Good, Safe, Banned

The HV McKay Lecture for 2004

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'Ignorance ain't what you don't know, it's what you do know that ain't correct.'
[Will Rogers, late American humorist]

PERHAPS more than most people, I have long been concerned with reducing pesticide use. I decided to become an entomologist 30 years ago when I happened upon a copy of Rachel Carson's *Silent Spring* in my local community library, and consumed it in two days. In my earliest classes in entomology a few months later, I learned that cotton was the most important crop for insecticide use, accounting for about 50 per cent of world-wide applications in agriculture. I began working on cotton in 1975, and have remained actively involved with the crop ever since.

When I first learned in the mid-1980s that scientists were trying to express genes from the bacterium *Bacillus thuringiensis* (Bt) in plants, especially cotton, I thought that this was a bad idea, probably like most entomologists at the time. We were especially concerned that this would lead to the rapid evolution of resistance to Bt, which many of us saw as having great potential to reduce the use of chemical insecticides. However, scientists are trained to confront their opinions with new facts, and as I will discuss later in this short article, the facts converted me to become a supporter of the genetically modified (GM) crops that are currently registered around the world. In retrospect, the decision should have been simple: the evidence that these crops can contribute to sustainable agriculture is overwhelming. GM crops and sustainable agriculture have already demonstrated that they can be the best of friends. I'll first discuss this history and then describe advances in GM crops that show potential to improve the sustainability and reduce the environmental impacts of agriculture. The whole history of GM crops illustrates the innovation and imagination that characterized the life of the man we honour with the H.V. McKay lecture.

WHAT HAVE GM CROPS DONE FOR US ALREADY?

GM crops that are resistant to herbicides, viruses and insecticides are now commercialized in 16 countries that include half the world's population,[1] but first in China with virus-resistant tobacco by 1992. The overall impact on pesticide use of just the GM crops currently available has been enormous. Reductions in pesticide use from just 8 GM crops in the US have been calculated at more than 21 million kg in the year 2001 alone. GM crops also increased yields by about 1 billion kg, saved more than $1 billion in production costs, and reduced the use of tillage in agriculture.[2] Virus-resistant papaya cultivars have saved the papaya industry on the 'Big Island' of Hawaii.

China has benefited more from agricultural biotech than any other country in the world, solely due to reduced insecticide use in Bt cotton. For at least several years until 1997, there were at least 10,000 insecticide poisonings and about 400–1000 deaths per year in Chinese cotton-growing areas. In 1998, insect resistant Bt cotton was introduced into Hebei Province and, by 2000, most of the crop was insect-resistant. The use of insecticides on Bt cotton has been reduced by more than 80 per cent, greatly improving the health of these farm workers. For conventional cotton, 22 per cent of cotton farm workers reported headaches, nausea, skin pain or digestive problems. For ▶

Not only do GM crops in Australia produce a healthier environment for rivers and streams by reducing the use of chemicals, they also have the potential to address major issues such as nitrogen fixation to help soil acidity.

those growing all Bt cotton, this was reduced to 4.7 per cent. Bt cotton is now grown by at least five million of China's 12 million cotton growers and has probably saved at least 200 lives per year. In addition to the improved health of workers, there are economic benefits. The cost of producing cotton was reduced by 30 per cent, the number of applications of insecticide reduced from 20 per season to seven, and the quantity of insecticide from 61 to 12 kilograms per hectare, with a reduction in costs of 80 per cent. Some 97 per cent of the financial benefits of Bt cotton go directly to Chinese cotton farmers, and only 3 per cent to seed companies (Monsanto and an independent Chinese company)[2,3].

Because almost half of the insecticide used in agriculture is applied to cotton, with roughly half of that used against caterpillars, Bt cotton alone has the potential to wipe out 10–25 per cent of the world's agricultural insecticide use, and probably an even greater proportion of the risks of the insecticide use. It seems ironic in retrospect that Monsanto, with an eye on profits (as all companies must do), has probably done more in this one development to reduce pesticide use than all of the rest of us in pest management, including devotees of organic farming.

For at least several years until 1997, there were more than10,000 insecticide poisonings and about 400–1000 deaths per year in Chinese cotton growing areas. Reduction in their use, through GM, will save thousands of lives worldwide.

Further, there is no risk to the consumer. A key point about many genetically engineered crops is that the foods they produce are not genetically engineered. In the case of cotton, the foodstuff is cottonseed oil, and like most oils and sugars, no detectable protein or DNA remains after processing. That is, sugars and oils produced from insect (or herbicide) resistant crops are the same as from standard crops.

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In a public letter, I initially opposed the registration of Bt corn in the US. What changed my mind about Bt corn was strong evidence that Bt corn was safer for humans and livestock than conventional corn. Fusarium ear rot is the most common ear rot disease in corn, and is encouraged by insect damage to corn kernels, which provides sites for the fungi to grow.[4] Fusarium produces mycotoxins, particularly the fumonisins, which can be fatal to horses and pigs, and are human carcinogens. Field studies have demonstrated that hybrids containing Bt genes experience significantly lower incidence and severity of fumonisin concentrations than their non-Bt counterparts.[5] Throat and other cancers due to fumonisin in insect-susceptible corn are at epidemic levels in southern Africa.

Environmental and agronomic concerns about Bt included increased resistance in insects and effects on non-target species. What about the threats of resistance to Bt? Bt has been used in sprays for more than 40 years, but due to its poor persistence, still accounts for less than 1 per cent of the total insecticide market. Bt sprays were never at threat from the Bt crops already registered because the sprays are ineffective and almost unused against insect pests of cotton and corn, which feed extensively inside plant tissues where they can't eat the sprays. When produced inside the plant, the persistence of Bt is much greater, and even pests that bore into the plant (and which might not eat a spray) can be controlled.[4] Further, resistance-management strategies for Bt cotton and corn have been implemented around the world and are being improved with two gene cultivars.[4,6] Contrary to the predictions of critics, there is no resistance to Bt crops, even after 7 years of their intensive use.

Impacts on non-target species have been intensively investigated and published since 1994, but in spite of the publicity generated by a small laboratory study on Monarch butterflies (and the lack of publicity to several more extensive papers published in 2001 in the *Proceedings of the US National Academy of Sciences* in 2001), the effects of Bt crops on non-target species are clearly and consistently much less than in conventional agriculture.[4]

The benefits from Bt cotton alone are enormous. Where grown in the USA, Bt cotton reduces insecticide use by 70–90 per cent. In Australia, the reductions have been about 50 per cent over the last 3 years,[4] but based on trials over the last two years, this should further improve toward 90 per cent with the introduction of 'two-gene' cultivars expected in 2005.

Peter Raven and David Pimentel, both prominent ecologists in the US, have written that bird populations in the US have increased due to Bt corn. Rachel Carson would surely have been pleased.

The more controversial class of genetically engineered crops, however, are those crops resistant to herbicides. Roundup-resistant soy alone accounts for some 60 per cent of all GM crops

planted by area. Much of the public has apparently been convinced that there are alternatives to herbicides that can be used in broad-scale agriculture. The hard facts are that there aren't any with less environmental impact. The environmental costs of the prime alternative to herbicides—cultivation—are clearly much higher than herbicides. Not only does reduction in tillage reduce soil loss through erosion by wind and water, it increases soil organic matter and reduces loss of soil carbon to the air as CO2, thereby potentially reducing atmospheric warming.

A major concern of environmental activists, that transgenic herbicide-tolerant crops will lead to increased herbicide use, is inconsistent with grower practice to use the least amount of herbicide that they can without losing yields and contrary to the facts in eight years of use. Even now, Australian growers don't use the full labelled rates of most herbicides just to save costs, so the mere fact that a crop can tolerate a high level of herbicide use has provided no incentive to growers to actually use that much herbicide.

WHAT CAN GM CROPS DO FOR US NEXT?

Africa is likely to be the greatest beneficiary of GM crops in the future. Viruses, weeds, drought, and insects take as much as 50 per cent of crop yields in Africa now, and crops that can address each of these problems already exist. Although there are problems with food distribution in Africa, the costs of improving the transportation system in Africa are enormous. Further, it is a key to the self-esteem and economic welfare of individual African farmers to be self-sufficient.

Australian farming contributes enormously to our economy and the maintenance of rural infrastructure, but is under threat from a wide range of forces, including salinity, climate change (which will promote a climate that is at least more variable and probably drier), and soil acidity. In the long term, GM crops still have potential to address major issues such as nitrogen fixation, which can help soil acidity, worsened by the addition of the fertilizers agriculture needs to retain its productivity.

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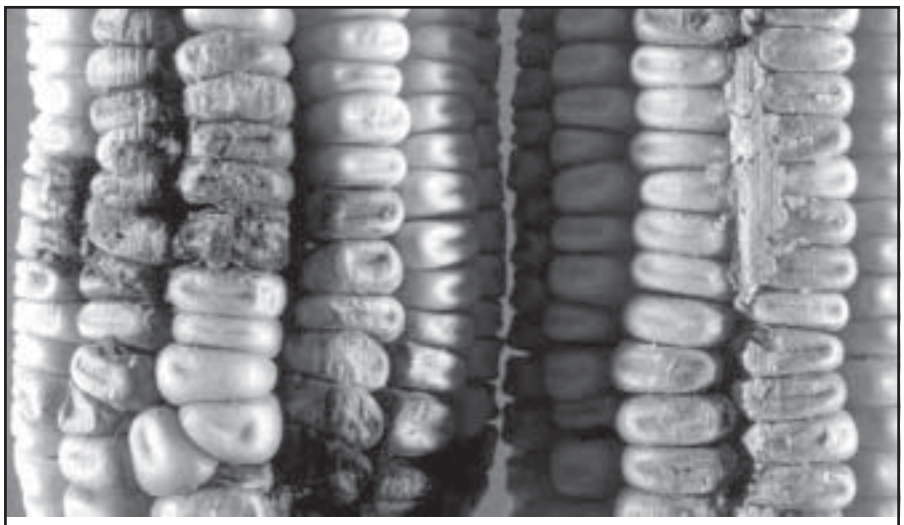
We don't have to look that far into the future, however, for traits that are useful to Australia. GM salt-tolerant canola and drought-tolerant wheat are already in trials in the US and Mexico,[8] and entirely independent means of obtaining salt and drought tolerance have been developed in India and South Africa, all by government or university researchers. One of the more important near-term applications in Australia would be for virus-resistant pasture crops such as clovers. Although rejected for political grounds in the southern states, it has been independently estimated that the decision to reject GM canola has cost Western Australian growers alone about $170 million per year.[7]

FOOD SAFETY

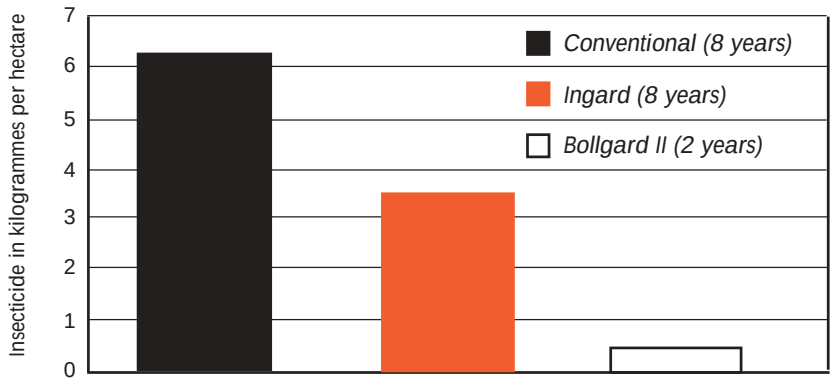
The principal food safety concerns for GM plants are potential toxicity and allergenicity of the newly introduced proteins, changes in nutrient composition of the plants, and the safety of antibiotic resistance marker-encoded proteins included in the transgenes. Some people are also concerned with the potential that DNA can be passed from GM feeds to livestock or meat. A wide range of studies, however, have shown that consumption of milk, meat and eggs produced from animals fed GM crops should be considered as safe as traditional practices.[9] In particular, recognizable fragments of DNA are broken down in digestion and not taken up in animals.[10] If this were not true, all animals would have been overcome by a large amount of plant DNA over evolution. Instead, mechanisms have evolved to make sure that that doesn't happen.

In contrast to concerns about toxicity and allergens from GM, there is clear evidence for health benefits from Bt corn, due to reductions in fumonisins, as discussed above.



Throat and other cancers due to fumonisin in insect susceptible corn are at epidemic levels in southern Africa. Hybrids containing Bt genes experience significantly lower incidence and severity of fumonisin concentrations than their non-Bt counterparts

Reduced Pesticide Input in Australian Cotton



The reduction in insecticide when using genetically modified in cotton is dramatic. The best results are with second generation [Bollgard II] GM cotton which has been used for the last two years.

FEARS ABOUT MARKET ACCESS FOR TRANSGENIC CROPS

Consumers did not initially reject GM crops, even in Europe. Before the activist campaign against GM crops picked up steam in the UK for example, the supermarket chain Sainsbury's sold tomato paste from GM crops, and answered one of the most consistent of consumer interests—more quantity for the same price. Europe imports some 35 million tonnes of soybeans, most of which are GM. Some 70 per cent of British cheese is made using enzymes produced from genetically modified bacteria, with no uproar or labelling required.

Mark Twain once advised, 'Get the facts first. You can distort them later.' Unfortunately, it's probably rare in modern times that Will Rogers' comment at the start of this article has applied so aptly to the attitude to GM crops. Never mind policy makers in developing countries, Westerners with excellent access to reputable sources of information continue to believe in their ignorance the wildest tales about GM crops. Due to fears about market access, Africa has been reluctant to adopt technologies that have already saved lives in China and could save even more lives in Africa, just for fumonisins alone. So-called civil society organizations have also deliberately exploited the misconceptions and prejudices that people have about science and multinational corporations. Some have been answered in this article. Multinational corporations are neither in control of GM nor the main beneficiaries of it. Food and environmental safety of GM crops have been studied for years, and even European scientists have concluded that they are as safe as conventional crops.[11] Although people love to hate corporations, and Monsanto is often depicted as a multinational giant, in fact it is smaller than Qantas Airlines.

CONCLUSIONS

Activist groups often complain that consumers never asked for genetically engineered crops and stand to gain little from them. Consumers, however, have consistently demanded a reduction in the health and environmental risks of agriculture. GM crops have answered that demand. GM crops have already reduced the costs of food production. More importantly, the risks of pesticide exposure are far greater to farm workers that to the general public, and we should be mindful of their needs.

There are potential risks attached to genetically modified crops, but many of those raised in the popular press have achieved the status of urban myths. Genetically modified foods have not been rushed to market and are much more extensively scrutinized than many potentially risky conventional foods that are on the market and not receiving attention.

The public has every right to reject genetic modification of plants, but it also has the right to be well-informed about its choices. For the benefit of Australia's environment and the sustainability of our agriculture, we need to set aside myths and prejudices and make rational choices for the future of Australia and the world.

NOTES

1 http://www.isaaa.org/

2 http://www.ncfap.org/whatwedo/40casestudies.php, see also www.ers.usda.gov/epubs/pdf/aer786/ and www.ers.usda.gov/publications/aer810/ Anti-GM activists like to quote Chuck Benbrook to the contrary, a consultant who works with NGOs concerned with alternative agriculture, but Benbrook's claims have been repeatedly rebutted by experts, including in Universities and the USDA.

3 Huang, *et al*. 2002. *Science* 295, 674-677.

4 Shelton, *et al*. 2002. *Annual Rev Entomology* 47, 845-881.

5 Munkvold, et al. 1999. *Plant Dis*. 83, 130-138.

6 Zhao, *et al*. 2003. *Nature Biotechnology* 21: 1493-97.

7. http://www.no-till.com.au/publications/pressrelease.html

8. Pellegrineschi *et al*. 2004. *Genome* 47, 493-500; Zhang, *et al*. 2001. *Proceedings National Academy Sciences* USA 98:12832-12836.

9. www.fass.org/Factsheet2.htm, www.afaa.com.au click on 'Agbiotech Resources' and then 'animal feed', and http://www.ncga.com/news/notd/2003/october/100903.htm).

10. Einspanier *et al*. 2001. *Eur Food Res Technol* 212, 129-134

11. http://europa.eu.int/comm/research/quality-of-life/gmo/index.html

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