BT MAIZE FOR SMALL SCALE FARMERS : A CASE STUDY

Maize is South Africa's most important field crop, and white maize is the staple food for the major part of the population. Yellow maize is mainly cultivated for animal consumption. Maize contributes approximately 35% to the gross value of field crops, and the average annual gross value of maize for the past five years amounts to R5481 million. Over the past five years, a swing towards the production of white maize has taken place. The present ratio of production is 71% white and 29% yellow maize.

During 2003/04, the commercial sector planted an estimated 3 204 110 ha of maize and of this area 2 123 890 ha were white maize and 1 080 220 ha were yellow maize, respectively. The maize crop was estimated at 9 710 070 tons, with an estimated yield of 3,33 t/ha.

The area planted to maize by the small farming sector for 2003/04 was estimated at 360 810 ha, consisting of 281 890 ha white maize and 78 920 ha yellow maize. The expected production was estimated at 228 070 tons, 170 890 tons of white maize and 57 180 tons of yellow maize. Maize grown by this sector is mainly for own use.

Maize production in South Africa is hampered by a number of factors but one of the most important is pests. The major pests of maize in Africa are stalk boring insects and viruses. Stalk borers are mainly African species that have moved over to maize from related grasses. The most important of these are the maize stalk borer, *Busseola fusca*, and the sorghum stem borer, *Chilo partellus*.

Maize stalk borer moths lay their eggs between the leaf sheaths. After about nine days the eggs hatch and the young caterpillars make their way up the plant to fed on the young unfurled upper leaves. These feeding caterpillars produce irregular holes that become visible when the leaves unfold. The older caterpillars move down in the stalk of the plants, usually finishing up one to a stalk. Maize stalk borer moths also lay their eggs on the tender growth in the cobs and the enveloping leaves. Considerable damage is caused to the cob and young seeds. As the caterpillars grow they may invade adjoining plants while others make their way into and down the stalks of the plants th are on, feeding as they go.

Depending on the severity of infestation, stem borer damage may reduce yields by 10% to 45%. Furthermore, damage to the cob creates conditions suitable for secondary fungal infection that in turn can lead to the production of mycotoxins - fungal toxins that are known to cause adverse medical problems in people that consume the contaminated product [5, 12, 13, 14, 15, 20, 21]

WHAT IS *Bt*?

Bt is the term commonly used to indicate proteins extracted from a bacterium (called *Bacillus thuringiensis*) which is present naturally in the soil worldwide. A unique feature of this bacterium is its production of crystal-like proteins that selectively kill specific groups of insects. These bacterial proteins have been used for over 40 years as spray-on insecticides by both conventional and organic farmers. The *Cry* 1 Ab protein, for example, provides excellent protection against stalk borers and other moth and butterfly caterpillars. While effectively targeting specific insects, the *Bt* proteins have no affect on other insect families, birds, fish, reptiles or mammals, making them a very environmentally friendly alternative to broad spectrum chemical insecticides.

Bt MAIZE

Bt maize is conventional maize that has been genetically modified to be insect tolerant using biotechnology techniques. It offers significant advantages as a pest management tool to be used for countering the effects of the stem borers. The crop has the additional benefit of offering safer food and feed. The *Cry* 1 Ab protein produced in Bt maize provides season-long protection against stem borers. The *Cry* 1 Ab gene has the potential to increase maize production by up to 35 million t and decrease losses by half, from 9% to 4,5% worldwide). The *Cry* 1 Ab protein provides effective control of several of the primary pests of maize, principally the stalk borers, and intermediate control for other caterpillar pests including armyworm and earworm.

GM MAIZE IN SOUTH AFRICA

South Africa has officially approved GM yellow maize for animal feed and white maize for human consumption under the GMO Act 15 of 1997.

There are approximately 3 million communal or subsistence farmers and their dependents rely on maize for their survival. However, most small-scale farmers do not control stalk borers because:

- The damage caused by the caterpillars is hidden and difficult to detect;
- Heavy infestations are unpredictable;
- Checking the fields multiple times each summer takes time and skill
- It is difficult to time spraying in windy and wet conditions;
- The high costs of conventional and organic chemical treatment.

Small-scale farmers that do spray, often risk exposure to the chemicals because they use unsuitable equipment and/or fail to use protective clothing. GM maize provides a new management tool for small-scale farmers and has the potential to increase yields where stalk borer is a problem and thus decrease the need for chemical applications [10,18,19]

CONSUMPTION

The local commercial consumption requirements for white maize is approximately 4,2 million tons, of which about 80% is used for human consumption. The local commercial consumption requirements for yellow maize is approximately 3,3 million tons. Most yellow maize (80%) is sold for animal consumption and for use in the manufacturing of animal feeds. However, during times of white maize shortages, yellow maize may be mixed with white maize for human consumption. Maize is the most important consumer product in South Africa with a per capita consumption of more than 92 kg/person/year.

ADVANTAGES

In developing countries, the production of Bt maize offers the following advantages:

- Pest damage is significantly higher in developing countries because of more intensive infestations and overlapping generations therefore effective pest control is a major factor in efficient crop production.
- Depending on the intensity of infestation, two or more insecticide sprays may be required to control stalk borer damage. With *Bt* maize there is a significant reduction in pesticide use.
- Increased yields with *Bt* maize are significantly higher in developing countries although the average yield may be lower;
- *Bt* maize is more suitable for small farmers because it does not require the equipment, knowledge and information required for insecticide applications. It also reduces the farmers exposure to chemical pesticides.

mycotoxin levels are significantly higher in developing countries, the use of Bt maize to lower mycotoxin levels is important [17].

- Increased yield directly affects food security and food/feed safety. Increased income from higher yields contributes to the alleviation of poverty in those cases where the need is the greatest.

DEVELOPMENTS

It is expected that the use of Bt maize will continue to grow in the traditional markets such as the US, Canada, Argentina, South Africa, Spain, Philippines and Honduras. In South Africa the area planted to Bt maize increased from 6 000 ha in 2001 to 84 000 ha in 2003 [9]. This trend is expected to continue into 2005.

Subject to regulatory approval markets will also open in China, India, Indonesia and Brazil. In Africa, Egypt, Kenya and Nigeria are expected to start growing *Bt* maize in the near future. In Europe, France, Italy and Germany could benefit from *Bt* maize but political considerations have so far prevented further progress. In Spain, *Bt* maize has been an unqualified success and the area under *Bt* maize will continue to expand.

ECONOMIC BENEFITS TO FARMERS

Presented here are the results of demonstration trials conducted in different provinces in South Africa. In the 2003/2004 season, demonstration plots of GM and conventional maize were planted at Potchefstroom (North West Province) and Zuurbekom (Gauteng Province) under conditions similar to those available to small-scale farmers (Table 1). At Potchesfstroom, plants displaying symptoms of moisture stress were irrigated while plants at Zuurbekom were dependent upon rainfall for moisture.

Table 1. Results of field trials with *Bt* white maize in South Africa

	Potchefstroom (Irrigated)	Zuurbekom (Dryland)
Yield (kg/ha)		
Bt	12110	1360
Non-*Bt*	8950	1070
Yield increase	3160 (35%)	290 (27%)
% Cob damage		
Bt	0.9	0.7
Non-*Bt*	18.6	8.5

YIELD ADVANTAGE

Bt maize has a yield advantage over non-*Bt* maize ranging from 27% to 35%, depending on the conditions of cultivation. At Potchefstroom where the maize was cultivated under irrigation the *Bt* maize showed an average yield of 12 110 kg/ha compared to 8 950 kg/ha of the non-*Bt* maize. This means a 35% yield advantage of the *Bt* cultivar. At Zuurbekom, where the maize was cultivated under dryland conditions, the *Bt* maize out-yielded the non-*Bt* maize by 290 kg/ha for yield advantage of 27%.

REDUCED MYCOTOXIN LEVELS

Damage to maize tissue by stem borers allows fungi, particularly *Fusarium* species, to colonise the damaged tissue leading to stalk and cob rots and the accumulation of harmful mycotoxins. Fungal infection can result in degraded and toxic grain that contributes to food and feed safety hazards. Studies in France, Spain and Italy with *Bt* maize have shown that there was a significant reduction in the damage caused to the cobs by stem borers and a corresponding reduction in the amount of tissue infected by *Fusarium* [2, 6, 17].

Lower mycotoxin levels are of particular significance to maize [illegible] developing countries with warm and humid climates that are conducive to the accumulation of these toxic compounds. Inadequate storage conditions increase the problem leading to losses as a result of contaminated grain that fails to meet food and feed standards. Rejection of grain as food leads to downgrading and a lower of price; rejection as feed leads to major economic loss.

It is largely unknown that the level of fumonisin mycotoxin contamination of maize has been reduced by up to 93% with the reduction in insect damage and therefore decreased fungal spore infections, realised by the introduction of European Corn Borer resistant *Bt* maize [16]. This reduction in fumonisin levels has direct safety benefits to humans and animals because those mycotoxins are some of the most noxious substances on crops, resulting in ailments from liver cancer to brain damage. Most consumers are also unaware of the significant reduction in the use of chemical insecticides [4].

ECONOMIC ADVANTAGE

Significant economic benefits are derived from increased yields and reduced pesticide applications.

Table 2: Cost of planting *Bt* maize (in Rands)

Item	Conventional maize	GM. maize
Seed cost per hectare*	210	280
Insecticide cost (2 x R40)	80	none
Application cost (tractor)	80	none
Crop yield value**	3900 (3 tons)	4290 (3.3 tons)
Gross profit	3530	4010

- *Based on an average seeding rate of 12 kg/ha, average yields of 3 tons/ha and an average grain price of R1300/ton.
- ** An average yield increase of 10% is used. If conventional maize is not treated against stalk borer attack yield losses could range from 20 to 80%.

In a study of the economic impact of biotechnology in EU agriculture using the example of transgenic *Bt* maize [3], it was found that GM maize is able to control maize stalk borers that cause economically important damage to maize grown in Spain. Since 1998, Spain has grown the GM maize variety Compa CB commercially on about 25 000 ha, annually. During the 6-year period 1998-2003, the authors estimated a total welfare gain of 15.5 million euros from the adoption of *Bt* maize, of which Spanish farmers captured two thirds and the seed industry one third.

In Argentina, where *Bt* maize comprises about 50% of the 3 million ha of maize grown in the country, 79% of the benefits accrued to the input provider (sale of seed) and 21% to the farmer (increased production) [7].

In a survey of Argentina farmers on the direct benefits of growing GM crops 65% of respondents mentioned the reduction in production costs, 63% that GM crops were easier to work with than the conventional counterpart and 50% the increased yields. Indirect benefits mentioned were greater crop yields available for export, increased employment in the agricultural sector and environmental benefits [1,7].

SAFETY OF *BT* MAIZE

Bt maize has been grown internationally for over seven years [8]. It is officially approved for cultivation in the United States, Canada, the European Union, Argentina and South Africa. It is approved for food and feed imports in Australia, Japan and many other countries. The approval mechanism for any GM crop requires extensive testing and independent scientific review of safety to human health and the environment. Transformed maize, known as "*Bt* maize" is the most widely planted transgenic insecticidial crop in the world. In 2003 it was estimated that 15.5 million ha had been planted to this crop [8, 9].

More recent studies on the direct effects of *Bt* crops on organisms that feed on crop tissues has shown no short-term negative impacts [11]. However, a complete assessment of non-target impacts needs to include measures of how ecological functions are impacted by transgenic crops in comparison to how they are impacted by conventional pest management tactics.

The adoption of *Bt* maize will play a key role in achieving increased food security in Africa. Significant benefits include yield increases, reduced pesticide usage and lower mycotoxin levels.

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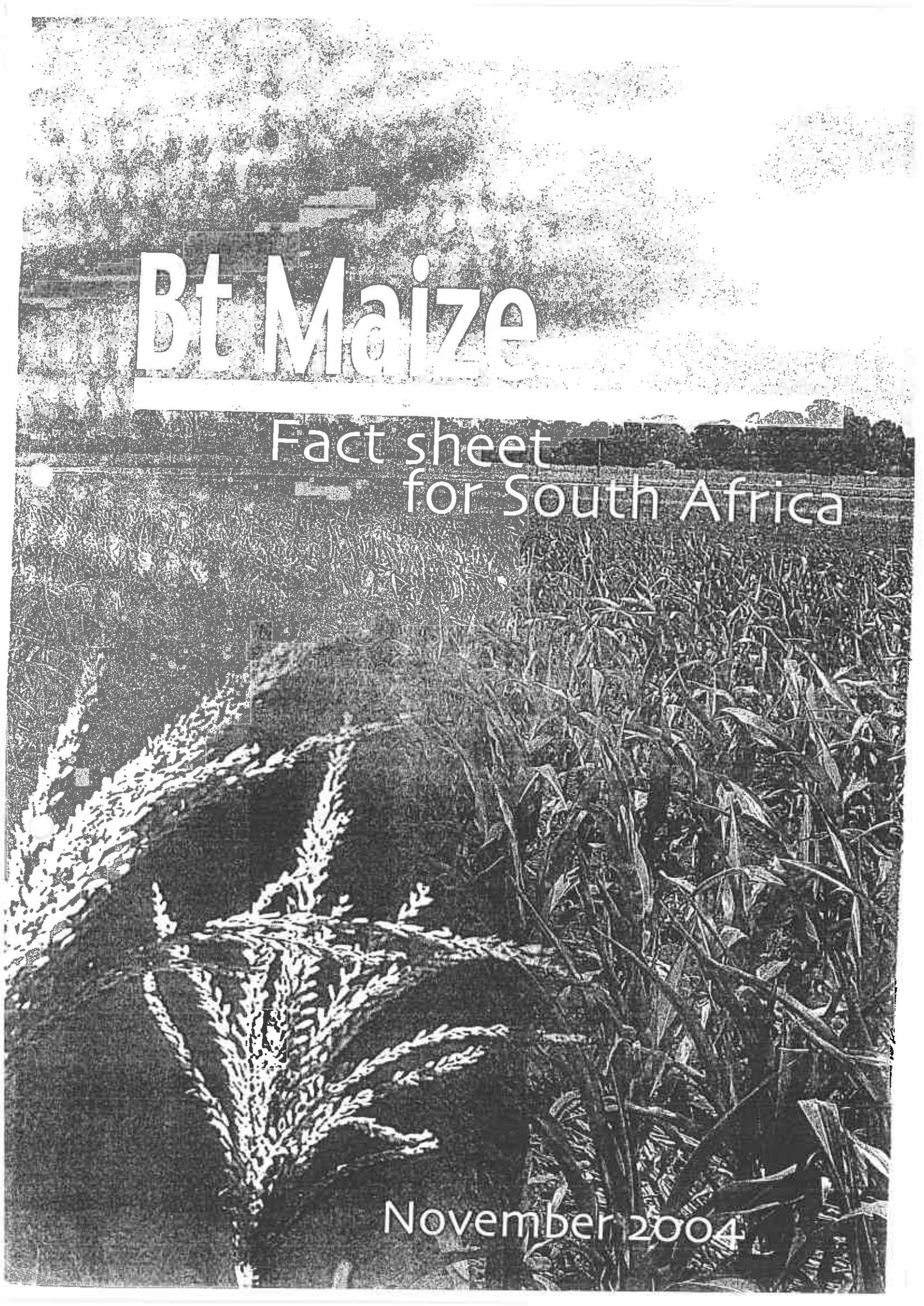
Bt Maize

Fact sheet for South Africa



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