TechTalk

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Gene technology and food

Gene technology refers to the alteration of the genetic material of living things so they may produce new or modified substances, or have a novel function. As with any technology, gene technology carries with it potential risks and benefits. These potential risks and benefits are not limited to those linked to science, but include social, political, economic, agronomic and ethics. This publication explores some of the questions and issues raised about gene technology and its use in the development of novel crops.

In this publication genetically modifed (GM) crops and food refer to those that have had their genome modified by either the addition of one or more genes from another species or the specific modification of existing genes, for example through gene silencing techniques.

Is gene technology natural?

Plants and animals can have more than one hundred thousand genes (humans have about 23,000). In this context, adding one or a few new genes using gene technology is a tiny change to the overall genetic makeup of a living thing, although depending on the gene or genetic alteration, small changes can have a dramatic effect, for example those that can lead to disease. In contrast, conventional breeding technology, which includes non-GM methods such as mutagenesis where a seed's DNA is altered by chemical or radiation treatment, involves the change and/or transfer of many genes in a less specific way[1].

Gene technology used to create GM crops is definitely different from historical genetic changes made via breeding within a species or between closely-related species. Gene technology enables the transfer of genes across species barriers, and this has virtually never happened before, even over evolutionary timescales.

Species have evolved with their genes working together in complex systems. It is difficult to predict the consequences of inserting a foreign gene into an organism. For example, what effect the foreign gene might have on existing and unrelated genes or traits. Also, rapid alteration of a species by gene technology could have unforeseen consequences in ecosystems that are not adapted to the new version. However, one could potentially argue the same is possible using conventional breeding techniques such as mutagenesis.

Stuff to think about.

What do we mean by natural (or unnatural)?

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Would the non-GM breeding techniques such as mutagenesis be considered natural? Is agriculture natural? That is, how natural are the crops we have domesticated and the environments we grow them in? How many of these crops would be able to survive in the natural environment, outside a well-tended paddock? What about the affect of agriculture as a whole (GM or conventional) on the environment?

What about health effects?

There are strict legal requirements that control the development, release and use of genetically modified organisms (GMOs) in Australia.

The Office of the Gene Technology Regulator (www.ogtr.gov.au) has a role to protect the health and safety of people and the environment, by identifying risks posed by or as a result of gene technology, and by managing those risks through regulating certain dealings with GMOs.

Food Standards Australia New Zealand (FSANZ - www.foodstandards.gov.au) carries out a risk assessment of all food derived from or containing ingredients from GMOs before they can be sold. This includes examining whether the food has additional allergens or toxins as a result of the GM process. It is up to the reader to determine if they think the regulatory process is sufficiently rigorous.

Antibiotic resistance marker genes are a type of marker gene derived from bacteria. They provide the bacteria with natural resistance to particular antibiotics. They are sometimes used in GM plants to determine if the transgene (new gene) has been taken up by the plant. If such an antibiotic resistance gene moved from a GM plant to a bacterium that causes human disease, the antibiotic to which the marker gene provides resistance may no longer be useful for treating the disease.

Although genes that provide for antibiotic resistance have been used as markers in some GM plants, the antibiotics involved are not usually those used in human medicine, and the marker genes can now be removed from the plant before commercial production. It is extremely unlikely that these genes could transfer from plants to bacteria as there are a number of barriers to such transfer. There are several common marker genes that do not confer antibiotic resistance.

Concerns

Some people are concerned that added genes could make 'safe' plants produce toxins or allergy-causing substances. And the technology (transgenics) used to develop GM foods is quite new, and there have been no studies of the long-term effects on human health. Yes, this is the case and, again, the same concerns can apply to some conventional breeding techniques.

Stuff to think about

How do you define safe? All foods naturally contain toxins, allergens and anti-nutrients and all plant breeding techniques (GM and conventional) can potentially introduce these chemical compounds into a food crop or change their levels, so how safe must your food be before you are prepared to eat it?

In reference to 'long-term effects', what do we mean by long-term? In reality we don't know the long-term effects of eating conventionally-bred food either becasue we continually bring out new varieties each year.

How will gene technology affect the environment?

Pesticide and herbicide

GM crops such as insect-resistant Bt cotton reduce pesticide use by farmers and should therefore be less harmful to the environment than synthetic chemical insecticides. Bt cotton (called Bollgard in Australia) contains two genes from the bacterium *Bacillus thuringiensis*. This makes the cotton plant produce bacterial toxins that specifically target moths and butterflies, a key pest of cotton crops.

There are conerns that Bt pesticides may 'leak' out of GM plant roots, harming non-target insects and soil microbes in addition to the pests they are designed to kill[5].

And farmers will still be faced with pests becoming resistant to pesticides, even if pesticides are engineered into crops. This aspect of pest control will always exist.

Herbicide-tolerant crops can allow farmers to spray more benign herbicides than those commonly used, and give farmers more weed control choices, including the employment of conservation tillage practices which can decrease soil erosion and water loss, and improve carbon retention in the soil.

It is known that the herbicide tolerance trait in some GM and conventionally-bred herbicide-tolerant crops can transfer to weeds. With proper agronomic practices, however, this risk can be managed. If not then there is the risk of creating weeds that are difficult to control and likely to require the use of more toxic herbicides.

Research suggests that the frequency of transfer of genes from GM crops to related crops and weed species under Australian conditions is actually low[2, 3, 4]. In addition, precautionary steps, such as the use of 'buffer' zones around GM crops, can be used to further reduce the risks of gene transfer. The likelihood of gene transfer though will depend on the crop and its ability to outcross.

From a more ethical/social perpective some people are concerned that the companies that produce herbicide-tolerant crops often manufacture the corresponding herbicide, which locks farmers into a single supplier.

Fertiliser-use efficiency

Research has shown we can produce plants that make more efficient use of available soil nutrients or added fertilisers so the crops will not need as much artificial fertiliser, reducing run-off to the environment and, in the case of nitrogen fetilisers, reducing emissions of the potent greenhouse gas, nitrous oxide.

Other traits

Growing GM crops that are more tolerant to drought or poor soils may encourage farmers to encroach on lands not suited to agriculture, resulting in environmental damage. If the genes from these crops tolerant to drought, salinity or other environmental stresses transfer their stress-related genes to weedy or related species it might create invasive plants that could monopolise fragile or saline ecosystems. This is a risk that requires careful management, and is a risk that is equally likely with conventionally-bred crops with the same traits. That is, we can create drought-, salt-, herbicide-tolerant crops through conventional breeding techniques. Will such conventionally-bred crops have a greater effect on the environment than GM versions?

Stuff to think about

There are risks to growing GM crops and these risks differ for each crop. Can these risks be managed in an acceptable way? How acceptable are the risks compared to growing conventional crops?

Are there markets for GM crops?

There is debate if overall yields of GM crops are higher than their conventional counterparts[6]. Certainly in some instances they are higher, in others lower or about the same as conventional crops. Other factors farmers will consider, however, include production costs, ease of management, effects on long-term productivity, market prices and market acceptability of the crop.

Research shows that most export markets for Australia (such as Japan) are prepared to buy GM crops[7].

Markets that ban GM products can be replaced with those that tolerate low levels of GM content, eg. Canada's GM canola is now sold to Japan rather than to the European Union (EU).

With the possible exception of niche markets, GM-free crops have not generally commanded a higher market price than GM crops[7].

From an alternative perspective, many countries, such as in the EU, do not want to buy GM products so farmers may lose markets if they grow GM crops. Farmers may also be able to get a price premium in some markets if they can certify that their crops are GM-free.

But, depending on the crop, 100 per cent segregation of GM and non-GM products may be difficult to achieve and the costs may outstrip any potential benefits to farmers from GM crops.

The costs of identity preservation process, that is clearly verifying GM or non-GM crops, may also deter buyers of GM products.

Stuff to think about

Segregation only guarantees that contamination of a non-GM crop with one that is GM will be below a certain threshold, for example in Australia the allowable contamination of non-GM canola with GM canola is 0.9%. Is there an acceptable level of contamination and does this change the perception of any effects on humans for the non-GM variety?

Will genetically modified crops help feed the world?

Although not intended to eliminate world poverty, gene technology is one of many modern plant breeding tools that has the potential to develop plants that are more nutritious or be more efficient to produce[8]. This could be in addition to crops with greater resistance to disease and stresses such as drought. One example with potential benefits for the developing world is 'Golden Rice' modified to produce beta carotene, the molecule that the human body uses to form vitamin A. This vitamin, which is often deficient in people in developing nations where rice forms the bulk of their nutrition, is essential for good health and helps prevents blindness. Other examples in the research pipeline include CSIRO research that has modified oilseed crops with a gene from a marine micro-algae to produce the long-chain omega-3 fatty acids vital for human health, and Spanish researchers that have modified corn with three genes to produce Vitamin C, beta carotene and folic acid[9].

Gene technology may help produce animals that are more productive or resistant to parasites and diseases, thus improving livestock quality in developing nations.

GM plants that can grow in poor soils will enable countries with poor lands to be able to grow more of their own food and reduce land-clearing.

At the moment, however, feeding the world is more to do with politics, economics and population than hi-tech developments. We have enough food to feed everyone, at the moment. But those in poverty often cannot afford to buy from the food surpluses. Also, poorer nations are often encouraged to clear land and grow cash crops and animals for export, rather than subsistence crops to feed their population. Other issues include corruption, war, poor distribution of the food becasue of lack of access to markets and deficient infrastructure and political systems. GM crops are unlikely to alleviate these issues.

In many instances, depending on the crop, transgenic technology and intellectual property rights, many poor farmers may not be able to afford the GM seeds and the related herbicides they need from companies. There may be other more immediate and effective solutions to helping farmers in developing nations improve their agricultural output and local food security.

Stuff to think about

Given that genetic engineering is not a tool that alone will feed the world, if it could, in specific situations, help farmers in developing nations increase the reliability of a viable crop and improve food security, would such a situation change the acceptability of risk for that GM crop? Under what circumstances, if any, would it be acceptable for farmers in a developing nation to grow a GM crop?

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Further discussion on GM crops and gene technology can be found at the TechNyou web site and blog:

www.technyou.edu.au

TechNyou also has access to or files of reports and peer-reviewed papers related to the information in this fact sheet that can be sent to anyone interested.

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