

A Bad Decision: why WA should reverse course on GM crops

The Background

On Monday 25th January 2010, the WA government announced their decision to allow commercial cultivation of Genetically Modified (GM) canola. This decision has angered many farmers and environmental groups, whilst some Farm lobby groups welcome the result.

A moratorium on the commercial growing of GM crops was put in place in WA after an inquiry by the Standing Committee on Environment and Public Affairs in 2002. The committee specifically considered the proposed powers under section 21 of the Commonwealth Gene Technology Bill 2001 which recognises State legislation in designating areas for the purpose of preserving the identity of one or both of GM and non GM crops for marketing purposes (see WA Parliament weblink).

The moratorium came into effect on the 24 December 2003. Section 19 of the GM Free Areas Act 2003 specifies that the Minister for Agriculture and Food had to conduct a review of the Act's operation and effectiveness after five years from its commencement. This review (in which over 80% of the 400 submissions received called for an extension to the moratorium) was completed and tabled in Parliament in November 2009 (see full review on the Department of Agriculture and Food website).

Over the years, there have been claims from both sides of the debate i.e. those who support the technology want the moratorium to end, and those who are non-supporters of the technology want a permanent ban on GM crops in this state. This has been an issue that has the potential to divide the community.

There are questions as to whether there has really been a thorough 'debate' on the adoption of GM crops and release of GM foods into our food supply. Has only one side of the story been presented to the public? Is it a case of 'minorities' promoting GM crops (and foods), while the unsuspecting (and perhaps uncaring) majority remain oblivious to what it being done to Australian agriculture and subsequently their food?

Most people, I would suggest have no idea that they may have been eating some GM foods in some form in their daily dietary intake, either directly (as an ingredient in their food) or indirectly (i.e. animals fed on GM). One should remember that every single GM ingredient through the food chain will eventually reach the consumer (Dona and Arvanitoyannis 2009).

While some scientists and Government agencies continue to promote GM foods as being safe, there have been relatively few toxicity studies. Hence in the absence of adequate food safety studies, the lack of evidence showing GM food as unsafe should not be interpreted as proof that it is safe (Dona and Arvanitoyannis 2009).

It has been nearly fifteen years since the introduction of GM in food and its use continues to increase across the globe. Since commercialization, area of planted biotech crops globally has increased from 1.7 million hectares in six countries in 1996, to 143 million hectares in 23 countries in 2007. The world's top six producers – the United States, Argentina, Brazil, Canada, India, and China – account for more than 90% of global GM production, with more than 50% being produced in the United States alone. GM soybean has been the principal biotech crop, occupying 51% of the global biotech area in 2007, followed by maize (31%), cotton (13%), and canola, 5% (see Magaña-Gómez and Calderón de la Barca 2009).

We are now at the crossroad for the future of agriculture. On one hand, we have serious environmental problems arising from past unsustainable agricultural practices, for example salinity and overuse of chemicals in many parts of WA. On the other hand, GM proponents claim that the new technology will solve all those problems. Meanwhile lack of certainty in the safety of GM foods continues and while consumers are nervous, some food companies concerned about market share has continued to assure their customers with GM free promises. For example, Coles supermarkets have assured customers that their home brands are non-GM:

Genetically Modified Foods (GM)

In recognition of our customers' strong preference for non-GM foods, all Coles Housebrand food products (over 2700 products) are formulated using non-GM ingredients. For this reason, we were the only Australian supermarket to achieve a green listing in the 2008 Greenpeace Truefood Guide

<http://www.coles.com.au/About-Coles/Community/Community-Sustainability-Report/Report.aspx#GM>

Several other brands openly labelled their products GM free (e.g. Orgran www.orgnan.com).

Regardless of the outcome of whether the moratorium is extended or not, some issues have not been adequately discussed or examined by policymakers.

This paper examines issues such as environmental concerns, human health implications, biodiversity, patent laws etc which have been raised over the past 10 years. There are an equivalent number of studies outlining benefits as there are risks.

The aim of this paper is not to ignore one aspect of the debate or the other, but to call for the application of the precautionary principle. This states that where an action has suspected risk to the public or the environment, lack of full scientific consensus should not be used as reason to postpone measures to reduce risks to the environment or public. As there is still uncertainty on several aspects of GM technology at present, the onus of proof should fall on those advocating the risks and policy makers have the responsibility to protect the public from harm (Deville & Harding 1997).

The Future of Agriculture

There is no doubt that agriculture as a whole has contributed to serious environmental problems. Surface and ground water pollution, soil degradation and erosion, salinity and an overuse of chemicals as a result of unsustainable agricultural practices have contributed to the loss of biodiversity (Mason 2004, www.fao.org – various publications). Increasing oil prices, declining oil supplies and escalating use of artificial petrol-chemical based fertilisers and pesticides will have an effect on the continual use of large machinery in broadscale farming practices.

The report of the first international Agriculture Assessment of Agricultural Knowledge, Science and technology for Development (IAASTD) approved by 54 governments in Johannesburg in April 2008 is an account of the failures of industrial farming.

The report called for an urgent and fundamental change in the way we farm; to move away from destructive, chemical-dependent industrialised agriculture and to adopt environmentally sound farming methods to address soaring food prices, hunger, social inequities and environmental disasters (www.agassessment.org).

The Manifesto on the Future of Food (produced by the International Commission on the Future of Food and Agriculture) stated that industrialised agriculture, based on uniformity and monocultures will continue to add to the stresses of climate change because of the dependency on intensive energy and water. The change of small-scale farming to large-scale, monoculture production has also created loss of traditional knowledge, cultures and community (<http://www.farmingsolutions.org/pdfdb/manifestoinglese.pdf>).

Climate change in terms of the water accessibility and timing of water availability will increasingly limit production in this country unless we adopt a new approach to water storage, diversifying farming activities and practice opportunistic planting regimes. Rather than attempting to modify the environment, planting species that are appropriate to the climate may have to become more than just an ideal.

In WA, the agriculture sector accounts for about 19% of the State's greenhouse gas emissions, most of which are from methane generated by livestock and the

burning of savanna grasslands. Furthermore we are faced with the challenges of increasing drought conditions (see State of the Environment report 2007 and relevant references).

Hence, new biotechnology methods such as GM are strongly promoted by some farming groups and biotechnology companies as the solution to many problems faced by agriculture, going as far as to promising the production of more sustainable crops and environmentally friendly farming practices (Clark 2003, Johnson 2000). Assurances of “weedless” and “pestless” high-yield, high quality crops are tempting to many farmers already battling with difficult farming conditions such as drought. There are of course promises of drought and frost tolerant crops as well as salt tolerant for those who are farming in such conditions.

Background on GM

First of all, what are GM crops, and how are they developed?

GM technology has been (falsely) compared to conventionally bred plants. Claims that farmers have been genetically modifying plants for thousands of years are not strictly correct. In traditional or conventional farming trait selection normally occurs within a species (i.e. intraspecies), and uses ‘crossing’ techniques to share plant characteristics.

In GM plants by contrast, genes are artificially inserted into a plant in order to make it capable of producing new substances or perform new functions. The only way for this artificial insertion is through the use of viruses, bacteria or a gene gun to randomly move genes from one species into another.

There are several generations of GM plants (as listed by Magaña-Gómez and Calderón de la Barca, 2009). These are first-generation GM crops such as herbicide-resistant (glyphosate) plants (e.g. glyphosate resistant soybean, insect-resistant maize, and herbicide and insect resistant potato). Second generation GM plants consists of crops with “additional” value-to-the-consumer traits e.g. improved flavour or increased micronutrients (e.g. rice with beta-carotene). The emerging third generation of GM plants are those designed to withstand abiotic stress, and those containing additional health benefits (e.g. “pharmaplants containing active pharmaceutical ingredients).

At present, there are only two main traits of GM crops promoted within Australia. These are insect-resistant plants i.e. plants that are resistant (or toxic) to targeted insects and, herbicide-resistant i.e. plants that can withstand the specific herbicide. In WA, GM cotton has been approved for commercial release in the Ord Stage II, and large-scale GM canola trials commenced in 2009.

A common insect-resistant plant is known as Bt, which is the abbreviation for the bacterium *Bacillus thuringiensis*. Farmers have used Bt sprays on their crops for decades as an alternative to chemical insecticides. This bacterium produces a protein that is toxic to certain crop damaging insects such as the *Helicoverpa* larvae (Pretty 2001).

To produce a crop such as Bt corn, a piece of DNA that directs production of insecticidal proteins is transferred into the corn plant. This then allows the corn to produce its own insecticide. Clearly this is not an event that would happen through natural evolution.

Similarly, a gene that is immune to a particular herbicide (usually glyphosate or glufosinate ammonium) is inserted into a plant rendering it resistant to the specific herbicide. Hence when a field of GM crops is sprayed with the specified herbicide, it will survive whilst all other crops or weeds will die. These crops are commonly known as Roundup Ready (under the trademark of Monsanto) or Invigor (under the trademark of Bayer CropScience).

Example of GM herbicide tolerant plant is Roundup Ready® canola, which was created by inserting two genes from a soil bacterium into the plant, and making it tolerant to Monsanto's Roundup® herbicide as well as other glyphosates.

These inserted genes need a promoter gene to switch them on. Unlike nature, which has the ability to turn genes on and off, GM genes are permanently switched on.

Environmental concerns – Cross pollination/ hybridization and impacts

Hybridization is extremely widespread in nature (see Armstrong et al. 2005). Factors such as pollinator behaviour and density, and timing of flowering, will directly influence the rate of gene flow. Wind-pollinated plants will potentially undergo even less-constrained hybridization owing to their independence from pollinators (see Wolfe and Blair 2007 and related references).

Occurrences of gene flow between intraspecific species are reported in Ellstrand (2003) including one example where pollen from corn containing pig vaccine was found to have pollinated nearby crops.

Cross pollination events between Brassica and its relatives

Some plant families such as Brassicaceae are more likely to experience hybridization (see Bourdôt et al. 1999; Poaceae, Edgar & Connor 2000 in Armstrong et al. 2005). As such, there is no reason to doubt that transgenic canola (*Brassica napus*) will not hybridize with its relatives i.e. other Brassica varieties, mustard (e.g. *Sinapis arvensis*) or wild radish (*Raphanus raphanistrum*), creating hybrids which may be difficult to control.

It has been reported that hybridization between Canola (*B. napus*) and field or turnip mustard (*B. rapa*) occurred in field experiments and commercial fields respectively (see Warwick et al. 2008). Crops such as *B. rapa* have weed-like characteristics so hybridization and adoption of transgenic traits may cause them to become weedier and more invasive.

Genetically Modified Canola – implications of hybridization

Canola pollen can remain viable for up to a week and can be found to travel up to 2.5 kilometres from the source. Gene flow between canola fields can also occur via the shattering of seed pods and dispersal of seeds during harvesting or transportation being found on roadsides and verges (Légère 2005). The

author also reported that hybridization between *B. napus* and *B. rapa* averaged 7% and 13.6% in field experiments and commercial fields respectively.

Pessel et al. (2001) found an unmarketable cultivar type of canola persisting in a semi-natural habitat (road verges) for at least 8 years. The dynamics of the feral oilseed rape plants was also more complex than those resulting from spillage from agricultural machines or from neighbouring fields cultivated the previous year. Hence based on Pessel et al's (2001) results, if a GM farmer later decides to grow non-GM crops, they are prevented from declaring themselves non-GM for at least 8 years.

It is foreseeable that GM canola may grow wild in reserves or on road verges in WA, becoming difficult to manage and developing as a competitor to native plant species. In Japan, wild GM canola has been found along road verges from some ports (Seikatsu Club, pers. comm.) so the possibility of a similar occurrence in this state is high particularly given presence of windy conditions and animals which travel great distances (e.g. Kangaroos).

If transgenic crops become incorporated into other species in the same manner as other crops, and gene flow become widespread, the removal of weeds (such as GM canola from nature reserves) may become costly. In addition as the current technology is based on resistance to glyphosate, any hybrid weeds will involve manual removal from sensitive areas i.e. nature reserves. Pretty (2001) stated that GM crops may become problem weeds in subsequent crop rotations.

Snow (2002) concluded that "Where there is good scientific evidence to support the potential of gene flow to exacerbate weed problems or threaten biodiversity, a prudent solution is to delay commercialization." Ellstrand (2001) stated that scientists should recognize that "just because we are now able to create something is an inadequate reason for embracing a new technology".

In addition, there is the relatively unknown of what impacts these hybrids and subsequent generations will have on WA native fauna species such as parrots and cockatoos which are known to feed on canola seeds.

A three year UK field study showed that commercial use of some GM crops could alter the balance of weed species that thrive on British farmland. Researchers found that there were fewer bees and butterflies in the GM crops compared to conventional *B.napus* and after flowering, there were a reduced number of bees and butterflies in the GM crops (Bohan et al. 2005). Their results indicated that bees and butterflies may prefer the types of weed (similar dicots) eliminated by the herbicide. As such, there could be a foreseeable affect on pollinator species and other taxa at higher trophic levels which may also be reliant on those specific dicot weeds as a food resource (see Bohan et al. 2005).

There is also increasing speculation that Colony Collapse Disorder (CCD) may be linked to GM crops. CCD is where bee colonies suddenly disappear without apparent reason, and has affected 24 US states. Examinations reveal the bees

dying from multiple diseases showed severely compromised immune systems (see Ho and Cummins 2007).

Some WA beekeepers have expressed concern that they might experience a similar loss as bees have been known to be particularly attracted to canola flowers because the nectar has relatively high concentration of sugars. Bees have been known to forage up to 5 – 12 kilometres (Commercial Bee Keepers December 2008 pers. comm., Ratnieks 2000). Hence, recommended buffer zones of 50–400 metres to segregate crops (see Agrifood Awareness Australia www.afa.com.au) seems unlikely to be effective to prevent cross pollination between crops.

Impacts on soil

Massive use of Bt toxins in cotton or any other crop occupying a large area of the landscape can result in major environmental consequences. Lynch et al. (2004) discovered that GM plant DNA from degraded plant material persisted in soil.

The potential for soil biota to be exposed are high (Altieri et al. 2004) as persistence of insecticidal toxin remains active in the soil where it binds rapidly and tightly to clays and humic acids. The bound toxin has been known to retain its insecticidal properties, persisting in various soils for up to 234 days (Palm et al. 1996 in Altieri et al. 2004). Cry1A proteins produced by Bt cotton leaves remain bound in the soil even after 140 days (Palm et al. 1996 in Altieri et al. 2004).

Similarly, Gupta and Watson (2004) discovered that different plant parts of Bt cotton contained large concentrations of toxin and may have the potential to act as a reservoir in the fields. Furthermore, the researchers discovered that Bt toxin from dead leaves is not easily degraded by soil microorganisms, hence there is potential for such toxins to accumulate in the soil.

Accumulation of toxins during degradation of plant biomass will lead to increase in doses of Bt toxin to which soil organisms are exposed will also increase with time. Therefore impacts on soil biology could be worse in the longer term (Altieri et al. 2004). In a state where soil conditions are already poor, we can ill afford to take chances on further degrading the soil biology.

Furthermore, in the Midwestern United States, Bt corn byproducts (e.g. pollen and detritus) was found in streams. Studies on non-target insects fed with Bt corn byproducts showed reduced growth and increased mortality indicating a potential problem for ecosystem health (Rosi-Marshall et al. 2007). It is feasible to imagine that large-scale plantings of Bt cotton may have similar impacts on the Ord river in WA.

Adaptation and development of resistance

The “one gene – one pest resistant” approach has been proven to be easily overcome by pests continuously adapting to new situations and evolving detox mechanisms (Robinson 1997, in Altieri 2000a). GM crops follow closely the pesticide paradigm of using single control mechanisms which has proven to fail over and over again with insects, pathogens and weeds (Altieri 2000a).

In some Queensland and New South Wales crops, Bt cotton has failed to provide season-long control of cotton bollworm, *Helicoverpa armigera* (Hilder and Boulter 1999), and *H. armigera* were able to develop resistance to the toxins (Gunning et al. 2004). Bt toxin expression and bollworm mortality levels decreased consistently as the plant aged (Kranthi et al. 2005), hence making the technology ineffective over time.

A more recent field study showed that resistance in subsequent generation of bollworms was 12 times greater than estimated 9 years ago, which means that larvae of *H. armigera* had evolved to develop a resistance to Bt (Liu et al. 2009).

In India, cotton bollworm was able to survive more on particular fruiting parts i.e. the ovary of flowers and boll rinds of green bolls – the most favourite sites of bollworm attack. Study showed that differential rate of *H. armigera* survival on fruiting parts in some parts of India, especially under conditions of high pest pressure (Kranthi et al. 2005).

Bt cotton can be effective against certain lepidopteran pests but have been found to not be potent enough to control cotton bollworm adequately. The continual expression of Bt toxin in a plant exposes pests to selection pressure in contrast to sprays that are generally applied in response to monitoring pest densities (Altieri et al. 2004).

Natural enemies of pests come into contact with Bt toxins more often via non target herbivores because the toxin does not bind to the receptors on the midgut membrane as with target species (Altieri et al. 2004). At present, there are not enough studies done on the total effects so there are concerns about the effects on non-target animals. Potential of Bt toxins moving through arthropod food chains poses serious implications for natural biocontrol in agroecosystems (Altieri 2000b).

Certain aphids are capable of sequestering toxin from Bt and transferring it to coccinellid (beetles) predators (Birch 1997, cited in Altieri 2000b). Larvae of lacewings (a beneficial predatory insect) fed on Bt showed mean mortality of 62% compared to 37% for those raised on non Bt (Hilbeck et al. 1998, cited in Altieri 2000b).

The effectiveness of Bt toxin will vary or decrease over time just like any other pesticide and can also affect non target pest. When specific pests are eliminated from their niches, the ecological system would realign itself and it is possible that other insect pests would increase in numbers to fill those niches (Purves et al. 1998).

Examples of increases in non-target pests are as follows:

Mirids – Mirid populations on Bt cotton exceeded pesticide action threshold and received pesticide applications compared to mirid populations on non-transgenic cotton that did not require insecticide applications (Ma et al. 2004, Men et al. 2005).

Leafhoppers/Grasshoppers – Populations of leafhoppers on Bt cotton were larger than on non-transgenic cotton and needed insecticide applications in all 3 years (Men et al. 2005).

Monsanto had previously observed that grasshoppers are the most common and most destructive insect and trials in Northern Territory support these observations. Grasshoppers are unaffected by the Cry toxins produced by Bollgard II cotton. The increase in population and subsequent insecticide use suggest that the Bt cotton is more suitable for the development of leafhoppers.

Spider mites – Bt has no effect on spider mites populations which have the potential for severe damage on Bt cotton fields (Ma et al. 2006).

Whitefly – Bt does not affect whitefly and populations of whitefly populations on Bt cotton tend to be higher because of reduced leaf feeding damage by lepidopterans (moths) (Cui and Xia 1998, cited in Altieri 2000b).

Most crops have a diversity of insect pests, not just the two covered by Bt trait in GM crops, so various other insecticides or pesticides will still have to be applied to control non-Lepidoptera pests. Integrated Pest Management (IPM) systems are strongly promoted for use in GM crops as they are in non-GM, but increasingly there is some doubt in the claims of less pesticide use. In some cases e.g. China and the Mississippi Delta, significantly more pesticides were used on Bt versus non Bt (as shown in the examples above). Therefore we may see a return to high pesticide use in the Ord River Stage II expansion.

Other claims

In WA, GM cotton has been given the green light for the Ord Stage II expansion as with GM canola (large scale trials in 2009).

Rainfall in northern Western Australia is predicted to decline by 1.5% – 3.5% by 2030 and higher evaporative demand from more frequent hotter days will result in less river flow. This will place a greater demand on the water supply in the north, so many proponents are advocating for GM cotton to be grown in the Ord, as an alternative to the more water intensive sugar cane. However, claims of moderate water usage of GM Cotton crops, using approximately only one-third of sugar cane crops should be questioned. The inserted gene into Bt cotton does not render it less water intensive, merely resistant to particular pests (although this has been shown to be losing its effectiveness as stated in the above section).

Other than stated environmental issues, of particular concern is that GM cotton will be grown as a monoculture crop in the Ord. Should we be investing so heavily in one type of crop given that growing condition may become more challenging with climate change for food crops in the south? Planting only one crop species, whose price is currently subject to global market fluctuations, is short-sighted and fails any sensible sustainability assessment criteria. Many environmental groups have urged the State government to not repeat past mistakes but instead need to optimise production on already cleared areas using a mix of crops.

Human health

Is it safe to eat? This question is first and foremost in most consumers' mind when told about GM in their daily diet. Unfortunately, the answer is we do not really know.

In Australia, food safety falls under the Commonwealth government's responsibility under the independent statutory agency Food Standards Australia New Zealand (FSANZ), which is part of the Health and Ageing Portfolio (www.foodstandards.gov.au).

FSANZ does not conduct its own feeding trials, or replicate the research on GM Foods, but relies on analysis from reviews by companies involved in the development of GM foods (see FSANZ website)

Most GM research is conducted by the companies that produce the seeds, and questions should be asked about the lack of independent tests.

FSANZ applies the "comparative approach" when assessing GM foods. This means that they "compare GM food with food with a similar, commonly eaten conventional food from a molecular, toxicological, nutritional and compositional point of view". For example, a new GM corn variety will be compared to existing conventional (non-GM) corn varieties <http://www.foodstandards.gov.au/consumerinformation/gmfoods/>. Again, there should be some concerns about this method. GM foods ought to be considered novel in that they have foreign genes in them and as such, are not comparable to their conventional counterparts with no foreign DNA.

There is already some evidence that the evaluation method is flawed. Despite assurances, this process led to a corn variety (MON863) being accepted despite worrying results in some overseas animal feeding trials (see Seralini et al 2007). Other research on same corn variety had shown liver and kidney toxicity, and increase in male white blood cells in test animals (Hammond et al. 2006). A study on another transgenic corn variety (MON810) also showed changes in white blood cell level in tested animals (Sagstad et al. 2007).

Numerous independent feeding studies on various animals have shown lung problems and allergic reactions (GM pea, Prescott et al. 2005); stomach lesions

(GM potato, Ewen and Pusztai 1999); abnormally large intestinal cell lining (GM potato, Fares and El-Sayed 1998); lower white blood count, increased relative and absolute weight of testis and uterus (GM rice, Schröder et al. 2007) and increased weight of small intestine, stomach and pancreas (GM rice, Poulsen et al 2007).

In mammals, transgene fragments have been detected in gastrointestinal tract tissues in sheep, and in duodenal and cecal tissues in pigs. Study shows that DNA fragments survive the terminal gastrointestinal tract and that uptake into gut epithelial tissues does occur (Sharma et al. 2006). A study in 2002 showed that GM transgenes were able to survive in the cross over to gut bacteria in humans (Martin-Orúe et al. 2002).

Furthermore, there are concerns that there are very few long-term or generational studies. Some studies have shown increased mortality rates in test animals (see Dona and Arvanitoyannis 2009 and related references) so there is uncertainty as to whether future generations will be more at risk.

Taken together, these studies would seem strongly to suggest that more rigorous scientific effort and investigation is needed to ensure that consumption of GM foods is not likely to provoke any form of health problem to humans. There would seem to be little advantage for WA in being at the forefront of GM crop introduction - and much to be gained from the opposite strategy, particularly given increasing consumer resistance here and overseas.

Segregating GM crops

The suggestions that GM crops can be grown alongside non GM crops without contamination problems (e.g. Agrifood Awareness Australia www.afa.com.au) seem to contradict evidence that has been collected globally. The website "GM Contamination Register" has a comprehensive list of all known contamination incidences across the world. Their website list 274 reported GM contamination incidents, within the last twelve years. These include an incident here in Australia where human error was thought to have contributed to canola contamination in 2005 (GM contamination register).

It appears that segregation is impossible and contamination is inevitable. It is also very costly. A report from the federal government has confirmed that contamination is unavoidable, and a tolerance level of less than 0.5% would be prohibitive because of costs. These extra costs would be borne by the non GM farmer and would include buffer zones in fields, separate harvesting, haulage, containers and testing as well as loss of premium.

If as suggested above GM crops cannot be segregated, then it would be reasonable to assume that despite assurances non-GM products may contain a percentage of GM contamination. This has already happened overseas.

In January 2006, a variety of GM rice produced by Bayer, not approved for human consumption, was found to have cross-bred with crops of two Missouri

farmers Bayer CropScience LP was told to award damages of \$2 million for losses sustained by the farmers (Farm Business news)

Similarly, Starlink, a GM corn variety for use in feed only accidentally ended up in corn products for human consumption in the US (Siruguri et al. 2004, Magaña-Gómez and Calderón de la Barca 2009).

This resulted in a recall, which occurred after severe allergic reactions came to light, stripped the products from supermarket shelves both in the US and abroad. The cost to the company was in the billions of dollars.

The total potential cost of GM contamination clean ups and fines can be measured – although no attempt to do this for WA has been made – but does not include the long term losses of future markets, sales, consumer support and reputation.

Even though Victoria and New South Wales have lifted their moratoria on commercial growing of GM crops, South Australia remains and Tasmania remains firm on their stance on their bans), thus potentially giving WA a competitive edge for non-GM canola production. Due to the state's geographical location, contamination from GM is less likely to occur via animals, insects or wind. However with the recent lifting of the moratorium on GM canola, contamination is inevitable here as shown by some 'contamination' incidences with the trials in 2009.

Consumer perceptions

Consumers are opposed to GM foods due to the uncertain health and safety problems, and the lack of long term independent research. A Japanese consumers group which is a collective of 57 different organisations representing 2½ million Japanese has shown its support for the GM moratoria in Australia (The West 18 October 2007, Ryoko Shimizu, pers. comm).

Various studies in Australia and overseas have shown that consumers had a negative disposition towards GM foods. For example, approximately 73% from a sample of over 16,000 participants said they were less likely to buy a food product labelled with a GM ingredient (Fallon et al. 2007), and a study in Victoria found that people surveyed were generally negative about GM foods raising concerns about (unknown) health effects (Lea 2005).

However proponents of GM claim that there is increasing consumer acceptance – this is disputed by several consumer groups (including Network of Concerned Farmers). Even though FSANZ has mandatory labelling requirements, there are several exemptions e.g. when ingredient is highly processed (oils and sugars), processing aids or additives. In addition the standard allows a food in which an approved GM food is 'unintentionally' present in a quantity no more than 1% per ingredient to remain unlabelled (FSANZ). So how can consumers protest when they are unaware of the true content of their food?

Farming issues

Is it more economical?

This is the question which underlines some farmers and farming groups' eagerness to adopt this technology. The purported benefits of GM varieties should be examined against other agricultural approaches that have shown documented gains for food production and the environment.

The amount of money spent on researching non-GM varieties is much smaller than that invested in GM technology but the advances, many argue, are more promising, such as the development of non-GM drought tolerant wheat (see Colmer et al. 2006) whereas a GM variety is estimated to be several years away (see also <http://www.bangmfood.org/feed-the-world/17-feeding-the-world/14-non-gm-breakthroughs>).

Researchers found that thousands of Chinese farmers using agroecologic techniques such as crop diversification saw yield increases of 89% while completely eliminating some of their most common pesticides (Zhu 2000). Other studies have shown that farmers using ecologic techniques significantly reduced pesticide use without expensive, patented gene-modified seeds (Yanqing 2002).

GM crops are promoted to produce greater yields, use fewer chemicals and find ready markets. There is no gene that enables a GM crop to yield more (the genes inserted only enable the plant to combat particular pests or tolerant to herbicide).

The IAASTD report challenged the perception of GM crops producing higher yields, "some GM crops indicated highly variable 10 - 33% yield gains in some places and yield declines in others." The emphasis on increasing yields and productivity has in many cases had negative consequences on environmental sustainability. In addition, to date these so-called higher yields have not solved hunger problems in many countries, nor has it meant higher profits for many farmers in Canada. In addition, GM crops continue to be totally reliant on artificial chemicals and oil-reliant technologies.

The economic advantage of GM crops in using fewer chemicals appears short term as pest resistance, or secondary pest growth, and weed resistance has led to a growing use of chemicals in some countries. Some of these examples were outlined in the above sections.

Then there is the question of liability - who pays for contamination and loss of income? At the moment it is up to WA farmers to keep GM out of their fields, rather than GM farmers keeping it under control. This concept is akin to a neighbour having to keep a ferocious dog out of his yard rather than the owner keeping the pet in.

There is still no strict liability law in place which protects the non GM farmer from the costs of contamination. WA has not even begun to address the question – although the State Legislature certainly should, if GM crop programs are to continue in our State. The use of GM organisms (GMOs) is prohibited in certified organic food/produce hence some certifiers may choose to test for GM presence (e.g. NASAA www.nasaa.com.au). Organic farms found to have GM contamination may face suspension of accreditation, which will mean a loss of income when the farmer cannot sell the crop as certified organic.

Some organic farmers and a farming network in WA have already taken the unprecedented step of sending their GM farmers a warning letter about the possibility of legal action should GM contamination occurs.

This raises another important reason why farmers ought on their own initiative to stop using GM crops, and that is economic risk. Farmers cannot insure against the risk that the State Government might outlaw their GM crops, nor that consumers may decide that the potential health risks are not worth the reduced prices. Regaining uncontaminated status for their land might take generations. Farmers using GM crops are as short-sighted as bankers making unsustainable loans: risking future prosperity for short-term gains.

Human rights vs Intellectual Property Rights (IPRs)

Concerns have been raised about ownership. Does any company or individual have the right to own seeds or biodiversity? And is biodiversity for sale to the highest bidder?

Biodiversity is closely linked with cultural diversity and biocultural diversity or traditional knowledge (Gepts 2004).

For hundreds of generations, farmers worldwide have been continuously selecting crop varieties to suit the different agro-climatic, soil conditions, specific needs and resistance against different pressures (Bala Ravi 2003). This practice has significantly contributed to the genetic diversity and conservation, resulting in several economically important traits in each crop type. In addition, farmers have contributed this knowledge voluntarily without cost, in the spirit of sharing and exchange of resources. There has been no effort to establish ownership on these resources or seeds, and knowledge and global agriculture has benefited greatly from the spirit of common heritage of humanity (Gepts 2004).

Traditional rights of farmers to free access or exchange of seeds came to an end when patent right on some plant varieties in the USA was granted and ownership right on plant varieties under plant breeders right (PBR) was established (Bala Ravi 2003). With genetic modification, biodiversity is now a commodity and subject to intellectual property rights (IPRs).

The nature of patents is contentious in that patents are awarded for elements of biodiversity at gene level or organismal level, contradicting with the idea of

patents to be awarded for novelty or inventiveness (Pretty 2001, Gepts 2004). Those in favour state that locating and isolating the new gene is ground for eligibility, but critics argue that DNA sequencing are now routine so does not qualify as being a new invention. Patents of the 'novel' gene however extend to any plant the gene is inserted into (Gepts 2004).

One of the moral issues arising from IPR and patents is if the party adding a gene to a pre-existing variety can claim total ownership. One such controversial example is the *nuña* or popping beans (sold as a snack in Bolivia and Peru); these are a mixture of one of the most diverse common bean mixtures. Generations of farmers in Latin America have cultivated these beans, but have now been patented by a biotechnology company (Gepts 2004). What about the ownership rights of those who developed the *nuña* or popping beans by adding and mixing traditional varieties?

This act of awarding patents without appropriate authorisation or compensation is called "biopiracy". The new IPRs and patents systems do not offer any reward for past efforts in conservation of biodiversity. WA has no legislation to combat biopiracy - but if GM crops are to be grown here, and new genetically modified varieties created from existing crops developed through adaptation or selective breeding, attention needs to be given to this issue as well.

Needless to say, biotechnology is expensive and biotechnology companies have significant investment in ensuring that there is a return on their investment, and profits cannot be made unless they have the rights on the genetically modified plant/seed, and they have market monopoly.

Currently the 10 major seed companies come from the United States, Switzerland, United Kingdom, France, Mexico, Japan, and Germany, and most have significant biotechnology investments, which have resulted in the worldwide release of genetically modified cultivars (Gepts 2004).

This monopoly has led to a situation where only five major companies now sell genetically altered or modified seeds: Monsanto, DuPont/Pioneer, Aventis, Syngenta and Dow, who account for more than a quarter of total seed sales (Gepts 2004).

Biodiversity

Should these same five seed companies have the right to "own" biodiversity or intellectual property rights (IPRs) on traditional knowledge? Or the right to own crops developed by indigenous societies or group of local farmers through hybridisation between landraces and modern cultivars over several generations, who in the past have promoted the existence of biodiversity in general and crop biodiversity and freely disseminated the information?

It would seem that the regime of IPRs and patents for biodiversity benefit the powerful players such as the biotechnology companies and patent holders. What about the rights of indigenous, local people who have conserved biodiversity

over many generations? Despite promises of great yields and having the solutions to every farmer's problems, the question of whether common heritage i.e. seeds and local cultivars should become private property and whether biodiversity should be 'owned' must be kept foremost in our minds. Perhaps genetic modification (and proposed solutions) is promoted simply because they are proprietary, and other more holistic, system-based approaches are not considered because they are not.

There are numerous concerns about GM technology including risks to biodiversity, with transfer of certain genes such as resistance to insects or herbicides, possibly resulting in the creation of aggressive weeds or plants that dominate the population (Johnson 2000). There has not yet been research carried out as to the potential biodiversity risk to WA, but this is yet another area of work needed if the GM experiment is to be continued.

The old paradigm of industrial, energy-intensive agriculture must surely now be a concept of the past with small-scale farmers and agro-ecological methods being the way forward to avert the current food crisis and meeting the needs of local communities.

The IAASTD report emphasised that ecological agricultural systems such as improving nutrient, energy and land use efficiency; improving the understanding of soil-plant-water dynamics; and enhancing biodiversity conservation and use at both field and landscape scales and others must be adopted to counter the effects of agriculture on climate change and at the same time lessen the impacts of climate change on agriculture.

There is some irony that the same economic interests promoting chemical-based agriculture are now promoting the emergence of biotechnology. Advocates for the technology affirm that GM will increase agricultural productivity, make farming more profitable, more environmentally friendly and put an end to starvation in developing countries.

The latter is based on the assumption that hunger is due to a gap between food production and human population density or growth, and that GM is the only or best way to increase production.

The IAASTD report challenged this assumption stating that "ensuring food security is not merely a matter of producing enough to eat: food must also be available to those who need it." The real causes of hunger are poverty, inequality and lack of access to food and land. Too many people are too poor to buy the food that is available (but often poorly distributed) or lack the land and resources to grow it themselves. Pretty (2001) poses the question of whether GM technology in crops has eliminated choice for poorer farmers, and notes that sustainable agriculture without the use of technology and modern chemicals promotes self reliance in developing countries.

Conclusion

Agriculture will remain central to the WA economy. The solution to the 'problems' we are faced with in WA agriculture are not, however, to be found within one method, and certainly not solved by the GM magic-bullet. We should reject our first instinct, to find a single simple solution when faced with the difficult issues such as climate change or soil erosion, especially when the evidence suggests that GM crops cannot be sustained in increasingly difficult climate conditions

There is no one solution to address the current problems in WA agriculture but the right way forward is to adopt local, socially and environmentally responsible methods. This may mean having to change old habits or practices, and adopting ideas which in the long term will benefit all, instead of the few multinationals and their shareholders. In short, we would be very foolish to try and fix one problem by introducing another, instead of taking the time to consider all options for the way forward. In the long term this will be in the interests of both farmers and consumers.

What would therefore make sense is more investment in sustainable methods of farming instead of adopting biotechnology in farming. In parallel, all precautionary steps that the State Government can take to protect the environment for WA's crops and livestock, and all steps that it can take to guarantee their quality and marketability, are surely to be welcomed.

The review of the GM Free Area Act 2003 considered the current Act to be effective and has a place in the regulatory framework, and made the following recommendations:

- Consider the introduction of more certainty, transparency and public participation into the decision-making process relating to granting of exemptions to allow cultivation of GM crops;
- Consider providing accurate information of the location of GM crops to producers who might be affected;
- Submissions to the review should be examined to determine suggested amendments to the Act which could enhance its continued operation; and,
- A further review of the operation and effectiveness of the Act if and when the Act has been in operation for a further five year period.

The moratorium on GM crops stands as exactly one of those bulwarks, and needs strongly to be supported and maintained. However, the Government has ignored the findings of its own review and proceeded with lifting of the moratorium without further examining some of the issues raised. This will have serious implications on our State agriculture and potential affect local and overseas markets.

Author

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Group (chaired by the former Minister for Agriculture and Food, Mr Kim Chance). Dr Lilith is also the former Vice President of the Organic Growers Association of WA and continues to liaise with them on this issue. Some information in this paper was provided by the GM Free Consumers Network. For further information on this group, see www.no-gmo.asn.au

References

Altieri, M.A. (2000a). The Myths of Agricultural Biotechnology: some ethical questions http://www.cnr.berkeley.edu/~agroeco3/the_myths.html (accessed 14/01/2010).

Altieri, M.A. (2000b). The ecological impacts of transgenic crops on agroecosystem health. *Ecosystem Health* **6**: 13 – 23.

Altieri, M.A., Gurr, G. M. and Wratten, S. D. (2004). Genetic engineering and ecological engineering: a clash of paradigms or scope for synergy? In *Ecological Engineering for Pest Management: Advances in Habitat Manipulation for Arthropods*. Eds. G.M. Gurr, S. D. Wratten and M.A. Altieri. CSIRO Publishing

Armstrong, T. T., FitzJohn, R. G., Newstrom, L. E., Wilton, A. D. and Lee, W. G. (2005) Transgene escape: what potential for crop-wild hybridization? *Molecular Ecology* **14**: 2111-2132.

Bala Ravi, S. (2003) Biodiversity, Farmers' Rights, Biotechnology and Patents. In Adhikari, Ratnakar and Kamalesh Adhikari (eds.) *Farmers' Rights to Livelihood in the Hindu-Kush Himalayas*, SAWTEE, Kathmandu, Nepal.

Bohan, D. A., Boffey, C. W. H., Brooks, D. R., Clark, S. J., Dewar, A. M., Firbank, L. G., Haughton, A. J., Hawes, C., Heard, M. S., May, M. J., Osborne, J. L., Perry, J. N., Rothery, P., Roy, D. B., Scott, R. J., Squire, G. R., Woiwod, I. P., Champion, G.T. (2005) Effects on weed and invertebrate abundance and diversity of herbicide management in genetically modified herbicide-tolerant winter-sown oilseed rape. *Proceedings of the Royal Society B: Biological Sciences* **272**(1562): 463-474.

Clark, E. A. (2004) *Genetically Engineered Crops: Myths and Realities*. Presented to the Yale School of Forestry and Environment Studies

Colmer, T. D., Flowers, T. J., and Munns, R. (2006) Use of wild relatives to improve salt tolerance in wheat. *Journal of Experimental Botany* **57** (5): 1059-1078

Department of Agriculture and Food

http://www.agric.wa.gov.au/objtwr/imported_assets/content/fcp/gmcrops/gmcfa%20act%20review%20report-web.pdf URL accessed 18 January 2010

Deville, A. and Harding, R. (1997). *Applying the precautionary principle*. The Federation Press, Sydney.

Dona, A. and Arvanitoyannis, I.S. (2009) Health Risks of Genetically Modified Foods. *Critical Reviews in Food Science and Nutrition* **49**: 164–175

Ellstrand, N. C. (2001) When Transgenes Wander, Should We Worry? *Plant Physiology* **125**: 1543–1545.

Ellstrand, N. C. (2003) Going to "great lengths" to prevent the escape of genes that produce specialty chemicals. *Plant Physiology* **132**: 1770–1774.

Ewen, S.W and Pusztai A. (1999) Effect of diets containing genetically modified potatoes expressing *Galanthus nivalis* lectin on rat small intestine. *Lancet* **354**:1353–1354.

Fallon, M. J., Gursoy, D. and Swanger, N. (2007) To buy or not to buy: Impact of labeling on purchasing intentions of genetically modified foods. *Hospitality Management* **26**: 117–130

Fares, N.H. and El-Sayed, A.K. (1998) Fine structural changes in the ileum of mice fed on delta-endotoxin-treated potatoes and transgenic potatoes. *Nat Toxins*. **6**: 219–233.

Farm Business News – available on URL

<http://www.farmbusiness.com.au/index.php/features/373-bayer-coughs-up-for-gm-rice-crop-contamination.html?ff44d9f87768162db085922a6777f129=edc6dcd966e460bef2827ef4007b8c83>

[accessed 18 January 2010]

Food Standards – available on URL

<http://www.foodstandards.gov.au/consumerinformation/gmfoods/frequentlyaskedquestionsongeneticallymodifiedfoods/part2safetyassessmen4658.cfm>

[accessed 18 January 2010]

Gepts, P. (2004) Who owns biodiversity, and how should the owners be compensated? *Plant Physiology* **134**: 1295 –1307.

GM contamination register – available on URL

<http://www.gmcontaminationregister.org/index.php?content=re®=0&inc=0&con=0&cof=0&year=0>

[accessed 18 January 2010]

Gunning, R. V., Dang, H. T., Kemp, F. C., Nicholson, I. A., and Moore, G. D. (2005) New Resistance Mechanism in *Helicoverpa armigera* Threatens Transgenic Crops Expressing *Bacillus thuringiensis* Cry1Ac Toxin. *Applied and Environmental Microbiology* **71** (5): 2558 – 2563

Gupta, V. S. R. and Watson, S (2004) Ecological impacts of GM cotton on soil biodiversity. Final report for a project funded by the Australian Government, Department of the Environment and Heritage. CSIRO, Canberra.

Hammond, B., Lemen, J., Dudek, R., Ward, D., Jiang, C., Nemeth, M., and Burns, J. (2006) Results of a 90-day safety assurance study with rats fed grain from corn rootworm-protected corn. *Food and Chemical Toxicology* **44**: 147- 160.

Hilder, V. A. and Boulter, D. (1999). Genetic engineering of crop plants for insect resistance - a critical review. *Crop protection* **18**: 177 - 191.

Ho, M.W and Cummins, J. (2007) Mystery of disappearing honeybees. *Science in Society* **34**: 35-36.

Johnson, B. (2000) Genetically Modified Crops and Other Organisms: Implications for Agricultural Sustainability and Biodiversity. In G.J. Persley and M.M. Lantin, eds., *Agricultural Biotechnology and the Poor: Proceedings of an International Conference, Washington, D.C., 21-22 October 1999*. Washington, D.C.: Consultative Group on International Agricultural Research.

Kranthi, K. R., Naidu, S., Dhawad, C. S., Tatwawadi, A., Mate, K., Patil, E., Bharose, A. A., Behere, G. T., Wadaskar, R. M. and Kranthi, S. (2005). Temporal and intra-plant variability of Cry1Ac expression in Bt-cotton and its influence on the survival of the cotton bollworm, *Helicoverpa armigera* (Hübner) (Noctuidae:Lepidoptera). *Current Science* **89**: 291 - 298

Lea, E. (2005) Beliefs about Genetically Modified foods: A qualitative and quantitative exploration. *Ecology of Food and Nutrition* **44**: 437-454

Légère, A. (2005) Risks and consequences of gene flow from herbicide-resistant crops: canola (*Brassica napus* L) as a case study. *Pest Management Science* **61**: 292-300

Liu, F., Xu, Z., Zhu, Y. C., Huang, F., Wang, Y., Li, H., Li, H., Gao, C., Zhou, W., and Shen, J. (2009) Evidence of field-evolved resistance to Cry1Ac-expressing Bt cotton in *Helicoverpa armigera* (Lepidoptera: Noctuidae) in northern China. *Pest Management Science* **66** (2): 155-161

Lynch, J. M., Benedetti, A., Insam, H., Nuti, M. P., Smalla, K., Torsvik, V., and Nannipieri, P. (2004) Microbial diversity in soil: ecological theories, the contribution of molecular techniques and the impact of transgenic plants and transgenic microorganisms. *Biology and Fertility of Soils* **40**: 363-385

Ma, X. M., Zhang, Q. W., Cai, Q. N., Xu, H. L., Li, J.J., Zhai, L. X. and Yang, Y. F. (2004). Outbreak of *Lygus lucorum* Meyer-Dür in south of Hebei cotton region in 2003. *Plant Protection* **30**: 90.

Ma, X. M., Liu, X.X., Zhang, Q. W., Li, J.J., and Ren, A. M. (2006). Impact of transgenic *Bacillus thuringiensis* cotton on a non-target pest *Tetranychus* spp. in northern China. *Insect Science* **13**: 279 - 286

- Magaña-Gómez, J. A. and Calderón de la Barca, A.M. (2009). Risk assessment of genetically modified crops for nutrition and health. *Nutrition Reviews* **67**(1): 1-16.
- Martín-Orúe, S.M., O'Donnell, A.G., Ariño, J., Netherwood, T., Gilbert, H. J. and Mathers, J. C. (2002) Degradation of transgenic DNA from genetically modified soya and maize in human intestinal simulations. *British Journal of Nutrition* **87**: 533 -542
- Mason, J. (2004) *Sustainable Agriculture*. 2nd Edition CSIRO Press, Collingwood, Australia.
- Men, X., Ge, F., Edwards, C. A. and Yardim, E. N. (2005). The influence of pesticide applications on *Helicoverpa armigera* Hübner and sucking pests in transgenic Bt cotton and non-transgenic cotton in China. *Crop Protection* **24**: 319 - 324.
- Pessel, F.D., Lecomte, J., Emeriau, V., Krouti, M., Messean, A. and Gouyon, P.H. (2001) Persistence of oilseed rape (*Brassica napus* L.) outside of cultivated fields. *Theoretical and Applied Genetics* **102**: 841-846
- Poulsen M, Schroder M, Wilcks A, Kroghsbo, S., Lindecrona, R. H., Miller, A., Frenzel, T., Danier, J., Rychlik, M., Shu, Q., Enami, K., Taylor, M., Gatehouse, A., Engel, K-H. and Knudsen, I. (2007) Safety testing of GM-rice expressing PHA-E lectin using a new animal test design. *Food and Chemical Toxicology* **45**: 364-377.
- Prescott, V. E., Campbell, P. M., Moore, A., Mattes, J., Rothenberg, M. E., Foster, P. S., Higgins, T. J. V. and Hogan, S. P. (2005) Transgenic expression of bean α -amylase inhibitor in peas results in altered structure and immunogenicity. *Journal of Agricultural and Food Chemistry* **53**: 9023 - 9030.
- Purves, W. K., Orians, G. H. Craig Heller, H and Sadava, D. (1998) *Life: The Science of Biology* (5th Edition). Sinauer Associates, Massachusetts, USA.
- Ratnieks, F. L. W (2000) How far do honey bees forage? *Bee Improvement* **6**: 10-11,
- Rosi-Marshall, E.J., Tank, J. L., Royer, T. V., Whiles, M. R., Evans-White, M., Chambers, C., Griffiths, N. A., Pokelsek, J. and Stephen, M. L. (2007) Toxins in transgenic crop byproducts may affect headwater stream ecosystems. *Proceedings of the National Academy of Sciences of the United States of America* **104**: 16204-16208; published online before print October 8, 2007, doi:10.1073/pnas.0707177104
- Sagstad, A., Sanden, M., Haugland, O., Hansen, A.C., Olsvik, P.A., Hemre, G.I. (2007) Evaluation of stress and immune-response biomarkers in Atlantic salmon, *Salmo salar* L., fed different levels of genetically modified maize (Bt maize), compared with its near-isogenic parental line and a commercial suprex maize. *Journal of Fish Diseases* **30**:201-212

Schrøder, M., Poulsen, M., Wilcks, A., Kroghsbo, S., Miller, A., Frenzel, T., Danier, J., Rychlik, M., Emami, K., Gatehouse, A., Shu, Q., Engel, K-H., Altosaar, I., and Knudsen, I. (2007) A 90-day safety study of genetically modified rice expressing Cry1Ab protein (*Bacillus thuringiensis* toxin) in Wistar rats. *Food and Chemical Toxicology* **45**: 339-349

Seralini, G., Cellier, D., Vendomois, J. S. (2007) New Analysis of a Rat Feeding Study with a Genetically Modified Maize Reveals Signs of Hepatorenal Toxicity. *Archives of Environmental Contamination and Toxicology* **52**: 596-602.

Sharma, R., Damgaard, D., Alexander, D., Dugan, M. E. R., Aalhus, J. L., Stanford, K and McAllister, T.A. (2006) Detection of Transgenic and Endogenous Plant DNA in Digesta and Tissues of Sheep and Pigs Fed Roundup Ready Canola Meal. *Journal of Agricultural and Food Chemistry* **54**: 1699-1709

Siruguri, V., Sesikeran, B., Bhat, R.V. (2004). "Starlink genetically modified corn and allergenicity in an individual." *Journal of Allergy and Clinical Immunology* **113**(5): 1003-1004.

State of the Environment report (2007) available on URL
<http://www.soe.wa.gov.au/report/atmosphere/greenhouse-gas-emissions.html>
[accessed 18 January 2010]

Snow, A. A. (2002). Transgenic crops - why gene flow matters. *Nature Biotechnology* **20**: 242

WA Parliament available on URL
[http://www.parliament.wa.gov.au/web/newwebparl.nsf/pgFrameset?openpage&fcontent=http://www.parliament.wa.gov.au/parliament/commit.nsf/\(InqByName\)/2D99E7ABF3A3A62448256BF30008245E?OpenDocument](http://www.parliament.wa.gov.au/web/newwebparl.nsf/pgFrameset?openpage&fcontent=http://www.parliament.wa.gov.au/parliament/commit.nsf/(InqByName)/2D99E7ABF3A3A62448256BF30008245E?OpenDocument) [accessed 18 January 2010]

Warwick, S. I., Légère, A., Simard, M.-J. and James, T. (2008) Do escaped transgenes persist in nature? The case of an herbicide resistance transgene in a weedy *Brassica rapa* population. *Molecular Ecology* **17**: 1387-1395.

Wolfe, L. M. and Blair, A. C. (2007) Born to run: competition enhances the spread of genes from crops to wild relatives. *New Phytologist* **173**: 450-452

Yanqing W. 2002. Integrated pest management and green farming in rural poverty alleviation in China. In: *Rural Poverty Alleviation through Integrated Pest Management (IPM) and Green Farming. Proceedings of the Regional Workshop on Integrated Pest Management and Green Farming in Rural Poverty Alleviation, Suwon, Republic of Korea, 11-14 October 2000*. Bangkok: United Nations Economic and Social Commission for Asia and the Pacific, 32-40. Available: <http://www.unescap.org/rural/doc/ipm2002/ch04.pdf> [accessed 17 August 2005].

Zhu, Y., Chen, H., Fan, J., Wang, Y., Li, Y., Chen, J. Fan, J., Yang, S., Hu, L., Leung, H., Mew, T.w., Teng, P.S., Wang, Z., and Mundt, C.C. (2000) Genetic diversity and disease control in rice. *Nature* **406**:718–722