INFLUENCE OF ROUNDUP READY ® MAIZE ON THE SOUTH AFRICAN MAIZE HERBICIDE MARKET

by

WILLEM ABRAHAM JACOBUS STEENEKAMP
MSc Agric (UP)

Submitted in partial fulfillment of the requirements for the Degree Masters in Business Administration (MBA) at the Potchefstroom Business School

FACULTY OF ECONOMIC AND MANAGEMENT SCIENCES
NORTHWEST UNIVERSITY
POTCHEFSTROOM

STUDY LEADER: PROF CA BISSCHOFF

NOVEMBER 2004

ABSTRACT

The first Roundup Ready crop to be commercialised was soybean in 1996. Soybean farmers, initially in the USA and more recently in Argentina, rapidly accepted these varieties. Roundup Ready soybeans were commercialised in South Africa in 1999. Since then Roundup Ready maize, canola and cotton have also been introduced in the USA. The introduction of Roundup Ready technology may be viewed as a disruptive technology. This innovative technology emerged 25 years after the discovery of the non-selective herbicide (glyphosate) that is now selective in maize, cotton, soybeans and other crops. This means that the crops are now (due to genetic modification) tolerant to this herbicide, but that weeds remained susceptible. In light of the introduction of Roundup Ready maize into the South African market in 2004, and the subsequent influence thereof on the South African maize herbicide market, the objectives of this research is to:

- *evaluate the influence of Roundup Ready maize on the South African maize herbicide market;*
- *determine which benefit, contributed by Roundup Ready maize, is ranked to be the most and to be least important as perceived by maize growers;*
- *propose strategies to maximize Roundup Ready maize adoption amongst maize growers; and to*
- *propose strategies for the sustainable marketing of conventional herbicide programs in conjunction with Roundup Ready maize programs.*

A total number of 260 respondents were telephonically interviewed, covering 198 415 hectares which represents 7% of the total maize plantings in South Africa. The most significant results are that:

- *>60% of the respondents believe that weed infestation have a fair to serious influence on maize yield;*
- *60% of respondents apply herbicides on the total soil surface;*
- *>60% of the respondents rely on triazine containing herbicides;*
- *the dominant weed types in the West are broad leaf weeds, irrigation area is grasses and East is a 50/50 split between these two types;*
- *more than 50% of the respondents have weed control costs exceeding R200/hectare;*
- *less than 80% respondents believe that their current weed control program's efficacy is more than 90%;*
- *respondents believe that the use of residual herbicides will decrease with 37,6% due to Roundup Ready maize;*
- *95% of first users of Roundup Ready are satisfied. The biggest perceived benefit is the broad spectrum of weed control;*
- *8% of respondents indicated that they will already plant Roundup Ready maize in 2004/05;*
- *>75% of the respondents will plant RR/YG, but price is the major influence factor; and*
- *demand for Roundup Ready maize and the stacked hybrid is relatively elastic.*

The following recommendations were derived:

- *weed control costs increase in the order - dry land West < dry land East < irrigation and also low < fair < serious infestation. Due to these differences, marketing needs to be focused on segments in which the greatest customer value can be created and sustained over time;*
- *the positioning should be along the benefits as perceived by the maize growers. These include, firstly, the broad-spectrum weed control (main benefit), secondly the control of difficult weeds and thirdly flexibility of the programme;*
- *the demographics section reflected that the Roundup Ready growers are < 50 years of age and have higher education levels and are subsequently more receptive than later adopters or non-adopters. Marketing efforts should be directed at these two categories;*
- *the growth stage will be entered next season (05/06), in which sales will start climbing quickly. Stacked hybrids (RR/YG) need to be released in this stage to drive the growth. The early adopters will continue to buy and will be followed by late adopters. The marketing objective now is to create product awareness and to get as many growers as possible to test the technology. A total of 95% of first time users are satisfied and will use the technology again. High intensity sales promotion to create awareness and perception of optimum weed control programme;*
- *price elasticity of demand should be taken into account when new prices are set. Due to the bigger demand than supply (seed shortage) that is expected over the next two to three years, both companies could ignore this elasticity and maintain value-based pricing. Demand for the stacked hybrid is relatively elastic. The recommended technology fee should be R 500/bag. The fee for the Roundup Ready maize should remain R 270/bag;*
- *the perception of Roundup Ready growers is that the use of residual herbicides in maize production will decrease by 44,6% due to the introduction of this technology. This will come mainly at the expense of atrazine and atrazine-containing products. The focus needs to move to the promotion of high quality acetanilide herbicides as part of the Roundup Ready weed control programme to ensure success. Residual herbicides will also be a valuable tool in resistance management.*

ACKNOWLEDGEMENTS

The author is greatly indebted to the following people and institution without whom this dissertation would not have been possible:

All participating maize growers;

My study leader, Prof C.A. Bisschoff for his guidance;

My wife Pamela and two sons, Stéfan and Christiaan, for sacrifices made unknowingly;

My mother and other family members for support;

My Creator for this opportunity and support; and

Monsanto South Africa for this opportunity.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The development of herbicide-tolerant crops has mainly involved genetically modified plants based on single gene technology. The application of single gene technology in the herbicide-tolerant sector has been aided by the fact that several of the leading herbicides act via a single enzyme step. This feature has enabled researchers to produce plants that contain modified genes that confer resistance to particular herbicides. Monsanto, leading Biotechnology Company, has developed a variety of crops that are tolerant to the non-selective herbicide, namely glyphosate. Genetically modified (GM) crops based on this technology, are sold under the brand name Roundup Ready, meaning that it is enabled to tolerate the Roundup herbicide. The Roundup Ready herbicide contains glyphosate and is sprayed over-the-top.

The first Roundup Ready crop to be commercialised, was soybean in 1996. Soybean farmers, initially in the USA, and more recently in Argentina, rapidly accepted these varieties. Roundup Ready soybeans were commercialised in South Africa in 1999. Since then, Roundup Ready maize, canola and cotton have also been introduced in the USA (McDougall, 2003: 307).

To date, the commercial impact of herbicide-tolerant crops has been limited to North America, Canada and Argentina. The technology are changing the way weeds are controlled in South Africa from this planting season (September 2004) when Roundup Ready maize is being planted on more than 50 000 ha. There also remains potential for further area increases in herbicide-tolerant soybeans in the USA. Maize hectares in most of the market where it has been registered, are now approaching maturity.

During the eight-year period 1996 to 2003 the global area of GM crops increased 40-fold from 1,7 million hectares in 1996 to 67,7 million hectares in 2003 (James, 2003: 3).

Almost 30% of this was grown in developing countries. Herbicide-tolerance (73% of global hectares in 2003) has consistently been the dominant trait, with insect resistance being second. The Yieldgard (maize - YG) and Bollgard (cotton - BG) traits, both contain the Bt-gene, make plants resistant to attacks by stalk borers and bollworms respectively. These traits are already available in combination with Roundup Ready in the USA, thus enabling the plants to fend off insects and also allows the application of glyphosate over-the-top. This will increase the rate of adoption of Roundup Ready maize.

The following problem statement will reveal the necessity for this study.

1.2 PROBLEM STATEMENT

The introduction of Roundup Ready technology may be viewed as a disruptive technology. According to Burgelman, Maidique and Wheelwright (2001:1) technologies (such as Roundup Ready crops) that disrupt an established trajectory of performance improvement, or alternatively redefine what performance means, are called disruptive technologies. This innovative technology emerged 25 years after the discovery of the non-selective herbicide (glyphosate) that is now selective in maize, cotton, soybeans and other. This means that the crops are now (due to genetic modification), tolerant to this herbicide, but that weeds remained susceptible.

The conventional soybean and cotton herbicide market has almost been eradicated by the introduction of Roundup Ready soybean and Roundup Ready cotton varieties since 1996. This was primarily due to the growth type (canopying due to high planting density) of the soybean and cotton plants. The single herbicide (glyphosate) programme proved to be superior to conventional herbicide programs and therefore no other herbicides are needed for weed control purposes. Roundup Ready maize has a less devastating effect on the conventional maize herbicide market in the USA, but still reduced the use of conventional herbicides. The USA Roundup Ready maize market has not yet reached maturity and will continue to grow to an expected 30% (McDougall, 2004: 1).

Roundup Ready maize is available in commercial quantities in South Africa. Concerning the agricultural market, South Africa is a quick adopter of technology. For example: Yieldgard maize has been sold out every year since its introduction in 2001. The same trend is expected with Roundup Ready maize. The purpose of this study is, therefore, to investigate the adoption of Roundup Ready maize in South Africa and the subsequent influence on the South African maize herbicide market.

1.3 OBJECTIVES

In light of the introduction of Roundup Ready maize into the South African market in 2004, and the subsequent influence thereof on the South African maize herbicide market, the objectives of this research is to:

- evaluate the influence of Roundup Ready maize on the South African maize herbicide market;

- determine which benefit, contributed by Roundup Ready maize, is ranked to be the most and to be least important as perceived by maize growers;

- propose strategies to maximize Roundup Ready maize adoption amongst maize growers; and to

- propose strategies for the sustainable marketing of conventional herbicide programs in conjunction with Roundup Ready maize programs.

1.4 RESEARCH METHODOLOGY

Telephone interviewing has been selected to gather the data due to its flexibility and interaction with the respondent. The sample consists of 260 South African maize growers. These growers were screened before the commencement of the telephonic interview to exclude those farmers that plant less than 300 ha dry land maize or less than 50 ha irrigated maize, as well as those who are not responsible for decision making on the farming unit (those in supporting roles). Objectivity PTY (Ltd), a Johannesburg based company specializing in gathering data, conducted the interviews.

The population consisted of a list of 1500 names that has been submitted to Objectivity PTY (Ltd) from which respondents were randomly selected. The growers have been selected to represent the three maize growing areas of South Africa, namely dry land West, dry land East and irrigation.

1.5 GLOSSARY

Gene	A portion of a chromosome that contains the hereditary information necessary for the production of a protein.
Genetically modification	The technique of removing, modifying or adding genes to a living organism.
Glyphosate	Active ingredient of the herbicide that is used on Roundup Ready crops.
Herbicide	Chemical that is used to kill plants, especially weeds.
Plant biotechnology	The addition of selected traits to plants to develop new varieties.
Roundup Ready-trait	Genetically modified to tolerate glyphosate application.
Stacked variety	Variety containing both traits, Yieldgard and Roundup Ready.
Weeds	Plants that are growing where they are not supposed to be growing, i.e. in fields.

Yieldgard-trait	Genetically modified to resist insects.

1.6 DEMARCATION OF THE STUDY

Chapter 1 consists of an overview and purpose of the study. The problem statement, goals and research methodology are presented.

In Chapter 2 an extensive literature study will be conducted to describe the global situation and background is given on the South African industry and also specifically the herbicide called glyphosate.

The results of the study are reported in Chapter 3 and discussed.

Chapter 4 is the final chapter. It renders conclusions and recommendations follow. The summary at the end of the chapter rounds off the dissertation by putting all the pieces together.

1.7 SUMMARY

One of the major factors affecting the crop protection industry since 1996 has been the commercialisation of herbicide-tolerant and insect-resistant crop varieties containing genetically modified (GM) input traits. It is evident that the strategy of several agrochemical companies has involved the repositioning of their businesses to take account of the change in the competitive position of the industry in the crop sectors and countries where this technology has been accepted. It is also evident that Research and Development investment for many companies has shifted with an aim of taking part in this new and expanding industry.

As a result it is expected that the most competitive sector of the GM market in the immediate future is likely to be maize. A high 49% of the maize hectares in the USA in 2003 was due to GM varieties; only 17% of this was due to Roundup Ready, a figure that is expected to increase to around 30% at the maturity stage (market saturation). The growth will come in the combination of the Yieldgard- and Roundup Ready-traits in the so-called stacked varieties (McDougall, 2004: 1).

A literature study (Chapter 2) was undertaken to understand the global situation on Roundup Ready crops, especially maize. This study assists in measuring and predicting the influence of Roundup Ready maize on the South African maize herbicide market that has also dramatically been influenced since major herbicides (especially from the acetanilide group) reached maturity and patents were dropped. This has led to an influx of generic products into the South African maize herbicide market.

CHAPTER 2

LITERATURE STUDY

2.1 INTRODUCTION

One of the major factors changing weed control practices since 1996 has been the commercialisation of herbicide-tolerant crop varieties containing the Roundup Ready trait (glyphosate tolerant). It is evident that the strategy of several agrochemical companies has involved the repositioning of their businesses to take account of the change in the competitive position of the industry in the crop sectors and countries where this technology has been accepted. It is also evident that Research and Development investment for many companies has shifted with an aim of taking part in this new and expanding industry (McDougall, 2004: 1).

Herbicides, like glyphosate, can be categorised in a variety of ways most of which are generally related to either their chemical type or their physiological and biochemical action in plants. Amongst the various criteria that are used to group herbicides are the following:

- application timing (pre-plant incorporated, pre-emergence or post-emergence);
- selectivity (broadleaf weed control, grass weed control, cross spectrum action or non-selective action);
- translocation or movement within the plant (systemic or non systemic);
- chemical class; and
- site of herbicide uptake (foliar, root).

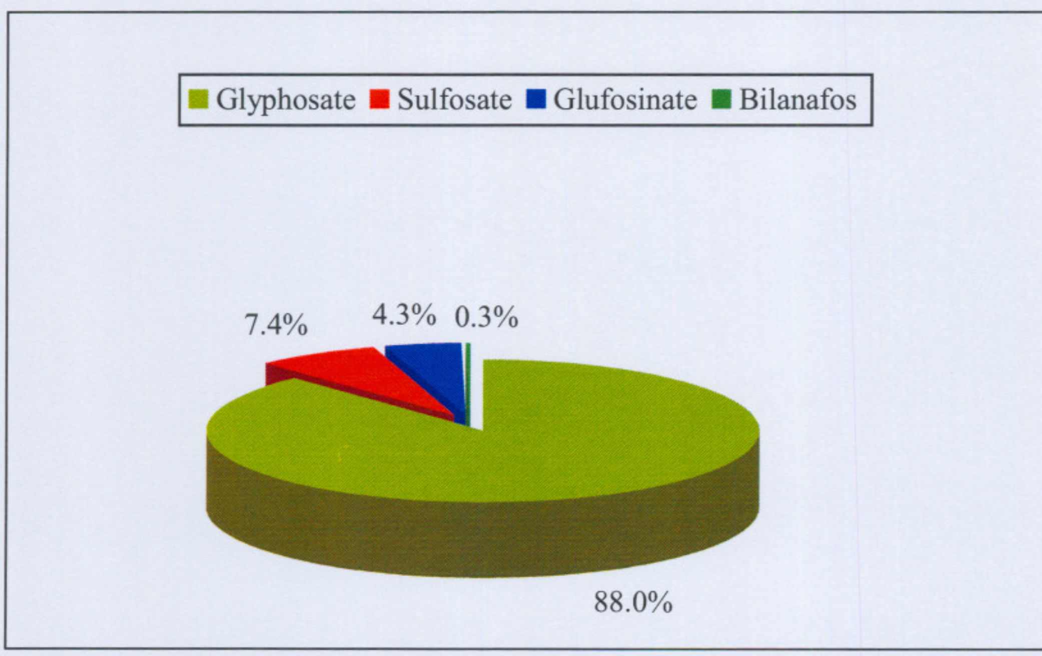
This system of classifying herbicides is particularly important as it describes the mode of action of the product in the plant and can therefore be used as the basis for the development of a suitable biological screen that mimics the particular mode of action. Glyphosate is a systemic, non-selective, post emergence herbicide with no soil working (McDougall, 2002: 1).

2.2 THE HERBICIDE GLYPHOSATE

Glyphosate was the first amino acid herbicide to reach the market, being introduced by Monsanto in 1972. The product's non-selective activity, low toxicity profile and rapid breakdown on contact with the soil resulted in rapid acceptance for total vegetation clearance in agricultural, industrial and home and garden situations. Glyphosate is now the largest selling single product in the global crop protection market. The success of glyphosate against its main competitor in the marketplace, the bipyridyl herbicide paraquat from Syngenta, resulted in a number of companies undertaking research in the area. The first true competitor to glyphosate came with the introduction of glufosinate by Bayer CropScience (then Hoechst) in 1986, although the product had been preceded by bilanafos from Meiji Seika in 1984. These two products are structurally related, with bilanafos produced by fermentation, whilst glufosinate is chemically synthesized (McDougall, 2003: 27).

This class of herbicides are active through the inhibition of amino acid synthesis. The glycines, glyphosate and sulfosate are inhibitors of EPSP synthase, while the phosphonic acids, glufosinate and bilanafos, are inhibitors of glutamine synthase. This difference, coupled with varying absorption characteristics, provides differentiation between the products making some more suitable than others to certain market conditions. Because glyphosate is completely systemic in plants it is extremely active in the control of perennial weeds, particularly in those grass species with underground rhizome systems. Initially glyphosate did not compete in the annual weed control sector, the major market for paraquat (non-selective contact herbicide). Annual weeds are weeds that germinate from seed every year, while perennial weeds survive throughout the winter and grow from an existing root system. However, the patents on glyphosate started to expire and the price of glyphosate was reduced to combat generic competition. This brought the products into direct competition and resulted in an expansion of the market for glyphosate (Figure 2.1). Another factor that resulted in sales growth for the product was the increase in no-till and reduced tillage farming (initially in North America) although the practice is now being promoted around the world. Glyphosate is used in these situations as a pre-plant treatment to kill weeds and volunteer crops prior to planting through the weed residue. In recent years another major market for the product has been in non-crop situations for total weed control, particularly in industrial usages, on railways, road verges and ditches as well as in home and garden situations.

Figure 2.1: Market share of amino acid herbicides



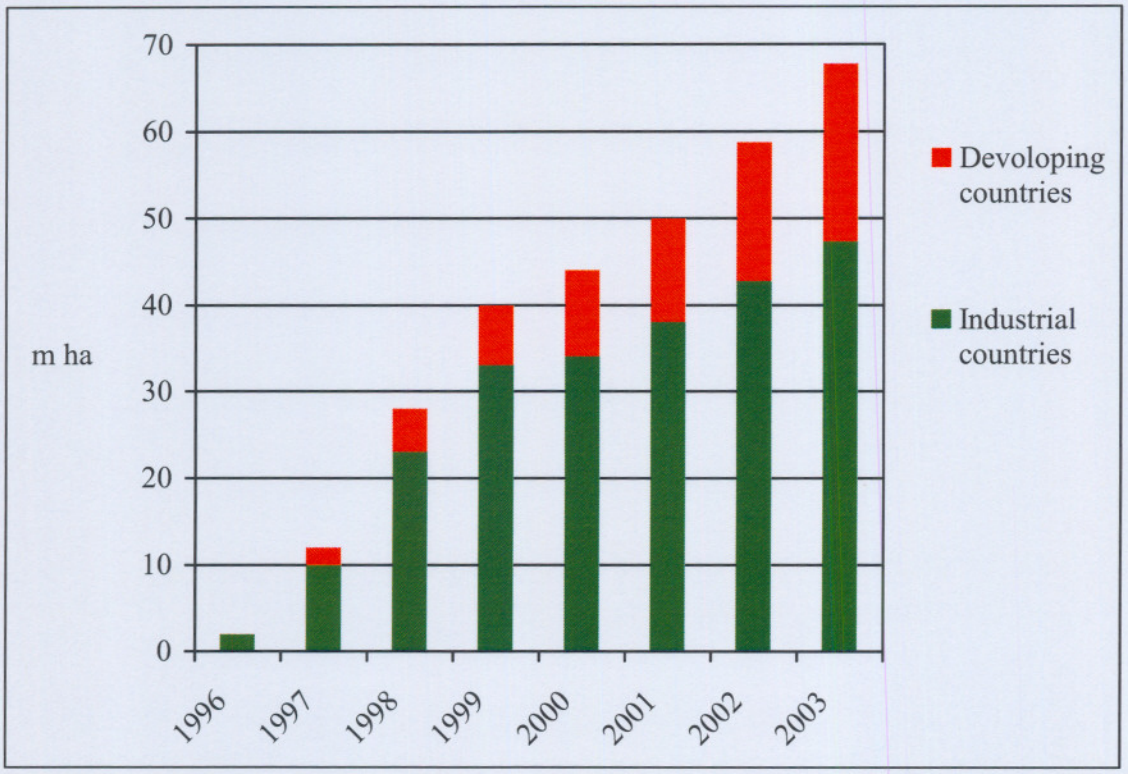
Source: McDougall (2003: 25)

The latest development to result in further expansion, and probably the most significant, is the introduction of Roundup Ready crops, genetically manipulated to tolerate the herbicide, allowing the use of this non-selective herbicide in over-the-top applications while the crop is growing (McDougall, 2003: 27).

2.3 ADOPTION OF GENETICALLY MODIFIED GRAIN CROPS

The global area planted with genetically modified crops rose by 15% to 67,7 million hectares in 2003 according to The International Service for the Acquisition of Agri-Biotech Applications (James, 2003: 3). A sustained annual growth rate of 10% has been recorded since the introduction of GM crops in 1996 (Figure 2.2).

Figure 2.2: Global genetically modified crop growth



Source: McDougall (2003: 6)

Six countries were responsible for planting 99% of the world's GM crop hectares in 2003 compared with four in 2002. Brazil and South Africa joined the USA, Argentina, Canada and China as the leading growers of GM crops. The USA remained by far the largest producer of GM crops in 2003. USA GM crops rose by 10% to 42,8 million ha, representing 63% of the global total. This was due to significant increases in Yieldgard maize and herbicide-tolerant maize plantings and continued growth of herbicide-tolerant soybeans.

Argentina remained the second largest market for GM crops with 13,9 million ha or 21% of global plantings. Canada's GM crop plantings grew by 26% to 4,4 million ha or 6% of the global plantings. Of the six leading GM crop countries, China and South Africa recorded the largest annual increases, each having a 33% expansion. South Africa planted 400 000 ha of GM maize, soybeans and cotton. Maize grew from 6 000 ha in 2001 to 84 000 ha in 2003 (James, 2003: 11).

Soybeans remained the dominant GM crop in 2003, representing 61% of the global GM crop area. This is only herbicide-tolerant, namely glyphosate tolerant. The GM maize, second largest area, grew by 25% to 15,5 million ha or 11% of the total maize area. Cotton remained the third largest GM crop with the area up by 6% to 3,9 million ha or 21% of the global crop (James, 2003: 14).

2.3.1 Adoption of herbicide-tolerant maize in the USA

Herbicide-tolerance has consistently been the dominant trait among GM crops between 1996 and 2003, thus staying ahead of insect resistance. Herbicide-tolerant soybeans, maize and cotton were planted on 49,7 million ha in 2003, representing 73% of the global GM crop area. There were 12,2 million ha of Bt crops (18%), while stacked genes for herbicide-tolerance and insect resistance in maize and cotton amounted to 5,8 million ha (8%).

Herbicide-tolerant maize was first introduced in the USA, followed by Canada and South Africa in 2003. Argentina is the latest country to get government approval. The first crop was planted in 2004.

According to USDA's NASS report for March (2004: 20) GM maize will be planted on approximately 46% of the USA hectares. This is 6% higher than the 2003 figure. The herbicide resistant maize hectares increased from 11% in 2003 up to 14% in 2004 whilst the stacked type (containing both herbicide resistant and insect tolerant traits) increased from 4% to 5% in 2004.

2.3.2 Satisfaction with herbicide-tolerant maize in the USA

A market research study conducted in the USA, by Marketing Horizons, Inc. (2001) revealed that the satisfaction level amongst growers is very high. Telephone interviews were conducted with a total of 410 growers who planted Roundup Ready maize in 2001.

The objective of this research was to profile usage of Roundup Ready maize in 2001 and to measure customer satisfaction and re-use intentions.

Growers who have planted Roundup Ready maize are clearly satisfied with the programme. Some of the key measures behind the appeal of this programme include the following:

- Almost all the growers are satisfied overall with Roundup Ready maize. Currently 97% are either "very" or "somewhat" satisfied with it.

- The majority of the growers (88%) are more satisfied with Roundup Ready maize than non-Roundup Ready maize.

- Over 9 in 10 growers (97%) perceive that Roundup Ready maize provides either a "greater" or "the same" value as non-Roundup Ready maize.

- 8 out of 10 growers rated Roundup Ready maize as a very good (35%) or good (46%) value. An additional 18% considered the technology to be a fair or average value in 2001.

- The likelihood of planting Roundup Ready maize again in 2002 is quite high, as 92% of current users indicated they definitely (69%) or probably (23%) will plant Roundup Ready maize again in 2002.

It seems as though the key to expanding use of Roundup Ready maize is to get growers to at least try it on some of their hectares. Growers that have planted Roundup Ready maize are highly satisfied. In addition, it is perceived to provide superior weed control, is cost-effective, and is a simple program.

It should be noted that most current users were not negatively impacted by weed resistance concerns, lack of market acceptance, or concerns with volunteer Roundup Ready maize. Likewise, the option to apply Roundup herbicide over-the-top up to the eight-leaf stage would have little impact. This is not to say, however, that these issues are not impacting planting intentions among non-users of Roundup Ready maize.

2.3.3 Tendencies in the global herbicide market

According to the latest USDA survey in the maize growing states in the USA (http://usda.mannlib.cornell.edu/reports/nassr/other/pcu-bb/agcs0504.pdf), 20% of the maize crop was treated with glyphosate in 2003, while only 9% was treated in 2002. Glyphosate became the third most widely used herbicide, along with s-metolachlor (20%), in 2003. Atrazine (68%), acetochlor (26%) and s-metolachlor have been the leading maize herbicides in USDA surveys for the previous three years (2000-2002). Glyphosate is the only systemic, non-selective and post emergent herbicide. The other three are applied on the soil surface and have a residual effect and are selective.

Glyphosate was applied to 69% of the cotton area in 2003. The next most widely used herbicides were trifluralin (39%), diuron (28%) and pendimethalin (20%). These three herbicides are residual and are selective.

The increasing glyphosate use is a consequence of the rapid growth in glyphosate tolerant crops in the USA. This growth comes at the expense of the residual herbicides.

2.4 THE SOUTH AFRICAN MAIZE HERBICIDE MARKET

2.4.1 Dominant economic features

- **Market size**

The average maize market is around 2,8 million hectares and varies from year to year due to the maize price at the beginning of the season and rainfall patterns. The average farm size is 500 hectares with a total of 8000 maize growers. The market will be described in more detail in a while.

- **Scope of competitive rivalry**

The majority of the glyphosate supply companies present in the South African maize market today are local companies (Table 2.1). Villa is a company that acts as a wholesaler for various supply companies with off-patented products.

The glyphosate market is dominated by 360 g/lt glyphosate formulations, and can be characterized as generally less attractive than other markets due to low profitability, low capital requirements, over capacity and ease of entry and exit.

Competition is fierce and has led to a downward price spiral over the last 10 years due to the entrance of various new suppliers. The trend has been broken in 2004, due to raw material price surges, and prices are rising slowly to above break-even levels.

Table 2.1: **Scope of competitive rivalry, glyphosate supply companies**

	Multinational	National	Regional
DOW AgroScience	x		
Monsanto	x		
Syngenta	x		
Cash Chemicals			x
Gap Chemicals			x
Plaaskem		x	
Unisun			x
Villa		x	
Volcano AgroScience		x	
Zetachem			x

Distributors are regionally focused, and normally have access to more than one supply company's portfolio. Wenkem SA and Novon are the only true national operations (Table 2.2). Distributors source herbicides directly from the supply companies or the wholesaler and deals directly on farm level via their network of commissioned contracted agents.

Table 2.2: Scope of competitive rivalry, glyphosate distributors in the maize market

	National	Regional
Avello		x
Farmkem		x
Lowveld Agrochem		x
Novon	x	
Midchem		x
Plantchem		x
Qwemico		x
Technichem		x
Vrystaat Oesbeskerming		x
Wenkem	x	

2.4.2 Maize production in South Africa

South Africa annually plants in the region of 2,8 million hectares of maize that produce, under normal climatic conditions, 8 million tons of grain. This is broadly categorized as three areas that differ significantly as indicated in Table 2.3. Heidelberg and Delmas are typically East dry land areas, whereas Bothaville and Lichtenburg are typically West dry land areas. The N1 highway is generally regarded as the border between east and west. The planting season starts in KwaZulu-Natal and the irrigation areas in September, followed by the East dry land area and finishes off in the dry land West area in December.

Table 2.3: Practices of the maize growing regions

	Irrigation	East, dry land	West, dry land
Area (ha)	200 000	1 000 000	1 600 000
Planting density (kernels/ha)	70 000	20 000 – 40 000	12 000 – 20 000
Row width (m)	0.9	0.9	1.5 – 2.4
Herbicide application frequency	2-3	2-3	1-2

Major constraints in maize production are soil moisture, competition from weeds and insects. If weeds are not successfully controlled during the first six to eight weeks after planting, maize yields will be reduced significantly. It is therefore of utmost importance to achieve optimum weed control (Kanyomeka, 2001: 1).

2.4.3 Weed control in maize

Weed control in maize is mainly a combination of mechanical actions (such as ploughing and cultivation) and herbicides. Weeds may be controlled at different times, before planting (pre-plant spray), pre-emergence (at the time of planting), and post-emergence (after crop establishment). The timing depends mainly on weed pressure and type of weeds present on a specific field. Recommendations are largely based on history, where available. Plants (crops and weeds) are either susceptible or tolerant to herbicides and in the worse case, resistant.

Susceptible plants will generally be killed or their growth inhibited when exposed to a particular herbicide at the recommended rate (Kanyomeka, 2001: 2). *Tolerant* plants are not affected or injured by a herbicide at normal recommended rates. It is this characteristic that allows the use of herbicides in a crop without injuring the crop but controlling the weeds. These crops and also some weeds have natural tolerance. Roundup Ready crops are genetically modified to be tolerant against glyphosate.

Resistant plants lack a metabolic site of action for the herbicide (Kanyomeka, 2001: 2). Resistance is normally associated with one group of products and other groups may control weeds resistant to one group of herbicides.

Many researchers have reported differential tolerance among maize genotypes to specific herbicides (Kanyomeka & Reinhardt, 2000: 13). These differential tolerances may lead to crop damage and are triggered by environmental conditions and soil factors that are not foreseeable at the time of planting. Differential tolerance may also be increased by herbicides, with the same active ingredient, that are less safe due to use of older technology.

Herbicides need to be registered and are regulated in South Africa by Act 36 of 1947 (http//www.nda.agric.za/act36/AR/herbicides.htm). Although Roundup herbicide has been on the market for 30 years it is still the top selling agro-chemical, including insecticides and fungicides. Table 2.4 gives an overview of some of the more than 50 registered glyphosate formulations in South Africa. Table 2.5 gives an overview of some of the acetochlor containing herbicides registered for use in South Africa. The glyphosate and acetochlor active ingredients have been off-patent for more than 10 years.

Table 2.4: **List of some of the glyphosate formulations registered and sold in South Africa**

Salt	a.i	Trade name	L no.	Registration holder
glyphosate isopropylamine salt	360 g/l	Roundup	0407	Monsanto
glyphosate isopropylamine salt	360 g/l	Clear Out	4734	GAP Chemicals
glyphosate isopropylamine salt	360 g/l	Profit 360	4774	Unisun
glyphosate isopropylamine salt	360 g/l	Mamba 360 SL	4817	Dow AgroSciences
glyphosate isopropylamine salt	360 g/l	Glyphogan 360 SL	5393	Makhteshim-Agan
glyphosate isopropylamine salt	360 g/l	Scat 360 SL	5716	Universal Crop Protection
glyphosate isopropylamine salt	360 g/l	Roundup Ultra	6068	Monsanto
glyphosate isopropylamine salt	360 g/l	Erase 360 SL	6206	Plaaskem
glyphosate isopropylamine salt	360 g/l	Roundup Ready	6702	Monsanto
glyphosate isopropylamine salt	360 g/l	Springbok	6719	Volcano Agroscience
glyphosate isopropylamine salt	360 g/l	Senator Xtra	6884	Farmers Agri-Care
glyphosate isopropylamine salt	360 g/l	Persuador	6948	GAP Chemicals
glyphosate isopropylamine salt	360 g/l	One Shot	7085	Cash Chemicals
glyphosate isopropylamine salt	360 g/l	Nexus Glyphosate 360	7113	Volcano Agroscience
glyphosate isopropylamine salt	360 g/l	UAP Glyphosate 360	7114	Volcano Agroscience
glyphosate isopropylamine salt	450 g/l	Roundup Turbo	7166	Monsanto
glyphosate potassium salt	500 g/l	Touchdown Forte Hi Tech	7305	Syngenta
glyphosate sodium salt	500 g/kg	Glyphosate WSG	7119	Volcano Agroscience
glyphosate trimesium	480 g/l	Touchdown Plus	5565	Syngenta

Source: **http//www.nda.agric.za/act36/AR/herbicides.htm: [Date of access: 20 Sept. 2004]**

Table 2.5: List of some of the acetochlor formulations registered and sold in South Africa

Active ingredient	g/l	Trade name	L no.	Registration holder
acetochlor	700 g/l	Acetochlor S 700	7155	Volcano Agroscience
acetochlor	750 g/l	Relay 750 EC	3898	Dow AgroSciences
acetochlor	750 g/l	Crocodile	6620	Volcano Agroscience
acetochlor	750 g/l	Safier 750	7049	Natural Crop Protection
acetochlor	840 g/l	Buffalo	6869	Volcano Agroscience
acetochlor	840 g/l	Prefix S EC	7362	Meridian Agritech
acetochlor	900 g/l	Harness	3029	Monsanto
acetochlor	900 g/l	Acetochlor 900 EC	6514	Volcano Agroscience
acetochlor	900 g/l	Acetak EC	6904	Meridian Agritech
acetochlor	900 g/l	Acetochlor 900	7233	GAP Chemicals
acetochlor	960 g/l	Har-I-Cane EC	5801	Monsanto
acetochlor	960 g/l	Tremor	6858	Volcano Agroscience
acetochlor (+ safener)	700 g/l	Wenner 700 S EC	3895	Dow AgroSciences
acetochlor (+ safener)	700 g/l	Acetochlor 700	5940	Kynoch Agrochemicals
acetochlor (+ safener)	700 g/l	Lion	6622	Volcano Agroscience
acetochlor (+ safener)	700 g/l	Hippo	6629	Volcano Agroscience
acetochlor (+ safener)	700 g/l	Diamant 700S	7050	Natural Crop Protection
acetochlor (+ safener)	840 g/l	Guardian S	4862	Monsanto

Source: **http//www.nda.agric.za/act36/AR/herbicides.htm: [Date of access: 20 Sept. 2004]**

2.4.4 Competitive forces

The state of competition in an industry is a composite of five competitive forces according to Porter (Thompson & Strickland, 2003: 80). The **first major competitive force** consists of the rivalry among competing sellers. The **second competitive force** is that of potential entry of new players to the industry. "Barriers to entry" to keep out these new players is an important concept. The **third competitive force** stems from substitute products/services. An important concept here is that of "switching costs". The competitive threat posed by substitute products/services is strong when substitutes are readily available and attractively priced, buyers believe substitutes have comparable or better features, and buyers' switching costs are low. The **fourth competitive force** arises from the power of suppliers. Suppliers are in a strong competitive position when they can offer their products/services at a lower price than competitors, or if these products/services are of higher quality and performance than the offerings of their competitors. The **fifth competitive force** stems from the strategic power of buyers. Buyers are a strong competitive force when they are able to exercise bargaining leverage over price, quality, service or any other terms of the sale.

The important competitive forces are discussed now in the South African context in sequence of importance.

- **Rivalry amongst competing sellers**

  The strongest of the competitive forces is rivalry amongst competitors. Cross-company rivalry as discussed here is centered on price competition. Several factors seem to influence cross-company rivalry (Porter, 1980: 137).

  - Rivalry intensifies as the number of competitors increases. As indicated earlier there are more than 50 registered glyphosate formulations and a host of residual off-patented products (such as acetochlor) in South Africa.

- Rivalry is usually stronger when demand for the product is growing slowly. The glyphosate market is growing slowly and maximum penetration has been reached in almost all of the segments. The residual herbicide market (acetochlor) is stable and will not grow further.

- Rivalry is more intense when industry conditions temp competitors to use price cuts to boost volumes. Glyphosate prices change on a daily basis, as competitors want to increase volumes to utilize their formulation capacity to the maximum. Acetochlor prices are seasonal but constantly downward.

- Rivalry is stronger when customers' cost to switch brands is low. Switching cost in all segments (Cane, forestry, pre-plant and fruit) is low, except in Roundup Ready crops where it is high. Switching cost of residual herbicides is overall very low.

In the case of Roundup Ready crops, this is also the biggest threat. There is only one herbicide registered for use on Roundup Ready crops, Roundup Ready herbicide (L6702) from Monsanto, but due to the growth potential of Roundup Ready crops, unregistered applications are done on a daily basis by generic suppliers to share in this growth. Rivalry among competitors in the glyphosate and off-patented residual market is fierce to strong.

- **Low level of entry barriers**

New entrants to a market bring new capacity and the desire to establish a secure position in the market. A barrier to entry exists whenever it is difficult for a newcomer to break into the market or economic factors put a potential entrant at a disadvantage relative to its competitors (Thompson & Strickland, 2003: 84).

The success of glyphosate has inevitably attracted the attention of generic manufacturers, including Dow AgroSciences, as well as a variety of Indian and Chinese producers. Local formulators purchase raw materials from these Asian suppliers. Due to a strong defense strategy, Monsanto still holds a dominant position in the glyphosate market, accounting for more than 60% of glyphosate sales in 2003.

Although sales of Roundup by Monsanto will benefit from an increase in the planted area of Roundup Ready crops, the company's overall share of the glyphosate market may decline due to price pressure from generic manufacturers. There is currently a selection of more than 50 glyphosate products available in South Africa, varying in quality and normally lower in price than the original Roundup product. These formulations keep increasing due to low level of entry barriers. One can basically buy a so-called sister registration and start formulating without delay at one of the toll formulators which are all running at under capacity.

Generic suppliers have also eroded the prices of the off-patent residual herbicides leading to very low end user prices. Prices have dropped in some cases (eg. acetochlor) by more than 50% in the last two years. Toll formulators are running at under capacity and entry barriers for new entrants are very low.

- **Substitute products**

Roundup Ready technology is a destructive technology. The latter, therefore, qualifies as a substitute threat as it replaces conventional weed control programs that are dependant on the use of residual herbicides like acetochlor.

According to Thompson & Strickland (2003: 87) three factors determine how strong the competitive pressures from substitutes will be:

- The availability of attractively priced substitutes;
- How buyers view the substitutes as being satisfactory in terms of quality, performance, and other relevant attributes; and

- Can buyers switch to substitutes easily?

The lower the price (tangible and intangible) of substitutes, the higher their quality and performance, and the lower the user's switching cost, the more intense the competitive pressure posed by substitute products.

Monsanto is in the unique position that it is developing and introducing an excellent substitute, i.e. Roundup Ready maize, in the conventional weed control market where they are market leaders currently. This dissertation's focus is therefore on Roundup Ready maize as a substitute product and resulting destructive effect on conventional weed control programs, and how to position it to achieve maximum penetration.

- **Buyer bargaining power**

  Buyers create a relatively strong competitive pressure due to the low cost of switching to competing brands or substitutes, and buyers can decide which brand to buy.

- **Supplier-seller relationship**

  There are literally a herd of suppliers of raw materials. This, however, does not pose a strong competitive pressure, as they generally have weak bargaining power.

2.4.5 Driving force

An industry's driving forces are the major underlying causes of changing industry and competitive conditions (Thompson & Strickland, 2003: 93). Although numerous forces are in motion that can create pressures for change, only the three or four most dominating factors (those having the biggest influence on what kind of changes will take place) qualify as driving forces.

The dominating driving force in the South African maize herbicide market is product innovation as presented by the substitute, i.e. Roundup Ready crops, for conventional weed control programs.

Product innovation

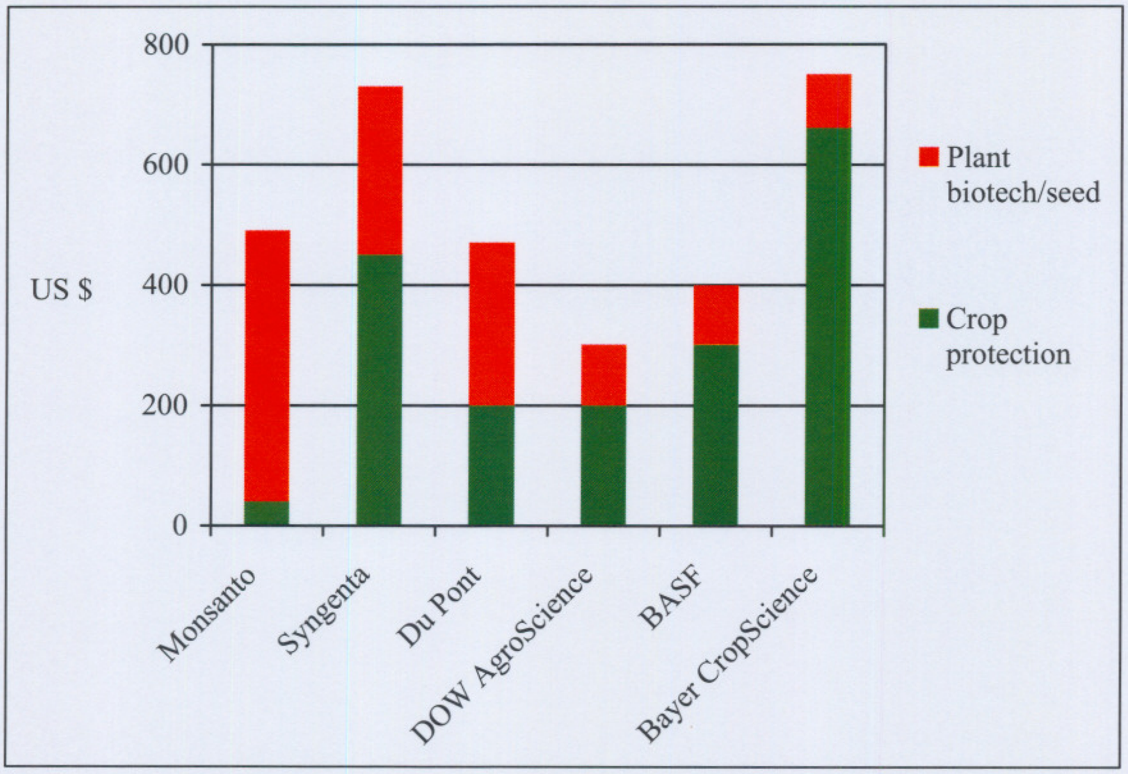
The introduction of herbicide (Roundup Ready) tolerant crops is changing the way weeds are controlled. It has revolutionized weed control. Glyphosate was once a non-selective herbicide for total weed control. A gene has been identified, and integrated in the DNA structure of plants, that produces a new protein that acts as a path around the protein inhibited by the glyphsate (mode of action). This new protein ensures that the plant continues to grow after application of the glyphosate over-the-top. The herbicide, glyphosate, therefore now acts as a selective herbicide in a Roundup Ready crop.

Due to the expansion of the GM maize area, the competitive nature of the agrochemical sector is likely to increase following some recent moves (McDougall, 2004: 1). Syngenta purchased the Advanta seeds operations in cooperation with the investment fund business, Fox Paine. As a result of this purchase, Syngenta's share of the maize and soybean markets in the US is expected to increase to 11% and 10% respectively. At the same time, Syngenta announced the acquisition from Bayer CropScience of the rights to glyphosate tolerance technology, event GA21, for use in maize. Syngenta announced plans to offer the technology through its NK brand hybrids and through licenses with other companies. Syngenta will offer an alternative to the Monsanto trait range in the maize sector. Monsanto is, however, by far the dominant company in the maize traits market.

Whilst these moves indicate a significant increase in the competitive nature of the input traits sector, it is also evident (McDougall, 2004: 3) that the focus of Research and Development attention in the agricultural biotechnology sector has significantly shifted toward the development of GM traits, a sector where the potential commercial return is difficult to calculate, but is likely to dwarf the value of the input traits market.

By far the greatest Research and Development investment in the seeds and biotechnology sector is made by Monsanto (Figure 2.3). Research and Development investment between the crop protection and seeds/biotech areas being out of proportion to the sales achieved in these two areas (McDougall, 2004: 3). In 2003, Monsanto dedicated an estimated $458 million to Research and Development in the seeds/biotech area, equivalent to 27,8% of the sales made in these sectors. Seeds/biotech R&D expenditure by Syngenta and DuPont/Pioneer amounted to $273 million and $270 million respectively, whilst the expenditure by Dow AgroSciences, BASF and Bayer CropScience is estimated in the $80-85 million range. For DuPont/Pioneer, seeds/biotech Research and Development expenditure in 2003 equated to 11,9% of sales, whilst all of the other major companies are currently spending between 23% and 39% of sales on Research and Development in this area. This clearly indicates investment in technologies some way from the market. Of the major crop protection companies, DuPont/Pioneer currently achieves the largest turnover in the seeds/biotech area, however it is evident from the level of Research and Development expenditure made in this area by Monsanto and Syngenta, and the other moves highlighted by these companies above, that both have significant future aspirations in these markets. Whilst the more chemically focused companies are investing in the area, the emphasis is not so great.

Figure 2.3: **Research and Development expenditure in 2003 by multi-national Ag-companies (in millions of $)**



Source: **McDougall (2004: 3)**

2.4.6 Herbicide-tolerant maize in South Africa

The potential positioning of Roundup Ready maize in South Africa could be done along the following benefits:

- Unsurpassed, broad spectrum weed control;
- Simple and cost effective;
- Ease of use;

- Proven crop safety and yield potential;

- Optimum flexibility – wide window of application; orCompatible with conservation tillage, other Roundup Ready crops.A total of 50 000 hectares of Roundup Ready maize will be planted in the 2004/2005 season.

Weed scenarios in maize fields can be broadly categorised (Table 2.6) according to area, weed pressure and weed types. The implication of these differences is that no one single programme is suitable for successful weed control.

Table 2.6: Weed scenarios as found in the three agronomic maize growing regions

Irrigated	Dry land East	Dry land West
Cyperus esculentus, early germinating grasses and/or broadleaf weeds	*Cyperus esculentus*, early germinating grasses and/or broadleaf weeds	Early *Cyperus esculentus*, germinating grasses and broadleaf weeds
Medium to low *Cyperus esculentus*, medium to low grass and broadleaf pressure throughout the season	Medium to low *Cyperus esculentus*, medium to low grass and broadleaf pressure throughout the season	Mechanical weeding for early germinating grasses and broadleaf weeds. No late germinating weeds
Medium to low *Cyperus esculentus*, grass and broadleaf pressure throughout the season, and also late germinating grasses and/or broadleaves	Medium to low *Cyperus esculentus*, grass and broadleaf pressure throughout the season, and also late germinating grasses and/or broadleaves	Late germinating weeds, esp. grasses and some key broadleaf weeds

Weed control programs, with Roundup Ready technology, are presented in Table 2.7. This will result in optimum weed control. Although Roundup Ready technology is an excellent weed control addition, trials have shown that residual herbicides (eg.

acetochlor) are needed for optimum weed control in several of the scenarios as described in Table 2.6.

Table 2.7: Weed control programs for scenarios given in Table 2.6

Irrigated	Dry land East	Dry land West
Lowest registered rate of Guardian S®, followed by 2.5 lt Roundup Ready before weeds reach 10 cm. A 2^{nd} application of Roundup Ready may be required.	Full rate of Bullet® band-applied at planting, followed by Roundup Ready before weeds reach 10 cm.	2.5 lt Roundup Ready before weeds reach 10cm, followed up again with 2^{nd} 2.5lt if required.
2.5 lt Roundup Ready before weeds reach 10cm, followed up again with 2^{nd} 2.5lt if required.	Lowest registered rate of Bullet® broadcast-applied at planting, followed by Roundup Ready before weeds reach 10 cm. Follow up with 2^{nd} application if required.	Atrazine band-applied at planting, followed by Roundup Ready before weeds reach 10 cm. Follow up with 2^{nd} application if required.
2.5 lt Roundup Ready before weeds reach 10cm, followed up again with 2^{nd} 2.5lt in combination with Harness®.	2.5 lt Roundup Ready before weeds reach 10cm, followed up again with 2^{nd} 2.5lt in combination with Harness®.	2.5 lt Roundup Ready before weeds reach 10cm, followed up again with 2^{nd} 2.5lt in combination with Harness®.

2.5 SUMMARY

The latest development to result in further expansion of glyphosate, and probably the most significant is the introduction of Roundup Ready crops, genetically manipulated to tolerate the herbicide, allowing the use of this non-selective herbicide in over-the-top applications while the crop is growing. Roundup Ready maize will become a substitute for conventional weed control programs.

The success of the substitution will depend largely on the positioning strategy along the perceived benefits from current users and future users of this technology. The influence of Roundup Ready maize on the South African maize herbicide market will consequently be determined by the rate of adoption (penetration) of this technology.

The empirical study was undertaken and the results are presented in Chapter 3.

CHAPTER 3

RESEARCH METHODOLOGY AND RESULTS

3.1 INTRODUCTION

In this chapter the research methodology is described and results are presented.

3.2 RESEARCH METHODOLOGY

3.2.1 Purpose

The four-fold purpose of this study (as outlined in the survey instrument, Appendix A) were to:

- evaluate the influence of Roundup Ready maize on the South African maize herbicide market;
- determine which benefit, contributed by Roundup Ready maize, is ranked to be the most and to be least important, as perceived by maize growers;
- propose strategies to maximize Roundup Ready maize adoption amongst maize growers; and to
- propose strategies for the sustainable marketing of conventional herbicide programs in conjunction with Roundup Ready maize programs.

3.2.2 Sample

The population consisted of a list of 1500 names that has been submitted to Objectivity PTY (Ltd) from which respondents were randomly selected. The growers have been selected to represent the three maize growing areas of South Africa, namely dry land

West, dry land East and irrigation (Table 3.1). The total surveyed hectares of 198 415 ha represent 7% of the total 2003/2004 planted maize hectares.

The sample consists of 260 South African maize growers. These growers were screened before the commencement of the telephonic interview to exclude those growers that plant less than 300 ha dry land maize or less than 50 ha irrigated maize as well as those who are not responsible for decision making on the farming unit (those in supporting roles). Objectivity PTY (Ltd), a Johannesburg based company specializing in gathering data, conducted the interviews.

Table 3.1: **Number of respondents per maize growing area**

Classification	Number of respondents	Hectares captured ('000)
Dry land West	123	105.1
Dry land East	107	79.1
Irrigation	30	14.2

Source: **Objectivity (2004)**

Roundup Ready maize has been planted on a small scale in the 2003/04 planting season already and most of the so-called experimenters were interviewed (Table 3.2).

Table 3.2: **Number of respondents**

Classification	Number of respondents
Roundup Ready growers	43
Non-Roundup Ready growers	217
Yieldgard growers	66
Non-Yieldgard growers	194

Yieldgard maize has been planted from the 1999/2000 planting season already and were included in this study, as combination or stacked hybrids (Yieldgard and Roundup

Ready) will be commercialized in the near future (Table 3.2).

3.2.3 Time line

Interviewing started on the 22nd of July 2004 and continued for three weeks. This period was chosen as harvesting of the current maize crop ended mid-July and respondents could be interviewed without bothering them.

3.3 RESULTS

Combined and dissected results (per grower type) are presented.

3.3.1 Demographics (Question 13)

All respondents were male and distributed in age from 20 to 60+ (Figure 3.1) with a wide range of educational backgrounds (Figure 3.2). The majority of the respondents were in the age group 31-50 years. Commercial farms are managed as family businesses with father and son teams and the successor of the age group 51+ is most likely already part of the business, but generally not yet in a deciding capacity.

Figure 3.1: **Respondents' age distribution**

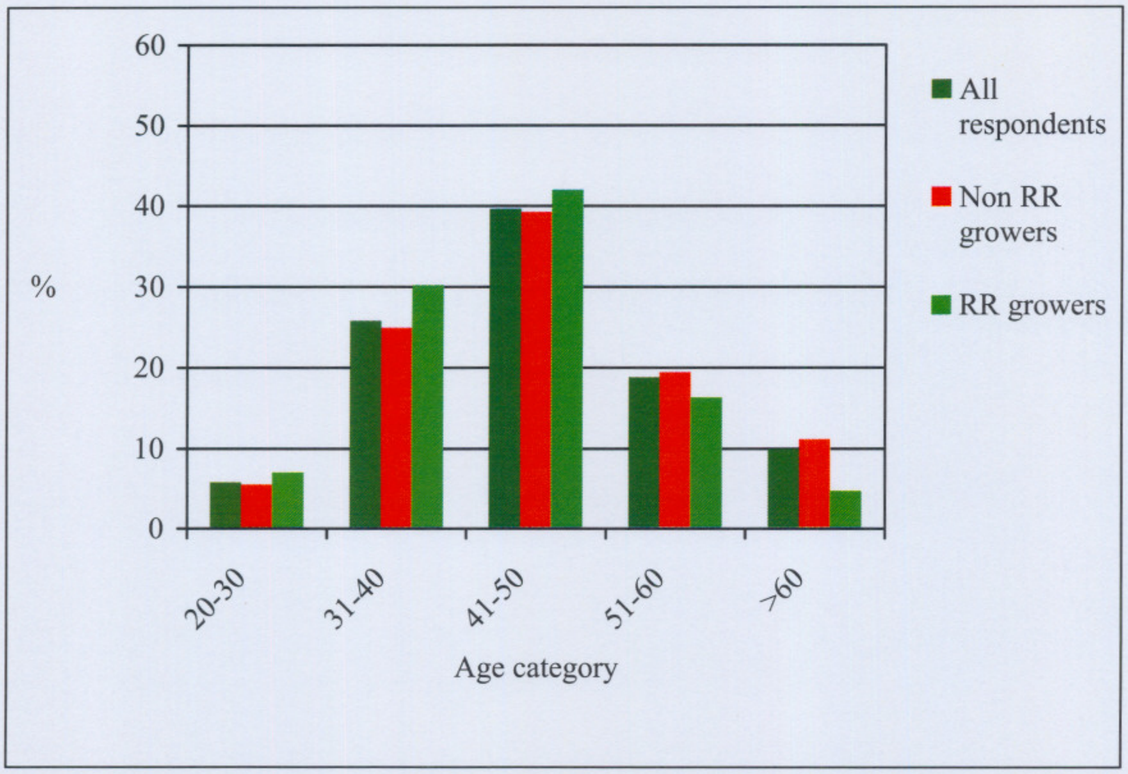
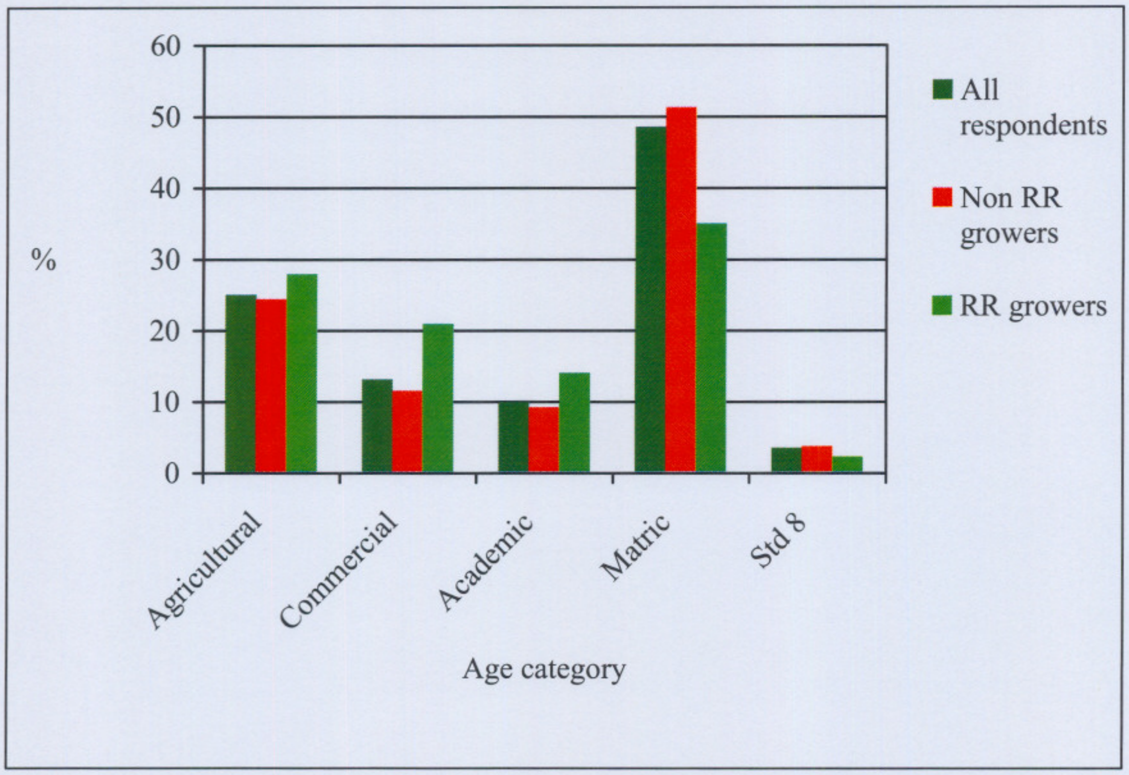


Figure 3.2: **Respondents' educational distribution**

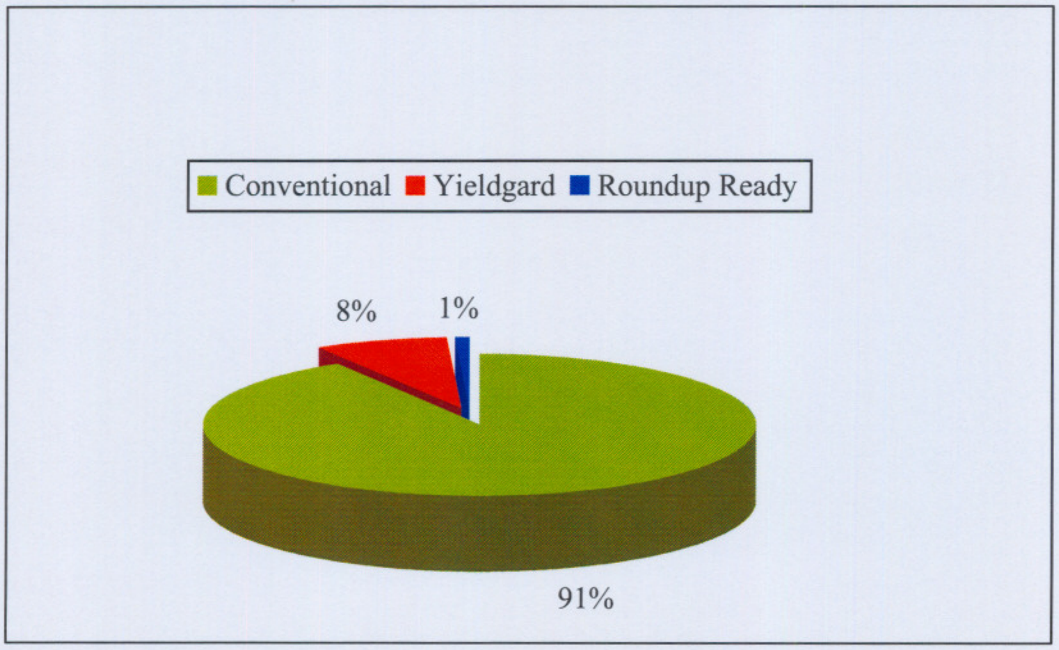


A total of 125 farmers (48% of all respondents) completed tertiary qualifications (diploma or degree). More Roundup Ready growers (63%) than non-Roundup Ready growers (45%) have tertiary qualifications (Figure 3.2). The obvious first choice is a diploma or degree in agricultural science.

3.3.2 Maize planted (Question 1)

How many hectares of conventional, Yieldgard and Roundup Ready maize did you plant in 2003/2004?

<u>Figure 3.3</u>: Percentage planted to conventional, Yieldgard and Roundup Ready maize



The majority of respondents' (Figure 3.3) maize hectares were planted to conventional maize, followed by Yieldgard and Roundup Ready maize. Since Yieldgard maize has been introduced, the demand could not be satisfied. Roundup Ready maize was introduced in 2003/2004 season in very small quantities. Table 3.3 gives detailed data in hectares.

Table 3.3: **Respondent hectare split**

Type	Dry land East	Dry land West	Irrigation	Total
Conventional	72 812	96 228	12 504	181 544
Yieldgard	5 896	8 069	1 417	15 382
Roundup Ready	400	803	286	1489
Total	79 108	105 100	14 207	198 415

3.3.3 Maize planting rates (Question 2)

What was your planting rate per hectare for conventional, Yieldgard and Roundup Ready maize 2003/2004?

Table 3.4: **Average planting rates (kernels/ha)**

Type	Dry land East	Dry land West	Irrigation
Conventional	25 000	19 000	63 000
Yieldgard	28 000	20 000	64 000
Roundup Ready	28 000	18 500	63 000

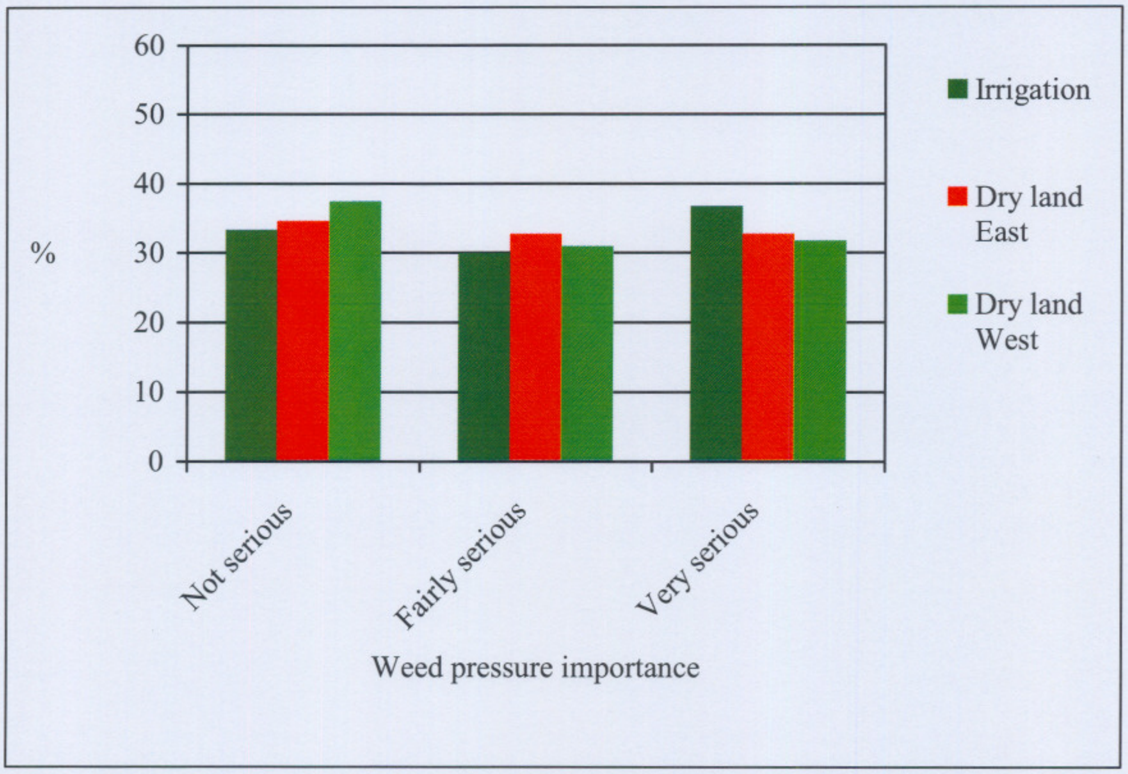
Growers, on average, roughly plant the same number of plants per hectare for conventional, Yieldgard and Roundup Ready maize (Table 3.4). This is especially important since the, technology fee, is paid per one thousand of kernels. The technology fee per hectare, therefore, increases as the planting rate increase.

3.4 WEED CONTROL

3.4.1 Weed infestation (Question 9)

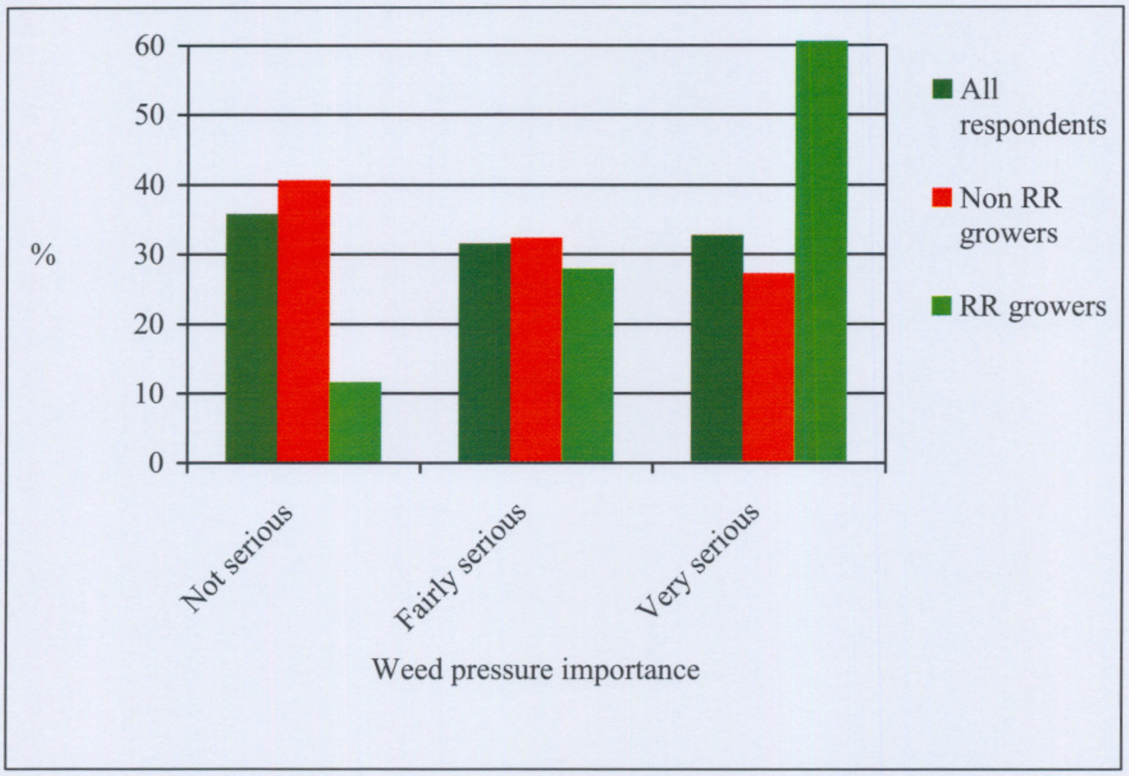
How important are weed infestations in determining maize yield on your farm?

Figure 3.4: **Importance of weed infestation on maize yield per area**



Less than 40% of the growers believe that their current on-farm weed infestation does not have a serious influence on their annual maize yield (Figure 3.4). More than 60% of the respondents (all areas) believe that their maize yields are reduced due to high weed pressures.

Figure 3.5: **Importance of weed infestation on maize yield of Roundup Ready growers and non-Roundup Ready growers**



First-time Roundup Ready users (2003/2004 season) believe that weed infestation has a definite negative effect on their maize yield (Figure 3.5).

3.4.2 Tillage methods (Question 3)

What method of tillage do you employ before planting maize?

More Roundup Ready growers than non-Roundup Ready growers have moved to reduced tillage (Figure 3.6). Roundup Ready technology is an excellent tool to manage reduced tillage scenarios where weed infestation normally increased due to reduced mechanical weed control operations.

Figure 3.6: Method of tillage

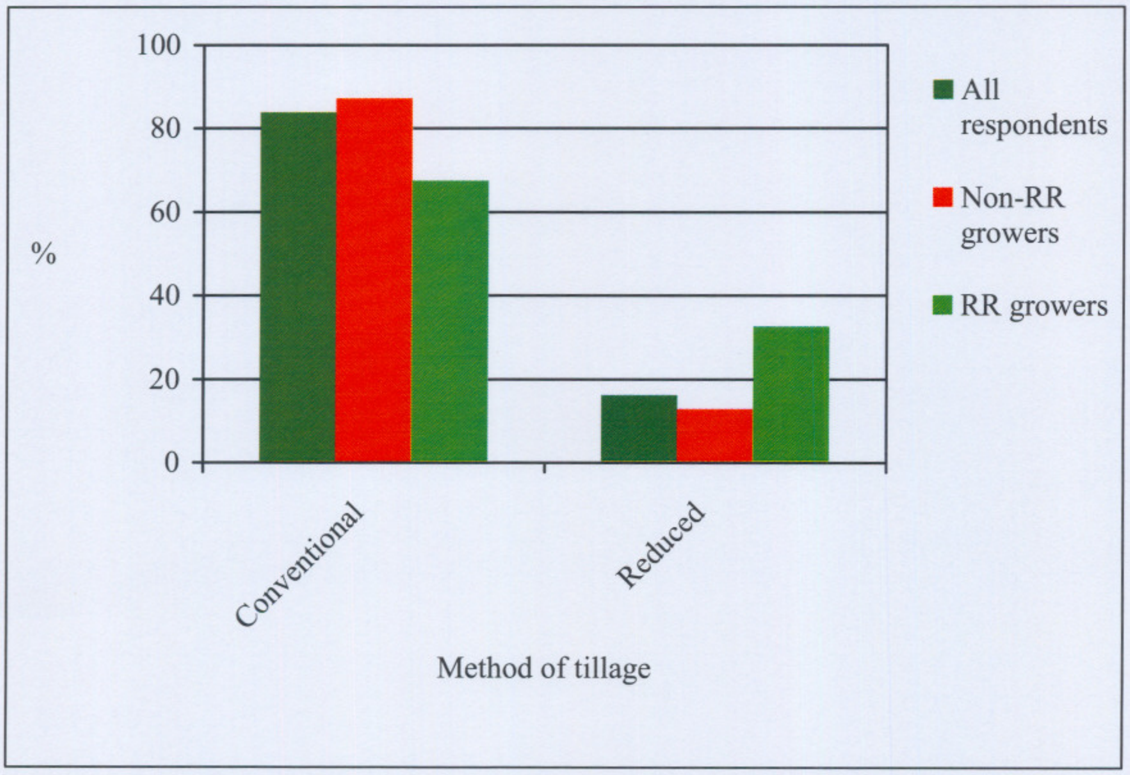
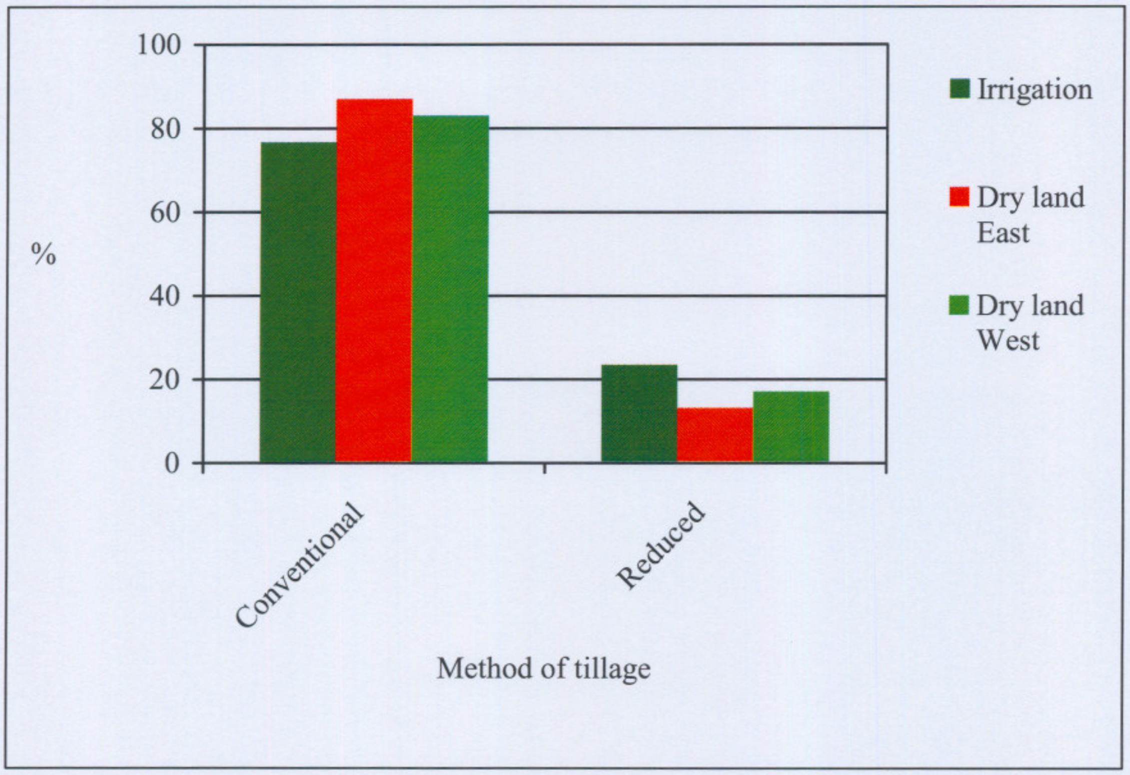


Figure 3.7: **Tillage practices for dry land East, dry land West and irrigation**

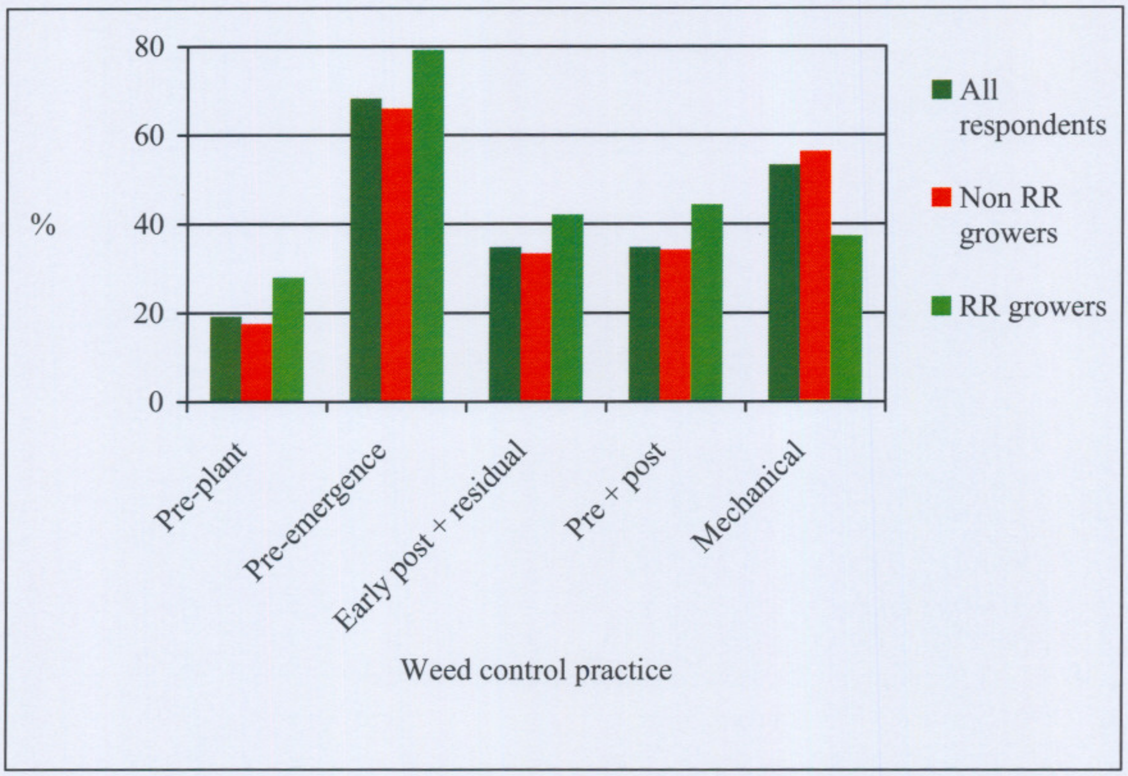


Slightly more dry land West growers have moved to reduced tillage than dry land East growers (Figure 3.7). Dry land West growers' aim is to conserve soil moisture.

3.4.3 Weed control practices (Question 4)

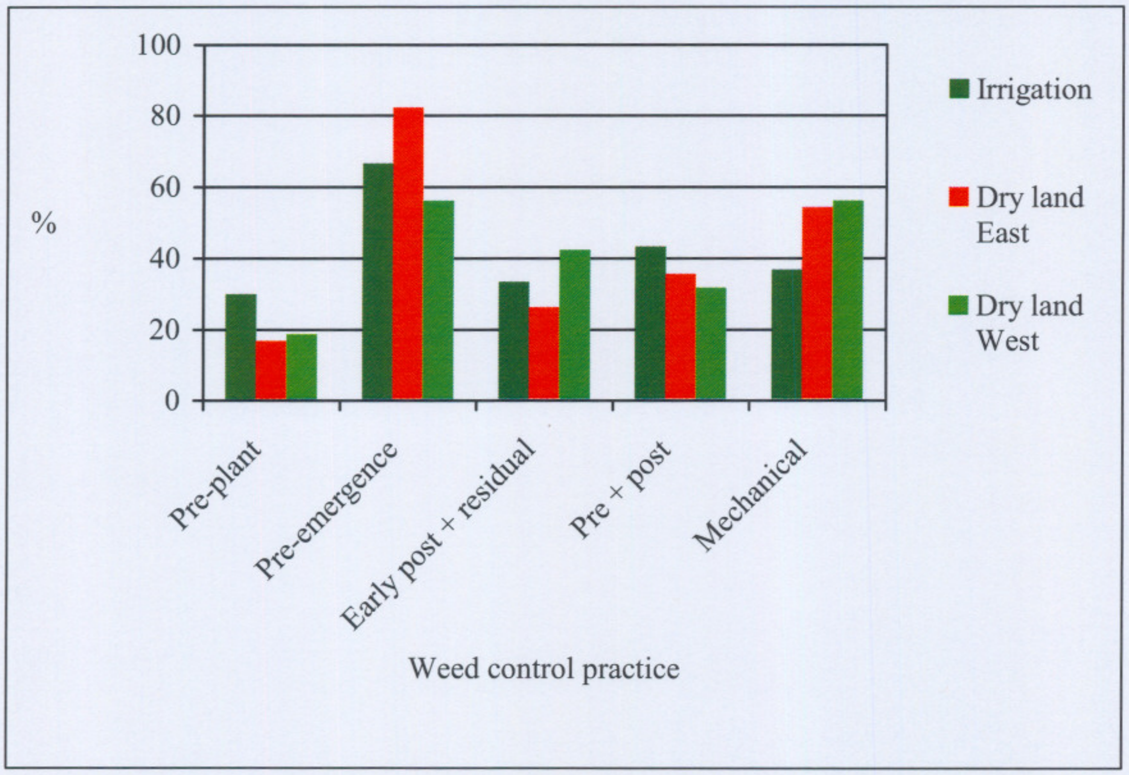
What weed control practices do you employ?

Figure 3.8: Weed control practices



Growers generally employ more than one method of weed control (Figure 3.8). Pre-plant weed control, i.e. pre-plant spraying, is still on the increase and is ideally to reduce mechanical operations. The majority of growers control weeds with a herbicide application at planting (177 respondents) followed by mechanical cultivations (138 respondents) during the growth cycle of the maize crop. A Roundup Ready programme will typically consist of a pre-emergence herbicide (like acetochlor) plus a post-emergence (Roundup Ready) application or a post-emergence (Roundup Ready) plus a residual herbicide-like acetochlor.

Figure 3.9: **Weed control practices for dry land East, dry land West and irrigation**

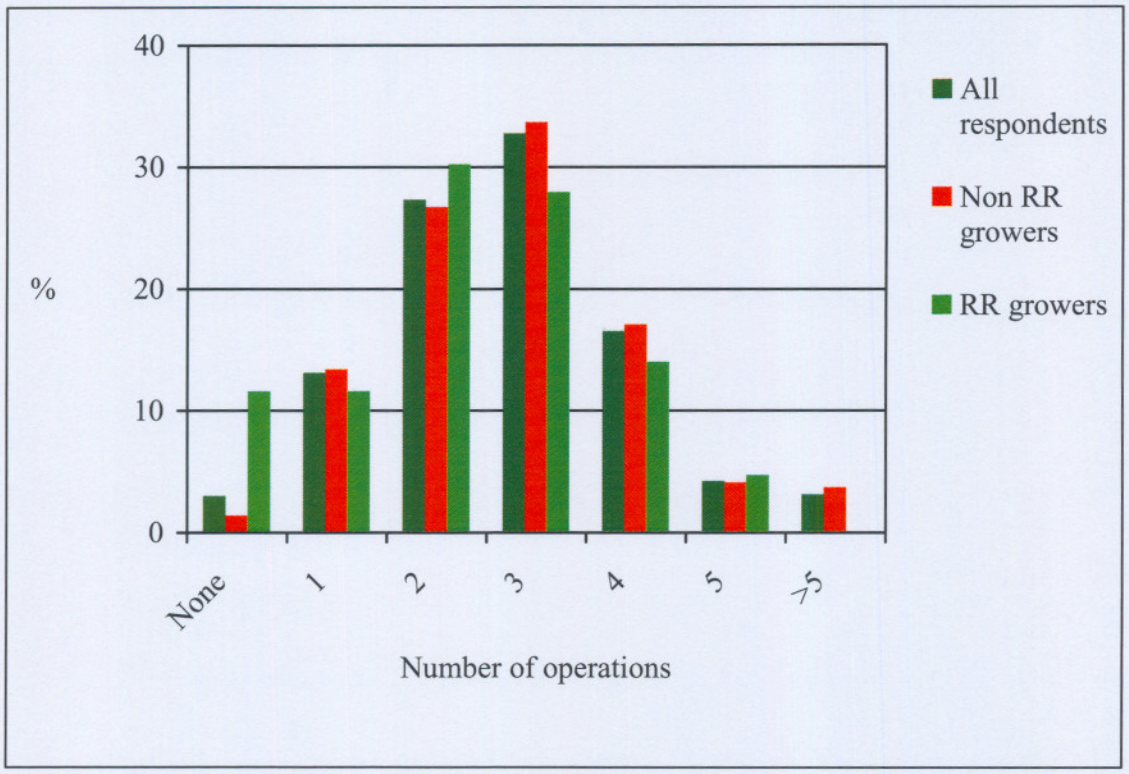


Growers in the dry land East and West areas prefer mechanical and pre-emergence weed control programs (Figure 3.9). Irrigation farmers prefer a combination of pre- and post- emergence herbicides.

3.4.4 Weed control practices (Question 4)

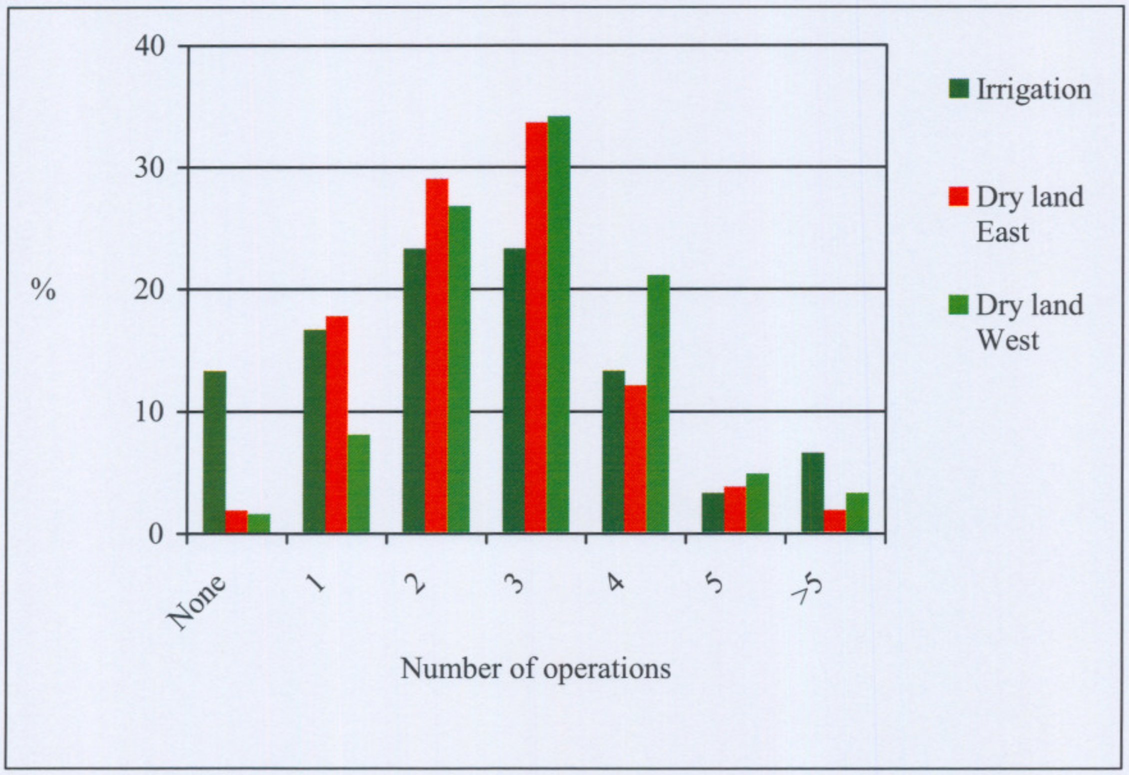
How many mechanical weed control actions do you employ from seedbed preparation up to harvesting?

Figure 3.10: Mechanical weed control operations



A total of 76% of all respondents employ three or less mechanical weed control operations (Figure 3.10). Roundup Ready growers have already moved to a lower number of mechanical operations. A total of 85% of these Roundup Ready growers employ three or less operations while 74% of the non-Roundup Ready growers employ three or less.

Figure 3.11: Mechanical weed control practices for dry land East, dry land West and irrigation

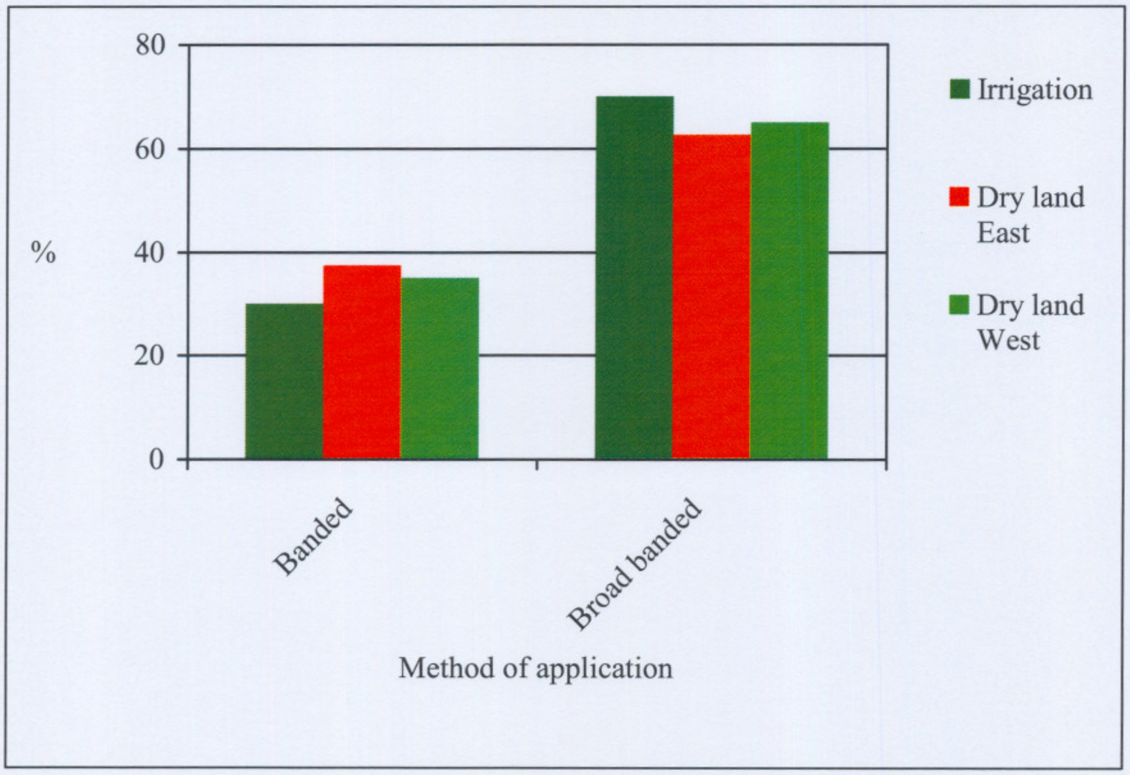


Growers in the dry land West area are more dependant on mechanical weed control operations mainly due to wider row widths (up to 2,4 m) and late germinating weeds (Figure 3.11). Narrow row widths in the dry land East and irrigation areas make mechanical operations at a later growth stage impossible.

3.4.5 Weed control practices (Question 4)

How do you apply herbicides?

Figure 3.12: Herbicide method of application for dry land East, dry land West and irrigation

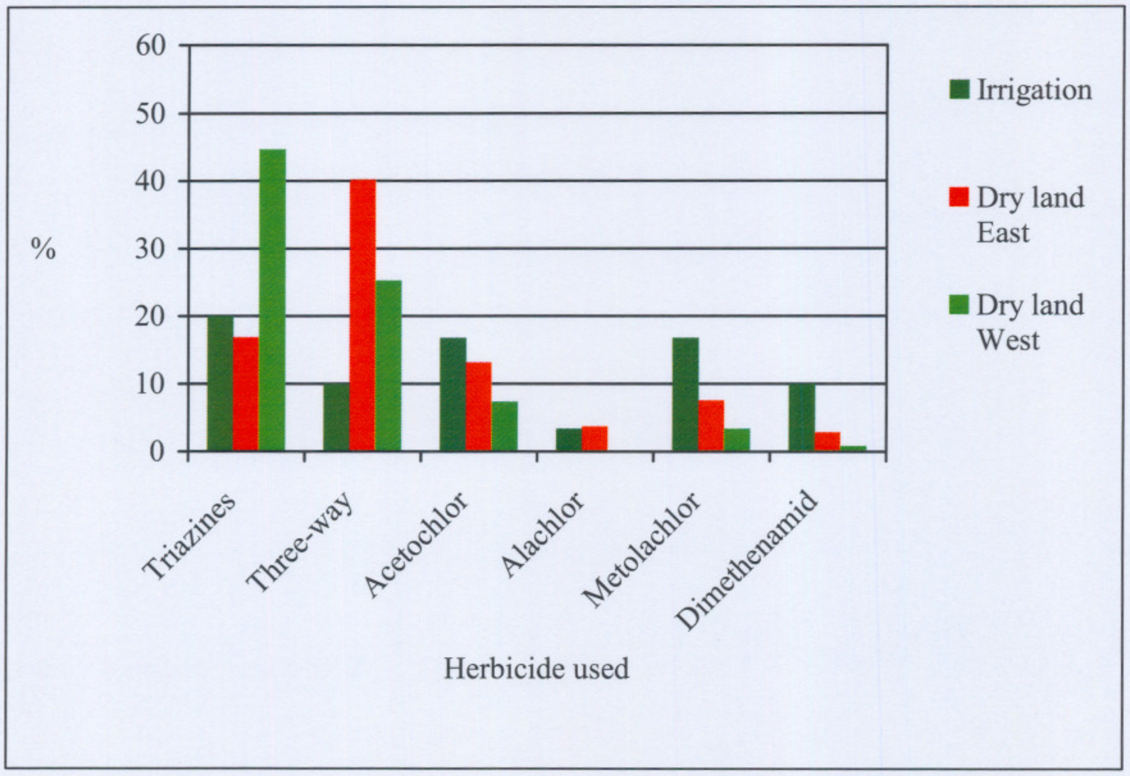


Less than 40% of all growers apply herbicides only on the planting row (Figure 3.12). The other 60% apply the herbicide on the total soil surface. Roundup Ready herbicide and other post-emergence herbicides are applied broad banded. Pre-emergence herbicides can either be applied banded or broad banded.

3.4.6 Herbicides used (Question 5)

What herbicides have you used in 2003/2004?

Figure 3.13: Herbicides used in 2003/2004

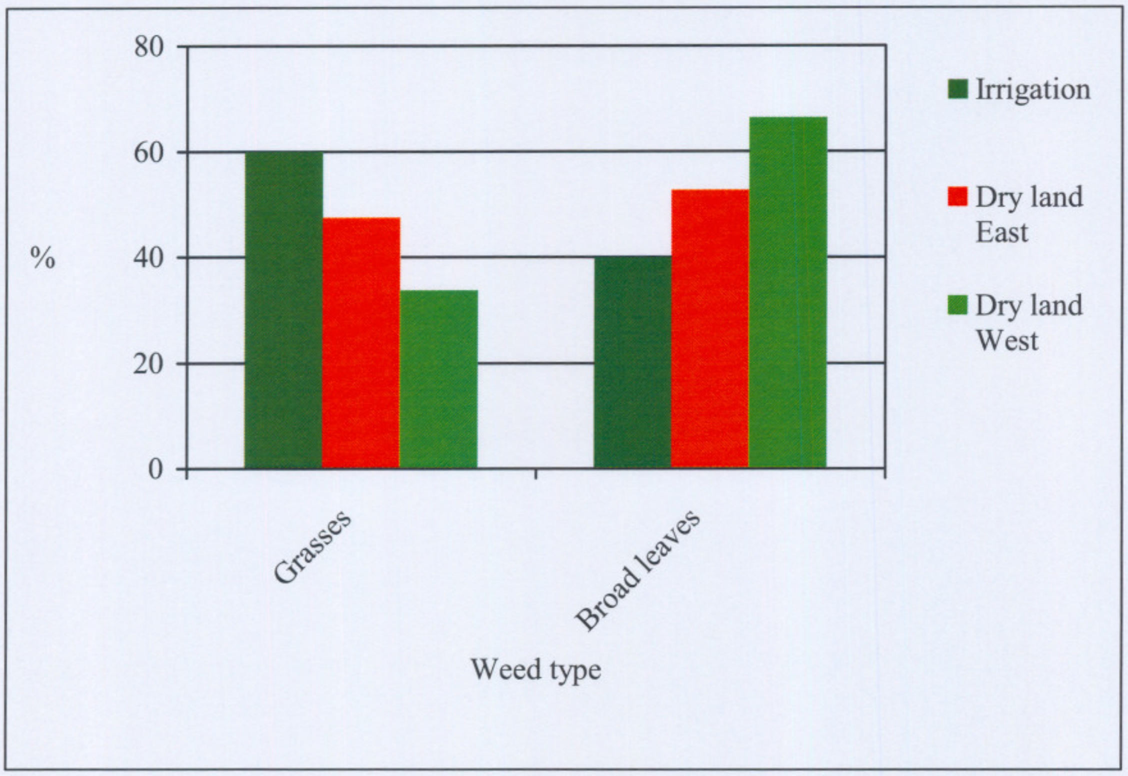


More than 80% of the growers in the dry land West area use triazine or triazine-containing herbicides (Figure 3.13) while less than 65% of the dry land East growers use these herbicides. This reflects the weed type, namely broad leave weeds (Figure 3.14), that was rated the predominant type in the dry land West area. Growers from the irrigation area prefer to use far less of these two groups of herbicides.

3.4.6 Weed type (Question 5)

Which weed type did you plan to control with the mentioned herbicide?

<u>Figure 3.14</u>: Target weed type

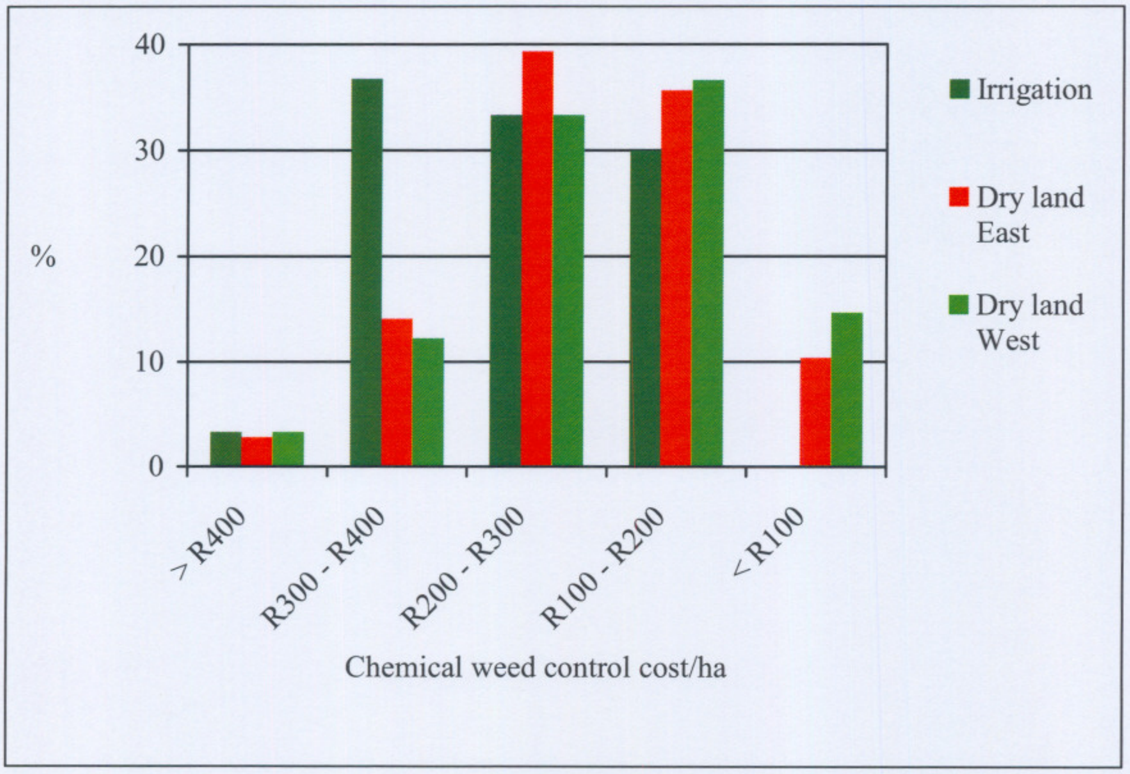


The dry land West area is dominated by broad leave weeds (Figure 3.14) and therefore requires specific herbicides as represented in Figure 3.12. More than 80% of the growers in the dry land West area use triazine-containing herbicides. Growers in the irrigation area have less problems with broad leave weeds and need to adhere to crop rotation criteria and therefore uses much less of these herbicides.

3.4.6 Weed control costs (Question 9)

What do your chemical weed control cost per hectare?

<u>Figure 3.15</u>: Chemical weed control costs per hectare

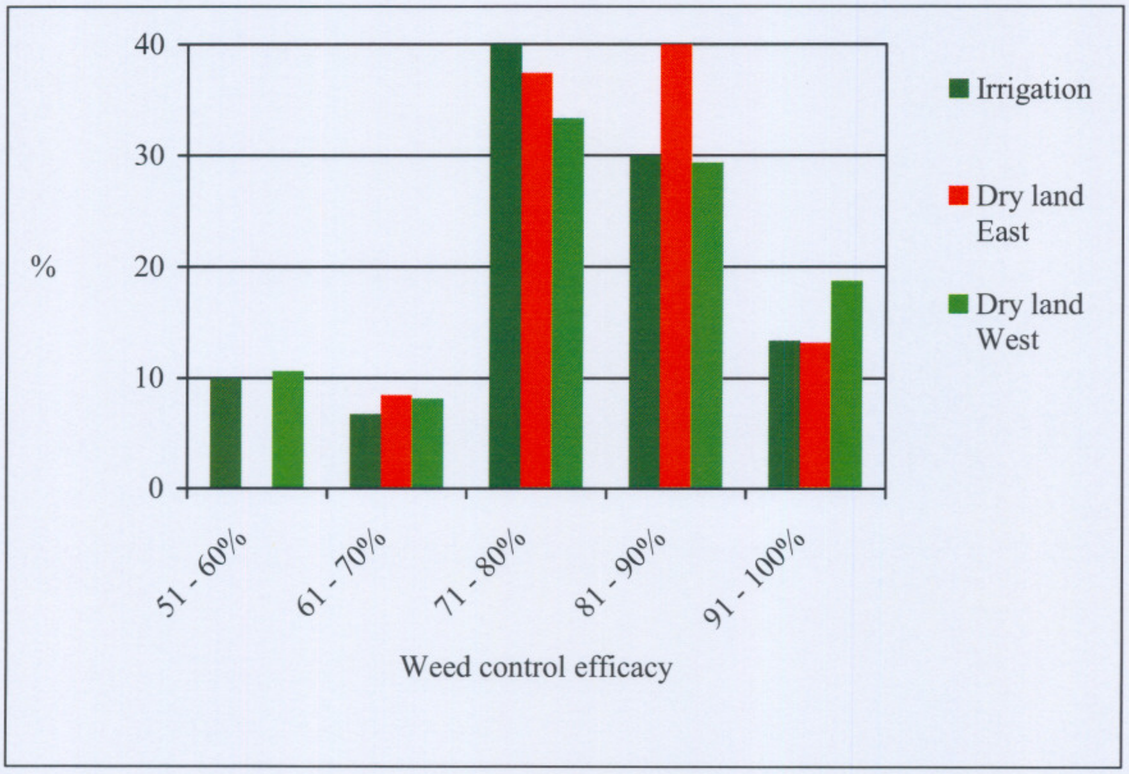


Growers in the dry land West area have lower chemical weed control costs per hectare (Figure 3.15) than the other two areas. A total of 53% of these growers spend less than R200/ha, while only 30% of growers in the irrigation area and 44% of growers in the dry land East area spend less than R200/ha. The majority of the irrigation growers have high weed control costs due to high use of more expensive herbicides (pre- and post-emergence) and difficulty to control grass weeds.

3.4.9 Weed control efficacy (Question 9)

How effective do you believe your weed control programme to be?

Figure 3.16: Weed control efficacy



Growers from the irrigation area believe that the efficacy of their weed control programs is less than the dry land West and East growers (Figure 3.16). This is due to the difficulty to control grass weeds and low mechanical cultivation frequency. An astonishing high percentage of growers achieve less than commercially acceptable control (< 90% efficacy).

3.4.10 Residual herbicide use (Question 11)

Do you think that the use of residual herbicides will decrease with the introduction of Roundup Ready maize? What percentage?

Table 3.5: Change in residual herbicide use

Classification	Number of respondents	Percentage decrease
Roundup Ready growers	18	44,6%
Non-Roundup Ready growers	56	35,3%
Combined	74	37,6%

A total of 74 respondents believe that the introduction of Roundup Ready maize will lead to a decrease in the quantity of residual herbicide use (Table 3.5). Roundup Ready growers have experienced this already and estimate a bigger reduction (44,6%) than non-Roundup Ready growers.

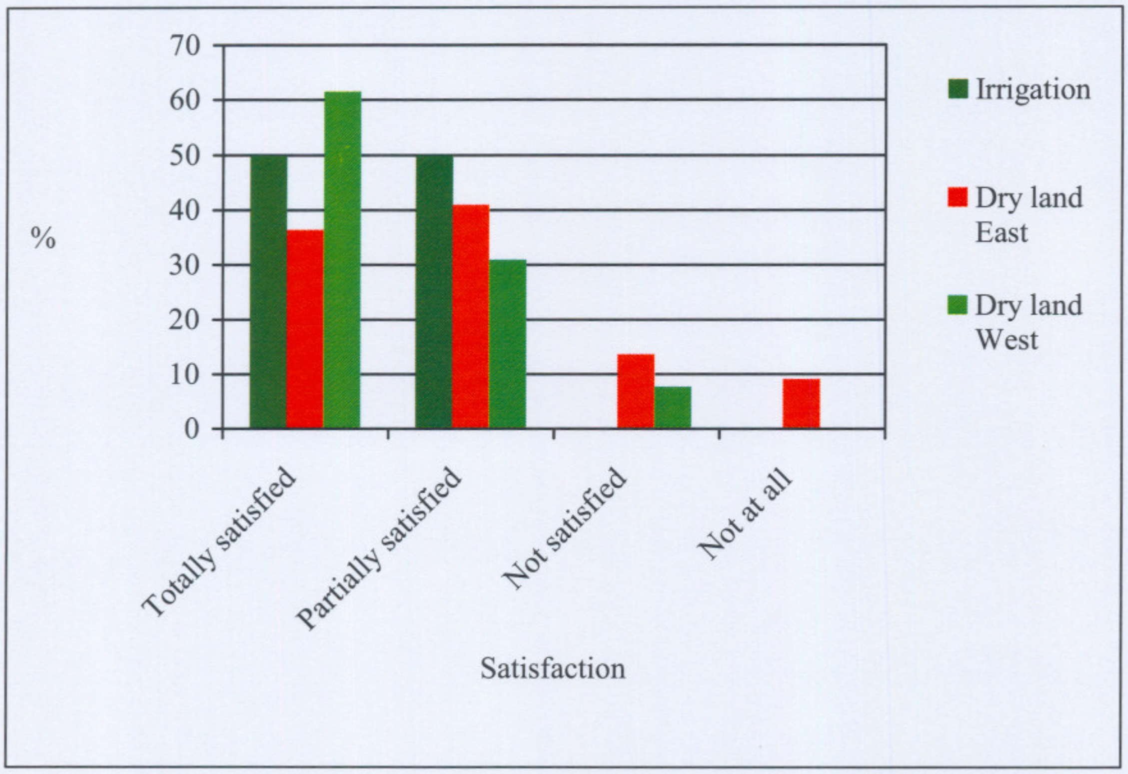
3.5 ROUNDUP READY MAIZE

3.5.1 Roundup Ready maize satisfaction (Question 10)

In Q1.2 you said you planted Roundup Ready maize. How satisfied were you with the Roundup Ready technology?

Overall satisfaction was very good (Figure 3.17) and 95% of the growers planting Roundup Ready maize in 2003/2004 will do so in 2004/2005.

<u>Figure 3.17</u>: Satisfaction of Roundup Ready growers



Two growers (Dry land East area) indicated that they were not at all satisfied with the performance of the Roundup Ready programme and will not continue to use it. According to the first grower, yield was not comparable to the available conventional hybrids. The second grower felt that the Roundup Ready programme is not cost efficient. Four growers indicated that they are not totally satisfied, but will continue to plant Roundup Ready maize. They had problems with weed control efficacy, compatibility with current weed control operations, yield and cost effectiveness of the Roundup Ready programme.

Above you said that you were totally/partially satisfied with Roundup Ready maize. List reasons for satisfaction?

Table 3.6: Reasons for satisfaction with Roundup Ready maize

	1st reason	2nd reason
Broad spectrum	50,0%	8,3%
Yield	14,7%	8,3%
Control difficult weeds	11,8%	16,7%
Cost effective	11,8%	16,7%
Flexibility	8,8%	41,7%
Management ease	2,9%	8,3%

The biggest benefit to Roundup Ready growers is the broad spectrum of weed control achieved with this technology (Table 3.6). Both grasses and broad leave weeds are controlled by the Roundup Ready herbicide.

3.5.2 Future use, all respondents (Question 10)

Will you plant Roundup Ready maize in 2004/2005? List why?

A total of 97 respondents (38% of all respondents) indicated that they will plant Roundup Ready maize in 2004/2005. Reasons are presented in Table 3.7.

<u>Table 3.7</u>: Reasons for future planting of Roundup Ready maize in 2004/2005

	1st reason	2nd reason
Broad spectrum	40,0%	5,0%
Control difficult weeds	30,0%	5,0%
Flexibility	10,0%	15,0%
Yield	8,0%	50,0%
Cost effective	8,0%	5,0%
Management ease	4,0%	20,0%

The primary and most important use criteria will be the broad spectrum of weed control (Table 3.7). Control of difficult weeds and flexibility are the second and third most important reasons for future planting of Roundup Ready maize.

Why don't you want to plant Roundup Ready maize in 2004/2005? List why?

A total of 146 respondents (56% of all respondents) indicated that they will not plant Roundup Ready maize in 2004/2005. Reasons are presented in Table 3.8. There are only two real reasons listed for not planting Roundup Ready maize, namely low weed pressure (18,5%) and no benefit (3,4%). New technology will be rejected due to higher price and will be less available initially. A high 34,9% of the respondents are not aware of this technology.

Table 3.8: Reasons for not planting Roundup Ready maize in 2004/2005

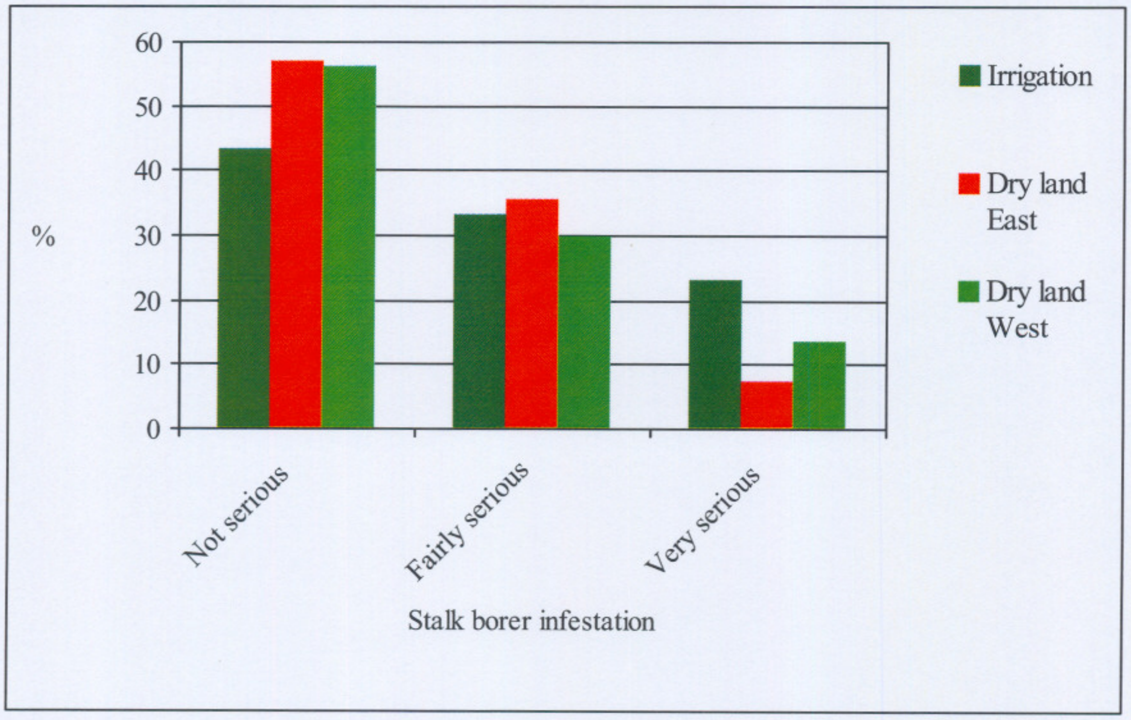
	1st reason
Unknown technology	34,9%
Price	30,1%
Low weed pressure	18,5%
Availability	10,3%
No benefit	3,4%
Buyer resistance	2,7%

3.6 YIELDGARD MAIZE

3.6.1 Stalk borer infestation (Question 6)

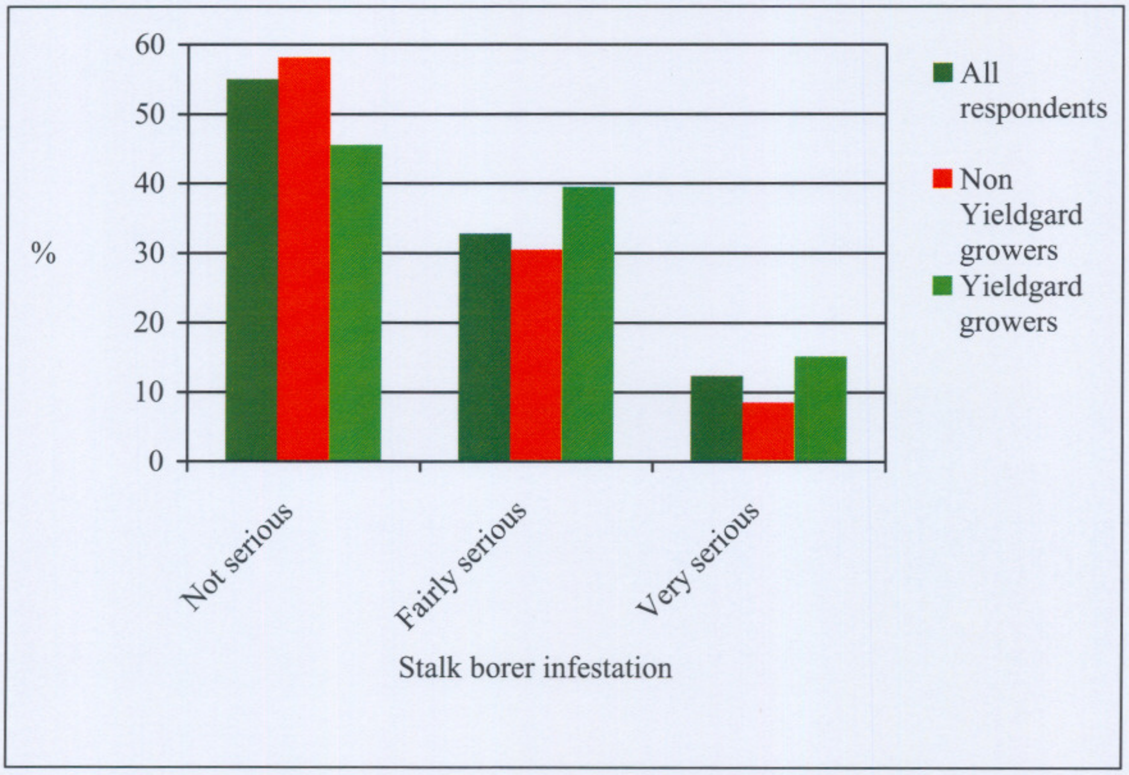
How would you describe your stalk borer infestation?

Figure 3.18: Stalk borer infestation per area



Less than 60% of dry land East and West growers believe that their stalk borer infestation is not serious (Figure 3.18). Only 43% of the irrigation area growers believe that their infestation is not serious.

Figure 3.19: Stalk borer infestation per user and non-user



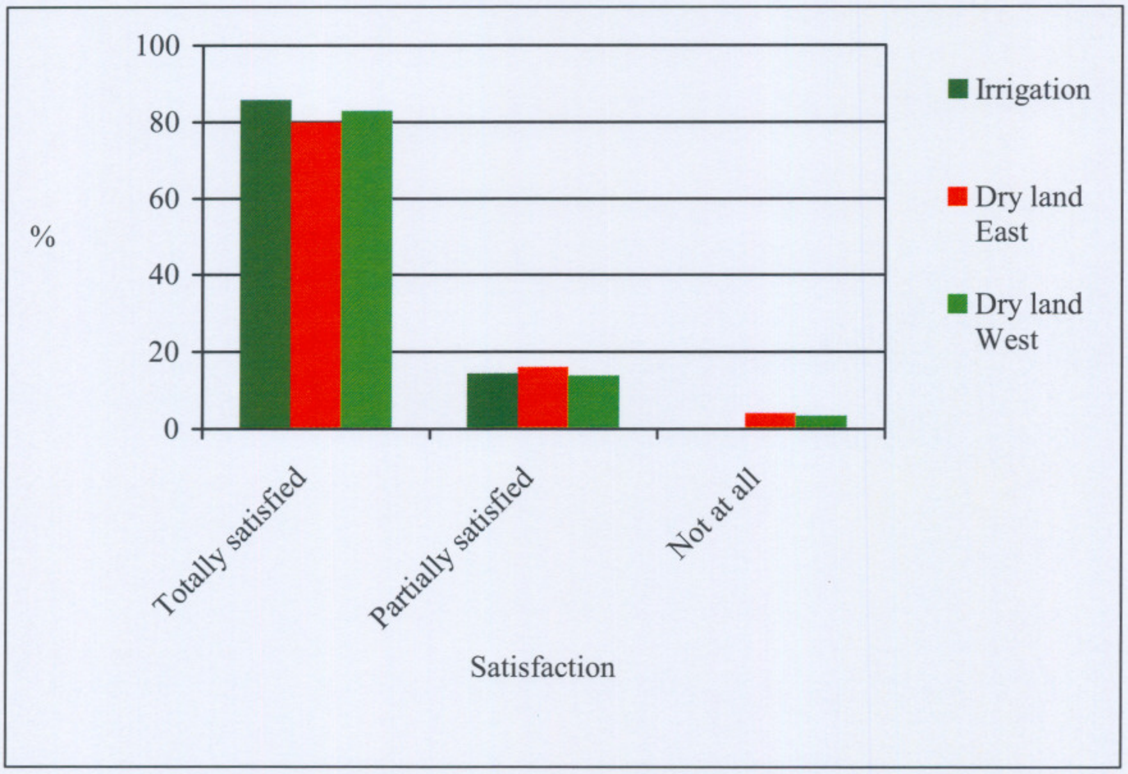
Current Yieldgard users (Figure 3.19) believe that their stalk borer infestation is fairly to very serious (53,7%) whereas less non-users (41,5%) believe this.

3.6.2 Yieldgard satisfaction (Question 6)

In Q1.3 you said you planted Yieldgard maize. How satisfied were you with the Yieldgard technology?

Overall satisfaction was very good (Figure 3.20). More than 80% of respondents from all three areas are totally satisfied.

Figure 3.20: Satisfaction of Yieldgard growers



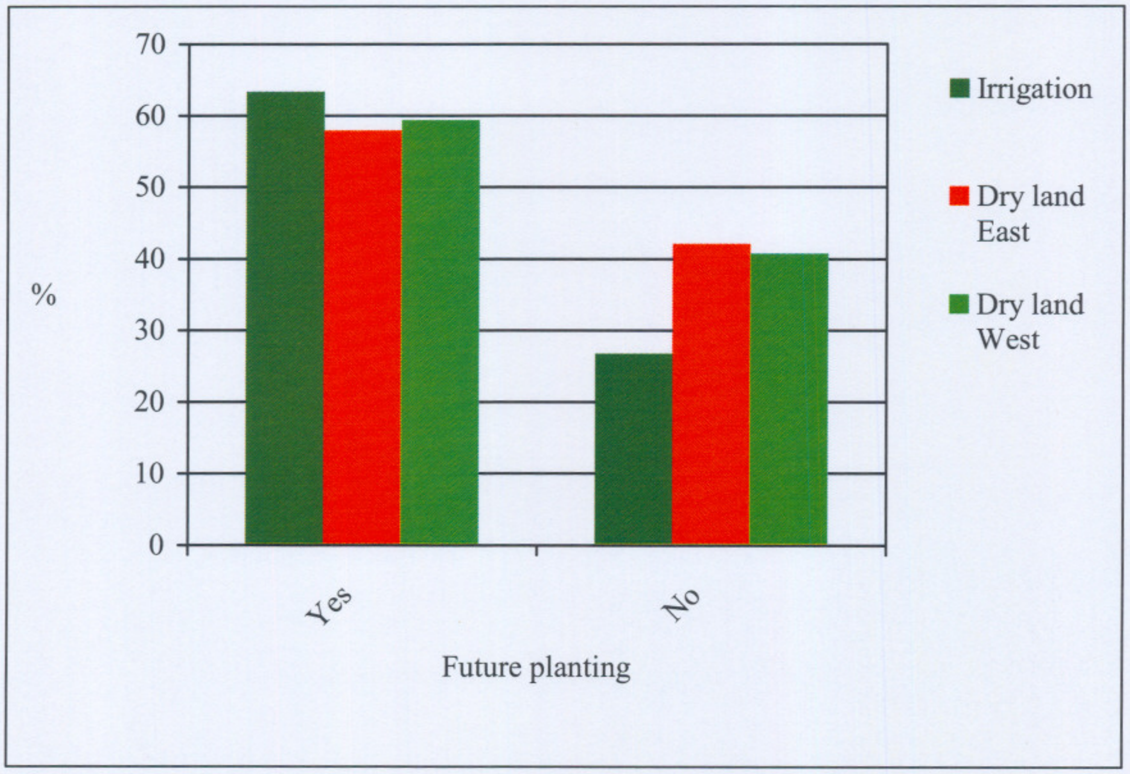
Two growers (Dry land East and West area) indicated that they were not at all satisfied with the performance of the Yieldgard technology and will not continue to use it. According to both growers efficacy was not comparable to the available conventional control methods.

3.6.3 Future use, all respondents (Question 8)

Will you plant Yieldgard maize in the 2004/2005 season?

More than 60% of the respondents from the irrigation area plan to plant Yieldgard maize in 2004/2005 (Figure 3.21). These growers believe that their stalk borer infestation is more serious than both of the other areas.

<u>Figure 3.21</u>: Future planting of Yieldgard maize in the 2004/2005 season



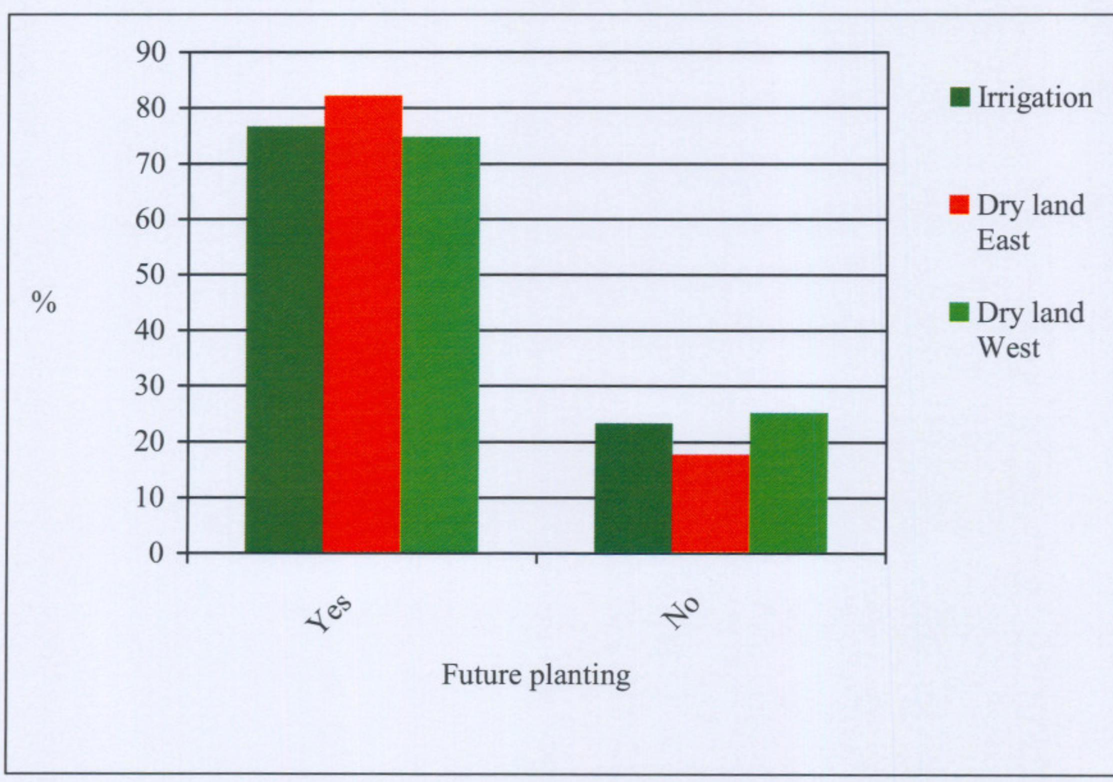
3.7 COMBINATION HYBRIDS

3.7.1 Future use, all respondents (Question 12)

Will you plant Yieldgard/Roundup Ready maize when commercialized?

More than 75% of the respondents from all areas will plant Yieldgard/Roundup Ready stacked maize hybrid when commercialized (Figure 3.22). This is more than the percentage (60%) for the single Yieldgard trait as given in Figure 3.21 and also more than the percentage (38%) for Roundup Ready trait. There is, therefor, a huge need from growers to have both traits in one hybrid (product).

<u>Figure 3.22</u>: Future planting of Yieldgard maize in the 2004/2005 season



3.7.2 Importance factors (Question 12)

What factors would determine how many hectares you would plant of the combination hybrid?

Table 3.9: Importance factors for combination hybrid

	Irrigation	Dry land East	Dry land West
Price	63,3%	58,9%	39,8%
Yield potential	10,0%	12,1%	16,3%
Efficacy	3,3%	6,5%	5,7%
Weed pressure	3,3%	4,7%	8,9%
Planting date	0%	3,7%	4,9%
Availability	0%	1,9%	2,4%
Nil	6,6%	12,1%	22,0%

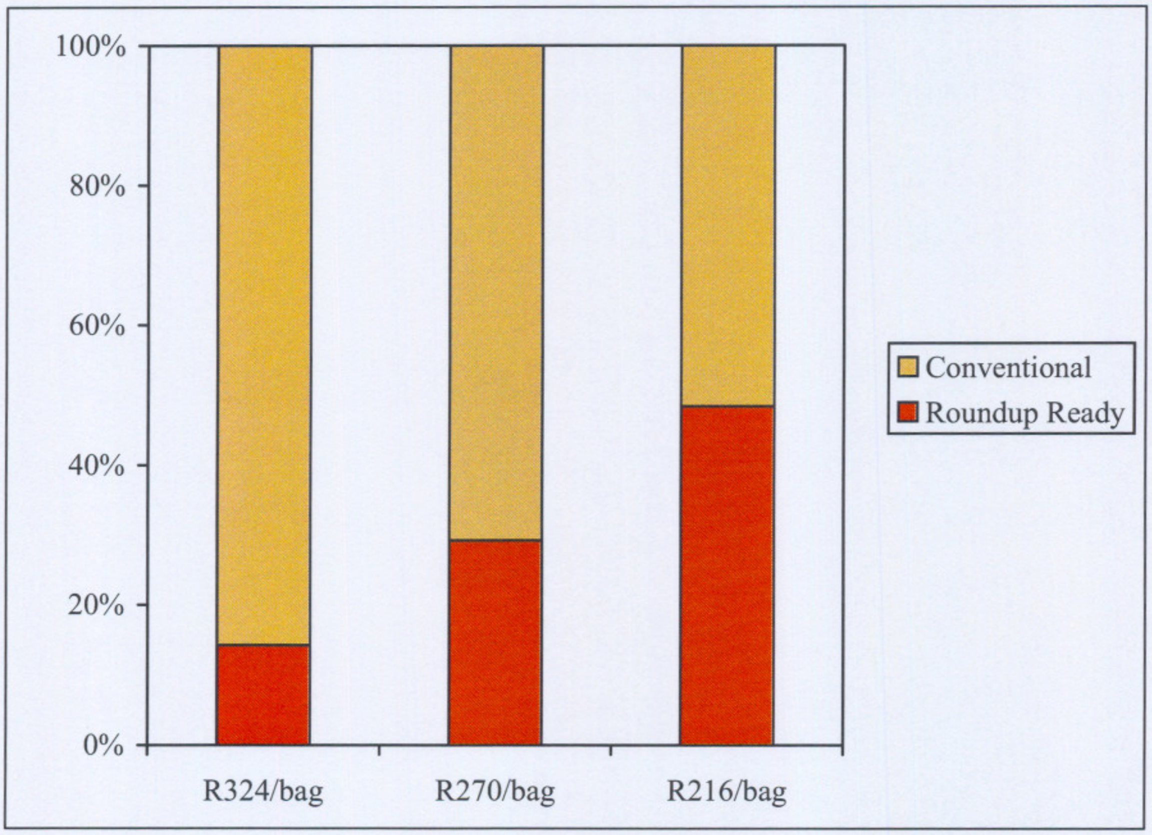
Price is always a critical factor in the agricultural sector due to the overall increase in input costs. The most important, after price, is the yield potential of the hybrid (Table 3.9). This implies that high value products will be needed.

3.7.3 Price elasticity (Question 10)

If the price of "Roundup Ready" technology went up by 20% to R324/bag, stay unchanged, or is reduced to R216/bag, what % of your farm would you plant with "Roundup Ready" maize?

Roundup Ready R324/bag R270/bag R216/bag

Figure 3.23: Price elasticity, all areas



(n=113 respondents)

Table 3.10: Price elasticity of demand

	If price change to R324/bag	If price remains R270/bag	If price change to R216/bag
Roundup Ready maize	14,3%	29,3%	48,4%
Conventional maize	85,7%	70,7%	51,6%

Demand for Roundup Ready maize is relatively elastic (Figure 3.23). As indicated in Table 3.10 the percentage of Roundup Ready maize will increase to 48,4% if the technology fee is reduced by 20% to R216/bag.

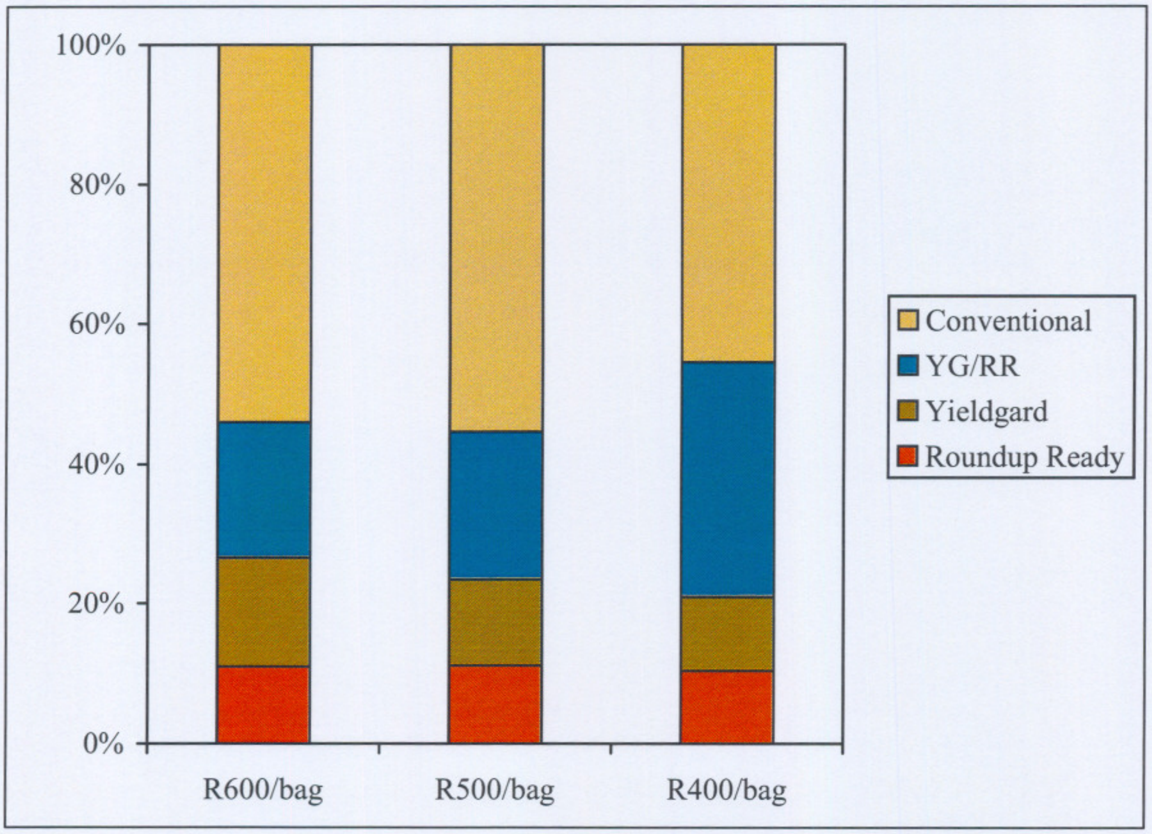
3.7.4 Price elasticity (Question 12)

Irrigation: *Assuming that Roundup Ready and Yieldgard were available in a hybrid of your choice and the following technology fees applied:*

Roundup Ready	*R270/bag*		
Yieldgard	*R230/bag*		
YG/RR	*R600/bag*	*R500/bag*	*R400/bag*

What percentage of your maize plantings would you plant to each of the above and conventional maize?

Figure 3.24: Price elasticity in irrigation area



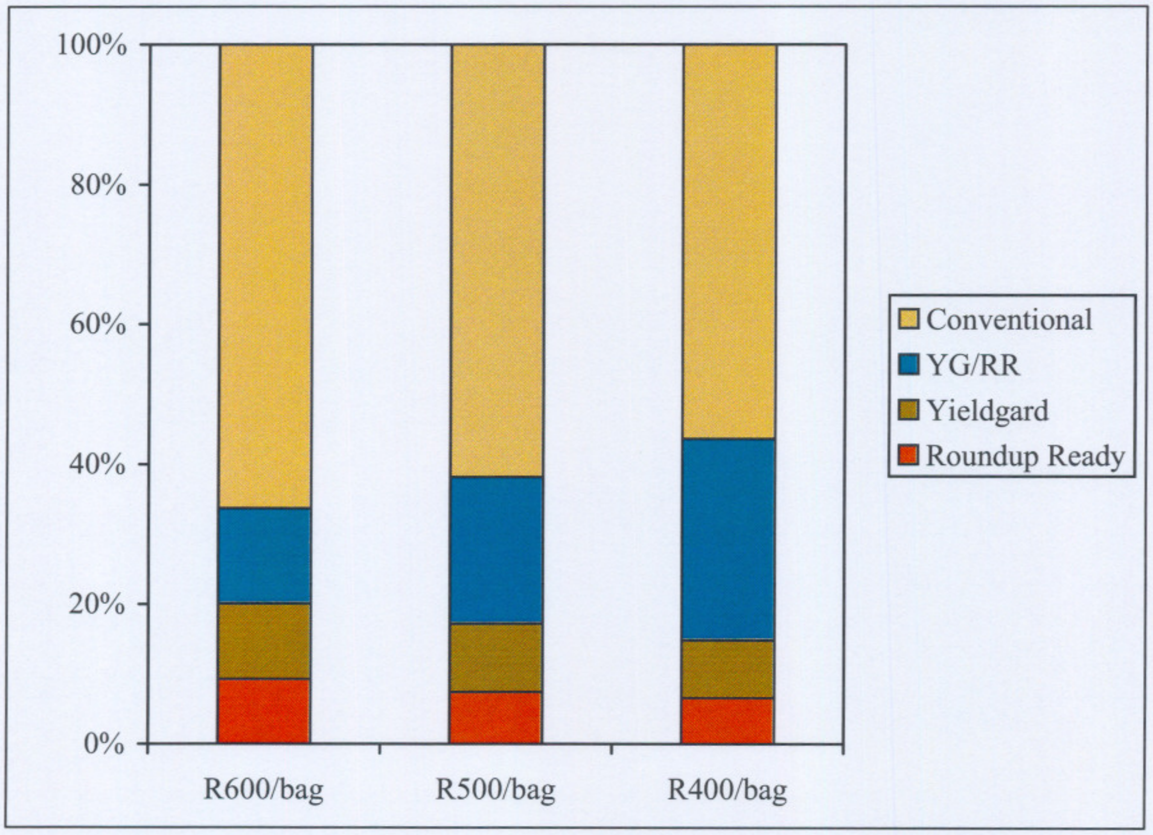
(n=25 respondents)

Dry land East: *Assuming that Roundup Ready and Yieldgard were available in a hybrid of your choice and the following technology fees applied:*

Roundup Ready	*R270/bag*		
Yieldgard	*R230/bag*		
YG/RR	*R600/bag*	*R500/bag*	*R400/bag*

What percentage of your maize plantings would you plant to each of the above and conventional maize?

<u>Figure 3.25</u>: Price elasticity in dry land East area



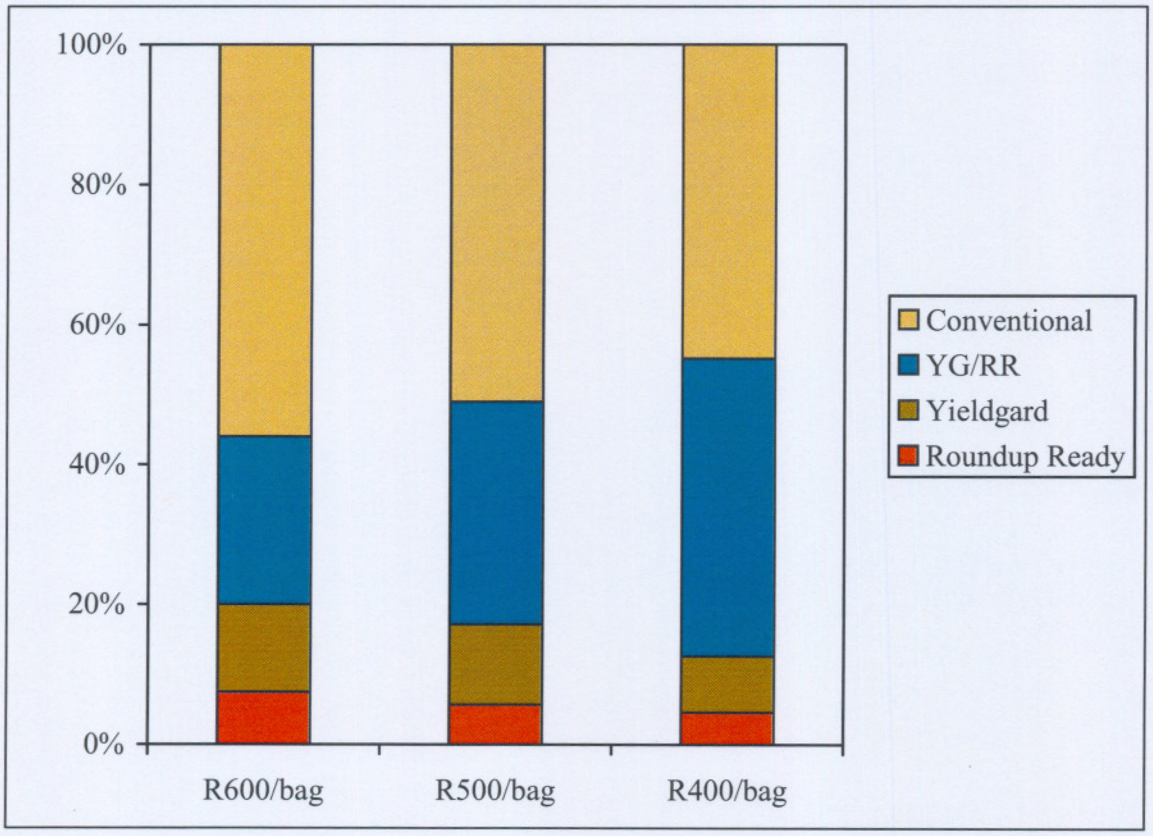
(n=85 respondents)

Dry land West: *Assuming that Roundup Ready and Yieldgard were available in a hybrid of your choice and the following technology fees applied:*

Roundup Ready	*R270/bag*		
Yieldgard	*R230/bag*		
YG/RR	*R600/bag*	*R500/bag*	*R400/bag*

What percentage of your maize plantings would you plant to each of the above and conventional maize?

Figure 3.26: Price elasticity in dry land West area



(n=93 respondents)

Table 3.11: **Price elasticity of demand per area**

	If price change to R600/bag	Influence on income (R) vs 1000 bags	If price change to R400/bag	Influence on income (R) vs 1000 bags
Irrigation	-3,0%	R 582 000	11,4%	R 445 600
Dry land East	-7,4%	R 555 600	7,9%	R 431 600
Dry land West	-7,8%	R 552 000	10,7%	R 442 800

(Income from 1000 bags @ R500/bag = R500 000)

Demand for the stacked hybrid is relatively elastic (Figure 3.25 – 3.27). As indicated in Table 3.11 income will be less if technology fee is reduced to R 400/bag vs R 500/bag. If price is increased to R 600/bag, income will increase to more than R 500 000 per 1000 bags. Growers from the irrigation area are less sensitive for higher prices than the two dry land areas, whereas the dry land East area is less sensitive to lower prices than the other two areas.

3.8 SUMMARY

A total number of 260 respondents were telephonically interviewed, covering 198 415 hectares which represents 7% of the total maize plantings in South Africa. Results have been presented for the three areas and also dissected into growers and non-growers (Yieldgard and Roundup Ready) where applicable. The most significant results are that:

- 65% of the respondents were in the 31-50 years age group;
- 48% of the respondents have a tertiary qualification;
- >60% of the respondents believe that weed infestation have a fair to serious influence on maize yield;
- 60% of respondents apply herbicides on the total soil surface;
- >60% of the respondents rely on triazine containing herbicides;
- The dominant weed types in the West are broad leave weeds, irrigation area is grasses and East is a 50/50 split between these two types;
- More than 50% of the respondents have weed control costs exceeding R200/hectare;
- Less than 80% respondents believe that their current weed control program's efficacy is more than 90%;
- Respondents believe that the use of residual herbicides will decrease with 37,6% due to Roundup Ready maize;
- 95% of first users of Roundup Ready are satisfied. The biggest perceived benefit is the broad spectrum of weed control;

- 38% of respondents indicated that they will already plant Roundup Ready maize in 2004/05;

- 34,9% of respondents indicated that they will not plant Roundup Ready maize in 2004/05 as a result of not being aware of this technology;

- >80% of Yieldgard users are satisfied and 60% of the respondents indicated that they will plant it again in 2004/05; and that

- >75% of the respondents will plant RR/YG, but price is the major influence factor.

- Demand for Roundup Ready maize and the stacked hybrid is relatively elastic.

The focus of the following chapter will be to address the following four aspects as outlined in the introduction, namely to:

- evaluate the influence of Roundup Ready maize on the South African maize herbicide market;

- determine which benefit, contributed by Roundup Ready maize, is ranked to be the most and to be least important as perceived by maize growers;

- propose strategies to maximize Roundup Ready maize adoption amongst maize growers; and to

- propose strategies for the sustainable marketing of conventional herbicide programs in conjunction with Roundup Ready maize programs.

The next chapter also serves as the final chapter of this research, and offers conclusions and recommendations to the research.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 INTRODUCTION

In this final chapter conclusions will be presented resulting from the empirical study. Recommendations will follow afterwards.

4.2 CONCLUSIONS

4.2.1 Demographics

- Roundup Ready technology adoption is higher amongst younger (< 50 years) than older growers. A total of 70% of the Roundup Ready maize growers are in the < 50 group. Resistance to change is lower in this group.

- Roundup Ready technology adoption is higher amongst growers with a tertiary qualification. A total of 48% of respondents have a tertiary qualification. Growers with tertiary qualifications are thinking strategically and want to optimize operations to increase income.

4.2.2 Weed infestation

- More than 60% of the respondents (all areas) believe that their maize yields are reduced due to high weed pressures. This and the low efficacy, due to type of weeds present, of conventional weed control programs are responsible for significant yield reductions.

- A total of 88% of first time Roundup Ready users (2003/2004 season) believe that the level of weed infestation has a definite negative effect on their maize yield.

4.2.3 Herbicide application method

- The majority of growers use a combination of herbicides and mechanical weed control operations. Post-emergence herbicide application is not a new practice.

- Adoption of Roundup Ready maize will lead to a reduction in mechanical weed control operations, but will not eliminate it.

- More than 60% of growers apply herbicides on the total soil surface (broad banded). The other 40% apply herbicides only on the row (banded).

4.2.4 Herbicides used, weed types

- Triazine and triazine-containing herbicides are extremely important amongst maize growers, followed by other herbicides with broad leave activity, namely acetochlor and alachlor. The triazine group of herbicides will be impacted more severely than others, like acetochlor.

- Grass weed infestation: Irrigation > dry land East > dry land West.

- Broad leave weed infestation: Dry land West > dry land East > irrigation.

4.2.5 Weed control costs

- Chemical weed control costs is less in the dry land West area due to higher use of less expensive triazines to control broad leaf weeds.

- Grass weed control is more expensive than broad leaf control and is currently mainly achieved with pre-emergence herbicides since no post-emergence herbicide is available.

- The majority of all respondents spend more than R200/ha on chemical weed control costs.

- The cost of a Roundup Ready maize programme needs to be well managed to remain competitive to a conventional programme. This will become more important after two to three years when demand decreases.

4.2.6 Weed control efficacy

- Optimum weed control (> 90% efficacy) is achieved by less than 18% of all respondents.

- Difficult to control weeds and a grass/broad leave weed mixture causes unsatisfactory control. There is currently no conventional weed control programme to address this type of situation.

4.2.7 Influence of Roundup Ready maize on residual herbicide use

- Use of residual herbicides by Roundup Ready growers will decrease with 44.6%.

4.2.8 Roundup Ready satisfaction / benefits / importance factors

- 95% of first time users of Roundup Ready maize are satisfied. The biggest perceived benefit is the broad spectrum of weed control. Management ease is far less important and crop safety has not been mentioned once.

- 38% of all respondents indicated that they would already plant Roundup Ready maize in 2004/05. Broad spectrum, control of difficult weeds and flexibility are the most important benefits as perceived by this group.

- A total of 146 respondents indicated that they are not going to plant Roundup Ready maize in 2004/05. A high 34,9% of these respondents indicated that they will not plant Roundup Ready maize in 2004/05 as a result of not being aware of this technology. Weed resistance has not been mentioned once.

4.2.9 Yieldgard satisfaction

- More than 80% of Yieldgard users are satisfied with this technology. About 60% of all respondents indicated that they will plant Yieldgard maize in 2004/05.

4.2.10 RR/YG stacked / combination hybrid

- More than 75% of all respondents will plant RR/YG stacked hybrid when commercialized, but price is the major influence factor. The RR/YG stacked hybrids will increase the adoption of Roundup Ready maize.

- Growers are sensitive for pricing and will plant more hectares if the technology fee is reduced.

- Roundup Ready hybrids, as a single trait, need to remain on the market to plant refuge area for insect resistance management. This will allow growers to spray total area with Roundup Ready herbicide.

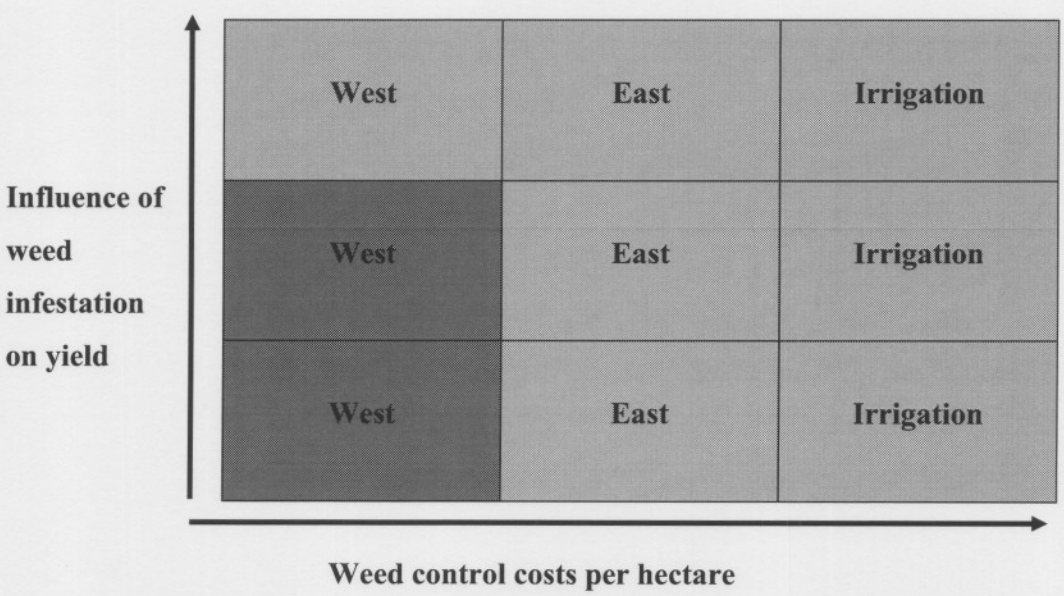
4.3 RECOMMENDATIONS

4.3.1 Marketing process

- **Market segmentation.** The maize grower market consists of three broad distinct segments, namely dry land West, dry land East and irrigation. These can then be sub-segmented as growers with low, fair and serious weed infestations. As was presented in Chapter 3, weed control costs increases in the order dry land West < dry land East < irrigation and also low < fair < serious infestation. Due to these differences marketing need to be focused on segments.

- **Market targeting.** Segments in which the greatest customer value can be created and sustained over time should be targeted. The dry land East and irrigation segments should be targeted as whole segments, whereas selective areas within the dry land West segment should be targeted. This is due to the very low weed infestation and subsequent low weed control costs in mainly the marginal areas in the dry land West segment (Figure 4.1).

Figure 4.1: **Market targeting matrix**



- **Market positioning.** Roundup Ready weed control technology (destructive technology) will be positioned against conventional weed control programs. The positioning should be along the benefits as perceived by the maize growers. These include firstly the broad-spectrum weed control (main benefit), secondly the control of difficult weeds and thirdly flexibility of the programme.

4.3.2 Buyer decision process

- **Adoption process.** The mental process through which an individual passes from first learning about an innovation to final adoption (awareness, interest, evaluation, trial, adoption) should be managed and potential customers need to be led through these stages. People differ greatly in their readiness to try new products (innovators, early adopters, early majority, late majority, laggards). The demographics section reflected that the Roundup Ready growers are < 50 years of age and have higher education levels and are subsequently more receptive than later adopters or non-adopters. Marketing efforts should be directed at these two categories:

  - **Innovators.** Innovators try new ideas with some risk (first 43 users).

  - **Early adopters.** They are opinion leaders in their communities and adopt new ideas early but carefully.

4.3.3 Product life-cycle strategies

- **Introduction stage.** Monsanto and Pannar (licensee of technology) have just recently launched Roundup Ready technology. The single trait will be available, namely Roundup Ready maize.

- The **growth stage** will be entered next season (05/06), in which sales will start climbing quickly. Stacked hybrids (RR/YG) need to be released in this stage to drive the growth. The early adopters will continue to buy and will be followed by late adopters.

- The **marketing objective** now is to create product awareness and to get as many as possible growers to test the technology. A total of 95% of first time users are satisfied and will use the technology again. High intensity sales promotion to create awareness and perception of optimum weed control programme.

4.3.4 The market and demand

- **Oligopolistic competition.** There are two sellers (Monsanto and Pannar) of Roundup Ready maize today. They are highly sensitive to each other's pricing and marketing strategies. The technology fee for both sellers are the same and is calculated per 1000 kernels. The seed price differs significantly between the two sellers and is a function of the yield potential of the particular Roundup Ready hybrids.

- **Elastic demand.** This elasticity should be taken into account when new prices are set. Due to the bigger demand than supply that is expected over the next two to three years, both companies could ignore this elasticity and maintain value-based pricing. Demand for the stacked hybrid is relatively elastic. The recommended technology fee should be R 500/bag. The fee for the Roundup Ready maize should remain R 270/bag.

4.3.5 Residual herbicides

- The perception of Roundup Ready growers is that the use of residual herbicides in maize production will decrease by 44,6% due to the introduction of this technology. This is in line with the perceived decrease in the USA. This will come mainly at the expense of Atrazine and Atrazine containing products. These products are being phased out in Europe due to its negative effect on the environment.

- The focus needs to move to the promotion of high quality acetanilide herbicides as part of the Roundup Ready weed control programme to ensure success. As discussed in Chapter 2, certain situations will still require the use of residual herbicides.

- Residual herbicides will also be a valuable tool in resistance management. The different mode of actions will take out all potential resistant weeds.

4.4 SUMMARY

The first Roundup Ready crop to be commercialised was soybean in 1996. Soybean farmers, initially in the USA and more recently in Argentina, rapidly accepted these varieties. Roundup Ready soybeans were commercialised in South Africa in 1999. Since then, Roundup Ready maize, canola and cotton have also been introduced in the USA. The introduction of Roundup Ready technology may be viewed as a disruptive technology. This innovative technology emerged 25 years after the discovery of the non-selective herbicide (glyphosate) that is now selective in maize, cotton, soybeans and other. This means that the crops are now, (due to GM modification) tolerant to this herbicide, but that weeds remained susceptible. In light of the introduction of Roundup Ready maize into the South African market in 2004, and the subsequent influence thereof on the South African maize herbicide market, the objectives of this research is to:

- evaluate the influence of Roundup Ready maize on the South African maize herbicide market;
- determine which benefit, contributed by Roundup Ready maize, is ranked to be the most and to be least important as perceived by maize growers;
- propose strategies to maximize Roundup Ready maize adoption amongst maize growers; and to
- propose strategies for the sustainable marketing of conventional herbicide programs in conjunction with Roundup Ready maize programs.

Glyphosate was the first amino acid herbicide to reach the market, being introduced by Monsanto in 1972. The product's non-selective activity, low toxicity profile and rapid breakdown on contact with the soil resulted in rapid acceptance for total vegetation clearance in agricultural, industrial and home and garden situations. Glyphosate is now the largest selling single product in the global crop protection market. The success of glyphosate against its main competitor in the marketplace, the bipyridyl herbicide paraquat from Syngenta, resulted in a number of companies undertaking research in the area. The first true competitor to glyphosate came with the introduction of glufosinate by Bayer CropScience (then Hoechst) in 1986, although the product had been preceded by bilanafos from Meiji Seika in 1984. These two products are structurally related, with bilanafos produced by fermentation, whilst glufosinate is chemically synthesized. The latest development to result in further expansion, and probably the most significant is the introduction of Roundup Ready crops, genetically manipulated to tolerate the herbicide, allowing the use of this non selective herbicide in over-the-top applications while the crop is growing. The population consisted of a list of 1500 names that has been submitted to Objectivity PTY (Ltd) from which respondents were randomly selected. The sample consists of 260 South African maize growers. These growers were screened before the commencement of the telephonic interview to exclude those growers that plant less than 300 ha dry land maize or less than 50 ha irrigated maize as well as those who are not responsible for decision making on the farming unit (those in supporting roles). Objectivity PTY (Ltd), a Johannesburg based company specializing in gathering data, conducted the interviews. A total number of 260 respondents were telephonically interviewed, covering 198 415 hectares which represents 7% of the total maize plantings in South Africa. The most significant results are that:

- >60% of the respondents believe that weed infestation have a fair to serious influence on maize yield;
- 60% of respondents apply herbicides on the total soil surface;
- >60% of the respondents rely on triazine containing herbicides;
- the dominant weed types in the West are broad leave weeds, irrigation area is grasses and East is a 50/50 split between these two types;

- more than 50% of the respondents have weed control costs exceeding R200/hectare;
- Less than 80% respondents believe that their current weed control program's efficacy is more than 90%;
- respondents believe that the use of residual herbicides will decrease with 37,6% due to Roundup Ready maize;
- 95% of first users of Roundup Ready are satisfied. The biggest perceived benefit is the broad spectrum of weed control;
- 8% of respondents indicated that they will already plant Roundup Ready maize in 2004/05;
- >75% of the respondents will plant RR/YG, but price is the major influencing factor; and
- demand for Roundup Ready maize and the stacked hybrid is relatively elastic.

The following recommendations were derived:

- weed control costs increases in the order dry land West < dry land East < irrigation and also low < fair < serious infestation. Due to these differences, marketing need to be focused on segments in which the greatest customer value can be created and sustained over time;
- the positioning should be along the benefits as perceived by the maize growers. These include firstly the broad-spectrum weed control (main benefit), secondly the control of difficult weeds and thirdly flexibility of the programme;
- the demographics section reflected that the Roundup Ready growers are < 50 years of age and have higher education levels and are subsequently more receptive than later adopters or non-adopters. Marketing efforts should be directed at these two categories;
- the growth stage will be entered next season (05/06), in which sales will start climbing quickly. Stacked hybrids (RR/YG) need to be released in this stage to drive the growth. The early adopters will continue to buy and will be followed by late adopters. The marketing objective now is to create product awareness and to get as many as possible growers to test the technology. A total of 95% of

first time users are satisfied and will use the technology again. High intensity sales promotion to create awareness and perception of optimum weed control programme;

- price elasticity of demand should be taken into account when new prices are set. Due to the bigger demand than supply that is expected over the next two to three years, both companies could ignore this elasticity and maintain value-based pricing. Demand for the stacked hybrid is relatively elastic. The recommended technology fee should be R 500/bag. The fee for the Roundup Ready maize should remain R 270/bag;
- the perception of Roundup Ready growers is that the use of residual herbicides in maize production will decrease by 44,6% due to the introduction of this technology. This will come mainly at the expense of atrazine and atrazine-containing products. The focus needs to move to the promotion of high quality acetanilide herbicides as part of the Roundup Ready weed control programme to ensure success. Residual herbicides will also be a valuable tool in resistance management.

REFERENCES

BURGELMAN, R.A., MAIDIQUE, M.A. & WHEELWRIGHT, S.C. 2001. Strategic management of technology and innovation. 3rd ed. New York: McGraw-Hill. 990 p.

JAMES, C. 2003. Preview: Global status of commercialized transgenic crops: 2003. *ISAAA Briefs* No. 30. ISAAA: Ithaca, NY. 25 p.

KANYOMEKA, L. & REINHARDT, C.F., 2000. Corn genotypes show distinctive growth responses to various herbicides. *J. New Seeds*, 2, 13-28.

KANYOMEKA, L. 2001. Tolerance of maize genotypes to selected herbicides. Pretoria: UP. (Thesis – Ph. D.) 149 p.

KOTLER, P & ARMSTRONG, G. 2001. Principles of marketing. 9th ed. New Jersey: Prentice-Hall. 785 p.

McDOUGALL, P. 2002. Herbicide mode of action. *Agri-Service*, 1-18, June.

McDOUGALL, P. 2003. Products section: 2002 market. *Agri-Service*, 1-322, Oct.

McDOUGALL, P. 2004. Agrochemical company focus. *Agrifutura*, 55: 1-4, May.

PORTER, M.E., 1980. Competitive Strategy: Techniques for analyzing industries and competitors. New York: Free Press.

THOMPSON, A.A. & STRICKLAND, A.J. 2003. Strategic management: Concepts and cases. 13th ed. New York: McGraw-Hill. 788 p.

http//www.nda.agric.za/act36/AR/herbicides.htm [Date of access: 22 Aug. 2004].

http://usda.mannlib.cornell.edu/reports/nassr/other/pcu-bb/agcs0504.pdf [Date of access: 22 Aug. 2004].

APPENDIX A: QUESTIONNAIRE

SCREENING and CLASSIFICATION QUESTIONS:

1) Do you grow more than?

50 ha maize under irrigation	**or**	300 ha maize dry land	(tick box) If "no" cease interview

2) Are you responsible for decisions regarding the purchase of herbicides and seed?

Yes	No	(tick box) If "no" cease interview

Read: As you know "Roundup Ready" technology allows you to spray "Roundup Ready" maize with Roundup Ready herbicide without any damage to the crop.

Q.1 AWARENESS: PRODUCT
MAIZE PLANTED:

CONVENTIONAL MAIZE PLANTED:

Q1.1 How many hectare of conventional maize did you plant in 2003/04?

None	ha	(tick or enter box)

"ROUNDUP READY" MAIZE PLANTED:

Q1.2 How many hectare of "Roundup Ready" maize did you plant in 2003/04?

None	ha	(tick or enter box)

"YIELDGARD" MAIZE PLANNED:

Q1.3 How many hectare of "YieldGard" maize did you plant in 2003/04?

None	ha	(tick or enter box)

Q.2 AWARENESS: PRODUCT
SEEDING RATE

As applicable ask: What was your seeding rate?

Q2.1	Irrigated, conventional maize?	rate	(enter box)
Q2.2	Dry land, conventional maize?	rate	(enter box)
Q2.3	Irrigated "RR" maize?	rate	(enter box)
Q2.4	Dry land "RR" maize?	rate	(enter box)
Q2.5	Irrigated "YieldGard" maize?	rate	(enter box)
Q2.6	Dry land "YieldGard" maize?	rate	(enter box)

Q.3 AWARENESS: WEED CONTROL
TILLAGE METHOD

Which method of tillage do you use before planting: (Read both and tick one box only)

Q3.1 No tillage/reduced tillage with pre-plant spray? ☐

Q3.2 Conventional mechanical seed bed preparation? ☐

Q.4 AWARENESS: WEED CONTROL PRACTICES

What weed control practices do you employ? (read all and tick box or boxes)

Q4.1	Pre-plant spray with glyphosate?	Yes	No
Q4.2	Pre-emergence application with residual herbicide?	Yes	No
Q4.3	Early corrective post emergence treatment with residual herbicide?	Yes	No
Q4.4	Pre-emergence treatment followed by post emergence treatment?	Yes	No
Q4.5	Mechanical weeding?	Yes	No

Q4.6 How many times do you cultivate in one season for weed control? This is the period from seed bed preparation up to harvesting. times (enter box)

Do you apply herbicides on: (tick one box only)

Q4.7 Total soil surface?

Q4.8 Only banded on the rows?

Q.5 AWARENESS: PRODUCT

HERBICIDES USED

What herbicides have you used this past 2003/4 season. Please list the herbicides you have used in the order of their importance to you. When herbicides given ask:

1) What major weeds were you trying to control with each herbicide?
2) Can you remember what you paid per litre for each herbicide?
3) What was your application rate per ha for each herbicide?

	Herbicides	Weight	Weeds	Weight
Q5.1		7		7
Q5.2		6		6
Q5.3		5		5
Q5.4		4		4
Q5.5		3		3
Q5.6		2		2
Q5.7		1		1

Q.6 AWARENESS: PESTS

STALKBORER

Q6.1 How severe is the stalkborer infestation on your farm?

not serious		fairly serious		very serious		(read and tick one box only)

Q.7 AWARENESS: "YIELDGARD": EFFICACY

If "yes" to Q1.3 ask: In Q1.3 you said that you planted "YieldGard" maize in 2003/4.

Q7.1 In terms of efficacy of stalk borer control, how satisfied are you with the "YieldGard" technologies? (Read all four and tick one box only.)

1) Totally satisfied - will continue to use	
2) Partially satisfied - well continue to use, but could be improved	
3) Not satisfied - will continue to use, until something better is available	
4) Not satisfied - will not purchase again	

Q.8 IMPORTANCE FACTORS:

AWARENESS: "YIELDGARD" 2004/5

Q8.1 Will you purchase and use "YieldGard" in the 2004/5 season?	Yes	No	(tick box)

If the answer to Q8.1 is "yes" ask:

Please give me three reasons for your decision to **start** using "YieldGard" technology listing your reasons in the order of importance to you.

Sequence of mention	List the criteria in the order given	Weight
1		7
2		6
3		5

If the answer to Q8.1 is "no" ask:

Q8.2 Please give me three reasons why you **will not** use "YieldGard" technology this coming season listing your reasons in the order of importance to you.

Sequence of mention	List the criteria in the order given	Weight
1		7
2		6
3		5

Q.9 AWARENESS: WEED CONTROL: DEGREE OF INFESTATION

Q9.1 On your farm, how important are weed infestations in determining your final maize yield? (Read all three and tick one box only.)

not serious		fairly serious		very serious	

Q9.2 How effective do you believe your weed control programme to be, as a percentage, ie what percentage of the weeds do you control when spraying or mechanically weeding?

%	(enter box)

Q9.3 What does your weed control cost you per hectare for herbicides only? (Read all eight and tick one box only.)

1) More than R400 per hectare	
2) R300 - R400	
3) R200 - R300	
4) R150-R200	
5) R100 - R150	
6) R50 - R100	
7) Less than R50	
8) Nothing	

Q.10 AWARENESS: "ROUNDUP READY" MAIZE SATISFACTION

If positive in Q1.2 ask:

Q10.1 In Q1.2 you said you planted "Roundup Ready" maize. How satisfied were you with "Roundup Ready's" performance? (Read all four and tick one box only.)

1) Totally satisfied - will continue to use	
2) Partially satisfied - well continue to use, but could be improved	
3) Not satisfied - will continue to use, until something better is available	
4) Not satisfied - will not use again soon	

If positive in Q12.1 ask:

Q10.2 In Q12.1 you said you were **totally/partially** satisfied with "Roundup Ready" maize Please give me three reasons for your satisfaction with "Roundup Ready" maize listing your reasons in the order of their importance to you.

Sequence of mention	List the criteria in the order given	Weight
1		7
2		6
3		5

If negative in Q12.1 ask:

Q10.3 In Q12.1 you said you were **not satisfied** with the performance of "Roundup Ready" maize. Please give me three reasons for your dissatisfaction listing your reasons in the order of their importance to you.

Sequence of mention	List the criteria in the order given	Weight
1		7
2		6
3		5

Q10.4 Will you purchase and plant "Roundup Ready" maize this coming 2004/5 season?

Yes	No	(tick box)

If the answer to Q10.4 is "yes" ask:

Q10.5 Please give me three reasons for your decision to use "Roundup Ready" maize this coming season?

Sequence of mention	List the criteria in the order given	Weight
1		7
2		6
3		5

If the answer to Q10.4 was "no" ask:

Q10.6 Please give me three reasons why you will **not** plant "Roundup Ready" maize this season listing your reasons in the order of their importance to you.

Sequence of mention	List the criteria in the order given	Weight
1		7
2		6
3		5

(Read all three and enter each box)

Q10.7 If the price of "Roundup Ready" technology went up by 20% to R324/bag **what %** of your farm would you plant to "Roundup Ready" maize?	%	(enter box)
Q10.8 If the price of "Roundup Ready" technology stays the same at R270 per bag **what %** of your farm would you plant to "Roundup Ready" maize?	%	(enter box)
Q10.9 If the price of "Roundup Ready" technology dropped by 20%to R216 per bag **what %** of your farm would you plant to "Roundup Ready" maize?	%	(enter box)

Q.11 AWARENESS: RESIDUAL HERBICIDE

Q11.1 Do you think that the use of residual herbicides will decrease with the introduction of "Roundup Ready" maize? (tick box) **If "yes" ask:** What percentage do you think it will decease? (enter box)

Yes		%	No decrease		(tick box)

Q12. AWARENESS: PRODUCT COMBINATION HYBRID: "YGRR"

Q12.1 Assuming that both "YieldGard" and "Roundup Ready" technology were available in a single maize hybrid of your choice (ie. stacked gene), would you be interested in purchasing this hybrid for use on your farm?	Yes	No	(tick box)

IMPORTANCE FACTORS: COMBINATION HYBRID: YGRR

Q12.2 What factors would determine how many hectare you would plant of this hybrid (YGRR) containing both traits?

Sequence of mention	List the criteria in the order given	Weight
1		7
2		6
3		5
4		4
5		3
6		2
7		1

AWARENESS: COMBINATION

RR + YG - R600:

Q12.3 Assuming that "Roundup Ready" and "YieldGard" were available in a combination hybrid of your choice, and the technology premium on "Roundup Ready" was R270/bag, on "YieldGard" R230/bag and on the combination ie YGRR R600/bag, **what %** of your maize plantings would you plant to each of:
(Read and enter each box)

"Roundup Ready"	%	
"YieldGard"	%	
YGRR combination maize	%	
Conventional maize	%	
TOTAL	100%	(Check total to 100%)

AWARENESS: COMBINATION

RR + YG - R500:

Q12.4 Assuming that "Roundup Ready" and "YieldGard" were available in a hybrid of your choice, and the technology premium on "Roundup Ready" was R270/bag, on "YieldGard" R230/bag and on the combination ie YGRR was R500/bag, **what %** of your maize plantings would you plant to each of:
(Read and enter each box)

"Roundup Ready"	%	
"YieldGard"	%	
YGRR combination maize	%	
Conventional maize	%	
TOTAL	100%	(Check total to 100%)

AWARENESS: COMBINATION

RR + YG - R400:

Q12.5 Assuming that "Roundup Ready" and "YieldGard" were available in a hybrid of your choice, and the technology premium on "Roundup Ready" was R270/bag, on "YieldGard" R230/bag and on the combination ie YGRR R400/bag, **what %** of your maize plantings would you plant to each of:
(Read and enter each box)

"Roundup Ready"	%	
"YieldGard"	%	
YGRR combination maize	%	
Conventional maize	%	
TOTAL	100%	(Check total to 100%)

Q.13 DEMOGRAPHICS: (Read all five and tick one box only)

Q13.1 Age group?

20-30 yrs	31-40 yrs	41-50 yrs	51-60 yrs	60 + yrs

Q13.2 Education?

Agricultural diploma	Commercial degree/diploma	Academic degree	Matric	Std 8