Africa bullied to grow defective *Bt* Maize:

the failure of Monsanto's MON810 maize in South Africa

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The African Centre for Biosafety (ACB) is a non- profit organisation, based in Johannesburg, South Africa. It was established to protect Africa's biodiversity, traditional knowledge, food production systems, culture and diversity, from the threats posed by genetic engineering in food and agriculture. It has in addition to its work in the field of genetic engineering, also opposed biopiracy, agrofuels and the Green Revolution push in Africa, as it strongly supports social justice, equity and ecological sustainability.

The ACB has a respected record of evidence based work and can play a vital role in the agro-ecological movement by striving towards seed sovereignty, built upon the values of equal access to and use of resources.

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ACRONYMS

AC	Advisory Council
ABSF	Africa Biotechnology Stakeholders Forum
AATF	African Agricultural Technology Foundation
AGERI	Agricultural Genetic Engineering Research Center
CIRAD	Agriculture Research for Development
Bt	*Bacillus thuringienis*
EC	Executive Council
EFSA	European Food Safety Authority
FTA	Free Trade Agreement
GE	Genetic Engineering
GM	Genetically modified
GMO	Genetically modified organism
HT	Herbicide tolerant
IRMA	Insect Resistant Maize for Africa
CMMYT	International Maize and Wheat Improvement Centre
ISF	International Seed Federation
IP	Intellectual property
IR	Insect resistant
IRM	Insect Resistance Management
IRMA	Insect Resistant Maize for Africa
ISAAA	International Service for the Acquisition of Agribiotech Applications
KARI	Kenyan Agricultural Research Institute
KEPHIS	Kenyan Plant Health Inspectorate Services
NCST	National Council for Science and Technology
NEMBA	National Environmental Biodiversity Management Act
NBC	National Biosafety Committee
PIPRA	Public Intellectual Property Resource for Agriculture
PPP	Public private partnership
SFSA	Syngenta Foundation for Sustainable Development
SAGENE	South African Committee on Genetic Experimentation
SANBI	South African National Biodiversity Institute
SANSOR	South African National Seed Organisation
USAID	United States Agency for International Development
WEMA	Water Efficient Maize for Africa
WTO	World Trade Organisation

USE OF TERMS

In this briefing we use the terms 'genetically engineered' and 'genetically modified' to refer to transgenic techniques used to develop genetically modified organisms.

KEY FINDINGS

1. Monsanto's *Bt* maize, MON810, has failed hopelessly in South Africa as a result of massive insect resistance, after only 15 years of its introduction into commercial agriculture. In an effort to deal with the pest infestation, Monsanto has compensated South African farmers who experienced more than 10% damage on their genetically modified (GM) insect resistant crops – some farmers experienced as high as 50% insect infestation. MON810 is now obsolete in SA and has been replaced with Monsanto's GM stacked variety, MON8903, which expresses two different cry proteins, Cry1A.105 and Cry2Ab.
2. *Bt* technology was approved in SA before regulatory authorities were capacitated to regulate it properly. MON810 was not fit for commercial release and should never have been granted commercial approval. The necessary monitoring of insect resistance was not carried out and regulators did not ensure that farmers were carrying out the required insect resistance management (IRM) strategies, i.e. planting refuges.
3. In any event, IRM strategies were based on the false assumption that the inheritance of resistance to MON810 was a recessive, not dominant trait. In terms of this false assumption, current IRM strategies require farmers to plant a 5% non-*Bt* maize 'refuge' which may not be sprayed, or a 20% refuge which may be sprayed. However, recent research has shown that the inheritance of resistance is a dominant trait and that in order to stem rapid and large-scale resistance, farmers will need to plant more than 50% non-*Bt* maize as a refuge where non-resistant individuals can breed. This requirement is not viable for farmers, highlighting the unsustainability of the technology.
4. In Kenya, an attempt to commercialise publically developed *Bt* technology in open-pollinated seed (which can produce a viable crop year after year) by a charitable project called Insect Resistant Maize for Africa (IRMA), funded by the Syngenta Foundation, failed after 10 years of work. IRMA was unable to find *Bt* genes in the public domain that were effective against the African stem borer. It also came to realise that *Bt* technology cannot be used in open-pollinated varieties because reusing seed that has been engineered with *Bt* genes would expedite the development of insect resistance, rendering the technology useless within a couple of seasons. The IRMA project also found the cost of biotech seeds prohibitive for typical African farmers. Hence IRMA abandoned their attempt to bring *Bt* technology to resource poor farmers.
5. Another charitable project, the Water Efficient Maize for Africa (WEMA) project which for the best part of five years only focused on drought tolerant maize varieties in South Africa, Tanzania, Mozambique, Kenya and Uganda is now incorporating MON810 into their drought tolerant varieties. Monsanto has donated MON810 to the project, royalty free. Unlike IRMA, WEMA's values are not underpinned by a desire to bring GM crops that are appropriate for African farmers onto the market. Although WEMA's products are said to be 'royalty free' to small-holder farmers, the seed will be sold to seed companies under strict licensing conditions. Under the auspices of the WEMA project, trials of MON810 are already taking place in Kenya and Uganda. WEMA is thus a convenient vehicle for Monsanto to gain regulatory approval in Africa for the commercial cultivation of MON810.
6. In Egypt, MON810 has been genetically engineered into a local Egyptian maize variety called Ajeeb. This Egyptian variety has now been patented by Monsanto. The introduction of GM technology on a large scale in Egypt has largely failed to date, due to corruption and difficulties in passing its Biosafety law. The Egyptian government has published three peer reviewed studies in the past two years on Ajeeb YieldGard maize that have found:
7. *Bt* maize showed significant differences when compared to its conventional

counterpart and may be toxic to the human food and animal feed; and

8. Several changes were noted in the organs, body weight and serum biochemistry in rats fed on GM maize.

INTRODUCTION

Genetic engineering (GE) is undoubtedly one of the most controversial technologies to emerge in the 20th century; the advent of modern biotechnology has 'triggered major scientific, social and political controversies' since its introduction in the 1970's[1]. The story of one of the first genetically modified (GM) products to come onto the market, Monsanto's MON810 maize, which contains Monsanto's patented *Bt* gene Cry1Ab, embodies much of the controversy about genetically modified organisms (GMOs).

The *Bt* trait, which is toxic to certain agricultural pests, is derived from a soil microorganism called *Bacillus thuringienis (Bt)* [2]. MON810 is the 'event' name for the *Bt* maize variety owned by Monsanto which expresses the Cry1ab *Bt* toxin and sold commercially in South Africa as 'Yieldgard' maize. The *Bt* toxin expressed in the crop is meant to render the use of pesticides to control insect pests unnecessary. MON 810 is one of the oldest GM events on the market and is approved for human consumption in more than a dozen countries worldwide, including South Africa[3]. It is also the only GM variety cultivated in some parts of the European Union, mostly in Spain. It is, however, banned in eight European countries on environmental grounds[4]. According to the United States, these bans are not about safety concerns, but rather political in nature and constitute unfair 'trade barriers' to American produce[5]. Unfortunately, Africa has become one of the battle grounds of the GMO trade war between the US and Europe, and the adoption or rejection of GMOs in Africa will mean a victory for one side or the other. The story of MON810 in Egypt is a rich illustration of Africa's awkward position in this trade war.

South Africa was an extremely early adopter of GM technology, not just in Africa, which is yet to commercialise GM food crops on a large scale, but even globally. The South African government issued a permit for the commercial release of MON810 in 1997 – even before GMO legislation was in place[6]. This decision opened the door for Monsanto to colonise the production of our staple food through aggressive acquisitions of the South African seed industry and patent laws protecting Monsanto's GM technology[7]. The majority of maize production in South Africa is carried out by large-scale commercial farmers, who eagerly adopted the technology for ease of pest management, savings on pesticides and reduced loss of yield through pest damage[8].

However, South Africa is the first place in the world where insect pest resistance has developed on a large scale[9]. It is now recognised by the scientific community and South African regulators that this resistance cannot be managed or remediated; MON810 has decisively failed. The product has been withdrawn in South Africa from the 2013 planting season and has been replaced by Monsanto's MON89034 in an attempt to deal with the insect resistance problem[10]. A recent peer-reviewed study has revealed that the African maize stem borer (*Busseola Fusca*) has an inherently low susceptibility to *Bt* toxin. Long held assumptions that the inheritance of resistance to *Bt* is recessive have been shattered[11].

Although MON810 will no longer be cultivated in South Africa, the Department of Agriculture's GM permit lists indicate that Monsanto is exporting MON810 seeds to Kenya and Uganda for field trials. This, despite the fact that the most damaging pest that needs to be controlled in sub-Saharan Africa is the very *Busseola Fusca* that has proven to be impervious to MON810 in South Africa. One of the major vehicles pushing MON810 onto African countries is the public/private partnership (PPP) spearheaded by the Gates Foundation and Monsanto, called Water Efficient Maize for Africa (WEMA).[i] The aim of WEMA is to develop drought resistant crops,

i. WEMA projects are running in South Africa, Uganda, Kenya, Tanzania and Mozambique through both conventional breeding and genetic engineering. However, since 2011[12], with little fanfare, it has become evident that MON810 will also be engineered into these new drought tolerant GM varieties. The veneer of the 'charitable' orientation of the project provides an excellent opportunity for Monsanto to gain regulatory approval for a stacked GM event that is said to be both drought tolerant and resistant to stem borers.

Another PPP, funded by the Syngenta Foundation for Sustainable Agriculture (SFSA) project, called Insect Resistant Maize for Africa (IRMA), spent many years attempting to develop *Bt* maize varieties appropriate for African conditions. While the project succeeded in developing scientific capacity in GM technology, it ultimately failed to find an effective gene to control the African maize stem borer[13]. This, along with massive obstacles created by intellectual property rights on the technology, led the IRMA project to abandon the GM side of its project in 2006[14]. IRMA will now share its wealth of technical know-how with the WEMA project, as well as assisting with implementation of biosafety legislation and procedures (such as risk assessment and experimental protocols) in Kenya, to pave the way for the introduction of the very technology that has failed in South Africa – MON810. It is anticipated that the first GM drought resistant and insect resistant varieties will be released in Uganda and Kenya in 2015[15].

ABOUT THIS BRIEFING

This briefing gives a background of MON810 and provides some contextual issues, particularly with regard to the cost of *Bt* technology for farmers who foot the exhorbitant bill for expensive research and development and intellectual property, out of their per acre earnings. It then presents South Africa's experience with the MON810 to date and the deployment of MON810 on the rest of the African continent. The briefing highlights a number of trends, including: the adoption of GM technology before the necessary legal frameworks are complete, lack of regulatory capacity to regulate and monitor GM crops, skewed power relations in public-private partnerships that favour the commercial interests of the private sector, mistrust around intellectual property rights and political bullying. The stark reality also emerges that GM technology is in its infancy in terms of scientific understanding and of the complexity of the issues at play. An increase in the publication of independent biosafety studies is beginning to provide some of the information necessary for informed scientific debate on the long-term safety studies required[16].

BACKGROUND

The corporate stranglehold on *Bt* technology makes farmers pay

MON810 was genetically engineered to produce a toxin that provides crop protection against certain pests of the *Lepidopteran* insects, (caterpillars), such as maize stem borers[17]. This is achieved by incorporating a gene isolated from a soil organism called *Bacillus thuringienis*, commonly known as *Bt*. This soil organism has been used as a natural pesticide since it's registration in the States in 1961, in a crystalised form that is dusted on the crops[18]. It is completely natural and may be used in the production of certified organic crops. When natural *Bt* is used, the toxin only becomes active when eaten by target pests, due to the particular nature of their digestive systems and is therefore not toxic to non-target organisms or people[19]. Several disadvantages of the *Bt* biopesticide include that it has to be sprayed directly on infestations, application needs agricultural machinery, and the toxin breaks down in sunlight and rain, necessitating further applications[20].

The ability to engineer the genes responsible for expressing *Bt* toxin into crop plants was seen as an extremely exciting breakthrough in agricultural technology. One that would overcome the above mentioned disadvantages and decrease the use of toxic chemicals in industrial agricultural systems, thereby reducing input costs, increasing productivity, and benefiting workers and the environment[21].

The developers of the technology claimed that, like natural *Bt*, the *Bt* protein expressed in plants is not harmful to mammals, birds or fish, nor to beneficial insects[22].

The real name of the game, however, was the identification of the right genes to ensure protection against the above mentioned pests. Once efficacious genes were identified, these could be patented by the developer (e.g. Monsanto) and thereby be granted exclusive rights over its use. Research and development of GM crops is expensive and has therefore been carried out largely in the domain of agribusiness, which now has a stranglehold on the technology. A handful of corporations decide who may use the genes identified, for what purpose, and at what cost. A 1997 industry report on *Bt* development reported that:

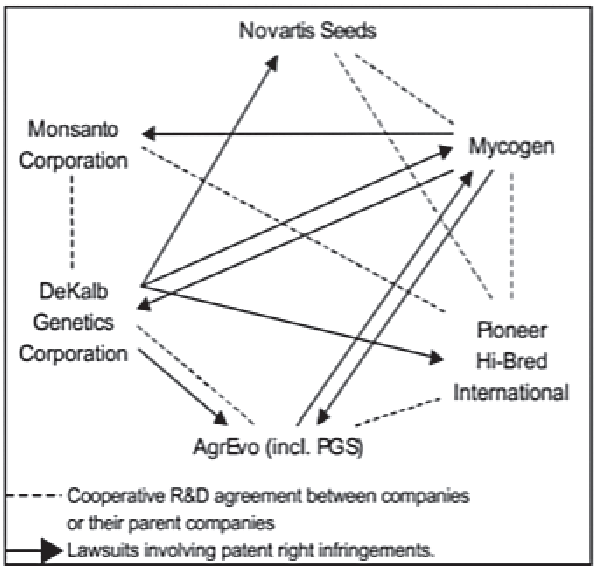
> *All commercialised* Bt *crops are developed by the private sector, which is not surprising considering that 410* Bt*-related patents were issued over the last 11 years: just over half of* Bt*- related patents were granted to institutions in North America, 30% to European and Russian organisations, and 18% to companies mainly from Japan; of the total patents, over half are directly relevant to transgenics; and 57% of all* Bt *patents have been issued to only eight companies. An analysis of commercialised* Bt *crops and of recent field trials demonstrates that a subset of these eight corporations are the major players in transgenic* Bt *plant technology, viz. Monsanto, Novartis (now Syngenta), AgrEvo and Mycogen with their own technologies, and DeKalb Genetics Corporation and Pioneer Hi-Bred International (Du-Pont) through strategic alliances"*[23].

In 1997, 23 lawsuits on *Bt* ownership were pending, and it was reported that litigation on plant patent infringements had doubled in that year[24]. Legal battles over intellectual property infringement have continued until today, as well as a complex web of cross-licensing deals between seed and chemical companies.

The impact of the exorbitant cost of GM technology and the premiums charged to recoup costs was almost immediately felt after their introduction. In 2002, seven years after the commercialisation of *Bt* crops, it was reported in the United States that:

> *The case of* Bt *corn, thus far, suggests that farmers will be expected to finance a*

Figure 1: Cooperative R&D Agreements compared with Lawsuits involving Patent Right Infringements



AgrEvo: Patents covering truncated genes and plant cells, tissues and plants containing those genes.

DeKalb: Patent covering fertile, transgenic corn expressing *Bt* proteins. Monsanto owns a large equity stake; yet DeKalb works with AgrEvo to launch LibertyLink™ corn hybrids.

Monsanto: Patents covering microorganisms that colonize plants to introduce *Bt*, including *Bt* toxin proteins used to make plants insect resistant.

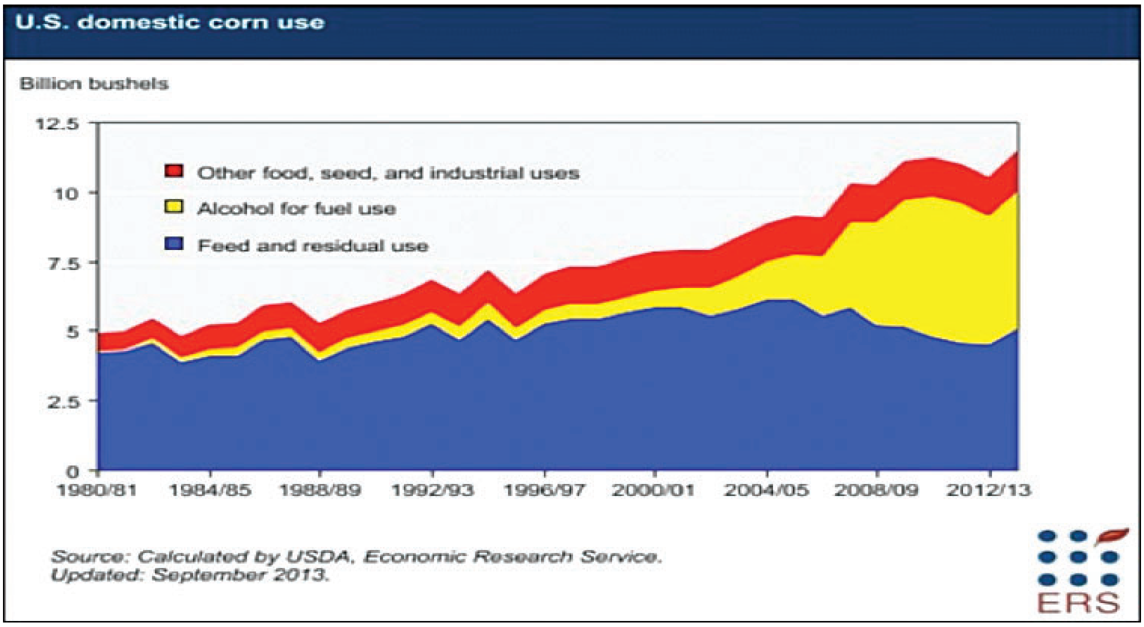
Mycogen: Two patents covering the transformation with *Bt* toxins into plants where the toxins will be expressed at levels to control pests. Also patents for making *Bt* proteins more plant-like, allowing better expression in plants. Various patents on specific *Bt* genes for different crops. DowElanco owns 45% of equity.

Novartis: Patents covering purified toxins and genes from *Bt*. Also patents covering *Bt* strains and methods of growing *Bt* and expressing insecticidal genes.

Pioneer: Notified to receive patent covering insertion of DNA into corn. License from Monsanto to use of YieldGard™ *Bt* corn. Research agreement with Mycogen to develop/market *Bt* transgenic crops.

Modified and extended after Horstmeier (1997).

Source ISAAA. 1997. Insect Resistance in Crops: A Case Study of Bacillus thuringiensis (*Bt*) and its Transfer to Developing Countries



Source: http://www.ers.usda.gov/topics/crops/corn/background.aspx#.Ujq6-8amhc4

> *greater share of seed industry intellectual property, research, and development costs from their per acre earnings. The evidence also suggests that these costs are markedly higher for new corn varieties including traits introduced via genetic engineering. Since* Bt *corn has been introduced, corn seed expenditures grew at $1.34 per acre annually between 1995–1999, compared to just $.30 per year in the previous five years. The impact of the* Bt *corn premium on seed industry profits has been remarkable. The* Bt *corn premium boosted earnings for Pioneer Hi-Bred by 7.3%, Monsanto by 9%, and Syngenta by over 18% between 1998–2000. Based on current seed pesticide industry pricing policies and financial performance goals, it is likely that the purchase of technologies like* Bt *corn will transfer another slice of farm income from growers to the seed-biotechnology industry*[25].

GM Maize – hi-tech, high cost crop

The biotech industry aggressively sells their product on the basis that it is a key contributor in the global fight against hunger. However, there are only four GM crops available on the market (soya, maize, cotton and canola) and these crops are not primarily valued for their contribution to global food security. This expensive technology is being deployed in lucrative commodity crops for the sake of profit.

Maize is the world's tenth most valuable agricultural commodity, and the second most profitable grain, after wheat[26]. It is the most important crop in the United States, valued at US$76.5 billion in 2011, representing over 53% of global maize exports[27]. In 2012, 90% of maize production in the United States was genetically modified (GM)[28]. While many of us in South Africa know maize as a staple food for many millions of Africans in several countries on the continent, maize as a staple is not common outside of Africa, except in Mexico and some parts of the Andean region. The usage of maize in the United States, provides a good illustration of what maize is generally produced for; animal feed and agrofuels, with lesser amounts being used for industrial purposes and tiny amounts for food.

The genetic modification of crops is a lengthy and obscenely expensive business. In 2012 Monsanto claimed that it 'invests more than $500 million annually to identify and develop new solutions for growers'[29]. A number of studies looking at the development costs of GM crops found that the costs involved in gaining regulatory approval were even more expensive than the costs of the research and development (R&D) itself[30]. The resultant seed is expensive as farmers pay for the technology costs[31]. Farmers are also contractually bound to abide by very specific crop management practices to ensure that crops are safely grown. GM crops are high-end and high-tech, well suited to the cut-throat agricultural commodities business and not to feeding the poor, as we have been led to believe. Within this context, it is easy to understand why the technology has not readily been adopted in Africa, where maize is a staple and the majority of the continents' food is produced by smallholder resource poor farmers who cannot afford expensive seed or related off-farm inputs. As discussed below in the section describing the Insect Resistant Maize for Africa (IRMA) project, the cost of the technology was a major barrier to the introduction of *Bt* maize in Kenya, despite complicated negotiations to waiver royalties and 10 years of funding from the Syngenta Foundation for Sustainable Development (SFSA) to develop Africa-appropriate *Bt* maize varieties.

MON810 in Africa: failed in South Africa, stalled in Egypt, sneaked into Kenya and Uganda

This section looks at the failed experience of MON810 in South Africa and the reasons for this failure. South Africa's agriculture systems are very different to those on the rest of the continent – they are developed industrial systems that incorporate a relatively small number of large-scale commercial farmers. South Africa is the main maize producer in the SADC region, with an average production of about 9.7 million tons (Mt) a year over the past 10 years. It is estimated that more than 8,000 commercial maize producers are responsible for the major part of the South African crop[32]. South Africa provides a good policy, economic and scientific environment for the introduction of GMOs in Africa and is often referred to as the 'springboard' for GMOs into Africa. Nonetheless, the lesson for Africa is that MON810 has failed in this 'ideal' corporate-friendly environment and is likely to be utterly disastrous for countries and farmers that are less equipped to deal with this new and onerous technology on the rest of the continent.

The section also explores MON810 in Kenya and Uganda, where it is being tested under the auspices of the WEMA project, with technical assistance from the IRMA project. These projects acknowledge that typical African farmers are resource poor and have different needs to those of globally competitive commercial farmers. MON810 is therefore being deployed in charitable projects, royalty free. The underlying imperative of this 'charitable' gesture is interrogated and exposed.

Last, the section provides an update on GM developments in Egypt, which is the only other African country that has permitted the cultivation of *Bt* maize and the first African government to produce independent biosafety research into the potential long-term health impacts of consuming *Bt* maize.

MON810 in South Africa – early adopters of a short-lived technology

When MON810, traded under the name YieldGard, was commercialised in the United States in 1995, global debate on the safety of GM crops was raging. Monsanto and the biotechnology machinery claimed that the technology had great potential to address global food security through increase in yields, the provision of nutritionally enhanced seeds, and seeds that would produce good yields under environmental stress as well as reduce pesticide use[33]. However, the international community responded that traditional breeding was as effective in producing these results without corporate patents or scientific uncertainty about the long-term impacts that these novel organisms might have on the environment, and human and animal health[34]. Many felt that pre-market risk assessment procedures were vital and that precaution with this very new technology was wise. According to the African Union Commission, 'The later view prevailed in the international discourse and led to the establishment of regulations to ensure biosafety regulation of modern biotechnology in a safe and sustainable manner'[35]. The Cartagena Protocol was developed under the United Nations Convention on Biological Diversity (CBD), based on the 'Precautionary Principle' and setting minimum biosafety standards for the transboundary movement of genetically modified organisms (GMOs). The Protocol came into force in 2000. (The United States is not Party to this Protocol as they are not signatories of its 'mother' convention, the CBD). Three years before the finalisation of the Cartagena Protocol, South Africa became the first African country to commercially produce *Bt* crops when permits were given for Monsanto's Bollgard Cotton and YieldGard Maize (MON 810) in 1997. South Africa's GMO Act would only come into force two years later, in 1999. In the absence of a regulatory framework for GMOs in the country, a body called the South African Committee on Genetic Experimentation (SAGENE) was responsible for decision-making, following the American model of GMO regulation[36]. This model is underpinned by an assumption that GMOs are as safe as their conventional counterparts (termed 'substantially equivalent') and do not need special safety assessment. At that time, the USA was fighting a vicious battle in the international arena to undermine the Biosafety Protocol and ensure that as little regulation as possible would be applied to GM seeds and grains. In one of the ISAAA's earliest briefings on the global status of GM crops in 1997, they state that:

> *South Africa has harmonised its regulations for use of products from transgenic crops with the USA. Accordingly, applicants in South Africa no longer need to seek a permit for using a product from a transgenic crop if that specific product has been approved for use in the USA; under these circumstances the applicant simply notifies the regulatory authority, SAGENE, in South Africa, which reserves the option to further consult on a case by case basis. However, South Africa does require applicants to submit applications for field trials, and biosafety/environmental clearances must be obtained as well as approval to grow any transgenic crop commercially*[37].

When South Africa's GMO Act came into force in 1999, SAGENE was dissolved and decision making was taken over by the Executive Council (EC) of the GMO Act under the Department of Agriculture and comprised of members from the governmental departments of Environment and Water Affairs, Health, Trade and Industry, Agriculture, Forestry and Fisheries, Science and Technology, Labour, and Arts and Culture. The EC is assisted by the Advisory Council (AC) – a group of experts that are appointed by the Minister of Agriculture, Forestry and Fisheries. AC members should be adequately qualified to review the scientific data contained in the risk assessments submitted by any company or research institution that applies for a permit. The members of the AC give their scientific opinion to the EC, therefore playing a crucial role in the approval or rejection of any new permit. The names of the members serving on this committee have been classified as confidential information. An administrative appeal against the decision by the EC not to disclose the names of the ACB members was instituted by the ACB during 2011, but this failed as the Minister of Agriculture, too, insisted that their names be kept secret. Hence, the South African public has no way of knowing if members on this committee have conflicting interests or if they are suitably qualified to assess GMO applications.

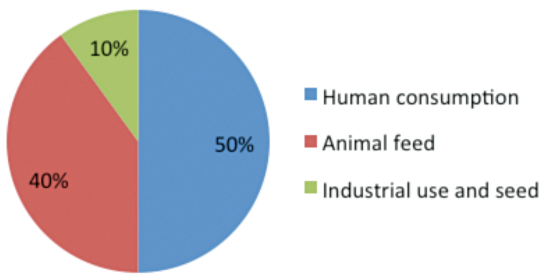
Once South Africa ratified the Cartagena Protocol in 2000, amendments were made to the GMO Act, to bring it in line with international obligations under the Protocol.[38] Risk assessment is now carried out on a case-by-case basis by South African authorities, but still rests on the unproven assumption that GM foods are inherently as safe as non-GM foods, or 'substantially equivalent'.

More than a decade later, South Africa remains the only African country that is cultivating GM food crops and the only country in the world that has allowed the genetic modification of its staple food. Having adopted the technology long before legislation and administrative procedures were properly in place, South African authorities have never quite managed to catch up with the runaway pace of corporate research and development of GMOs to ensure adequate monitoring, administration and safety research.

Maize – South Africa's staple food compromised

South Africa has eagerly followed GM developments in the United States, however, an important difference between South Africa and the world's largest producer of maize, is that maize is the staple food in South Africa. About 60% of South Africa's maize production is white maize, used primarily for human consumption, and 40% is yellow maize, used primarily for animal feed[39]. Maize is eaten several times daily in a relatively unprocessed form, for example, milled and boiled into porridge. It is commonly used as a first food for babies, to wean them off the breast. In 2000, the ultra-poor spent over 50% of their income on food, of which up to 20% was spent on maize meal alone. In general, the 'typical' maize meal consumer refers to a low-income individual residing in an urban and rural area[40].

South Africa domestic maize use



Source: Department Agriculture Forestry and Fisheries, 2011/2012

South Africa is unique in the world in that it has allowed the genetic modification of its staple food. As GM varieties now comprise close to 90% of the country's maize production, and no segregation of GM and non-GM exists, consumers have no access whatsoever to non-GM maize. Recent tests carried out by the ACB on a number of popular maize-based foods, produced by one of South Africa's largest producers of fast moving consumer goods, Tiger Brands, revealed high levels of GM content:

- Ace super maize meal **78%** GM maize content
- Ace maize rice **70%** GM maize content
- Ace instant porridge **68%** GM maize content
- Lion samp and beans **48%** GM maize content
- Jungle B-fast energy cereal **41%** GM maize content

Civil society has petitioned the South African parliament to seriously look into the matter, claiming that this situation is a contravention of human rights. Having no choice but to eat a highly controversial staple food, which is severely restricted in many countries around the world, has been labelled 'food fascism' by local social movements. They have also called for a review of government's risk assessment procedures, to include, amongst other things, long-term safety studies on human health[41]. Currently, South African regulatory authorities rely solely on safety data generated by the producers of GMOs and long-term feeding trials to determine safety are not required. This safety data is neither peer-reviewed nor available to the South African public in its entirety, being protected under laws that allow for the exclusion of information considered to be 'confidential business information' (cbi).

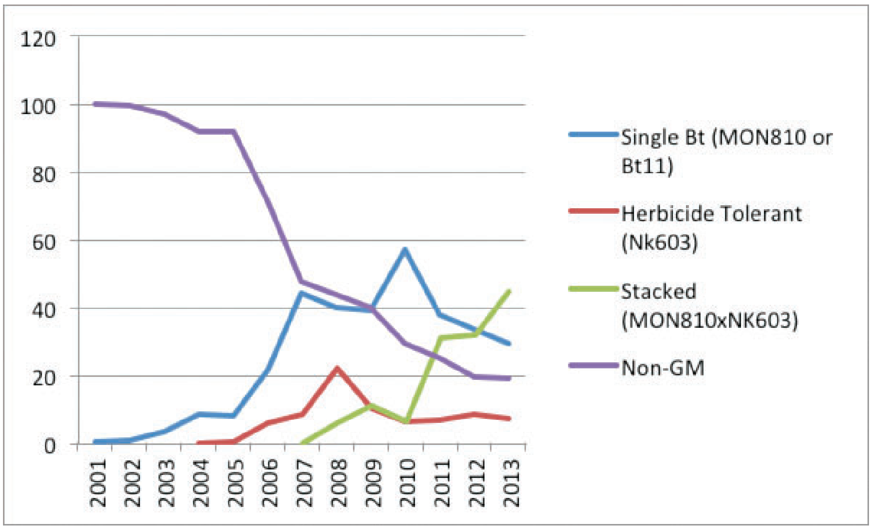
Corporate takeover of South Africa's maize

As noted earlier, in 1997 Monsanto's GM 'insect resistant' (IR) maize variety MON810 was approved for environmental release, meaning that GM maize could be grown on a commercial scale. The first commercial plantings took place in 1998. During the 2004/05 cropping season, when the South African National Seed Organisation (SANSOR) began publishing such information, GM maize seed accounted for 20% of maize seed sales. By this time two further varieties were approved for commercial cultivation: Syngenta's *Bt*11 (also insect resistant) and Monsanto's herbicide tolerant variety NK603.

The adoption rate of GM maize seed in the intervening period has been astounding: in 2012, 86% of all maize grown in South Africa was GM[42]. Up until 2003, when Syngenta's *Bt*11 was commercially released in South Africa, all *Bt* maize hybrids involved MON810[43]. By 2008 three new GM maize events had been approved for cultivation in South Africa, but MON810 remained the most popular event – over 80% of all GM maize seed imported into South Africa that year was MON810.

The graph below shows the rapid uptake of GM white maize in South Africa between 2000 and 2012. Once Monsanto's stacked variety (MON810 x NK603), incorporating both insect resistance and herbicide tolerance, was released in 2007, the cultivation of MON810 as a single GM variety started to slowly decline.

Uptake of GM white maize in South Africa 2001–2012



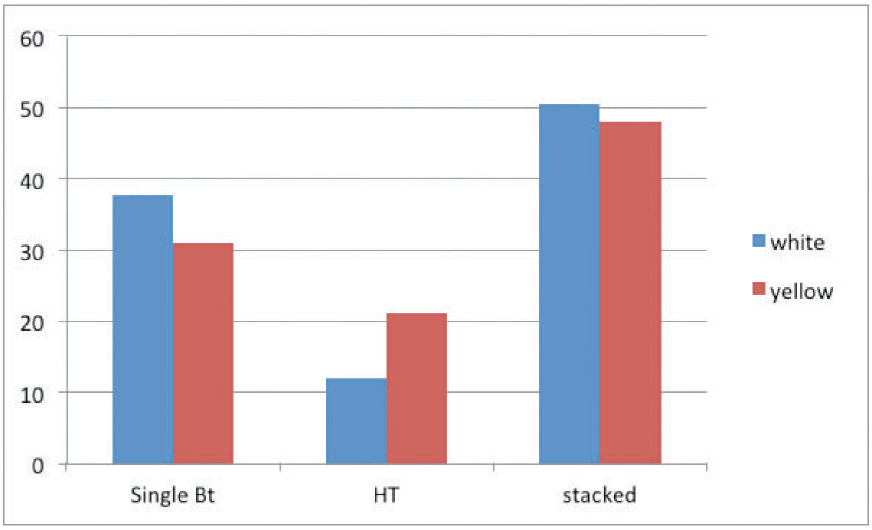
Derived from: Final report on the area planted to GM maize in South Africa for the 2007/2008 season and USDA GAIN report [46]

Interestingly, farmer surveys have revealed that it is not uncommon for farmers to plant *Bt* traits as their main crop and herbicide tolerant crops as their refuges[44] .Currently, 80.5% of white maize cultivated in South Africa is GM. However, we have now suddenly reached the end of the line with MON810 in South Africa; in the 2013 season, MON810 will not be planted at all due to the development of widespread resistance to the Cry1ab toxin. As MON810 can no longer provide farmers with reliable protection against stem borers, and MON810 has now been replaced by a stacked variety, MON89034, which expresses two different cry proteins, Cry1A.105 and Cry2Ab2[45].

In 2012, the ISAAA reported that 86% of the total area planted to maize in South Africa was GM (2.428 million ha). The total maize planted consisted of 58% white maize and 42% yellow maize. The chart below shows the breakdown of the 86% biotech maize planted in 2012 by maize colour and trait.

As demonstrated above, the uptake of MON810 and subsequent GM varieties in South Africa was extremely rapid, and Monsanto soon dominated South Africa's maize seed market. In 1999 and 2000 Monsanto acquired two of South Africa's largest seed companies, Sensako and Carnia, giving them a dominant share in the maize seed market[47]. By 2009, Monsanto controlled 50% of the maize seed market and about 10% of all maize varieties registered with

Breakdown of white and yellow GM maize planted in 2012 (86% of total maize)



Source: derived from ISAAA

the Department of Agriculture's Directorate for Plant Improvement were registered in Monsanto's name[48].

When it comes to GM maize varieties, both white and yellow, Monsanto holds about 25% of all registrations on the Plant Variety listing. However, it is not apparent from the seed variety list that nearly all of the GM maize varieties available in South Africa, whether they are licensed to small local seed companies or transnational giants such as Pioneer Hi-Bred, contain Monsanto's patent protected transgenic traits. Of the more than 140 registered GM maize varieties on the South African market, only one does not contain a trait owned by Monsanto; a yellow maize variety that contains Syngenta's insect resistant gene (also a cry1Ab gene, known as Bt11), sold by Klein Karoo seed. All other varieties on the market contain Monsanto's proprietary traits, meaning the companies who sell them are charged a 'technology fee' for this privilege, which is then passed on to the farmer[49].

In some instances, seed companies are selling only Monsanto's genes, sold under license from a third party. For example, through its network of 80 dealers nationwide, Agricol sells several hybrid and GM varieties under license from Pioneer Hi-Bred. Although these varieties are registered in Pioneer's name, they contain the MON810 trait. In this case, Pioneer pays the licence fee to Monsanto, not Agricol. The size of these fees is difficult to ascertain, as they are not listed separately, but are included in the seed price. Research from the International Seed Federation (ISF) has established that these fees can be as much as 25% in the case of maize, and a substantial 40% and 55% for soya and cotton respectively. These figures are only for single gene GMOs. In the case of 'stacked' GMOs, the fees are much higher, sometimes amounting to as much as 67% of the overall seed cost[50].

Monsanto currently has five different GM maize varieties approved for commercial cultivation in South Africa:

- MON810 – insect resistant, approved in 1997
- NK603 – herbicide tolerant (better known as 'Roundup Ready'), released in 2003
- Stacked MON810 x NK603, insect resistant and herbicide tolerant, released in 2007
- MON89034 – insect resistant, approved at the end of 2010
- MON89034 x NK603 – insect resistant and herbicide tolerant, approved at the end of 2010[51]

Syngenta is the only other company that has successfully released a GM trait onto the South African market: the aforementioned *Bt*11, which was given clearance in 2003[52]. More recently, during the latter part of 2010, Syngenta received approval for the commercial

Maize events granted conditional environmental release in South Africa

Event	Trait	Company	Year approved
BT11 x GA21	Insect resistance (IR) Herbicide tolerant (HT)	Syngenta	2010
GA21	HT	Syngenta	2010
MON89034 x NK603	IR x HT	Monsanto	2010
MON89034	IR	Monsanto	2010
MON810 x NK603	IR x HT	Monsanto	2007
Bt11	IR	Syngenta	2003
NK603	HT	Monsanto	2002
MON810 / Yieldgard	Insect resistant	Monsanto	1997

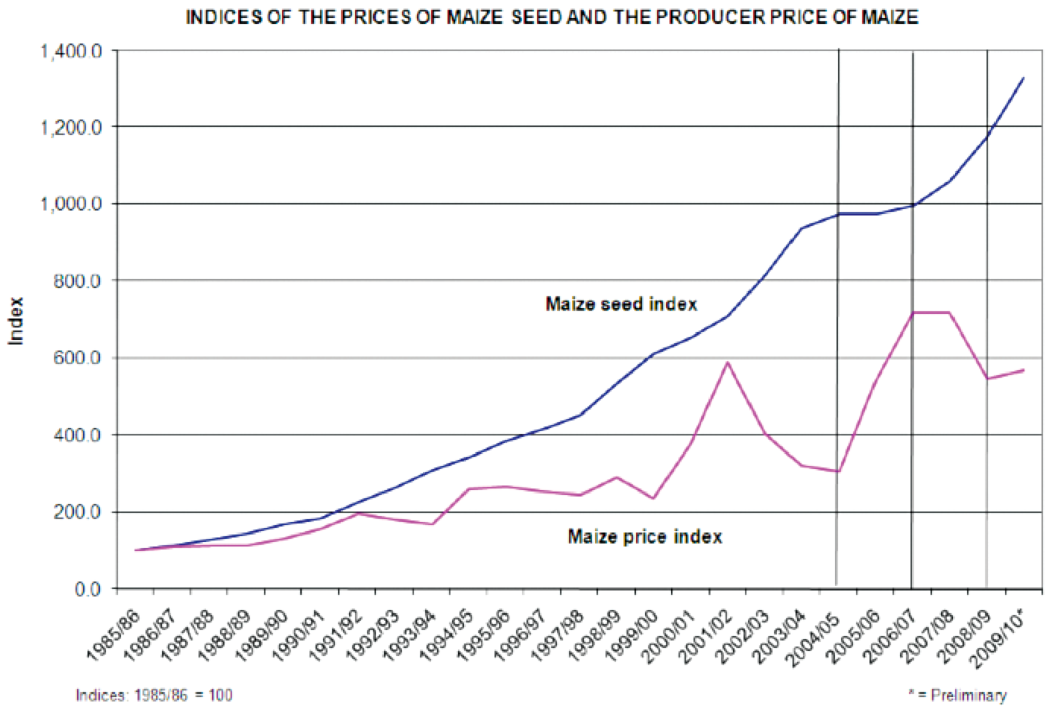
Source: Department of Agriculture GMO permits[54] cultivation of two new varieties, GA21 (for herbicide tolerant) and the stacked *Bt*11 x GA21[53].

As the proportion of GM maize seed sold on commercial markets has increased, so too has its price, as the price list data (below) from Grain SA for seeds from the largest players in market, Monsanto, Pannar and Pioneer Hi-Bred, clearly illustrates. It should be noted that this is not necessarily the end price farmers pay for seed, as some scope for discounts is offered for early or bulk purchases, for example. However, it does provide a good indication of the general upward trend, with the average price for yellow GM maize seed being 35% higher, as offered by the three companies in 2011, than it was in 2008. For white maize the figure is 30%. Of further interest is that price increases were highest for single gene *Bt* varieties, which, though still the most popular varieties, have seen their share of total plantings fall from 71% to 46% over the same period[55]. This is consistent with practices in the United States, where seed companies raise the prices of their older, single trait varieties in order to encourage farmers to use their latest products[56]. According to Grain SA, in the 2004/05 season, the cost of seed accounted for 6% of a maize producer's overall costs, by the 2010/11 season this figure had more than doubled, to 13%[57].

MON810 – complete product failure in South Africa

MON810 is approved for human consumption in more than a dozen countries worldwide. By 2011, *Bt* Crops were planted on 66 million hectares in 25 countries across the globe. Studies have reported a significant decrease in pesticide use against *lepidopteran* pests of cotton and maize[58]. However, despite the success of *Bt* crops, sustainable control of pest populations is threatened by the evolution of resistance[59]. While *Bt* crops remain effective against four target pests in the USA after a decade of intensive production, the experience in South Africa has been vastly different. The African stem borer (*Busseolla fusca*) was one of the first pests in the world to develop resistance to the Cry1ab toxin produced by MON810[60]. *Busseolla fusca* occurs throughout sub-Saharan Africa and is the major target pest against which *Bt* maize will be commercialised in African countries within the next few years[61].

Before the advent of *Bt* crops in South Africa, farmers were spraying broad spectrum insecticides, such as montocrophos and pyrethroids[62]. Average annual yield losses



Source: Grain SA

due to the stem borer damage prior to the deployment of *Bt* maize was estimated at 10%. Farmers started adopting *Bt* yellow maize (used mainly for animal feed) during the 1998/99 season and white maize (for human consumption) during the 2001/2 season. Today the adoption rate is over 80%, and in certain areas the market penetration of the *Bt* trait is nearly 100%[63]. This high adoption rate is ascribed to the convenience of pest management and the economic gains made through savings on pesticide use and reduced loss of yield to pest damage. Even though the seed is more expensive, farmers claim that their income has increased. Irrigation and dryland commercial farms reported yield increases of about 10% in the 1999/2000 and 2001 seasons, while small-scale farmers reported a 32% yield increase in the same period. However, in seasons when insect pressure was low, yields of *Bt* and non-*Bt* were similar[64]. The success of this technology has, however, been rather short-lived.

According to South African expert, Dr Jannie van den Berg, 'The current state of *B. fusca* resistance in South Africa is that resistant populations are reported at new localities on a regular basis. Cry1Ab-toxin therefore lost its efficacy against *B. fusca* at many localities throughout the maize producing region where single-gene *Bt* maize events are planted. The single-gene *Bt*-events are often in combination with herbicide tolerance traits'[65]. As discussed, a stacked event expressing two different Cry proteins, Cry1A.105 and Cry2Ab, has replaced MON810 in South Africa for the 2012/13 growing season to control the African stem borer larvae[66]. It is uncertain how long this stacked variety will remain effective because when similarly high levels of resistance in *B.fusca* develop in the near future, the range of options for new stacks is limited to those used before resistance development or to Cry proteins that are very similar to Cry1Ab. Should resistance develop in other toxins in the Cry1 or Cry2 class, there are few alternative Cry toxins left for plant breeders to exploit[67].

Factors contributing to the rapid evolution of *Bt* resistance in South Africa

The greatest concern for developers of *Bt* crops, from the outset, was always how to slow down inevitable insect resistance to the *Bt* toxin expressed by the crops[68]. Once pests develop resistance the crop is no longer protected, rendering the technology useless. A large amount of research was dedicated toward managing this eventuality. A number of insect resistant (IRM) strategies were developed and tested, the most common being the 'high dose/refuge' system. This system is predicated on three assumptions:

- The plant must express enough toxin to kill off most of the target pest feeding on the crop;
- A refuge of non-*Bt* crop must be planted to allow a non-resistant insect population to flourish; and
- The gene that confers resistance is recessive and therefore not easily passed on.

The theory was that through the use of this insect resistant management (IRM) system, the majority of potentially resistant insects feeding on the *Bt* crop would be destroyed and those that survived could mate with non-resistant insects feeding in the refuges. Thus it was deduced (incorrectly as will be discussed below) that due to the recessive resistance gene, the next generation produced would not inherit resistance.

Biotechnology proponents showed great confidence in the safety of the GM technology in public and regulatory arenas. However, a 1997 industry report on the management of resistance (the year that South Africa approved their first GM crops), shows clearly that the understanding of insect management of GM crops was rather rudimentary:

> *The effect of the strategies proposed or adopted, whether or not in conjunction with various other management practices, such as IPM, is still somewhat speculative and based on extrapolation from scientific experiments and predictions based on prior experiences. Unfortunately, only large-scale deployment will provide the true test for the durability of the genes and the generation of a body of evidence that will allow optimum and safe deployment strategies to be developed[69].*

Indeed, we are only now beginning to understand some of the environmental impacts almost two decades after the release of Bt crops. This has proved to be a steep learning curve for South African farmers and regulators.

The blame for the rapid development of pest resistance in South Africa is usually placed on farmers for not complying with the refugia requirements set out in their contractual agreements on purchase of the seed. The lack of compliance has played a major role in the development of resistance, but other important players have also contributed to the problem. Resistance has occurred as a result of irresponsible management of GM crop technology by farmers, chemical and seed companies'[70] as well as regulators, who should not have approved MON810 on the basis of the scientific data before them and then failed to carry out their vital monitoring and enforcement role.

Regulatory incompetency and false scientific assumptions

The pre-commercialisation data on MON810 shows that the transformed maize was expressing lower doses of the Cry1Ab protein in relation to the local stem borer pest than it should have. According to international pest expert, Bruce Tabashnik, the levels of expression would not have met US requirements for such events and would therefore not have gained clearance for commercial release there[71]. However, South African regulators considered the efficacy of the *Bt* sufficient from a crop protection perspective to warrant commercial release of MON810 hybrids even though the expressed Bt toxin in the crop plant did not comply with the high dose requirement[72]. Local scientist, Dr Jannie van den Berg, the first person to publish data on resistance in South Africa, states that, 'Results from these first efficacy screenings with B.Fusca and the absence of a high-dose event should have highlighted the likelihood of quick resistance development and should have prompted intensive monitoring of resistance levels as well as one of the major components of the IRM strategy, i.e. refuge compliance'.

The results of this pre-commercialisation data led to a question about whether in fact resistance inheritance in the African stem borer is recessive, as previously assumed. A ground breaking study was published in July 2013, showing that 'that resistance of *B.fusca* to *Bt* corn is dominant, which refutes the hypothesis of recessive inheritance'[73]. This dominant resistance gene can be expected to 'lead to rapid evolution of resistance in a pest population and to drastically reduce the efficiency of the refuge strategy'[74]. This finding will need to be factored into future insect resistant management strategies and the authors of the study suggested that in such a context, a refuge should account for about 55% of the total surface to delay the time for resistance to develop at 10 years[75]. Mon810 was doomed to resistance in South Africa before it even came out of the starting block.

Monitoring – too little too late

Between the first plantings of MON810 crops in 1998 and the first official report of resistance in 2007, no systematic monitoring of resistance was carried out[76]. Even in the first growing season there were reports of stem borer damage on MON810 crops, but these were not interpreted as early warning signals of impending resistance. In 2007, the first study on resistance was published by Dr van den Berg, showing that there were resistant populations of stem borers in the Christiana area in the Northern Cape province. Within one year of the first official report of pest resistance, other cases of control failure were observed by farmers in the Vaalharts area, approximately 50 km from the initial site. According to results from an extensive farmer survey conducted during 2010, the presence of resistant populations in the maize production region showed that borer damage to *Bt* maize had been observed over a number of cropping seasons between 2003 and 2008. A 2010 survey found resistant populations, with farmers in some regions experiencing over 50% infestations, compelling them to spray insecticides or risk significant financial losses. A conservative estimate is that approximately 250 cases of *Bt* maize failure have been reported annually over the past few years[77].

In 2010 the government finally woke up when SANBI published the results of a joint research project, carried out with the Norwegian government on the environmental impact of MON810. This is the first and only study published to date in fulfilment of their mandate under the National Environmental Biodiversity Management Act (NEMBA), requiring them to monitor the post-commercialisation impact of GMOs.

SANBI confirmed the development of resistance in their research and they identified further factors that could have caused resistance. They found that the maize expressed different doses of Cry1Ab toxin in different parts of the plant, e.g. stem and cob. Insects feeding on the low dose areas were in essence getting 'vaccinated' against the toxin. They also found that cross-pollination of *Bt* maize and non-*Bt* maize could produce low dose expressing plants, again, contributing to resistance. Their research concluded that where resistance had already set in, current refuge strategies would not be useful in managing the problem[78].

Lack of compliance on refugia

South African farmers were quick to adopt the technology, but for a variety of reasons did not comply with refuge requirements. The current refuge requirements are either that a 20% refuge of non-*Bt* maize must be planted, which may be sprayed with insecticides, or a 5% refuge area that may not be sprayed[79]. The vast majority of farmers choose to go with the 5% refuge, but often still spray with insecticide to prevent economic loss.

Permit conditions that are set when approval is given for the commercial release of GM crops require that GM producers must sign contracts with farmers obliging them to follow specific management practices, such as the planting of refuges. However, the vast majority of farmers admit that they did not familiarise themselves with the contents of the contract or the accompanying user's manual. Most said that they relied on seed suppliers for this information rather than reading the documentation. In the so-called 'resistant hotspot', Vaalharts, only 7.7% of farmers planting *Bt* crops planted refuges in 1998. The level of compliance increased, on average, by 9.3% a year, reaching 92.3% in the 2007/8 season. In some regions, many farmers continued to spray insecticides on their fields as a preventative measure, therefore negating the basic benefits of *Bt* crops, i.e. ease of management and reduced input costs.

The average area farmers planted to maize in Vaalharts was between 4ha and 400ha. About 28% planted between 71ha and 80ha, and about 23% of farmers planted over 100ha. 96% of farmers used varieties containing MON810 while the other 4% used *Bt*11.

In a survey done across the maize producing regions, some of the reasons for non-compliance included:

- A belief that others were planting non-GM maize, therefore providing the necessary refuges. The rapid adoption of GM, for example in the Vaalharts irrigation area, which rose to almost 100% over a nine-year period, meant that this was not the case.
- Difficulty due to the small size of plots, and a belief that such small plots did not warrant refuges.
- An unwillingness to take responsibility for the common management of insect resistance and a belief that others would do so.
- Fear of economic damage to the refugia[80].
- Difficulty following prescribed refuge layouts due to pivot irrigation methods.
- Refuges are labour-intensive and time-consuming

Where farmers were planting refuges, it was found that many of them were planting incorrect refuge layouts, which can exacerbate the problem of resistance.

The graph below shows the adoption of *Bt* crops and refugia compliance between 1998 and 2009. The cumulative percentage of farmers planting refugia followed the same tendency as the cumulative percentage of farmers signing first-time contracts. Survey data showed that no first-time contracts were signed during 1999, 2002 and 2004[81].

Once reports of resistance began to emerge in the Christiana area, and through concerted efforts of seed companies and regulators, compliance with refuge requirements began to increase, until almost 100% compliance was realised in 2009. This may have resulted from stewardship programmes instituted during the 2008/2009 growing season, which involved grower education programmes as well as the signing of contracts between companies

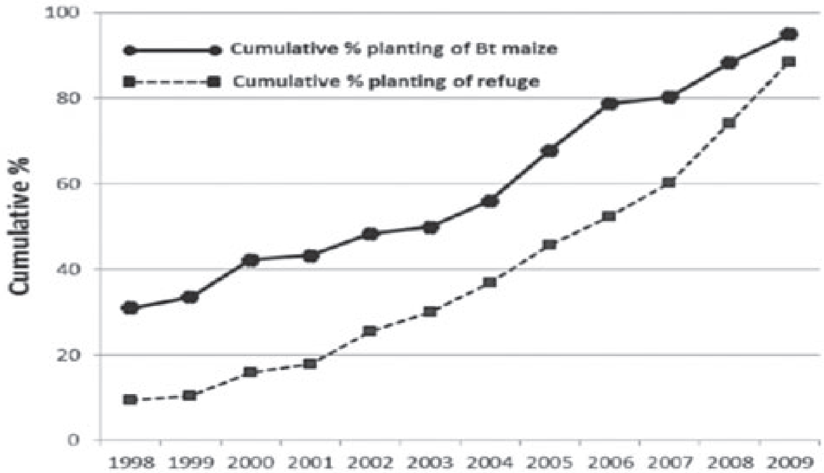


Figure 2. The cumulative incidence of farmers planting Bt maize and complying to refuge requirements between the 1998 and 2009 growing seasons in South Africa (Data pooled over several maize production districts).

Source: Kruger, et. al

and farmers that contractually bound them to comply with refuge requirements. Seed companies began to carry out on-farm inspections to investigate cases of possible non-compliance and also instituted punitive measures for farmers that did not comply[82]. By this time, some farmers were experiencing more than 50% infestation and during the 2007/8 cropping season, Monsanto absorbed the spraying costs against stem borers for those farmers that planted early in the season and on whose *Bt* maize fields the incidence of stem borer infestation was higher than the economic threshold level for control (10% of infested plants)[83].

Another notable finding regarding farmer practice with *Bt* crops, was that because farmers had faith that the technology was providing the necessary pest control, they engaged less in scouting missions, checking for damage. According to farmers, the increasing pest pressure of stem borers on *Bt* maize was realised too late, possibly contributing to the rapid development of resistance[84].

As the resistance has now reached an advanced level, the only available future strategy to delay resistance development is to plant maize cultivars that express different Cry genes. A stacked event that expresses Cry1A.105 and Cry2Ab (MON89034), approved in 2010, will be planted on a large scale in South Africa from the 2012/13 growing season onwards. However, it is as yet unknown how long these will remain effective against this tenacious pest and the future number of Cry genes available for pest management are limited.

While the use of MON810 has come to an end in South Africa, it is just the beginning for the rest of Africa. South African GMO permit lists indicate that Monsanto exported 1654 grams of MON810 seed to Kenya for planting, and 4.1kgs to Uganda[85], presumably for field trials. Efforts to develop public *Bt* crops for Africa have been ongoing since 1999, but have not to date yielded any results.

Insect Resistant Maize for Africa (IRMA) fails to commercialise *Bt* maize

The Insect Resistant Maize for Africa (IRMA) project was initiated by the International Maize and Wheat Improvement Centre (CMMYT) in 1997 to develop an African-wide solution to the African maize stem borer. It was launched in Kenya in 1999 with the Kenyan Agricultural Research Institute (KARI) as a co-implementing agent. Financial support came primarily from the Novartis Foundation, which later merged with AstraZeneca to form Syngenta.

The key collaborators (and their contributions) included:

- the Ministry of Agriculture (MoA) for

advisory and public awareness;
- the Kenyan Plant Health Inspectorate Services (KEPHIS) and National Council for Science and Technology (NCST) for regulatory affairs,
- the University of Ghent for training on regulatory and biosafety issues;
- Agriculture Research for Development (CIRAD) of France for synthesis of *Bt* events for the development of IRMA maize lines;
- Africa Biotechnology Stakeholders Forum (ABSF) for communication and awareness creation;
- the Rockefeller Foundation for funding; and
- the University of Ottawa and Monsanto became involved at various phases.

A naïve wish to develop biotechnology for the poor

IRMA was based on rather naïve and noble principles at the begining – they wanted to make *Bt* technology available to resource-poor farmers and therefore were intent on creating open pollinated *Bt* maize varieties and use *Bt* technology that they thought was in the public domain[86]. Both of these ideals were soon shattered by environmental, political and economic realities.

The reason for wanting to use open-pollinated varieties of maize is that resource-poor farmers are unable to afford the purchase of fresh seed from year to year. Open-pollinated varieties are therefore preferred as they remain viable year after year while hybrid maize varieties must be bought annually to ensure yield advantage. Apart from the cost issues, IRMA noted that farmers are in the habit of 'recycling' and selling seed and will do so regardless of what they are told or contractually bound to do[87]. This fundamental fact was acknowledged by IRMA staff and catering for this reality was a core principle of the project. An immense amount of participatory appraisal was carried out under the auspices of IRMA to understand the reality of Kenyan agricultural practice, the problems they face and the solutions they apply[88]. This approach was also adopted in trying to come up with appropriate strategies to ensure the implementation of refuges, once *Bt* technology became available. This participatory research resulted in innovative solutions for refugia compliance that match current practices, such as the planting of napier grass, which can ultimately be used for fodder[89]. However, in 2005 IRMA finally had to acknowledge that *Bt* technology simply cannot be employed in open-pollinated varieties[90]. If *Bt* maize is recycled or cross-pollinates, the new plants will not express the necessary high dose of toxin needed for insect resistance management. Instead, the lower doses expressed in the next generation will assist pests to acquire resistance very quickly. Intellectual property issues aside, the technology can only be used for one season if it is to remain effective.

Over the first two phases of the project (1999–2006) IRMA experimented with Cry1Ab and CryBa1 genes that had been made available to them by the University of Ottawa and backcrossed these into elite maize germplasm supplied by CIMMYT-Mexico[91]. *Bt* genes with resistance to four of the five major stem borers (*Chilo partellus, Chilo orichalcociliellus, Eldana sacharina* and *Sesamia calamistis*), were successfully incorporated and tested in insect bio-assays in Kenya.

In 2005 the first open field trials of *Bt* maize were planted. Contained use trials had already been carried out in Kenya's state-of-the-art greenhouse. (The level II safety facility, costing US$11.5 million, was funded under the IRMA project by Syngenta and the Kenyan government.) However, in August 2005 the trials had to be destroyed when it was discovered that the crops had been sprayed with insecticide, jeopardising the results of the trials. Wilson Songa, Kenya's agriculture secretary and chair of the National Biosafety Committee was quoted in Kenya's *Sunday Nation* newspaper as saying that the error had occurred as local scientists had yielded to pressure from international organisations and were 'rushing projects'[92].

A major blow came to the project in 2005 when they learnt that their genes were protected by intellectual property rights that only allowed them to be used for experimental purposes[93]. Intellectual property agreements, which were not sufficiently understood at the time of negotiation between Ottowa University and CIMMYT, meant that they would never be allowed to commercialise their new varieties. They entered into urgent negotiations with

Ottawa University in an attempt to sidestep the problem, but in the end the intellectual ownership of the cry genes resided in a number of private hands and there was no way around the problem[94].

An even greater blow to the project was the difficulty in finding suitable genes to control the most serious pest, which is mainly found in the highland ecologies, the African stem borer – *B. fusca*. Two pest species had been identified as of major economic importance: *B. fusca*, causing 82% of all stem borer losses in Kenya, and *C. partellus*, causing 16%. It was therefore found that 'if the project manages to find a *Bt* gene that is effective to the fifth stem borer, *Busseola fusca*, adoption rates are likely to be high, and therefore the returns. ... However, if such gene cannot be found, *Bt* maize technology would only be effective in the low potential areas, and adoption rates would be fairly low, although benefits would still exceed costs'.[95] The genes that the project had access to were simply not giving the hoped for results.

In an attempt to save the situation, in 2006 IRMA began to negotiate with Monsanto for use of MON810 in their project. This was the absolute last resort for the project, which had begun with a core principle of using public technology to keep end-user costs as low as possible, not to mention that Sygenta and Monsanto are major competitors, who were at that time embroiled in a litigious web of suits and countersuits regarding intellectual property[96]. However, Monsanto had recently applied for a permit to experiment with MON810 in Kenya and the technology had been used effectively in South Africa to control *B. fusca* up until then. (Although resistance had been noted informally in South Africa at that time, the first official scientific paper confirming resistance only came out in 2007. Even then, it was not clear that the technology would be rendered useless within the next five years.)

According to an independent journalist who was following and documenting the IRMA project as it unfolded, 'While this development could be explained on both scientific and financial grounds, IRMA was effectively forced to its knees by existing patent law, as all cry events available to CIMMYT were stamped in this respect with the mark of Cain: "for scientific use only". This gave private industry a headlock on existing biotechnological research funded with public resources. The multinational seed companies alone determine who will profit when, and where, from the potential benefits of agricultural biotechnology'[97].

The focus of IRMA in 2006 was on negotiations with Monsanto. It was decided that smaller packs of seed, appropriate for small-holder plots, would be sold royalty-free by IRMA. However, Monsanto remained determined to produce only hybrid varieties, this was non-negotiable. A point of contention in the negotiations was the demand of the seed producer to limit freedom from licensing for a number of years. 'The rationale that farmers' incomes would increase so much as a result of higher yields that they would no longer need assistance seemed far-fetched to practitioners'[98]. In the meantime, IRMA continued with the development of hybrid and open-pollinated varieties as well as work on insect resistant management strategy.

It is unclear how the licensing negotiations finally panned out, but it would seem that no agreement was reached. However, an application was made to the Kenyan National Biosafety Committee (NBC) in April 2007, to compare MON810 and the CIMMYT varieties for efficacy against *B. fusca*. The application was revised from an earlier one approved for research at KARI. The revised application reflected the new testing location, and research objectives that would include comparison of efficacy with the IRMA *Bt*-maize public events with MON810. The results, published in 2011, showed effective control from MON810 hybrids, while the public event did not control *B. fusca*. The researchers found that 'Deploying *Bt*-maize Event MON810 may, therefore, be used to control the two species of stem borers. However, the efficacy of *Bt*-maize Event MON810 will need to be evaluated under field environments'[99].

At the end of 2008, IRMA announced that the next phase of their project would focus on sharing expertise gained in the first two phases. In their project report they stated that 'IRMA III (2009 to 2013), which is funded by the SFSA, seeks to share the benefits from IRMA II to the Eastern and Southern Africa regions. This phase focuses on developing and deploying conventional maize that is resistant to field and storage insect pests. *Bt* breeding, which was initially planned, is no longer being pursued in phase III'.[100]

IRMA had failed to bring the promised *Bt* technology to the market after much media hype and fanfare. The fact that they could not deliver was a great blow for the credibility of the technology. Bringing a *Bt* product onto the African market remains a vital goal for the biotech lobby, now for the sake of the industry and its proponents, rather than for the good of farmers. In an interview with an IRMA staff member, they said, 'I would not like to imagine that [the] project will not come out with products. Because people might not trust GM again in Kenya'[101].

Nonetheless, the project succeeded in developing a great amount of scientific research capacity in Kenya. IRMA's principle scientist, Dr Steven Mugo, stated that, 'The project has already had a tremendous impact on Kenya's capacity to conduct research with GM crops. Many scientists and technicians were trained in biotechnology, and information and guidance was provided to help the National Biosafety Committee deal with this new technology. Infrastructure was also provided to execute the research. On top of regular equipment such as cars and computers, biosafety laboratories, greenhouses, and a quarantine station were provided. The project is likely to have a spillover effect as Kenya gains experience in GM technology'[102].

Water Efficient Maize for Africa (WEMA) sneaks MON810 into its programme

In 2008, The Bill Gates and Warren Buffet Foundations announced a pledge of US$47 million towards the development of the Water Efficient Maize for Africa (WEMA) project. This public/private philanthropical partnership aimed to increase food security in sub-Saharan Africa through the development of 'drought-tolerant African maize using conventional breeding, marker-assisted breeding, and biotechnology' and avail this to smallholder farmers royalty-free. Monsanto has pledged to contribute four drought resistant varieties from its research and development pipeline to the project[103]. The project is being rolled out in five countries – South Africa, Uganda, Kenya, Tanzania and Mozambique.

Through a quiet sleight of hand, MON810 was incorporated into the WEMA project plans in 2011[104]. There seems to have been little publicity created about Monsanto's decision to donate MON810 to WEMA royalty-free; news bulletins and updates about WEMA now simply state that the project aims to increase food security 'by helping develop seeds that mitigate drought risk and manage insect pressure', as if this had always been the aim.[105] The use by Monsanto of a seemingly philanthropical project as a vehicle to gain regulatory approval for their lucrative *Bt* technology is extremely expedient, especially in light of widespread doubt that their single-gene drought resistance technology will actually work[106]. In addition, collaboration in this project gives Monsanto access to excellent African germplasm that has been specifically chosen and bred for its drought and insect resistant qualities and adaptation to African conditions.

In a recent gathering of WEMA stakeholders for the purposes of reviewing the project to date and planning the next phase, Global Maize Programme Director, B. M. Prasanna, thanked Monsanto for donating the drought tolerant and *Bt* genes, saying, 'This is a tremendous opportunity to address some of the biggest challenges to African smallholder farmers (drought and stem borer infestation). Mon810 presents yet another great opportunity for WEMA to tap into the products from the Insect Resistant Maize for Africa project to develop a product that addresses many of the insect related constraints'.[107]
Other WEMA project collaborators include the International Maize and Wheat Improvement Centre (CIMMYT) and the National Agricultural Research Agencies (NARS) in the participating countries in East and Southern Africa.

The implementing agency for the project is the African Agricultural Technology Foundation (AATF), an organisation set up to assist in developing enabling policy environments for the adoption of GM technology in Africa. The AATF's stated role in the WEMA project is the

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contribution of their 'expertise in product stewardship, regulatory affairs management and technology delivery'. Their role has so far been to lobby for African governments to put in place weak and permissive biosafety regulatory regimes to facilitate the introduction of GMOs in African agriculture. AATF is allowed to distribute the maize varieties developed under the auspices of the WEMA project using Monsanto's drought tolerant transgenic trait, to African seed companies, royalty free.

WEMA trials MON810 in Kenya and South Africa

WEMA proponents predict that drought tolerant crops will increase yields by 30%, translating into an estimated two million additional tons of food during drought years in the participating countries. The project is preparing to release 29 conventional drought tolerant, early maturing, disease resistant hybrids, which are slated to be available in 2014 to farmers in Kenya, Uganda and South Africa, and in 2015 to farmers in Mozambique and Tanzania. The WEMA project states that "the 29 hybrids advanced to national performance trials is a record release by an entity in Africa in all times"[108]. They are promising 20-35% higher yields under moderate drought conditions compared to commercially available hybrids that were available in 2008. These yield gains are exactly the same as those promised from GM drought varieties, so one has to wonder if it is worth the incredible expense and regulatory rigmorale to develop GM varieties when hybrids perform as well?

Nonetheless, field trials for GM drought resistant varieties have begun in South Africa, Kenya and Uganda already, with Kenya and Uganda in their third year of trials and South Africa in its fourth. Kenya has also just harvested the results of its first field trial of MON810 under the auspices of WEMA.[109] While Uganda's Biosafety Bill is still before parliament, trials of the drought resistant GM variety were conducted at the foothill of Mt Rwenzori, western Uganda[110]. The next trials are planned for Namulonge in central Uganda. Uganda's trials on *BT* maize are being carried out in tandem with those for GM drought-resistant maize as well as stalk-borer resistance using conventional methods[111].

Tanzania ran mock trials in 2009 to simulate the ideal field trial conditions and put in place procedures and regulatory oversights to enable the actual trials to take place. A liability clause in the regulaitons to the Tanzanian Environment Management Act on Biotechnology is reportedly holding back the roll out of GM trials in Tanzania. WEMA has threatened that 'Tanzania could lose out and get isolated from technical assistance in ... WEMA if it doesn't review the strict liability clause in its biotechnology law'. The clause places strict liability on developers and partners should anything go wrong.

In South Africa, the drought tolerant field trials have met with opposition from smallholder farmers in the vicinity of the trial. A formal objection to the GM trials was submitted to the South African Government under the auspices of the Right to Agrarian Reform for Food Sovereignty Campaign, assisted by the Surplus People's Project. These small scale farmers from Lutzville, Northern Cape, also held a protest to show their opposition to GMOs. In their written objection, the farmers complained that they had not been consulted about the trials taking place in their area where in fact, they are practicing agroecological farming methods. A particular concern raised was that Monsanto's proprietary technology would undermine seed and food sovereignty:

'The introduction of biotechnologies like drought resistant maize for South Africa and sub-Saharan Africa undermines the seed and food sovereignty of the countries people and farmers. Seed saving is an important component of farmers in sub-Saharan Africa, and South Africa in particular. This technology would further deskill and destroy the farming practices of poor black farmers'. They called on the South African government to redirect their activities to support alternative and more appropriate production systems like agroecology[112].

These concerns were dismissed by the South African GMO authorities as being unscientific and the trials went ahead.

Intellectual property rights in WEMA

Despite their reluctance to donate MON810 to IRMA five years earlier, Monsanto agreed to provide MON810 royalty-free to the WEMA project for sub-Saharan Africa, except in South Africa where smallholder farmers already have access.[113] The term royalty-free should not be confused with the word 'free'. Essentially what it means is that a certain category of farmers will not have to pay the premium price for the biotech crops and will therefore get it at a similar price to conventional varieties. Monsanto maintains all intellectual property (IP) rights on the technology. When one carefully examines policy documents around IP and licensing requirements in WEMA, it becomes apparent that this is a project to kick-start the hybrid market and supply chain, which is largely undeveloped as of yet across Africa.

Unlike IRMA, WEMA has a well-defined intellectual property policy. CIMMYT has engaged the services of an organisation called PIPRA (the Public Intellectual Property Resource for Agriculture), founded by the Rockefeller Foundation in 2004, to provide services such as the assessment of potential IP constraints to projects. The AATF is an affiliate of PIPRA and a key organisation in the WEMA project in terms of smoothing over biosafety and intellectual property policy and law in implementing countries. According to the PIPRA attorney chosen to integrate public sector issues and interests on behalf of CIMMYT into the WEMA public-private partnership (PPP) research agreement, 'PPPs can be difficult to negotiate, given the deep cultural differences between the public and private sectors related to confidentiality, publication rights, public goods, and intellectual property rights. PIPRA offers a unique resource with its experience in articulating public sector goals and its mission to provide services to support the strategic management of intellectual property rights among public agricultural research organisations worldwide'[114].

The following provisions are provided for in WEMA's IP policy[115]

Confidentiality

The parties will keep the drought tolerance transgenic event(s) in the Project confidential during the period of regulatory review, and prior to commercialisation of the same events outside the project territories. The obligation to maintain in confidence confidential information will last for the duration of the project plus 10 years.

Intellectual Property

Project partners are free to seek IP protection for any discoveries and creations made during the project; these can be protected through plant breeders' rights, patents, or other means according to the domestic law of the member country. Each party in the project will have their own breeding programmes and discoveries or creations made during the project are to be jointly owned by the employers of the creator (e.g. the State in the case where one or more of the national research system was involved). The exceptions include that discoveries will be owned by the partner whose breeding programme developed it, regardless of the source of the starting germplasm used to develop it. In other words, Monsanto, who has superior breeding technology will gain free access to germplasm brought into the project and will own the new varieties developed within its own breeding programme (As noted earlier, they did this effortlessly in Egypt, accessing Egyptian maize and cotton germplasm and ultimately owning exclusive rights).

Product allocation and licensing

The development of a distribution chain for the sale of seed is an important aspect of this PPP. According to WEMA documents, 'the intent of WEMA is to move towards an exclusive licence environment, but there will always be non- and semi-exclusive to hybrid licensing to accommodate small and medium-sized seed companies. Companies who receive exclusive licences must reach a minimum sales target after the hybrid's third year, in order to retain exclusive licence'[116.] WEMA also plans for seed companies with exclusive rights to be granted first opportunity to market transgenic versions. It is expected that companies with exclusive licenses will be able to provide their own production needs and will provide their own product management function and assume all risks associated with the supply and demand of their exclusive WEMA hybrids. However, WEMA breeding material is not up for licensing.

Liability

Implementing agency, AATF, protects technology donors from liability through indemnification provisions and warranty disclaimers in agreements and by conducting a comprehensive risk analysis for each project. Most not-for-profit organisations are typically averse to providing indemnification in the agreements they sign, but AATF is not a typical not-for-profit organisation. On a case-by-case basis, AATF indemnifies technology donors. AATF also uses warranty disclaimers, allowing donors to disclaim guarantees that would otherwise arise by law. AATF's risk analysis procedures identify risks early and allow for the development of risk-mitigation strategies for each project, thus reducing exposure to possible liability claims.[117]

At the time that the policy documents outlining these IP and licensing criteria were developed, it was not yet clear that MON810 would also be incorporated into the project. It is not absolutely clear if these criteria apply to the use of MON810. However, Monsanto has stated that they have 'donated' MON810 to WEMA, so it is assumed that all of the above applies to this technology. It is also interesting to note that MON810 came off patent in 2011 and is therefore no longer protected. However, when it is stacked with new events, such as drought tolerance, it retains its intellectual protection under the new stacked event. It is also possible that royalty payments are linked to the size of the market seed companies are able to tap and expand.

Technology for technology's sake – promoting MON810 in Africa at all costs

IRMA's principle scientist, Dr Stephen Mugo, is now the principle scientist on the WEMA project. IRMA is collaborating with WEMA to share their considerable knowledge and experience in biotechnology, biosafety, and farmer relations in an effort to finally bring *Bt* technology to African farmers. It is quite possible that a Kenyan *Bt* maize could come on to the market in the near future, scoring a win for the biotech industry, desperately in need of a PR victory on the continent. However, this will be a far cry from the initial aims of the IRMA project, which sought to bring a product that was developed with the needs and practices of smallholder farmers in mind.

Initially, the goal was to bring public, not private technology onto the market to keep costs within the reach of farmers. The other goal was to develop open-pollinated insect-resistant maize varieties in recognition of farmers' practice of recycling and sharing seed. This is a cultural imperative and also a practice that ensures that farmers have access to seed even when they have no cash; an important survival strategy. These were core principles of the project, developed through extensive stakeholder engagement. It will be a hollow victory to commercialise a *Bt* product that is unaffordable for the majority of farmers unless it is subsidised, with the double whammy of encouraging farmers to abandon their survival strategy of replanting farm-saved seed in favour of purchasing hybrids annually.

To make matters even worse, their new technology is already second-hand, having been abandoned in South Africa after the rapid development of large-scale resistance. The reason for the failure can now be attributed to the biology of the African stem borer as well as the fact that management practices to stop resistance are burdensome to farmers and regulators. As pointed out by Jannie van den Berg, this will be even more so in other African countries, where, unlike South Africa, very small plots of land are the norm[118]. Monitoring and enforcing compliance over thousands of smallholdings and ensuring that seed is not recycled and shared is going to be a mammoth task, and if it is not managed properly, resistance is almost a given.

PPPs' promise to transfer technology to the continent comes at a high price; the policy environment must be adjusted to suit private investors and kick-start their business. This can include tightening up IP measures, and seed trade laws (e.g. phytosanitary laws), which ultimately privileges corporate seed while undermining the importance of, or even criminalising, farmer varieties.

The privatisation of breeding and the concomitant erosion of public breeding work also means that only commercial varieties receive attention while important food security crops, which have little monetary value, are ignored. In addition, biosafety measures are relaxed, including risk assessment procedures and strict liability for damages. Once extremely lax and permissive biosafety measures are in place, agribusiness is free to trade their commercial products, while the philanthropical projects may or may not successfully bring promised products to the market. Even if they do succeed in bringing products to the market, it remains questionable whether those products will be appropriate to African agricultural systems and customs or efficacious in the long term.

These kinds of projects are effectively transforming African agriculture through policy and knowledge creation in favour of proprietory commercial products while eroding the genetic and knowledge base that underpins African agriculture.

Peasant agriculture has fed the human population successfully over the past 10 000 years and, even today peasant agriculture feeds over 70% of the global population[119]; industrial agricultural is nowhere near as effective. According to a recent report by the ETC group that analysed who actually provides our daily food, 'There has been a Pavlovian conviction that agricultural technology can meet our future food needs – and a pathological denial that industrial agriculture has contributed to today's food crisis. If we are to survive climate change, we must adopt policies that let peasants diversify the plant and animal varieties on our menus. Only they have the know-how and patience to find out what plants and livestock will thrive'[120].

http://people.uwec.edu/ARNSR/Images/Maize%20crop.jpg

It stands to reason that we should continue to nurture and support the time-tested system that has given us these incredible results rather than trade it in for a new form of agriculture that has increased yields in a small number of commodity crops while wreaking environmental and social havoc.

Scientific and political support for this view is gaining a lot of weight in the international arena, with the United Nations publishing a growing number of studies in the last 5–10 years and one very recently in 2013, showing that family farming and agroecological methods can provide sufficient quantities of healthy, culturally appropriate food at the same time as increasing socio-economic and environmental well-being[121].

MON810 in Egypt – coercion, corruption and muddy waters

The development of Egyptian MON810 maize

Egypt is the only African country besides South Africa that has given approval for the cultivation of a GM food crop. Egypt's experience with modern biotechnology began as early as 1990, with the United States investing heavily in creating an enabling environment for the production and sale of GMOs in Egypt. USAID funded the 'state-of-the-art' Agricultural Genetic Engineering Research Center (AGERI) in 1990 and began concerted efforts to inform stakeholders about the benefits of GMOs in 2003. USAID also funded a two-phase process to 'develop a Competent National Authority for Biosafety', consisting of a policy and regulatory development phase and assistance to the Ministry of Agriculture's Competent National Authority. Teams of scientists from both Egypt and the United States were established to address specific commodity constraints and policy issues such as biosafety and intellectual property rights, and management and networking within the project[122].

The development of an Egyptian maize variety containing MON810 began in 1999 when an Egyptian seed company, Fine Seeds, approached Monsanto to negotiate their distribution of Monsanto's Roundup herbicide. Instead, Monsanto persuaded Fine Seeds to partner with them to develop a *Bt* yellow maize, using a local maize variety called Ajeeb. Fine Seeds was responsible for getting the variety through all of the regulatory hoops, as well as ensuring the distribution of seed, while Monsanto worked with their South African team to do the transformation[123].

In 2000 Fine Seeds submitted an application for regulatory approval of Ajeeb-YieldGard to the National Biosafety Committee (NBC) in Egypt, on behalf of Monsanto[124]. At that time Egypt did not have a domestic Biosafety Framework in place and followed the Cartagena Protocol, ratified by Egypt in 2003. It is claimed that the government used European guidelines for risk assessment. From 2005 to 2008 the NBC lead the testing and risk assessment process, resulting in approval for the commercial release of MON810 in 2008[125]. In that year the Egyptian government allowed the importation of about 28 tons of MON810 seeds into Egypt, but in 2009 the NBC stopped further importation of GM seed (mainly from South Africa) with the intention of first completing the Biosafety framework in the country; yet they allowed Monsanto's GM seed that was produced locally to be planted[126].

The decision to commercialise MON810 in Egypt does not appear on the international Biosafety Clearing House (BCH), a mechanism under the Cartagena Protocol to share decision making and scientific information on the use of GMOs. The risk assessment on which the decision was based also does not appear on the BSH.

Commercialisation – controversy and confusion

Egypt's approval of the planting of Ajeeb-YG maize was deeply controversial, with some officials 'refusing even to talk about it'[127]. An Egyptian official who had been involved in drafting Egypt's biosafety law, claimed that the drafting process had been a very transparent one, resulting in an excellent law approved of by all stakeholders. The draft was completed in 2004 and should have been published that year. According to the official, one of the key problems for Monsanto, was the strong liability clause in the draft, making the technology producer liable for any environmental damage[128]. The commercialisation of Egyptian MON810 maize was therefore permitted in the absence of national biosafety legislation and, as a result, was not subject to the rigorous biosafety procedures envisioned by the drafters of Egypt's biosafety law. In 2013, the biosafety legislation is yet to be passed by the Egyptian government.

Another massive controversy also surrounded the intellectual property rights of the new GM maize, which now belonged to Monsanto. Monsanto had begun in a 'partnership' with Fine Seeds to pave the way for the introduction of their technology and ended with ownership of an Egyptian variety[129]. According to Nagib Nassar, Egyptian professor of genetics and plant breeding at the University of Brazil, 'At the end of the day what was originally an Egyptian variety will become not only registered in Egypt, but owned by Monsanto, and Egyptian scientists will end up only making the backcrossing'[130].

Many academics expressed grave concern that Monsanto is also engaged in developing a *Bt* version of Egypt's elite long-staple cotton. They questioned whether Monsanto would ultimately lay claim of ownership to these quality varieties that Egypt is famed for, simply by inserting their gene into the germplasm. [131] A 2009 USDA report suggests that their fears were well-founded, reporting that a potential 'new cotton crop will contain a gene purchased from Monsanto that makes the plants resistant to certain insects, but it will retain its unique Egyptian characteristics in every other respect. The new plants produce the sought-after long staple fibers for which Egypt is known. The selection was done by the breeders, making the collaboration a multi-disciplinary approach. The new cottonseeds contain a patented gene. Any future user of the gene must pay a royalty to Monsanto, but advocates say that increased output, along with the amount farmers will save on chemical fertilisers, will more than cover the price of the switchover'[132].

A representative from Fine Seeds described the relationship between Fine Seeds and Monsanto as being negatively affected by power imbalances and a lack of shared decision-making. He says as follows: 'They [Monsanto] are our masters. That is talking in the old, before the revolution mentality. There is the big dictator and the small dictator sitting and meets all of us here. We [Fine Seeds] are the servants; we are the slaves in the private sector or whatever. And when we need anything to move, they need to put their say. So we go and beg and then they come down to our level and they try to listen to us and sometimes they say "yes"'[133].

A further concern expressed about the introduction of GM maize seed was the increased cost of biotech seeds. According to Al-Tayeb, hybrid seeds on the Egyptian market were already being sold for up to 15 times more than conventional seed. He pointed out that with hybrids a farmer would probably get a higher yield, but that it would be unlikely to offset the 15-fold difference in the cost of seed. Mon810 would cost even more than they hybrid varieties and therefore did not make economic sense[134]. Other factors to consider include that in years of low pest infestation there is little to gain from the higher cost[135], that the adoption of GM crops could affect market acceptance, and also fluctuating prices on the international market can affect profit.

It remains unclear how much Ajeeb YG is being planted in Egypt at present. South African GMO export permit lists show that two shipments of MON810 seed, destined for planting, were granted in 2012. One shipment was for 50 tons and the other 40 tons. In July 2012 the Egyptian media reported that 40 tons of MON810 maize was seized and destroyed due to irregularities in the approval process. The *Egyptian Times* reported that 'The January shipment has been imported without the formal approval from the Ministry of Environment, the agency that should approve imported genetically modified organisms (GMOs)'[137]. The Ministry of Agriculture, which is not mandated to approve transboundary movements of GMOs, had apparently signed the importation papers.

Independent African research on health impacts of GMOs

According to Monsanto's data on MON810, which is supplied to government regulators for risk assessment, the Cry1Ab protein has selective toxicity to specific *lepidopteran* insects but is harmless to humans, fish, wildlife and beneficial insects that can help control other pests[139]. This dangerous assumption has effectively delayed the necessary scientific exploration into the long-term impacts of consuming the toxin that crops express due to the insertion of cry genes from *Bt*. This false claim is largely based on the fact that *Bt* proteins have been used safely for nearly 40 years in microbial insecticides[140]. However, current research shows that natural *Bt* and *Bt* expressed in plants are not necessarily the same[141].

Until quite recently, there was an absolute dearth of peer reviewed studies exploring the potential long-term risks of GM foods. In a peer reviewed study conducted in 2007, which aimed to collate the available peer reviewed data on GM safety and toxicology, the author stated that, 'According to the information reported by the World Health Organisation (WHO), the genetically modified (GM) products that are currently on the international market have all passed risk assessments conducted by national authorities. These assessments have not indicated any risk to human health. In spite of this clear statement, it is quite amazing to note that the review articles published in international scientific journals during the current decade did not find, or the number was particularly small, references concerning human and animal toxicological/health risks studies on GM foods'. He concludes by asking, 'Where is the scientific evidence showing that

http://praag.org/wp-content/uploads/2013/07/maize.jpg

GM plants/food are toxicologically safe?'[142]

A follow up study by the same researcher in 2011 found a rapid rise in peer reviewed published papers on GMOs, although research focusing particularly on safety assessment was still limited[143]. He found that papers published or funded by biotech companies tended to conclude that GM foods are safe. However, he also noted an equal amount of independent studies raising serious concerns, concluding that 'the scientific community may finally be able to critically evaluate and discuss all that information, which was not possible until now'. The study concludes by bringing attention to a recent literature review which found that 'results of most studies with GM foods would indicate that they may cause some common toxic effects such as hepatic, pancreatic, renal, or reproductive effects, and might alter the hematological, biochemical, and immunologic parameters'[144].

It is heartening, however, to see that independent Egyptian government studies on the safety of Ajeeb Yieldgard maize have been published and are adding to this growing body of science. It would appear to be a world first. Certainly not even the South African government, which has allowed the cultivation of GM crops for the past 13 years now, has managed to publish independent data on the potential health impacts of commercialised varieties in the country.

Two studies, carried out by the Egyptian government were published in the Journal of American Science in 2012. A feeding study, conducted with rats fed Ajeeb Yieldgard, concluded that GM maize intake had caused statistically significant impacts on the liver, kidney, testes, spleen and small intestine. The researchers recommended that more scientific investigation, including case-by-case and long-term studies are clearly necessary to ensure that consumption of GM foods would not result in health problems[145].

The other was a feeding study with male rats. The results of the study 'showed several changes in organs/body weight and serum biochemistry in the rats fed on GM corn. These findings indicate potential adverse health/toxic effects of GM corn and further investigations still needed'.[146]

In 2013 another government study, in partnership with the Alexandria University, was published in the Journal of Applied Chemistry. This study was a chemical analysis of MON810 Ajeeb maize and the original non-GM parent Ajeeb. The research found that the genetic modification of *Bt* maize showed significant differences from the conventional counterpart, that may be toxic to the human food and animal feed. Accordingly, further long term feeding studies are required to assess the actual safety of *Bt* maize.[147]

It is now scientifically accepted by the international scientific community that international protocols for long-term research are urgently needed. The European Food Safety Authority has begun the process of developing such a protocol for long-term food safety testing[148].

Some of the concerns that have already emerged from independent scientific research, particularly about *Bt* crops include[149]:

- Effects on gastro-intestinal tract: inflammations, ulcerations and excessive growth of stomach and gut lining;
- Disturbance of liver, pancreas and kidney function;
- Disturbance of testes function (male function);
- Alterations in haematology (blood composition) including a possible link to leukaemia;

- Altered body weight;
- Allergenicity / Immune responses; and
- Impacts on second generation.

These findings all suggest the need for follow-up research and long-term studies to determine the safety of consuming *Bt* crops. This is particularly urgent for Africa because maize is not an industrial crop on this continent, but a staple food for many millions.

Egypt stuck in the middle of a GMO trade war

GMOs do not, in reality, contribute to fighting global hunger; the advancement of this notion however, is important for GM proponents to win the GM trade war that continues to rage between the US and the European Union. In 2003, Egypt became a football in this trade war that resulted in a diplomatic nightmare for the country. In 2002, the United States announced that Canada, Argentina and Egypt would join them in their demand to the World Trade Organisation (WTO) to intervene in the European Union's 'ban' on GMOs, which they claimed constituted unfair trade practice according to WTO rules[150]. The USA felt that the support of Egypt was essential to their case because the USA argued that GM crops were vital to global food security. Egypt's support of the USA's case would fortify the US's claim that the technology was appropriate for developing countries and of value to their food security efforts. The United States had invested a fortune in biosafety capacity and infrastructural development in Egypt over the past decade[151]. The two countries were also on the brink of negotiating a Free Trade Agreement (FTA).

While the Ministry of Foreign Trade officially gave their support to the case, the Ministry of Foreign Affairs was concerned about the impact their support would have on their relationship with their major trading partner, the European Union. Consequently, the government sent mixed messages about their support, both through diplomatic channels and in the media. When the Ministry of Foreign Trade sent Egypt's complaint about the EU's position on GMOs to the Egyptian Embassy in Geneva, diplomats did not deliver it to the WTO secretariat. Instead, the Egyptian ambassador to the European Union issued a statement at the end of May saying that Egypt had reconsidered its support of the US in its complaint against the EU, stating that, 'The Government of Egypt took this decision to preserve adequate and effective consumer and environmental protection and with the desire to reduce further distortions and impediments to international trade that may result due to the further pursuit of this matter within the WTO'.[152] The Egyptian government had decided to keep their major trading partner happy at the expense of a possible trade agreement with the USA, the potential benefits of which were still unclear.
While the decision was welcomed in the European Union, and particularly by consumer campaign groups there, it infuriated the US government. The incident caused great embarrassment to the Egyptian government when the US trade representative, Robert Zoellick, lambasted Egypt in front of 1,200 businessmen and experts at the Davos Forum, describing their economic policies as unprepared and leading to an unfriendly investment climate[153]. Previous talk of an FTA between the two countries dried up.

RESISTANCE TO MON810 IN EUROPE

Mon810 is one of only two GM crops that may be cultivated in Europe and it is mainly grown in Spain for the animal feed. The other is BASF's 'Amflora' potato, developed to produce starch for paper making. However, BASF withdrew GM production from the EU in 2012[154].

Although the European Union has granted approval for the commercial cultivation of MON810, there is no consensus on its cultivation among the European member states. Over the years, France, Germany, Austria, Hungary, Greece, Luxembourg, Italy and Poland have prohibited the cultivation of MON810 in their countries, citing uncertainty about long-term environmental impacts[155]. According to the Eurobarometer, a series of public opinion surveys conducted regularly on behalf of the

European Commission since 1973, no more than 20% of the people in the countries concerned are in favour of GMOs in food[156].

In May 2013, the European Food Safety Authority (EFSA) was asked to assess the documentation submitted by the Italian government supporting their ban on MON810 in that country. EFSA in relation to the ban concluded that 'there is no specific evidence on risk to human and animal health or the environment that would support the notification of an emergency measure under Article 34 of Regulation (EC) No 1829/2003 and that would invalidate its previous risk assessments of maize MON810'[157]. However, in August 2013, the Italian government signed an inter-departmental decree banning the cultivation of MON810 maize on environmental grounds. According to Agriculture Minister Nunzia De Girolamo 'It is a measure that protects our specificity and safeguards Italy from standardisation. Our agriculture is based on biodiversity and quality'[158].

Similarly, in August 2013, a French court ruled that the country's ban against MON810, instituted in February 2008 and extended in 2012, was illegal and ordered that it be revoked. The court found that, under EU rules, such a prohibition 'can only be taken by a member state in case of an emergency or if a situation poses a major risk to people, animals or the environment'[159]. However, French President Francois Holland has since announced that the ban will be upheld and that the French ruling would have to be reviewed at a national and European level[160]. He, like his predecessor Nicolas Sarkosy, is determined to keep GM cultivation out of France.

Despite bans on the cultivation of MON810 in many EU member states, the GM permit list published by the GMO authorities in South Africa shows that Monsanto, during 2012 and 2013, exported from South Africa over 418 000 kgs of MON810 seed to France for contained use experimentation. In the same period, Pioneer Hi-Bred exported 360 kgs of MON810 to Austria for the same purpose[161]. Monsanto has also imported small amounts of MON810 seed to South Africa from France[162], essentially using South Africa as a greenhouse and experiment lab for its international business.

CONCLUSION

This briefing has looked at South Africa's experience with Monsanto's earliest *Bt* technology MON810 and has found that the product failed within 15 years of adoption. Factors that contributed to this failure include that the African stem borer behaves somewhat differently to pests in other countries; the pest seems to have an ability to resist *Bt* toxin and quickly adapt to survive. Other causes for the failure also inlcude the fact that MON810 was introduced before the technology was properly understood and should not have gained approval based on the scientific data available to regulatory authorities. This was compounded by the fact that an effective regulatory framework was not yet in place to monitor and administer GM crops. In addition, farmer management of GM crops is new and burdensome for farmers and the monitoring of compliance is expensive and difficult. However, if such compliance is not met, the technology cannot succeed in the long term. Once the product fails, the temporary solution is to introduce yet another GM crop – a stacked variety – and thus continue to keep farmers on a treadmill of ever-increasingly costly seed that is, too, doomed to failure in the long run.

Despite these lessons, other African countries are showing an eagerness to try out the same failed technology, which is being brought into their agricultural systems through charitable projects such as WEMA. Investigation into how such projects work has shown that bringing GM crops to smallholder farmers in a way that does not undermine their current farming practices and survival needs is nigh impossible. The greatest beneficiary in the end is the developer or the owner of the technology, like Monsanto, who has: captured charitable projects as a way to introduce its product onto the market; undermined good biosafety policy and gained access to public germplasm and patented these. At the same time, classical breeding programmes continue to develop new varieties that are performing very well in African conditions, and this is done quicker, cheaper and without the dangers of patents or the need for excessive regulatory requirements.

It is now time for African governments to take cognisance of the recommendations of many international reports that support agroecological farming methods and distance themselves from privately owned industrial agriculture. Agroecology is the key to our future food security, social and environmental well-being. Policies need to be shaped, not to hand over our food systems to transnational agribusiness, but to support smallholder farmers using the resources they have available to cultivate diverse food systems for local consumption. Small farmers are, after all, the people who have fed us for millennia and continue to do so today.

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