual Winter Cropping System'. CRC for Weed Management Systems, Technical Series No.4.

Moyes, CL and Dale, PJ (1999), 'Organic Farming and Gene Transfer from Genetically Modified Crops', John Innes Centre, Colney Lane, Norwich.

Public Research and Regulation Initiative (2007), 'Are GM crops killing honey bees?'. www.prri.net

'Questions and Answers on the Commercial Release of Roundup Ready and Roundup Ready/Ingard Cotton' (2000), Information Bulletin No. 6. Interim Office of the Gene Technology Regulator.

Rieger, MA, Preston, C, Potter, T and Powles, SB (1999), 'Gene flow from transgenic canola to wild radish — a model system to determine the risks', in: Lutman, PJW (Ed), *Gene Flow and Agriculture: Relevance for Transgenic Crops*, British Crop Protection Council, pp. 131–136.

Rieger, MA, Preston, C and Powles, SB (1999), 'Risks of gene flow from transgenic herbicide-resistant canola (Brassica napus) to weedy relatives in southern Australian cropping systems', *Aust. J. Agric. Res.* 50, pp. 115–28.

Rieger, MA, Lamond, M, Preston, C, Powles, SB and Roush, R (2002), 'Pollen-Mediated Movement of Herbicide Resistance Between Commercial Canola Fields', Science 296, 2386–2388.

Smyth, S, Gusta, M, Phillips, P, and Castle, D (2010), 'Assessing the Economic and Ecological Impacts of Herbicide Tolerant Canola in Western Canada'. www.canolacouncil.org/media/504427/assessing_the_economic_and_ecological_impacts_of_herbicide_tolerant_canola_in_western_canada.pdf

Timmons et al (1995), 'Assessing the risks of wind pollination from fields of genetically modified Brassica napus ssp. oleifera', *Euphytica* 85, 417–23,

United Kingdom Government Report, Department of the Environment, Transport and the Regions, Advisory Committee on Releases to the Environment (1999), *Environmental Risks of Herbicide-Tolerant Oilseed Rape: A Review of the PGS Hybrid Oilseed Rape*.

User Guide — Labelling GM Food User Guide to Standard A18/1.5.2 — Food Produced Using Gene Technology, Food Standards Australia New Zealand (FSANZ). www.foodstandards.gov.au