COST BENEFIT ANALYSIS OF LIVING MODIFIED ORGANISMS FOR MAIZE AND COTTON IN SWAZILAND

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FOR AND ON BEHALF OF

SWAZILAND ENVIRONMENTAL AUTHORITY (SEA)

SEPTEMBER 2016

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LIST OF ACRONYM

Bt	*Bacillus thuringensis*
DNA	Deoxyribonucleic acid
GM	Genetically Modified
GMOs	Genetically Modified Organisms
HT	Herbicide tolerant
IR	Insect resistant
LMOs	Living Modified Organisms
MoA	Ministry of Agriculture
NAMBoard	National Agricultural Marketing Board
PMOs	Produce Marketing Organizations
RR	Roundup Ready
SADC	Southern African Development Community
SCB	Swaziland Cotton Board
SEA	Swaziland Environmental Authority
SNAU	Swaziland National Agricultural Union
ToRs	Terms of References

1.0 INTRODUCTION

1.1 Background Information

Agriculture plays an important role in the economy of Swaziland not only as a source of food, but also in its ability to create employment opportunities. Over 70 % of the country's population is living on rural rain-fed subsistence farming and more than 60 % are employed in the agriculture sector (Thompson, 2013). Agricultural production is declining resulting in food insecurity. Since 1996, developed and developing countries have been adopting modern biotechnology as it is perceived to have the potential of increasing production and yields for major crops (Brookes & Barfoot, 2013). Modern biotechnological advances have generated products that have a tremendous commercial application for the present and future markets (Kranthi, 2000). However, this technology has been linked with many concerns on health, biodiversity, ethical, cultural practices. Therefore, social, economic and environmental implications and considerations associated with the adoption of biotechnology should be taken into account. Genetically Modified (GM) crops need to be carefully regulated and tested before legalized as currently GM crops are illegal in the country.

In 2006 the Kingdom of Swaziland adopted a National Policy entitled 'Creating an Enabling Environment for the safe use of Biotechnology and its Products in Swaziland', which sets the framework for the Biosafety issues in the country. The country further enacted the framework legislation, the Biosafety Act, 2012, which does not only domesticate the Cartagena Protocol on Biosafety, but also outlines the procedure for handling Living Modified Organisms (LMOs) and a public participation procedure in the management of modern biotechnology practices. The major objective of the Biosafety Act, 2012 is to ensure an adequate level of protection in the field of safe transfer, handling and the use of Genetically Modified Organisms (GMOs) resulting from modern biotechnology that may have an adverse effect on conservation and sustainable use of biological diversity, taking into account human health.

The Government of Swaziland through the Swaziland Environmental Authority (SEA) has since commissioned a consultant to undertake an ex-ante cost benefit analysis baseline study of the

GMOs in Swaziland. The analysis was based on three important field crops; maize which is the staple crop, cotton an important cash crop for rural subsistence households and soybeans which is an important ingredient for animal feed (one of the major agricultural industries in the country). The results obtained from the study would assist in decision making with regards to the introduction of GM crops in the country. This would be based on economic, environmental and social impact analysis on these crops.

1.2 Terms of References (ToRs)

i) Formulate and compare non-GM and GM crops (maize, cotton and soybeans) gross margins for primary production (small-scale and large-scale farmers on irrigation and rain fed);

ii) Provide financial implications of growing GM crops (maize, cotton and soybeans) in the country by identifying any cost differences between these GM and non GM crops;

iii) Produce a socio-economic report detailing the implications and considerations of growing GM crops in Swaziland; and

iv) Capacitate local economists and stakeholders on Biosafety Socio-economic considerations and present an analysis of risks on conservation of Biodiversity by identifying socio-economic impacts of GM crops.

1.3 Evaluation Questions

Key guiding questions for the consultancy were as listed below;

1. What are the gross margins for non-GM and GM cotton, maize and soya beans?
2. What are the benefit and cost differences between GM crops and non-GM crops?
3. What are the financial implications for growing GM crops in Swaziland?
4. What are the socio-economic implications and considerations of growing GM crops in Swaziland?
5. What are the environmental implications and considerations of growing GM crops in Swaziland?

1.4 Hypothesis

Hypothesis 1:

H_0: There are no differences in financial benefits from growing GM crops compared to non-GM crops in Swaziland.

H_1: There are financial benefits from growing GM crops compared to non GM crops in Swaziland.

Hypothesis 2:

H_0: There are no differences in socio-economic implications for growing GM crops in Swaziland.

$H_{1:}$ There are socio-economic implications for growing GM crops in Swaziland.

Hypothesis 3:

H_0: There are no health and environmental risks associated with GMOs as perceived by the stakeholders.

$H_{1:}$ There are health and environmental risk associated with GMOs as perceived by the stakeholders.

2.0 LITERATURE REVIEW

This section covers information about GM crop varieties, socio-economic benefits of GM crops, environmental and health benefits.

2.1 Types of GM

GM refer to the introduction of new traits to an organism by making changes directly to its genetic makeup, through intervention of a DNA to plants or animals at the molecular level and without traditional breeding methods (Griffiths et al., 2005). There are three main types of GMs traits that are currently available, that includes herbicides-tolerate (HT) traits, Insect-resistant (IR) traits and stacked containing both herbicides tolerate and insect resistant traits.

2.1.1 Herbicides-tolerate (HT) traits

The GMs crops that have traits that provide herbicides tolerance (HT) are crops that scientist have made by adding a gene that will be able to tolerate certain highly effective herbicides. The most successful HT traits introduced to date have enabled GM crops to grow in the presence of foliar-applied, broad-spectrum and non-selective herbicides, such as glyphosate which is marketed as Roundup and glufosinate.

2.1.2 Insect resistant (IR) traits

The GMs crops that have insect resistant (IR) traits are crops that have been inserted by a gene from the soil bacterium called *Bacillus thuringensis* (Bt) that produces a protein which is toxic to certain larvae of some *lepidopteran* and *coleopteran* insect species, protecting the plant over its entire life and is used as a substitute for chemical insecticides (Qaim, 2009). Insect resistant varieties in maize have been made to resist most common pests such as stalk borer, while resistant to bollworms in cotton (Herrera, 2000).

2.1.3 Stacked Traits

Gene stacking refers to the process of combining two or more genes of interest into a single plant. Gene pyramiding and multigene transfer are other monikers in the scientific literature referring to the same process. The combined traits resulting from this process are called stacked traits. A biotech crop variety that bears stacked traits is called a biotech stack or simply stack. An example of a stack is a plant transformed with two or more genes that code for *Bacillus thuringiensis* (*Bt)* proteins having different modes of action. It is a hybrid plant expressing both insect resistance and herbicide tolerance genes derived from two parent plants.

Why Gene Staking?

- Compared to mono-trait crop varieties, stacks offer broader agronomic enhancements that allow farmers to meet their needs under complex farming conditions. Biotech stacks are engineered to have better chances of overcoming the myriad of problems in the field such as insect pests, diseases, weeds, and environmental stresses so that farmers can increase their productivity.

- Gene stacking enhances and simplifies pest management for biotech crops as demonstrated by multiple insect resistance based on Bt gene technology. Experience has shown that the resistance conferred by a single Bt gene has the potential to break down as the target insect pest mutates and adapts to defeat the Bt trait.

- To prevent or delay the emergence of resistance to the *Bt* gene, many regulatory agencies require a refuge or an area planted to a non-*Bt* variety alongside the *Bt* crop. Typically a refuge is about 20 percent of the total crop area for a mono-*Bt* trait variety.

- While the refuge strategy lessens the chance for the insect pest to overcome the *Bt* trait, farmers cannot realize the full production benefit of the *Bt* crop. The next generation of *Bt* crops with multiple modes of action for insect control were then developed by stacking several classes of Bt genes. This gene stacking approach has reduced the potential of resistance breakdown as it is more difficult for the pest to overcome multiple insecticidal proteins. This greater durability of *Bt* stacks allow a lower refuge area requirement that somehow limits yield.

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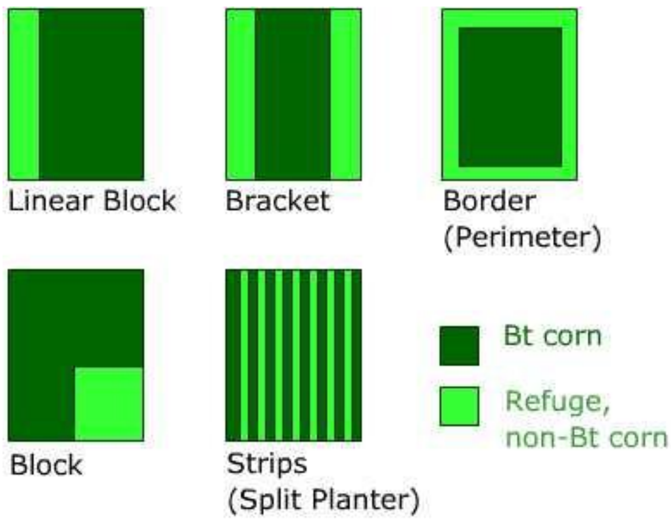
- The *Bt* gene stacking principle is also used in weed management. Weed resistance to commercial herbicides has been documented for different herbicidal modes of action[2]. To catch up in countering weed resistance, biotech seed developers have stacked up genes to broaden the herbicidal mode of actions. For example, this is done by combining the glyphosate resistance gene *epsps* with the *pat* gene conferring resistance to herbicide glufosinate and/or with the *dmo* gene conferring resistance to herbicide dicamba.

GM seed varieties benefit both small and large scale farmers. Bennett (2006) discovered that smallholder growers in Makhathini benefited as much as larger holdings, if not more, from the adoption of Bt cotton. According to Bennett (2006), the benefits of growing Bt cotton are apparent regardless of the size of plot available to smallholders, with some of the largest benefits appearing to accrue to the smaller cotton growers. In China, GM cotton seeds have been adopted by millions of smallholder farmers with average farms of 0.4 hectares, while in India millions and millions of smallholder farmers adopted GM cotton.

2.1.3.1 Refuge Crop

Fields with *Bt* crops are required to provide refuge areas to help control resistance. The refuge area supply a source of wild-type (non-mutant) insects to mate with possible resistant insects to produce non-resistant insects. *Bt* crops are planted with alternating rows of regular non-*Bt* crops.

The insects that have developed resistance to *Bt* have more chances of mating with an insect that has not developed resistance to *Bt*. By the laws of genetics, the progenies produced will be insects that are not resistant to *Bt* (ISAAA, 2013).



- Growers may plant up to 80% of their corn acres with *Bt* corn. At least 20% must be planted with non-*Bt* corn (refuge area)
- Refuge area must be within, adjacent to or near the *Bt* cornfields. It must be placed within 1/2 mile of the *Bt* field.
- If the refuge is strips within a field, the strips should be at least 4 rows.

2.2 Socio-economic Benefits of Genetically Modified Crops

The economic potential of GM crops among others are; effect on yield, pesticide/insecticide and herbicide use, seed cost, increased profits, and mitigating climate change.

2.2.1 Effects of GMO on Yield

GM seeds varieties guarantee yields in crops by reducing the effects of drought, pests and weeds in plants. In developing countries like Swaziland, cotton is mainly grown by smallholder subsistence farmers. However, the harvest is particularly threatened by insect pests such as the cotton bollworm, caterpillars feeding within the fruit. These are conventionally combated by spraying with pesticides. According to Heldt (2006) more pesticides are applied per hectare in cotton than to any other crop and the number of sprayings necessary per growing season vary from 2 to 12 sprayings, but sometimes higher depending on the climatic conditions. *Bt* cotton adopters achieved consistently higher yields at 85% higher on average than those growing the conventional crop (Bennett, 2006). The GM crop varieties guarantee yields because they are pest and disease resistance, as well as resistant to environmental stresses such as drought. This therefore improves crop quality and yields **(**Arundel & Sawaya, 2009).

2.2.2 Pesticide/Insecticide and Herbicide Use

In a study carried out in South Africa, on average, farmers using the *Bt* variety sprayed less insecticide per season than farmers using conventional seeds, they used three sprays (3) less (Bennett, 2006). However, adopters still sprayed against pests such as aphids, *jassids* and *thrips*. Elimination of three (3) sprays for bollworm inevitably reduce the costs, the amount of labour and the distance walked given that all spraying is carried out with knapsacks [hand sprays] for most smallholder farmers. It also saves time and water. Farmers who adopt herbicide tolerant (HT) technology benefit in terms of lower herbicide expenditures. HT technology reduces the cost of production through lower expenditures for herbicides, labour, machinery, and fuel. The main reasons for farmers to continue using HT technologies were; easier weed control and savings in terms of time management (Qaim, 2009).

Where pest pressure is high, farmers using conventional crop use a lot of chemical insecticides yet *Bt* adoption would lead to substantial reductions in use of insecticide. Even though the *Bt* gene does not affect potential yield, it can lead to a reduction in crop losses, when there is previously uncontrolled pest damage, thus leading to a higher yield (Qaim, 2009).

2.2.3 Seed Cost

Cultivation and commercial production of GM crops are capital intensive owing to high costs of seed and technology. Nevertheless, their cultivation has generally increased, mainly because of the benefits accrued from low labour and production costs, the reduction in use of chemical inputs and improved economic gain. They are also marketed with an obligation that fresh seeds must be purchased each year so seed saving and informal seed exchange is not possible. This has been cited as a reason for their unsuitability to developing countries where the majority of subsistence farmers saved seeds (Heldt, 2006). It also makes it easy for farmers to go into debt because they constantly need to afford new seeds (Bennett, 2006). However, hybrids are the predominant seeds used by more than 84% subsistence farmers in developing countries because of the high yields.

2.2.4 Increased Profits

According to Kraft (2001) there is a statistically significant relationship between an increase in the use of GM seeds and an increase in net returns from farming operations. The increase in net returns for herbicide-tolerant cotton crops and *Bt* cotton crops. Other studies have obtained similar results. Studies in Tennessee and Mississippi found higher returns from herbicide-resistant soybeans than from conventional soybeans. A study conducted in North Carolina indicated that GM soybeans yielded $6 more per acre than traditional varieties.

2.5 Labour Cost

The herbicide tolerant (HT) variety allows for no or minimum tillage in maize and cotton production. This makes GM crops to be less labour intensive due to the use of herbicides for weed control. However, with increased yields in GM crops, harvesting labour cost is likely to increase. Where labour or time is a constraint, this convenience effect (saved labour cost and time) has an economic impact on the farmers growing GM crops (Clover, 2003). This motivates farmers to increase their production scale as labour costs are reduced. It also allows for mechanization in large commercial production, therefore, reducing the labour cost for weed control. Bennett (2006) in a study done at Makhathini also found higher labour input for weeding for non-adopters, however, *Bt* adopters consistently used more labour for harvesting due to the higher yields achieved, and substantially less labour for spraying pesticides.

2.3 Environmental and Health Implications of GMOs

2.3.1 Health Effects

From the food and health perspective, the main concerns are related to the possibility of toxicity and allergenicity of genetically modified foods and GM food products. Nevertheless, public perceptions about GMOs in food and agriculture are divided with a tendency toward avoiding genetically modified food and products. This has resulted in the adoption of non-human food crops such as cotton than genetically modified food crops like potatoes, maize, and eggplant (Modern biotechnology in agriculture, 2010). Heldt (2006) stated that in principle, no absolute guarantee can ever be offered for the safety of any food, whether produced conventionally or from GM plants. The scientific evidence concerning the environmental and health impacts of GMOs is still emerging, but so far there is no conclusive information on the definitive negative impacts of GMOs on health (Bennett, 2006).

Moreover, in the European Union it is now obligatory that all food ingredients from GM plants are so labelled if they exceed a threshold content of 0.9% for each ingredient. This is not the case in United State of America. According to Modern Biotechnology in Agriculture (2010), it has been noted that strict GMO regulations in the European Union are hindering the uptake of genetically modified crops in Africa due to a fear of losing export markets.

Toxicity and carcinogenicity are tested in feeding trials with livestock and rats before the product can be approved for the market and developing genetically modified seeds takes many years giving researchers enough time to test the toxicity. Trials with thousands of animals have shown genetically modified products to be harmless; no scientifically substantiated reports have suggested that the neither health nor productivity of animals is impaired after being fed genetically modified fodder in comparison with the conventional equivalent.

Moreover, for some ten years genetically modified food products have been part of the human diet in the US and some other countries. There have been trillions of genetically modified meals eaten without any scientifically-based report indicating a single health hazard. Furthermore, in spite of a number of attempts to do so, there has been no successful consumer claim in any country anywhere for compensation for damage supposedly incurred from the consumption of genetically modified products (Bennett, 2006). Since 1996, hundreds of millions of people in America and elsewhere have regularly been consuming genetically modified products as part of their normal diets without any proven evidence of adverse health effects (Bennett, 2006).

According to Heldt (2006), since the introduction of GMOs in 1996, hundreds of million people have consumed products from GM-maize and it has been widely used as animal feed. However, there is no scientific evidence of consumption of GM maize and its products of being harmful to health. Instead, there is clear evidence that GM maize offers a health advantage of being much less subject to contamination by *mycotoxins* such as *fumonisin* and *aflatoxin*, toxins produced by fungi that infest maize cobs and which cause serious illnesses in man and animals. So, *Bt*-maize offers a critically important advantage for consumers concerned about food safety.

Fumonisin is a serious problem; it is so stable that it survives processing and can sometimes be found in cornflakes. In conventional breeding, in which genes are altered at random by experimentally caused mutations or unexpected gene combinations generated by crossings, such tests are not legally required. For this reason, the risk of GM plants causing allergies can be regarded as substantially lower than that of products from conventional breeding. The “new” genes in GM plants derived mostly from other organisms already present in conventional food, viruses and soil bacteria are present in vegetables. All DNA, transgenic or not, is degraded in the digestive track although this process may not always be complete. Experiments with animals have shown that very limited quantities of DNA fragments from food may be taken up into blood and body cells of animals. This would have no effect on the genetic composition of human cells. The stable integration of plant DNA into animal genomes has never been observed, with natural barriers apparently in place to prevent any such horizontal gene transfer (Bennett, 2006).

2.3.2 Environmental Issues: Biodiversity and Pollution

Industrial farming reduces biodiversity as agribusinesses clears the land of all native plants and focus on producing only one type of crop. This large-scale monoculture crop production has resulted in a 75% reduction in plant diversity since the 1900s. There are concerns about environmental risks include the impact of introgression of the transgenes into the natural landscape, impact of gene flow, effect on non-target organisms, evolution of pest resistance and loss of biodiversity.

According to Heldt (2006), extensive field studies indicated that the cultivation of *Bt*-maize has no measurable impact on Monarch butterflies. In addition the populations of many non-target insects are higher in fields of *Bt*-cultivars than in fields of conventional crops regularly receiving applications of broad-spectrum pesticide. This is because *Bt*-proteins are toxic only to selective insect pests. So, combating those pests which are insensitive to the *Bt*-toxin still require the application of pesticides although the number of pesticide sprays required is much lower than with conventional cultivars. Decreases in pesticide applications are beneficial not only for the environment but also to farm labourers and the health of the farmer.

Environmental costs associated with spraying could decrease if fewer chemical sprays were used. Reduced contamination of soils and groundwater could also be expected. In addition, pesticide and herbicide resistant GM crops provide occupational health and safety benefits by reducing the need for farmers to handle harmful chemicals (Acworth, Yainshet & Curtotti, 2008).

2.3.3 Super Pest and Resistance

There is concern both in China and India that pest resistance to the *Bt* toxin may already be emerging. Pest refuges are recommended as a way of controlling this problem, but these may be unworkable or ineffective on the tiny plots of land farmed by smallholders. Genetically modified crops threaten to cross-contaminate surrounding farmlands and natural habitats, leading to monoculture and low biodiversity among food crops.

Cross contamination may be prevented with refuge crop between different fields; however, there are still investigations of different factors, such as wind and animal life, which could be transferring the pollen beyond the planted area. Even with these measures, cross contamination is very difficult to avoid because there are so many ways in which the seed can spread. If a farmer has not planted a particular GM crop, but through cross contamination has the crop growing on his fields, he can be subject to a lawsuit at the hands of the people who have a patent on the said GM crop.

According to Heldt (2006), the use of refuge crops limit the build-up of super pest. This ensures that susceptible insects are available in sufficient numbers to mate with any resistant survivors from *Bt* fields, thus preventing the build-up of resistant insect populations. For smallholder farmers, having small fields with diverse crops also save as a refuge crop.

2.3.4 Mitigating Climate Change

GM crops also mitigate climate change by reducing the amount of greenhouse gases produced by agricultural management activities. The herbicide tolerant (HT) variety allows for no tillage or minimum tillage in maize and cotton. GM crops also reduce environmental challenges such as air pollution and water pollution by limiting the use of pesticides because the insect resistant varieties are tolerant to pests and diseases. This helps to improve the health status of farmers and community members.

2.4 Implications of Genetically Modified Crops Beyond Farm-gate

2.4.1 Binding Contract

Farmers that intend to grow the GM crop, is required to sign a binding contract, adhering to procedures for growing/using the technology. The contracts that seed companies require from buyers of their GM seeds sign when obtaining these seeds may disadvantage farmers. According to Kruft, (2001) *s*eed companies have invested significant funds in research and development of GM seeds, and they protect this investment through their contracts with agricultural growers.

These contracts aggressively protect the biotechnology company's rights to the seeds, frame the context within which disputes may be settled, and limit the liability of the company. Moreover, Kruft (2001) states that the contract has provision prohibiting growers from saving seed and/or reusing seed from GM crops. In effect, the provision requires growers of GM crops to make an seasonal purchase of GM seeds.

2. 5 Ex-ante Methodologies

Ex-ante methodologies are used in setting priorities and allocating financial and human resources for technology development that addresses specific needs of targeted users, such as enhanced income or food security in a sustainable way. The available *ex-ante* methodologies for economic assessment for GM crops are; Partial Budget Approach, Consumer/Producer Surplus and Cost-Benefit Analysis (Babu & Rhoe, 2003). However, the consultancy team adopted a combination of these methods to address the cost and benefits of GM crops in Swaziland.

Snowball Sampling

In sociology and statistics research, snowball sampling (or chain sampling, chain-referral sampling, referral sampling) is a non-probability sampling technique where existing study subjects recruit future subjects from among their acquaintances.

Snowball sampling is designed to identify people with particular knowledge, skills or characteristics that are needed as part of a committee and/or consultative process. Snowball sampling uses recommendations to find people with the specific range of skills that has been determined as being useful for the survey, as such identifiers for survey population. Snowball sampling aims to make use of community knowledge about those who have skills or information in particular areas. It helps in determining stakeholders, increases the number of participants in process, builds on resources of existing networks as well as determines stakeholders unknown to you. Some of the special considerations in using snowball sampling include choice of initial contacts, and the participation process should be drafted prior to the sampling to encourage participation from potential contacts.

3.0 METHODOLOGY

A descriptive exploratory research design was adopted for the study conducted in Swaziland. The target population for the study was maize and cotton farmers. South Africa was used as a reference country for GM crops performance and the Tonga and Matlerekeng areas were visited through advice from the Agri-Bio South Africa in consideration of their proximity and almost similar climatically conditions to Swaziland. Agri-Bio is an agricultural research institution based Pretoria, South Africa.

The Lowveld was used for cotton because it is the region where most of the cotton is grown. Technical officers from the extension department in the Ministry of agriculture helped advice on the areas to be covered under each agro-ecological zone. In the Lowveld, areas covered by the survey included; Manyonyaneni, KaLanga, Lokhayiza, Mahlabaneni, Makhondvolwane, Khalamfene, and Mpolonjeni. In the Middleveld areas covered were; Tikhuba, Deda, Lushikishini, Mabovini, Mhlatane, Cana, Ngwempisi, Sibovu and Velezizweni. While in the Highveld areas covered were Mshingishingini, Lomshiyo, Sigangeni, Ntjonjeni and Sigeledvu.

3.1 Sampling Techniques

In Swaziland, the sampling method adopted was the non-probability sampling technique called Snowball (Referral sampling technique). This method enables a resource person to refer one target farmer who then refers the surveyor to a farmer among his/her acquaintances. This method was used in the study to identify the active farmers that informed the survey. Key informants for the study were farmers and extension officers. A total 96 farmers and 11 extension officers were interviewed in Swaziland. Table 1 shows the sample size by area in the three agro-ecological zones (Highveld, Middleveld and Lowveld). Swaziland is currently using only convectional varieties therefore data on GM crops was purposively sourced from the South Africa in the Tonga and Matlerekeng area which have similar climatic condition with the agro-ecological zones sampled in Swaziland.

Table 1: Survey Sample by Area

Region	Area	Sample
Lowveld	Manyonyaneni	5
	KaLanga	16
	Lokhayiza	6
	Mahlabaneni	5
	Makhondvolwane	1
	Khalamfene	2
	Mpolonjeni	1
Middleveld	Tikhuba	2
	Deda	8
	Lushikishini	2
	Mabovini	3
	Mhlatane	3
	Cana	1
	Ngwempisi	2
	Sibovu	1
	Velezizweni.	3
Highveld	Sigangeni	14
	Ntfonjeni	7
	Lomshiyo	8
	Sigeledvu	3
	Mshingishingini	3
Total sample		96

3.2 Data Collection

Given the nature of an *ex-ante* study, it was important to incorporate the views of farmers and extension officers. The data were collected from the local producers in the three ecological zones using a structured questionnaire which was administered by the researchers. Data collected from farmers included farm characteristics, socioeconomic characteristics of farmers, awareness and perception of farmers to GM crops. For comparison of gross margins data from South Africa were used. In South Africa, data were obtained from farmers at the Mpumalanga and Limpopo province using a guided questionnaire.

Secondary data were obtained from the Swaziland Cotton Board (SCB) and Produce Marketing Organization (PMO) (National Marketing Board (NAMBoard), National Maize Corporation (NMC)) as well as a desk review of related documents. The Middleveld and the Highveld were used because they are regions conducive for maize production, whilst the Lowveld is conducive for cotton production.

3.3 Limitations

Like any study, this study had the following limitations experienced during the research:

i) At the time of data collection there were no GM crops grown in Swaziland hence the data used to calculate gross margins for GM Maize and Cotton were obtained from SA farmers.

ii) There were no data on soybeans from both countries; as the sampled farmers were not growing soybean; hence the gross margins for soybeans were not computed.

iii) None of the interviewed farmers were irrigating their crops; therefore, the analysis did not cover irrigated crops.

iv) Farmers in South Africa were not cooperating and did not honor the appointments set for the survey i.e. Makhathini farmers. They made promises to invite us during their meeting dates and some never showed up on the set day of meeting.

v) At the time when the research was conducted the country had a draft Biosafety Regulations, which might be different from the final biosafety policy such that recommendations made, might not apply for the final Biosafety regulations.

4.0 RESULTS AND DISCUSSION

4.1 Demographic Characteristics of the Respondents

Table 2 depicts the demographic characteristics of farmers who participated in the study on Swaziland. Almost thirty eight percent (37.5%) of the farmers were from the Lowveld, 36.4% of farmers were from the Highveld and 26.1% were from the Middleveld. Famers in the Highveld and the Middleveld grew only maize except for only 2 farmers in the Middleveld that grew cotton as well. The farmers from the Lowveld grew a combination of maize and cotton. The majority (68.8%) of the farmers were males and were between the ages of 41 to 59 years old (43.2%). Sixty five percent of the farmers were married and about one-third (31.3 %) of them had primary education (Table 2).

Table 2: Demographic Information of the Respondents

Item	Frequency	Percentage (%)
Agro-ecological zone		
Lowveld	36	37.5
Middleveld	25	26.1
Highveld	35	36.4
Total	**96**	**100**
Gender		
Male	66	68.8
Female	30	31.3
Age		
18-30 years	11	11.5
31-40 years	13	13.5
41-59 years	42	43.8
Above 60 years	30	31.3
Marital Status		
Single	15	15.6
Married	62	64.6
Widow	15	15.6
Separated	4	4.2
Level of Education		
Illiterate	11	11.5
Primary	30	31.3
Junior Secondary	23	24.0
Senior Secondary	23	24.0
Sebenta	3	3.1
Tertiary	6	6.3

Source: Survey Data, 2014

Most (62.5 %) of the farmers relied fully on farm income and had no other income as shown in Table 3. About 37 % had other income sources, 47.7 % were self-employed, 30.6% had monthly salary from other jobs, and another 30.6 % had remittances from extended family including pension grants.

Table 3: Farmers with Off-farm Income and other sources

Off-farm income	Frequency	Percentage (%)
No	60	62.5
Yes	36	37.5
Income source		
Monthly salary	11	31.0
Pension and remittances	11	31.0
Self-employment	14	48.9

Source: Survey Data, 2014

4.2 Farm Characteristics

Table 4 shows the farm characteristics and it shows that on average the land size for maize growing farmers was 2.1 ha in the Highveld, 1.8 ha in the Lowveld and 1.2 ha in the Middleveld, while for cotton farmers the average land size in the Middleveld and Lowveld was 3.1 ha and 2.1 ha respectively. The minimum land holding from the three agro-ecological zones was 0.4 ha and 8 ha being the largest observed land holding size, whereas under cotton production, the minimum land holding was 0.5 ha to 7.5 ha as the maximum and 0.4 ha and 4 ha under maize production.

Table 4: Farm Characteristics

Agro-ecological Zone	Average Land Size (ha)
Lowveld	
Maize	1.8
Cotton	2.1
Middleveld	
Maize	1.2
Cotton	3.1
Highveld	2.1
Maize	

Source: Survey Data, 2014

Table 5 shows that a majority (53.8 %) of the farmers had more than 10 years of experience in cotton farming. All the 39 cotton farmers also grew maize and were mostly using family labour for carrying out farming work. However, 26 (53.1 %) of those cotton farmers had more than 10 years' experience in growing cotton. Of the 84 maize farmers, 94% had over ten years maize faming experience, while 2.4% had less than five years' experience.

Table 5: Farming Experience

Farming Experience	Frequency	Percentage (%)
Cotton		
Less than 5 years	10	25.6
Between 5 to 10 years	8	20.5
More than 10 years	21	53.8
Total	**39**	**100.0**
Maize		
Less than 5 years	2	2.4
Between 5 to 10 years	3	3.6
More than 10 years	79	94.
Total	**84**	**100**

Source: Survey Data, 2014

Table 6 shows that a majority (57.3%) of the respondents were using family labour for farm activities, while 33.3% used a combination of family and hired labour. Most (95.8%) of the farmers were using tractors for ploughing and only 4.2 % were using both tractor and oxen.

Table 6: Other Farm characteristics

Item	Frequency	Percentage (%)
Source of Labour		
Family	55	57.3
Hired	9	9.4
Both	32	33.3
Ploughing Method		
Tractor	92	95.8
Tractor and Oxen	4	4.2
Farmer Group Affiliation		
Yes	47	49.0
No	49	51.0
Access of Extension		
Yes	67	69.8
No	29	30.2

Source: Survey Data, 2014

Table 6 further revealed that fifty-one per cent (51%) of the farmers were not affiliated to a farmer group or association or cooperative, and mostly were cotton farmers for ease of collection of produce by the market. Sixty seven (69.8%) of the participants received extension services, government and extension officers assisted maize farmers, while the Swaziland Cotton Board cotton farmers.

4.3 Sources of information on GMO

Farmers who heard or read something about GM crops were also asked about the source of such information (Table 7). The results show that 52.2% of the sampled farmers had heard something about GM crops. The most important sources of information on GM crops was briefs in farmers' workshops (47.9 %). The second most common source was through audio-media (25 %). The third most common source was through newspapers and magazines (16.7%). Other sources that were mentioned included family members (6.2%), and nighbours (4.2%).

Table 7: Farmers' sources of GMO Information

Source of information	Frequency	Percentage (%)
New Paper and Magazines	8	16.7
audio-media	12	25
Farmer's workshop	23	47.9
Family members	3	6.2
Neighbours	2	4.2
Total	48	100

Source: Survey Data, 2014

4.3 Farmers' Awareness and Perceptions on GMOs

Farmers' perceptions and awareness on GMO crops as well as their impact to society were split up into three categories [general perception, social perception and environmental perception (natural resource conservation perception and flora protection perception)], measured by five-point scale statements (1 = "strongly disagree", 2 = "disagree", 3 = "neutral" as midpoint, 4 = "agree", 5 = "strong agree"). Table 8 presents the means and standard deviation of the farmers' perceptions on statements within the general perception category. The overall average from the survey for general perception was 4.1, which reflects that farmers were positive about GM crops and were well informed, since the variation amongst responses was 0.96. Specific statements such as perceived high return on GMO crops, high yield, less labour usage and high seed costs were considered most positive within the general perception.

However, when analysed by ecological zone, the general perceptions on GMOs were more reflective of the farmers' awareness by crop and location. Farmers in the Lowveld were positive about GM crops, with an overall mean of 4.3 and standard deviation of 0.84. Lowveld farmers agreed that GM crops improve crop yield, are less labour intensive, less pesticides usage as well as provide cheaper food for consumers. The results are in line with the findings in literature, which suggests that GMO crops have less labour intensity, while producing high yields from expensive seed. In the Middleveld, famers were slightly positive about GM crops since they had an overall mean of 3.6 and standard deviation of 0.82. The farmers slightly agreed that GM crops will ease the burden of farming through receiving high returns, high yields and cheaper food for consumers. Farmers in the Middleveld agreed that GM crops will contributes to high seed cost. However, farmers in the Highveld recorded an overall mean of 3.51 and standard deviation of 1.07 that suggested that most farmers in the Highveld were slightly positive about the GM crops and had slight idea that GM crops will contribute to high seed cost and less pesticides usage.

Table 8: Perception on Economic benefits of GMO

GENERAL PERCEPTION ON GMOS	**Lowveld**		**Middleveld**		**Highveld**		**Overall**	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Higher returns compared to conventional	4.67	0.65	3.9	0.88	3.40	1.14	4.38	0.87
Higher yield	4.67	0.65	3.9	0.74	4.00	0.71	4.44	0.74
Lower Production cost	3.42	1.54	2.9	0.74	3.40	1.14	3.31	1.37
Less labour intensive	4.73	0.63	3.5	0.97	3.20	1.10	4.31	0.97
Less pesticide usage	4.67	0.65	3.1	0.74	3.60	0.89	4.23	0.95
Cheaper food for consumers	4.52	0.97	3.6	0.70	3.40	1.14	3.46	0.80
High seed cost	3.42	0.79	4.4	0.94	3.60	1.34	4.31	1.04
Overall	***4.3***	***0.84***	***3.61***	***0.82***	***3.51***	***1.07***	***4.06***	***0.96***

Source: Survey Data, 2014

GMO awareness on the social perspective is important as it impacts on the culture, health and time of the growers. Table 9 shows the respondents on some social issues that may prevent the growing and use of GMO crops. Respondents had slight knowledge of GM crops and their effects on society with an overall mean of 3.49 and standard deviation of 1.02. When analyzed by ecological zones, the Lowveld farmers perceived GMO crops as healthy food and requires less time spent on farm management, an overall mean of 3.62 and standard deviation of 1.02.

Table 9: Perceptions on Social benefits of GMO

Social perception on GMOs	**Lowveld**		**Middleveld**		**Highveld**		**Overall**	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Better health	3.21	0.65	3.2	1.03	3.00	0.71	3.19	0.73
Less time spent on farm management	4.45	0.87	3.5	0.85	3.40	1.14	4.15	0.99
Healthier food	3.97	0.98	2.9	0.99	3.00	0.71	3.65	1.06
Unsafe for human consumption	3.18	0.95	2.9	0.88	2.80	0.45	3.08	0.90
No sharing seeds	3.30	1.63	3.6	0.52	3.40	1.14	3.38	1.41
Overall	***3.62***	***1.02***	***3.22***	***0.85***	***3.12***	***0.83***	***3.49***	***1.02***

Source: Survey Data, 2014

Farmers from the Middleveld perceived that GM crops require less time spent on farm management and there is no sharing of seeds. The overall mean for this ecological zone 3.22

with standard deviation of 0.85 that suggests that the famers were almost uncertain on the social benefits of using GM crops. Farmers from the Highveld were also almost uncertain on the social benefits of using GMO crops (overall mean of 3.12, standard deviation of 0.83).

The study further evaluated farmer's perceptions on the impact of GMOs on environment using likert-scale, the study looked (i) Perception on the effect of GMO crops on natural resources, and (ii), Perceptions on the effect of GMOs on flora protection. Table 10 presents the responses for perception on natural resource conservation considerations by ecological zones. The results indicate that respondents slightly agreed (overall mean of 3.88 with standard deviation of 1.03) with the statements on the impact of GMOs on natural resources. They agreed that GM crops reduce pesticides use, allow efficient use of herbicides.

Table 10: Perceptions of farmers on GMO and Natural Resource Conservation

Perception on GMO & Natural resource conservation	**Lowveld**		**Middleveld**		**Highveld**		**Overall**	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
More effecient herbicide use	4.33	1.05	3.40	0.70	3.00	0.00	4.00	1.05
Reduce pesticide use	4.61	0.66	3.00	1.05	3.20	1.10	4.13	1.06
Reduced energy use (less fuel used in field activities)	4.06	0.10	3.20	0.63	2.80	0.45	3.75	1.00
Reduction of CO_2 emissions	3.91	1.07	3.20	0.42	2.80	0.45	3.65	1.00
Overall	**4.23**	**0.72**	**3.2**	**0.7**	**2.95**	**0.5**	**3.88**	**1.03**

Source: Survey Data, 2014

However by ecological zone, Lowveld farmers perceived GMO crops as more environmentally friendly as it requires less herbicide use, less energy used in irrigation as well as reduction in carbon dioxide emissions, with a mean of 4.23 and standard deviation of 0.72. The Middleveld had mean 3.2 and standard deviation of 0.7, reflecting that they were almost uncertain on the impact of GM crops on natural resource conservation. Farmers from the Highveld were in agreement with information on the GM crops interaction with natural resources and conservation because the overall mean is 2.95 and standard deviation is 0.5.

Table 11 shows that local farmers are almost neutral informed about implications of GMO crops on flora protection, since the overall mean is 3.24 and standard deviation of 0.89.

Table 11: Farmers' Perceptions of GMO Crops on Flora Protection

Perception on GMO & flora protection	**Lowveld**		**Middleveld**		**Highveld**		**Overall**	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Reduces crop diversity	3.15	0.91	3.10	0.74	3.20	0.45	3.15	0.83
Contaminates other crops	3.27	0.98	2.90	0.99	3.40	0.55	3.21	0.94
Possibility of super weeds	3.48	1.00	3.00	0.47	3.40	0.55	3.37	0.89
Overall	***3.3***	***0.96***	***3.0***	***0.73***	***3.33***	***0.52***	***3.24***	***0.89***

Source: Survey Data, 2014

Based on the ecological zones on perception of Lowveld farmers on GM crops and flora protection, were almost uncertain (neutral) that GM crops may impact on flora protection since the overall mean is 3.3 and the standard deviation is 0.96. In the Middleveld farmers were neutral on the impact of GMOs on flora protection since the overall mean is 3.0 and standard deviation is 0.73, while in the Highveld, the farmers were slightly above neutral (mean of 3.3) on the impact of GMO crops on flora protection.

4.3.2 Farmers' willingness to grow GMO crops

Farmers were given a chart detailing production characteristics of two crop varieties of maize and cotton, labelled number 1 and number 2, without disclosing which of the two crops is convectional or GMO variety (Appendix 1). Farmers were then asked to choose the cropping characteristics that they would prefer when choosing a seed to grow in their farms. Table 12, 13, and 14 present the farmers' choice of varieties. Table 12 shows that 55.7 % of farmers were willing to use GMO cotton seeds, while 44.3 % of farmers were not willing to change from convectional cotton seed. This is because the majority of them had not heard of the GMO varieties.

Table 12: Willingness of Farmers to Use Cotton seed

Item	Frequency	Per cent
Conventional cotton seed	27	44.3
GM cotton seed	34	55.7
Total	***61***	***100.0***

Source: Survey Data, 2014

Table 13, however shows the willingness of farmers to use GMO for maize seed, and 77 % of the respondents were willing to adopt GMO maize seed while 22.9 % were not willing. Most (40.5%) of the farmers were willing to use GM maize seeds were for the Lowveld. Furthermore, farmers were required to advise on which attributes of crop management should be addressed by biotechnology that would act as an incentive for GMO adoption. Two incentives for growing GMOs were considered; these were affording cost savings in production as well as providing improved crop management flexibility.

Table 13: Willingness of Farmers to Use Maize Seed

Item	Frequency	Per cent
Conventional Maize seed	22	22.92
GM Maize seed		
Middleveld	21	28.4
Highveld	23	31.1
Lowveld	30	40.5
Total	***96***	***100.0***

Source: Survey Data, 2014

Table 14 present the results of farmers who indicated that GMOs provide a cost saving strategy in both maize and cotton farmers. Table 14 shows that amongst the 22 maize farmers who preferred the convectional seed, 54.5% of them were willing to adopt GMO seed if it is provides cost savings on production. Out of the 74 maize farmers who were willing to use GMO seed, 97.3% of them were willing to adopt GMO if it provides cost saving on production.

Table 14: Willingness of Farmers to use GMO Seeds as a Cost saving strategy on Maize and Cotton Production

Incentive		Conventional Maize seed (n=22)	GM Maize Seed (n=74)	Conventional Cotton seeds (n =27)	GM Cotton seed (n=34)
Willingness to grow GMOs if it afforded cost saving	No	45.5	2.7	11.1	0
	Yes	54.5	97.3	88.9	100
Total					

Source: Survey Data, 2014

Table 14 further revealed that amongst the 27 cotton farmers who preferred the convectional seed, 88.9% of them were willing to adopt GMO seed if it results in reduced cost of production. All the 34 cotton farmers who were willing to use GMO seed were willing to adopt GMO if it results in cost savings.

Table 15 presents the results of farmers who preferred GMO maize and cotton provided improved crop management flexibility on both maize and cotton farmers. Table 16 shows that amongst the 22 maize farmers who preferred convectional seed, 50% were willing to use GMO if it afforded them improved flexibility in crop management while for the 74 maize farmers who preferred GMO seeds, 95.9% were willing to adopt GMO if it afforded them improved flexibility in crop management. Table 15 further revealed that amongst the 27 cotton farmers who preferred the convectional seed, 88.9% of them were willing to adopt GMO seed if it provided improved cotton management flexibility. All the 34 cotton farmers who were willing to use GMO seed were all willing to adopt GMO if it provided improved cotton management flexibility.

Table 15: Willingness of Farmers to use GMO Seeds for ease in crop management in Maize and Cotton Production

Incentive		**Conventional Maize seed (n =22)**	**GM Maize Seed (n = 74)**	**Conventional Cotton seed (n = 27)**	**GM Cotton Seed (n =34)**
Willingness if provided greater flexibility in crop management	No	11 (50)	3 (4.1)	3 (11.1)	0
	Yes	11 (50)	71 (95.9)	24 (88.9)	34 (100)
Total		***100***	***100***	***100***	***100***

Source: Survey Data, 2014

4.4 Factors affecting farmers' willingness to grow GMO crops

Factors influencing farmers' willingness to grow GM cotton were identified using the logistic regression technique. The results of the logistic model are presented in Table 16. Using the Cox and Snell R square and Nagelkerke R square the model best fit the data. They explain 54% and 76% of the model respectively. The results indicate that farmers' willingness to grow GM cotton is influenced by age ($p \leq 0.05$), education level ($p \leq 0.10$), access to extension services ($p \leq 0.10$), off-farm income ($p \leq 0.10$), affiliation to farmer organization ($p \leq 0.05$) and experience in growing cotton ($p \leq 0.01$). The coefficient of age is -1.320 and the odd ratio is 0.267, which means holding all other factors constant the likelihood of being willing to grow GMOs is 0.267 times less than that of not willing to grow GMO cotton. This suggest that an increase in age by 1 year will reduces the chances of willing to grow GMO cotton by 73.3% (1-0.267). The results show that as farmers grow older they became reluctant to adopt GM technology.

The odd ratio of education level is 1.947 implying that with one unit increase in education level, the chances of being willing to grow GMOs increases by 1.947 times the chances of not willing to grow GMO cotton. The results show that with one level increase in education, the willingness to grow GMOs increases by 94.7%. This means that the more the farmers get educated, the more willing they are to grow GMOs.

Table 16: Factors Affecting Farmers Willingness to Grow GMO cotton Seed

Variable	**B**	**S.E.**	**Wald**	**Sig.**	**Exp(β)**
Gender	-.050	1.072	.002	0.963	.951
Age	-1.320**	.650	4.127	0.042	.267
Education level	.666*	.379	3.082	0.079	1.947
Farm size	.042	.197	.045	0.831	1.043
Access Extension	1.882*	1.100	2.928	0.087	6.569
Off farming income	-1.653*	.930	3.158	0.076	.192
Affiliation to org	2.155**	.970	4.932	0.026	8.626
Experience cotton farming	2.372***	.628	14.286	0.000	10.719
Marital status	.345	.788	.192	0.661	1.412
Constant	-5.346*	2.858	3.499	0.061	.005
-2 Log Likelihood	44.366[a]				
Cox & Snell R Square	0.542				
Nagelkerke R Square	0.761				

Note: β = logistic coefficient; Wald = Wald statistics; S.E. = standard errors;

Exp(β) = Odds Ratio;

***, **, * indicate statistically significance at the 1%, 5% and 10% levels, respectively.

The odd ratio of access to extension services is 6.569 implying that access to extension service increases the farmers chances of willingness to grow GMO cotton by 6.569 times the chances of not willing to grow GMO cotton. The results show that the improvement in access to extension services improves the farmer's willingness to grow GMOs by 556.9%. The odd ratio of off-farm income is 0.192, and implies that holding all other factors constant the likelihood a farmer being willing to grow GMOs is 0.192 times less than that of not willing to grow GMO. This suggest that a one lilangeni increase in off farm income, is associated with an 80.8% decrease in the chances of farmers' willingness to grow GMO cotton. The odd ratio of affiliation to farm association is 8.626, implying that affiliation to farm associations the chances of famers being willing to grow GMO, are 8.626 times more than the chances of the farmers not willing to grow GMO cotton. The odd ratio of experience for cotton farming is 2.372, suggesting that an increase in farming experience is associated with an increase in the chances of being willing to grow GMO cotton by 10.719 times the chances of not willing to grow GMOs and hence the willingness to grow GMOs increases by 971.9%.

Table 17 presents factors influencing farmers' willingness to grow GM maize seed, the computed -2Log-likelihood is 81.094, suggesting a good model fit. The results indicate that farmers' willingness to grow GM maize is influenced by agro ecological location ($p \leq 0.05$) and access to credit ($p \leq 0.05$). The odd ratio for ecological zone is 0.120 implying that the change in the agro-ecological zone from Highveld, Middleveld to Lowveld increases the chances of the farmers' willingness to grow GMO by 0.120 times that of not willing to grow GMOs. The odd ratio of access to credit is 14.565 implying that increase in the access to credit is associated with the chances of willing to grow GMOs increases by 14.565 times the chance of not willing to grow GMOs. The results show that the access of credit improves the farmers' willingness to grow GM maize crop by 1356.5%.

Table 17: Factors Affecting Farmers Willingness to Grow GMO maize Seed

Variable	B	S.E.	Wald	Sig.	Exp(β)
Gender	.729	.721	1.023	0.312	2.073
Age	-.322	.391	.678	0.410	.725
Education level	.159	.250	.404	0.525	1.172
Farm size	.127	.153	.688	0.407	1.135
Access Extension	-.081	.715	.013	0.910	.923
Off farm income	-.158	.630	.063	0.802	.854
Affiliation	.210	.888	.056	0.813	1.234
Marital status	.779	.652	1.428	0.232	2.180
Experience in maize	.221	.300	.545	0.460	1.248
Agro-ecological zone	-2.124**	.853	6.201	0.013	.120
Credit Access	2.679**	1.100	5.931	0.015	14.565
Constant	1.783	2.783	.410	0.522	5.946
-2 Log likelihood	81.094[a]				
Cox & Snell R Square	0.207				
Nagelkerke R Square	0.314				

Note: β = logistic coefficient; Wald = Wald statistics; S.E. = standard errors; Exp(β) = Odds Ratio; ***, **, * indicate statistically significance at the 1%, 5%, and 10% respectively.

Source: Survey Data, 2014

5.0 PROBLEMS FACED BY FARMERS

5.1 Maize

Drought, pest control, high input cost and theft of produce were the top problems that the maize farmers from the Middleveld are facing. This was a similar case even in the Lowveld, however, unreliable markets and low produce prices was pointed out as the leading problem amongst all the others as shown in Table 18.

Table 18: Problems Faced by Maize Farmers

Problems	Maize Middleveld (%)	Lowveld (%)	Highveld (%)
Drought	95	18	74
Pest control	95	21	3
High input cost	86	18	54
Theft of produce	73	18	26
Unreliable market and low produce price	64	26	34
Delaying tractors	0	3	66
Weed control	0	3	26

Source: Survey, 2014

5.2 Cotton

Table 19 depicts that 51% of the farmers indicated pests control as the most problem faced by cotton farmers as well as drought (49 %).

Table 19: Problems Faced by Cotton Farmers

Problems	Cotton (%)
Pest Control	51
Drought	49
Unreliable market and low produce price	33
High input costs	31
Delaying tractors	10
Weed control	8
Low yields	3
Poor seed quality	3

Source: Survey, 2014

The farmers reported to have spent so much money on pesticide, but no results this was for the control of mealy bug that attacked the fields and are persistent in the field from year to year attacking the stems and drying the crop. Drought as expected was also the top common problems faced by farmers especially in the Lowveld. Some of the farmers stated that drought forced them to stop growing maize completely and concentrate on cotton growing, as it is a drought tolerant crop, hence obtain better yield compared to maize.

6.0 GROSS MARGINS ANALYSIS

Table 20 presents the average land holding cultivated for each crop, the average yield per holding as well as the average price for the maize and cotton observed in the study. Cotton farmers grew an average of 2.26 ha and yield of 535.56 kg on average, while maize farmers grew 1.94 ha on average and obtained yield of 1400.89 kg in Swaziland. The price received per kilogram of cotton was E6.12 and for maize was E2.33 per kilogram.

Table 20: Average Production Results from Farmers in Swaziland

ITEM	CROP
COTTON	
Average land size (ha)	2.26
Average yield (kg/ha)	535.56
Average price (E/kg)	6.12/kg
MAIZE	
Average land size (ha)	1.94
Average yield (kg/ha)	1 400.89
Average price (E/kg)	2.3264

Source: Survey, 2014

Maize price per tonne in Swaziland and South Africa were almost similar in 2014, as it was at E2, 326 per tonne and E2, 400 per tonne respectively. A tonne of cotton was E 6, 117.10 in Swaziland and E6, 200 per in South Africa.

The average variable costs of producing maize and cotton are presented in Table 21. In cotton, the cost for labour was the highest, accounting for 11.4 % of the average revenue per hectare, while chemicals follow at 10.4% of revenue and thirdly was land preparation with 6.5% of revenue. For maize, the cost of labour was also the highest with 35% of the average revenue per hectare, while fertilizer follows at 14.8% of revenue per hectare, and seeds were third with 14%

of revenue per hectare. The average gross margin for cotton per ha was E2, 096.39 and E718.91 for maize per hectare, which is 64.2% and 22.1% of total revenues respectively.

Table 21: Average Gross Margins per ha for farmers in Swaziland

ITEM	COTTON	MAIZE
Average Yield [kg]	535.56	1400.89
Average Price [E/kg]	6.12	2.3264
Average Total Revenue	**3 267.48**	**3 259.03**
Operating Costs		
Land Prep	212.66	354.08
Seeds	205.83	459.15
Fertiliser	27.74	483.67
Chemicals	340.68	76.90
Transport	12.77	24.94
Labour	371.41	1141.38
Average Total Operating Costs	**1 171.09**	**2540.12**
Average Gross Margin	**2 096.39**	**718.91**
% of Gross Margin	**64.2**	**22.1**

Source: Survey Data, 2014

Table 22 presents the gross margins for cotton farmers in Swaziland and South Africa. The gross margins for Swaziland was calculated based on literature from the Swaziland cotton Board and also from the surveyed farmers. The gross margin was also calculated based on the two agro-ecological zones (Middleveld and Lowveld). The yield obtained in each area varies across the two countries since both countries grow different seed varieties; GM and non-GM varieties and varying climatic conditions. The gross margin percent to the total revenue in South Africa is at 56.3% while the gross margin percentage to total revenue for the Swaziland surveyed cotton farmers is at 64.2% against 23.7% based on literature. The reason could be the yield differences in both areas, where farmers in Swaziland harvest 30.5% of what is observed in South Africa and the Swaziland Cotton Board projected the cotton yield to be 75.6% of SA yield/ha. The main cost driver of the surveyed cotton farmers is labour cost at 11.4% of total revenue followed by chemicals cost at 10.4% of total revenue.

Table 22: Cotton Gross Margins per Hectare by Farmers in Swaziland and South Africa

Items	Middleveld	Lowveld	Sampled Famers	Swaziland*	South Africa
Av. Yield (kg)	597.91	492.80	535.56	1327.72	1757.06
Total Revenue	**3, 659.21**	**3, 015.94**	**3, 267.48**	**8, 125.65**	**10, 893.75**
Operating Costs					
Land Prep	146.77	278.55	212.66	900.00	1,566.67
Seeds	249.19	162.46	205.83	240	555.00
Fertilizer	0.00	27.74	27.74	2124.00	760.00
Chemicals	379.03	302.32	340.68	315.20	220.00
Transport	0.00	12.77	12.77	0	500.00
Labour	69.68	673.15	371.41	2,625.00	1,132.33
Rent	0	0	0	0	0
Packaging	0	0	0	0	30.00
Total Operating Costs	**844.67**	**1, 456.99**	**1, 171.09**	**6,204,82**	**4,764.00**
Gross Margin	**2,814.54**	**1, 558.95**	**2,096.39**	**1,920.83**	**6, 129.75**
% of GM to revenue	**76.9**	**51.7**	**64.2**	**23.6**	**56.3**

Source: Survey Data, 2014

**sourced from Swaziland Cotton Board, 2013.*

However by agro-ecological zone, the gross margins percentage to the total revenue is higher in Middleveld at 76.9%, while at the Lowveld the gross margins percentage to the total revenue was at 51.7%. The differences in the gross margins percentage to the total revenue is attributed to the difference in the yield among the two agro-ecological zones in Swaziland. The Middleveld yields were 34.3%, Lowveld yields were 28% of the total yield per hectare in South Africa. The main cost driver in the Middleveld and Lowveld were chemicals and labour respectively, that accounted for 10.4% and 22.3% of total revenues respectively. Seeds at 6.8% in the Middleveld and chemicals at 10% of total revenue were the second highest costs in the two regions. Reducing chemical expenses and labour cost such as the elimination of sprays for bollworm due to adoption of insect resistant cotton varieties will inevitably affects the chemical cost, amount of labour and distance walked during the spraying activities. The adoption of HT cotton varieties will also reduce labour cost for weeding since the HT variety allows for minimum tillage.

6.1 Frequency distribution of Cotton Gross Margins

Table 23 shows that farmers in the middleveld veld had a gross margin of E2401 to 3600 per ha. In the lowveld 10% had negative gross margins and most (16.3%) had gross margins of E1201 to E1800 per ha.

Table 23: Frequency distribution of Cotton Gross Margins per Hectare for the ecological zones in Swaziland

	Middleveld (N =2)		**Lowveld (N = 37)**		**Swaziland (N =39)**	
GM Level (E)	**No**	**%**	**No**	**%**	**No**	**%**
< 0	0	0	4	10.8	4	10.3
0-600	0	0	4	10.8	4	10.3
601-1200	0	0	4	10.8	4	10.3
1201-1800	0	0	6	16.3	6	15.4
1801- 2400	0	0	4	10.8	4	10.3
2401- 3000	1	50	3	8.1	4	10.3
3001- 3600	1	50	2	5.4	3	7.6
3601- 4200	0	0	4	10.8	4	10.3
4201- 4800	0	0	3	8.1	3	7.6
4801-5400	0	0	0	0	0	0
5401-6000	0	0	0	0	0	0
>6000	0	0	3	8.1	3	7.6

Table 24 presents the gross margins for maize farmers in Swaziland and South Africa. The gross margins percentage for Swaziland is at 22.1%, lower than the South African gross margin percent at 43% of the total revenue. This is contributed by the yield obtained in Swaziland that is

24.4% of what is observed in South Africa. The main cost driver of the surveyed maize farmers is labour cost at 35% of total revenue followed by fertilizer cost at 14.8% of total revenue.

Table 24: Maize Gross Margins per Hectare by Farmers in Swaziland and South Africa

Items	**Highveld**	**Middleveld**	**Lowveld**	**Average Sampled Farmers**	**South Africa**
Av. Yield (kg)	2, 282.61	1, 417.66	627.75	1, 400.89	5, 750.00
Total Revenue	**5, 157.12**	**3, 293.54**	**1, 506.61**	**3, 259.03**	**9, 775.00**
Operating Costs					
Land Prep	290.87	511.08	260.29	354.08	2,500.00
Seeds	697.61	470.82	209.02	459.15	555.00
Fertilizer	819.33	592.10	39.59	483.67	1,520.00
Chemicals	146.26	76.50	7.93	76.90	0
Transport	37.91	11.98	0	24.94	0
Labour	2, 008.61	1, 165.01	250.53	1,141.38	996.67
Total Operating Costs	**4, 000.59**	**2, 827.49**	**767.36**	**2,540.12**	**5,571.67**
Gross Margin	**1, 156.53**	**466.05**	**739.23**	**718.91**	**4, 203.33**
% of GM to revenue	**22.4**	**14.2**	**49.1**	**22.1**	**43.0**

Source: Survey Data, 2014

However by agro-ecological zone, the gross margins percentage to the total revenue is higher in the Lowveld at 49.1%, followed by the Highveld at 22% while the Middleveld has the lowest gross margins percentage to the total revenue at 14.2%. The differences in the gross margins percentage to the total revenue is contributed by the difference in the yield among the three agro-ecological zones in Swaziland. The Lowveld yields were 10.9%, Highveld yields were 39.7% and Middleveld yields were 24.7% of the total yield per hectare in South Africa. The main cost driver in the three agro-ecological zones was labour cost followed by the land preparation cost for Lowveld, fertilizer cost for Highveld and Middleveld. The labour cost for Highveld, Middleveld and Lowveld was 38.9%, 35.4% and 16.7% of total revenues respectively. Fertilizer cost is at 15.9% and 18% of total revenue were the second high cost in the Highveld and Middleveld respectively. Land preparation cost is at 17.3% of total revenue for the Lowveld.

Frequency distribution of Maize Gross Margins

Table 25 shows that a majority of farmers (60%) in the middleveld had gross margins of less than zero, 40% in the Highveld and 36.1% in the lowveld had less than zero gross margins respectively. About 26% of farmers in the Highveld had GM between 0 and 600, whilst there were 36% in the lowveld and only 12% in the middleveld. Only the middleveld had farmers (8%) with GM above 6000.

Table 25: Frequency distribution of Maize Gross Margins per Hectare for the ecological zones in Swaziland

	Highveld (N =35)		Middleveld (N = 25)		Lowveld (N =36)	
GM Level (E)	**No**	**%**	**No**	**%**	**No**	**%**
< 0	14	40	15	60	13	36.1
0-600	9	25.6	3	12	13	36.1
601-1200	2	5.7	2	8	3	8.3
1201-1800	3	8.6	0	0	2	5.6
1801- 2400	2	5.7	0	0	1	2.7
2401- 3000	1	2.9	2	8	2	5.6
3001- 3600	0	0	0	0	2	5.6
3601- 4200	2	5.7	0	0	0	0
4201- 4800	1	2.9	1	4	0	0
4801-5400	1	2.9	0	0	0	0
5401-6000	0	0	0	0	0	0
>6000	0	0	2	8	0	0

7.0 IMPLICATIONS FOR GROWING GMO CROPS

7.1 Financial Implications for growing GM crops versus non-GM crops

7.1.1Pesticide and Herbicide use

Insect resistant GM (in the case of Bt seed type) crops provide their own protection against pests and therefore, reduce the need for pesticides. Whilst, herbicide tolerant (in the case of HT type) crops allow the use of relatively inexpensive broad spectrum herbicides which effectively control most weeds affecting the crop (Acworth, Yainshet & Curtotti, 2008). This allows farmers to replace previous mixes of expensive and weed specific herbicides, thereby reducing the expenses in pesticide and herbicides. However, one of the farmers consulted in SA, stated that the larger the cultivated farm the more likely that they use herbicides for weed control, hence less expenses on labour. The findings suggest that the cost for chemicals (pesticides) in cotton production in Swaziland and South Africa was at 10.4% and 22.3% of total revenue respectively. The findings further suggest that the cost of chemicals in maize production in Swaziland and South Africa was at 2.4% and 0% of the total revenue respectively.

7.1.2 Farm management and labor savings

Managing genetically modiefied crop production is deemed to be generally easier and less time consuming than non-GM crop production. GM crops reduce the number of annual sprays required and enable minimum-tillage or non-tillage cropping, therefore, reducing labour, machinery and fuel costs (Acworth *et al*, 2008). Farmers from Matlerekeng stated that the larger the cultivated land, the more likely they would use mechanization to do farm-activities (planting, weeding, etc.). However, when it is small, they hire farm workers. The labour cost in cotton production for Swaziland and South Africa was at 11.4% and 10.4% of total revenue respectively, whilst in the maize production the labour costs in Swaziland and South Africa were at 34% and 10.2% of total revenue respectively.

7.1.3 Seed prices, technology fees and user agreements

Farmers opting to grow genetically modified crops are likely to face additional costs in terms of higher seed prices since they have to buy new seed each planting season. According to Acworth *et al* (2008*)*, higher GM seed prices and the imposition of technology fees to users, largely based on the area of land planted to GM crops increase the cost of using GM seed compared with non-GM seed. In South Africa the price of seed was more than two times that of non-GM seed in Swaziland.

7.2 Socio-Economic implications for Growing GM crops in Swaziland

7.2.1 Government support on policy and regulation

In order to have a viable agriculture sector that incorporates genetically modified crops, there is a need to have a guiding Act, policies, and regulations guiding the whole biotechnology industry and such regulations should be enforceable by law.

7.2.2 Research and development from public and private sector

The performance of transgenic crops depends heavily on the local suitability of the varieties into which the gene constructs are inserted. Therefore, well established research community is necessary to carry out the assignment efficient and effectively. This means government and the private sector should provide well equipped laboratories and well trained human resources for the industry.

7.2.3 Training and awareness campaigns

Technology providers and the government should provide training for extension officers and farmers on how to manage GM crops from planting to marketing. Farmers are expected to have refuge crops to minimize pollution and contamination with non GM crops and plants.

GM crops require a separation distance of up to 1000m away from non-GM crops, depending on crop type, to avoid cross pollination which may temper with purity of non-GM gem-plasma. However, in a community where settlements are marked by close neat of households to fields and livestock pastures, such a desired distance may not be possible to observe as such buffer zones may interfere with boundaries as well as reduce the amount of land later remaining for GM crop farming as the average holdings are less than 2 hectares.

7.2.4 Implication on household food security

Cultivated fields in Swaziland contribute to household food security way before the crop is harvested through the consistent supply of indigenous herbs that are used as household food i.e. *vegetable jute*, *amaranthus*, *Black Jack* and help alleviate the food imbalance prior to the harvest season. These herbs are nutritious and marketable and some vendors always look forward to the income surplus from harvests during the thinning and weeding period. With GM crops herbicide tolerant, the growth of such herbs can be compromised hence the incomes thereof and as food source.

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Appendix

Cost Benefit Analysis of Living Modified Organisms (LMOs) in Swaziland

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Questionnaire number: ______________ Date of interview: ________________________

Name of Area:____________________ Farmer's family name: ___________________

Farmers contact details: _________________

Circle (….) the letter that indicates the option selected by the respondent.

Section 1: Farm Characteristics

1. Please give the agro-ecological zone where your farm is located.
   a. Highveld b. Middleveld
   c. Lowveld d. Lubombo

2. Please indicate your nearest RDA……………………………………………..
3. Do you have access to extension service?
   a. No b. Yes

4. If yes, please state the services received.
   a. Technical assistance b. Market information
   c. Industry update d. Market linkage

5. Please indicate your tenure system.
   a. SNL b. TDL

6. What is your farm size?..
7. What other crops do you grow?
   a. Cotton b. Maize
   c. Soy beans d. Other legumes
   e. Vegetables f. Sorghum and other corns
   g. Soya beans

8. How long have you been involved in the Maize/Cotton/Soya beans business?

	Maize	**Cotton**	**Soy beans**
a. < 5yrs			
b. >5<10 yrs			
c. > 10yrs			

9. What was your motive of venturing into farming production?
   a. Subsistence purposes b. Commercial purposes
   c. Hobby d. Other (specify)___________________________

10. State the reason for growing **<u>each</u> crop** specified?

Crop/Purpose	Income generation	Consumptions	Others
Cotton			
Soy beans			
Other Legumes			
Maize			
Sorghum			
Vegetables			

11. What is the area under cultivation of each crop (ha)?
    a. Cotton_____________________ ha
    b. Soy beans___________________ ha
    c. Maize______________________ ha
    d. Sorghum____________________ ha
    e. Vegetables___________________ ha
    f. Other legumes_________________ha

12. What do you use to plough the land on which the crops are grown?

____

____

13. If you use hired tractor, how much does it cost per hour?

....

14. How many tractor hours does it take to plough the following crops?

Crop	**tractor hours (hours)**	**Oxen**	**Others**
Cotton			
Maize			
Soya beans			

15. What is your source of labour?

a. Family members   b. Hired labour   c. Both

16. If using family labour, state **numbe**r of the composition of the team

Labour composition	**Numbers**
Men	
Women	
Children:	Boy: Girls:
State age of children	

17. Please fill the table below:

Activity	**No. of people**	**Total days**	**Hours per day**	**Daily rate (E)**
Planting				
Weeding				
Top dressing				
Spraying				
Pest control				
Harvesting				
Total man-days				

18. If you use both oxen and tractor for plot preparation, please indicate the plot size allocated to each technology.

Land size ploughed by oxen (ha)......................................

Land size ploughed by tractor (ha)...................................

Total land size ploughed (ha)..

19. If you used own tractor, what was the fuel cost for cotton/maize/soya beans?

Maize__________________

Cotton________________

Soy beans______________

20. Do you irrigate your crops?

Cotton ____ Yes____ No

Maize _____ Yes____ No

Soya beans __ Yes ___ No

21. Please fill the table below;

Type of Crop	**Cultivated area (ha)**	**Harvested yield (kg)**	**Quantity sold (kg)**	**Selling price per unit**	**Market where output was sold**
Maize					
Cotton					
Soya beans					

22. To support your answer, please fill the table below the costs and benefits of farming using information from the last production season.

Activity	**Maize**	**Cotton**	**Soya beans**
Land preparation (E)			
Seeds (E)			
Fertilizer (E)			
Chemicals(E)			
Labour (E)			
Transport (E)			
Irrigation (E)			
Total costs (E)			
Revenue (E)			
Profit/loss(E)			

23. What problems do you encounter with maize/cotton production in your area?

Problem	**Maize**	**Cotton**	**Soya beans**
Insect pests and diseases			

Drought			
Theft			
High input costs			
Unreliable market			
Low produce price			
Other (specify) _______________			

24. Please suggest ways of improving crop production in Swaziland.

Problem	**Maize**	**Cotton**	**Soya beans**

25. Do you keep livestock : Yes________________ No ______________

26. If yes, state which type.

Cattle	
Sheep	
Piggery	
Goats	
Other_______________	

Section 2: AWARENESS AND KNOWLEDGE ABOUT GMOS

27. Have you heard about modern biotechnology/GMOs?

a. Yes b. No

28. If yes, state where you heard about GMOs.

a. News paper____________________________
b. Television______________________________
c. Magazine______________________________
d. Farmer's workshop______________________
e. Other (specify)____
f. N/A

29. If yes, what is your understanding of GMOs?

____
____
____
____
____
____
____

NB: The following section is for the respondents who have indicated knowledge about GMOs

Section 3: PERCEPTION ABOUT GM CROPS

A. **Economic perceptions about GMOs**

Statements on GMs	**Strongly Agree (1)**	**Agree (2)**	**Don't know (43**	**Dis- Agree (4)**	**Strongly Disagree (5)**
Higher returns compared to the conventional crops					
Higher yield volumes received compared to conventional crops					
Lower production costs compared to conventional crops					
Less labour intensive compared to conventional crops (herbicide usage)					
Less pesticides usage					
Development of a biotech industry					
Cheaper food for consumers					
Profits for biotech industry					

High seed costs compared to conventional seeds					

B. Social perception about GMOs

Statements on GMs	**Strongly Agree (1)**	**Agree (2)**	**Don't know (3)**	**Dis- Agree (4)**	**Strongly Disagree (5)**
Food with added nutrients					
Food with built-in vaccines					
Better health					
Less time spent on farm management					
Healthier food as less chemicals used					
Unsafe for human consumption					

Reduces social responsibility of sharing seeds among relatives					

C. **Environmental perception about GMOs**

Statements on GMs	Strongly Agree (1)	Agree (2)	Don't know (3)	Dis- Agree (4)	Strongly Disagree 5)
Affect the bio-system					
Reduce crop diversity					
Contaminates other crops					
Less irrigation required					
More efficient herbicide use					
Reduced pesticide use					
Reduced energy use through less fuel used in field activities					
Reduction in Carbon dioxide emissions					
Possibility of super bugs and super weeds appearing					

Section 4: Willingness to Grow GMOs

Answer 1 or 0 to the following.

A. Would you use GM crop if they afforded you **cost savings** over conventional crops/Seed?

YES/NO____________

B. Would you use GM crops if they provided greater flexibility in crop-management practices i.e. pesticides?

YES/NO ________________

Section 6: Socio-economic characteristics

30. Please indicate your Age:

a. 18-30 years	b. 31-40 years

c. 41-59 years	d. Above 60 years

31. Sex: a. Male	b. Female

32. Marital Status:

a. Single	b. Married

c. Widow/widower	d. Separated

e. Cohabiting/ Consensual

33. What is the highest educational level you hold?

a. Primary level	b. Junior Secondary level

c. Senior Secondary level	d. Tertiary level

d. Sebenta / adult education	f. Illiterate

g. Other: specify......................................

34. Do you have any source of off-farm income?

a. No	b. Yes

35. If yes, what is the source of your off-farm income?

a. Monthly salary	b. Self-employment (other than farming)

c. Remittances	d. Any other (specify)…………………………

e. N/A

36. If yes in Q9, please indicate your off-farm income bracket per month.

a. E100.00-E499.99 b. E500.00-E999.99

c. E1, 000.00 -E4, 999.99 d. E5, 000.00-E10, 000.00

e. Above E10,000.00 f. N/A

37. Are you a member of a farming group or organization?

a. No b. Yes

38. If yes in 36, please specify the name of the group (s).

a. ____

____

b. N/A

39. What services/benefits do you receive from the group/organization (s)?

a. Access to credit b. Access to markets

c. Technical information d. All of the above

e. All of the above f. N/A

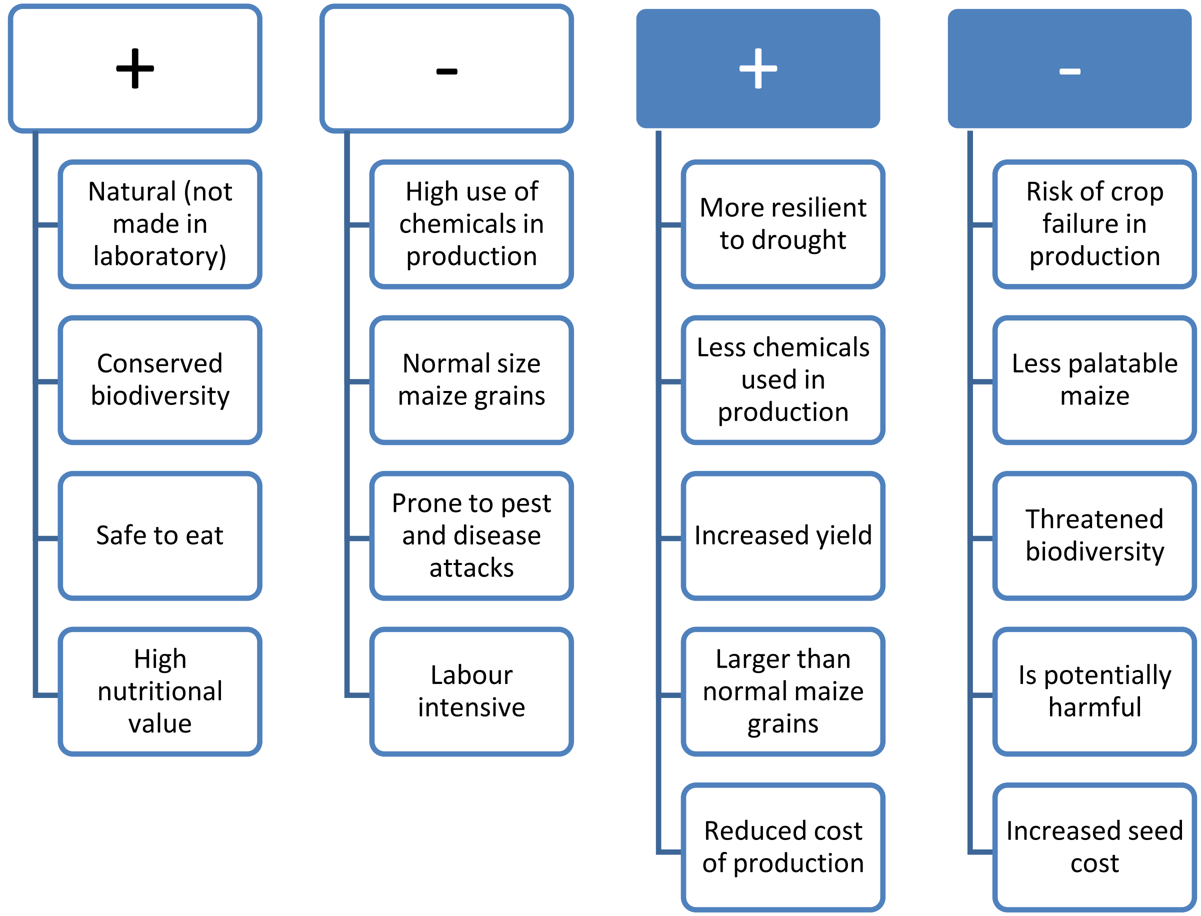
Please indicate which Maize would you prefer to grow, Maize 1 or Maize 2?

____

Give reason/s for your

selection:____

Maize 1 **Maize 2**


+
Natural (not made in laboratory)
Conserved biodiversity
Safe to eat
High nutritional value
-
High use of chemicals in production
Normal size maize grains
Prone to pest and disease attacks
Labour intensive
+
More resilient to drought
Less chemicals used in production
Increased yield
Larger than normal maize grains
Reduced cost of production
-
Risk of crop failure in production
Less palatable maize
Threatened biodiversity
Is potentially harmful
Increased seed cost

Please indicate which Cotton would you prefer to grow, Cotton 1 or Cotton 2?

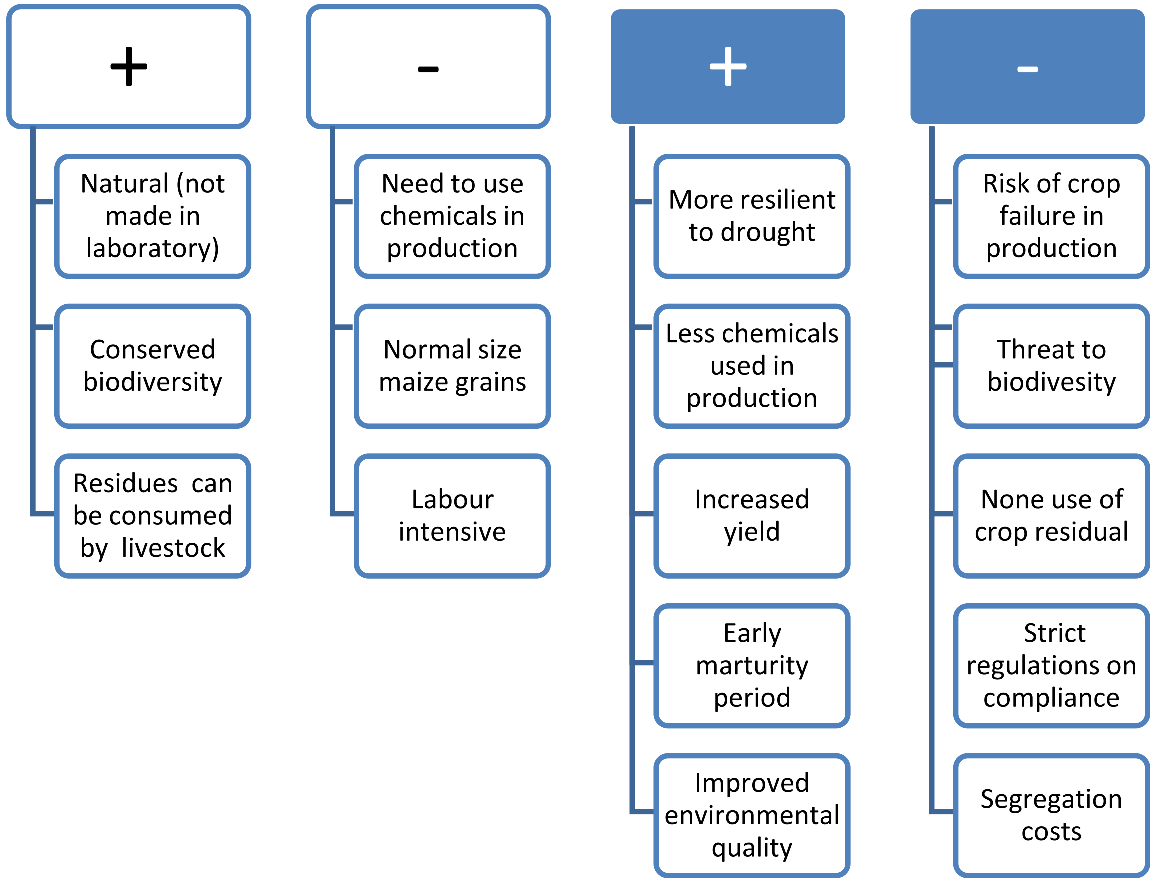
____

Give reason/s for your

selection:____

Cotton 1

Cotton 2



Please indicate which Soy Bean would you prefer to grow, Soy beans 1 or Soy beans 2?

____

Give reason/s for your

selection:____