AgBioForum, 7(1&2): 9-12. ©2004 AgBioForum.

The Status of Plant Biotechnology in Africa

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Most of the plant biotechnology in Africa is being carried out in South Africa, Egypt, and Kenya. At the University of Cape Town, maize resistant to maize streak virus (MSV) and drought-tolerant maize are being developed, as well as vaccine production in tobacco. The South African Sugar Experiment Station is developing herbicide-resistant sugarcane. The Council for Scientific and Industrial Research has engineered fungi-resistant maize and millet. The Agricultural Genetic Engineering Research Institute in Cairo has developed insect-resistant Egyptian cotton and is carrying out field trails on a variety of other genetically modified (GM) crops. The Kenya Agricultural Research Institute is conducting field trials on virus-resistant sweetpotatoes. Problems faced by many scientists on the continent are the slow passage of GM crops from experimental to commercial stages and the difficulties in meeting regulatory requirements.

Key words: crops, virus resistance, abiotic stress resistance, herbicide resistance, insect resistance.

Introduction

The African countries most involved in plant biotechnology are South Africa and Egypt, with some research and field trials being carried out in Kenya. In this paper, I will examine the progress being made, especially with respect to products nearing commercialization. I will also consider potential new products in the pipeline and discuss the constraints to their development and commercialization.

Biotechnology in South Africa

In 1994 and 1995, the Agricultural Research Council's fruit research institute, Infruitec, developed and field tested strawberries resistant to the herbicide Ignite. The results were extremely good, but the project was shelved because it was too expensive for the company involved to license Ignite for use on strawberries in South Africa.

Scientists in the Department of Molecular and Cell Biology at the University of Cape Town are working on maize resistant to the African endemic Maize streak virus (MSV; Figures 1 & 2) and tolerant of drought and other abiotic stresses. They are also investigating the use of transgenic tobacco to produce vaccines against HIV and human papilloma virus—the largest cause of cervical cancer in African women.

Because MSV is a DNA virus, expressing the viral coat protein (which has resulted in excellent resistance to RNA viruses) is not appropriate. We have used a multiply mutated, truncated version of the gene encoding the replication-associated protein. Laboratory trials have shown excellent levels of resistance. We are in partnership with a South African seed company to test the plants in greenhouses and embark on a breeding program to cross the transgenic lines into commercially viable varieties.

The source of the genes for abiotic stress resistance is the endemic South African resurrection plant, *Xerophyta viscosa* (Figure 3; for reviews see Mundree et al., 2002 and Mowla, Thomson, Farrant, & Mundree, 2002). Our first transgenic lines of Arabidopsis and tobacco, carrying a membrane protein (Garwe, Thomson, & Mundree, 2003), are showing good resistance to osmotic stress, heat, and salinity (Figure 4). Transgenic maize plants are currently being tested in the laboratory; we will then embark on a breeding program with scientists at the University of KwaZulu-Natal. A South African seed company has expressed interest in becoming a partner in this project. Another group at the University of Cape Town is introducing genes into tobacco for the production of vaccines against the South African HIV subgroup and papilloma virus, the biggest cause of cervical cancer among women in Africa.

The South African Sugar Experiment Station has had considerable success in developing sugarcane resistant to the herbicide glufosinate ammonium ('Buster'). It showed phenotypic stability through five ratoons in field trials (Figure 5; Leibbrandt & Snyman, 2003).

The Council for Scientific and Industrial Research has genetically engineered maize with a gene isolated from beans to develop resistance to the most serious fungal pathogen, *Stenocarpella maydis*. Field trials are currently underway. In collaboration with overseas partners, the researchers have introduced four antifungal

Figure 1. MSV symptoms on a maize plant.

Figure 2. A small-scale maize farmer whose crop is suffering both from MSV and drought.

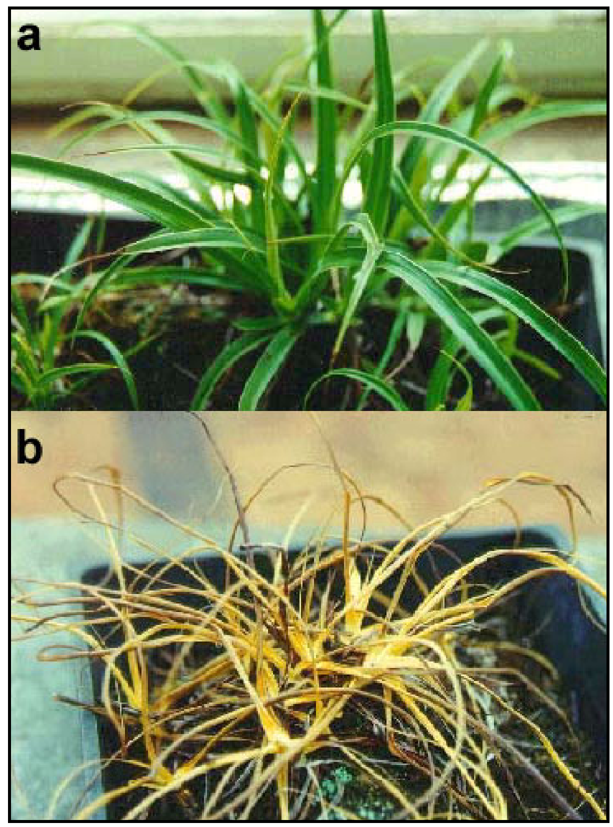

Figure 3. *Xerophyta viscosa* (a) hydrated and (b) dehydrated.

genes into maize to confer resistance to *Fusarium moniliforme*. In addition, pearl millet has been engineered with a ß-1,3-glucanase gene isolated from the biocontrol fungus *Trichoderma harzianum* to render the crop resistant to *Sclerospora graminicola*, which causes downy mildew.

South Africa has a GMO Act and a set of regulations passed by parliament that are the basis for the monitoring of imports, trials, and commercialization by the National Department of Agriculture. Thus, regulatory issues are not a constraint to the development of genetically modified (GM) crops in South Africa.

Biotechnology in Kenya

The Kenya Agricultural Research Institute (KARI) is conducting field trials on sweetpotatoes engineered to be resistant against the viruses that infect it. Yields in Kenya are 7 tons/ha, compared to 18 in China and 33 in the United States. This poor performance is partly due to the Sweetpotato feathery mottle virus, which infects fields in eastern and central Africa.

Technical assistance has been provided by Monsanto and more recently by the Donald Danforth Plant Science Center in the United States. Monsanto and KARI signed a nonexclusive, royalty-free licensing agreement in 1998. This allows KARI to use and further develop

Figure 4. Transgenic tobacco (T) showing tolerance to lack of water compared to control (C) under laboratory conditions.

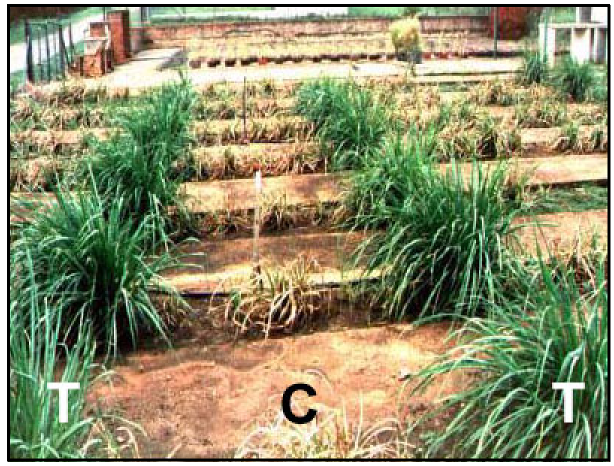

Figure 5. Field trial of herbicide-resistant transgenic sugarcane (T) compared to control (C).

transgenic virus resistance technology for sweetpotatoes. KARI is also permitted to protect the resulting transgenic varieties under the plant breeders' rights convention or similar regulations effective in Kenya. Additionally, the technology may be transferred to any other country in Africa. It has been estimated that these varieties could produce an aggregate annual benefit equivalent to US$5.4 million (Qaim, 1999). Kenya is now in the process of developing biotechnology regulations.

Trials took place in 2001 and 2002, but no significant differences were seen between control plants and transgenics. In retrospect, this is not surprising, as the coat protein (CP) gene was taken from an American strain of the virus. However, the trials were considered a success in achieving transgenic plants in the field, compliance with regulations, scoring for disease symptoms, management of the trials at four different field trial sites, and so forth. This places Kenya second only to South Africa among sub-Saharan African countries able to undertake field trials of transgenic crops, and the trials were a success from the point of view of capacity building.

At present, scientists at the Danforth Center are analyzing transgenic plants of the Kenyan sweetpotato cultivar CPT60. These plants have been transformed with the CP and replicase genes from the severe Kenyan Muguga strain.

Biotechnology in Egypt

Most of the research and field trials in Egypt are being carried out by the Agricultural Genetic Engineering Research Institute (AGERI) in Cairo. Through a collaboration with Monsanto, AGERI has developed an insect-resistant long-staple GM cotton strain by crossing Egyptian elite germplasm with Monsanto's Bollgard II. Egyptian cotton is known as one of the world's finest and is the country's most important agricultural export. Field trials are pending. Other GM crops that have been in field trials for more than one season include potato tuber moth-resistant potatoes, virus-resistant squash and tomatoes, corn borer-resistant maize and drought-tolerant wheat.

Problems cited for the slow passage of GM crops from experimental, to trial, to commercial stage include the lack of capacity to negotiate licenses to use genes and research techniques patented by others, especially for crops with export potential. In addition, there are difficulties in meeting regulatory requirements and a lack of effective public commercialization modalities and working extension networks. A problem facing Africa in particular is the lack of a dynamic private sector to take technologies to the farmer. It has also been estimated that regulatory costs might exceed the costs of research and experimentation needed to develop a given GM crop, which is a major problem in releasing such crops to the market. A way to reduce the costs of generating food and environmental safety data is to develop regional "centers of excellence" with complementary facilities where food safety testing can be done reliably and regulatory costs could be reduced.

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