The adoption and impact of agricultural biotechnology innovations in South Africa

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Working paper: 2002-09

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THE ADOPTION AND IMPACT OF AGRICULTURAL BIOTECHNOLOGY INNOVATIONS IN SOUTH AFRICA.

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Prepared as chapter in: Nicholas Kalaitzandonakes (ed). Economic and Environmental Impact of Agbiotech: A global perspective: Kluwer-Plenen, Academic Publishers. (Forthcoming)

1. Introduction

Various biotechnology innovations have partly been responsible for the changes in much of the input industry in South Africa just like it happened in Europe and the US.

South Africa is one of the few developing countries and probably the only one in Africa that has adopted some new biotechnology inputs – largely maize and cotton seeds. South Africa also has a number of active biotechnology research programmes and the chapter will also highlight those briefly.

This chapter starts with an overview of the structure of the South African agricultural input industry and shows the changes in the industry in response to some of the innovations in the agricultural input industry more specifically that of biotechnology. It then discusses the adoption of the new biotech cultivars of maize and cotton amongst farmers in South Africa. The chapter concludes with one of the first preliminary analyses of the economic and environmental impact emanating from the adoption of these two biotechnology inputs.

2. The size and structure of the South African Agricultural Input Industry

Expenditure by South African farmers on intermediate goods and services during 1998/99 is estimated to be R21 392 million ($3 billion) — an increase of 6.8 % on the 1997/98 figure. The individual expenditure on the major intermediate inputs is as follows (National Department of Agriculture, 1999):

Farm feeds	R 4 896 million
Fertiliser	R 2 076 million
Maintenance and repairs on machinery and fixed improvements	R 3 774 million
Packaging material	R 968 million
Dips and sprays	R 2 019 million
Fuel	R 2 318 million

Expenditure on imported intermediate inputs is around R3 000 million or 14% of total expenditure on intermediate goods and services. Intermediate goods and services – those inputs and services consumed in the production process – contributes a total of 51% of all expenditure while capital expenditure on machinery, implements and fixed improvements is second with a 25% share.

Information on the agricultural input industry is rather sketchy due to the confidentiality of most information. It is therefore not possible to provide a comprehensive picture of market structure and market share in each of the main industries.

2.1 Seed industry

The South African seed market has an annual turnover of almost R1 000 million (SANSOR, 1998). Seed for maize and wheat production accounting for 66% of the seed market, dominates the market. Vegetable seed is second with 18%, followed by pasture/forage with 13% and flowers with 3%. In total the South African farmer has access to almost 2 000 varieties. Most of South Africa's seed requirements is produced locally under contract with farmers and extensive use is made of irrigation to ensure good seed quality.

The agronomic seed market is dominated by hybrid maize with some 230 hybrids available. More than 800 vegetable varieties are on the official lists, half of which are F1 hybrids (Van der Walt, 1997). On July 1, 1989 the South African National Seed Organisation (SANSOR) was officially designated by government as the authority to manage the Seed Certification Scheme. The organization has 90 members including co-operatives and many of the leading international and local seed companies such as Pannar, Pioneer Hi-bred and Hygrotech. The organisation has active campaigns to remove levies paid on seed. It was also responsible to negotiate a zero tariff for all imported seed.

2.2 Fertiliser industry

The South African fertiliser is largely dominated by 3 primary manufacturers of fertilisers namely Kynoch (a subsidiary of AECI), Sasol and Omnia (each with a market share of between 20 and 50%). There is however one additional manufacturer namely Indian Ocean Fertilisers located at Richards Bay manufacturing mainly for the export market. The nitrogenous components required for fertiliser production are derived from ammonia, which is produced by Sasol and AECI. Phosphate rock is locally mined and used in the manufacture of phosphates by Foskor. Products sold by the fertiliser manufacturers in South Africa include materials prepared from local phosphates, imported components and locally compounded materials. Kynoch, Omnia and Sasol also sell raw materials to a relative large number of secondary manufacturers of specific fertiliser combinations or products whom often also serve a specific geographical region. Some fertiliser manufacturers import most of their raw materials. Blended granular solid fertilisers are manufactured by the 3 major players plus 5 other large suppliers namely Nitrochem, Atlas Organic, Nitrophoska, Plaaslike boeredienste, Profert (Venter, 1999, 2000).

The annual consumption of fertiliser is estimated at 2 051 000 tonnes (Venter, 2000). Of this total around 442 258 tons (Customs and Excise, 1999) are imported – mainly potash. Fertiliser imports are free and thus local manufacturers are not protected from foreign competition. Despite the fact that fertiliser can be imported free of duty we have not witnessed a large increase in fertiliser imports. Current statistics show that only 20% of total fertiliser sales are imported.

2.3 Agricultural chemical industry

Agricultural chemicals include crop protection chemicals and animal health products. There is an active market for agricultural and crop protection chemicals including herbicides, insecticides, fungicides and various other, associated products in South Africa. A large number of international companies, including Bayer, Novartis, Dow Agro Sciences (who recently acquired Sanachem) Zeneca, Rôhne-Poulenc manufacture and distribute agricultural chemicals in South Africa. Companies active in the animal health sector are ICI, Bayer, Pfizer and Hoechst. Raw materials are largely imported from these companies and manufactured and formulated under license here in South Africa. Some companies have their own manufacturing, formulation and/or packaging plant in South Africa. These products are distributed by large distribution networks and local agents.

The total retail sales in the crop protection during 1997 were R1300 million while farmers also spend around R650 million on veterinary medicine. In total the agricultural chemical industry in South Africa is worth around R2 billion.

All agricultural chemicals are imported free of duty into South Africa. According to Customs and Excise statistics (1999) South Africa imported R215 million worth of insecticides (raw materials as well as already packed) as well as fungicides to the value of R116 million during 1998.

The rest of the paper will focus largely on the developments and market structure in the seed and the agrochemical industry in South Africa since it is within those sectors that most of the biotechnology innovations are taking place.

3. Evolving input market structure in South Africa in response to biotechnology developments

Many of the US and European based agricultural input manufacturers have turned their attention to international markets. Since the democratic reforms in South Africa there was a considerable number of large multinational input manufacturers investing in South Africa to expand sales and increase research efforts here. These firms include names such as Monsanto, Novartis, Bayer, Pioneer Hi-bred, Zeneca, etc. Many of the products of these companies have been known to South African farmers but now these multinationals have either merged with local distributors/manufacturers or has acquired a stake (often a controlling share) in local agricultural input firms.

In the fertiliser industry for example Norsk Hydro one of the world's largest fertiliser companies has acquired a 50% stake in Kynoch fertiliser while Interore acquired a 50% share of Senwes' new established fertiliser subsidiary, Profert - both of these developments taking place during 1999. The same trend happened in the chemical and seed industry with investments by Novartis, Dow-Agro Sciences, Monsanto, Delta and Pineland Company (D&PL) and Pioneer Hi-bred in South Africa.

In the agrochemical industry the most important development in the last couple of years was the involvement of Dow AgroSciences in the South African market. Dow AgroSciences is a global company that provides pest management, agricultural and biotechnology products with worldwide sales of more than $2 billion. The company began as a joint venture in 1989 between the Agricultural Products Department of the Dow Chemical Company and the Plant Sciences business of Eli Lilly and Company that resulted in the creation of DowElanco. In 1997, The Dow Chemical Company acquired 100 percent of DowElanco and the new wholly owned subsidiary was renamed Dow AgroSciences in 1998.

This trend of mergers and acquisitions in the agrochemical industry hit South Africa when DowElanco's parent company Dow Chemical acquired the South African chemical company Sentrachem. Included in the transaction was total ownership of Sanachem, the world's third largest manufacturer of generic crop protection and pest control products. Sanachem is the leading distributor of crop protection products in South Africa, with more than $200 million in annual sales, 500 registrations world-wide and a product line including glyphosate, triazines, mancozeb, aldicarb, carbofuran and phenoxies.

According to a statement by Dow "*..this acquisition plays an important part in DowElanco's strategy to gain leadership in an industry driven by biotechnology, consolidation, and generic competition..*". This acquisition will provide the Dow group of companies to capitalise on both the growing biotechnology and generic products businesses as well as on growth from new offerings in value-added conventional chemistry.

Dow's acquisition of Sentrachem gives DowElanco technology needed to produce glyphosate, the world's largest selling and rapidly expanding crop protection product. The acquisition also includes total ownership of potential glyphosate manufacturer Hampshire Chemical, a U.S.-based intermediates company acquired by Sentrachem in 1995. Sanachem had been laying the groundwork with Hampshire Chemical to commercialise glyphosate at the time of the acquisition.

In addition to the previously referenced products, Sanachem manufactures asulam, bromoxynil, cypermethrin, diuron, propiconazole, tebuthiuron and other products. DowElanco participates in global generic products as well through sales of technical phenoxy herbicides and through both the joint venture Dintec for the global production and marketing of dinitroaniline herbicides and the joint venture DE Nocil for production and sale of chlorpyrifos in India.

The same trend took place in the South African seed industry when two of the well-known and well-established local (grain) seed companies Carnia and Sensako recently became part of Monsanto (Carnia in 1998 and Sensako in 1999). Monsanto bought a 51% stake in Sensako but the company continues to market seed under the same brand name with virtually no effect on price of the seed. It is only the Bt corn varieties that are more expensive as a result of the technology fee. Bt Corn varieties are marketed under the Carnia label such as CRN 7821 for example. Other examples of seed companies merging are Mayford Seed and Cikata (mainly flower and vegetable seed).

Apart from the Monsanto group – the other major suppliers of grain seeds (maize, wheat, and sorghum) are the PANNAR group of companies and Pioneer Hybrid. Together these 3 companies take up more than 90% of the market share and totally dominate the market. The PANNAR group of companies is one of the largest privately owned seed groups in Africa and was founded in 1958 in Greytown, in the heart of the Natal Midlands, on the Eastern Seaboard of South Africa. PANNAR is perhaps one of the few private seed companies left in the world and by far the largest supplier of grain seeds in South Africa. PANNAR also owns Stark Ayres who are one of the large suppliers of vegetable seed. Mayford Seeds and the OTK group (with 26% market share) are the other major players in the seed input industry. In the cotton industry there are only two players supplying virtually all cotton seeds and they are Delta and Pineland and Clark Cotton (part of the OTK group).

The number of foreign owned patents for agricultural technologies and research investments by multinational firms expanded in South Africa – the same trend that happened in many other countries. The number of patents in the maize industry registered in South Africa increased from 0 in 1985 to 22 in 1999. The ownership of patents in the seed biotechnology industry has already led to substantial price differences between the "new" seeds and the traditional hybrid varieties.

In the case of Bt maize the difference is approximately R200 per 25-kg bag of seed or a difference of 60% above the price of traditional hybrids. This amount is a "technology fee" received by Monsanto and varies between R137 and R246 per 25kg bag. This amount is sometimes calculated as R2.74 per 1000 seeds. In the case of Bollguard cotton the price differential is only 8% but the farmers pay an additional "technology fee" of R600 per bag of cottonseed. The cotton farmers are more upbeat about the benefits of the biotechnology innovation in cotton and argue that despite paying the fee of R600 they still save around R200 per hectare.

Table 1: A summary of the input market structure in South Africa (mainly manufacturers)

Input industry	Number of multinationals involved	Estimated # of fully locally owned manufacturers
Seed	5	19
Fertiliser	2	6
Agrochemical	9	? (many local distributors)
Machinery	Little manufacturing – some local assembly but largely imports	1?

4. Who is doing Agbiotech research in South Africa?

With intellectual property rights and patents playing an increasing role in the way the input markets are structured it is important to know who is doing research in this field. From the overview provided below it is clear that a lot of the research is done in the public domain - at the institutes of the Agricultural Research Council (ARC) and at Universities. There are however a number of instances where certain companies work together with universities on aspects of agricultural biotechnology.

3.1 Public sector

South Africa has a well-developed agricultural research infrastructure. The parastatal and semi-autonomous Agricultural Research Council (ARC) comprising of 16 research institutes situated across the country is responsible for the majority of public funded agricultural research in South Africa. The ARC receives a substantial, although declining, parliamentary grant but earn in some cases as much as 60 per cent of its budget through private contracts with the input industry, producer organizations or other international organizations active in Southern Africa. Most of the ARC institutes have one or more programmes in tissue culture/micropropagation. The main biotech research projects of the ARC institutes as well as universities and other semi-state organizations currently involved in biotechnology research and are summarised in Table 2 below. (For more detail see Rybicki, 1999).

Table 2: Public institutions in South Africa involved in agricultural biotechnology research

Institution	Summary of main research programmes
ARC-OVI (Onderstepoort Veterinary Institute)	• Identification, cloning and expression of relevant genes, and preparation of prototype viral-vectored and genetic vaccines for African horse sickness, Newcastle disease, bovine ephemeral fever and Rift valley fever as well as lumpy skin disease.
ARC-Infruitec Division for Plant biotechnology and Pathology	• Development of efficient adventitious shoot regeneration from single cells of in vitro grown leaves of apple, pear, apricot and strawberry varieties • Transformation of and regeneration of transgenic plants • Generation of unique DNA fingerprints for 17 pear, 15 plum, 13 peach and 16 wine grape cultivars.
ARC-Roodeplaat Biotechnology Division	• In-house genetic transformation protocols for melon, potato and tomato • Three potato cultivars have been transformed with genes, which confer resistance to potato leaf-roll virus and potato virus Y. • A gene transfer system for some species of indigenous flowering bulbs
ARC - Institute for Tropical and Sub-Tropical Crops	• Biotechnology and tissue culture techniques used in breeding programs for papaya, guava, ginger, pineapple, coffee and avocado
ARC- Grain Crops Research Institute	• Embryo rescue techniques in order to expedite sunflower breeding and create interspecific crosses in dry beans • Meristem culture techniques to produce disease free dry bean seed • Plant regeneration from tissues in order to create transgenic plants after ballistic bombardment in groundnuts. • Cultivar identification at DNA level in groundnuts, sunflowers and soybeans. • Incorporation of alien genes in order to enhance herbicide resistance in lupins and drought resistance in groundnut. • Marker assisted selection for nematode resistance in soybean. • Breeding of maize cultivars for disease resistance to ear rot and maize streak

	disease. • Maize breeding for insect resistance to stem borers (Busseola fusca)
CSIR (Foodtek /Bio-chemtek)	• Genetic engineering of cereals – successfully transforming and regenerating a laboratory strain of maize (Hi-II). • Maize was genetically engineered to combat maize cob rot caused by one of the most serious fungal pathogens of maize. • Genetic enhancement of the protein quality of sorghum • Genetic enhancement of maize to improve food safety through the introduction of four plant anti-fungal genes to combat contaimination by the post harvest pathogen Fusarium moniliform which produces mycotoxins which are toxic to humans and animals
SA Sugar Experiment Station (SASEX)	• Production of transgenic sugarcane in which desirable characteristics have been added. Varieties containing genes for herbicide resistance. • Developing transgenic sugarcane resistant to sugarcane mosaic virus.
University of Pretoria (Forestry and Agricultural Biotechnology Institute)	• Improvement of disease resistance and the general quality of widely planted forest trees such as *Eucalyptus spp*.and *Pinus spp.* • Improvement of wheat resistance to Russian wheat aphid, leaf rust, strip rust and stem rust.
University of Stellenbosch (Institute for Wine Biotechnology and Instiute of Plant Biotechnology)	• The establishment of efficient transformation and regeneration systems for grapevine cultivars. • The construction of genomic and cDNA libraries of grapevine cultivars. • The cloning and characterization of the PGIP encoding gene in grapevine. • The identification of grape cultivars using genetic marker technology. • Genetic manipulation of carbon flow in sugarcane and grapes. • Characterisation of carbon flux in non-photosynthetic plant systems with special reference to sugarcane and grapes. • Isolation and characterisation of plant

	movers.
University of Cape Town	• Collaboration with PANNAR to develop techniques for the reliable regeneration and transformation of local maize varieties. • Engineering of transgenic resistance in maize to maize streak virus. • Investigation of desiccation tolerance in plants.
University of the North	• Micro-propagation of indigenous trees - Marula
University of the Free State	• Vaccines for diseases in the poultry industry

Sources: Rybicki, 1999
www.arc.agric.za/lnr/insitutes/gci retrieved from the World-Wide Webb on 11 July 2000
www.csir.co.za/world/plsql retrieved from the World-Wide Webb on 11 July 2000

An indication of public research on biotechnology in the most important field crop, maize, is reflected in the number of field trails done by the Grain Crops Research Institute at Potchefstroom (Table 3). It is quite striking that the first trials were done only in the 1998/99 season – immediately following the first commercial release of Bt corn/maize cultivars.

Table 3: Annual number of maize cultivar evaluation trials done by the Grain Crops Research Institute in Potchefstroom

Season	Total number of maize field trials*	# of trials with GM maize
1985/86	45	0
1986/87	52	0
1987/88	58	0
1988/89	55	0
1989/90	55	0
1990/91	53	0
1991/92	64	0
1992/93	75	0
1993/94	71	0
1994/95	66	0
1995/96	72	0
1996/97	71	0
1997/98	57	0
1998/99	62	14**
1999/00	71	18

Source: ARC-GCI, 2000

Notes:

* *Phase 2 trials with registered varieties*

** *From 1998/99 the trails included GM maize cultivars. Before 1998/99 no trial was done with GM maize.*
From 1995 onwards 20 additional field trials were done testing the adaptability of cultivars under small farming conditions

3.2 Private sector

A number of private companies in South Africa are also involved in biotechnology research. The most notable are PANNAR (grain and vegetable seed), Mondi (tree improvement), Monsanto and Pioneer Hi-brid. Some of this research is done in close association with some of the Universities listed earlier. Following Monsanto's acquisition of Sensako and Carnia a joint research team was formed to cut costs on research investments. Table 4 gives an indication of the involvement of the major multinational life science companies as well as some local breeders in research on genetically engineered maize cultivars. The number of field trails gives a useful indication of the extent of research investment in this new technology.

Pannar initiated its hybrid maize-breeding program in 1960 and began developing its own improved cultivars, specifically adapted to meet the demands of farmers in South Africa. A few years later, it became the first private seed company in South Africa to register a maize hybrid for the local market. Over the years many more PAN hybrids followed with demand exceeding all expectations and lately Pannar has introduced some genetically engineered research in its research programme and field trials on genetically engineered maize have rapidly increased from 2 trials in 1995/96 to 105 in the 1998/99 season to 112 during the 1999/2000 season. Two of the trials during each of the last few seasons are testing GMO's which are on experimental release while the rest of the trials are done with the Bt gene which are currently commercially available n South Africa. Pannar uses the Yieldgard Bt technology from Monsanto in the breeding of their own cultivar lines and hybrids. During 1999/2000 they sold their first GM maize seed to farmers and these sales made up only 0.3% of all Pannar seed sales in that season.

Table 4: Field trials of GM maize by major life science and seed companies in South Africa, 1999

Company	**Number of field trials**
Monsanto	3
Agr evo (Aventis)	2
Novartis	1
Pioneer Hi-bred	15
Carnia	7*
BASF	1
Link Seed	6
PANNAR	112
Total	**147**

* Part of Monsanto, South Africa.
Source: Schimmelpfinnig, *et al* 2000
Own research

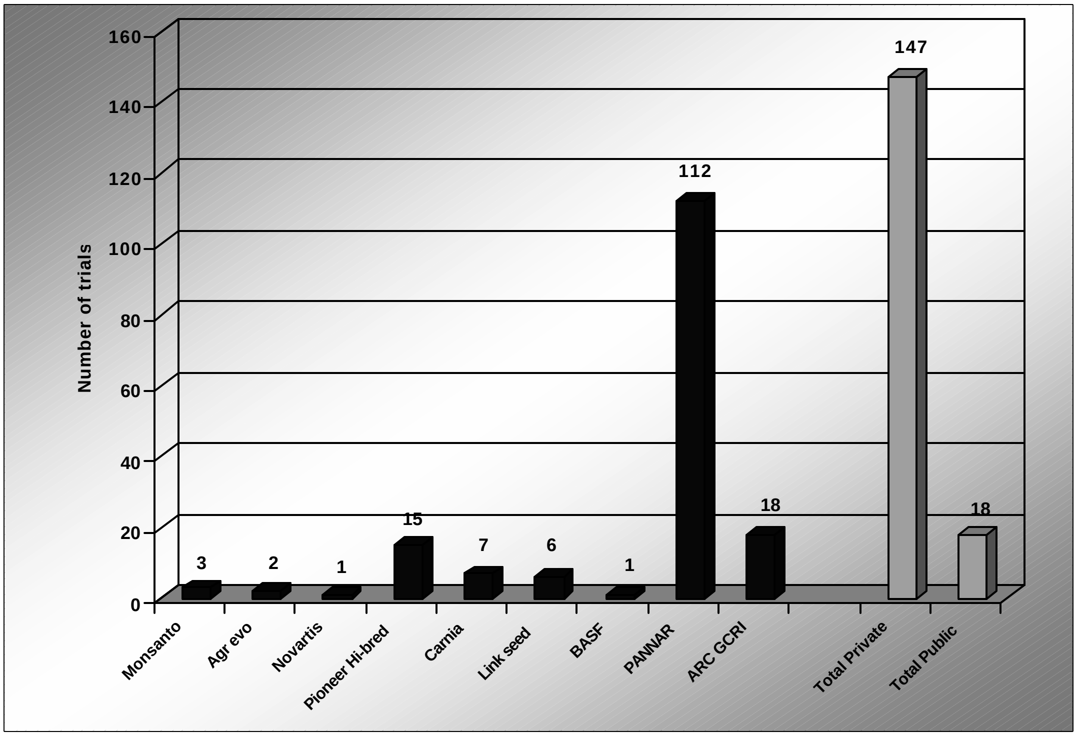

Figure 1: Number of field trials of Bt corn in South Africa during the 1999/2000 season.

Note: *Dark dotted bars are the individual number of trials per private company and the one public research institute the Grain Crops Research Institute of the Agricultural Research Council (ARC-GCRI)*

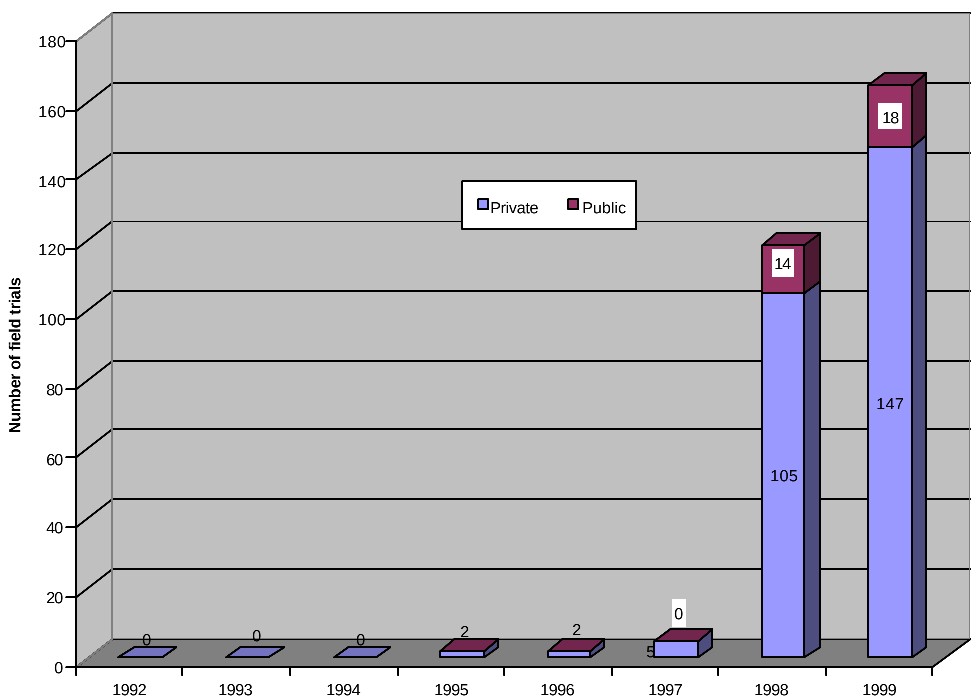

Figure 2: Increase in field trials of Bt Corn in South Africa by private companies and public research system: 1992 - 1999

5. The release and adoption of genetically engineered crops in South Africa.

The South African government has recently introduced legislation (The Genetically Modified Organisms Act, Act 15 of 1997) to promote the responsible development, production, use and application of genetically modified organisms (GMO's). The Act establishes appropriate procedures for the notification specific activities involving the use of GMO's and also provides for the establishment of a council for genetically modified organisms. The task of the council is to advise the Minister of Agriculture on the development, production, use, application and release of GMO's. Up to now the council has only approved the release of Bt Corn/maize and genetically engineered cotton for commercial use and distribution. All indications are that Round-up-Ready soybeans as well as Round-up-Ready maize will be released soon.

The latest estimates (Kruger, 2000) are that 3% of all maize planted was BT maize while between 50 and 60% of all cotton planted was Bollgard cotton. A large number of smallholders in the Makhatini flats in Kwazulu-Natal are already planting the new genetically engineered cotton varieties.

After the introduction of Bollgard Cotton on the Makhatini flats it was adopted with great enthusiasm. After two seasons more than 50% of the small farmers are planting Bollgard cotton. The Makhatini Flats in the Northern region of KwaZulu Natal has traditionally been a cotton production area and with the use of Bollgard Cotton seed, profit margins have reportedly increased rapidly. The high adoption rate can be attributed to the success of the farmers who first started planting Bollgard. A couple of success stories from certain individual farmers encouraged the farming community in the Makatini flats to favourably consider the adoption of this new technology. In a recent survey (November 2000) amongst cotton farmers on the Makatini flats, most respondents indicated that they are aware of the benefits of Bollgard Cotton and that they would like to plant it in the future. Even the farmers who do not plant Bollgard are aware of the benefits. Their reasons for not planting Bollgard are that they do not know the variety and that production information on this variety is limited. This is a valid complaint since Bollgard requires different production practices. In most cases where Bollgard was not adopted successfully the failure was attributed to a lack of information and general production knowledge. A local company, Vunisa Cotton - part of Clark Cotton, is very active in this regard and provides training to farmers in the production of cotton. This is done by field extension officers as well as through farmer-days held across the region. At the moment there are more than 38 farmers' organizations, which vary in membership between 15 and 300 – mainly women.

6. A preliminary assessment of the impact of GM crops in SA

Thus far there has been no study in South Africa that tried to determine the economic and environmental benefits of GM crops. The University of Pretoria in collaboration with the University of Reading, UK has embarked on what we consider the first study to do this. The deadline of this book prevented us from reporting all the results from our surveys amongst the cotton farmers in the Makatini flats and commercial maize growers on the Highveld. In this section we make use of some field trail results from the study areas to give readers a first indication of the likely benefits.

6.1 Bollgard Cotton

There are different reasons why Bollgard Cotton could be successfully grown in smallholder farming areas. In rural areas where infrastructure, transport and services are almost non-existing, managing pest infestation in their crops is a major problem. In many cases the closest chemical supplier is a day's travel away. Most spraying is done by hand and by the time the farmer is finished spraying his cotton, Bollworms have already caused severe damage. Manual spraying also causes illness and dumping of chemicals cause contamination of vital water supplies. Reports of higher gross margins due to higher yields, lower insecticide costs, and labor saving because of less pesticide applications provide some indication that this Cotton variety has potential benefits.

Yield

Due to the fact that the 1998/1999 and 1999/2000 seasons were not normal years in the study area, it would be hard to make an effective judgement of the performance of Bollgard cotton under small-farmer conditions. Drought in 1998/1999 and floods in 1999/2000 caused low yields and in many instances financial losses were reported. According to field-tests done by the Agricultural Research Council on the Makhatini flats, Bollgard has outperformed most conventional varieties. Under irrigation Nu Cotn 37B has outperformed the closest non-Bt rival with 52% and under dryland conditions with 6%. On average Nu Cotn 37B has outperformed the conventional varieties with 39% under dryland conditions (See Table 5). All these field-tests were performed under conventional pesticide spraying practices and all varieties received the same treatment.

Table 5: ARC field test results for dryland Cotton on Makhatini

Cultivar	Yield kg/ha	Fiber %	MIC
Nu Cotn 37B	1926	37	4
DP4049	1812.5	37.7	3.5
DPI4074	1793	38.8	3.6
Siokra V15	1380.8	38.2	3.4
F135	1213.5	41.6	3.8
Sicala	1208.4	34.7	3.6
CS189+	1174.7	38.2	3.9
CA223	1051.9	41.2	3.8
Palala	1024.1	33.1	3.7
Tetra	992.7	36.8	3.5
Delta Opal	976.6	37.7	3.8
Sabie	775	38.4	3.2
Gamka	740.8	33.4	3.4

Insecticides

The efficacy of Bollgard can be see in the tests done by the ARC for Monsanto. These tests where done at the ARC research station at Rustenburg (See figure 3). Tests done on the Makhatini by Monsanto showed that on average Bollgard Cotton can be sprayed 5.8 times less than conventional varieties and still render a yield 27% higher. According to extension officers in this area, weed is an even bigger problem than insects and the introduction of Round-up Ready Cotton could thus be very welcome one.

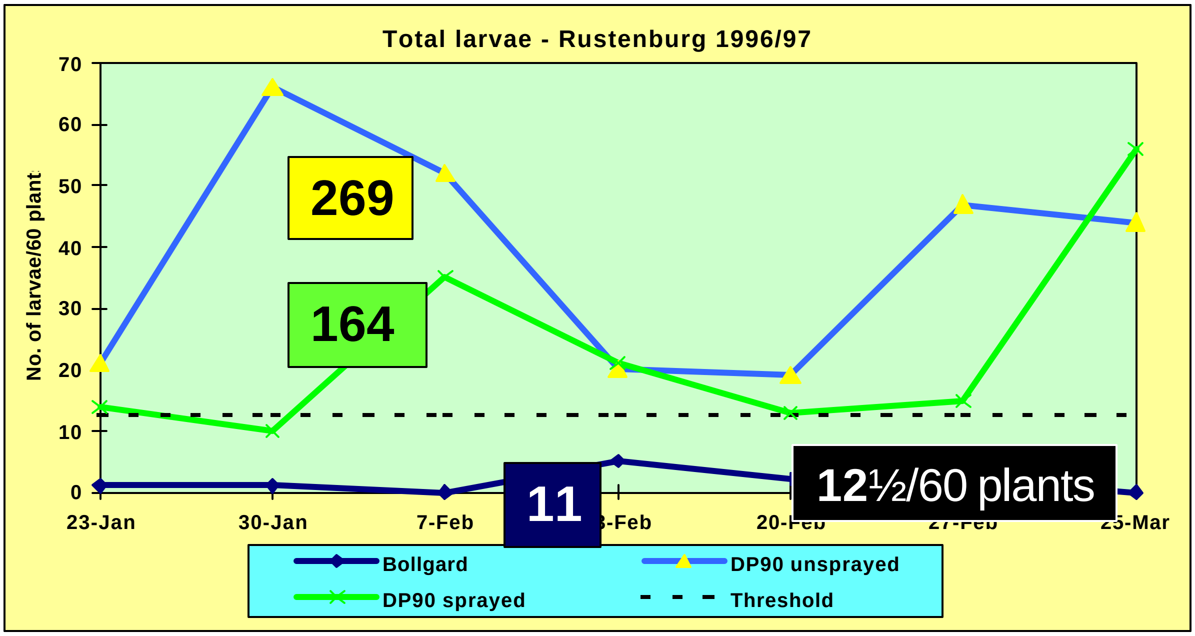

Figure 3: No of larvae's in different cotton varieties: Rustenburg 1996/97

Table 6: Field-tests done on the Makhatini flats comparing Bollgard Cotton with a non-Bt Delta & Pineland variety.

	Grower	Yield (kg/ha) Bollgard	Yield (kg/ha) non-Bt	Yield (kg/ha) increase	% increase	Saved sprays
1	Makhatini 1	2349.4	2005.3	344.1	17.2	7
2	Makhatini 2	1507.8	1205.5	302.3	25.1	6
3	Makhatini 3	1475.0	1149.3	325.7	28.3	6
4	Makhatini 4	2090.4	1509.4	581.0	38.5	4
	Mean	**1855.7**	**1467.4**	**388.3**	**27.3**	**5.8**

According to further field-test done by Monsanto an average of 5.8 sprays can be saved if Bollgard is planted. Only spraying for secondary insects now we estimate that between R150 and R200 can be saved.

Labour

Labour saving because of less pesticide applications are more or less canceled out by the need for more harvesting labour.

6.2 Bt Maize

Adoption of Bt Maize (commonly known as Yieldgard) has not been that impressive. In the last season (2000/2001) the adoption of Bt maize in South Africa has stagnated because of perception or rumours that buyers of maize are willing to pay a premium for non-Bt maize only because of export possibilities. The white Bt Maize variety may be excepted with more enthusiasm, especially by small-farmers. The Bt Maize variety introduced is a yellow maize variety, traditionally used for animal feed in South Africa. Yieldgard holds immense potential for farmers especially small-scale farmers who often lack capital and skills to manage pests effectively. A greenhouse assessment by the ARC in 1996/1997 showed the efficacy of the MON 810 Bt-event to control larvae numbers. The Bt maize clearly show a much lower number of living larvae – thus reducing the need for chemical control of the pest (See Van Rensburg, 1999).

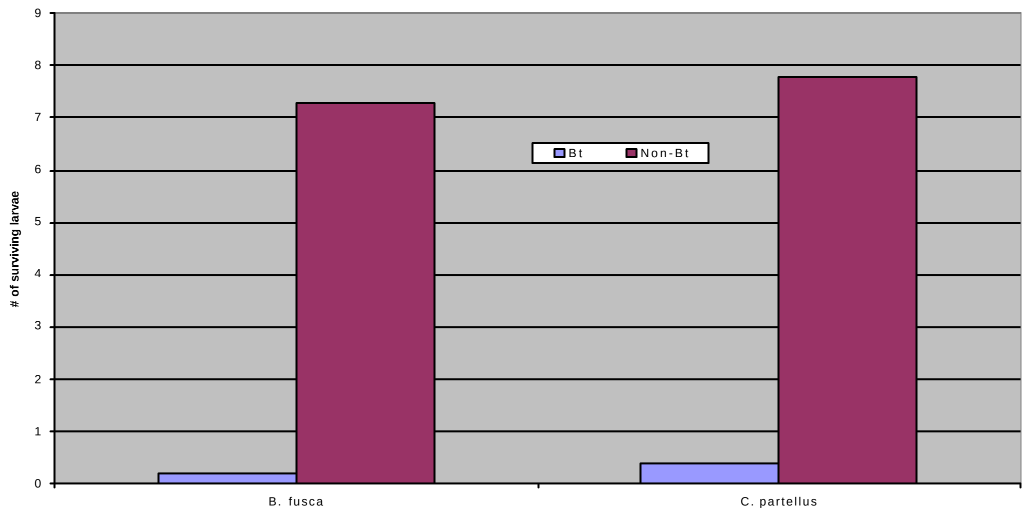

Figure 4: **Greenhouse assessment (1996/1997) of survival of Busseola fusca and Chilo partellus after 10 days feeding on a maize hybrid with and without the Bt-event MON810**

In other field-trails also done by the ARC the plant damage at harvest, and plant responses at harvest was documented. In this field-trail again a hybrid including a Bt event was compared with the same hybrid without the Bt event. Three test situations were created. In the first the study the maize was artificially infested with 10 to 12 neonate larvae. In the second situation the maize was left alone for natural infestation, and in the last test situation the maize was treated with insecticide twice after artificial infestation.

Table 7: **Assessment of plant damage and realised yield on a maize hybrid containing the Bt-event MON810, following artificial infestation with Busseola fusca (ARC, 1996/1997)**

	Damaged plants (out of 20)			Grain yield (t/ha)		
	Infested	**Uninfeste d**	**Treated**	**Infested**	**Uninfested**	**Treated**
SNK2340 Bt	1.2	1.0	1.2	6.475	6.673	6.806
SNK2340 Non-Bt	16.5	6.3	6.7	4.029	5.277	5.254

7. Summary

This chapter provided an overview of the structure of the agricultural input market in South Africa. Particular focus was given to the evolving market structure in response to new biotechnology innovations. The trend of mergers and acquisitions characterizing the agricultural input industries (seed and agrochemical companies) in Europe and USA has evidently also affected the South African market. It is however not mergers and acquisitions between local companies that took place but it was largely the increased role of the large multinationals such as Monsanto, DowAgrosciences, and Novartis in the South African input market which was most notable.

The chapter provided some preliminary assessments of the impact of the adoption of new GM crops such as Bt Maize and Bollgard cotton. The University of Pretoria is currently implementing a farm level survey of small-scale cotton growers and commercial maize and cotton growers who have adopted the GM varieties. As a result this chapter could only rely on field trial results to form an idea of the likely economic and environmental impact. Nevertheless these provided evidence of the higher yields and lower pest infestations possibly leading to higher profits.

References

ARC-GCI (2000). Unpublished information, Grain Crops Research Institute, Potchefstroom.

Bennett, A (2000. Personal Communication, Monsanto, South Africa. November 2000

DowAgroSciences (2000). Various news items retrieved from the World Wide Web at www.dowagro.com

Kruger, H (2000). Personal Communication, Monsanto, South Africa. 25 July 2000.

National Department of Agriculture (1999). *Economic review of the South African agriculture: 1998/99*. Pretoria, August 1999.

Pray, C.; Schimmelpfennig, D. and M. Brennan (2000). Market Structure And Innovation Intensity In Agricultural Biotechnology. Contributed paper presented at the Annual meeting of the AAEA, 31 July to 2 August 2000, Tampa, Florida.

Rybicki, E. (1999). Agricultural molecular biotechnology in South Africa: new developments from an old industry. *AgBiotechnet*, Vol 1, ABN 023, August 1999. Available on the World-Wide Web.

SAAMA (1999). Personal Communication. South African agricultural machinery manufacturers' association.

SANSOR. (1998). *The South African seed industry: gateway to Africa*. Promotion leaflet. SANSOR, Pretoria.

VAN DER WALT, W. (1997). South Africa: leader in African seed trade. *Asian Seed*, Vol. 4 no 3, June 1997:7 – 8.

VAN RENSBURG, J.B.J. (1998). Evaluation of Bt. – Transgenic maize for resistance to the stem borers Busseola fusca (Fuller) and Chilo partellus (Swinhoe) in South Africa, ARC-Grain Crops Institute, October 1998, Potchefstroom, South Africa.

Venter, H. (1999, 2000) Personal communication, Fertilizer Society of South Africa