Is South Africa ready for genetically MODIFIED potatoes?

Michele Cloete, Graham Thompson and Muffy Koch, ARC-Roodeplaat

Transgenic applications involving potatoes

The first genetic modifications of potatoes were to give them characteristics that benefited the farmers by helping them with production. One of the biggest problems experienced world-wide by potato farmers is virus infection. Another common problem is insect damage, especially by potato tuber moth (PTM). In South Africa the annual yield losses associated with PTM is estimated to be R40 million. Scientists have found genes to help with both of these problems.

It has long been known that a mild strain of a virus can prevent the infection of the plant it occurs in by another more virulent strain of the same virus. The first applications of biotechnology was based on this principle whereby the coat protein gene of the virus was inserted into the plants genome. This simple bit of deception now protects GM potatoes from potato virus X and Y and potato leaf roll virus, with the potential to save farmers millions of rands. In South Africa the major virus problems are associated with PVY, PLRV and tomato spotted wilt virus. GM potatoes resistant to PVY and PLRV have been approved for general use in the USA and Canada.

The potato tuber moth is controlled with a gene from a common soil bacterium, called the Bt gene. This gene makes a protein that gives potato tuber moth caterpillars indigestion and will kill them if they continue to eat it. However, the protein, called Bt, is only toxic to the larvae of the family Lepidoptera and not to any other insect or animal, including man. This modification has been

Historical perspective of Genetically Modified Organisms (GMOs)

Since the first genetically modified plants were described almost 20 years ago, and the first Genetically Modified (GM) crops commercialised in 1996, the global production of GM crops has increased to 52.6 million acres planted globally in 2001. This was an increase of 19% from 2000. The growth in the six year period between 1996 and 2001 was more than 30-fold. Current commercialised transgenic crops have either one of two traits, namely herbicide tolerance or insect resistance. Herbicide tolerance is against Roundup, and insect resistance is the *Bacillus thuringiensis (Bt)* protein, which has a very narrow host range, and is specific for the *Lepidoptera.* International experts have extensively studied biotechnology crops over the past three years, and they have concluded that the current biotechnology products are as safe as conventional foods. These include reports from: the World Health Organization, Food and Agricultural Organization, seven National Academies of Sciences, US National Academy of Science, American Medical Association, Organization for Economic Coordination and Development and the European Commission.

approved for general use in the United States and in Canada and was very effective at protecting potatoes up until there was an activist outcry against the technology. At this point farmers stopped growing the GM potatoes because food processors would not use them for fear of Greenpeace and activist attacks.

GM potatoes with higher starch content, or larger tuber size have also been developed. In addition, GM potatoes containing high value proteins have also been developed. Transgenic potatoes containing the protective gene against the enteric bacteria *Escherichia coli* were able to elicit antibody responses in human volunteers in the USA. However, none of these GM potatoes have been commercialised.

Research on Genetically Modified Potatoes in South Africa

ARC-Roodeplaat Vegetable and Ornamental Plant Institute (VOPI) has been involved in the development of transgenic potato cultivars for resistance to potato leafroll virus (PLRV) and PVY, as well as drought tolerance. Three potato cultivars that are important to the local potato industry transformed the PLRV and PVY coat protein genes to confer coat protein mediated resistance to these viruses. Glasshouse trials with the transgenic lines containing the PLRV gene showed significant reduction of the virus titers in all the lines tested, in comparison with the infected untransformed controls. During the field testing of transgenic potato lines for resistance to PLRV in 1997, some lines showed less symptoms and reduced virus titers to the controls, but no immunity to PLRV was obtained. This was the first glasshouse trial and field test of transgenic potatoes in South Africa. Glasshouse trials of transgenic potato lines of the cultivar BP1 containing the PVY coat protein gene yielded one line that showed reduced virus titer and symptoms, but it was not immune to PVY. The potato cultivar Aviva, was transformed with the CuZn Superoxide dismutase (SOD) gene, isolated from *Arabidopsis thaliana*, for increased drought tolerance. Glasshouse trials showed that the transformed potato lines were more drought tolerant than the untransformed plants.

Field trials have also been conducted with transgenic potatoes for resistance to potato tuber moth (PTM). First Potato Dynamics carried out field trials in the Ceres district in the Western Cape in the summer season of 1999/2000 on behalf of the Israel Biotechnology company Vitality Biotechnologies. Vitality developed genetically modified potato lines of the cultivars Desiree, Lady Rosetta, O'Maya and Shepody that contained a Bt cry gene for resistance to PTM. All the transgenic lines were 100% protected from potato tuber moth damage, in comparison to the non-transformed lines that all showed PTM damage. ARC-Roodeplaat , in collaboration with Michigan State University and the Agricultural Biotechnology Support Project, carried out a field trial in the summer season of 2000/2001 with transgenic Spunta lines containing the Bt cry V gene. All the transgenic lines were protected from PTM. In a "free choice" tuber test only the non-transformed tubers showed PTM feeding damage, whereas the tubers from all the transgenic lines showed no damage. A follow-up field trial is planned for the following summer season.

Acceptance of GMOs in the world

While there is rapid adoption of the technology throughout the world in both medical and agricultural sectors, there is still some activism against GMOs originating mainly from Europe and environmental activist groups. This opposition was initially a concern for safety, but as these safety concerns are well covered in international and national GM regulations, the opposition has turned primarily to socio-economic impact concerns. Certainly not all applications are of immediate relevance to the developing world. However, those that are, have proved to benefit socio-economics, the environment and food security in farming communities that are able to test and adopt modifications that they have found to be effective and safe.

Countries like the Phillipines and Japan have had extensive public awareness programmes to inform the public about the benefits of GMOs before the first GMOs

Benefits to consumers

The benefit of the current commercialised transgenic crops for the producers is that they were sprayed with less harmful herbicide or insecticide than their conventional counterparts. An additional benefit of insect tolerant maize is that they also contain reduced levels of the toxin fumonosin, which is produced by the fungal pathogen *Fusarium monoliforme.* The cobs of insect tolerance maize plants do not have insect feeding damage, and are thus less susceptible to infestation by *Fusarium spp.*

It has been estimated that globally the use of GM soybean, oil seed rape, cotton and maize varieties modified for herbicide tolerance and insect protected GM varieties of cotton reduced pesticide use by a total of 22,3 million kg of formulated product in the year 2000. An estimated decrease of 14.5 million kg formulated pesticides (4,4 million kg active ingredient) would be used in Europe if 50% of the maize, oil seed rape, sugar beet and cotton grown was GM. As less spraying would be done, 20.5 million litres of diesel would be used resulting in a reduction of 73 000 tonnes of carbon dioxide being released into the atmosphere. The real environmental benefits of biotech crops are now only being established.

Plants are now being utilised as inexpensive production units for the production of industrial enzymes and antibodies as well as edible vaccines. These products will make vaccines available that are more affordable to developing countries.

were commercially available.

Situational analysis in South Africa and Africa

The Genetically Modified Organisms Act, 1997 (Act No 15 of 1997) was promulgated in 1997, and is administered by the Directorate: Genetic Resources in the National Department of Agriculture. All facilities that work with GMOs must be registered at the Directorate: Genetic Resources. Applications are filed at the Directorate: Genetic Resources to carry out contained use experiments, field trials, general release, import, and export of GMOs. Each application is reviewed on a case-by-case basis. It calls for an independent scientific review of the safety of the activity and for public input into all decision-making regarding GMOs. It also allows for assessment of the socio-economic impact of a GM product before a national decision is taken.

Before any GM crop can be considered for a general release the biosafety regulation requires extensive toxicity, allergenicity, and nutrient testing. The safety of each GMO is assessed separately. Remember that all technology comes with risk. Consider electricity, farming, cars, flying, etc. We do not call for a moratorium because there is risk; instead we regulate the risk to enable us to have access to the benefit. Where the risks do not justify the benefit, we just say 'no'.

Biosafety of GMOs falls into two areas: impact on food and feed safety and impact on the environment. In South Africa, an independent scientific body assesses all the biosafety issues related to each GMO in each release area and determines whether identified risks are acceptable or can be managed in a way that will lower their risk.

The Food Safety Testing is the most expensive part of the risk assessment procedure. In general, the costs of risk management are borne by the applicant. This is the most limiting factor to development of GMO's locally. One such example is fungal resistant strawberries that were developed in South Africa. Although all three of the genes that were used in these GM strawberries are common in regular foods, they have not been tested in the strawberries. Due to the high cost of the food safety testing, the plans to release these GM strawberries have been shelved indefinitely. The food safety testing is usually the most expensive part of the risk assessment testing.

In South Africa insect tolerant yellow and white maize, insect tolerant cotton, herbicide tolerant cotton and herbicide tolerant soyabeans have been approved for commercial release.

Labellling

The Department of Health (DOH) regulates food labelling and GMOs that alter the composition, nutrition or intended use of any food stuff need to be labelled, as do foods that contain known allergens. In addition, the DOH has drafted regulations for the labelling of foods derived from GM to help meet the need for consumer information and choice. This regulation allows voluntary labelling which must be accredited. In addition, the government has initiated a mass public awareness campaign to provide GM information to a wider group of consumers in both cities and in the country.

At present South Africa is the only country that grows GM crops on a commercial scale in Africa. Kenya is currently field testing virus resistant sweet potato, but these will not be commercially available.

Cartagena Protocol on Biosafety

The Cartagena Protocol on Biosafety is a proposed international agreement that requires exporters of living GMOs to allow importing countries to assess their potential environmental impact and food and feed safety before approving or refusing the import. This Protocol requires nations to have biosafety frameworks to check the safety of GMOs on a case-by-case basis and the Protocol has allocated a lot of funding to assist developing countries to put effective biosafety frameworks in place. As a result of this, there is a flurry of GM regulation development throughout the world and by the end of 2003 over 40 countries in Africa should be able to assess and approve or refuse approval for activities with GMOs.

GM potatoes have undergone several years of testing in South Africa under the regulation of the GMO Act. They have been tested using procedures that have minimised their impact on the environment, including people, and ensured that at the end of each test all potatoes are carefully removed from the environment. The tests for virus tolerant and tuber moth tolerant potatoes all show that the technology has real benefit for local production and will have no negative effect on our environment. In some instances the technology needs to be bred into local varieties and this will be carried out under confined growing conditions. Where the existing GM varieties perform adequately, the companies are ready to apply for approval to market the new technology. However, they are unlikely to do so until the public has an understanding of the technology and shows a willingness to use the new potatoes. As such, we can probably expect the benefits of GM potatoes in South Africa only in two to three years' time.

References

Ismael et al., (2000). Efficiency effects of Bt cotton adoption by smallholders in Makhathini Flats, KwaZulu-Natal, South Africa, 5th International. Conference on Biotechnology, Science and Modern Agriculture, Ravello, Italy.

Lochner, H. (2000). Motbestande aartappels toon groot belofte. Landbouweekblad. 22 September 2000, 36-40.

Murray S.L., Burger J.T., Oelofse D., Cress W.A., Van Staden J., Berger, D.K. (1998a) Transformation of potatoes (cv Late Harvest) with the potato leafroll virus coat protein gene, and molecular analysis of transgenic lines. South African Journal of Science, 94, 263-268.

Murray, S.L., Thompson, G., Visser, A., and Berger, D.K. (2002). Transgenic potatoes (cv. Late Harvest) show increased tolerance to potato leafroll virus in greenhouse and field trials. South African Journal of Science 98, 97-101.