Will the second generation of genetically modified crops be more accepted?

A series of review articles in a special issue of *Nature* published in early May tackled a range of issues thrown up by current experience in the production of GM crops, how the science is presented and what the prospects are for the future. Author of the David Cressey took a look at the opportunities that may come about with the new generation of crops and how they may prove more acceptable to consumers and to governments in countries where hitherto there has been a reluctance to accept the technology (*Nature* 497 27-29 (02 May 2013)).

Anastasia Bodnar is a biotechnologist with Biology Fortified, a non-profit GM advocacy organisation based in Middleton, Wisconsin. She repeats the widely quoted message that, so far, the advances have been almost invisible to ordinary consumers. At worst, they have helped to fuel the rage of opponents of genetic modification who see power and profits concentrated in the hands of a few large corporations.

Cressey’s review concludes that a new generation of GM crops now emerging will offer more benefits to the consumer such as apples that do not readily discolour, *Golden Rice* and bright-orange bananas fortified with nutrients. Some next generation crops will put to use advanced genetic manipulation techniques that allow highly precise alteration of the plant’s own genome. Without needing to modify commercial crops with genes imported from other species, a practice responsible for much of the public concern, their acceptability might be that much easier.

Reassuring a sceptical public will not be easy, whatever benefits the crops offer. Philip Bereano, from the University of Washington, Seattle studies the political and social aspects of new technologies. He considers that the arguments over GM organisms are quite diverse ranging from concerns about safety and labelling to ethical issues with the patenting of life. As people are concerned about what they are feeding their children these entrenched attitudes will not change readily.

Nonetheless, according to the *Nature* article most plant biotechnology researchers seem convinced that the worst of the technology’s problems are over. The developments in the pipeline are quite diverse. Some have been described in previous *Crop Scene* features.

Benefits for the farmer

As we all know the first wave of GM crops have been marketed to farmers, with the goal of making their jobs easier, more productive and more profitable. Farmers will continue to be a core market for the coming generation of GM organisms. For example the GM wheat under evaluation at Rothamsted Research, where an introduced 'alarm pheromone' is targeted to drive away aphids, will potentially rule out the need for insecticide application.
Herve Vanderschuren at the Swiss Federal Institute of Technology in Zurich leads a team working on cassava (*Manihot esculenta*) the tuber from which is a staple food in the developing world. Vanderschuren and his team are genetically engineering cassava to be resistant to two particularly damaging viruses. They started with a variety that is naturally resistant to cassava mosaic virus and then inserted genes that confer resistance to cassava brown streak virus. The naturally resistant strain was already tailored to local needs and markets. Vanderschuren considers that this kind of local adaptation is very important as it is rarely embraced by the global agribusinesses. They have successfully produced GM cassava plants and are now collaborating with colleagues in Africa to prove that they can be grown in the field.

**Enhanced nutrition**

Much of the work on crops in developing nations is geared towards nutritional enhancement. The most widely publicised example is *Golden Rice*, so called because of its distinct yellow colour which is brought about by the addition of β-carotene. This is a precursor to vitamin A which is deficient in many East Asian diets. The original version of *Golden Rice* was announced in 2000 but after many objections it is only now undergoing field trials in the Philippines where it could reach the market in 2014.

At the Centre for Tropical Crops and Biocommodities at Queensland University of Technology in Brisbane, James Dale, the centre’s director is aiming develop bananas with resistance to the economically important fungal Panama disease. He is also aiming to introduce increased β-carotene levels as well as other nutrients including iron. James Dale explained that: "Levels of micronutrient deficiencies are really very high" in Uganda and all across Africa where bananas are a staple food. Field trials have already been conducted in Australia.

![Fortified Bananas (reproduced from Nature)](image)

**Helping food processors**

Some next-generation GM organisms can benefit the next step in the food chain, the industrial food processors. Chris Dardick, a molecular plant biologist at the US Agricultural Research Service’s Appalachian Fruit Research Station in Kearneysville, West Virginia, was reported to be looking at the development of a stoneless plum. It is generally difficult to get plums into processed foods, because removing their hard, woody cores leaves shards behind. But starting with genes from a mostly stoneless, conventionally bred plum, Dardick and his team are in the early stages of engineering a fruit with no stone at all. He recognises that there could be
resistance from the industry and from consumers. To date, however, he reports that feedback has been quite positive.

The Arctic Apple is potentially of interest to both the processor and the consumer. This type of apple does not brown rapidly after it is cut or bitten into. The effect is achieved by the insertion of genes from other apple varieties that produce lower than usual levels of polyphenol oxidase, a key enzyme in the series of biochemical events that induce browning.

The Arctic Apple has been developed by Okanagan Specialty Fruits in Summerland, British Columbia. Neal Carter, president of the company expressed concern that apple consumption is in decline. He believes that apples are losing ground in the supermarket to carrots and other fresh produce that is sold in bags, cleaned, sliced and ready to eat. So apples that could be processed in such a way without browning could be a real boon for the industry. According to Neal Carter if the apples are received well, Arctic avocados, pears and even lettuce could be next.

Advanced techniques

New techniques to achieve genetic modification offer much better precision than the gene-gun approach. Enzymes called transcription activator-like effector nuclease (TALENs) and zinc-finger nucleases (ZFNs) can cut DNA at specific points selected by the researcher. According to Dan Voytas, University of Minnesota in St Paul, by controlling how this break is repaired, it is possible to introduce mutations, single-nucleotide changes or even whole genes at precise sites. Voytas was quoted: “We can do precise insertion so we know where in the chromosome the foreign gene resides.” By being able to insert the new gene in a spot in the genome where its expression is optimal it reduces the risk of disrupting the plant’s genome in undesirable ways.

Using these techniques Voytas’s group have successfully used ZFNs to introduce herbicide resistance into tobacco plants. Other groups have been reported to induce herbicide resistance into maize, and using TALENs it has proved possible take out the rice gene that confers susceptibility to bacterial blight.

Voytas believes that the real benefit from such techniques lies in the ability to confer new traits by modifying native plant genes, rather than introducing genes from other organisms such as bacteria. Induced drought resistance is a realistic objective using these techniques.

Derek Jantz, is co-founder of Precision BioSciences, a biotechnology company based in Durham, North Carolina. He is also positive on the applications from the use of a plant’s own genes. It should be possible to create similar Roundup Ready crops by editing a plant’s own version, rather than bringing in an external gene. Without disclosing details Jantz was reported: “What we are trying to do is take advantage of the wealth of functional genomics data that is becoming available.”
Accelerated plant breeding

The *Nature* review also cited examples of how some researchers are using genetic modification to accelerate conventional breeding techniques. Ralph Scorza, from the Appalachian Fruit Research Station, leads a team working on the breeding of plum trees.

By inserting a gene from polar trees the modified plum trees flower early in their life cycle than conventional varieties and then continue to flower. This means that researchers can breed the trees throughout the year, using selection, cross-breeding and other traditional techniques to develop traits such as disease resistance in just a few years. Normally it could take a decade or more. Also once the desired traits have been bred in, the transgenes that drive flowering can be bred out, leaving a modified but non-GM plant. Scorza and his colleagues are using this breeding strategy in an effort to generate resistance to the plum pox virus, and to increase the sugar content of the fruit. Researchers elsewhere are applying it to other tree crops such as citrus.

The future is now

Early indications from the US regulatory authorities suggest that organisms modified with the newer techniques so that they do not contain DNA from other species will be treated differently from conventional GM organisms. A different approach from regulators may help to reduce public concerns.

Anastasia Bodnar commented that when GM crops first arrived we were promised "... futuristic, ultra-nutritious crops that would bring exotic produce to the supermarket and help to feed a hungry world." She believes the future is now bright and the new era is "happening now".