Maize. Genetically engineering a staple food.

Maize (*Zea mays*), commonly known as mealies in South Africa, originated in Mexico, which is the centre of diversity for maize. Maize diversity is directly related to food security, with maize a staple food for many poor communities in southern Africa. In 2001, permission was granted for genetically engineered (GE) white maize to be grown in South Africa, the first country ever to introduce a GE staple food for direct human consumption. In 2004, GE maize accounted for an estimated 35% of all maize grown in South Africa. The need and desirability of GE maize raises fundamental questions for food security in southern Africa.

This briefing investigates experiences to date with GE maize in South Africa and describes some of the issues that require urgent attention.

Maize farming

Maize plays a vital role in food security for many poor households and is a critical food and cash crop with a per capita consumption of over 100 kg. Both large and small-scale commercial farmers produce maize. Maize production is unstable because of erratic rainfall, and yields range from 1 to 4 tons/ha. Trends towards lower rainfall in the drier areas of southern Africa suggest these areas are becoming increasingly unsuitable for maize production.

In South Africa, the area planted to maize has decreased with the deregulation of the industry, from over 5 million ha in the mid to late 1980s to around 3.5 million ha in 2004. Grain SA states that South Africa has about 8 000 commercial maize farmers. Since deregulation of the industry, the price of maize has been derived from international prices and dependent on the exchange rate. The value of the maize crop varies from below 10% to over 20% of total agricultural production in the country. Large-scale maize production is highly capital intensive and due to rising input costs, farmers become increasingly tied to credit, input suppliers and marketing agents.

White maize is preferred for human consumption and is also used for animal feeds, with yellow maize used mainly for animal feed and for some processed foodstuffs such as cereals. Maize is also used to produce starches and syrups used in a vast array of foods and industrial products. African Products is a major processor of maize and purchases about 10% of the annual maize crop, contracting farmers to grow GE free maize. South Africa exports and imports maize and maize products. Maize is also an important input for the poultry industry, which is South Africa's second largest agricultural sector.

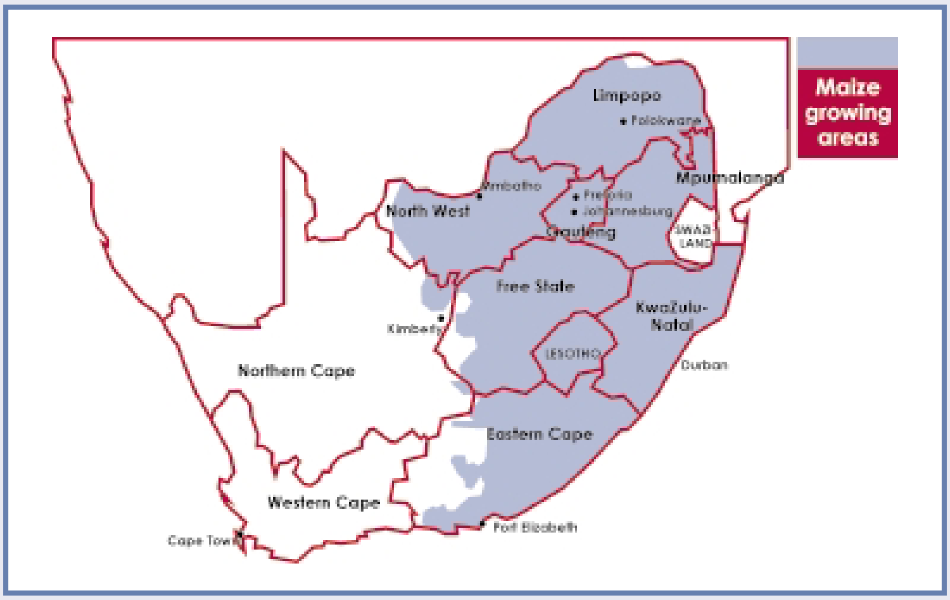
▶ *Small-scale maize farming*

The vast majority of maize farmers are small-scale farmers, farming on less than 3 ha. Some small-scale farmers may be committed to the managed schemes described above for large-scale farmers, but many, along with subsistence producers, follow low input cultivation practices using landraces and saved seed for planting. Small-scale farmers plant mostly their own varieties, which are typically robust and comprise qualities important to them. As these are open-pollinated varieties (OPV) they can replant the seed without experiencing yield reduction as with hybrids. The use and development of OPVs is not officially encouraged or supported. One recent exception is the release of two OPV maize varieties (Grace and ZM521) developed by the International Maize and Wheat Improvement Centre (CIMMYT), specifically with the needs of small-scale farmers in mind. These qualities include early maturation, and higher yield under drought and low soil fertility conditions. ZM521 has been shown to yield 34% more than currently grown varieties.

▶ *Maize research*

Maize research, development and extension work is dominated by industry, with Pannar the leader in developing local varieties. The Grain Crops Institute of the ARC in Potchefstroom undertakes research projects on maize on request by industry. The ARC also responds to the needs of small-scale farmers to some extent, making available OPV varieties on request. The National Maize Producers' Organisation (NAMPO) lobbies for farmers' interests, including research and development.

Genetically engineered maize



The South African Department of Agriculture granted permits for commercial planting of Bt yellow maize (Yieldgard) to Monsanto and Pioneer Hi-Bred in 1999, and approved Bt white maize in 2001. Bt maize is resistant to stalk borer, a maize pest, reducing the need for pesticides, as the plant in effect produces its own pesticide. Roundup Ready (RR) maize was permitted for commercial planting in 2003. RR maize is resistant to Monsanto's glyphosate-based herbicide, Roundup. This enables farmers to apply the broad-leaf herbicide Roundup indiscriminately to their fields without affecting the maize, thus making weed management less labour intensive.

Stalk borer is just one of the many pests South African farmers have to fight and farmers therefore cannot rely on a single strategy to protect their crops. According to the 2000 ARC technology report, the average annual yield loss due to stalk borer is 10% while yield loss due to maize streak disease and leaf blight is 30% and 40% respectively. The occurrences of pests are seasonal as well as area specific.

Pioneer Hi-Bred and Monsanto sell almost all the GE maize seed used in South Africa to commercial farmers. Pannar, the leader in hybrid maize varieties in southern Africa, has entered the GE seed market rather reluctantly. Syngenta entered the GE maize market when it was granted a permit in mid 2003 for Bt11 yellow maize. GE seed costs around 60% more than non-GE seed with the difference mainly accounted for by the technology fee that goes directly to the patent holder. Yellow maize makes up about 60% of the GE plantings while white GE maize, introduced in 2001, makes up 10% of GE plantings. As a result of pressure from the animal feed industry to push down local prices with cheap imports, import permits for GE maize have been granted since 2002. Over 1.4 million metric tons of GE maize have been imported, mainly from Argentina, because it is cheaper for animal feed producers and grain millers in the Western Cape to import from Argentina than to import from other parts of South Africa.

Permits issued for GE maize as of July 2004

Company	Pioneer Hi-Bred		Monsanto		Syngenta		Pannar	Advanta Agr Evo Aventis	Import for human and animal feed
Permit type	Field Trials	General 1 Release	Field Trials	General Release	Field Trials	General Release	Field Trials	Field trials	
GE Trait									40 permits = 1.4 million metric tons
Insect resistant: Bt Yieldgard	37	14	31	16	15	7	2	5	
Herbicide resistant: RR	3	2	17	5			4	6	
Stacked genes: Bt +RR	2		1		1	1		1	

Source: Department of Agriculture website (www.nda.agric.za)
***Note**: These figures are an estimate only as the information provided by the Department of Agriculture is not complete or reliable.*

Impacts of GE maize

▶ *Environment and health implications*

Two events illustrate the serious implications GE maize can have for human and environmental health. In 2000, a type of GE maize, called Starlink, which was not approved for human consumption, ended up in the food supply in the US. There were reported cases of allergic reactions and furthermore it cost the company, Aventis, US$ 1 million to remove the maize from the food chain. This clearly showed how difficult it is to keep GE out of the food chain. In 2001, researchers found that up to 60% of farmers' varieties in Mexico contained evidence of transgenic material. Mexico is a centre of diversity for maize. Maize is not indigenous to South Africa, but this does not diminish the long-term threat to food security as farmers have adapted maize for hundreds of years to local conditions in Africa, and these so-called landraces have become indigenous and an important source of germplasm.

Bt maize pollen has been shown to impact negatively on non-target insects, and increases selection pressure on target insects, causing the emergence of resistance to Bt, a natural and very important insect toxin. RR maize is a single weed management strategy and leads to the emergence of resistant weeds and reduces biodiversity.

▶ *Yield and cost implications*

Farmers interviewed in South Africa have mixed reactions to GE maize. In spite of industry marketing GE maize as having higher yields, there is no evidence of increased yields. In the experience of one farmer doing trials for Monsanto, there has not been any increase in yield. Many farmers are not prepared to pay the high technology fee and would rather maintain good pest management systems. Results on reduced expenditure on pest control, the main selling point for Bt maize, are inconclusive. However, the massive marketing drive in agricultural media and on industry-organised farmers' days, creates enough hype for farmers to want to try the new technology. Farmers in areas where there are major stalk borer problems have indicated an intention to go over to Bt maize in the hope that they will get better yields and prices as a result.

In any event, benefits are more likely to materialise in high potential areas yielding over 5 tons/ha such as those under irrigation. Under more marginal dryland conditions with yields of 1-2 tons/ha, returns are not sufficient to justify the extra expense of GE seed. Small-scale farmers who do not have ready access to markets are unlikely to benefit from the technology. They also cannot afford to buy the expensive seed and accompanied inputs such as fertilisers and pesticides.

▶ *Access to markets*

The main concern over GE expressed by farmers is access to markets. Internationally, consumer sensitivity has been the main force behind resistance to GE products. Market barriers to the EU will remain for the foreseeable future, while the SADC countries, Brazil, Japan and some South African processors and manufacturers also require GE-free products. The South African milling industry, the primary purchaser of maize, supports the principle of consumer choice. For example, maize miller African Products supplies clients like SA Breweries and export manufacturers who require non-GE containing maize and cornstarch. Other suppliers and millers trade in both GE and non-GE maize, and try to maintain separation on farms, in storage and in transport.

▶ *GE-free farms*

Farmers in a few areas have agreed to keep their farms GE free, because they are contracted to do so by export and processing companies and also in the hope of securing better prices for GE-free maize. One group is negotiating with a local co-operative to set aside a silo to prevent contamination of their product with GE maize. So far they have not succeeded in negotiating a premium price and if this fails to materialise they may switch to GE maize.

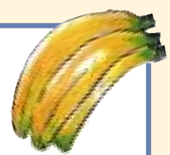
Grain SA officially favours technological innovations, including genetically modified organisms (GMOs) as long as (a) they do not harm humans, creatures or the environment, (b) all market implications are thoroughly investigated, and (c) there is a system to preserve the identity of non-GE grain. However, none of these systems are in place in South Africa and the risks of GMOs to people and the environment remain uncertain.

▶ *Monitoring and risk assessment*

The main barrier to a wider and more rapid adoption of Bt maize is the market reluctance to accept Bt maize, coupled with the high seed price and the low maize price. Since Bt maize crops are not monitored in any way (other than by individual farmers), it is impossible to say whether problems are developing with increased resistance to pests, increased chemical use and contamination of non-GE varieties. There are also no systems in place to monitor this, neither are any environmental or health impact studies being done.

Contamination by GE maize

Contamination through pollen spread is a reality with maize and threats to food security are serious as there is a significant risk that farmers' varieties and local germplasm will be contaminated. Maize is a highly variable, naturally cross-pollinated crop, in which all forms hybridise freely. It is generally pollinated by wind and is also visited by bees. Maize pollen is amongst the largest of that of the grass family. Published data for the length of time that maize pollen remains viable under natural conditions differs from about 24 hours through to several days. Pollen is shed over a period of 2-14 days. In normal field conditions at least 95% of the flowers are fertilised by pollen from other plants. Maize pollen is produced in enormous quantities. In conditions of low to moderate wind speed maize pollen can spread to a distance of 12 km or more.



There is considerable data that shows that maize pollen spreads far beyond the 200m cited generally as being the acceptable separation distance to prevent cross-pollination. Widespread contamination of local maize varieties was recently discovered in Mexico, the centre of maize diversity, providing further reason for extreme caution to be exercised.

Small-scale farmers and GE maize

Commercial farmers grow most GE maize in South Africa but some small-scale farmers in KwaZulu-Natal began growing Monsanto GE maize in 2002. Monsanto is also involved in a Landcare project in Mpumalanga with the provincial government and the Land Bank to promote GE maize amongst small-scale farmers. Companies supply farmers with trial packs containing GE and non-GE seed to plant alongside their own seed for comparison. Syngenta, another supplier of GE seed, is working with the National Department of Agriculture to promote GE maize amongst small-scale farmers. Because of weak extension services, farmers have to rely mainly on seed and chemical companies for information about the properties, cultivation practices and risks associated with a particular seed. Reports from industry suggest farmers in Hlabisa (KwaZulu-Natal) have dramatic increases in yield with Bt maize but it is unclear whether this is due to the seed itself or the support package provided to the farmers. Figures on yield vary so much that reliablilty is questionable.

▶ *Contracts*

In addition to paying the technology fee farmers sign a technology agreement stipulating that they may not:

- use the licensed maize seed for more than one season;
- use the seed for any other purpose including breeding, research, seed production and analysis;
- resell or transfer the seed to any other person or grower;
- save any crop produced from the GE seeds for future planting, or supply saved seed to anyone else.

▶ *Pest Management*

In terms of their contract, growers also have to implement an insect resistance management programme, which entails planting a refuge of non GE-seed, required to be 5-20% of the area of their GE crop. This is a requirement also in the US as it is a scientific certainty that insects will develop resistance over a period or 3-5 years. However the success of this strategy is now questioned. Even though it is not in their interest to do so, GE seed suppliers are responsible for monitoring compliance but the farmers Biowatch SA interviewed confirmed that monitoring and enforcement is not taking place in South Africa.

GE food aid for Africa

Controversies about GE food aid have firmly placed GE crops under the spotlight in Africa. The controversy first surfaced in 2000 and again in 2002 and 2004 when many countries in southern Africa experienced a food crisis. Some of these countries initially refused to accept GE grain as food aid but eventually agreed to accept the food, provided it was milled. Zambia was the only country that did not accept GE food aid in any form at all. These countries all experienced enormous political pressure and were presented with a situation of no choice by the World Food Programme and the US. Zambian NGOs showed that if financial resources were made available, more appropriate food such as cassava could be moved from those parts of the country where there was overproduction, to areas with a food deficit. The World Food Programme, however, did not support this proposal.

The US uses its food aid programmes, through the US Agency for International Development (USAID) and other agencies, to get rid of surplus agricultural products and to open new markets. Since the food aid crisis, USAID has sponsored at least five 'study' trips for delegates from African countries to South Africa, mainly to convince them to accept GMOs. Two of these trips were for Zambian delegates, putting enormous pressure on Zambia to reverse its position. In 2004, it was the turn of Sudan and Angola to be criticised for requesting GE-free food aid. President Bush's direct interference on this issue has made it abundantly clear that the US is desperate for an alternative market for their GE crops and Africa is the target. In the meantime Zambia has now produced surplus maize for two years in a row.

References

Research in this briefing paper is based on that done by Biowatch researchers. Other key references include:

1. *ARC-Grain crops Institute. 2000. Technology report.*
2. *Emberlin, J. 2000. National Pollen Research Unit, UK in GM on Trial. Scientific evidence presented in the defence of 28 Greenpeace volunteers. April 2000.*
3. *Quist, D. & Chapela, I.H. 2001. Transgenic DNA introgressed into traditional maize landraces in Oaxaca, Mexico. Nature 414, 541-3.*
4. *Stotzky, G. 2000. Persistence and biological activity in soil of insecticidal proteins from Bacillus thuringeinsis and of bacterial DNA bound on clays and humic acids. Journal of Environmental Quality 29, 691-705.*

Conclusion

The introduction of GE maize in South Africa seems to have been driven almost entirely by vested interests, with little regard for the long-term social, health and environmental impacts. But clearly, the costs and risks of GE maize in terms of markets, food security, health and the environment are unacceptably high. Instead of the aggressive marketing of GE maize, it would be far more appropriate for government and industry to provide other forms of production support to farmers such as improved extension services, integrated pest management practices, appropriate processing and storage facilities, and the development and improvement of OPV varieties. As one perceptive farmer commented, it would make economic sense for South Africa to declare specific maize regions GE-free, as this would help to guarantee access to a large export market that does not want GE products. GE maize is one crop that deserves a full investigation in terms of its feasibility and desirability in the region. Surely no one can argue with the fact that people have a right to choose whether or not their staple food becomes fundamentally and irreversibly changed.

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