Chapter 5

Genetically Engineered Plants Grown in South Africa

5.1 Provision of information

5.1.1 Literature search and personal interviews

Beside a literature survey carried out with the use of published material at the university library or on the Internet the following persons contributed with general information about genetically engineered plants to the survey.

J. Webster, Director of Africa Bio, provided references and website addresses that helped to identify the possible risks that are caused by the transgenic maize and cotton in South Africa and the potential benefits that are associated with transgenic crops. The website www.africabio.com provided information about the problems and opportunities of biotechnology for developing countries like South Africa.

S. Moephuli, Director of Genetic Resources at the Department of Agriculture, contributed information concerning the Genetically Modified Organisms Act (GMO Act 15) of 1997 in South Africa.

The website www.biotechnology.gov.au provided by M. Koch helped to find out what the possibilities are for gene flow between weedy relatives and transgenic plants in South Africa. By finding these various possibilities, it allowed to formulate reasonable solutions to reduce the risk of gene flow.

The cotton articles, provided by Dr C.L Bredenkamp, gave information on different types of cotton. More importantly, it gave information on the weedy relatives of cotton in

South Africa, which was used to find out what chance there was of gene flow between transgenic cotton and the weedy relatives. By doing so, a safety precaution was recommended.

The website address www.agbiotechnet.com from Prof. D. Berger contained information related to the risks of transgenic crops, which helped to identify the risk that may be associated with the transgenic maize and cotton of South Africa.

5.1.2 Personal telephone interviews with companies

Personal interviews were also conducted with two seed companies involved in genetically engineered plants to obtain information about the current use and growth areas of these plants. Information obtained from Monsanto/Johannesburg (MC) and Pioneer Hybrid/Centurion (PH) was as follows:

What types of crops are already released commercially?
Maize and Cotton (MC); Maize and Sunflower (PH)

Who are the main customers?
Farmers in Bethel (MC); no answer (PH)

In which Province are the sales of hybrid seeds biggest?
Mpumalanga (MC); Natal (PH)

Do you only sell hybrid maize seeds or do you sell ordinary seeds as well?
Company sells both (MC and PH).

Of these two, which one is of higher demand?
Ordinary seed is of higher demand. Hybrid seeds are of low demand, about 3-5% (MC and PH)

Which is more profitable?

Hybrid seeds (MC and PH)

What are the different traits of hybrid seeds you are selling?

Bt maize, Bt cotton. Round up Ready (RR) soya is already registered, but the seeds are not available. Monsanto also registers RR maize but the seeds are not available (MC). Bt maize (PH)

Is anyone doing research on the environmental impact on flora?

No idea (MC); Department of Agriculture (PH)

5.2 Result of survey

5.2.1 Current growth areas

The study was concentrated on maize and cotton, as they are the main genetically engineered crops currently grown in South Africa. The overall survey showed that the current use of transgenic hybrid seed by farmers in South Africa is 3-5%. According to the survey, Monsanto's and Pioneer Hybrid's transgenic maize and cotton are mainly planted in the Mpumalanga and Natal region. South Africa is further the only African country in which genetically engineered crops are commercially grown, and it has adopted the technology more quickly than any other country in the world. Already 28% of cotton and 6% of the maize planted in South Africa is genetically engineered (Wynberg, 2002).

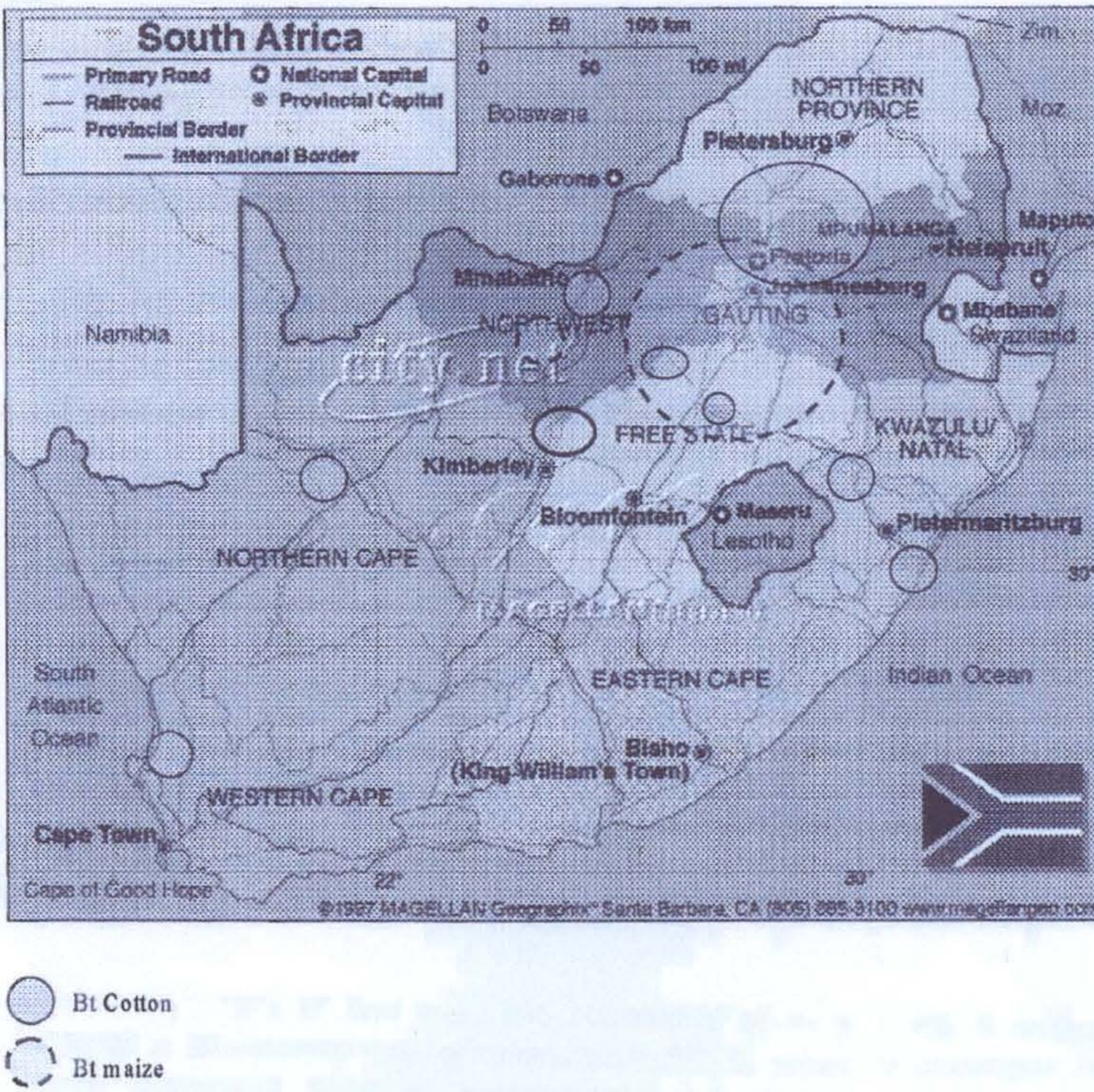

Figure 5.1: Commercial plantings of genetically modified maize and cotton in South Africa (Viall, 2001).

From Figure 5.1 it is evident that Bt cotton is planted in many parts of South Africa. It is also evident that Bt maize is planted within one area covering all of Gauteng and stretching to the North West Province, Free State and Mpumalanga. Around 200 field trials are currently taking place in South Africa and five commercial releases have been approved (Wynberg, 2002). In 2002, Bt cotton has been commercially planted in eight provinces. These are Eastern Cape, Kwazulu Natal, North West Province, Free State, Northern Province, Gauteng, Northern Cape and Mpumalanga. Bt maize is planted in Kwazulu Natal, Eastern Cape, North West Province, Free State, Gauteng and Mpumalanga (Figure 5.2). Field trials of Bt maize are currently conducted in Northern Province and Northern Cape (Figure 5.2). Since 2000, Bt maize was planted in two additional provinces, Kwazulu Natal and Eastern Cape, while Bt cotton was planted additionally in Eastern Cape Province by the year 2002 (Figure 5.1 and 5.2).

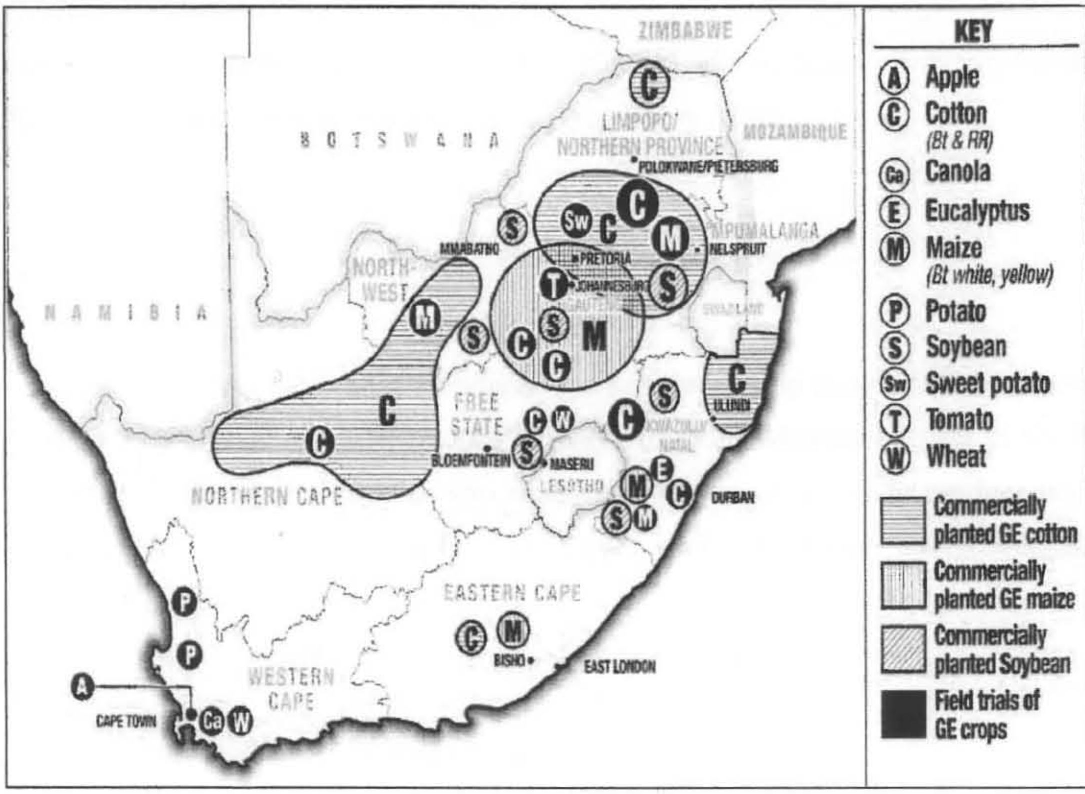

Figure 5.2 Planting of genetically engineered crops in South Africa, 2002 (courtesy of Bio watch South Africa).

5.2.2 Potential benefits

From the interviews carried out, the proponents of genetically modified plants mentioned the following benefits for a developing country like South Africa.

5.2.2.1 *Economic benefits*

The survey showed that those who introduced the transgenic crop benefited from a yield increase of 25% (CropBiotechNet, 2002). Results from the Makhathini flats in South Africa further indicates that farmers who adopted Bt cotton were able to produce high level of output with lesser amount of input, such as labour and chemicals (CropBiotechNet, 2002).

5.2.2.2 *Socio-economic and health benefits*

Even though very poor farmers may not be able to afford GM seeds, the survey on small scale farmers at Makhathini farmers showed that genetically engineered plants might provide the following socio-economic and health benefits:

- Alleviation of hunger and malnutrition in Southern Africa due to increased production of food crops.
- Improvement of the standard of living of the farmers due to drought and insect resistant crops.
- Decrease of farm worker exposure to insecticides and pesticides improving the quality of the environment.
- Bt cotton might give small-scale farmers, mainly women, more time to care for their children and the sick.

5.2.2.3 *Environmental benefits*

The survey further showed that genetically engineered plants might provide the following environmental benefits:

- More efficient land utilization through improved yields, as land is fast becoming a limited resource.
- Promotion of less use of pesticides and herbicides.
- Less need for weed control, fewer passes of machines through the field are needed.
- Reduction of work in the field resulting in less soil compaction with higher oxygen content in the topsoil.
- Reduction in herbicide and insecticide usage reduces the risk of contamination of domestic water sources in rural areas.

5.2.3 Potential risks

From the survey the following two major risks specifically for the flora of a developing country like South Africa were outlined:

- Pollen viability of transgenic crops will determine gene flow between genetically engineered plants and possible wild relatives.
- Gene exchange between varieties of cultivated and genetically modified crops.

5.2.3.1 *Out-crossing with cultivated crops*

The literature survey showed that gene exchange between Bt cotton or maize and cultivated cotton and maize is a risk in South Africa. This is due to the identical ploidy level of species and the planting in close proximity to each other (Figures 5.1 and 5.3). Gene exchange can occur due to wind pollination in cultivated maize and via insect pollination in cultivated cotton. Hybrid production would also pose a serious threat to the environment over time, because any hybrids might be toxic to beneficial insects in addition to bollworm as the target insect. A study conducted at Cornell University in New York conducted by Losey *et al.* (1999) showed that Bt maize pollen may drift onto milkweed around maize fields and can affect the survival of the monarch larvae. According to the laboratory tests, it was found that monarch butterflies feeding on milkweed leaves, which had been dusted with pollen from Bt maize, ate less, grew more slowly and suffered higher mortality than larvae that ate milkweed leaves without any Bt maize pollen. Similar interactions between a cultivated genetically engineered plant and a weed can also not be excluded in South Africa.

Continuous planting of genetically engineered plants might also increase herbicide resistance not only in cultivated plants but also in closely grown weeds. For example, a continuous usage of glyphosate in genetically engineered maize and cotton could increase the resistance for this herbicide in non-crop plants associated with these two crops and promote the development of 'super weeds'. This would require the use of a higher herbicide dosage for weed control and might reduce yield because of competition with the new 'super weed'. An increase in herbicide resistance due to the use of genetically engineered plants has been already found in the U.S. (S. Duke, personal communication). Such a possibility should also be considered in South Africa as a longer-term effect on the environment.

5.2.3.2 *Out-crossing with wild relatives*

5.2.3.2.1 *Maize*

The survey showed that there is no sexually compatible wild or weedy relative of maize that is currently known in South Africa. Maize has only one related wild species, teosinte, which grows only in Mexico and Guatemala but not in South Africa. Thus, concerning gene flow to wild relatives by out-crossing, genetically engineered maize can be considered as relatively safe for South Africa.

The literature survey also showed that some relatives of corn are wild plants but with no pronounced tendency for weediness (Galiant, 1984). In the U.S., but not in South Africa, a cross occurs between *Tripsacum*, (a genus closely related to Zea) and *Zea mays*. But resulting hybrids are often sterile, because of difference in chromosome number and lack of pairing between chromosomes (Eubanks, 1997; Carpenter *et al.*, 2002). A herbicide-resistant character, however, might create volunteer transgenic plants in crop rotation fields, which might also be relevant to South Africa. If viable genetically engineered maize seeds are lost in the harvesting process, weediness will become a problem as volunteer weeds reduce yield. Maize also appears as a volunteer at roadsides, but it has never been able to establish itself outside of cultivation.

From the literature survey it is also evident that the hypothesis that escape of volunteer corn plants will have a selective advantage and become weeds is empirically unfounded. This has been clearly dismissed by the results of an intermediate term experiment conducted in the UK. In the experiment, oilseed rape, potato, maize and sugar beet were grown in 12 different habitats and monitored over a decade to find out whether genetically engineered plants were likely to persist in the wild in the event of dispersal from their cultivated habitat. The results showed that plants were no more invasive or persistent than their conventional counterparts (Crawly *et al.*, 2001).

Due to the difference in climatic conditions between South Africa and the UK, a study should be conducted in South Africa to find out whether volunteer weeds become persistent or invasive in the natural environment.

5.2.3.2.2 *Cotton*

The literature survey showed that among the African species (Figure 5.3), *Gossypium triphylluim* is closely related to *G. anomalum* and artificial hybrids show a certain degree of fertility (Saunders, 1961). But where the two co-exist (the border area between Angola and Namibia), natural hybrids have never been recorded (Fryxell, 1980). *Gossypium arboreum* (diploid; 2n) is one of the four domesticated *Gossypium* species and is the only one for which a wild progenetor has never been identified (Liu *et al*., 2001). *G. annomalum* also called WaWra and Peyr is a wild diploid cotton indigenous to the African continent. This species and G. *somalense* have been collected in natural vegetation in the Sudan (Saunders, 1958).

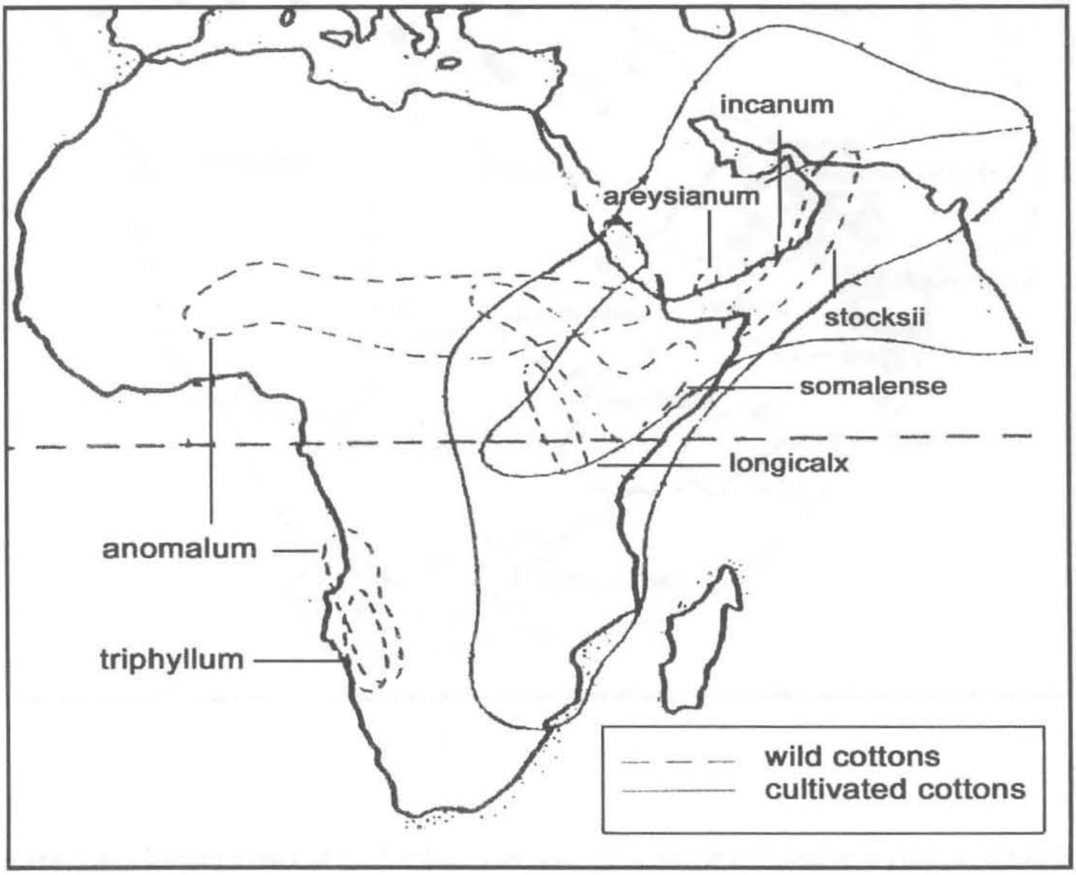

Figure 5.3: The natural geographic distribution of *Gossypium* species in Africa (Valicek, 1978).

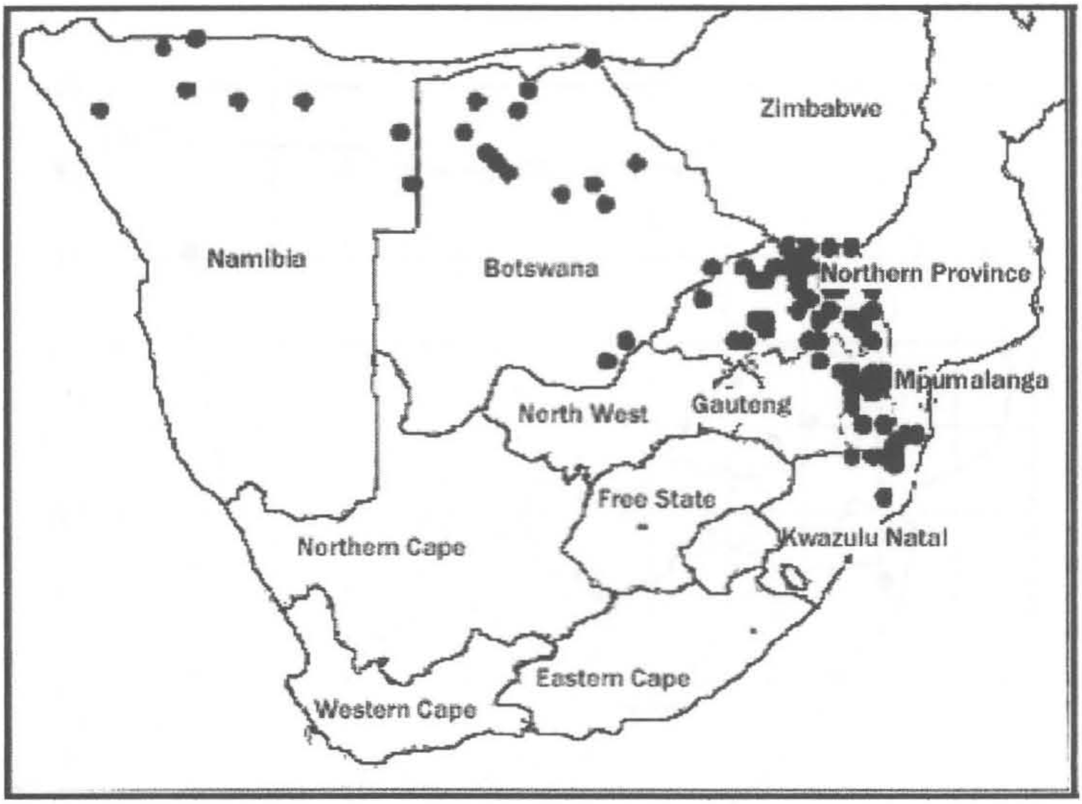

Figure 5.4: Growth areas of *G. herbaceum* race *africanum* in Southern Africa (Saunders, 1961).

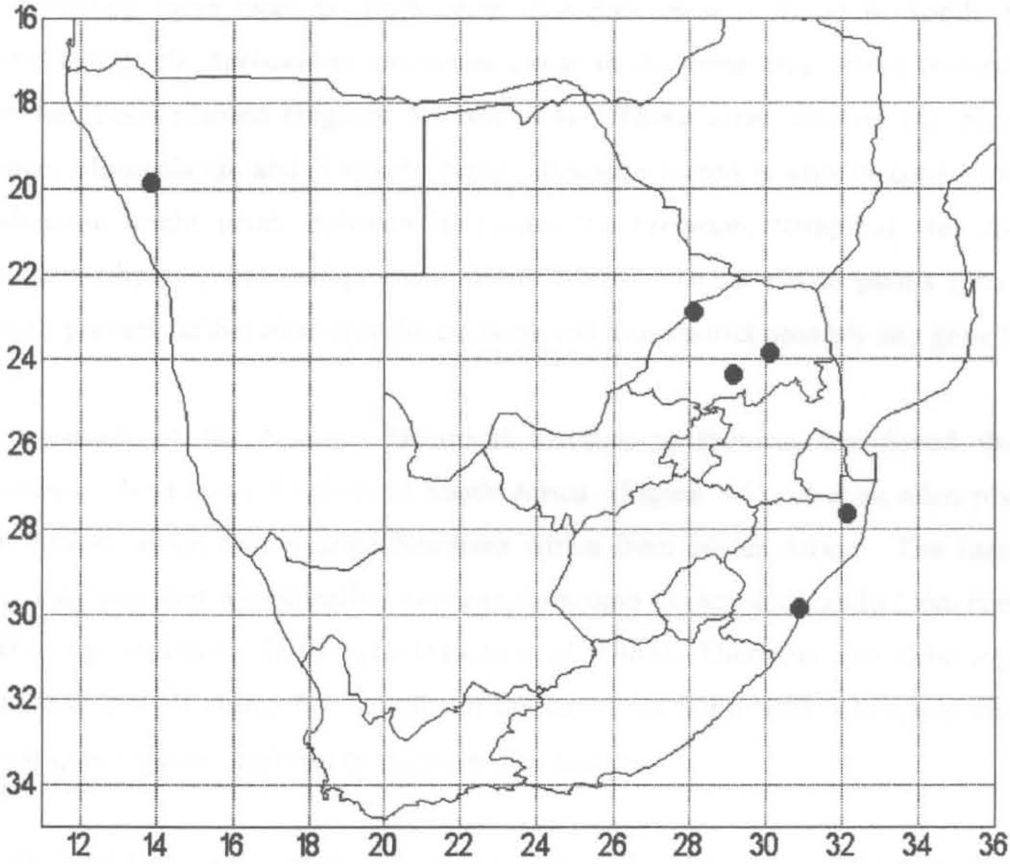

Figure 5.5: Growth areas of *G. barbadense* in Southern Africa, 1999 (map obtained from National Botanical Institute, Pretoria, South Africa).

G. herbaceum is divided into five geographical races, which are now isolated from each other. Among these races *G. herbaceum* race *africanum* is found in South Africa (Munro, 1987). *G. herbaceum africanum* exists in the same area where currently Bt cotton has been planted (Figures 5.1 and 5.4). These areas include the Northern Province, Mpumalanga and Kwazulu Natal. Because cotton is also insect-pollinated, hybridization might occur between Bt cotton (*G. hirsutum*, tetraploid; 4n) and *G. herbaceum* (diploid; 2n) and produce sterile plants. These sterile plants (3n) will, however, prevent further inter-specific crossing and thus restrict possibly any gene flow.

A data search, at the National Botanical Institute in Pretoria, has found that *G. barbadense* (Pima cotton) occurs in South Africa (Figure 5.5). It is an alien plant in South Africa, which has invaded Southern Africa from North Africa. The literature survey indicates that hybridization between tetraploid *G. hirsutum* and *G. barbadense* occurs and produces fertile F1 hybrids (Ano *et al.*, 1983). Therefore a cross between *G. barbadense* and Bt cotton has significant relevance for South Africa because they are both tetraploid species and can be pollinated by insects.

G. thuberi Todaro occurs in the mountains of Southern Arizona and Northern Mexico (Wozniak, 2002). There is evidence of hybridization between *G. hirsutum* (4X=52) and *G. thurberi* (2X=26) to produce triploid (3X=39) sterile plants (LaSota, 1996). Even though there is no *G. thuberi* in South Africa the above evidence shows that a cross between diploid *G. herbaceum* and Bt cotton can take place to produce sterile plants.