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THE ECONOMIC IMPACT OF GENETICALLY MODIFIED (GM) CROPS IN SOUTH AFRICA

By

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Submitted
in partial fulfilment of the requirements
for the degree

MSc Agric

Department of Agricultural Economics, Extension, and Rural Development
Faculty of Natural and Agricultural Sciences
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February 2004

Acknowledgements

Firstly I would like to express my sincere appreciation to the maize and cotton farmers who invited me into their homes and shared their knowledge and information. Without their patience this study would not have been possible. My sincerest appreciation also goes to the Rockefeller Foundation who financed this study through a research grant.

To Prof. Johann Kirsten[1], Dr. David Schimmelpfennig[2], Prof. Carl Pray[3], Ferdi Meyer[1] and Zuna Botha[1] my deepest gratitude for their guidance, ideas, insight, enthusiasm and their faith in me.

To my parents and sister who have taught me the qualities of hard work, self-discipline and compassion. I thank them for their love and support and I dedicate my MSc degree to them.

Finally to the Almighty who has provided me with an opportunity to, through this study, marvel at the wonder of His creation.

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February 2004

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ABSTRACT

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Agricultural biotechnology is not a new phenomenon. Man has been manipulating living organisms to solve problems and improve his way of living for millennia. Genetic engineering in agricultural biotechnology however brought a whole new dimension to the development of products and operations. It is these transgenic techniques and the crops they make possible that caused an international outcry amongst certain consumers and advocacy groups. Different groups support and oppose genetically modified crops for different reasons and are motivated by and acting according to different perceptions and ideologies.

South Africa has for approximately 25 years been involved with biotechnology research and development through governmental, parastatal and academic institutions. Due to this strong scientific background, role-players were able to competently and efficiently develop and implement regulatory guidelines when the biosafety process was kick-started in 1989. South Africa currently has a well-established and accredited regulatory system and is in a position to make informed decisions regarding genetically modified crops and their uses.

Agricultural biotechnology is the most rapidly adopted agricultural technology in history and it is said that the impressive adoption rates of these crops are evidence of

their perceived value to farmers. In the 2002/2003 cotton production season an estimated 82% of cotton seed sold in South Africa were genetically modified. Insect resistant yellow and white maize covered approximately 197 000 and 55 000 hectares respectively during that season.

South African large-scale cotton farmers, for whom cotton production is usually not the dominant farming activity, indicated better crop and risk management, pesticide saving and peace of mind as the main benefits. Small-scale resource poor cotton farmers in comparison indicated higher yield and saving on insecticides as the major benefits. Large-scale commercial yellow maize farmers indicated higher yields, better pest control, easier crop management and peace of mind as the main benefits, while small-scale farmers who depend on their harvest for food security, indicated higher yield and better quality as the major benefits. It is thus clear that different benefits appeal to different farmer groups and these benefits are the reasons why farmers adopt the new technology.

The direct costs and benefits associated with Bt crop adoption, as indicated by small- and large-scale maize and cotton farmers, were quantified and expressed in monetary terms. For both large-and small-scale cotton farmers as well as large-scale maize farmers, the increased seed cost (higher seed cost and / or an additional technology fee) were partly offset by a decrease in the need for chemical pesticide application, but mainly by a significant increase in yield due to better pest control. Bt adopting large-scale irrigation farmers enjoyed an 18.5% yield increase on average and large-scale dryland farmers a 13.8% yield increase. The impressive 46% yield increase of small-scale dryland farmers can partly be explained by the ineffective pesticide application practices of these small-scale farmers on their conventional cotton. Commercial yellow maize farmers who adopted Bt maize enjoyed yield increases of between 7 and 12 percent and 7 and 11 percent under irrigation and dryland conditions respectively. Bt adopting cotton and maize farmers enjoyed a higher income per hectare than farmers producing conventional varieties. Early indications suggest that small-scale maize farmers are also able to benefit from Bt technology – predominantly through an increased yield.

The additional economic rent, income or increase in welfare created by the introduction of Bt cotton in South Africa is distributed between four major role-players: The innovator or biotech company, the germplasm or seed supplier, the farmer as cotton producer and the cotton gins as primary consumer of seed cotton. Despite facing two monopolists and a dormant monopsonist, cotton farmers receive the lion's share of the additional income created through the introduction of the new technology.

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TABLE OF ACRONYMS AND DEFINITIONS

Acronym or Term	Full name and / or definition
GMO	Genetically Modified Organism
GM Crop	Genetically Modified Crop
Bt Crops	Refers to the genetically modified crops (insect resistant) that carry the gene from the soil bacterium *Bacillus thuringiensis*.
Bt Cotton	Insect resistant cotton.
Bt Maize	Insect resistant maize.
DNA	Deoxyribonucleic acid. DNA molecules carry the genetic information necessary for the organization and functioning of most living cells and control the inheritance of characteristics (*www.nti.org*).
Recombinant DNA	Recombinant DNA refers to DNA which has been altered by joining genetic material from two different sources. It usually involves putting a gene from one organism into the genome of a different organism, generally of a different species (*www.nti.org*).
ISAAA	International Service for the Acquisition of Agri-biotech Applications
WTO	World Trade Organisation
FARNRPAN	Food, Agriculture and Natural Resources Policy Analysis Network
IFPRI	International Food Policy Research Institute
SAGENE	South African Committee for Genetic Experimentation
ARC	Agricultural Research Council
CSIR	Council for Scientific and Industrial Research
FABI	Forestry and Biotechnology Institute at the University of Pretoria
TB	Tuberculosis
SAGIS	South African Grain Information Service
ICAC	International Cotton Advisory Committee
CIRAD	A French research institute – Agricultural Research for Developing Countries
GPS	Global Positioning System
D&PL	Delta and Pineland
SADC	Southern African Development Community
Vunisa	Clark Cotton ginning company's name in KZN and Swaziland
MCG	Makhathini Cotton (Pty) Ltd

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The Genetically Modified Organisms Act, Act 15 of 1997 was implemented in December 1999 to promote the responsible development, production, use and application of genetically modified organisms in South Africa. Through July 2003, the council for Genetically Modified Organisms (GMO) had approved the commercial release of insect resistant (Bt) cotton and maize and herbicide tolerant (RR) soya-beans, cotton and maize. Cotton with the "stacked gene" (herbicide tolerant & insect resistant) is currently being evaluated in regulatory field trials. Farmers have started adopting GM varieties and insect resistant (Bt) cotton has been produced since the 1997/1998 season and insect resistant (Bt) yellow maize since the 1998/1999 season. Herbicide tolerant cotton was made available for commercial production in the 2001/2002 season and a limited quantity of herbicide tolerant soya-bean seed was also released. Bt white maize was introduced in the 2001/2002 season and 2002/2003 saw the first season of real large-scale production. A limited quantity of herbicide tolerant maize seed will be commercially released for the 2003/2004 season.

Multinational agricultural biotechnology and seed companies have spent significant amounts of money on research and development of new genes, varieties and products. Their aim is to earn a profit on a substantial capital and time investment. Thus, part of the monetary benefit attained from the use of the new technology, genetically modified crops, belongs to them. Farmers on the other hand will only implement or adopt a new technology if there is an additional profit to be made, or if through adoption they are able to manage crops and production risk more effectively.

The international debate surrounding agricultural biotechnology is fascinating, confusing and disappointing. Ethical, moral, socio-economic, political, philosophical and scientific issues complicate the debate. The vocal champions of agricultural biotechnology exaggerate their claims of biotechnology as saviour of the poor and hungry, while the equally loud opponents declare it to be the doomsday devil of agriculture. "Sandwiched between these two camps is the rest of the public, either absorbed or indifferent" (Kelemu et al, 2003).

Agricultural biotechnology companies claim that genetically modified crops will render a range of production benefits. Some of these include:

- Higher yields
- Quality increases
- Labour savings
- Reduction in insecticide use
- Healthier environment

These benefits can also be carried over to the consumer by increasing the availability of healthier, less expensive food or fibre. Various ex ante socio-economic, welfare and environmental studies, conducted by research and academic institutions have focussed on the introduction of genetically modified crops in both developed and developing countries. The findings of these studies differ, but in general the introduction and adoption of genetically modified crops has had a positive impact on the applicable agricultural sectors.

South Africa, Zimbabwe, Nigeria, Kenya and Egypt are the only African countries that have some form of GMO legislation in place, whilst some countries including Namibia, Ethiopia, Tanzania, Zambia and Cameroon either have biosafety guidelines being drafted or are entering into discussions regarding some legislation. Currently South Africa is the only African country commercially producing transgenic crops. This may mean that the success of genetically modified crops in South Africa will greatly influence adoption and regulatory decisions in other African countries. To date, no comprehensive study has looked at the economic impact of genetically modified crops in South Africa.

1.2 PROBLEM STATEMENT

Modern agricultural biotechnology has been developed largely by American and European companies and in most instances adopted by farmers in developed countries. The question that can be asked is, can developing country farmers, and more specifically South African farmers, benefit from the adoption of an agricultural technology created for agriculture in developed countries? And, if indeed an additional benefit is created through the utilisation of this new technology, who captures the benefits?

1.3 OBJECTIVE

The main objective of this study is to ascertain and quantify the costs and benefits of insect resistant (Bt) cotton and maize in South Africa, as produced under different production conditions, and the distribution thereof between input suppliers, farmers and consumers. This is an important question for both small-scale and large-scale farmers in South Africa's dualistic agricultural sector and also in surrounding less-affluent southern African countries.

This objective will be reached through the following specific objectives.

- Determining farmers' reasons for adoption of the technology
- Determining the on-farm impact of adoption of the new technology
- Analysing the distribution of the additional benefit and cost created by the new technology

1.4 HYPOTHESES

Despite a higher seed cost, adoption of insect resistant cotton and maize results in a higher gross margin, due to an increased yield through better pest management and a decrease in insecticide use.

1.5 SURVEYS, FARMERS, METHODOLOGY AND DATA

Data were gathered through surveys amongst small and large-scale farmers. During the 2000/2001 production season a survey was conducted amongst small-scale cotton farmers on the Makhathini Flats in northern KwaZulu Natal (KZN)[1]. Data from this survey will be used in this dissertation. In 2002, production data for individual small-scale farmers were obtained from the Vunisa Cotton Ginnery in Pongola (KZN) for farmers on the Makhathini Flats as well as farmers in the Kangwane (Tonga) area.

[1] This survey was conducted in collaboration with the University of Reading in the United Kingdom

In order to obtain production and perception data from large-scale maize and cotton farmers, a postal survey was conducted. This survey proved to be less successful as few farmers replied despite follow-ups. Consequently large-scale yellow maize and cotton farmers were visited on their farms during the 2000/2001 production season where a comprehensive questionnaire was filled in for each individual farmer. Both irrigation and dry land farmers were surveyed. Very few large-scale maize and cotton farmers plant only one maize or cotton variety and farmers were thus able to compare the performance of the new modified seed with that of conventional varieties. A total of 43 large-scale cotton farmers were surveyed in the Limpopo Province, Northern Cape and Mpumalanga (see Chapter 2 for map). A total of 33 large-scale yellow maize farmers were surveyed in the Northern Cape, Mpumalanga and the Free State. A relatively small number of farmers had adopted Bt yellow maize at that stage but the sample is representative and includes a range of growing conditions.

During 2001 a further study was initiated to investigate the expediency and successfulness of insect resistant white maize production by small-scale and subsistence farmers in South Africa. The 2001/2002 season saw the first national introduction of Bt white maize. Farmers were asked to compare the Bt variety to a conventional isoline (same variety but without the Bt gene). Both the white Bt seed and the isoline were distributed free of charge by Monsanto after farmers were informed about the characteristics of the seed through workshops and follow-up support organised by Monsanto. A total of 344 subsistence maize farmers were surveyed across four provinces in six different areas. Some of the data and findings of this research project will also be used in this dissertation.

1.6 OUTLINE OF THE STUDY

This dissertation is divided into six chapters. Chapter one introduces the problem statement, hypotheses and objectives of the study. Chapter two provides a literature review focussing mainly on the background of agricultural biotechnology, the debate surrounding international agricultural biotechnology and GMOs and the development and adoption thereof in South Africa and other countries. Chapter three identifies and discusses the reasons why small and large-scale South African farmers adopt insect resistant cotton and maize. The benefits and costs of insect resistant cotton and maize adoption is quantified in chapter four while chapter five discusses the distribution of the "economic rent" created through the introduction of the new insect resistant technology. The dissertation concludes in chapter six with an overview of the study and closing remarks.

CHAPTER 2

AGRICULTURAL BIOTECHNOLOGY: A LITERATURE REVIEW

2.1. INTRODUCTION

The year 1998 was the 200th anniversary of the publication of Reverend Thomas Malthus's well known, "*Essay on the Principal of Population*". According to Malthus the blind biological urges of mankind would cause the population to increase in a geometrical fashion and quickly exhaust the finite resources of the earth. Malthus stated that "The power of population is indefinitely greater than the power in the earth to produce subsistence for man" (Malthus, 1798). But according to Petersen (1990), Malthus in a later work gave the answer to this dooming prospect himself: "..under the right circumstances and within appropriate institutional structures, impending scarcity could stimulate creative responses to mitigate or curtail resource depletion" .

Malthus was neither the only nor the first scholar of nature who observed that the crop production practices of the seventeenth century were going to lead the earth's population to food security problems. Jonathan Swift, author of *Gulliver's Travels*, expressed in 1727 through the mouth of the King of the Brobdingnag: "....whoever could make two Ears of Corn, or two blades of Grass to grow upon a Spot of Ground where only one grew before, would deserve better of Mankind, and do more essential Service to his Country than the whole Race of Politicians put together." (As seen in Prakash, 2001). Biotechnology - like innovation in irrigating, tilling, fertilising and those associated with the "Green Revolution" is a response to mitigate the dooming resource depletion.

The purpose of this chapter is to provide a brief summary of the history and development of agricultural biotechnology, to highlight the dominant issues in the controversial biotech debate and to shed light on the developing biotech industry in South Africa.

2.2 BACKGROUND AND BRIEF HISTORY OF BIOTECHNOLOGY

Biotechnology is not new. Man has been manipulating living things to solve problems and improve his way of living for millennia. Early agriculture concentrated on food production and animals, and plants were selectively bred according to preferred traits and nutritional value. Micro-organisms through yeast and fermentation were used to make wine, beer, bread and cheese. According to the United States Department of Agriculture (USDA), biotechnology can be described as a range of scientific techniques, including genetic engineering, that are used to create, improve, or modify plants, animals, and micro organisms for the benefit of humans (http://www.usda.gov/news/bioqa.htm).

The late eighteenth century and the beginning of the nineteenth century saw the advent of vaccinations, crop rotation involving leguminous crops, and animal drawn machinery. The end of the nineteenth century was a milestone for biotechnology. Microorganisms were (formally) discovered, Mendel's work on genetics was accomplished and institutes for investigating fermentation and other microbial processes were established by Koch, Pasteur and Lister.

Biotechnology at the beginning of the twentieth century began to bring industry and agriculture together. During World War I, fermentation processes were developed that produced acetone from starch and paint solvents for the rapidly growing automotive industry. World War II brought the manufacture of penicillin and the biotechnological focus moved to pharmaceuticals. The cold war years were dominated by work with microorganisms in preparation for biological warfare, as well as antibiotics and fermentation processes (Murphy and Perrella, 1993).

Biotechnology as we know it today consists of three historical types of coexisting biotechnological undertakings (Nef, 1998):

The "first generation", traditional mode (7000 BC to 1940s), is characterised by empiricism and a minimal input of science and engineering. It includes the conventional use of yeasts and fermentation for the production of food, beverages and energy.

The "second generation", or intermediate biotechnology (1940s to 1980s) was characterised by significant scientific and engineering inputs on an industrial scale, including industrial microbiology, biochemistry and industrial engineering. It utilised fermentation, bio-conversion and bio-catalysis to manufacture pharmaceuticals, produce chemicals and fuels, and to process residues.

The "third generation" or modern biotechnology (from the 1980s) is characterised by "new genetic combinations". It is based on molecular biology and the utilisation of genetic engineering techniques (such as recombinant DNA). Potentially the applications of the modern biotechnology encompass all biological processes, leading to new products and operations.

There are numerous current and potential applications of biotechnology in agriculture to produce genetically modified food, crops and fibre. The first wave of agricultural biotechnology has benefited farmers and producers by providing input or agronomic traits that make production easier and more effective. Most of the food in the market today that is referred to as genetically modified, is food that is produced through field crops that are either herbicide tolerant or has a genetically engineered resistance against certain insects, viruses or fungi. The second wave of agricultural biotechnology will be focussed more on output or quality traits and will benefit mainly the consumer through food with enhanced nutritional components and healthier oils. It is envisaged that the agricultural biotechnology industry will evolve into a third generation in which even more bio-industrial applications will emerge in industry, manufacturing and in the pharmaceutical sector.

2.3 THE ADOPTION OF GENETICALLY MODIFIED CROPS

According to the International Service for the Acquisition of Agri-biotech Applications (ISAAA) the global area under genetically modified crops exceeded 50 million hectares for the first time in 2001. It is estimated that 52.6 million hectares of GM crops were planted in 13 countries by 5.5 million farmers. In 2002 up to 6 million farmers in 17 countries planted 58.7 million hectares of genetically modified crops. The area under GM crops increased 19% (8.4 million hectares) between 2000 and 2001, with a further 12% increase (6.1 million hectares) between 2001 and 2002.

Since the international introduction of GM crops in 1996 the global area planted has increased more than 30-fold. (Figure 2.1.)

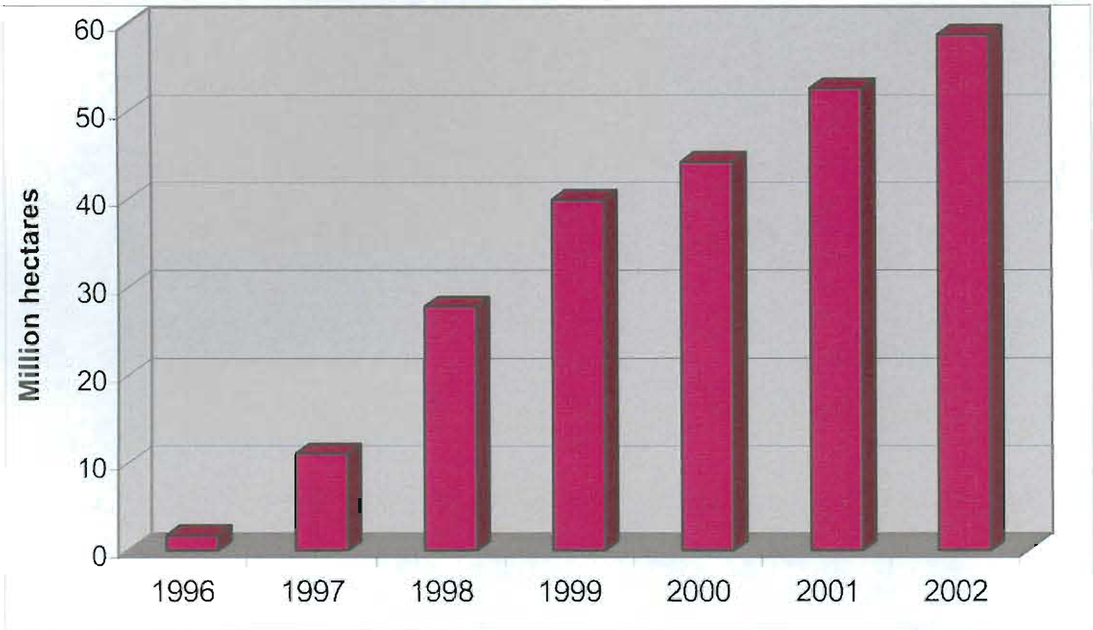

Figure 2.1: Global area under GM crops, 1996 to 2001

Source: www.isaaa.org

Table 2.1 shows that four countries had more than 99% of the total GM crop area. In 2002 more than 16 million hectares or 27% of global transgenic crop area was in developing countries, but the absolute growth in GM crop area between 2000 and 2001 was twice as high in industrial countries (5,6 million ha) than in developing countries (2,8 million ha). The percentage growth was higher in the developing countries of the South (26%) than in the industrial countries of the North (17%). Despite resistance, 2002 was the first year that more than half of the world's population lived in countries where genetically modified crops were produced.

Table 2.1: Areas planted to GM crops for 2000, 2001 and 2002

Country	Hectare (mil) 2000	Hectare (mil) 2001	Hectare (mil) 2002	Crops
USA	30.3	35.7	39.0	Soya beans, Cotton, Canola, Maize, Chicory, Potato, Rice, Squash, Sugar Beet, Tomato
Argentina	10	11.8	13.5	Soya beans, Maize, Cotton
Canada	3.0	3.2	3.5	Sugar Beet, Canola, Squash, Soya beans, Cotton, Linseed, Tomato, Potato, Wheat, Maize
China	0.3	1.5	2.1	Cotton
South Africa	0.2	0.4 **	0.6**	Cotton, Maize, Soya beans
Australia	0.2			Canola, Cotton, Carnation, Soya beans, Maize
Romania	<0.1			Soya beans, Potatoes
Mexico	<0.1			Soya beans, Cotton, Tomatoes
Bulgaria	<0.1			Maize
Spain	<0.1			Maize
Germany	<0.1			Maize
France	<0.1			Maize
Uruguay	<0.1			Soya beans
Indonesia	<0.1			Cotton
India	<0.1			Cotton
Honduras	<0.1			Maize
Colombia	<0.1			Cotton

** Estimated figure as total for remaining countries.

Source: Compiled from data on the ISAAA website and the Agbios Essential Biosafety CD.

According to a Reuters publication (2002, Feb 4), even though the number of European biotechnology companies outnumber American companies by 1570 to 1273, the American firms boast three times the stock market value and generate three times the revenue, as 28 percent of them are publicly listed versus only six percent of those in Europe. The publicly listed US biotechnology companies boast an estimated market capitalisation of $353 billion and a turnover of $22 billion per annum.

2.4 THE AGRICULTURAL BIOTECHNOLOGY DEBATE

Although the GMO debate is highly publicised, comprehensive objective literature on the issues is rather limited. Anti-GMO activists tend to stress issues like the Monarch butterfly and StarLink corn debacles. The full stories of these two issues are widely published on the World Wide Web. Scientists, developers and supporters of biotechnology on the other hand tend to focus rigorously on scientific proofs, ignoring the perceptions of consumers. Perceptions can sometimes be influenced by miscommunication from scientists, misinterpretation by sensation seeking media and false prior beliefs of "anti-something" advocacy groups. In the GMO debate people or institutes are portrayed to be either pro- or anti- GM with nothing in between.

It is not the aim of this chapter to enter into the intense and often emotion driven debate about the creation, production and consumption of genetically modified organisms. Only a brief overview of the ideologies and certain issues that have played a major role in the debate as well as some reasons why perspectives differ will be given. In the following chapters more comprehensive literature concerning issues like adoption, costs and benefits will be summarised.

2.4.1 THE ISSUES THAT DRIVE THE DEBATE

According to Gerald C. Nelson (2001) the GMO debate can usefully be defined in terms of three main issues, namely:

- Costs and benefits of the technology and its products.
- Regulatory strategies and human and environmental safety.
- Legal institutions and intellectual property.

Each genetically modified product has certain economic, social and ethical benefits and costs associated with it. Potential benefits include a more abundant food supply, plants which enhanced health characteristics as well as reduced chemical inputs resulting in a healthier environment. Possible costs include environmental and food safety hazards, as well as adverse distributional effects - if the technology were to favour only large-scale farmers or multinational corporations. The ethical concerns, according to Nelson (2001), arise from the notion that genetic engineering methods extend the intrusion of humans into natural processes far beyond that of normal plant breeding. The other side of the coin is that there are ethical considerations involved in repressing a technology that provides humanitarian benefits to the most needy.

The second set of issues regard the regulatory responsibility. Certain questions arise that need to be answered by governments and regulatory bodies responsible for product approval and releases. Questions like: "Have governments adequately assessed the possible health and environmental effects of GMOs or has the process of adoption been rushed as a result of commercial pressures by companies responsible for the technologies?", "Should one wait until long-term studies of the effects of GMOs on the environment and in the diet can be concluded, or is it enough to deduce from short term scientific studies what the impact will be?" Another set of questions concerns how regulatory responsibilities change as countries try to establish a bio-safety regime to suite trade regimes as established in the WTO (Nelson, 2001).

The third issue surrounds the legal and effective ownership of genetic material. The cost of developing GM crops, patent laws, intellectual property rights, genetic markers and the potential for genetic and biological enforcement of legal rights has shifted control of biotechnologies towards multinational biotech and seed companies. There is growing concern that the nature of global agriculture and the relationship between farmers and other parts of the food system is undergoing drastic change (Nelson, 2001).

With biotechnology, like with all technological innovation, the development, adoption and benefits of new technologies need to be communicated to the public in truthful, understandable ways. Many other innovations that are now common in our lives were met with scepticism and opposition when first introduced. Such fear of technology was and is especially pronounced in food-related innovations like pasteurisation, canning, freezing and the microwave oven. However, once consumers recognise that the new innovations can enhance their quality of life and once they understand that risks are either minimal or manageable, such technologies may enjoy widespread public acceptance (Prakash, 2001).

In a US State Department publication Calestous Juma (2003) mentions the case of the introduction of coffee. In the 1500s the Catholic bishops tried to have coffee banned from the Christian world for competing with wine and representing "new cultural as well as religious values". In public smear campaigns, similar to those currently directed at biotech products, coffee was rumoured to cause impotence and other ills and was either outlawed or its use restricted by leaders in Mecca, Cairo, Istanbul, England, Germany and Sweden. In a 1674 effort to defend the consumption of wine, French doctors claimed that when one drinks coffee: The body becomes a mere shadow of its former self; it goes into a decline and dwindles away. The heart and guts are so weakened that the drinker suffers delusions, and the body receives such as shock that it is thought to be bewitched (Juma, 2003).

Analysis of public reaction to agricultural biotechnology has rightfully focused on social, cultural, economic, and political issues as determinants of public attitudes. Some of these analyses have discounted the importance of personal and societal knowledge as factors shaping perceptions and public attitudes towards agricultural biotechnology, in part because of the failure of scientific arguments to sway attitudes and public policy decisions (Wolt & Peterson, 2000)

2.4.2 DIFFERENT IDEOLOGIES

In a "Concept note for a regional policy dialogue" prepared by the Food, Agriculture and Natural Resources Policy Analysis Network (FARNRPAN) and the International Food Policy Research Institute (IFPRI, 2002) the uncertainties and controversies surrounding the role of biotechnology in agriculture were explained in the following manner:

"In most cases these uncertainties and controversies appear to have two dimensions. One dimension applies to relatively well-informed stakeholders, the other to relatively un-informed stakeholders. Because the relatively un-informed, either by design or by default rely on the relatively well-informed for guidance, understanding the foundations of differences among informed stakeholders are crucial."

The foundations for these differences are discussed in three sub-sections on biophysical and social sciences, modernism and post-modernism, and north and south political myths.

A) Conflicting Disciplinary Perspectives: Biophysical Sciences vs. Social Sciences vs. Humanities

Many of the differences in perceptions of informed stakeholders in the debate surrounding agricultural biotechnology stem in part from the contrasting disciplinary approaches and methodologies in knowledge generation. Biophysical sciences make use of tight, narrow, experiment-based hypothesis-testing approaches while social sciences use looser, broader, collective behavioral hypotheses in which both theory and data provide ambiguous guidance on casual relationships. "This particular divide can be bridged through the increased use of experimentation in the social sciences but it reinforces another divide between the social sciences and the humanities. The reductionism that drives model building and hypothesis-testing in the sciences is negated in the humanities, where explanation is often built on narrative depictions of dialectic tensions between individual agency and social determinism" (FANRPAN & IFPRI, 2003).

B) Competing Paradigms: Modernism and Post-Modernism

"The deep divergences defined by alternative disciplinary perspectives are further accentuated by a more fundamental paradigmatic clash based on differences surrounding the role of science and technology in human development - the clash between the modernists and the post-modernists." Modernists believe that science and the technological innovations brought about by science are predominantly positive and advantageous, and that under scientific and technological advance, human progress and development are good and inevitable. For post-modernists, reality is constructed, knowledge is subjective, and thus interpretation is everything. Progress and development is far from being outcomes of scientific and technological advance or of human history. Rather the only sure outcome of science and technology, and of passage of time is change. According to this ideology science and technology have had their chance, but failed to deliver (FANRPAN & IFPRI, 2003).

C) Divergent Political Myths: South vs. North

A third disruptive force in the agricultural biotechnology debate relates to political myth-making, in other words, the different myths about the nature of the global political order dominant in the South versus those dominant the North. "In the South a significant thread of political myth-making springs from centuries of technology-driven domination by the North. In the North, despite efforts toward greater inclusion and participation of "Southern" voices in development policy formulation, elements of the famous "White Man's Dilemma" persist" (FANRPAN & IFPRI, 2003).

Key elements of these clashes in disciplinary, paradigmatic, and political perspectives can be found in almost every public utterance on the role of biotechnology in agriculture.

In a paper entitled "Rich and poor country perspectives on biotechnology", Pinstrup-Andersen (2001) discusses various reasons why the perspectives and perceptions of people in developed and developing countries regarding the use and adoption of GMOs might differ. According to Pinstrup-Andersen one can also expect that perspectives would differ within a country between the poor and the non-poor. Albeit a rather gross generalisation, it is revealing to consider how countries' and people's perspectives on agricultural biotechnology and GMOs are influenced by their disposable income. The following couple of paragraphs quote and summarise some of the reasons and discussions as indicated by Pinstrup-Andersen.

The utilisation of modern biotechnology in agriculture and food production may lead to increased productivity and thus a reduction in unit cost. This will lead to a combination of higher incomes to producers and reduced prices for consumers. Consumers spending a large share of their budget on food thus would tend to view the use of biotechnology in agriculture more favourably. Consumers in developing countries often spend 50-80% of their total disposable income on food in contrast with Europeans, Americans and Australians who spend on average 10-15%. The cost of the physical food commodity also occupies a much bigger portion of the consumer price among the poor. The cost of marketing and processing tend to dominate in food consumed by the rich. Unit cost savings in the production of food thus will have a larger price reduction in the consumer price paid by the poor (Pinstrup-Andersen, 2001).

In low-income countries a large percentage of the population depends on agriculture for their livelihood. More than 70 percent of the world's population reside in rural areas and between 50 and 80 percent of low-income country's population depends directly or indirectly on agriculture. On the other hand only between 2 and 5 percent of the population of industrialised countries depend on agriculture. Linking to this aspect is the importance of the agricultural sector in generating broad-based economic growth in society as a whole. Agricultural growth is essential to promote growth within as well as outside agriculture in low-income countries while it may be of very little importance in industrialised countries (Pinstrup-Andersen, 2001).

Historically, political logrolling by farmers in developed countries has earned them large farm subsidies, supported in part by fiscal resources and in part by artificially high consumer prices. However, the market power of the farmers in industrialised countries has gradually deteriorated as consumers have gained a greater say in the market for food. Thus while European farmers continue to receive their subsidies by exercising political power, they are unable to exercise similar power over the government regarding genetically modified food. The European consumers, who now have the political power over agriculture, in general do not look favourably on GMOs. The opposition is partly driven by a perceived lack of consumer benefits, ethical concerns, uncertainty about personal health and environmental effects as well as the perception that large corporations will be the primary beneficiaries. Despite their position of power, consumers still agree to pay large subsidies to agriculture through taxes as well as through inflated food prices even though it can be argued that the adoption of modern biotechnology could reduce the need for farm subsidies. It thus seems that European consumers are willing to pay European producers to not produce genetically modified food. Farmers in the United States are also enjoying vast agricultural subsidies, but up to now they have not yet met the same level of consumer and governmental resistance against genetically modified food. Farmers in developing countries possess very little political power and are taxed rather than subsidised. In contrast with consumers in industrial countries, developing country consumers cannot influence government due to lack of purchasing power (Pinstrup-Andersen, 2001). It is sometimes forgotten that in many cases in lower income countries, the producers are the consumers.

It would be wrong to suggest that all "rich countries" are against biotechnology and that all "poor countries" support it. Countries like Australia, Canada and the United States have supported biotechnological development but they strongly support agriculture overall. The simple reason for this could be the importance of agricultural exports to their economies. The negative or tentative attitude of the European countries and Japan, who substantially rely on food and feed imports, can be partially explained by perceived health risks. Notwithstanding the fact that consumers' health perceptions of genetically modified crops are based on very limited knowledge of basic biology, Europe has had some very real food scares in the not so recent past. "Mad cow disease" and the sad picture of thousands of possibly food-and-mouth disease infected cattle burning for days has left a bad taste in the mouth of the European consumer, but this had very little to do with genetic engineering.

Certain anti-GMO civil society groups with substantial political power have had a considerable influence on the GM debate and on government and consumer attitudes towards genetically modified food in Europe. These advocacy groups are also gaining power in developing countries to the regret of most food and agricultural decision-makers. This is one of the reasons why it would be wrong to say that all "poor countries" are supportive of biotechnology in agriculture. Decision-making in a country like the Philippines has been hugely influenced by advocacy groups with strong links to international groups like Greenpeace and British Christian Aid. Another reason why perspectives on biotechnology differ between developing countries is that a coalition of decision-makers in non-poor developing countries, and governments and other decision makers in high-income countries may be possible. Such a coalition might establish policies and standards that could be detrimental to the majority of the people in the country who are poor (Pinstrup-Andersen & Cohen, 2001).

The 2002/2003 food crisis in Southern Africa and the decision by governments of amongst others Zimbabwe, Zambia and Malawi to refuse relief food consisting of Bt maize is an example of how decision makers are influenced by outside advocacy groups to make policy decisions harmful to their own people. It is believed that before attending the World Summit On Sustainable Development in South Africa advocacy groups paid a brief yet influential visit to decision makers in these Southern African countries (www.consumerfrccdom.com).

Through globalisation, policies on issues like the current food safety levels preferred by the rich can be imposed on the poor at the expense of food security of the latter. Poorer people would tend to place a higher premium on quantity and very basic food safety until basic nutritional requirements are met. European, Australian and American consumers however are prepared to pay a premium for even small increases in food safety and reduced uncertainty (Pinstrup-Andersen & Cohen, 2001).

Proponents envision biotechnology as providing additional food, fibre and medical resources without increasing, and possibly decreasing, human demands on land and plant habitats. Opponents believe that biotechnology will increase the already excessive demands upon the world's resources by increasing human populations and consumer demands for food, clothes and other materialistic goods. Proponents view human populations and demands as positive opportunities for biotechnology (Kershen, 1999).

Even though there may shortly be scientific proofs of the economic, health and environmental benefits of genetically modified crops, it is unfortunate on the one hand but reassuring on the other to perceive that as Kershen (1999) suggests, the acceptance or rejection of biotechnology will not be based on information or understanding but biotechnology will stand or fall on the ideological belief and the cultural values adopted by individual human beings who, in turn, will shape social belief and values. This could mean that if farmers in developing countries, despite possibly not understanding the scientific concept of GMOs, perceive GM crops to render advantages to them as farmers and as consumers, then adoption and acceptance will take place.

2.5 AGRICULTURAL BIOTECHNOLOGY IN SOUTH AFRICA

According to the pro-biotechnology non-governmental organisation (NGO), AfricaBio, South Africa has been involved with biotechnology research and development for more than 25 years. There are more than 500 biotechnology projects spread over seven sectors in South Africa. There are approximately 110 groups, both academic and research institutions, involved in more than 160 plant biotechnology projects and it is estimated that more than 45 companies are using biotechnology in food, feed and fibre applications. The medical and pharmaceutical sector attracts the most funding with the plant sector being the second largest in terms of funding. Interesting to note is that despite the 25 years of research and development few local products have been developed and all sectors are heavily dependent on imported biotechnology applications that are driving commercialisation and industrial growth.

2.5.1 POLICY AND LEGISLATION

An application to the South African Department of Agriculture in 1989 to perform field trails with genetically modified cotton kick-started the South African biosafety process and initiated the first trials with transgenic crops on the African continent (Koch, 2000). The application came from the US seed company Delta and Pineland who in those years used South Africa as an over wintering haven for field trials and seed multiplication.

The South African Committee for Genetic Experimentation (SAGENE) was established in the early 1970s when international genetic engineering first began. The initial task of this committee was to develop guidelines for the safe use of GM bacteria in laboratories, and more recently for work with all GMOs (Thomson, 2002). The committee consisted of representatives from a number of bodies namely: the Agricultural Research Council, Council for Scientific and Industrial Research, Foundation for Research Development, Medical Research Council, Council of National Health and Population Development, Department of Environmental Affairs and Tourism, Committee for University Principals, the South African Institute of Ecologists and Environmental Scientists and the Industrial Biotechnology Association of South Africa. According to Thomson (2002) the committee for many years dealt with all requests for permission to carry out laboratory, glasshouse or field trials with GMOs. When the volume of work increased, members of SAGENE in collaboration with outside experts handled requests through ad hoc sub-committees. SAGENE was only an advisory body and thus had no legislative power to enforce compliance with their guidelines. Dealing mainly with plant material, SAGENE advised the National

Department of Agriculture regarding the merits of each application. It was the work of the Department to enforce and monitor conditions under which trials were conducted. This period in which SAGENE established procedures and guidelines and where the Department of Agriculture issued permits for GMO work under the Pest Control Act of 1983, in theory, came to an end on 23 May 1997 when Parliament passed the Genetically Modified Organisms Act (Act 15 of 1997). The GMO Act was only implemented in December 1999, 31 months after it was passed. According to Koch (2000) the belated implementation can be ascribed to the efficiency and the cost effectiveness of the interim procedure, but also to lack of capacity in the public service to implement the Act. During the interim period 1990 to 1999 over 150 applications where reviewed covering 13 plant types and several medical and industrial microorganisms (Figure 2.2).

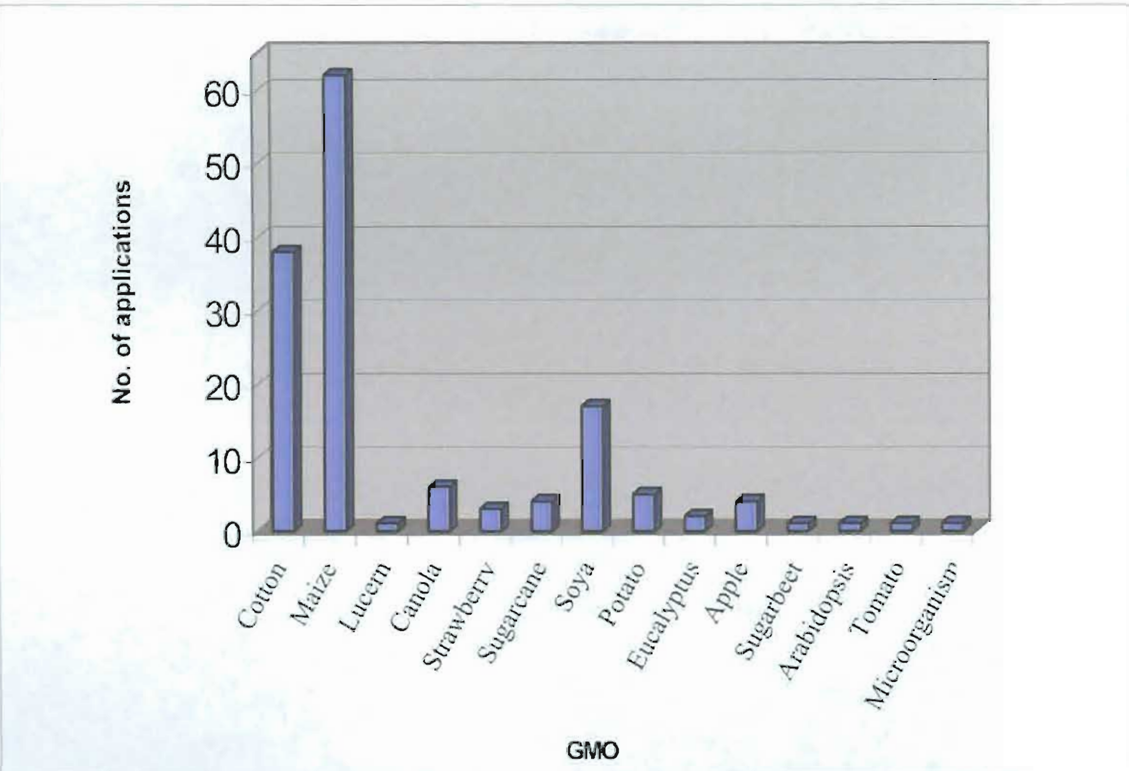

Figure 2.2: Applications for GMO permits in South Africa (1990-1999)

Source: Muffy Koch, 2000

Once the GMO Act of 1997 was implemented the following three biosafety structures were established to regulate all aspects of GMOs in South Africa.

1. The Executive Council. This is a national, independent decision making structure responsible for making decisions on all applications for work with GMOs. The council is comprised of representatives from 6 government departments (Agriculture, Environmental Affairs and Tourism, Health, Trade and Industry, Labour and Art, Culture, Science and Technology). The council also includes a scientific advisor who is the Chairperson of the Scientific Advisory Committee. The powers and duties of the Executive Council include:
   - Deciding on the issue of permits to undertake glasshouse and field trails or commercial releases of GM crops and other GMOs.
   - Overseeing the office of the Registrar.
   - Liaison with other countries.
   - Advising the Minister of Agriculture.
   - Ensuring law enforcement according to the GMO Act.

2. The Scientific Advisory Committee. This structure replaces SAGENE and will advise the Executive Council on human and environmental safety of applications submitted for permits. This committee consists of scientific experts approved by the Executive council and appointed by the Minister. The main functions of this committee is to:
   - Advise the Minister of Agriculture and the Executive Council on environmental impacts related to the introduction of GMOs.
   - Consider all matters pertaining to the contained use, import and export of GMOs.

3. The Registrar and Inspectorate. The Registrar administers the GMO Act on behalf of the Minister of Agriculture and the Inspectorate is used to monitor local work with GMOs. The duties of the Registrar include:
   - Administration of the Act.
   - Issuing permits.
   - Being pro-active in terms of any contravention of the Act.
   - Appointing inspectors to monitor field trails.
   - Ensuring compliance with the conditions of permits.

(Thomson, 2002) (Koch, 2000) (AfricaBio Website, 2002)

According to Thomson (2002) the process that is set in motion as soon as the Registrar receives an application can be summarised as follows:

- The Registrar appoints a member of the Advisory Committee to act as chair for the review.
- The Review Chair appoints a sub-committee of three reviewers who are not members of the Advisory Committee.
- The Review Chair receives reports from the sub-committee and compiles a report for the Registrar.
- The Registrar submits this report to all the members of the Advisory Committee for comment.
- The Advisory Committee reaches a decision and informs the Registrar.
- The Registrar presents a letter of recommendation to the Executive Council, which finally approves or rejects the application.

GMO regulations stipulate that this process should not take longer than 90 days for a decision on field trails and 180 days for a decision on general release applications (Thomson, 2002).

2.5.2 BIOTECHNOLOGY RESEARCH IN SOUTH AFRICA

In agricultural biotechnology the current major biotechnology companies are Monsanto, Pioneer Hi-bred International, Syngenta and Aventis. Almost all of these multinational companies have links with South African companies and research institutions. The major South African governmental or parastatal institutions that promote and conduct public agricultural biotechnology research are the Agricultural Research Council (ARC) and the Council for Scientific and Industrial Research (CSIR). Universities like the University of Cape Town, University of Natal and the University of Pretoria through amongst others the Forestry and Biotechnology Institute (FABI), also contribute to biotechnology research.

Following the compilation of the National Biotechnology Strategy by the Department of Arts, Culture, Science and Technology (DACST) in June 2001 certain bodies and partnerships have been organised to, in their own words "rapidly assemble the necessary teams and projects to place South Africa among the world leaders in the application of biotechnology to both regional and global issues" (www.biopad.org.za/mission). There exist three "BRICs" or Biotechnology Regional Innovation Centres that were established under the auspices of DACST and in partnership with a range of players, including the CSIR as lead organisation. The BRIC in Gauteng is known as BioPAD (Biotechnology for Africa's Development) and focuses on animal health and industry / environmental related biotechnology. Ecobio in KwaZulu-Natal focuses on human health, bioprocessing and plant biotechnology, while the Cape Biotech Initiative in the Western Cape concentrates on human health and bioprocessing (www.dst.gov.za).

Monsanto is the only company in South Africa that currently has genetically modified crops on the market for commercial production. Herbicide tolerant cotton and soya-beans, and insect-resistant maize and cotton currently being produced in South Africa, have been developed by and are licensed to others by Monsanto. Companies like Delta & Pineland with cotton, and Pioneer with maize buy the right from Monsanto to use specific traits in their own varieties. Syngenta that was formed in late 2000 through a merger between Novartis Agribusiness and Zeneca Agrochemicals has recently applied for permission to sell genetically modified maize seed in SA. Monsanto may soon lose its position as monopolist supplier of insect-resistant maize seed.

Over the last twenty years scientists in South Africa have been developing genetic engineering techniques and capacity. These techniques and technology are only now being used and commercialised. Only a small number of products have been developed despite the fact that over 600 biotechnology research projects are currently underway. According to a 1998 National Research Foundation financed survey of biotech research, an estimated 55 biotech companies are spending more than R100 million on research and development annually (AfricaBio, 2002). An estimated 50% was spent on medical research, 40% on plant biotechnology and the rest on environmental and industrial biotechnology research. Currently the total expenditure on biotech research and development is about $24 million (AfricaBio,2002).

Table 2.2: Summary of some of the past and current agricultural biotechnology research projects conducted by academic and parastatal institutions in SA.

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 soya beans. • Incorporation of alien genes in order to enhance herbicide resistance in lupins and drought resistance in groundnut. • Marker assisted selection for nematode resistance in soya bean. • 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 contamination 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)

Some other current biotechnology research and development projects include:

- Development of AIDS and TB treatments,
- Functional genomic and gene mining of South African plant resources.

A number of private South African companies are also involved in biotechnology research in South Africa. The most notable are Pannar (grain and vegetable seed) and Mondi (tree improvement). 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 added some genetically engineered varieties to its research programme with company field trials on genetically engineered maize rapidly increasing from 2 trials in 1995/96 to 105 in the 1998/99 season to 112 during the 1999/2000 season. Pannar uses Bt technology from Monsanto in their own cultivar lines and hybrids.

Following Monsanto's acquisition of Sensako and Carnia (two major South African seed companies) in 1999/2000, a joint research team was formed to cut costs on research investments. It is estimated that Monsanto currently spends about R40 million on research and development in South Africa annually (Green, 2002). The major share of Monsanto's research is done by institutions outside of the company on a contract basis. Institutions like the Agricultural Research Council (ARC) through their Grain Crops Institute in Potchefstroom and the Institute for Industrial Crops in Rustenburg, and the Council for Scientific and Industrial Research (CSIR) in Pretoria as well as smaller consultancy companies have been contracted to do research for Monsanto.

2.5.3 GENETICALLY MODIFIED CROPS IN SOUTH AFRICA

At present no genetically modified fresh produce is available in South Africa. The fresh produce varieties currently available on the shelf have been genetically enhanced by using only traditional breeding programs. The only genetically modified crops that have been approved for commercial production in South Africa up to now are herbicide-tolerant soya-beans, cotton and maize and insect-resistant cotton and maize. Bt cotton has been produced since the 1997/1998 season and Bt yellow maize since the 1998/1999 season. Herbicide tolerant cotton has been made available for commercial production in the 2001/2002 season while only a limited quantity of herbicide tolerant soya-bean seed has been released. Bt white maize was introduced in the 2001/2002 season and the 2002/2003 season will see the first season of large-scale production. A limited quantity of herbicide tolerant maize seed will be commercially released for the 2003/2004 season. Cotton seed containing the Roundup Ready – Bt combination has not commercially been released yet.

2.6 CONCLUSION

This chapter supplied a brief overview of the history, development, adoption and debate surrounding agricultural biotechnology and genetically modified crops. With a capable and informed albeit ad hoc regulatory system in place, South Africa was able to react to the availability of GM crops. Now with a well-established and accredited regulatory system, South African farmers will be able to make best use of new biotechnological innovations. Questions however remain whether South African farmers actually benefit by adopting genetically modified crops and if they do benefit, in what way and to what extent do they benefit. Chapter 3 will focus on farmers in South African who have adopted GM crops as well as the reasons why they have adopted.

CHAPTER 3

ADOPTION AND REASONS FOR ADOPTION OF GENETICALLY MODIFIED CROPS BY SOUTH AFRICAN FARMERS

3.1 INTRODUCTION

According to Clive James of the International Service for the Acquisition of Agric-Biotech Applications (ISAAA), agricultural biotechnology continues to be the most rapidly adopted technology in agricultural history. As has been mentioned in Chapter 2 the total global area under transgenic crops has increased by 8.4 million hectares from 2000 to 2001 and by a further 6.1 million hectares (12%) between 2001 and 2002. As can be seen in Table 3.1, herbicide tolerant soya beans covered 36.5 million hectares globally (62% of the total global transgenic area of all crops) in 2001 while insect resistant maize covered 7.6 million hectares (21% of the total global transgenic area). Herbicide tolerant crops - primarily soya beans and canola - covered 44.2 million hectares or 75 percent of the total global commercial transgenic crop area (ISAAA, 2003). The impressive rates of adoption for many of these transgenic crops are strong evidence of their perceived value to farmers (Marra et al., 2002)

Table 3.1: Most popular crops and genetically induced traits in 2001/2002

	GM crop	Million Ha	Million Ha	Crop traits
Most popular	Soya beans	36.5	44.2	Herbicide tolerant
2nd	Maize	12.4	10.1	Insect resistant
3d	Cotton	6.8	4.4	** Stacked gene
4th	Canola	3		

**Herbicide tolerant / Insect resistant combination

Source: ISAAA

This chapter reviews the adoption of genetically modified crops by South African farmers. Furthermore this chapter gives a brief overview of the cotton and maize industries and discusses the farm and household profiles of the adopters. This is necessary to put in context and to understand the reasons for adoption put forward by the different farming groups. The different reasons and their implications are discussed.

3.2 ADOPTION OF TRANSGENIC CROPS IN SOUTH AFRICA

South Africa is currently the fifth largest transgenic crop producer in the world and produces in extent of 300 000 hectares of transgenic cotton, maize and soya beans (ISAAA, 2003). Since the introduction of insect resistant cotton in South Africa in 1997 and insect resistant yellow maize in 1998 the adoption rate of these two new products by South African farmers has been impressive.

Figure 3.1 illustrates the percentage composition of annual cotton seed sales. Adoption in the introduction season (1997/1998) was rather insignificant but 1998/1999 saw close to 40% adoption. Bt cotton seed sales increased in 1999/2000 but decreased again in 2000/2001. According to surveyed farmers and extension officers from both Clark Cotton (the major ginning company in SA) and Delta Pineland (the only seed company distributing transgenic cotton seed in SA), the decrease was caused by a combination of factors, including low bollworm pressure in 1999/2000, and the popularity of a conventional variety called Delta Opal.

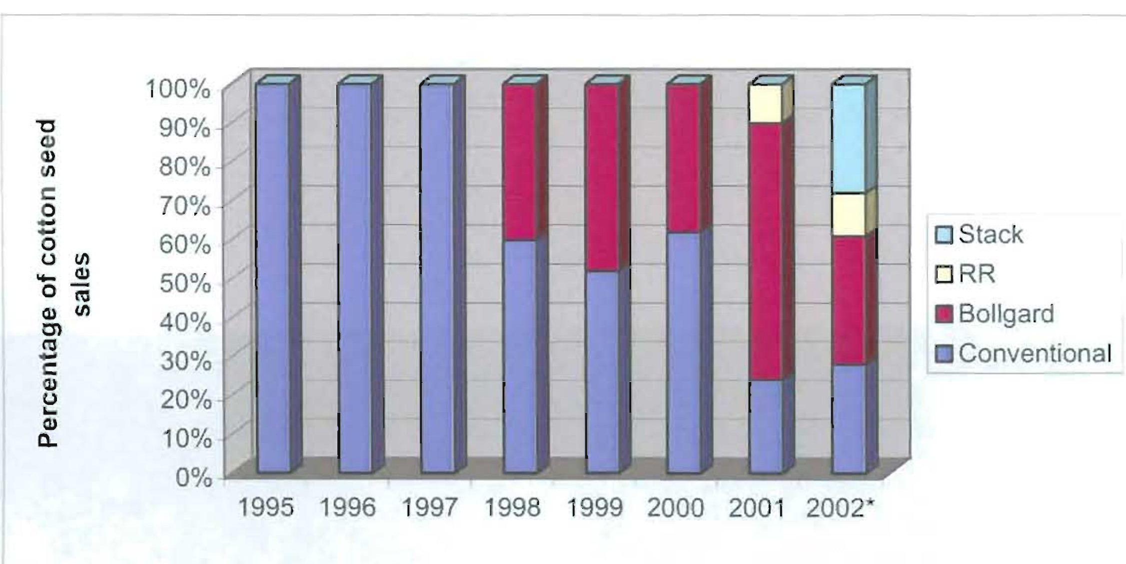

Figure 3.1: Adoption of new cotton seed varieties

* Estimation

Source: Cotton SA, Journal to the Cotton Industry

In 2001/2002 Delta Pineland introduced NuOpal (Opal with the Bt gene) and adoption increased again while this season also saw the introduction of herbicide tolerant cotton. According to a Cotton SA estimation (Figure 3.1) the demand for Bt cotton would have decreased for the 2002/2003 season due to the introduction of the "stacked gene" technology (Cotton SA, 2002). It has however become apparent that the "stacked" seed could not be released for the 2002/2003 season due to a delay caused by some additional legislative and regulatory requirements.

Table 3.2 indicates the current commercially produced transgenic crops in South Africa and the estimated areas planted, while Table 3.3 indicates the percentage of seed sales or the total crop area these crops cover.

Table 3.2: Estimated area planted to transgenic crops (ha).

Crop	1999/2000	2000/2001	2001/2002	2002/2003
Bt Cotton	13 200	12 000	25 000	18 000
RR Cotton	0	0	1 500	3 500
Bt Yellow Maize	50 000	75 000	160 000	197 000
Bt White Maize	0	0	6 000	55 000
RR Soya-beans	0	0	6 000	15 000

Source: SANSOR, Monsanto and own survey

Table 3.3: Transgenic crops according to percentage of seed sold or as percentage of area planted.

Crop	1999/2000	2000/2001	2001/2002	2002/2003
Bt Cotton*	50%	<40%	70%	70%
RR Cotton*	0	0	<10%	12%
Bt Yellow Maize**	3%	5%	14%	20%
Bt White Maize**	0	0	0.4%	2.8%
RR Soya-beans*	0	0	5%	10.9%

* Percentage of seed sales as estimated by Cotton SA and SANSOR

**Percentage of area planted

This study will not report on the introduction, adoption and performance of herbicide tolerant cotton and soya-beans. Table 3.3 clearly shows that the adoption of insect resistant cotton has been much more dramatic than that of insect resistant yellow maize. The reasons for this difference in adoption will become clear when the reasons why farmers adopted the new technology are considered. Firstly it is necessary to establish who these technology-adopting farmers are.

3.3 BRIEF INDUSTRY OVERVIEW AND PROFILES OF ADOPTING FARMERS

3.3.1 COTTON INDUSTRY OVERVIEW

In the 1999/2000 season an estimated 51 000 hectares of cotton were planted, showing a decline of more than 50% from the previous season's 99 000 hectares. In February 2002 Cotton SA estimated the seasons production on 31 224 hectares, a further decline of 45% from the 56 692 hectares in 2000/2001. This drastic decline in cotton area could be mainly attributed to a relatively lower world price for cotton while the latest area decline in 2001/2002, can also be attributed to farmers substituting maize for cotton due to a drastic increase in the price of maize, a competing crop, caused by factors like a weaker domestic currency, a regional drought, food insecurity and political uncertainty in Southern Africa. South African cotton farmers are dependent on, or rather exposed to a deflated cotton world price, caused by subsidised over production by large cotton producing countries. Chapter 5 will focus more on these aspects.

Despite various land reform projects attempting to settle small-scale cotton farmers in established cotton production areas, the traditional small-scale cotton production areas of Tonga (Kangwane) in Mpumalanga (just north of Swaziland, next to the border with Mozambique) and Makhathini in northern KwaZulu Natal (Locality C on the map in Figure 3.2) remain the major contributors. Cotton production by large-scale farmers mainly takes place in 6 production areas in South Africa. The most important dryland production areas are: the Springbok Flats (A) in the Limpopo Province and in the Dwaalboom region (B) in the North West. Irrigated cotton is produced around the towns of Marble Hall and Groblersdal and on the Loskop irrigation scheme (D) in Mpumalanga, at Weipe (F) next to the Limpopo River in the Limpopo Province and in the Northern Cape and Orange River area (E). There are also some large-scale farmers in the Pongola district close to the Makhathini Flats in northern KwaZulu Natal.

Figure 3.2: Main cotton production regions in South Africa

A – Springbok Flats, Settlers
B – Dwaalboom region
C – Makhathini Flats
D – Loskop Irrigation Sceme and areas around Groblersdal and Marblehall
E – Northern Cape with production on the Vaalharts Irrigation Scheme and areas around the Orange River next to towns and cities like Douglas, Prieska, Luckhoff, Keimoes and Upington.
F – Weipe

3.3.2 LARGE-SCALE COTTON FARMERS

In the 2000/2001 production season an estimated 300 commercial large-scale farmers produced 95% of the South African cotton crop. The 43 large-scale farmers surveyed and included in this study were from the irrigation areas in the Northern Cape, Mpumalanga as well as some dryland farmers on the Springbok flats in the Limpopo Province. Budgets and other information were also obtained from the Clark Cotton ginnery branches across the country.

Farmers surveyed on the Springbok flats planted between 85 and 550 hectares of cotton, irrigation farmers in the Groblersdal area plant between 20 and 160 hectares on average, with the farmers in the Northern Cape planting an average of 30 hectares. Cotton farmers on and around the Loskop irrigation scheme produce cotton in addition to their other farming enterprises such as the production of export table grapes, citrus, deciduous fruit and vegetables. The main farming activities of the farmers in the Northern Cape are viticulture (as the Northern Cape is a major wine producing area) export table grapes and the production of groundnuts. Some farmers in this area make use of flood irrigation instead of the more effective but more capital intensive pivot irrigation systems. Most irrigation farmers in Mpumalanga and the Northern Cape rotate or substitute maize and cotton in the summer and produce wheat in the winter. On the Springbok flats cotton is rotated with maize and sunflower. In most of the production areas cotton is usually not the dominant enterprise and is produced in combination with other crops. The choice of enterprise is usually determined by the rotation requirements of the soil and the relative prices of the competing enterprises. A profile of the surveyed farmers is provided in Table 3.4.

Table 3.4: Profile of surveyed large-scale cotton farmers

	Northern Cape		**Mpumalanga**	**Limpopo Province**
	Flood Irrigation	**Pivot Irrigation**	**Pivot irrigation**	**Dry land**
Dominant age group of farmers	50+	50+	40-49	30-39
Gender	98% Male			
Average farm size	78 ha	387 ha	550 ha	736 ha
Dominant farming enterprises	Groundnuts, Maize, Viticulture	Maize, Wheat, Viticulture	Maize, Cotton, Subtropical Fruit	Maize, Cotton, Sunflower
Mean area planted to cotton	22 ha	36 ha	51 ha	313 ha

Source: Own survey

3.3.3 SMALL-SCALE COTTON FARMERS

During the 2000/2001 production season there were more than 40 farmer organisations on the Makhathini Flats, with membership varying between 15 and 300 members per organisation. It is estimated that potentially 4 500 cotton farmers could be active in the Makhathini area planting on average between 1 and 3 hectares of rain fed cotton. Depending on credit availability and the price of seed cotton, between 2500 and 10 000 ha of cotton is planted annually (Bennett, 2001). Key players in the cotton industry envisage that small-scale farmers could produce up to 30% of the total cotton crop in South Africa by the year 2005 (Cotton SA, 1998). Whilst large-scale irrigation farmers can substitute or rotate cotton with maize, vegetables or groundnuts and large-scale dryland farmers, with less severe climatic conditions, can plant sunflower or maize, small-scale cotton farmers on the Makhathini are dependent on cotton, because of low, irregular rainfall and a lack of production credit for other crops. The Makhathini Flats is said to be one of the best, if not the best agricultural area in South Africa. The area has a deep, fertile soil and has an enormous (currently unutilised) irrigation potential – being situated close to the Jozini dam.

Until the 2000/2001 season, the Vunisa Cotton company (part of Clark Cotton – owned by AFGRI formerly known as OTK Holdings Ltd) was the main ginnery and credit source active on the Makhathini Flats. By managing and facilitating production credit supplied by the Land Bank, distributing production inputs on account, and by supplying production information and assistance through extension officers, Vunisa has vastly contributed to the success story of cotton farmers on the Flats.

Small-scale farmer data were gathered on the Flats through a survey in November 2000[2] (Ismaël et al, 2001). Input and production data were also gathered in collaboration with Vunisa administrative personnel. A brief profile of the average small-scale cotton farmer on the Makhathini Flats is supplied in Table 3.5.

The Makhathini Flats has shown an increase in the adoption of Bt cotton from 7% in 1997/1998 to 75% in 1999/2000 (Ismaël et al, 2001). An adoption rate of between 80 and 90 percent was expected for the 2000/2001 season and the same for the

[2] Research conducted by the University of Reading in collaboration with the University of Pretoria

2001/2002 season. (Van Jaarsveld, 2002). Over 95% of the cotton produced in the Tonga area is insect-resistant (Anthony, 2002).

Table 3.5: Profile of small-scale farmers on the Makhathini Flats

Mean age of farmers	40+
Gender of farmers	48 % Female 52 % Male
Land ownership per household	2.5 ha – 5 ha
Dominant farming activity	Cotton
Mean area planted to cotton	2 ha

Source: Ismaël et al., 2001

3.3.4 MAIZE INDUSTRY OVERVIEW

Maize is the most important field crop in South Africa and annually covers an estimated 30% of the total arable land. Maize serves as staple food for the majority of the South African population and also as the main feed grain for livestock. Maize is the largest contributor to the total gross value of agricultural production, with 16% in 2002. On average the South African maize harvest consists of 48% yellow maize and 52% white maize and is mainly produced by commercial farmers, although subsistence farmers produce white maize for own consumption. In spite of the fact that maize is grown in most parts of the country the main production areas are situated in the Free State, North West and Mpumalanga Province. Figure 3.3 illustrates South Africa's dryland yield potential.

The maize area planted has gradually declined from more than 5 million hectares in the mid eighties, to approximately 3.5 million hectares in 1998/99. Annual average maize production for the past decade has been approximately 8 million tons. Although the area planted has declined over the past years, the production has not declined dramatically. This can be attributed to the fact that the yield has increased over the years as production technologies have improved. The biggest limiting factor on the production of maize in South Africa is rain. Yellow maize's highest average yield of 3.35 t/ha was achieved in 1993/1994 which was a wet production season, with its lowest average yield in the drought of 1991/1992.

Domestic maize consumption requirements are estimated at 7.5 million tons with approximately 4.4 million tons of white maize and 3.1 million tons of yellow maize needed. The maize industry is also an important earner of foreign revenue for South Africa through the export of maize and maize products. South Africa mainly exports maize to Zimbabwe, Japan, Zambia, Malawi, Mauritius, Kenya and Mozambique. Figure 3.4 illustrates the maize utilisation in South Africa.

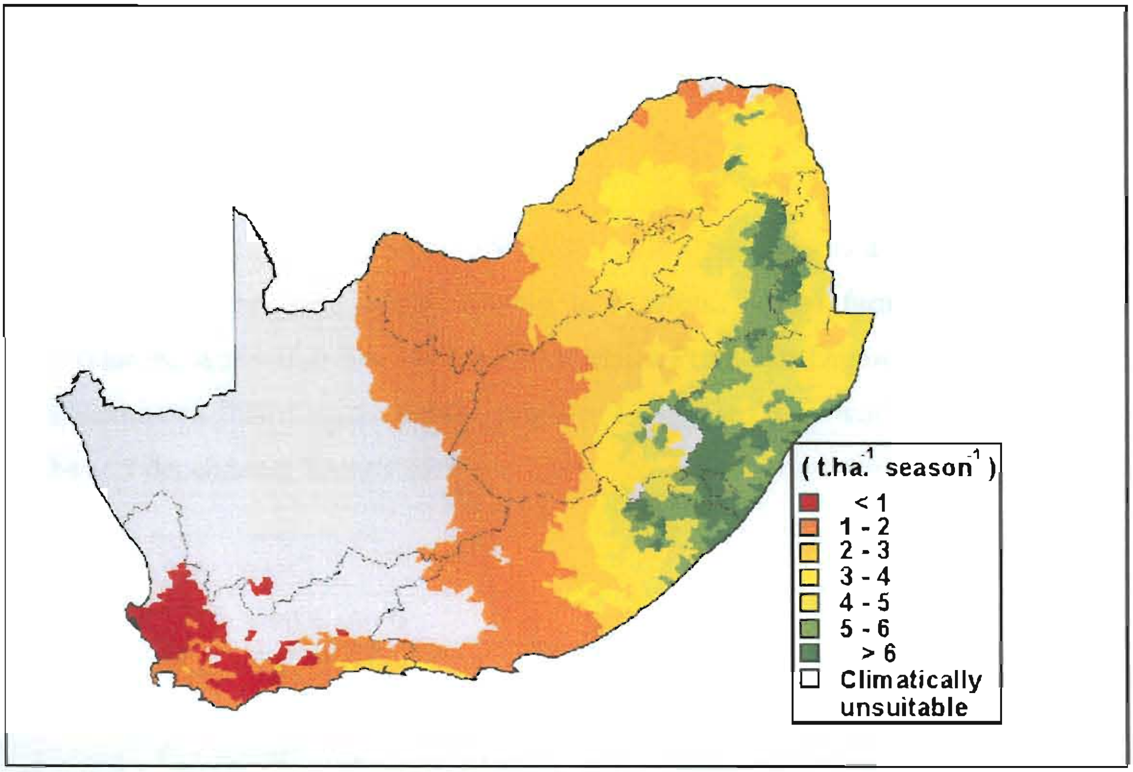

Figure 3.3: Maize yield estimation map of South Africa

Source: Department of Agricultural Engineering, University of Natal

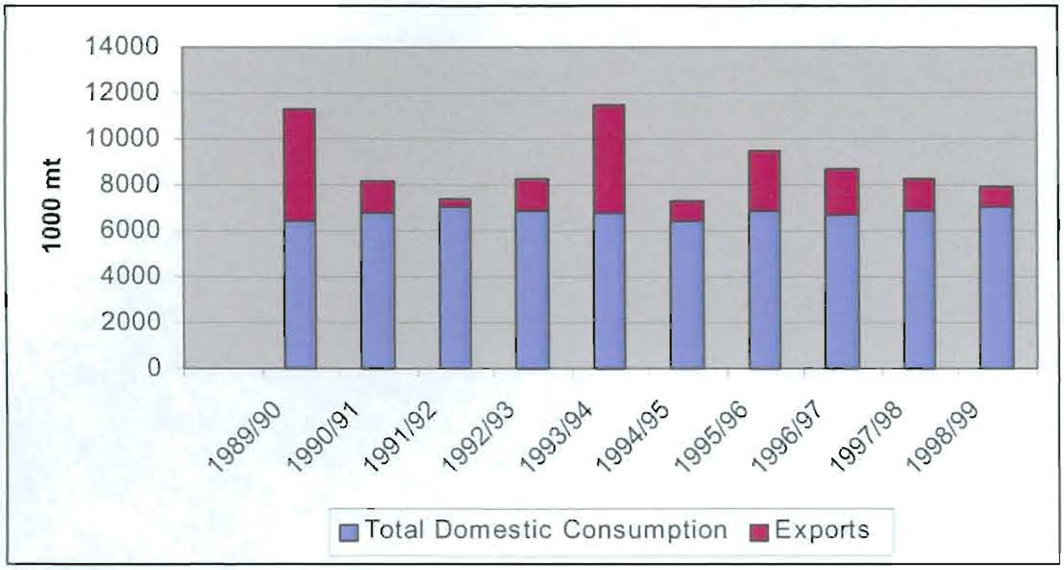

Figure 3.4: Maize utilisation

Source: SAGIS

3.3.5 LARGE-SCALE COMMERCIAL MAIZE FARMERS

White and yellow maize are produced under dryland and irrigation conditions by an estimated 6 000 large-scale maize farmers in South Africa. The age, gender and average farm size profile of maize farmers is very much the same as that of the cotton farmers as most cotton farmers surveyed are predominantly maize farmers. This study focussed mainly on irrigation farmers in the Northern Cape and irrigation and dryland farmers in Mpumalanga and the North West Province. Yellow maize production is the dominant farming activity of 94% of the surveyed farmers. 28% of the surveyed farmers were younger than 39 and 31% were older than 50 years of age. Irrigation farmers generally make use of beans, wheat, cotton or potatoes as rotating crops, while dryland farmers plant mainly sunflower, cotton or soya-beans. Table 3.6 gives an indication of the areas planted by surveyed maize farmers. The main aim of this table is to show the difference in areas planted by maize farmers within selected areas.

More than 66% of the farmers sold their yellow maize harvest to local cooperatives while 21% sold their maize directly to feedlots, broiler farmers or animal feed producers. According to a 1993 National Maize Producers Organisation publication, it is estimated that a maize farmer employs 15 regular farm workers who on average have 5 dependents living with them. They also employ a substantial number of casual workers for two to three months of the year. It is estimated that 40% of maize farmers have a qualification higher than a high school diploma (NAMPO, 1993).

Table 3.6: Maize areas planted by surveyed farmers

Province	Irrigation area	Dryland area
Northern Cape	95-1000 ha	
Mpumalanga	60-500 ha	300-3080 ha
North West	20-100 ha	150-1200 ha

Source: Own survey

3.3.6 SMALL-SCALE MAIZE FARMERS

Insect resistant white maize was introduced to small-scale subsistence farmers during the 2001/2002 season through a project initiated by Monsanto. Farmers or rural households producing maize under dry-land conditions were identified and selected in nine areas across Mpumalanga, KwaZulu Natal, Eastern Cape (Transkei) and Limpopo Province. Farmers in these areas where informed about the traits and characteristics of Bt maize through workshops held in their respective areas and were then supplied with small quantities of maize seed. Most farmers received two bags of seed, each containing 250g of white maize seed, but farmers planting larger areas received more seed. One of the bags contained Carnia 4549 seed, also known as Yieldgard, insect-resistant or Bt maize seed, while the other bag contained the isoline or conventional variety, Carnia 3549 that is genetically identical to Carnia 4549 except that it does not contain the Bt gene. Farmers were asked to plant and harvest these varieties separately but in all other practises to treat them the same way as they would treat their other maize. As most farmers plant a hectare or more of maize and only small amounts of seed were supplied by Monsanto, farmers still had to buy and plant, or use their own saved maize seeds

It would thus be wrong to refer to these farmers as adopters, as the seed was supplied to them for free. As data become available the 2002/2003 season will reveal more about the adoption of Bt white maize seed by subsistence farmers in South Africa, when these farmers, based on their 2001/2002 production experience, will have decided whether to buy Bt seed or conventional seed. Table 3.7 gives a breakdown of the characteristics of households in four of the six surveyed areas.

Table 3.7: Household and farm profile of subsistence maize farmers

Province & site	Mpumalanga Northern Highveld	KwaZulu Natal Hlabisa	Limpopo Province Venda	Eastern Cape Mqanduli
Avg. household size	6.17	6.38	6.50	7.64
Percentage of households with a pensioner	62%	52%	31%	41%
Avg. age of father	65	60	53	57
Avg. age of mother	58	57	46	52
Who makes decisions regarding maize farming?	Male 71% Female 29%	Male 57% Female 43%	Male 58% Female 42%	Male 62% Female 38%
Maize planting experience	>10 years 37%	>10 years 61%	>10 years 83%	>10 years 92%
Avg. total farm size	1.87 ha	1.93 ha	3.20 ha	4.07 ha
Avg. total maize area	1.44 ha	1.76 ha	1.97 ha	2.42 ha
Biggest household expenditure	Food 75%	Food 66%	Food 50%	Food 60%

Source: Own survey

3.4 REASONS FOR ADOPTION OF INSECT RESISTANT CROPS

In an attempt to provide objective, science-based information on the use of biotechnology in cotton production, the International Cotton Advisory Committee initiated an expert panel on biotechnology. In a report this expert panel concluded that numerous benefits of insect resistant cotton accrue to the grower, the global cotton industry, and society on many levels – economic, environmental and social (ICAC, 2000). According to various publications these benefits are not limited to Bt cotton but are in many cases also observed with Bt maize. These benefits are thus alleged to be inherent to the Bt gene and can be divided into direct and indirect benefits. Direct benefits consist of reduced pesticide use, improved crop management effectiveness, reduced production costs, enhanced yield and profitability, a reduction in production risk, and improved opportunity to grow crops in areas with sever pest infestations. The indirect benefits of the technology are the benefits that also appeal to the more environmentally conscious producers. These include improved populations of beneficial insects and wildlife in fields, reduced pesticide runoff, improved farm worker and neighbour safety, less air pollution and waste from the use of insecticides, a reduction in labour costs and time, a reduction in fossil fuel use, and improved soil quality because of less traffic in the fields.

An analysis of data from large-scale maize and cotton farmers, making use of a Logit model of factors such as area planted, age, education and credit did not render significant results as factors influencing the adoption of transgenic crops. An analysis of the characteristics of adopting small-scale cotton farmers compared to non-adopters and their reasons for adoption by Ismaël et al. (2001) rendered more satisfactory results. The tendency was for the older, more experienced farmers and those with larger farms to be the adopters. According to Ismaël et al. (2001), this can be explained by the fact that these were the farmers who were more likely to be granted credit, or were able to finance the higher seed costs from savings or from other income sources. The current situation on the Makhathini Flats supports this indication. The 2001/2002 season saw the emergence of a second ginning company on the Flats. Despite borrowing production credit from Vunisa and signing contracts vowing to deliver cotton to Vunisa many farmers delivered their cotton to the new gin. This caused Vunisa and the Land Bank to lose a substantial amount of money. Not surprisingly no credit was made available to cotton farmers on the Makhathini Flats for the 2002/2003 production season. Without production credit a very small number of small-scale farmers planted cotton (estimated 580 ha). Early indications of a 2002/2003 survey funded by CIRAD shows that the majority of farmers who did plant cotton this season are the older farmers who could fund inputs with pension money. The majority of these farmers planted Bt cotton (Hofs, 2003).

3.4.1 LARGE-SCALE COTTON FARMERS

Of the 43 large-scale cotton farmers interviewed, 39% indicated that the most important benefit of Bt cotton is saving on pesticides and application cost (Table 3.8). Peace of mind about bollworms came in as the second biggest reason for adoption with 25% of farmers indicating the benefit as most important. When asked to indicate all the benefits of insect-resistant cotton, 77% of farmers indicated peace of mind and 72% indicated better crop and risk management as a benefit. All the surveyed large-scale farmers were involved with other farming activities during the cotton season. Therefore, the large indication of peace of mind is not surprising. Using hired labour, scouting and spraying is especially difficult over the Christmas - New Year period and this is a crucial time in the production cycle of cotton in South Africa. The low labour saving perception may indicate that farmers feel that pesticide application is more capital- than labour intensive.

Table 3.8: Reasons for adoption of Bt cotton by large-scale farmers

Benefits and reasons for adoption	Most important reason / benefit (% of farmers)	Specific benefit (% of farmers)
Increased yield	7%	52%
Pesticide saving	39%	62%
Better crop and risk management	18%	72%
Better boll worm control	9%	55%
Peace of mind about bollworms	25%	77%
Labour saving	0%	2%
Better for environment	0%	37%
Other		9%

Source: Own survey

When asked about the disadvantages of Bt cotton the most common answer was the cost of seed and the technology fee. This is also the reason why some farmers have stopped planting Bt-seed. In 2000/2001 the cost of a 25kg bag of Bt seed amounted to about R210 and a farmer also has to pay an additional R600 technology fee. Large-scale farmers try to stretch a 25kg bag of Bt seed as far as possible using precision planters. A farmer planting 20kg of seed per hectare indirectly spends R 480 on bollworm control through the additional technology fee. Some commercial farmers who have already invested in spraying machinery feel that they can control bollworms for less. Most farmers don't spend R480/ha on the control of bollworms in a year with low bollworm pressure, but when the pressure is high, chemical and application costs can easily exceed this additional fee. In the 2001/2002 season, Monsanto, in alliance with Delta and Pineland, implemented a possibly more acceptable technology fee payment system. Farmers now have the option to pay R400/ha technology fee for irrigation land and R120/ha for dryland, on condition that they present a GPS map of the planned cotton field. The R600 per bag technology fee system is also still available for farmers, so each farmer can decide which option is the most cost effective.

3.4.2 SMALL-SCALE FARMERS

The impressive increase in the adoption of Bt cotton by small-scale farmers from 7% in 1997/1998 to around 90% in the 2001/2002 season can possibly be attributed to the success of the farmers who first adopted the new technology (DFID, 2001). Looking at the benefits indicated by the adopters and the perceived benefits indicated by the then non-adopters, it is revealing to compare the before and after benefit perception (Table 3.9). While 32% of non-adopters indicated that a yield increase is the most important benefit of Bt-cotton, increased yield was only indicated as the most important benefit by 18% of adopters. Increased yield is still indicated as a reason by more than 58% of adopters, but it seems that the most important benefit of Bt-cotton after adoption has become pesticide saving. In rural areas where infrastructure, transport and services are almost non-existent, managing pest infestation in crops is a major problem.

Table 3.9: Benefits of Bt-cotton as indicated by small-scale farmers

Real and perceived benefits	Most important benefit (% of farmers)		Specific benefit (% of farmers)	
	Non-adopters	Adopters	Non-adopters	Adopters
Increased yield	32%	18%	62%	58%
Better quality cotton	5%	3%	12%	30%
Higher price for cotton	0%	1%	12%	15%
Pesticide saving	35%	50%	77%	70%
Labour saving	10%	10%	42%	35%
Application saving	5%	3%	30%	18%
Other	10%	13%	27%	40%

Source: Own survey and Ismaël et al, 2001

3.4.3 DIFFERENCE IN ADOPTION BEHAVIOUR OF LARGE- AND SMALL-SCALE COTTON FARMERS

Compared to small-scale farmers the increased yield benefit is not that important to large-scale farmers. Although more than 50% of large-scale farmers indicated increased yield as a benefit, it is seen more as a bonus. The big advantage for large-scale farmers is that insect-resistant cotton gives them the peace of mind and the managerial freedom to go on with other farming activities. As previously mentioned, the whole process of pesticide application is more capital and management intensive than labour intensive for large-scale farmers. Large-scale farmers have to hire an aeroplane or use their own tractors to apply pesticides. The difficulty lies in fitting sprays in between the rain and irrigation schedules.

The large percentage of small-scale farmers indicating that pesticide saving is the most important benefit is not really surprising. When one includes saving on application cost, and labour saving with pesticide saving, more than 63% of small-scale Bt-adopters agree on the entire bollworm control benefit of Bt cotton. Pesticide application implies huge difficulties for small-scale cotton farmers. With a low level of education amongst small-scale farmers, problems with the mixing of pesticides and calibration of knapsack sprayers for different pesticides cause concern about the real efficacy and effectiveness of pesticide application. Applying pesticides is a labour intensive action for small-scale farmers. Walking with a knapsack sprayer on his back a farmer has to cover a distance of between 10 and 20 kilometres per hectare. Water has to be fetched from communal water points and water (especially in the Tonga community) is a scarce commodity and has to be fetched with water trucks or any other transport available. By the time a farmer has noticed bollworms, bought his pesticides and started to spray, severe damage has already been done.

Large-scale cotton farmers indicated some environmental or indirect benefits of Bt cotton. Spraying less pesticide or none at all has caused beneficial predator insects to flourish. More than 46% of farmers have noticed more beneficial insects on their Bt-cotton fields. Some farmers in the Northern Cape have indicated that Lady Bird beetles and Lacewings have reduced aphid populations to such a level that farmers did not have any need to spray for aphids on winter wheat. In the past some farmers in the Groblersdal area have experienced some pesticide resistance with bollworms. For them Bt cotton is a much needed solution. In seasons where bollworm pressure is high, farmers are forced to use pyrethroids, killing all beneficial insects and causing Red Spider Mites to thrive. Chemical control of Red Spider Mites is very expensive. The environmental effects of Bt crops however fall outside the scope of this study and still needs to be researched.

3.4.4 LARGE-SCALE COMMERCIAL MAIZE FARMERS

Large-scale maize farmers aim to maximise profit per hectare through high yields and cost minimisation by means of effective application of inputs. This statement is confirmed by the survey results in Table 3.10. Almost 70% of farmers indicated higher yield, better pest control or easier crop management as the most important benefits of genetically modified maize. It is thus also not surprising that more than 70% of the farmers indicated that the use of Bt maize seed offers them peace of mind regarding stalk borers. Even though none of the farmers indicated it as the most important benefit, 45% of the farmers did specify that they considered lower pesticide usage to be a benefit of Bt maize.

Table 3.10: Reasons for adoption of Bt maize by large-scale yellow maize farmers

Benefits and reasons for adoption	Most important benefit (% of farmers)	Specific benefit (% of farmers)
Higher yield	31%	62%
Lower pesticide use	0%	45%
Better pest control	15%	48%
Peace of mind	8%	72%
Easier crop management	23%	59%
Labour saving	0%	3%
Environmentally friendlier	0%	10%
Other	20%	

Source: Own survey

A number of farmers indicated the biggest advantage of Bt maize to be a longer planting period. Conventional maize is at risk of being severely damaged by stalk borers when planted early or late in the season - due to the peaking in stalk borer moth flights. Farmers planting Bt varieties have the freedom to make use of early rain or to wait for later better rain to plant their maize crop. With this freedom some farmers also felt that they are also able to be on the market earlier in the season and were able to secure a better price for their maize. Approximately 10% of farmers indicated that with Bt maize they had no more problems with lodging (falling over) of maize plants due to damage caused by the stalk borers.

When farmers were asked about disadvantages or problems with Bt maize the issues adopting-farmers were worried about were the same ones a small sample of non-adopting farmers presented as reasons for not adopting. These issues also seem to be the reason why the adoption rate of Bt maize has not been as impressive as that of Bt cotton. Most adopting farmers indicated that they were aware of and concerned about the international tumult about genetically modified food. In South Africa yellow maize is not directly consumed but is fed to animals and processed in the wet milling industry. Maize is however, as opposed to cotton, a foodstuff and more susceptible to consumer trepidation. Of the non-adopting farmers, 75% listed concern about "consumer response" and whether they "would be able to sell Bt maize" as a reason why they did not adopt. In the Northern Cape the local cooperative and main maize buyer in the area (SENWES) asked farmers not to plant Bt yellow maize. The reason for this is that this cooperative has maize export contracts to feedlots in Namibia and it is reported that feedlots are not allowed to feed GM maize to their cattle as they have beef export contracts with the EU. According to some farmers they were also promised a premium on non-Bt maize but this premium never materialised. The remarkable increase in adoption from 2000/2001 to 2001/2002 (Tables 3.2 and 3.3) suggests that after two seasons of Bt yellow maize production, farmers are less worried that they will not be able to sell their Bt harvest.

In 2000, when the survey was conducted, only a small number of Bt varieties were available to farmers. Some farmers indicated that they felt the Bt variety they planted was not the best suited for their specific production conditions. An increase in the number of different Bt yellow maize varieties as marketed by different seed companies would give farmers a broader choice of varieties.

3.4.5 SMALL-SCALE MAIZE FARMERS

During the 2001/2002 production season subsistence farmers in nine areas in South Africa were able to compare Bt white maize with the conventional isoline and with their own seed, whether it was a hybrid, an open pollinated variety or traditional white maize seed. Bt white maize seed was introduced to close to 1500 small-scale / subsistence farmers through this Monsanto project. Due to the impressive number of farmers in different areas who received seed, it is suggested that this study was not so much an attempt to test the expediency of insect resistant maize produced under small-scale conditions, as it was a marketing strategy to introduce Bt maize to small-scale farmers.

Figure 3.5 illustrates the biggest benefits of Bt maize indicated by small-scale farmers. The percentages indicate the percentage of farmers in each site that indicated the specific benefit. The "other" benefits include easier management, insecticide savings and less need for spraying water. For all the sites, the two major benefits indicated by farmers were increased yield and better quality of both fresh green mealies and harvested grain. The trade-off between the importance of yield and quality in Figure 3.5 can be better explained by considering the specific uses of the maize harvest and the poverty levels at each of these sites. As can be seen in Table 3.11 households on the Northern Highveld and in the Hlabisa area in KwaZulu Natal (KZN) consume substantially more green mealies than households in Venda and Mqanduli and thus the quality of the green mealies plays a more important role. The Moutse-Dennilton area in the Northern Highveld where the survey was conducted is more urbanised than the other sites and there is a market for green mealies with a large number of taxis and commuters travelling through the area on a daily basis. It is part of the Zulu tradition to consume green mealies and thus even though the Hlabisa area in KZN is one of the poorest of the six sites surveyed, green mealies are still consumed there. Subsistence farmers see the consumption of green mealies as a luxury.

The actual poverty level in these sites are indicated by the large number of farmers that keep a considerable portion of their harvest to process themselves instead of sending it to millers to be milled at a cost. For many of these farmers quantity is more important than quality. The area in Venda that was surveyed is less poverty stricken and a large number of farmers sell maize and takc maize to the miller to be milled for mealie meal.

It is interesting to note the labour saving perception difference between small-scale cotton farmers and subsistence maize farmers. The first seasons' study showed that on average less than 50% of small-scale maize farmers applied pesticides. In most cases a carbaryl is applied in granular form on a once-off basis when stalk borers are observed. Maize does not require the intensive insecticide-spraying program that cotton does and Bt adopting maize farmers thus have a lower pest control linked labour saving perception.

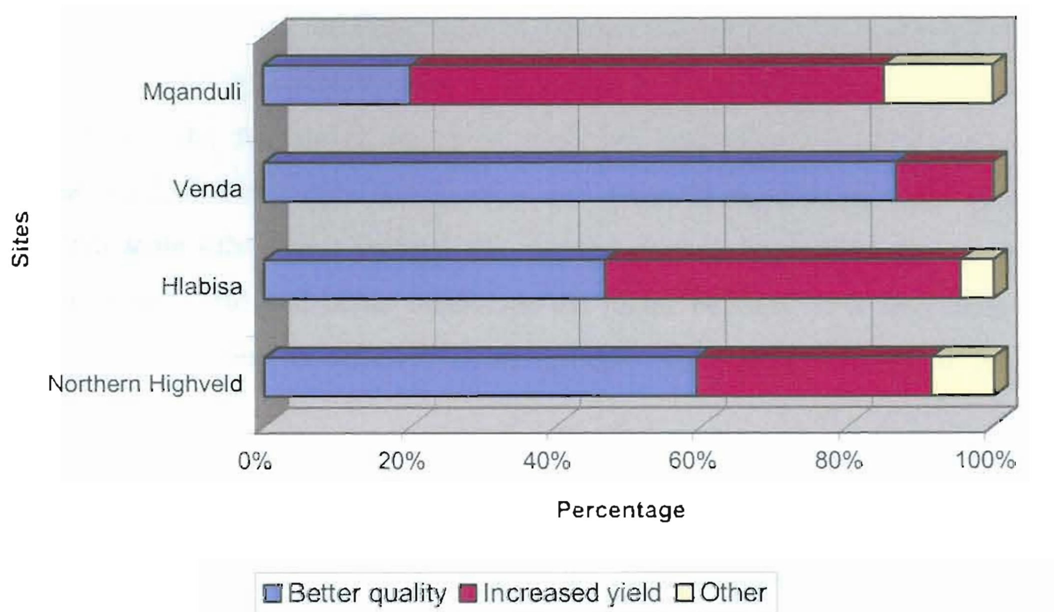

Figure 3.5: Benefits of Bt maize as indicated by subsistence farmers

Source: Own survey

Table 3.11: Harvest and use of maize by subsistence farmers

	Mpumalanga	KwaZulu Natal	Limpopo	Eastern Cape
Site	Northern Highveld	Hlabisa	Venda	Mqanduli
Harvested green mealies?	Yes 50%	Yes 66%	Yes 3%	Yes 0%
Sold green mealies?	Yes 20%	Yes 4%	0%	0%
What did farmers do with their harvested grain?	Sent to miller for milling 47% Sold 22% Kept 24%	Sent to miller for milling 10% Sold 16% Kept 75%	Sent to miller for milling 34% Sold 15% Kept 46%	Sent to miller for milling 12% Sold 10% Kept 76%

Source: Own survey

The one big problem farmers indicated with Bt maize was damage caused by birds. In the Southern Highveld, Hlabisa and Venda areas where farmers enjoyed the highest yields the maize cobs seem to be longer than the husk that covers it and birds fed on the part of the cob that protrudes from the husk. Some farmers however had this same problem with the conventional isoline so it is possible that this problem is linked to the variety and not to the presence of the Bt gene.

3.5 CONCLUSION

This chapter focused on the different farmers groups in South Africa who adopted genetically modified maize and cotton and highlighted the groups' different reasons for adoption. It is suggested that perceived and real benefits as indicated by seed agents and observed through own cotton and maize production experience can be accepted as reasons for adoption of the new technology. Large-scale cotton farmers for whom cotton production is usually not the dominant farming activity indicated better crop and risk management, pesticide saving and peace of mind as the main benefits. Small-scale resource poor cotton farmers in comparison indicated higher yield and saving on insecticides as the major benefits. Large-scale commercial yellow maize farmers who attempt to maximise profit per hectare indicated higher yields, better pest control, easier crop management and peace of mind as the main benefits, while small-scale subsistence farmers who depend on their harvest for food security, indicated higher yield and better quality as the major benefits. It is thus clear that different benefits appeal to different farmer groups - each group reacting to its own needs.

While Chapter 3 focused on the benefit perceptions of different farming groups, Chapter 4 will aim to quantify those benefits by focusing on the on-farm effects of adoption of insect resistant maize and cotton experienced by the different groups of farmers.

CHAPTER 4

FARM-LEVEL EFFECTS

"If it looks like a duck, and quacks like a duck, we have at least to consider the possibility that we have a small aquatic bird of the family anatidae on our hands."
Douglas Adams, 1988

4.1 INTRODUCTION

Bt crops refer to the genetically modified crops that carry the gene from the soil bacterium *Bacillus thuringiensis.* Bt is a bacilliform bacterium that produces spore and crystal protein toxins. Different subspecies produce proteins that are toxic to different insects. The Bt cotton for example produces CRYIA(c) proteins and Bt maize produces either CRYIA(b) CRYIA(c) or CRY9. All these mentioned proteins are toxic to Lepidoptera larvae. Crops containing the Bt gene are able to produce this toxin, thereby providing protection throughout the entire plant. These crops are said to be insect-resistant and are designed to reduce yield losses through better pest control.

Small-scale and large-scale cotton farmers as well as large-scale maize farmers in the previous chapter indicated higher yields and saving on pesticides as reasons for adoption of insect resistant cotton and maize. This chapter indicates whether and how these perceived benefits and advantages financially materialise in farmers' production budgets.

This Chapter will attempt to quantify the benefits as well as the disadvantages of insect resistant cotton and maize as produced by large-scale and small-scale farmers in South Africa.

4.2 FARM-LEVEL IMPACT OF INSECT RESISTANT CROP ADOPTION

Adoption of insect resistant (Bt) crops impacts farm income in at least three different ways:

- Increase in yield due to better pest management
- Decrease in input cost through savings on insecticide chemicals and application costs
- Increase in input cost through a higher seed price and an additional technology fee.

If the particular pests are present but not in sufficient numbers to significantly effect yield, or if the pests affect yield but can be inexpensively controlled by other means, then the producer of the pest resistant crop may not experience a net benefit. If the pests are prevalent to an economically damaging extent in the area, however, then this complete control can result in significant yield increases (Marra, Pardey & Alston, 2002).

Many studies show that the use of insect resistant crops reduces the number of sprays and thus pesticide volumes needed to control problem insects. If the reduced spraying need outweighs the additional cost of seed, then farmers gain. Table 4.1 summarises some studies and their findings. Most of these studies were conducted in the United States where the technology was developed, approved and first adopted.

Table 4.1: A summary of some selected previous farm-level impact studies

Bt Cotton					
Researcher	**Country - state**	**Data source**	**Yield**	**Insecticide use**	**Gross margin**
Stark, 1997	USA, Georgia	Survey	Increase	Decrease	Increase
Gibson et al., 1997	USA, Mississippi	Survey	Increase	N/A	Increase
ReJesus et al., 1997	USA, South Carolina	Experiments	Same	N/A	Increase
Bryant et al., 1998	USA, Arkansas	Experiments	Increase	N/A	Increase
Marra et al., 1998	USA	Survey	Increase	Decrease	Increase
Pray et al., 2000	China	Survey	Increase	Decrease	Increase
Fernandez-Cornejo et al., 2000	USA	Survey	Increase	Decrease	Increase

Bt Maize					
Crop and researcher	**Country - area**	**Data source**	**Yield**	**Insecticide use**	**Gross margin**
Marra et al., 1998	USA, Cornbelt	Survey	Increase	Decrease	Increase
European Commission, 2000		Field trails	Increase	N/A	Increase
Rice et al., 1998	USA	Variety trails	Increase	N/A	N/A
Gianessi et al., 1999	USA	Experiments	Increase	N/A	N/A
Brookes 2002	Spain	Survey	Increase	Decrease	Increase
STRIVE Foundation 2002	Philippines	Field trails	Increase	N/A	Increase

Source: Adapted from Marra, 2001.

4.3 FARM-LEVEL IMPACT OF Bt COTTON IN SOUTH AFRICA

In a field trial conducted by Clark Cotton on their Mpumalanga experimental farm, a comparison was made between the production budgets of Bt cotton (NuOpal) and a conventional cotton variety (Opal) as produced under irrigation. As illustrated in Table 4.2 the main difference between the budgets can be found in yield, insect control and seed cost. It is also interesting to note Bt cotton's increased harvesting cost due to increased yield.

Even though field trails give a good indication of the yield potential of different seed varieties under different production conditions, it is better to look at the production experience of a number of farmers in different areas to come to any conclusion regarding the on-farm effects of Bt cotton.

Table 4.2: Budget comparison of Opal (conventional) and NuOpal (Bt) cotton

Operation	Unit	Cost per unit	Opal		NuOpal	
			Quantity per ha	Cost in rand	Quantity per ha	Cost in rand
1.PRE –SOWING						
Soil correction (gypsum)	Ton	52.0	3.0	156.0	3.0	156.0
Ripping	Mach/hour	100.0	0.5	50.0	0.5	50.0
Disking	Mach/hour	72.0	2.0	144.0	2.0	144.0
Herbicides Cotonex	Liter	56.0	4.0	224.0	4.0	224.0
Metagan	Liter	118.0	0.7	82.6	0.7	82.6
Sub-total				**656.6**		**656.6**
2. SOWING						
Seeds - conventional	Kg	7.6	18.0	136.8	0.0	0.0
- Bt	Kg	8.4	0.0	0.0	18.0	151.2
Bt licence	R/bag	600.0	0.0	0.0	400.0	400.0
Fertiliser (13:7:10)	Kg	1.9	150.0	285.0	150.0	285.0
Operation	Mach/hour	48.0	1.0	48.0	1.0	48.0
Sub-total				**469.8**		**884.2**
3. GROWING						
Mechanical weeding	Mach/hour	56.0	2.0	112.0	2.0	112.0
Manual weeding	Man/day	24.0	8.0	192.0	8.0	192.0
Fertiliser (LAN:28)	Kg	0.9	380.0	342.0	380.0	342.0
Irrigation	Mm	0.7	260.0	182.0	260.0	182.0
Growth regulator	Liter	106.0	0.940	100.0	0.940	100.0
Sub-total				**928.0**		**928.0**
4. INSECT CONTROL						
Thioflo (Endosulfan)	Liter	75.0	3.7	277.5	0.3	22.5
Agromectin	Liter	352.0	0.3	105.6	0.3	105.6
Cypermethrin	Liter	84.0	0.5	42.0	0.5	42.0
Aerial costs		60.0	6.0	360.0	6.0	120.0
Sub-total				**785.1**		**290.1**
5. HARVESTING						
Hand picking	Kg seed cotton	0.55	6665.0	3665.8	7782.0	4280.1
Seed cotton cost				**6504.5**		**7039.0**
6. ECONOMIC COSTS						
Management & administrative				2344.0		2344.0
Interest on capital invested				160.0		160.0
All repairs						
General farm overheads						
7. FIXED COSTS				80.0		80.0
8. TOTAL COSTS				**9088.5**		**9623.0**
9. VALUE OF SEED COTTON	Kg	2.75	6665.0	18328.8	7782.0	21400.0
10. PROFIT				**9240.3**		**11777.0**

Source: Hofs, 2001

4.3.1 YIELD

The yield benefit enjoyed by farmers using Bt cotton differs between countries and between regions within countries. The yield advantage mainly depends on the pest pressure of the pest the Bt gene is controlling for, as well as the insect controlling practises of the farmers. Edge et al., (2001) refer to various studies in which yield increases were found. In the United States significant yield increases have been reported in studies across the Cotton Belt. Kerby (1996) found a yield increase of 20%, while Altman (2001) indicated a 14% yield increase. In China (Buranakanonda, 1999) and Spain (Novillo et al., 1999) yield increases of respectively 15 and 12 percent were found while a study in India recorded a yield increase of between 14 and 38 percent. Another study in India by Qaim (2002), found a yield increase of up to and in excess of 80%. The author contributes this huge yield increase to a very high level of bollworm infestation in the study season as well as ineffective bollworm-related yield loss control methods in conventional cotton due to lower pesticide usage levels, pesticide resistance and human capital as well as institutional constraints.

In Table 4.3 the yields of Bt cotton adopters and non-adopters in South Africa are compared. As Klotz-Ingram et al., (1999) admonish, caution must be exercised in interpreting results. Differences between yields and pesticide applications cannot solely and necessarily be attributed to the use of genetically engineered seed as they are also influenced by other factors. These factors include: irrigation, weather, soils, nutrients, pest management practises, crop management, pest pressure, other-crop practices and operator characteristics. The majority of large-scale cotton and maize farmers used in this study were able to compare Bt and non-Bt varieties as they produced both Bt and non-Bt crops and variation in production practises and conditions were thus kept to a relative minimum. Even though production conditions and practises of cotton farmers on the Makhathini Flats are also rather similar, caution is still advised when data for both large and small-scale maize and cotton farmers are interpreted.

The average cotton yield of South African adopters seems to be significantly higher than that of non-adopters for both the large-scale and the small-scale farmers (Table 4.3). Large-scale irrigation farmers enjoyed an 18.5% yield increase with the use of Bt cotton while field trails on the Clark Cotton experimental farm in Mpumalanga indicated a 16.8% yield increase (Hofs, 2001). Dryland large-scale farmers enjoyed a 13.8% yield increase with the use of Bt seed while dryland small-scale farmers on average experienced a 46% yield increase. The difference in yields was statistically significant at a 95% confidence level for the irrigation and dryland large-scale farmers as well as for the small-scale farmers.

Table 4.3: Comparing the average yield per hectare of large and small-scale adopters and non-adopters in South Africa

		Non-Bt Large-scale 2000/2001 (kg/ha)	Bt Large-scale 2000/2001 (kg/ha)	Non-Bt Small-holder 1999/2000 (kg/ha)	Bt Small-holder 1999/2000 (kg/ha)
Irrigation	**Mean**	3413	4046		
Dryland	**Mean**	832	947	395	576

Source: Large-scale data – own survey
Small-scale data – Ismaël et al., (2001) and own survey

The yield benefit enjoyed by large-scale farmers compares well with that of farmers in the United States. It can be argued that this is because of similar capital-intensive (mechanical) pest control practices. The yield benefit of small-scale farmers on the other hand is more like that of the Indian farmers. Qaim (2002) indicated low pesticide levels, lack of human capital and institutional constraints as some reasons for the large difference between the yield of Bt cotton and conventional cotton with conventional spraying practices. These reasons also apply to South African small-farmers. As was mentioned in Chapter 3, by the time a small-scale farmer has noticed bollworms, bought his pesticides and started to spray, severe damage has already been done. Many farmers indicated that they were not even able to apply pesticides on their whole field due to lack of time, knapsacks, labour and the cost of pesticide. With a low education level causing problems with the mixing of pesticides and the calibration of knapsack spraying nozzles, the efficacy and efficiency of pesticide applications is questionable for a large number of small-scale farmers.

According to Hofs (2001) the yield advantage of Bt cotton can be attributed to a better fruit retention at the first position and a significant higher number of bolls at secondary positions. In laymen's terms this means that the Bt cotton plants have more bolls closer to the main stem where it can take advantage of the maximum nutritional flow and are less sensitive to stress. These bolls are formed first and are the biggest and heaviest and are typically lost due to damage caused by bollworms.

There was also a yield difference between the cotton produced under pivot irrigation and flood irrigation. Some farmers in the Northern Cape use flood irrigation, which is less effective than pivot irrigation, and farmers especially have irrigation-labour problems during the grape season.

4.3.2 PESTICIDE USE

A significant benefit that Bt cotton brings to growers is a reduction in the use of conventional broad-spectrum insecticide sprays and the associated total kilograms of insecticidal active ingredients for control of lepidopteran species. Numerous studies conducted across the United States, Australia, China, Mexico and Spain demonstrated an overall reduction in the application of broad-spectrum insecticide sprays ranging from 1 to 7.7 sprays. In China the adoption of Bt cotton has reduced the total insecticide use by 60 to 80 percent and the applications of insecticides for lepidopteran pests by 90 to 100 percent (Edge et al., 2001). Qaim (2002) reports that on average, Bt cotton in India was sprayed three times less than conventional cotton varieties. The number of saved sprays and thus the pesticide saving benefit due to Bt cotton depends on the infestation level of the particular insect. Due to the cyclical and fluctuating nature of the seasonal emergence and presence of insects in nature and thus on crops, saving on pesticides and sprays will vary between seasons and regions.

Monsanto reports an average saving of 5.8 sprays on dryland field trails on the Makhathini Flats (Bennett, 2001), while Hofs (2001) reports a saving of 4 insecticide applications on irrigated cotton in Mpumalanga. These 4 applications would have consisted of approximately 3.4 litres of endosulfan (organophosphate). South African farmers still need to spray for sucking insects like Jassids and Aphids. With conventional cotton these pests are killed in the crossfire aimed at the bollworm complex but have now become the main cotton pests. Jassids and Aphids can be controlled with relatively inexpensive, environmentally less damaging organophosphates. These insecticides are less effective on bollworms however and most farmers have to apply a pyrethroid to control bollworms. Pyrethroids, rather detrimentally to the celebrated integrated pest management approach, also kill all the beneficial insects like lacewings and ladybirds and thus the risk of a Red Spider Mite invasion is increased due to the removal of the natural predators.

Table 4.4: Cost of insecticides for adopters and non-adopters

		Non-Bt Large-scale 2000/2001 (R/ha)	Bt Large -scale 2000/2001 (R/ha)	Non-Bt Small-holder 1999/2000 (R/ha)	Bt Small-holder 1999/2000 (R/ha)
Dryland	**Mean**	192	79	129	97
Irrigation	**Mean**	519	226		

Source: Large-scale data – own survey
Small-scale data – Ismaël et al., (2001) and own survey

It is important to note that the data shown in Table 4.4 represents the Rand value per hectare spent on chemicals to control insects harmful to cotton. These figures do not include application costs. For large-scale farmers who hire an aeroplane for spraying, 4 less sprays would mean a saving of between R182 and R336 per hectare. It is estimated that large-scale farmers spraying with a tractor save between R52 and R144 on average for diesel, lubrication and mechanical wear and tear. For small-scale farmers, having to spray less means saving labour – in most cases farmers apply the insecticides themselves. Less spraying time means more time for weeding or other activities.

4.3.3 COST OF SEED AND THE ADDITIONAL TECHNOLOGY FEE

At this time, little downside risk from Bt cotton use has been documented, other than that the cost of the technology fee, which in seasons when pest infestation is relatively low, can be greater than the cost of conventional broad-spectrum insecticide costs (Edge et al, 2001). The ICAC (1997) indicated that farmers planting Bt cotton in the USA paid US$ 80/ha for Bollgard technology, under the assumption that the technology would save them at least US$ 80/ha in insecticide spraying or bring about an increased yield.

The higher Bt seed price South African farmers have to pay is comprised of a seed price paid to the seed supplier (Delta and Pineland) and a technology paid fee to the technology supplier (Monsanto). In the 1998/1999 season the "seed cost" of Bt cotton seed was R165 for 25kg compared to R150 for the conventional isoline. In 1999/2000 farmers paid R20 more for Bt seed than the conventional variety and in 2000/2001 farmers paid a R25 premium.

Table 4.5 compares the cost of seed and pesticides of non-adopters with the cost of seed, additional technology fee and pesticide cost of adopters. It is clear that neither small-scale nor large-scale farmers were able to cover the higher seed cost and the additional technology fee purely out of savings on pesticide chemicals in either of the surveyed production seasons. If the costs of pesticide application were added for adopters and non-adopters, this table would probably show a different picture. This study has however not been able to quantify the labour-saving aspect for small-scale farmers.

Table 4.5: Comparing the total per hectare cost of seed and pesticides for non-adopters with adopters' seed-, technology- and pesticides cost.

		Non-Bt Large-scale 2000/2001 (R/ha)	Bt Large-scale 2000/2001 (R/ha)	Non-Bt Small-holder 1999/2000 (R/ha)	Bt Small-holder 1999/2000 (R/ha)
Dryland	**Mean**	255	375	254	385
Irrigation	**Mean**	671	796		

Source: Large-scale data – own survey
Small-scale data – Ismaël et al., (2001) and own survey

Another factor that distorts the seed cost, technology fee and pesticide figure of small-scale adopters in Table 4.5 and makes it difficult to make comparisons with large-scale farmers is the fact that large-scale farmers paid a technology fee of R600 / 25kg of Bt seed while small-scale farmers paid a technology fee of only R230 / 25kg. The lower technology fee for small-scale farmers can be explained by a combination of possible factors including willingness to pay, an effort towards poverty alleviation by the multinational technology innovator, but more likely an endeavour to establish a market for transgenic cotton among small-scale producers as the small-holder farming conditions in South Africa are more applicable to the rest of Africa than that of the South African large-scale farmers. The more agriculturally related reason is that large-scale dryland cotton farmers plant between 5.3 and 8 kg of seed per hectare while according to Vunisa many small-scale farmers are known to plant up to a bag (25kg) of seed per hectare. According to Ismaël et al., (2001) adopting small-scale farmers plant 11.5 kg of seed on average. Table 4.6 illustrates that the difference in technology fee per hectare, for small-scale farmers planting between 11.5 and 25 kg of seed per hectare and for large-scale farmers planting between 5 and 9 kg of seed per hectare, is not as substantial as the difference in technology fee per bag would suggest.

Table 4.6: Technology fee per hectare comparison between small-scale and large-scale dryland farmers

	Small-scale dryland farmers R230 / 25kg	Large-scale dryland farmers R600 / 25kg
Kg seed per ha	**Technology fee per ha**	**Technology fee per ha**
5	46	120
6	55	144
7	64	168
8	74	192
9	83	216
10	92	240
11	101	264
12	110	288
18	166	432
25	230	600

Source: Own survey

Many of the large-scale farmers indicated that they felt that Bt cotton could be seen as a kind of insurance against bollworms. In seasons with low bollworm pressure conventional cotton might be more profitable than Bt cotton, but in a season where bollworms cause enough damage to significantly affect the yield, the Bt insurance covers the loss.

4.3.4 THE INCOME EFFECT

Despite the higher seed cost and an additional technology fee, both large-scale and small-scale farmers realised higher net incomes per hectare with Bt cotton due to the higher yield and savings on pesticide chemicals (Table 4.7). This income benefit may be expected to increase if cost of application is taken into account. The advantage of less chemical application for small-scale farmers is both financial and health related. Some other benefits that cannot be directly expressed in monetary terms are less pest control labour needed, less water transport and less exposure to toxic chemicals. Large-scale farmers save on fuel, repairs and maintenance or on flying costs. There is also less tractor traffic in the cotton fields, realising indirect benefits to soil quality.

Table 4.7: Income effect of adoption of Bt cotton

	Small-scale farmer	Large-scale farmer	
	Dryland (R/ha)	**Dryland (R/ha)**	**Irrigation (R/ha)**
Yield Benefits per hectare @ R2.75/kg	498	314	1741
Reduced pesticides benefit	32	114	293
Increased seed and technology fee detriment	(163)	(234)	(419)*
Income advantage / disadvantage	367	194	1615

* This is a revised figure from an earlier publication (Kirsten, Gouse and Beyers, 2002)

In a country like South Africa where unemployment is a huge and very real problem, labour saving due to a lower need for insecticide applications cannot be good news for an already struggling rural labour force and community. However with a yield increase in excess of 40%, additional labour would be needed for harvesting. Thirtle and Shankar (2003) estimate the net effect of Bt cotton adoption is to increase hired labour on the Makhathini Flats by about 15%. Due to the mechanised pest control methods of large-scale farmers, the labour saving / job loss concern for farm workers is not significant. However with approximately 40% of South Africa's cotton being harvested by hand, a yield increase means an increase in the demand for labour. In a simplified example of a Bt adopter, a yield increase of 633 kilograms per hectare under irrigation and at an average picking cost of R0.55 per kilogram of seed cotton, would mean that a large-scale farmer making use of manual harvesting would have to spend R348 per hectare more on labour.

A high percentage of large-scale farmers have indicated peace of mind about bollworms as a very important benefit of Bt cotton. Peace of mind about bollworms gave large farmers more managerial freedom; thus more time to spend on the production of other crops or farming activities. This chapter did not attempt to quantify the value of peace of mind but it is suggested that this value can be expressed as a percentage of the income from other farming activities. This percentage represents the value of production that might have been lost if less time were spent on the management of other crops or activities.

4.4 FARM-LEVEL IMPACT OF BT MAIZE IN SOUTH AFRICA: LARGE-SCALE MAIZE FARMERS

According to Marra (2001) the only major benefit to date of Bt maize in the USA has been an increase in yield, because in most areas and over most years the European corn borer infestation level has not been significant enough to control with insecticides. However, in South Africa and other southern African countries the losses sustained in maize crops due to damage caused by the African maize stalk borer (*Busseola fusca)* are estimated to be between 5 and 75 percent and even higher (Annecke & Moran, 1982). According to Annecke and Moran (1982), it is generally accepted that B. fusca reduce the South African maize crop by an average of 10%. According to Kfir (1997), *Busseola fusca* and the *Chilo* stalk borer (*Chilo partellus)* are the most important pests of maize and grain sorghum in South Africa. A seemingly conservative estimation of 10% for damage caused by both B. fusca and C. partellus means an average annual loss of just under a million tons of maize with an approximate value of above R810 million. According to unpublished "Crop production guidelines" of the South African Department of Agriculture (1991), it is especially the November plantings on the Highveld that four in every five seasons come under considerable pressure from second generation stalk borers known as "kopruspe".

4.4.1 YIELD

The yield advantage created by the use of Bt maize depends on the stalk borer infestation level and the conventional pest management efficiency of the farmer, as the Bt gene does not increase maize yield but only decreases yield loss caused by stalk borers. The yield advantage thus differs between regions and between farmers within regions. Large-scale yellow maize farmers were asked to compare the yield of Bt maize with that of their conventional varieties. There is however an important difference to note between the maize yield comparisons and the cotton yield comparison discussed above. Cotton farmers were able in most cases to compare the Bt variety with either the conventional isoline (Acala 90) or the most popular conventional variety at the time, Delta Opal. Maize farmers however have a wide range of maize seed varieties marketed by a number of seed companies to choose from. Each season a number of new, genetically improved through conventional breeding but not genetically modified, maize varieties come onto the market. Each maize production area has certain maize varieties specifically bred to suite the production conditions of the area. In 2000/2001 when the survey was conducted only a limited number of Bt varieties were available for commercial production and farmers thus had to compare relatively older varieties containing the Bt gene with newer, in many cases better adapted, conventional varieties. Despite this fact the majority of large-scale farmers surveyed enjoyed yield increases with Bt maize and only about 10% indicated lower yield with Bt maize.

Marra, Carlson and Hubbell (1998) report that the use of Bt corn resulted in better control of the European corn borer, boosting yields in the US by 4 to 8 percent depending on location and year. Marra, Pardey and Alston (2002) indicate a range of yield increases in different US states, from 1138 kg/ha in Minnesota to 444 kg/ha in Iowa. In the Huesca region in Spain, Brookes (2002) reports a yield increase of 10% where pesticides where used on conventional maize and an increase of 15% where insecticides where not used. Other regions in Spain enjoyed an average of 6.3% with in a range of 2.9 and 12.9 percent. Gonzales (2002) recorded a yield advantage of 41% with Bt maize on field trails in the Philippines while Philippine farmers indicated a 60% yield benefit. According to Mr JHE Barry (2002), a large-scale maize, dairy and pork farmer close to Bergville in KwaZulu Natal, his Bt yellow maize outperformed his conventional maize varieties by over 8% on average over the last five seasons.

The differences in yield enjoyed by surveyed large-scale yellow maize farmers are indicated in Table 4.8. These data were calculated using farmers' collected production data for both the 1999/2000 and 2000/2001 production seasons and thus represent an average for the two seasons. Irrigation farmers in the Northern Cape and Mpumalanga are included while the sample of dryland farmers consists of farmers in Mpumalanga and North West Province. A 1200 kg/ha and 326 kg/ha yield increase translates to an 11.03 and 10.60 percent yield increase on irrigation and dryland respectively. It is important to note that even though these figures are accurate and give a good indication of the performance of Bt yellow maize varieties compare to conventional varieties, the statistical significance is questionable due to the small sample size.

Table 4.8: Yield differences between Bt and conventional maize - average for 1999/2000 and 2000/2001

Province	Conditions	Yield with Bt maize kg/ha	Yield with conventional maize kg/ha	Percentage yield advantage
Mpumalanga	**Irrigation**	11 280	10 500	7%
Northern Cape	**Irrigation**	12 160	10 860	12%
Average for total irrigation	**Irrigation**	12 081	10 881	11.03%
Mpumalanga	**Dryland**	5 000	4500	11%
North West	**Dryland**	3 130	2 920	7%
Average for total dryland	**Dryland**	3 398	3 072	10.60%

Source: Own survey

From these data it is clear that the surveyed large-scale yellow maize farmers benefited from the use of Bt maize through increased yields. The size of the yield benefit will however vary between seasons, regions, farmers and the conventional variety a farmer is comparing the transgenic variety to. Due to the more humid conditions on Mpumalanga irrigation schemes, which favour stalk borers, it might be expected that the yield benefit of Mpumalanga farmers will exceed the yield benefit of Northern Cape farmers over the longer term. In neither of the two survey seasons did farmers in any survey region indicate a high level of stalk borer infestation. One can thus expect that the yield benefit might increase in seasons with higher stalk borer pressure.

4.4.2 PESTICIDE USE

Brookes (2002) estimated that farmers in the Huesca region in Spain save on average approximately R364 (42 Euro's) in pesticide cost per hectare with the use of Bt maize. According to Marra (2001) the adoption of Bt maize in the US has not been associated with a significant decrease in insecticide usage due to the fact that the European corn borer infestation level very seldom reaches the point where it becomes economically beneficial to apply pesticides.

Stalk borers were indicated to be the dominant problem insect by 70% of the surveyed South African yellow maize farmers. In the Northern Cape, with its dry and very warm climate, 40% of the farmers indicated that they did not apply any pesticides on maize whatsoever. Of the farmers who did apply, 50% applied an aldicarb at planting time to control nematodes and in most cases only a single spray of endosulfan or a pyrethroid to control cutworm and stalk borers on their conventional varieties. None of the Northern Cape farmers sprayed any pesticides on their Bt maize but 25% still planted with aldicarb. Table 4.9 compares the average expenditure per hectare on chemical insecticides for conventional maize and Bt maize.

Insects prefer the more humid conditions in Mpumalanga, especially in the regions of the irrigation schemes at Groblersdal and Marblehall. All the surveyed farmers plant with aldicarb for nematodes and most had to spray at least once with both an endosulfan and a pyrethroid. Most large-scale farmers, dryland and irrigation, make use of seed treatments to control ground weevils, maize beetles and false wireworms amongst other pests. Of the dryland farmers surveyed in the North West Province 46% did not apply any pesticides while most of the remaining 54% applied a single organophosphate spray and / or a single pyrethroid spray to control stalk borer and cutworm. Where Bt maize was planted, farmers in most cases applied only one spray to control cutworm. In Mpumalanga where second generation stalk borers are sometimes a problem, farmers would apply an additional pyrethroid spray early in the new year if maize is not in seed at the time (if maize was planted late).

Table 4.9: Conventional vs. Bt maize – cost of applied pesticides comparison

	Irrigation	Insecticide cost with conventional maize (R/ha)	Insecticide cost with Bt maize (R/ha)
Northern Cape	Irrigation	178	73
Mpumalanga	Irrigation	225	80
Mpumalanga	Dryland	93	46
North West	Dryland	68	13

Source: Own survey

In Table 4.9, again, the application costs of insecticides are not taken into account. Large-scale farmers also indicated that one should not forget about the cost of application water. According to a dryland farmer in Mpumalanga, water pumping and transport costs amount to about 7 cents per litre. With the use of approximately 200 litres of water for spraying per hectare of maize per season, the cost of water adds up to a significant amount.

4.4.3 COST OF SEED

Bt maize seed prices are not as clear-cut as that for Bt cotton. Different companies charge different prices for their Bt seed and it is not clear what part of this price accrues to the particular seed company and what part to the technology developer (Monsanto). According to the Monsanto affiliate in South Africa they receive no income domestically from Bt maize seed sold by other seed companies. For seed companies using Monsanto's Bt gene technology in their maize the technology cost is specified and paid according to an agreement with Monsanto in the US.

The price difference between conventional yellow maize seed and Bt yellow maize seed varies between the different seed companies. The price difference in 2000/2001 typically ranged between R130 for 80 000 seeds to R220 for 60 000 seeds. At a yellow maize grain spot price of R800 / ton this means that a dryland farmer in the North West Province planting 10 kg of seed per hectare would have to realise a yield increase of at least 1.8% (based on the 2 year avcrage) to cover the extra seed cost if the saving on pesticide cost and other costs associated with pesticide application are not taken into account. An irrigation farmer in Mpumalanga would have to realise a yield increase of at least 1.5% to cover the extra seed cost. Comparing these figures with the yield increase percentages quoted in Table 4.8, it becomes clear that large-scale Bt maize farmers are benefiting financially from the use of Bt maize despite the additional seed cost.

4.4.4 THE INCOME EFFECT

Despite paying more for seeds, Bt adopting yellow maize farmers enjoyed increased income on Bt maize compared to conventional maize (Table 4.10).

Table 4.10: Income effect of adoption of Bt yellow maize – average for 1999/2000 and 2000/2001

	Mpumalanga Dryland (R/ha)	North West Dryland (R/ha)	Mpumalanga Irrigation (R/ha)	Northern Cape Irrigation (R/ha)
Yield Benefits per hectare @ R800/ton	400	168	624	1040
Reduced pesticides benefit	47	55	145	105
Increased seed cost detriment*	(120)	(53)	(175)	(101)
Income advantage / disadvantage	327	170	594	1044

*As indicated by surveyed farmers in different provinces
Source: Own survey

According to surveyed farmers no premiums for GM-free maize were realised in either of the two production seasons. Some GM-free maize has been exported to Japan and other countries but the premium was captured by the exporter or trading company. The future will tell whether the production of non-Bt maize for niche markets may become more profitable than Bt maize production for South African farmers. The benefit of being able to stretch the production season to make best use of early or delayed rainfall cannot be quantified using data from only two seasons. To measure the impact of this benefit, a longer time series will have to be analysed.

With more than 95% of South Africa's total maize harvest being harvested mechanically, the increased yield will probably not create increased demand for harvest labour as was the case for cotton. The remaining 5% or less, mainly white maize, produced by subsistence and small-scale farmers however is a different story as yield increases could cause an increased demand for picking hands in the rural areas.

4.5 FARM-LEVEL IMPACT OF BT MAIZE IN SOUTH AFRICA: SMALL - SCALE FARMERS

This section will briefly mention some of the yield findings of the current Bt white maize study. As only findings of the first season's survey are currently available, great care should be taken in interpreting these data. Most farmers planted and harvested the different maize varieties separately and were thus able to compare the yields from the different varieties, but due to different planting dates within sites, different harvesting practises and different maize grain usages, we had to trust on yield perceptions of farmers for yield data.

Farmers pick dried maize cobs by hand, remove the husks and store them in old maize meal bags or "containers" built out of corrugated iron, wood or woven branches. Depending on what farmers plan to do with their maize, the grain is removed from the stalk and transported to the miller or stored. Where it was not possible to physically count the bags of grain from the different seed types we had to trust on the memory of the farmer and his or her household. Women were more often than men able to recall specific quantities.

Table 4.11 summarises the average yields from own (hybrid, open pollinated or traditional saved seed), CRN 3549 (the isoline), and Yieldgard (Bt) seed:

Table 4.11: Yield comparison between own, conventional and Bt maize seed

				95% Confidence Interval of the Difference	
	Variety	**Mean yield ***	**Std. Deviation**	**Lower**	**Upper**
Northern Highveld	**Own seed**	33.69	32.22	21.20	46.19
	CRN seed	95.40	88.88	64.87	125.93
	Yieldgard seed	148.36	119.54	107.30	189.42
Southern Highveld	**Own seed**	116.89	105.26	87.58	146.19
	CRN seed	190.25	110.13	156.77	223.73
	Yieldgard seed	204.25	121.43	167.33	241.17
Hlabisa	**Own seed**	79.90	100.29	43.74	116.06
	CRN seed	121.23	80.47	91.71	150.75
	Yieldgard seed	177.73	116.58	134.97	220.49
Venda	**Own seed**	46.55	67.24	20.48	72.62
	CRN seed	114.14	66.41	83.91	144.38
	Yieldgard seed	178.26	97.92	133.69	222.83
Mqanduli	**Own seed**	45.57	36.72	30.07	61.08
	CRN seed	64.79	68.39	21.34	108.25
	Yieldgard seed	79.66	79.83	26.03	133.29
Flagstaff	**Own seed**	69.40	83.36	39.35	99.46
	CRN seed	112.18	61.02	87.53	136.83
	Yieldgard seed	129.29	88.59	96.79	161.79

*Expressed as kilogram of yield harvested per kilogram of seed planted
Source: Own survey

Yields are expressed per kilogram of seed planted. It is clear that in all six sites the yield from own seed is much lower than that of both the CRN and Yieldgard varieties. There are various reasons for this lower yield. The main reason is that saved seed planted year after year in most cases does not have the genetic potential to deliver the higher yields and intercropping also influences yield negatively. A small number of farmers planted the Monsanto seeds in their backyards instead of in their main maize fields. Many farmers in all six sites lose a substantial amount of maize annually due to cattle, goats, wild animals as well as theft, and additional management attention to CRN and Yieldgard maize may have kept them from experiencing the normal losses to animals and thieves. Another possible reason for the lower indicated yield with own seed is that some farmers only harvested green mealies from their own seed and not from the Monsanto seed.

A paired means analysis comparing the Bt and conventional maize yields indicated a significant yield advantage with Bt seed. The mean yield increases with Bt seed were statistically significant at a 95% confidence level in all sites except Mqanduli. A considerable number of outliers indicating erroneously high yields for both CRN and Yieldgard seed were excluded from the data set but even with these steps Table 4.12 indicates why the means in Table 4.11 present a distorted picture.

Table 4.12: Percentage of farmers indicating yield differences between conventional and Bt maize

	Mpumalanga		KwaZulu Natal	Limpopo	Eastern Cape	
Yield difference with Bt	**Northern Highveld**	**Southern Highveld**	**Hlabisa**	**Venda**	**Mqanduli**	**Flagstaff**
% Farmers with lower yield	3%	0%	3%	0%	9%	0%
% Farmers with same yield	37%	89%	56%	30%	45%	80%
% Farmers with yield increase between 1 and 50kg / 1kg seed used	23%	2%	13%	15%	37%	4%
% Farmers with yield increase above 50kg / 1kg seed used	37%	9%	28%	55%	9%	16%

Source: Own survey

A small number of farmers out of the total sample indicated that CRN seed rendered higher yields than the Yieldgard seed while a substantial number of farmers, especially in the Southern Highveld, Hlabisa and Flagstaff areas, indicated that they did not find a significant difference between the yield of the CRN and Yieldgard maize. In a production season where stalk borer numbers were abnormally low, and with a rough yield measure we expected not to find a substantial yield difference. However, substantial yield increases with Yieldgard maize seed were indicated by a large number of farmers in all six sites. Despite the low stalk borer numbers, 60% of farmers in the Northern Highveld area, 70% of farmers in the Venda area and 41%

and 46% of farmers in the Hlabisa and Mqanduli areas respectively indicated a yield advantage.

It is suggested that the Bt maize yield advantage perception, as indicated by subsistence farmers for the first production season, might be erroneously amplified. The results might be influenced by a combination of factors including a possible bias on the side of the farmer due to the Monsanto workshop; the free seed and the expectation of higher yields with Yieldgard as well as a possible bias in the method of yield measurement as a small advantage might be amplified when measured in maize bags.

After only one season of study it is concluded that for the first season of Bt maize production under subsistence conditions the Bt variety performed at least as good as the conventional variety. This conclusion is however already contradicted by the large number of farmers who ordered and bought Bt maize seed for the 2002/2003 production season, as well as preliminary findings in the current season indicating a significant yield advantage with Bt maize.

4.6 CONCLUSION

This chapter focused on the quantification of the direct farm-level benefits and costs of the adoption of insect resistant cotton and maize in South Africa. Despite higher seed costs, large and small-scale cotton farmers as well as large-scale maize farmers enjoyed a higher net income per hectare, due to higher yields through better pest management, and savings on pesticides and pesticide application related cost. Subsistence maize farmers indicated a yield advantage with the production of Bt white maize, but further study will be necessary to confirm these results.

Where Chapter 4 measured the direct benefits accruing to the farmer, Chapter 5 endeavours to discuss how the additional total benefit or "economic rent" created by the introduction of a new technology, in this case Bt cotton, is divided between the farmer, the seed company (Delta Pineland), the innovator (Monsanto) and the consumers of seed cotton (the cotton gins).

CHAPTER 5

DISTRIBUTION OF THE ECONOMIC RENT CREATED BY THE INTRODUCTION OF INSECT RESISTENT COTTON

5.1 INTRODUCTION

The distribution of economic rents from a biotechnology innovation has been closely examined for agriculture in developed countries. Moschini and Lapan (1997) stressed the importance of intellectual property rights (IPR) in determining how many of the benefits accrue to input or technology suppliers. Falck-Zepeda, Traxler and Nelson (2000) find that with strong IPR protection in the U.S., 59% of the benefits from the adoption of Bt cotton still goes to U.S. farmers, with only 21% going to the developer and intellectual property holder, the input supplier Monsanto. U.S. consumers get 9%, rest of world consumers 6%, and the supplier of germplasm gets 5%. Pray, Ma, Huang, and Qiao (2001) extend these results to a developing country by showing that with weak IPR protection, Chinese farmers "obtained the major share of benefits" and in particular small farmers benefited greatly.

South Africa is marked by a strong system of IPRs and a dualistic agricultural system with large and small-scale farmers operating under similar, but not the same market access conditions. This chapter describes a wider set of factors that influence the creation and distribution of economic rents from the adoption of Bt cotton in a developing country and builds on earlier work by Huang and Sexton (1996) and Alston, Sexton and Zhang (1997) who showed that imperfectly competitive markets influence the size and distribution of the benefits from research. Depressed world cotton prices also play an important role, which are in turn most likely influenced by subsidies enjoyed by farmers in developed countries. Insurance indemnity payments (particularly in the US) and government program payments (including both export and input subsidies) allow farmers in developed countries to cover their variable operating costs even when prices are low. Overall levels of support for US cotton in the form of direct payments from the US Commodity Credit Corporation typically range from $3 to $4 billion annually. These payments keep world prices from rising as much as they would if supply was allowed to decline more.

As was indicated in Chapters 3 and 4 the story of the introduction of Bt cotton in South Africa began well enough. The technology has been characterised by an impressive adoption rate. Farmers adopt new agricultural technology if the value of increased yield or the value of a decrease in input costs is higher than the extra cost of the technology. Large and small-scale farmers have adopted Bt cotton in South Africa because their income benefits are higher than the additional cost of the technology. The biotechnology companies are in most cases selling their products with the aim of realising maximum profit. The question thus arises: Who gets the greatest share of the income benefits? Who benefits the most?

To analyse the distribution of the income created by the introduction of insect resistant cotton one needs to first understand the structure of the South African (SA) cotton industry. The four major players competing for the spoils of agricultural innovation in South Africa are: the input or technology supplier, the seed or germplasm supplier, the producer who buys inputs and the consumers or the entity buying the agricultural product. These four parties and their share of the economic rent created by the introduction of Bt cotton will be discussed in turn in the next few sections.

5.2 THE INNOVATOR / BIOTECHNOLOGY COMPANY: MONSANTO

When there is only one firm in a market, that firm is very unlikely to take the market price as given. Instead, monopolists usually recognise their influence over the market price and choose a level of price and output that will maximise the overall profits of the firm (Varian, 1996). Intellectual property rights, which have been reasonably well enforced in South Africa, supply investors and innovators with limited monopoly power even in competitive markets and increase their ability to appropriate benefits created by their research effort (Traxler & Falck-Zepeda, 1999). Currently, the technology present in all the genetically engineered cotton varieties available for commercial production in South Africa belongs to one company. Monsanto thus has a monopoly on the supply of the new agricultural biotechnology (trait producing genes). Monsanto acts as a monopolist in setting the technology fee for Bt cotton but the company operates under a price ceiling because there is a maximum effective price level they can charge. If the charged technology fee is too high, farmers can substitute conventional seed for Bt seed and use traditional pest control methods. As soon as farmers feel that the cost of Bt seed outweighs the benefits they receive, they will stop planting Bt seed and perhaps, as some have indicated, cotton altogether if conventional practices are not profitable either. Figure 5.1 illustrates the share of additional income created by the introduction of the new technology that accrues to Monsanto.

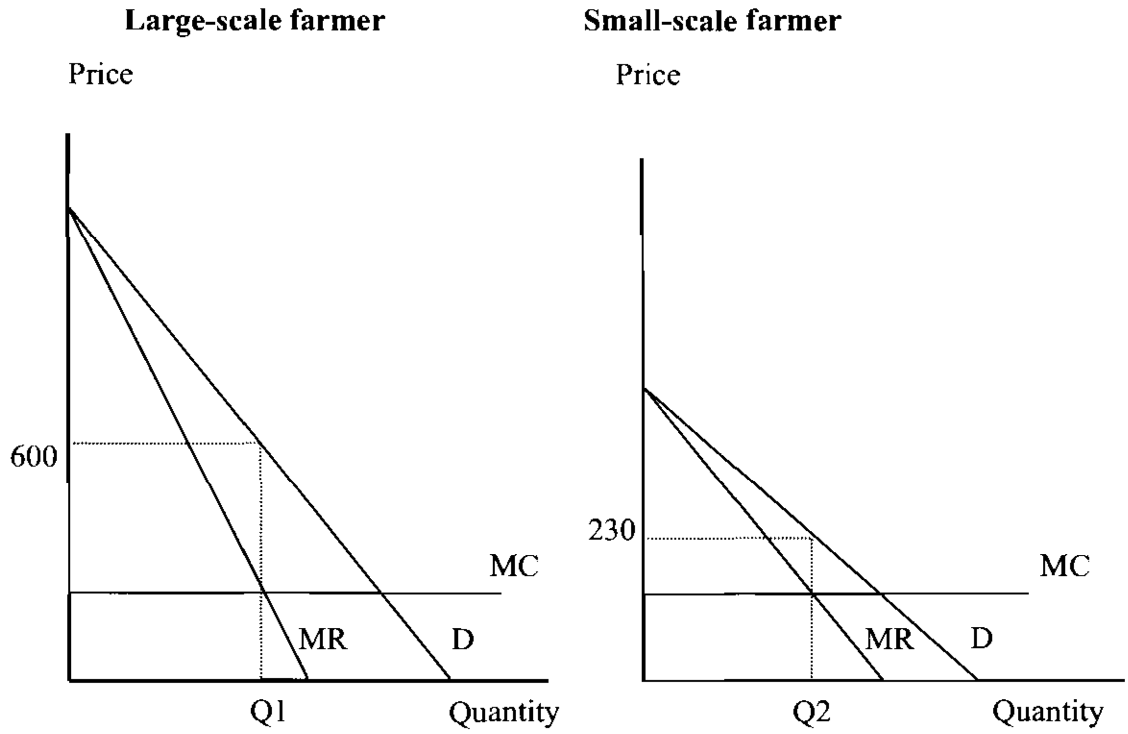

Figure 5.1: Monsanto's share of additional income created by use of Bt cotton

Since a monopolist maximises profit where marginal revenue equals marginal cost the price charged to large-scale farmers (R600, SA Rand) is higher than the seed price charged to small-scale farmers (R230) because of lower input demands and thus lower marginal revenue. Another factor that influences the difference between the two prices is that Monsanto would like to establish a market with small-scale farmers as the small-holder farming conditions are more applicable to the rest of Africa than that of the large-scale farmers. For Monsanto, the marginal cost of producing one extra unit of technology in South Africa is constant, with all the research and product development having already been done in the US. The cost of having a product registered and taken through the SA biosafety protocol and regulatory requirements does not depend on the level of sales of the specific product.

There is thus a constant marginal cost and perfectly elastic supply due to the fact that the technology was on the shelf and there is no additional cost for producing an extra unit of output in the case of Bt cotton seed. The income benefit to Monsanto can thus be calculated with a simple price multiplied by quantity minus marginal cost calculation.

5.3 THE SEED SUPPLIER: DELTA AND PINELAND

The cotton seed company Delta and Pineland (D&PL) has been given the sole right by Monsanto to use the Bt technology in their cotton seed. D&PL charges approximately R25.00 per 25kg bag more for Bt cotton seed than for their conventional varieties. D&PL's share of the additional benefit created is thus also easy to calculate by multiplying the R25.00 by the number of bags sold.

The sole right of distribution and an impressive adoption rate of the Bt technology have caused D&PL's market share in cotton seed sales to increase. An interesting fact is that the seed supplier who lost market share is Clark Cotton, a large ginning company who bad some cotton varieties on the market and in fact had most of the cotton seed market before D&PL started selling cotton seed in SA in 1995. In the 1997/1998 season D&PL introduced two Bt varieties named NuCotton 35B and NuCotton 37B. These two varieties were based on the Acala 90 variety of D&PL and were not initially adopted with great enthusiasm, as the Delta Opal non-Bt variety was very popular at the time. D&PL's market share increased as farmers recognised the benefits of the Bt technology, and when NuOpal (Opal with Bt) was introduced for the 2000/2001 season, D&PL captured a major share of the cotton seed market as can be seen in Figure 5.2. In conversations with surveyed large-scale farmers it appears that after paying R600 per bag of Bt seed to Monsanto, the additional R25 paid to D&PL for the new variety was insignificant.

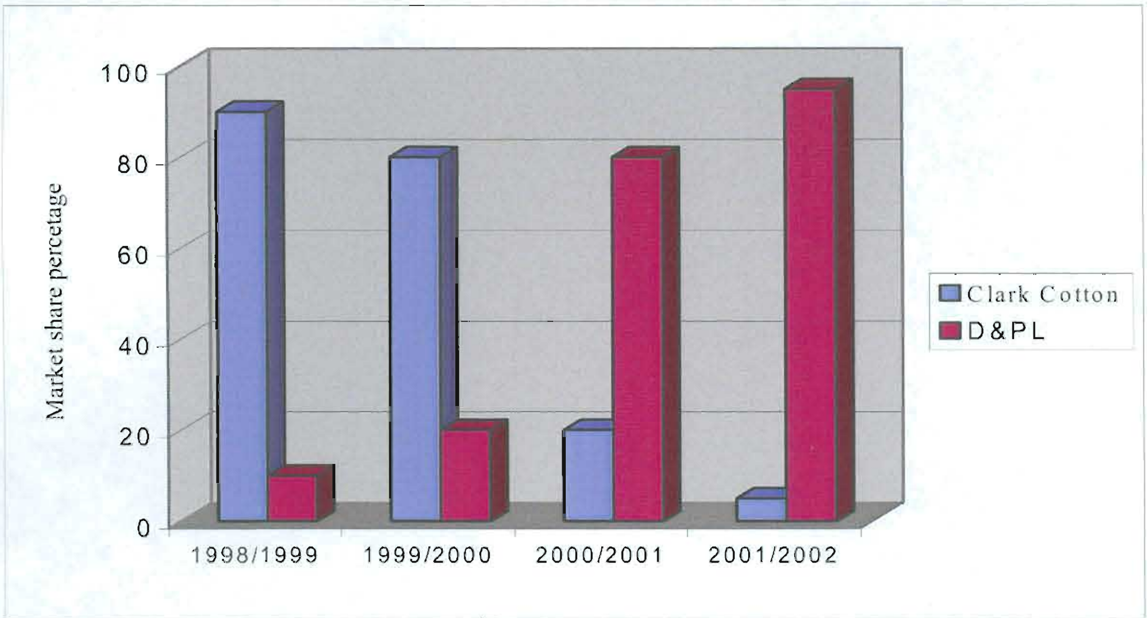

Figure 5.2: Cotton seed market share

Source: Clark Cotton

5.4 COTTON PRODUCERS: LARGE- AND SMALL-SCALE FARMERS

SA cotton producers can be divided into two groups, namely large-scale mainly white cotton farmers that produce under irrigation as well as dry-land conditions and small-scale resource poor, black farmers that produce dry-land cotton.

Not all the benefits enjoyed by producers due to the adoption of Bt technology are straightforward calculations. Yield increases are the main source of additional income for farmers and are easy to calculate. Pesticide savings and reduction in application costs can also be estimated but quantifying labour specifically for pest control is more difficult. Benefits like peace-of-mind and managerial freedom and also health benefits are not easy to measure.

Figure 5.3 shows the SA seed cotton production situation after the introduction of Bt cotton. This SA industry can be classified using the guidelines in Alston, Norton and Pardey (1995) as an importer in a small open economy. The introduction of Bt cotton has caused a parallel outward shift in the supply curves of both large-scale and small-scale cotton farmers due to higher yields per hectare. The size of the respective supply shifts as calculated in Chapter 4 are repeated in Table 5.1 and illustrated in Figure 5.3. The increase in yield for large-scale farmers using irrigation was more than three times that obtained by small-scale farmers. Large-scale dry-land farmers enjoyed the smallest yield gains. These supply shifts are represented by S3, S2 and S1 respectively in Figure 5.3, where S4 shows the total domestic increase in supply. As there has been an increase in domestic production per area planted, one could expect the amount of cotton imported to decrease from quantity A to B.

Table 5.1: Size of supply shift per hectare

	Q_1 (kilograms per ha with Bt cotton)	Q (kilograms per ha with conventional cotton)	$Q_1 - Q$ (kilograms per hectare)
Large-scale farmers: Irrigation	4 046	3 413	633
Dry-land	947	832	115
Small-scale farmers: Dry-land	576	395	181

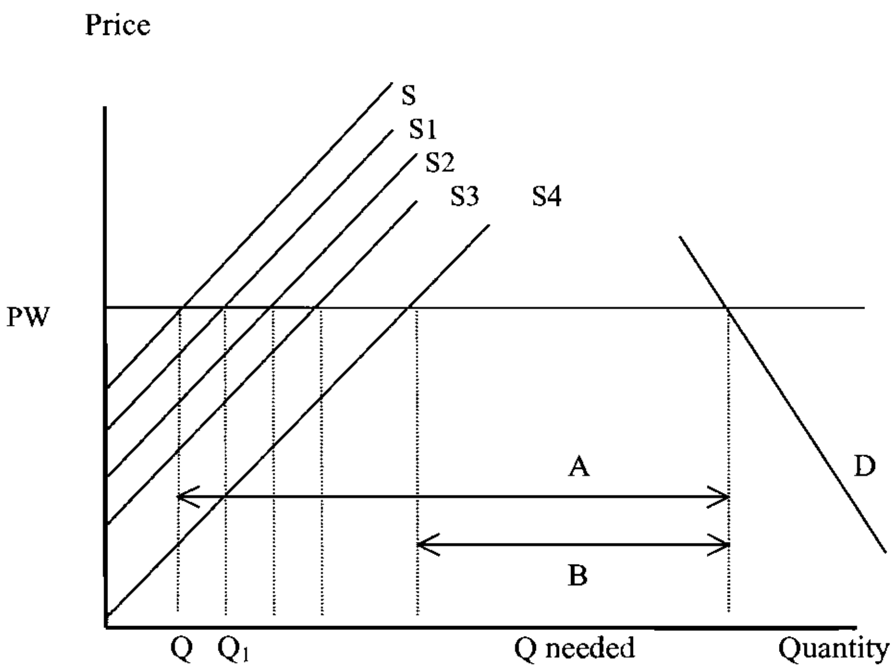

Figure 5.3: The South African seed cotton market - assuming a fixed seasonal area planted

The situation illustrated in Figure 5.3 would have represented the entire story if there had been a constant area planted under cotton in South Africa, but the cotton area has decreased the last couple of seasons mainly due to low cotton-lint world prices. So even though cotton production per hectare increased, total cotton production decreased and the size of cotton imports actually grew. This event and the impact thereof will be discussed later. The benefits of Bt cotton for small-scale and large-scale farmers and the quantitative extent thereof were already discussed in Chapters 3 and 4.

5.5 CONSUMER OR BUYER OF SEED COTTON

5.5.1 THE SOUTH AFRICAN COTTON GIN MILIEU

Seed cotton is an intermediate input in the production of cotton fabrics and other cotton products. As there is no consumer or retail market for seed cotton, the cotton gins as the "producers" of cotton lint, act as the consumers of seed cotton output. In South Africa there are mainly four ginning companies, with Clark Cotton being the largest with a market share estimated to be above 70% (Nolte, 2003). Clark Cotton is owned by AFGRI, formally known as OTK and operates under the name of Vunisa Cotton in KwaZulu Natal and Swaziland. Clark Cotton also has gins in Uganda, Zambia, Malawi and Mozambique.

South Africa is a small player in the world cotton market and has little or no influence on the world seed cotton price. The price paid to farmers by the ginners is derived from the Cotlook A Index, which is accepted worldwide as the indicator of international cotton prices and is the average of the five lowest prices of fourteen styles of cotton traded in northern Europe. But the Cotlook A Index is distorted by production subsidies of large cotton producing countries like the US and China. Subsidies stimulate production of seed cotton, increase supply and thus reduce the world price. The price paid to SA cotton farmers is on average about 30% of the Index in Rand value so when the world price is depressed by subsidies in other countries, the price received by domestic producers also falls.

SA cotton farmers produce about half of the cotton needed in the rather lucrative and expanding SA textile industry. The rest of the country's cotton is imported as seed cotton or as cotton lint from mainly Zimbabwe, Zambia, Mozambique, Botswana, Namibia and Swaziland. A duty on the importation of cotton lint is in place but due to the fact that South Africa cannot satisfy domestic demand for cotton from domestic production, a rebate of 100% of the import duty is allowed on cotton lint imports by way of a permit system (Calcaterra & Poonyth, 2002). A condition of the rebate is that the SA gins have to first buy the bulk of the domestic production before importing less expensive cotton from abroad.

Cotton production costs in other Southern African countries are lower than in South Africa and farmers are thus willing to accept lower prices for their cotton than SA farmers. It is thought that small-scale cotton farmers in countries like Zambia have higher gross margins than SA farmers, despite the fact that they receive lower prices. In fact, SA cotton farmers (large-scale as well as small-scale) find it difficult to compete with cheap cotton imports from the Southern African Development Community (SADC). According to trade liberalisation procedures of the SADC agreement, import tariffs on cotton were to be abolished at the end of 2003. This means that SA gins will be able to import cotton without any regard for domestic producers. The Cotlook A Index forms the basis of the price at which cotton is imported from SADC and other countries, so SA cotton growers are thus exposed to low prices (partially caused by developed country subsidies) on their own output and substitute imports coming from other SADC cotton growers.

Furthermore it is hypothesized that Clark Cotton acts as a monopsonist in the SA cotton industry. The market share of Clark that is influenced by mainly geographical separation can be used to test this hypothesis. Clark Cotton has a gin in, or very close to each of the cotton producing regions in South Africa. The profitability of ginning becomes marginal when cotton has to be transported over longer distances, so Clark can act as a regional monopsonist when conditions permit.

Clark Cotton (including Vunisa) can therefore set domestic prices at such a level that the quantity delivered at that price will maximise the company's profit. Figure 5.4 illustrates Clark Cotton's monopsonistic market where a constant area of cotton was planted before Bt cotton was introduced. Bt cotton led to an increase in yield per hectare and thus an increase in total domestic cotton production. The volume of cotton Clark had to buy before being able to import less expensive cotton thus increased and it appears that the introduction of the new technology influenced Clark Cotton's profits negatively.

In Figure 5.4, MC is the marginal cost curve of the monopsonist and S the supply curve of the cotton producer. Pw is the price farmers would have received had they sold their cotton in a competitive market. Because the price, Pm is set by the monopsonist, domestic cotton farmers only produce quantity Qm. The introduction of Bt cotton causes a parallel shift (as assumed previously) in MC to MC1 and from S to S1 and from MC to MC1. Thus a higher quantity is supplied (at every price) and in a big cotton producing country, the monopsonist could have dropped the price to P1 and still received increased output (Qm1). The quantity of seed cotton that SA gins would buy domestically would have increased from Qm to Qm1 because of the technology. With adequate production, S SADC would be the supply curve to SA gins from the other SADC countries producing cotton. Note that farmers in these countries are willing to produce much more (Import Q) at a lower price (Import P), but several factors other than the new technology contribute to cotton supply reductions in South Africa and the surrounding region.

As previously assumed, Figure 5.4 reflects the situation when cotton area is held constant. Because of lower world and import prices, as well as the very high prices obtained for substitute crops like maize and sunflower the last couple of seasons, SA cotton farmers have recently planted less cotton. Even though Bt cotton caused yields per hectare to increase, total production decreased. This may appear to have been beneficial to companies like Clark Cotton because they were able to process less of the "expensive" domestic cotton and import more cheap cotton from other SADC countries. One might expect monopsonists to make excess profits due to their dominant position in the market. Yet, Clark Cotton is buying domestic cotton at a higher price than it would need to pay for imported cotton (Pw instead of Import P). When cotton is imported the Cotlook A index is used as reference in determining the import price but a much lower price is negotiated with the sellers (Calcaterra & Poonyth, 2001 and discussion with Cotton SA).

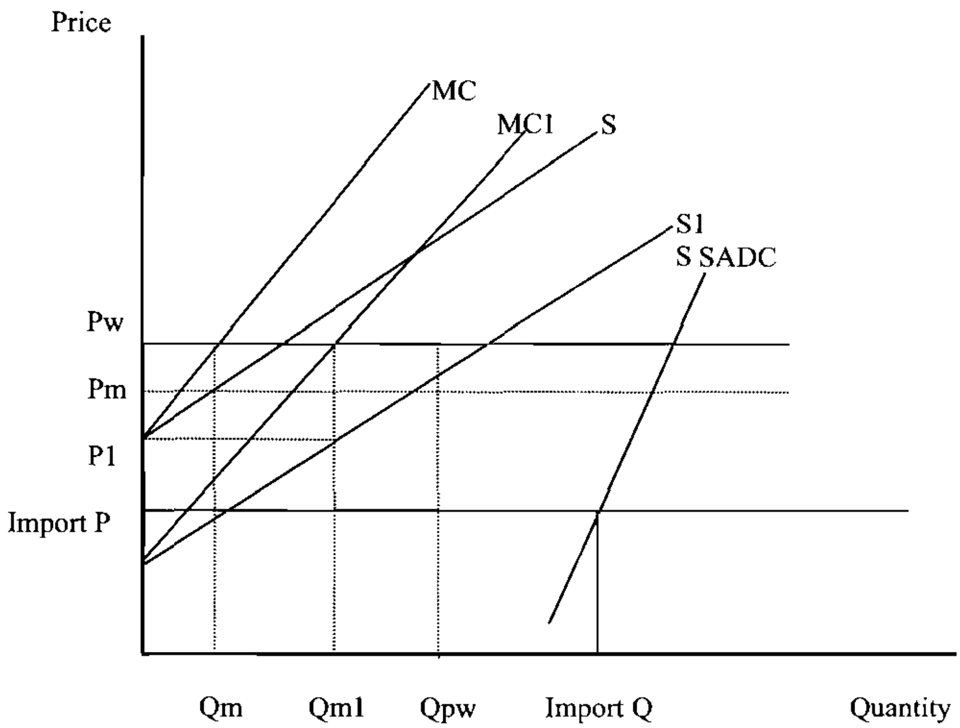

Figure 5.4: Monopsonistic cotton buyer

So why does Clark Cotton buy "expensive" domestic cotton? The reason for this is that even though Clark Cotton would like to import as much inexpensive cotton as possible they do not want to do so at the expense of domestic producers even when they are substituting away from cotton. Cotton gins need to have a consistent supply of cotton to cover their substantial fixed property, plant and equipment expenses. Political instability in countries like Zimbabwe, Zambia and Mozambique and frequent severe weather conditions in the SADC region as a whole, cause gins to be dependent on cotton farmers who can produce more reliably with less production risk – and these are the large-scale irrigation farmers. So even though Clark Cotton can import cotton for less, they have chosen to support the domestic market before venturing outside of SA, so that they can hedge themselves against adverse conditions and events in the import countries. Clark's holding company, AFGRI, used to in fact be a farmer coop (OTK). Clark thus has strong ties to SA cotton farmers through shareholding and also substantial loyalty to their shareholders. Furthermore, Clark Cotton also has cotton gins in Zambia, Malawi and Uganda which have the capacity to process most of the local production except in very good production years.

South Africa's cotton lint imports are nearly double its imports of seed cotton. Inexpensive lint imports are subjected to import tariffs but due to the SADC free trade agreement these tariffs are quickly disappearing. The 2001/2002 season saw yet another drastic decrease in the area planted under cotton in South Africa. The low world price of cotton and the very "persuasive" high price of maize influenced traditional cotton farmers to substitute maize for cotton on an even larger scale than the previous two seasons. With alarming levels of famine in countries bordering on South Africa and a weak SA Rand, maize prices have risen and have reached record nominal levels and it was expected that very little cotton would be planted in the 2002/2003 season. In traditional cotton areas where little cotton is now planted the profitability of the cotton gins has decreased as would be expected with limited supplies of import seed cotton available for processing. In a restructuring of AFGRI, the cotton gin at Modderrivier in the Northern Cape and the gin at Pongola close to the Makhathini flats were temporarily shut down in late 2002 in an effort to cut running costs while the gin in Swaziland was sold. All the domestically produced cotton will now be ginned at the Marblehall gin in Mpumalanga.

Domestically, Clark Cotton is thus struggling and their share of the income from the introduction of Bt cotton is close to zero. It appears that they may have forgone monopsonistic profit in an effort to set a price where cotton will be produced. Figure 5.5 illustrates how prices paid to domestic farmers for seed cotton stayed relatively constant while world lint prices dropped (here represented by the US cotton lint price). Clark is now focussing on obtaining adequate seed cotton for their gins outside of South Africa, while sitting out the production drought domestically. The sharp drop in the cotton world price in 2001/2002 was offset by a drastic weakening in the value of the South African Rand compared to the US$.

In 1992/93 the price differential between seed cotton and cotton lint was 348.5 cents but since then the price differential has widened substantially. Using 1992/93 as the reference year i.e., 1 for 1992/93, the price differential has increased to 1.6 in 2000/01 (Calcaterra & Poonyth, 2001). This indicates that ginners are reaping the benefits of the deregulated South African cotton environment and are not transmitting world prices of lint through to the farmers. This suggests a monopsonistic power.

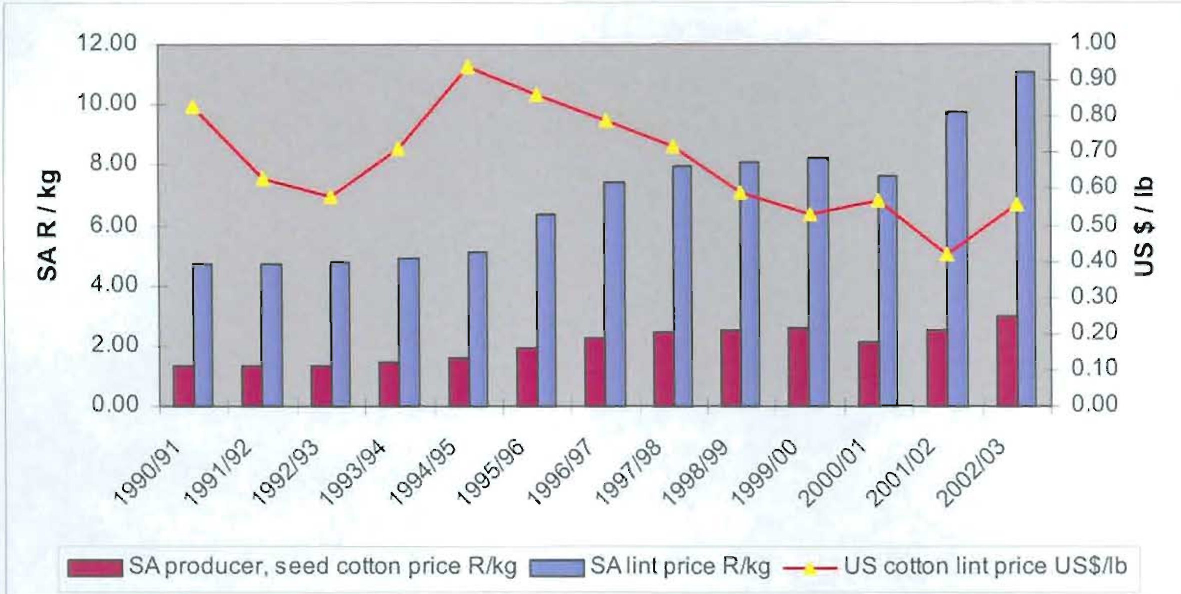

Figure 5.5: Seed cotton and cotton lint price trends

Source: Cotton SA

5.5.2 THE COTTON GIN AND THE SMALL-SCALE FARMER

The small-scale cotton producer situation on the Makhathini Flats in northern KwaZulu Natal has also taken a turn for the worse. To explain the problems and issues effecting cotton production on the Flats, one needs to understand the more recent cotton production history of the Flats. During the late 1980's Clark Cotton as well as Tongaat Cotton were active on the Flats, supplying credit and inputs and buying cotton from small-scale farmers. The two companies shared a weighing bridge and there was a positive attitude of cooperation between them. Even though some farmers borrowed production credit from one company and delivered their harvest under a different name to the other company, losses and gains balanced out for each company. Around 1989 Clark and Tongaat formed a partnership called Vunisa (which means "to harvest" in Zulu). In 1994/95 Lohnro Africa bought the cotton interests of the Tongaat-Hulett group and Tongaat's interest on the Flats was purchased by Clark. From then on Clark Cotton operated under the name of Vunisa in KwaZulu Natal and Swaziland. The Land Bank supplied credit and repayment default risk was shared between the Land Bank and Vunisa. Vunisa has administrated production loans since the 1998/99 season and according to Clark Cotton and Vunisa the first few years were very successful for both cotton farmers and the ginning company and there was a loan recovery rate of close to 90%.

During the 2001/02 production season a new company, Makhathini Cotton (Pty) Ltd (MCG) erected a new gin on the Flats, right next to the Vunisa depot. According to their website, their vision is "to stimulate rural development and reduce poverty on the Makhathini Flats by creating a world-class cotton agribusiness through construction of a ginnery in the heart of the area". But by opening a competing gin they have set in motion a chain of events where farmers borrowed production credit from Vunisa but delivered their harvest to the MCG. Due to substantial financial losses by Vunisa and the Land Bank, no credit was made available for the 2002/03 production season with the effect that very few farmers were able to produce cotton at all last season. Even with a new agricultural technology like genetically modified cotton, farmers still need production credit. At planting time 2003 a delegation of the Ubongwa farmer's association, that represents all the farmer's associations on the Flats, was still searching for a credit supplier. Vunisa was not planning to finance cotton on the Flats for the 2003/2004 season and they appeared to be focussing on their large-scale irrigation farmers in the Pongola area.

The Land Bank could probably provide credit but is understandably wary about investing in an area and in a crop that has already led to loan defaults of millions of Rands for themselves and other financial institutions. The South African Development Trust Corporation (STK), the Department for Development and Aid (DDA), the KwaZulu Finance and Investment Corporation (KFC) and the Development Bank of South Africa (DBSA) have all had roles in credit provision on the Flats over the years. The Land Bank and Vunisa do not seem interested anymore and it appears that MCG has decided that it would be more profitable to rent land for cotton production from farmers than to finance farmers to produce cotton themselves. This approach however also seems to have flaws as some farmers steal the cotton (produced on their own rented land) to deliver it to Vunisa and even to MCG. MCG is showing great initiative and determination in trying to establish irrigation cotton and wheat production units with the aim of establishing small-scale farmers on these areas over the longer term. From the history of the Makhathini Flats however we know that without some kind of cooperation between competitors (sometimes referred to as coopetition), development, poverty alleviation and economic progress on the Flats are not very likely.

5.6 WELFARE DISTRIBUTION

If the sum of the value of the yield and the value of the saving in insecticide costs (Chapter 4) are taken as the "additional benefit", increase in welfare / income or "economic rent" created by the introduction of new Bt technology in cotton, then the distribution of the additional income can be summarised as follows. (This distribution is based on the average production budgets of the different farmer groups.)

Table 5.2: Income distribution based on income advantage indicated by surveyed farmers

	Small-scale Dry-land farmers	Large-scale Dry-land farmers	Large-scale Irrigation farmers
Seed company: D&PL	3%	2%	1%
Technology supplier: Monsanto	28%	52%	20%
Farmer	69%	45%	79%
Consumer: Ginning companies	0%	0%	0%

Even though large-scale dry-land farmers are able to produce cotton more efficiently than small-scale farmers due to better management, mechanisation and use of fertiliser, small-scale farmers capture a larger share of the welfare because they pay a lower technology fee. Since world cotton prices are unaffected by SA production, yield increases in South Africa do not transmit down to consumers as they would if increased output led to lower prices. The welfare share accruing to the ginning companies is thus close to zero. Based on the pesticide savings indicated by surveyed farmers, we estimate that insecticide suppliers lost approximately 1.9 million SA Rand over the 2000/2001 season alone because fewer pesticides are used with Bt cotton.

Income distribution can also be calculated from the total monetary value created on the total area planted under Bt cotton. We make use of the 2000/01 figures for this calculation and seeding rates of 11.5, 8 and 20 kg/ha are assumed for small-scale, large-scale dry-land and irrigation farmers respectively. When percentage shares are calculated using the figures in Table 5.3, they are found to be similar to those indicated in Table 5.2 that was calculated using the average budget figures of the different farmer groups as was indicated in Table 4.7. The small difference in the figures can be explained by different seeding rates and different planting practises. Table 5.3 also indicates the monetary value of the total decrease in chemical pesticides used / purchased by different farmer groups due to the introduction of insect resistant cotton.

Table 5.3: Monetary value of the total additional benefit according to farmer groups for the 2000/2001 season (in SA Rand)

	Small-scale Dry-land farmers	Large-scale Dry-land farmers	Large-scale Irrigation farmers	Total
Seed company: D&PL	32 546	54 576	74 156	161 278
Technology supplier: Monsanto	299 425	1 309 824	1 779 744	3 870 676
Farmer	1 038 647	1 323 468	5 988 097	8 350 212
Pesticide companies	-90 563	-777 708	-1 086 385	-1 954 656

If small-scale farmers have as high a seeding rate as some suspect, their welfare share might be lower than that indicated in Table 5.3 which is based on the seeding rate used by Ismaël et al (2001). Table 5.4 shows the sensitivity of the income distribution calculations to different assumptions concerning seeding rates. Table 5.4 also considers what small-scale farmers' welfare share would be if they had to pay the same technology fee as large-scale farmers.

Table 5.4 shows that small farmers are adversely affected if they use a lot of seed and if they have to pay the commercial level of the technology fee.

Table 5.4: Distribution of benefits for small-scale farmers under different seeding rate scenarios and technology fees

	Small-scale Dry-land farmers With a 11.5 kg/ha seeding rate	Small-scale Dry-land farmers With 20 kg/ha seeding rate	Small-scale Dry-land farmers Paying R600/bag techno fee*
Seed company: D&PL	2%	4%	2%
Technology supplier: Monsanto	20%	35%	52%
Farmer	78%	62%	46%

*Planting 11.5 kg/ha seed

5.7 CONCLUSION

It is clear from the income distribution results in Tables 5.2 through 5.4 that both large-scale and small-scale farmers are reaping benefits from the adoption of Bt cotton. Farmers are realising benefits despite the fact that they are facing two monopolists on the input side and a dormant monopsonist on the output side. Between increased diffusion of the Bt technology and new innovations now in the pipeline with herbicide-tolerant varieties and stack gene varieties entering or nearing SA input markets, farmers will probably be able to considerably increase productivity if the new varieties are approved for commercialisation. The reasons why it seems that the cotton industry in South Africa has turned for the worse can thus not be attributed to the presence of monopolists like Monsanto and D&PL. The SA ginning companies are dependent on domestic cotton producers for a large, consistent cotton harvest to justify their investments in fixed property, plant and equipment. Even though Clark Cotton might possibly have captured monopsonistic profits in the past, the company's profit margin has decreased over the last couple of seasons due to the low world cotton price and domestic farmers' reluctance or inability to produce at such a low price.

The technology developed in the developed world thus had a substantially positive impact on the cotton industry in South Africa and it is clear that both the commercial and smallholder sectors in a developing country can benefit from a first-world commercial agricultural technology. The most important factor may not be the technology treadmill or intellectual property rights or market structure harming developing countries' agriculture, but agricultural subsidy policies of developed countries that stimulate production and force down world prices, which adversely effect domestic producers. Large-scale farmers in many instances can and do substitute maize or sunflowers for cotton when prices are low; but small-scale, resource poor farmers in most cases can not substitute away from cotton because of lack of credit or poor production conditions. In SA it may be small-scale cotton farmers that are hit the hardest by artificially low world cotton prices. Ironically it may be Western technology that is helping cotton farmers in this developing country survive the price squeeze created by developed country agricultural policies.

CHAPTER 6

CONCLUSION

6.1 INTRODUCTION

This chapter briefly summarises the findings of this dissertation and how it has attempted to meet the objectives specified in Chapter 1. The conclusion includes a discussion of some of the shortcomings of the study, indicates some further research opportunities, and discusses some issues that might determine the future of agricultural biotechnology in South Africa and other neighbouring African countries.

6.2 SUMMARY

Agricultural biotechnology is not a new phenomenon. Man has been manipulating living organisms to solve problems and improve his way of life for millennia. Genetic engineering in agricultural biotechnology however has brought a whole new dimension to the development of products and operations. These transgenic techniques and the crops they make possible have caused proponents of and scientists in the field of agricultural biotechnology to envisage a world without hunger and malnutrition. Product possibilities cause profit driven multinational biotech companies to invest billions of dollars in research and development and it is partly also these possibilities (seen as threats to the environment and mankind), as well as the profit driven endeavours of these multinational companies that cause an international outcry amongst certain consumers and anti-biotech advocacy groups. Different groups support and oppose genetically modified crops for different reasons, motivated by their different perceptions, ideologies and constituency.

South Africa has been involved with biotechnology research and development for approximately 25 years through governmental, parastatal and academic institutions. Due to this strong scientific background, role-players were able to competently and efficiently develop and implement regulatory guidelines when the biosafety process was kick-started in 1989. South Africa currently has a well-established and accredited regulatory system and is in a position to make informed decisions regarding genetically modified crops and their uses. Communication of risks and benefits to consumers on the other hand has been slow, leaving them vulnerable to exploitation by advocacy groups.

The only genetically modified crops that have been approved for commercial production in South Africa are herbicide-tolerant soya-beans, cotton and maize and insect-resistant cotton and maize. Bt cotton has been produced since the 1997/1998 season and Bt yellow maize since the 1998/1999 season. Herbicide tolerant cotton has been made available for commercial production in the 2001/2002 season while only a limited quantity of herbicide tolerant soya-bean seed has been released. Bt white maize was introduced in the 2001/2002 season and a limited quantity of herbicide tolerant maize seed will be commercially released for the 2003/2004 season. Cotton seed containing the Roundup Ready – Bt combination has not yet been released commercially.

Agricultural biotechnology is the most rapidly adopted agricultural technology in history and it is said that the impressive adoption rates of these crops are evidence of their perceived value to farmers. South African large-scale cotton farmers, for whom cotton production is usually not the dominant farming activity, indicated better crop and risk management, pesticide saving and peace of mind as the main benefits. Small-scale resource poor cotton farmers in comparison indicated higher yield and saving on insecticides as the major benefits. Large-scale commercial yellow maize farmers indicated higher yields, better pest control, easier crop management and peace of mind as the main benefits, while small-scale farmers who depend on their harvest for food security, indicated higher yield and better quality as the major benefits. It is thus clear that different benefits appeal to different farmer groups and these benefits have been the reasons that farmers have adopted the new technology. Farmers indicated the cost of the seed and the additional technology fee as the major disadvantage of Bt cotton and maize. A high percentage of large-scale cotton farmers who planted Bt cotton noticed environmental benefits through increased populations of beneficial insects in their Bt cotton fields.

The direct costs and benefits associated with Bt crop adoption, as indicated by small- and large-scale maize and cotton farmers, were quantified and expressed in monetary terms. For both large-and small-scale cotton farmers as well as large-scale maize farmers, the increased seed cost (higher seed cost and / or an additional technology fee) were partly offset by a decrease in the need for chemical pesticide application, but mainly by a significant increase in yield due to better pest control. Large- and small-scale Bt cotton farmers as well as large-scale Bt yellow maize farmers enjoyed a higher income per hectare with insect resistant varieties than with conventional varieties. Early indications suggest that small-scale maize farmers are also able to benefit from Bt technology – predominantly through increased yield.

The additional economic rent, income or increase in welfare created by the introduction of Bt cotton in South Africa is distributed between four major role-players: The innovator or biotech company, the germplasm or seed supplier, the farmer as cotton producer and the cotton gins as primary consumer of seed cotton. Despite facing two monopolists (Monsanto and Delta & Pineland) and a dormant monopsonist (Clark Cotton), cotton farmers receive the lion's share of the additional income created through the introduction of the new technology. It seems in fact that it is currently only this additional welfare that enables South African farmers to survive under the depressed cotton market conditions - in all probability caused by subsidised overproduction of large cotton producing countries.

6.3 SHORT-COMINGS OF THIS DISSERTATION

This study focussed mainly on economic farm-level impacts of insect resistant cotton and maize in South Africa. Even though the yield advantage and saving on chemical insecticides were quantified, this dissertation was not able to quantify the possible economic benefits of savings on insecticide application labour, and fuel cost and mechanical hours on large-scale farms. Another important issue that warrants in-depth research concerns the environmental effects of Bt cotton and maize adoption. Reduced insecticide spraying may increase populations of beneficial insects and improve the environment as a whole, but the possibility of gene flow, resistance development and the appearance of new problem insects particularly under small-scale conditions needs to be considered.

This study focussed on only one or two production seasons and due to the novelty of the technology, only a limited number of farmers were surveyed. In order to increase the significance of research findings a larger group of farmers' Bt production experiences should be followed for a number of seasons. By doing this, the economic consequences, socio-economic effects and performance of the new technology can be measured under different climatic conditions and insect pressures.

6.4 FUTURE RESEARCH OPPORTUNITIES

Future research on the performance of insect resistant cotton and herbicide tolerant cotton produced by small-scale farmers is currently being hampered by the situation on the Makhathini Flats where many small cotton farmers are located: Without production finance few farmers are able to sustainably produce cotton and the Flats has been plagued by some severe weather conditions the last couple of seasons that also decreases the number of researchable farmers. With Bt adoption on the Flats nearing 100% it would be interesting to see how many farmers adopt RR cotton. It is hypothesised that insect control is more problematic for small-scale farmers as weeds can be relatively inexpensively controlled by hired and family labour. It is possible that the stacked gene technology, when released, could be adopted quite readily.

Up to now no comprehensive, independent study has looked at economic, environmental or socio-economic (focused on labour) effects of herbicide tolerant soya-beans in South Africa. South Africa's domestic demand for soya-beans has increased the last number of years due to impressive growth in the poultry industry but approximately 70% of the domestic soya-bean demand still had to be imported. In dry hot seasons soya-beans struggle in South Africa and profit margins are small. It can be expected that a technology that decreases input costs will be welcomed.

The approval and release of insect resistant maize also introduced a number of other researchable topics. South Africa is the first country in the world where an agricultural biotechnology application has been introduced as staple food i.e. white maize. Some of the related topics include:

- The pertinence of Bt maize for small-scale farmers
- Consumer acceptance of Bt maize – subsistence farmers vs. other consumers
- Impact of Bt maize on export markets
- GM and Non-GM separation, costs, effectiveness and profitability

Impacts of Bt white maize as produced under small-scale subsistent conditions will be studied in a Rockefeller Foundation funded research project by the Department of Agricultural Economics, Extension and Rural Development at the University of Pretoria, in collaboration with the Promec unit at the Medical Research Council of South Africa and other overseas based research partners. The main objective of this study, that kicks off during the 2004/2005 season, is to investigate the link between esophageal cancer (EC), the mycotoxin fumonisin and maize produced by subsistence farmers in certain areas in South Africa. Stalk borers are periodically a major problem in some regions of South Africa and are considered to be a vector for both fumonisin and aflatoxin producing fungi. High levels of fumonisin have been shown to occur in homegrown maize consumed as the staple diet by people at high risk for EC in the former Transkei region in the Eastern Cape province of South Africa (Rheeder et al 1992). We hypothesise that if Bt technology can reduce the damage caused by stalk borers, then the hazardous fumonisin levels will also be reduced.

6.5 THE FUTURE OF AGRICULTURAL BIOTECHNOLOGY IN AFRICA

It is clear that both small and large-scale maize and cotton farmers in South Africa are benefiting from the use of genetically modified, in this case insect resistant, crops. It is worth restating that GM technology is no panacea, cure all, universal remedy or silver bullet. As was stated in Chapter 1, it is merely an agricultural tool like applying fertiliser and making use of irrigation. It is a tool to increase efficiency, decrease production risk and to enhance the ability of the farmer to manage his / her crop in the most profitable or food secure way.

Africa is awakening to the possibilities of agricultural biotechnology. Agricultural biotechnology research and development was, in some cases, initiated in a number of African countries by the agricultural research centres known as the "Future Harvest Centres". These centres include (amongst others) the International Maize and Wheat Improvement Centre (CIMMYT) in Malawi, Kenya, Ethiopia and Zimbabwe, the International Institute for Tropical Agriculture (IITA) in Nigeria and the International Livestock Research Institute in Kenya and Ethiopia. These are centres of the Consultative Group in International Agricultural Research (GGIAR) with the mandate to serve as a bridge between the advanced science and technology developed and available in developed countries and the specific needs of developing countries. A number of African countries are currently collectively developing biotech and biosafety legislation, policies and strategies. This process is driven partly through capacity built in the Consultative Group (CG) centres and through regional cooperation lead by (amongst others) the International Food Policy Research Institute (IFPRI), the Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN), the Forum for Agricultural research in Africa (FARA), Agricultural Biotechnology Support Projects (ABSP I +II) and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). Through these "Future Harvest Centres" a number of developing country and region specific agricultural biotechnology applications are being developed in local food crops like cassava, cowpeas and bananas. Some of these research and development projects are marked by private and public cooperation.

It is unlikely that the introduction and adoption of privately developed transgenic crops in other African countries will happen as quickly and as smoothly as in South Africa. Unlike most African countries, South Africa began with both public and private biotechnology research capacity and regulatory structures in place that could be adjusted to GM crop evaluation and regulation. If there is one thing the South African Makhathini experience can teach us it is that despite the presence of a new, on-farm profit boosting technology, the institutional structures on both input and output sides play an important role in the success and sustainability of small-scale agriculture. Without access to credit, fertiliser, insecticides or other inputs or necessary extension services and information, agriculture will struggle despite the presence of a "new type of seed". Likewise on the output side; if the crop is meant to be sold and not consumed on-farm there has to be transportation, marketing and the rest of the supply chain. There are many African countries where these basic input and output institutions and markets are not in place or not functioning to the benefit of farmers. Ineffective input and output markets and institutions will hamper the introduction, adoption and sustainable use of transgenic crops in Africa.

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APPENDIX A

EKONOMIESE IMPAK VAN GENETIES GEMANIPULEERDE (GM) PRODUKTE IN ONTWIKKELENDE LANDE

Opname onder kommersiële katoenboere in Suid-Afrika

Hierdie vraelys is deel van 'n navorsingsprojek uitgevoer deur die Universiteit van Pretoria met geen kommersiële belange nie. Die doel van die vraelys is om belangrike inligting van kommersiële boere te bekom om sodoende die ekonomiese impak van geneties gemanipuleerde gewasse op plaas-vlak te bepaal en ook om die verdere effek op die bedryf, op streek sowel as nasionale vlak te voorspel.

Ons sal dit hoog op die prys stel as u van u tyd kan afstaan aan die invul van hierdie vraelys. Ons wil u verseker dat hierdie inligting slegs vir navorsingsdoeleindes gebruik sal word en alle inligting sal dus as konfidensiëel gesien word. Vir enige navrae skakel Marnus Gouse by (012) 420 4583 of 082 646 5980

AFDELING A: Die Boerdery

1.1 Naam van eienaar / bestuurder ☐

1.2 Naam van naaste dorp ☐

1.3 U ouderdom? 20-29 ☐ 30-39 ☐ 40-49 ☐ 50+ ☐

Produksie en Inkomste

1.4 Wat was die hoof boerdery aktiwiteite vir 2000.

Boerdery aktiwiteite
Gewas produksie:
Lewende hawe:

AFDELING B Gewas produksie

2.1 Watter gesaaides is verbou? Spesifiseer asb. gewas variëteit en aantal hektaar per seisoen en dui asb. aan of dit onder besproeiing of droëland toestande verbou is.

			1998/99	**1999/00**	**2000/1**
Tipe gewas		Besproei of droëland	Area geplant	Area geplant	Area geplant
Katoen	**Variëteit**				

2.2 Totale grootte van plaas?

2.3 Wisselbou stelsel? Met wat?

2.4 Watter landboukundige probleme ervaar u met die produksie van katoen.? (Bv. Versouting, onvrugbare grond, lae reënval, onkruid, plae, siektes ens.)

Landboukundige probleme

2.5 Watter insekte het die grootste negatiewe effek op u katoen?

Insek

Insette

2.6 By wie koop u, u katoensaad?

Saad maatskappy

2.7 Waarom koop u die katoensaad van hiedie spesifieke saad maatskappy?
....
....

2.8 Wat is u duurste insette tov. katoen? (Saad, plaagbeheermiddels, onkruidbeheermiddels, spuitkoste (vliegtuig/trekker), versekering, besproeiing, arbeid, kunsmis ens.)

1	
2	
3	
4	

2.9 Hoeveel katoensaad plant u ongeveer per hektaar? Konvensionele katoen............kg/ha
Bollgard katoen..............kg/ha

Chemikalië

2.10 Aanwending van plaagbeheermiddels by **konvensionele katoen variëteite.**

Tyd in seisoen	**Plaag**	**Naam van produk aangewend**	**Aantal kere aangewend**	**Hoev./ ha** (of merk net indien u aanwend soos voorgeskryf deur verskaffer ✓)
Vroëe seisoen (week 0-7)				
Vroëe middel seisoen (8-11)				
Laat middel seisoen (12-20)				
Laat seisoen (week 21-22)				

2.11 Aanwending van plaagbeheermiddels by **Bollgard Katoen**.

Tyd in seisoen	**Plaag**	**Naam van produk aangewend**	**Aantal kere aangewend**	**Hoev./ ha** (of merk net indien u aanwend soos voorgeskryf deur verskaffer ✓)
Vroëe seisoen (week 0-7)				
Vroëe middel seisoen (8-11)				
Laat middel seisoen (12-20)				
Laat seisoen (week 21-22)				

Produksie

2.12 Wie is die grootste aankopers van katoen in die omgewing?

2.13 Waarvoor word u katoen gebruik?
Saad ☐ Lint (vesel)☐ Ander (spesifiseer) ☐

AFDELING C: Bollgard Katoen

Boere wat Bollgard Katoen plant asook boere wat dit nie plant nie moet hierdie afdeling asb. invul.

3.1 Wat is volgens u die voordele verbonde aan Bollgard Katoen?

....
....
....

3.2 Wat is volgens u die nadele verbonde aan Bollgard Katoen?

....
....
....

Afdeling D

Hierdie afdeling is slegs vir boere wat al Bollgard Katoen geplant het of huidiglik plant.

4.1 Wanneer het u die eerste keer van Bollgard Katoen gehoor ☐
en van wie? ☐

4.2 Waarom plant u Bollgard Katoen? Merk asb. en dui die belangrikste 3 redes aan. Met 1die heel belangrikste.

Redes	✓	1-3
Hoë opbrengs		
Laer chemikalië kostes		
Arbeid besparing		
Beter plaag beheer		
Prys wat u vir u katoen kry		
Omgewings voordele		
Gemoedsrus ten opsigte van bolwurms		
Vergemaklik bestuur		
Ander (Spesifiseer asb.)		

4.3 Wat is die hoof rede waarom u Bollgard Katoen plant?

....

....

4.4 Wie het u besluit om Bollgard Katoen te plant beinvloed?

....

....

4.5 Het u enige ekstra opleiding/inligting ontvang in verband met die produksie van Bollgard Katoen?

Ja ☐ Nee ☐

4.6 Wie het die opleiding georganiseer?

Voorligters ☐ Saad maatskappy ☐ Ander (Spesifiseer) ☐

4.7 Enige opmerkings oor opleiding of verskaffing van inligting ivm. Bollgard Katoen?

....

....

4.8 Bemerk u 'n toename in natuurlike predatore in u Bollgard lande?

Meer ☐ Minder ☐ Onseker ☐ Wat ? ☐

4.9 Is u tevrede met die Bollgard Katoen wat u geplant het. **Hoekom**? Ja ☐ Nee ☐

....

....

....

4.10 Wat is die tegnologie-fooi wat u betaal, en dink u die prestasie van die saad wat deur die tegnologie moontlik gemaak is, regverdig die fooi?

Fooi ☐

....

....

....

4.11 Indien die tegnologie fooi sou daal, sal u meer Bollgard katoensaad koop en plant?

Ja ☐ Nee ☐

4.12 Sou u bereid wees om 'n hoër tegnologie fooi te betaal , indien die voordeel wat u uit hierdie saad verkry konstant bly? Bv. as die tegnologie-fooi sou styg met dieselfde persentasie as die prys van plaagbeheermiddels.

....

....

Afdeling E

Boere wat <u>nie</u> Bollgard Katoen plant <u>nie</u> moet asb. hierdie afdeling invul <u>asook boere wat in die verlede Bollgard Katoen geplant het maar nie meer plant nie.</u>

5.1 Sal u dit oorweeg om in die toekoms / weer Bollgard Katoen te plant? Ja ☐ Nee ☐

Indien Ja:

5.2 Wanneeer?

....

....

....

5.3 Waarom sal u Bollgard Katoen plant?

....

....

5.4 Waarom plant u nie huidiglik Bollgard Katoen nie? Merk asb.

Redes	✔
Ken nie die variëteit nie	
Nie genoeg inligting oor die produksie van die variëteit nie	
Huidige Bollgard variëteit is nie regte variëteit vir u omgewing nie.	
Ontvang hoër prys vir Nie-Bollgard katoen	
Koste van die saad is te hoog	
Die plaag waarvoor Bollgard ontwikkel is, is nie 'n probleem in die gebied nie	
Bekommerd oor verbruiker/aankoper se reaksie/houding	
Nie goed vir die omgewing nie	
Nie winsgewend nie	
Ander (Spesifiseer asb.)	

5.5 Wat is die hoof rede/s dat u nie Bollgard Katoen plant nie?

....
....
....

AFDELING F Veranderinge en Inligting

(Almal vul asseblief hierdie afdeling in.)

6.1 Volgens u ervaring is daar hierdie seisoen 'n verandering in die aantal bolwurms op konvensionele katoen?

Minder ☐ Selfde ☐ Meer ☐

6.2 Bemerk u 'n toename of 'n afname in die verskynsel van ander skadelike insekte. Spesifiseer asb.

Insek	Meer of minder

6.3 In vergelyking met vorige jare is bolwurms .... gevoelig vir chemikalië.

Minder ☐ Geen verandering ☐ Meer ☐

6.4 Van waar ontvang u inligting oor:

Produksie	
Insette	
Uitsette (bemarking)	
Plaag beheer	

6.5 Wat dink u is die toekoms van biotegnologie in die landbou?

....
....
....

6.6 Enige ander opmerkings oor biotegnologie:

....
....

6.7 Sou u belang stel om in die toekoms geneties gemanipuleerde katoen te plant wat Roundup bestand is?

Ja ☐ Nee ☐ Waarom?

....
....
....

Merk asb. **Droëland** ☐ **Besproeiing** ☐ **Plaas begroting vir katoen .... seisoen** **Droëland** ☐ **Besproeiing** ☐

	VARIËTEIT 1 (Spesifiseer asb.)---------------------------(konvensioneel)				VARIËTEIT 2 (Spesifiseer asb.)-----------------------(Bollgard)			
	Hoeveelheid of Koste	**Eenhede**	**Opmerking**	**Totaal**	**Hoeveelheid of Koste**	**Eenhede**	**Opmerking**	**Totaal**
Hektaar geplant		ha				ha		
Gem. Opbrengs per hektaar		kg				kg		
Kostes per ha: Saad koste		R/ha				R/ha		
Kunsmis		R/ha				R/ha		
Onkruid beheer (Chemies)		R/ha				R/ha		
Insekbeheermiddels (Spesifiseer asb)		R/ha				R/ha		
1		R/ha				R/ha		
2		R/ha				R/ha		
3		R/ha				R/ha		
Pix		R/ha				R/ha		
Arbeid per hektaar	**Aantal ure**	**Koste per uur**			**Aantal ure**	**Koste per uur**		
Grond voorbereiding								
Plant								
Besproeiing								
Aanwending van insekmiddels								
Aanwending van onkruidmiddels								
Oes								
Masjienerie per hektaar	**Ure per ha**							
Grond voorbereiding								
Plant								
Besproeiing								
Insek bekamping								
Onkruid bekamping								
Oes								

APPENDIX B

Yieldgard Maize vs. Conventional Maize

Questionnaire for South African Small Holders

This questionnaire is part of a research project conducted by the University of Pretoria in collaboration with Monsanto. The aim of this survey is to collect necessary information from farmers to determine the possible reasons for adoption and to evaluate the performance of Bt maize as produced under smallholder conditions.

All information will be treated with utmost confidentiality.

Section 1. Personal information

1.1	Respondent Number												
1.2	Name of Interviewer												
1.3	Date of interview	2	0	0	2								
1.4	Nr on certificate												
1.5	Language												
1.6	Province												
1.7	Area												
1.8	Village												
1.9	Family name of respondent (surname)												
1.10	Own name												
1.11	Identification number												
1.12	Phone number (if available)												
1.13	Residential address												
1.14	Position in household												
1.15	Gender	Male		Female									
1.16	Age group	<20	20-29	30-39	40-49	50+							
1.17	How long have your household been farming with maize?		Years										
1.18	Did you personally attend the Yieldgard training course? If no, who did?												

Section 2. Household Background

2.1 Who are the members of your current household? Please specify below.

Members of household (e.g. father, mother, uncle, son)		**Age / Year of birth**	**Family members working on farm** Land preparation and planting (1), applying pesticides (2), fetching water (3), weed hoeing (4), harvesting and shelling (5), other please specify (6)		**Wage earner** Living in household	**Migrant worker** Work in town or city. Do not sleep at home	**Loeal business**
			Full time / part time	Days work in maize season			
1	Head						
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							

2.2 Who is responsible for on- farm decision-making? ....

Male	Female

2.3 What is decision maker's highest level of education?

None	
Grade 1-3 (Grade 1 – Standard 1)	
Grade 4-7 (Standard 2 – Standard 5)	
Grade 8-10 (Standard 6 – Standard 8)	
Grade 11-12 (Standard 9 – Standard 10)	
Degree/Diploma	
Training on commercial farm	
Other	

2.4 What are the sources of household income?

Source	**Estimated income in Rand value. Please specify whether it is monthly or yearly**
Crop Production: Green mealies	
Maize grain	
Cotton	
Other (specify)	
Livestock (specify)	

Off-farm income: (From whom / where?)	
Wage earner:	
Migrant workers:	
Other business:	
Pension:	
Total	

2.5 Please name your 5 biggest household expenses?

1	
2	
3	
4	
5	

2.6 If you an extra R1000 in, what would you spend it on?

Section 3. Farm and products

3.1 Area of total farm in 2001/2002 (Please specify units)

Area owned			Area rented		

3.2 Hectares of farm. (If farmer is not totally sure, or do not know this, go with farmer to measure the pastures and draw picture on back of page, indicating crop layout and size of pastures.)

	Ha of crop in 2001/2002 season
Maize	
Cotton	
Sugarcane	
Other field crops	
Area planted for vegetables	
Grazing	
Other	

3.3 Do you have any | Yes | No | livestock?

3.4 If yes, fill in the table below about the type and number of animals you own.

Livestock	**Number owned**
1. Cattle	
2. Goats	
3. Chickens	
4. Sheep	
5. Donkeys	
6. Other	

Maize seed

3.5 Where do you normally get the maize seed you plant? Please tick or fill in?

Buy hybrid seed from seed company / coop / agents (Go to 3.6)	I bought/received seed from neighbours/family that they saved from last season's harvest. (Go to 3.9)
I plant seed I save from the previous season's harvest (Go to 3.9)	I plant traditional maize seed (Go to 3.9)
If farmer does not buy hybrid seed. Why not?	

3.6 Who do you normally buy your maize seed from and how far do you have to travel to collect it?

Who? (coop.,company)	
Distance	

3.7 How much do you normally pay for your maize seed? Please specify units?

2001/2002 (this season)	
2000/2001 (previous season)	

3.8 If the price of hybrid maize seed went up/down how much less/more seed would you buy? Using price at question 3.7

Price up by 25%		Price up by 50%		Price up by 100%		Price down by 25%	
No change	% Less	No change	% Less	No change	% Less	No change	% More

3.9 What are the names of the maize seed types you have planted the last 2 seasons? (Not including the Monsanto seed)

2001/2002	
2000/2001	

3.10 How much maize seed did you plant this year and when did you plant which seed?

	How much seed? (Please specify units)	When did you plant?
Own seed		
Non Bt seed **(White sticker)**		
Yieldgard seed **(Yellow sticker)**		

3.11 Plant density. Please specify units. (Distance in steps.)

	How many rows or hectares	**How long is the row (steps)**	**How many plants in a row**	**Distance between plants in row**	**Distance between rows**
Own seed					
Non Bt seed **(White sticker)**					
Yieldgard seed **(Yellow sticker)**					

3.12 Do you practice intercropping with maize? Please name crops and explain how?

Yes	No

Green Mealies:

3.13	Did you harvest green mealies this year?	Yes	No	
3.14	From which maize seed did these green mealies come?	Own seed	White sticker	Yellow sticker Yieldgard seed
3.15	Did you sell green mealies in the community?	Yes	No	
3.16	From which maize seed did these green mealies come?	Own seed	White sticker	Yellow sticker Yieldgard seed

3.17 How many green mealies did you **harvest**? (Please specify mealies, bags containing how many mealies, rows etc.)

Seed	Quantity	Unit
Own seed		
White sticker		
Yellow sticker Yieldgard seed		
Total		

3.18 How many green mealies did you ____________ **sell**?

3.19 How much did your sell you green mealies for? (Specify unit e.g. R10 for 12 mealies or R2 per mealie)

Own seed	
White sticker	
Yellow sticker Yieldgard seed	

3.20 Which seed rendered the best green mealies according to the following? Tick and fill in reason?

		Own seed	White sticker seed	Yellow sticker Yieldgard seed	Please give a reason why you think the one you chose is better?
1	**Length of mealie**				
2	**Size of kernels**				
3	**Colour**				
4	**Insects present and damage caused**				
5	**Taste**				
6	**Which green mealies did you and the community prefer?**				

3.21 How do you like your green mealies? Please describe? (Size, colour, cooked how?)

3.22 Any notes or interesting stories about green mealies:

Grain

3.23 Use of maize. What do you do with your maize? (Can tick more than one)

Green mealies for own consumption	Green mealies sold in community	Sell grain to miller and get maize meal in return
Sell maize grain to millers for money	My maize is milled for me, by the miller at a cost	Sell maize grain to community
Animal feed	Other:	

3.24 Please tick the blocks and fill in the quantities that describe the bags you delivered your maize grain in. (To the coop or the miller)

1 Tick or fill in	**My bags are filled with:**	Shedded maize kernels (seeds)	Dried maize ears	?	?
2 Tick or fill in	**My bags are:**	Filled to the top and tied with rope or wire	Almost filled to the top and closed by making a knot with the bag	?	?
3 Tick or fill in	**What type of bags do you use?**	**40 kg maize meal bag**	**50 kg maize meal bag**	?	**?**
4 Fill in	**Quantity of bags harvested according to type of bag:**				
5 Fill in	**How much do you think one of these filled bags weigh?**				
6 Fill in	**How many bags did you deliver to the miller in return for maize meal?**				
7 Fill in	**How many bags did you deliver to the local Coop. / community or buyer in return for money?**				
8 Fill in	**How many bags of grain have you kept for own use?**				

3.25 How many bags of maize meal are you entitled to after delivering your grain to the miller?(in 3.24.6) Please specify size of meal bag and the cost you paid for the milling process?

3.26 Where is your maize usually milled, how far is it from you and how much do you have to pay to travel there? Please specify units?

3.27 If you **sell** your maize, who do you sell it to?

3.28 How much money did you receive from the coop. or community or buyer in return for the above-mentioned number of bags of grain? (in 2.24.7)

3.29 How far do you have to transport your maize and what is the cost of transport? Please specify units?

3.30 How many bags came from which maize seed? Please tick or fill in?

Type of bags you used	40 kg maize meal bags	50 kg maize meal bags	?	?
Own maize seed				
White sticker seed				
Yellow sticker Yieldgard seed				

3.31What do you think the quality of the maize grain you harvested was? Please tick?

Own maize seed	Excellent	Good	Average	Below average	Bad
White sticker seed	Excellent	Good	Average	Below average	Bad
Yellow sticker Yieldgard seed	Excellent	Good	Average	Below average	Bad

Section 4. Maize Enterprise

4.1 Do you practice crop rotation? Name crops

Yes	No

4.2 What is the distance from your maize field to the nearest fresh water point? Please specify units?

4.3 How far is your house from your maize field?

4.4 What are your main reasons for growing maize?

4.5 What are the difficulties when growing maize on your farm?

Agronomical (infertile soil, low rainfall, weeds, insects)
Non –Agronomical (land tenure, labour, credit, vandalism, transport etc)

4.6 What are the 5 most expensive inputs used in maize production and how much do you spend on these inputs? E.g. fertiliser, land preparation, pesticides, total labour, seed)

Rank of expensiveness	Inputs	Amount in Rand value as used on your total maize area
1		
2		
3		
4		
5		

Fertilizer

4.7 Do you use any type of fertilizer? If **Yes**, what and how much? Please specify units eg. 120kg / ha. If **No** please give a reason why not?

Yes	No

4.8 If farmer answered yes at 4.7: Where do you buy fertiliser and how far do you need to travel to collect your fertiliser?

Insects

4.9 Which insects have the biggest negative effect on your maize on the field, on your maize grain when harvested and in your stored maize meal?

Rank	Insects on maize in the field	Insects on stored maize	Insects in stored maize meal
1			
2			
3			
4			

4.10 Do you apply any pesticides on your maize crop? If so, please fill in?

On maize from which seed?	Name of product	Target insect	Times applied	Method of application (spraying, granules by hand)

Land Preparation, Planting and Weeding

4.11 How do you prepare your land for maize production? Please tick or fill in?

Land is prepared by a contractor	Plough with donkey or oxen	Prepared using own tractor
Don't plough (Conservation tillage)	Other	

4.12 How do you plant you maize seed? Please tick or fill in?

Land is planted by a contractor	Plant using an animal drawn planter	Plant with hand and hoe (skoffel)
Plant using own tractor and planter	Other	

4.13 How do you manage weed in your maize fields. Please tick or fill in?

Chemicals	Family labour	Hired labour	Other:

4.14 Quantifying the weed labour: Including yourself, how many people work for how many days and for how many hours a day weeding on your maize field?

Number of people	Number of days	Hours of weeding in day	Total of weeding hours

4.15 Do you need to supply hired workers with food through the day?

Yes	No

Section 5. Health

(If you apply pesticides please fill in this section)

5.1 Have you or a family member ever had any health problems after applying pesticides. Please supply the name of the pesticide or the insect the application was for and specify the health problem?

5.2 Have you or a family member ever had any health problems after eating mealies that were treated with any pesticides? Please supply the name of the pesticide or the insect the application was for and specify the health problem?

5.3 How do you apply the pesticide? Tick or fill in?

Apply granules by hand wearing protection	Apply granules by hand wearing no protection	Spraying with protective clothing
Spraying without protective clothing	Other:	

5.4 What do you do with the empty pesticide containers? Tick or fill in?

Wash it and through it away	Through it away without washing it	Wash it and use it to transport fresh water for household	Other:

Section 6. Savings and credit

6.1 Where do you get your production credit? (Please tick)

	2000/2001	2001/2002
Own money		
Commercial Bank		
Family and friends		
Micro lenders		
Private money lender		
Farmer support programme		
Other (specify)		

6.2 How much of your loan were you able to repay this year? Why? | %

6.3 Do you have any | Yes | No | savings?

6.4 What is the main income source of this savings?

Section 7. Adoption of Bt Maize

7.1 According to your experience of maize production this season, what are the benefits and problems of Yieldgard maize? (Monsanto's yellow sticker maize seed) Please tick

Benefit		Problem	
Increased yield		Difficult to manage	
Better quality		Bt maize does not control stalk borer well enough	
Receive higher price for Bt maize		Lower quality	
Insecticide savings		Low yield	
Labour savings		Low price for Bt maize	
Green mealies are very tasty		The green mealies are not tasty	
Renders very good maize meal		The maize meal is not tasty	
Less chemical health hazard		Millers will not buy Bt maize	
Better pest management		Weak grower	
Easy to manage crop		Other problem insects	
Peace of mind about stalk borers		Big problems with birds	
Reduce need for spraying water		Other	
Less stalk borers on maize			
Other			

7.2 Compared to a normal year how many stalk borers are there this season on the maize from **your own** seed?

Less than normal	Same	More than normal

7.3 Compared to the maize from **your own seed** how many stalk borers are there on the **white sticker** maize?

No stalk borers on the white sticker maize	Less than on my own maize	The same as on my own maize	More on than on my own maize

7.4 Compared to the maize from the **white sticker seed** how many stalk borers are there on the **Yieldgard (yellow sticker)** maize?

No stalk borers on the yellow sticker maize	Less than on the white sticker maize	The same as the white sticker maize	More on than the white sticker maize

Section 8. Next season

8.1 What type of maize seed will you plant next year?

8.2 Based on the Yieldgard maize seed benefits you have seen, are you **willing to pay more for the Yieldgard** maize seed than for conventional maize seed?

	Total					Own conventional seed	CRN 3549 (White sticker)	Yieldgard seed (Yellow sticker)
Area								
	Amount					Amount	Amount	Amount
Value of maize production								
Income out of green mealies								
Income out of grain sold								
Value of green mealies consumed								
Value of maize meal consumed								
Cost of inputs								
Land preparation and planting								
Seed								
Fertilizer								
Weed control (Chemical)								
Pesticides (specify)								
	Workers	Days	Hours / day	Cost / day	Total cost			
Total Labour								
Land preparation and planting								
Labour for weed controle								
Labour for harvesting and shedding								