An Agricultural Response to the Feeding Frenzy

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The ancestors of our agricultural plants and animals were subjected to stresses that selected among populations for fitness to survive in particular environments. But, for our purposes, survival was not enough—we wanted other properties as well, such as more starch, oil or protein in the seed, shorter stalk, more protein in the leaves. We selected parents with these properties, bred from them, and ruthlessly culled any inferior offspring. So, slowly, randomly, the genome of the population was nudged towards wanted goals. Obviously, this so-called selective line breeding was restricted to organisms where crosses produced fertile offspring. This severely restricted the pool of genes from which useful properties could be drawn.

In the middle of the last century, opportunities for improvements came from unnatural techniques like protoplast fusion, where cells of related, but incompatible, species were fused as protoplants and then regenerated into whole plants. Other sources of variation were developed using somoclonal variation, embryo rescue, and mutagenesis. By altering the genome, these techniques have added considerably to the range of agriculturally useful plants and animals. These new cultivars and animals have been readily accepted by farmers, and consumers now demand the improvements so achieved—who wants stringy beans, small, tough, high-tannin apples, bitter lettuce, or poisonous potatoes?

The first transgenic plant was developed In 1982, but it was a further 13 years before transgenic crops were grown on any significant area. Currently, that area is estimated at over 50 million ha in the west, with further significant, but unknown, areas in China. In Canada 55% of the canola is GM, the United States has extensive areas of GM cotton, corn, soya and canola. Argentina's soya crop is 95% GM, and a third of Australia's cotton crop is GM. The European

Union, however, has shown considerable reluctance to accept GM crops, particularly in certain countries, *e.g.* Denmark, Austria and Switzerland; Belgium, the United Kingdom and France are prepared to consider them, provided appropriate supervision is in place.

Why is Opposition to GM Crops So Heated?

It is clear that the reasons for the fuss must be addressed by farmers who adopt the technology with the intention ultimately of selling their produce. Consumers' perceptions are vital. The scientists may make and use the constructs, identify potential hazards and, with the regulators, assess risks and suggest appropriate management strategies, but they are often not well disposed to empathize with the perceived risks held by various sectors of the general public. This brings me to concerns I have observed in the debate about GM crops destined for the food supply. But, first I want to talk about risk and various ideas related to it.

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Risk Analysis, Acceptable Risk, Perceived Risk, Managing Risk

For me, risk analysis is the combination of some identified hazard or harm and the probability that that harm will come to pass. This is linked to considerations of the seriousness of the identified harm. Risk management follows from the information just listed, as it leads to devising ways to eliminate, minimize, or control serious harm. I believe we should not use the concept of acceptable risk, as it immediately raises unanswerable questions:

- Acceptable to whom?
- Who decides what that level of risk will be?

The concept is value-laden and, accordingly, the level of risk chosen tends towards zero, as the only acceptable risk. This fails to recognize that effort spent in risk reduction may be misapplied if, to be acceptable, risk must be zero or close to it. Effort in risk reduction is best spent after comparing the seriousness of the identified risks associated with an activity, and then putting effort into reducing the most serious—in other words, *managing the risk* in a cost-effective fashion.

When risk assessment of gene technology began in the 1970s, it was very much the autonomous domain of science and technology. Science methodology was applied to identifying hazards and quantifying risk. Social implications received scant attention, and the scientific and social sectors of the community engaged in name-calling; this fueled mistrust of science among the general public and a dismissive “irresponsible” label was applied by scientists.

From 1980 onwards, attitudes changed, and it is more widely appreciated that science and technology are also socially constructed and must interact with the public, companies, and farmers. Scientists must recognize that there are issues unrelated to science that are very significant to some sectors of the community that ultimately will buy (or not buy) GM products depending on whether they feel comfortable and consulted about the process of surveillance and regulation. The way in which surveillance and regulation was established made those with concerns for social issues feel powerless. Scientists and regulators must recognize that the resulting stand-off is counter-productive, and take time to meet with the stakeholders and explain in plain terms the process of surveillance and risk assessment, how it works, and how a reasonable accommodation can be reached between differing positions.

Concerns About GM Agricultural Crops

It may be helpful to recognize the types of concerns held by the community. They can be placed in two broad classes. One consists of concerns stemming from personal beliefs, moral values, religious convictions, lifestyle preference, and method of food production, or from socio-economic concerns about multinational companies that own the patents on many of the genes and processes, and make the chemicals associated with the use of some of them, for example GM plants with herbicide resistance. Others simply do not trust scientists. It is important to note that these concerns are not connected with any risk of the GM crop to the worker, the farmer or the environment, nor with claims of efficacy. The other class of concerns relates to hazards identified as possible outcomes from growing the GM organism.

It is not acceptable for GM advocates to dismiss the first class of concerns as inconsequential, any more than it is appropriate for GM opponents to deny others access to a technology that they perceive as beneficial. It is a dangerous path to develop regulations based on the religious beliefs or lifestyle preferences of particular sectors of the community. It is, however, possible to offer choice. In the case of GM foods and food ingredients, labeling will give those who do not wish to eat such foods the option to avoid them. Moral, religious or ethnic issues cannot be readily addressed by legislation, but those who oppose GM technology on these grounds must be prepared to accept the differing views of others. Similarly, with small-scale cottage agriculture/organic farming, those advocating these methods must recognize the escalating demands for food from the world's increasing population, and by populations currently undernourished. This requires us to be responsible in adopting every tool at our disposal to increase productivity, reduce predators in crops, competition from weeds, disease infestation and post-harvest losses. We know that the planet has no new land suitable for agriculture, but gene technology may enable marginal land to become productive by designing plants to tolerate high salinity, or with the ability to complete their life cycle in areas with a very short growing season. One could ask whether it is ethical to deny such possibilities.

Addressing Identified Hazards

Scientists must be seen to address honestly any hazards that might be associated with transgenic plants. A list of some of these follows:

- Crop plants might become weeds.
- Herbicide-resistance genes might pass to related weeds.
- Growing herbicide-resistant crops might result in greater use of herbicides.
- Plants carrying genes for a pesticide could result in insects becoming resistant more rapidly because of continuous selective pressure.
- Genes for pesticides could pass to weeds and encourage their growth, since they would not then be eaten by pests.
- Transgenic plants may cross with free-living relatives and thus contaminate the gene pool.
- The novel gene could cause the plant to produce a toxin, carcinogen, teratogen, or allergen.
- Transgenic plants could be inferior nutritionally, less digestible, or have inferior processing properties.
- A crop-plant resistant to one herbicide may acquire resistance genes for other herbicides from other crops. Such multiply resistant plants would become difficult to control in farming rotations.

Whether these hazards will materialize must be considered case by case. The growth habit and genetics of crop plants are, in most cases, well known, the gene being introduced and its product are fully characterized, and the properties of the donor organism also are known. If the host and donor organism have a long history of safe use, it is highly unlikely that the transgenic will exhibit injurious or unwanted properties. Nevertheless, pre-commercial trials offer every opportunity for such possibilities to be detected; such trials are usually conducted at multiple sites over 5 to 7 years. Problems of gene introgression can arise from outcrossing either to other crop plants or to weedy relatives. Canola is such a crop, whereas peas, clover, wheat, barley, *etc*., are essentially self-fertile, and present a less serious problem. Plants like cotton that are polyploid, are restricted by ploidy and type of genome from crossing with native *Gossypium* relatives. To manage gene escape in canola trials in Australia, for example, we require 15-m buffer rows of non-transgenic canola to be planted, and a 50-m zone to be rogued free of *Brassica* species and related weeds. During flowering, a 400-m zone is maintained free of *Brassica* species. Post trial, volunteer transgenic and weedy relatives are removed from the trial site, buffer rows, and the 50-m zone for three seasons. The area may be planted to pasture or cereals.

This management plan does not guarantee zero risk of pollen escape, but the likelihood is greatly reduced, and the hazard (a weed or canola plant becoming herbicide resistant) can be managed using a herbicide with a different mode of action.

To reduce the possibility that insects may become resistant to Bt, refuge areas of non-Bt cotton or sacrificial crops like maize are incorporated to allow a ready source of fully sensitive moths to mate with those that have acquired one copy of a recessive resistance gene. This strategy slows the emergence of resistant insects, which must be homozygous recessive diploids. This strategy, combined with constant observation of the insect population and appropriate timing of the application of other pesticides will enable the usefulness of Bt crops to be prolonged.

Good Agricultural Practice

Whereas the pre-commercial stages in the development of transgenic crop plants are under government surveillance in most countries, the real test comes when large areas are planted commercially and government surveillance is less direct, or absent. In an endeavor to meet this situation in Australia, the agriculture department combined efforts with the genetic surveillance, science, and farming sectors to produce guidelines for good practice in the use of GM organisms on the farm. A set of issues was drawn up to be addressed by those breeding, using, growing, or selling GM organisms, as well as consumer and environmental groups. It was recognized that diversity of crops/animals, agricultural region, climate, topography, soil, etc. made uniform rules impossible. Rather, the plan is to have a workshop of interested parties in the region at the time of the first field trial to ensure that the right issues are addressed. When all of the field results are available and commercialization is imminent, a second workshop will be held with the purpose of developing a clear set of instructions for growers and consultants as to the best practices to adopt in managing the GM crop in various rotations, so as to extend the useful life of the GMO and ensure sustainability of the farm, acceptance by consumers, and preservation of environmental values. It will also set out the monitoring regime required to control any unwanted spread of the introduced gene. It is recommended that the seed seller make it a condition of sale and license that the grower adopt the good agricultural practices arising from the results of the trials and the workshop.

What's in it for the Consumer?

The GM plants grown so far are largely those that benefit farmers or large multinational companies (resistance to insect-predation, herbicides, virus or fungal diseases). Whereas the technology reduces costs of production, the consumer does not see a direct benefit, especially as GM foods are not substantially different from their conventional counterparts, and the price differential is nonexistent or very small. However, when a 10% price advantage applied, a well publicized GM tomato paste sold very readily in the United Kingdom. The other change that will attract consumers is a GM product that has a clear quality advantage: e.g. a tomato that tastes as they once did. Consumers will accept what benefits them personally, as is very clear from the ready acceptance of therapeutics made by gene technology.

I believe that agriculturalists must respond to this reality and direct their research towards quality attributes that consumers value. This will be more difficult to achieve than the single-gene changes that have been exploited so far, but unless the consumer sees the gain, agriculture will bear the pain.

In addition to direct benefits to consumers, GM agriculture results in a number of important gains for the environment and the sustainability of the farm, with reduction in wind and water erosion, reduced use of pesticides and highly persistent herbicides, and an environmentally preferable control of insect-born viral infections. These benefits appeal to many consumers and indeed are complementary to the objectives of organic farmers; they need to be highlighted in discussions with consumers. In response, consumers often invoke the precautionary principle and seek an absolute guarantee of no risk.

Risks We Live With

I found a chart prepared by an insurance company to be very instructive. It plotted the age of the population against the probability of death within the year. The likelihood of death simply by being alive, increases rapidly with age—the best expectancy is about 1 in 1,000 in our early teens, and from then on it is all downhill. What disasters will kill us? Being hit by lightning is about 1 in 2 million, death in the air or by drowning is similar at around 1 in 60,000, death in a car is 1 in 8,000 and from contaminated air 1 in 1,000. We just live with risks that are beyond our control, but other hazardous activities that could be avoided, like driving a car, are shrugged off equally nonchalantly. The perceived benefit far outweighs the risk represented by the toll on the roads each weekend. So what about the precautionary approach?

Precautionary Principle

It is critical that the concept is fully understood. It is not a prescription for achieving zero risk. According to a European Union document, applying the principle requires:

- objective assessment of hazards and their probability,
- consideration of management options, and
- consistency and transparency in data collection and assessment.

Then the option adopted must:

- relate to the seriousness of risk,
- include a cost-benefit analysis, both economic and social,
- indicate who is responsible for risk assessment, and
- be provisional, so that management can be revised in the light of new scientific data.

My plea to agriculturalists and the food industry is to develop GM commodities that will benefit consumers directly, and to ensure that the precautionary approach is adopted by GM breeders, farmers and food manufacturers, both during trials and when in large-scale production. It is also essential to label GM products so that consumers have choice.

Q: You presented information on best practices for release of GM plants and for their management after release. However, in Australia only one GM crop has been released. Are regulations there too cumbersome?

A: Only Bt cotton has gained acceptance. Roundup-Ready cotton is coming along and canola will probably follow. Wheat is a major crop, but it has not had a lot of GM work done on it, as yet. On the food side, the rules are if a food is known to have been made from GM material, you must label it as such. If an ingredient is of GM origin, the ingredient must be so labeled. If it is intended that the food is conventional, but has a small inadvertent contamination, you can have up to 1% without requiring a label. In the case of cotton-seed oil, because it is refined and, therefore, does not contain novel DNA or protein, it does not require a label. This is true also of sugar and starch.

Q: You suggested that before field trials would be held, that there be a workshop. It seems to me that, in this country, we get at that in a different way. We have a virtual workshop through the *Federal Register* or other public notices, which provide opportunities for public comment. Do you believe that the actual workshop interaction is essential, or is the virtual workshop through the *Federal Register* and the comment period, *etc.*, an acceptable substitute?

A: We use both. The *Government Gazette* is the vehicle in which notice is given of release of a live organism to the environment, and public comment is permitted. In addition, at the time of the workshop, we are trying to inform people “on the ground” what sorts of problems might arise.

Q: I have a comment and a question. You noted the tremendous potential value of genetic engineering in providing the food that will be needed for a more populous world. It is worth noting that, if the United States, Europe, Australia and certain other countries, stopped the production of grain-fed livestock, we would have a tremendously increased availability of food, which, for agencies concerned with food production that may be an approach worth investing in. (*Dr. Millis:* I couldn't agree more.) My question is with regard to labeling in Australia and New Zealand. What are food manufacturers saying about that? Will they market foods with genetically modified ingredients?

A: This is yet to be fully tested. I have spoken with CEOs of food companies who have said, "A drop of 5% of sales is critical to me—I won't touch it. I want 'GM-Free' on my label." Now, this is an interesting statement in that the 'GM-Free' on the label has to be fully documented such that it may be audited. Therefore, you could find yourself in trouble with that label if someone detects contamination with PCR.

Q: In this country it seems that companies are afraid of marketing foods with that label. In Australia, they don't have to say 'GM-Free,' they can just say nothing. Do you think that is the approach that food companies will take?

A: Yes, I do. And there will be a price differential, I suspect. I cannot imagine a situation where the company pays but the consumer doesn't.

Q: But, will the companies actually market that alternative line with the GM label?

A: I don't know. But, I have the same feeling as you that they are suspicious of declaring 'this is GM.'