Biotechnology takes off: American agriculture takes the plunge

Critics charge several important issues about biotechnology and transgenic food have barely been raised, let alone given serious consideration. Karen Charman reports from the U.S.

This northern hemisphere spring, farmers have been planting hundreds of thousands of acres with bio-engineered insect-resistant corn, cotton and potatoes that are commercially available for the first time. Tractors have also been rolling across farms throughout the Midwest sowing the first commercial transgenic soybeans, engineered with a petunia gene for resistance to Monsanto's herbicide, Round Up.

Though this initial commercial planting is only a fraction of the total acreage for these crops - well over 100 million acres - the U.S. Department of Agriculture (USDA) expects adoption of genetically engineered crops to mushroom in the next 10 years. "By early in the next decade, literally everything will have some engineering in it," says Arnold Foudin, deputy director of the Biotechnology, Biologies and Environmental Protection Division within the department's Animal and Plant Health Inspection Service.

So far, however, the fruits of ag biotech have been disappointing. Expectations were very high when a lot of the biotech companies went public back in the late 1980s, says George Dahlman, a food industry analyst at Piper Jaffray, an investment firm in Minneapolis. "People thought products were just around the corner - this was back in 1989-1990. But pretty soon it was 1991, then 1992, and then 1993," he says. The first ag biotech offering, Calgene's FlavR SavR tomato, did not make it to market until 1994.

The FlavR SavR was an attempt to recover the taste of backyard, vine-ripened tomatoes. That archetypal taste of summer has been sacrificed in commercial varieties for traits and production practices enhancing durability so the fruit can withstand the rigours of large-scale distribution.

Calgene scientists inserted a gene to slow ripening and enable the tomatoes to stay on the vine longer to develop more flavour. But the FlavR SavR ran into trouble early on because the gene did not work as anticipated; FlavR SavRs that were supposed to arrive in supermarkets hard but ripe came in soft, ripe, bruised and broken. After significant losses due to damage, the FlavR SavR virtually disappeared from supermarket bins while Calgene replaced its tomato distribution system with peach handling equipment.

Several sources note Calgene has yet to come up with the right tomato variety for its delayed ripening gene. Dahlman adds that the FlavR SavR has simply failed to distinguish itself enough from conventional tomatoes.

Recombinant bovine somatotropin (rbST), the genetically engineered hormone injected into dairy cows to increase milk production, has also been beset with problems from the outset. Continuing controversy over unanswered questions about the safety of milk from cows treated with the hormone for human consumption has discouraged some farmers and dairy companies from using the drug. Much more significant to the potential users of the product, however, are numerous reports of adverse reactions in the cows - from deaths and an increase in spontaneous abortions to higher rates of udder infections, which are already rampant in American commercial dairy herds. The word circulating out in the dairy shed is that the extra expense and hassles with rbST is not worth the potential 15 percent increase in milk yields.

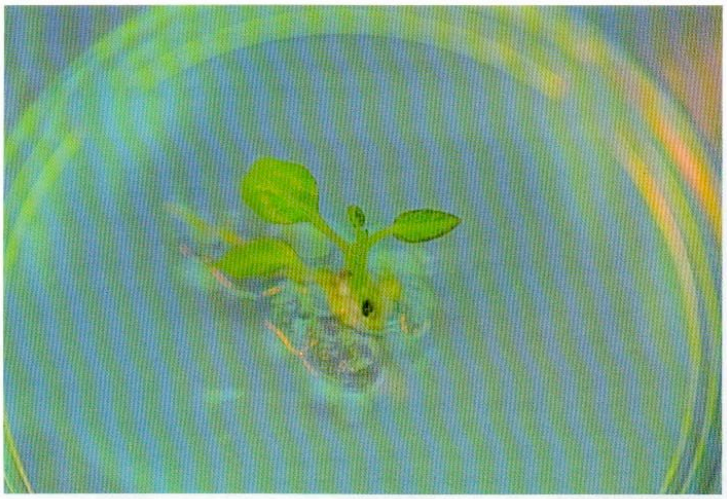
But this year is likely to mark a change in the fortunes of the ag biotech sector.

The industry is most excited about the commercial release of corn, cotton and potatoes modified to include genetic material from Bacillus thuringiensis (Bt). Bt is a naturally occurring soil bacterium that kills a range of leaf-eating caterpillar insects, including the European corn borer, the cotton bollworm, and the Colorado potato beetle, each the most destructive pest for its respective crop in the U.S. The European corn borer alone is estimated to cost American corn growers US$1 billion a year, and it has been known to devour up to a third of a heavily infested field.

Bt has been used by organic farmers for about 40 years as a highly effective, specific and environmentally benign biological control. Therefore, the use of Bt by biotechnologists appears to fulfil what has been an important selling point for the technology: to provide farmers with plants that require fewer, or, ideally, no pesticides.

Dahlman says the Bt crops have generated a lot of enthusiasm in the market over the last year as they have come through the approval process and investors have caught on to their market potential. Delta Pine and Land Co., the world's largest producer of cotton seed and the marketer of Monsanto's Bt cotton, has seen its share prices soar in the last year. During the same period, the share price of Dekalb Genetics, another seed company working with Monsanto on genetically engineered corn and soybean seeds, nearly doubled. Several other seed companies are also flourishing.

Underwriting this new-found success are billions of dollars of investment into ag biotech by deep-pocketed multinational chemical and pharmaceutical conglomerates. Besides Monsanto, they include DePont, W.R. Grace, Ciba-Geigy, Rhone-Poulenc and Eli Lilly. The biotechnology sector as a whole is consolidating as these larger companies either buy smaller biotech concerns outright or increase their ownership in them. Most observers agree the presence of the multinationals signals the beginning of a new, profitable era in agricultural biotechnology.



It is clear that genetically modified plants are set to become a common component of agriculture throughout the world.

Food for debate

Despite biotech proponents' laments about misconceptions and allegations that public resistance has slowed the use of biotechnology in agriculture, there never has been any real debate over whether the technology would be adopted. The U.S. government, urged on by the biotechnology industry, has deemed genetic engineering no different from conventional breeding. As a result, the government is not requiring genetically engineered food to be labelled, so the technology will seep into the food supply with little, if any, opposition.

Those calling for more information and real debate about changing our food supply maintain that taking a gene from one species and putting it into a completely unrelated species is, however, quite different from what conventional breeders have previously been able to do. "With genetic engineering, you can escape the natural boundaries of breeding and introduce things like bacterial genes to crops, which you couldn't do with traditional breeding techniques," says Rebecca Goldburg, a biologist with the Environmental Defense Fund. "And that is the real power of genetic engineering."

Fred Kirschenmann, a large-scale organic farmer and one of the leaders of the American sustainable agriculture movement, adds that this new ability to radically alter life forms cannot be dismissed as another step in a continuum of technological development. "It is a power of a different order from anything humans have heretofore experienced," he says.

It is worth noting that biotech companies are very clear about the differences between conventionally bred agricultural products and their genetically engineered counterparts; most are charging an additional licensing fee. Monsanto sees genetically engineered seedstock as intellectual property that it owns in perpetuity, unlike conventional seed that can be bought outright by the farmer. Besides charging farmers a US$32 per acre licensing fee for its Bt cotton, the company requires a signed contract that stipulates any seed not planted this season must be returned to the company. "It's a whole new mentality, like leasing a car," says Monsanto environmental communications director Gary Barton. "Just because you make payments on your leased Lexus doesn't mean you own it at the end of the leasing period."

Purchase and ownership issues aside, Kirschenmann argues we have a poor record of predicting the side-effects of human technologies that attempt to control nature. Conventional agriculture, a technology that seeks to maximise the production of uniform produce by altering the growing environment with synthetic fertilisers, pesticides, large machinery and irrigation, provides a prime example. If monoculture and synthetic agrichemicals worked so well, we wouldn't now be looking to biotechnology to solve or reduce problems

like insect and disease resistance and agrichemical pollution that have resulted from that approach. Because we can't and don't know what impact the new life forms that biotechnology enables us to create will have in the environment, he urges caution in adopting it.

Building better vegies?

An important selling point for ag biotech today is the promise to boost the nutritional content of foods. One such project is taking place at Texas and A&M University where plant breeders have developed an enhanced transgenic beta-carotene carrot. Beta-carotene has been shown to avert damage by disease-causing free radicals, substances generated by the body as a by-product of metabolism. Free radicals promote ageing and have also been implicated in an array of chronic diseases including cancer, heart disease, Alzheimer's and multiple sclerosis, among others. Attempts at engineering foods with higher levels of nutrients and protective substances are now occurring in labs across the country.

Kate Clancy, a professor of human nutrition at Syracuse University, points out that there are huge gaps in the knowledge about how nutrients and other compounds in food are processed in the human body to ensure its optimal functioning. Nor, she says, is it known what proportion of whole foods to manufactured synthetic foodstuffs is needed in a person's diet to keep the body healthy, even though it is known that the only way to guarantee a healthy diet is to eat mainly whole, unrefined foods.

In the last decade, Clancy explains, nutritionists have begun to discover all sorts of compounds in foods. These compounds are not defined as nutrients per se, but they may have beneficial effects on the body. Clancy points to carotenoids, which includes beta-carotene, as an example. Of the 300 to 500 different carotenoids that have been identified, she says nutritionists know a lot about four of them.

"We have a pretty good idea that a lot of these compounds act either synergistically or in tandem. But we have virtually no knowledge of what happens when you take one of these out, isolate it, and feed it to people." What this means, she says, is that by adding and subtracting single genes, biotechnologists may inadvertently damage the nutritional quality of whole foods.

A more specific and widely discussed health concern about genetically engineered foods is their potential for causing allergic reactions in people. True food allergies involve abnormal immune system responses. Compared to food intolerances and other adverse reactions, they are relatively rare, affecting an estimated one to two percent of the U.S. population. If that rate is true for New Zealand, that would be between 35,000 and 70,000 people. Reactions range from mild discomfort to life-threatening anaphylactic shock which begins immediately with exposure to minute amounts of the offending substance.

Fish, shellfish, milk, soybeans, nuts, wheat and gluten are the most common foods that cause allergies in the U.S., though the total list is much larger. Since nearly all known food allergens are proteins and genes are expressed as proteins, concerns have been raised about introducing new proteins into foods that have never been in the food supply. According to an article in The Gene Exchange, a newsletter on biotechnology and agriculture put out by the non-profit public advocacy group, Union of Concerned Scientists, scientists cannot predict in advance whether a particular protein will be allergenic, because there is no shared characteristic that all allergens have.

People with the most common food allergies are likely to be protected, says Environmental Defense Fund scientist Rebecca Goldburg, because the liability for introducing a known but unlabelled allergen into an unrelated food product would be huge. Earlier this year, for example, Pioneer Hi-Bred International dropped a soybean modified with Brazil nut genes to boost levels of the amino acid, methionine, after tests showed the allergic proteins of the Brazil nuts transferred through to the altered soybeans. "However, less common allergies or proteins that we put into food from non-food sources that turn out to be allergenic - that is where the big problems are going to be," she predicts.

Arnold Foudin of the USDA disagrees that transgenic food will endanger people with food allergies, something he characterises as "a significant world-wide health problem." Instead, he predicts scientists will figure out how to remove allergenic proteins so that sufferers will, for the first time, be able to eat food their bodies now reject.

In the meantime, the regulatory system for bioengineered foods is operating on an honour system of sorts, where companies notify the U.S. Food and Drug Administration (FDA) of any potential safety or regulatory issues. There appears to be little enthusiasm within the government to require transgenic food safety regulations, and in fact, the whole regulatory process regarding agricultural biotechnology is moving in the opposite direction.

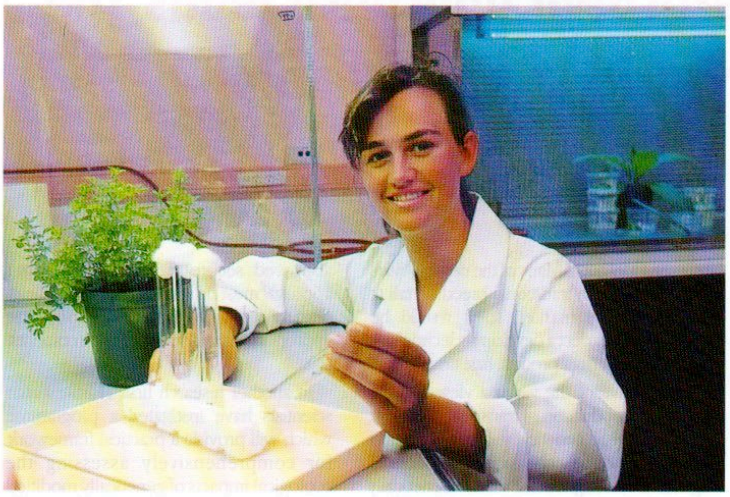
In the name of simplifying regulatory procedures, late last year the USDA proposed new rules that would deregulate nearly all releases of genetically engineered plants in the U.S. Instead of requiring researchers to obtain a permit that includes abiding by certain performance standards, the USDA is proposing that those conducting field trials notify the department. Permits would still be required for plants listed in the federal noxious weed register, those considered a weed in the area where the field trial is to be conducted, parasitic plants, and trials where certain viral genes or genes to make pharmaceutical products are being used.

Environmentalists and scientists like Goldburg and Margaret Mellon, a molecular biologist with the Union of Concerned Scientists, worry that such uncontrolled and widespread movement of genetically engineered organisms out into the environment will enable many transgenics to transfer their acquired traits to wild plants where they are not wanted. The phenomenon is called outcrossing, and it occurs naturally as the wind carries pollen from one plant to another.

If outcrossing of, say, genetically engineered herbicide resistance - one of the main uses of ag biotech to date - were to occur, critics say a weed of minor annoyance might turn into a super weed, or a plant that was not a problem now might become a weed. In her written comments to the USDA's proposed rules, Goldburg describes outcrossing as "arguably the most troubling and scientifically well-demonstrated ecological risk of genetically engineering plants."

Goldburg calls deregulating the release of transgenic plants premature because the decision is based on short-term experience with a narrow range of heavily domesticated crop plants that are unlikely to be hardy survivors or reproducers in

HortResearch scientists have initiated a programme which will provide a practical framework for comprehensively assessing the ecological impacts of genetically modified plants before *release.*



the wild. A much wider variety of genetically engineered plants is likely to be tested in fields in the future, and, she warns, plants, such as forest trees and native perennials intended for landscaping, may pose far greater gene transfer risks.

In the New Zealand context, gorse, possums and rabbits - none of which are genetically engineered - provide poignant reminders of the trouble introduced species can cause.

Arnold Foudin says the phenomenon of outcrossing is nothing new, and he doesn't see any particular risk with genetically engineered crops. "The process is very well understood - sex happens. We've known through plain old Mendelian genetics that sexually compatible plants do cross - wow!" He dismisses concerns about outcrossing as paranoia and is confident that USDA and those working with transgenic crops will be able to control it .

Bt brouhaha

Bt, the natural insecticide that has prompted the long-awaited market enthusiasm for ag biotech products, has stirred up another controversy. While ag biotech critics say the goal of producing crops that need less chemicals is laudable, they contend spreading Bt over millions of acres will inevitably lead to resistant strains of the pests it kills, rendering the substance useless. Besides potatoes, corn and cotton, Bt is effective on several pests that attack tomatoes and a wide range of fruit trees, including apple and peach.

Organic farmers would be the biggest losers with Bt resistance. "As far as a single application, broad use product, Bt is probably the most important tool organic farmers have," says Bill Wolf, an organic farming and food manufacturing consultant based in Virginia. The impending widespread use of genetically engineered Bt has sparked so much outrage in the organic community that in April the USDA organised a conference with industry representatives, scientists and organic farmers to discuss it.

Fred Kirschenmann, one of the panellists at the conference, says he was shocked to discover a "virtually unanimous" belief among scientists there that resistance to Bt would develop as a result of the transgenic application. "It was not a case of if, but a case of when," he said. "And the speed with which resistance will develop - they are talking about a three to ten year window - is entirely contingent upon the effectiveness of the resistance management plans that are adopted."

The companies selling transgenic Bt seeds are also concerned about resistance; they have invested hundreds of millions of dollars developing their products and are not keen to see that money wasted. However, they are not waiting until resistance management plans are worked out before putting Bt seed on the market. Writing in the journal of the National Biological Impact Assessment Program on Ciba Seed's resistance management strategy, the company's regulatory affairs manager Jeffrey Stein, admits specific strategies have not yet been developed.

The strategy of refugia, setting aside a certain proportion of a farm or field where Bt seeds will not be used, is currently getting the most attention. The theory is pests in those areas won't be exposed to the Bt toxin and therefore won't develop resistance. They will mate with the pests exposed to the transgenic Bt, which are expected to become resistant, but the mixing of the two strains will delay it. Farmers will continue to use insecticides to control the pests on the non-Bt acres. Though most advisors recommend an area equivalent to 25 percent of the land planted with transgenic Bt crops for refugia, that amount - or any other - has not been validated by field data.

Stein, along with several other ag biotech proponents, is confident that biotechnologists will be able to stay ahead of the resistance problem by isolating and using new Bt proteins. The USDA's Arnold Foudin says there are more than 1100 Bt genes in the department's Agricultural Research Service collection, and private companies have several thousand more. He is confident biotechnologists will be able to use this vast resource to come up with strategies like gene stacking, engineering several different traits to deal with a problem, that will prove fail-safe. "I think they are going to have a lot more success with that than management mechanisms like refugia," he says. "That's a good way when you don't know what you're doing. If you know what you're doing, there are probably going to be molecular ways of beating it."

Like everything else about this technology, it remains to be seen.