cordingly, savings from price discounts will increase as more and more cotton is proved to be non- sticky or only slightly sticky.

The project produced the following reports which are available free on line at http://www.icac.org/icac/Projects/CommonFund/Stickiness/english.html

- √ Technical Report No. 17/Final Report of the Project CFC/ICAC11 (English, 87 pages)
- √ Technical Report No. 17/Final Report of the Project CFC/ICAC11 (French, 88 pages)
- √ Technical Report on Research Activities (English, pages 243)
- √ Proceedings of the Final Seminar, Lille, France, July 2-4, 2001 (English, 191 pages)
- √ Proceedings of the Final Seminar, Lille, France, July 2-4, 2001 (French, 195 pages

The project also published a brief brochure in simple language on achievements of the project that can be requested at no charge from the Technical Information Section of the ICAC at Rafiq@icac.org

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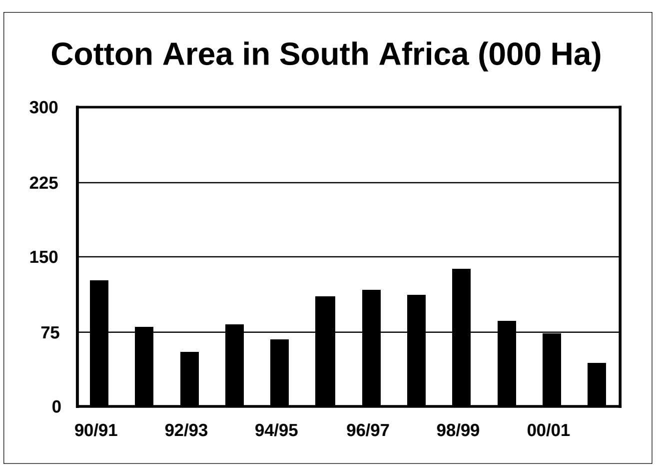
International Textile Manufacturers Federation, 2001. *Cotton Contamination Survey 2001*, International Textile Manufacturers Federation (ITMF), Am Schanzengraben 29, Postfach CH-8039 Zürich, Switzerland.

Khalifa Hassan, 2001. Historical background on cotton stickiness in the Sudan. *Proceedings of the Final Seminar of the CFC/ICAC11 Project, Improvement of the Marketability of Cotton Produced in Zones Affected by Stickiness*, Lille, France, July 2-4, 2001.

Transgenic Cotton in South Africa

South Africa is a cotton importing country. Mill use has varied between 62,000 tons and 81,000 tons since 1980/81. However, the quantity of cotton imported has varied more depending on local production. Imports were as low as 3,000 tons in 1980/81 and as high as 55,000 tons in 1997/98. It is estimated that during 2001/02, 72,000 tons of cotton will be required for the local industry, out of which 40,000 tons will be imported, 19,000 tons will be produced locally and the balance will be available from a 19,000-ton carryover, leaving the ending stocks at only 6,000 tons. South Africa exported 12,000 tons of cotton in 1998/99. In 2002/03, South Africa will have to import over 50,000 tons of cotton due to lower ending stocks at the end of 2001/02.

South Africa tries to meet its domestic needs from local production. Cotton was planted on 31,000 hectares in 1960/61, and 81,000 hectares in 1990/91. Area continued to increase during the 1970s, reaching 115,000 hectares in 1980/81. In 1988, cotton was planted on 208,000 hectares, the most devoted to cotton so far. But, cotton area fell to an estimated 44,000 hectares in 2001/02.



Cotton yields improved from 168 kg/ha in 1960 to 630 kg/ha in 1977/78, but they have remained stagnant since then, with very low yields in some years. The average yield in the country was only 258 kg/hectare in 1991/92. The latest ICAC estimates suggest that the yield in 2001/02 was 430 kg/ha.

Adoption of Bt Cotton

In 1996/97, the average cotton yield in South Africa was one of the lowest in the last twenty years. The government of South Africa decided to commercialize the production of Bt cotton, which was planted on a commercial scale starting in 1998/99. Bt cotton area accounted for three-fourths of the total cotton area in the country in 2001/02.

Transgenic Cotton Area in South Africa

Year	Transgenic Area (%)
1998/99	12
1999/00	28
2000/01	24
2001/02	74

During 2001/02, herbicide-resistant transgenic varieties were approved for commercial cultivation in South Africa. Out of the total transgenic cotton area, 63% was under Bt varieties while Roundup Ready herbicide-resistant varieties were planted on 11% of the area. Only one herbicide resistant variety, DP 5690RR, was grown during 2001/02, and it was also limited to only commercial (large-scale) growers. Although the reason for this is the late approval and supply of seed, leaving no time to contact small growers, it is not anticipated that herbicide-resistant varieties will become popular among small growers. The most popular Bt varieties are NuOpal, planted on almost 50% of the total area, while NuCot 35B and NuCot 37B together were planted on the other 50% of the Bt area. Plans are to phase-out the first adopted varieties, i.e. Nu35B and Nu37B, and replace them with NuOpal, which is a normal leaf variety from Australia.

The stacked gene transgenic varieties, with Bt and Roundup Ready genes put together in one variety, are in the approval process. It is anticipated that such varieties will be available for commercial production in 1-2 years, but whether stacked gene varieties will become popular is not certain. Reaction to the Roundup-resistant varieties in 2002/03 will indicate the prospects for stacked gene varieties.

Technology Fee

In South Africa, cotton is grown mostly in the northern and western parts of the country, although some cotton is also grown in the east. Small as well as large growers cultivate cotton under irrigated and rainfed conditions. The production area can be divided into eight different regions. Following are the three most important regions, their major insect pests and the average number of sprays prior to the adoption of Bt cotton:

Region	**Average Number of Sprays**	**Major Insects**
Northern Cape	8	*Thrips* spp. *Aphis gossypii* *Helicoverpa armigera* *Diparopsis watersi*
NW Province	6	*Aphis gossypii* *Helicoverpa armigera* *Diparopsis watersi*
Orange River	5	*Thrips tabaci* *Aphis gossypii* *Helicoverpa armigera*

D. castanae, Earias insulana and *Spodoptera exigua* could also become important pests in some parts of the country at certain times. The pink bollworm, *Pectinophora gossypiella*, has never been a problem in South Africa. Insecticides are hand-sprayed by small growers while most other spraying is done by tractor-mounted sprayers. In some regions, large growers use aerial spraying. Bt cotton has been adopted in all eight production regions.

As in Australia, the USA and other countries that have commercialized Bt cotton, the insecticide-saving technology has not come free to South African cotton growers. The technology fee for the Bt gene has been equivalent to US$60 (600 rands in local currency) per 25 kilograms of seed, enough to plant a hectare of cotton. The fee has remained the same for four years, but is expected to increase to US$70 or 700 rands in local currency in 2002/03. Savings in insecticide cost of more than US$60 per hectare have encouraged cotton growers to adopt transgenic cotton at a very fast rate.

Refuge Requirements

Refuge requirements were set in South Africa as in the USA, i.e. 20% sprayed and 5% unsprayed. However, the changes made in the USA in 2001/02 have not been incorporated in the South African program. Considering the 20% unsprayed option, it is clear that South Africa still has a chance to increase the area grown to Bt varieties before a limit is reached. There is a cushion to increase Bt area from the current 63% in 2001/02, to 80% (under the 20% refuge option) but efforts are already underway to get rid of refuge requirements. There are at least two strong reasons why a refuge is not required in South Africa.

- Under the small-scale cotton production system, a requirement that 20% of area be sprayed or 5% unsprayed is not sufficient to produce a hybrid population between insects feeding on Bt cotton and refuge crops. Scientifically, both refuge requirements are valid and have worked in countries with large scale farming systems, but they are not suitable for small scale farming systems where farmers plant only a few hectares or even less than a hectare.
- Some strong alternate insect host crops are also grown in South Africa at the same time cotton is in the field. Cotton is grown on a much smaller area in South Africa compared to millions of hectares planted to maize every year. Maize also serves as a host for major cotton bollworms and an automatic refuge is already available for the hybrid population.

No decision has been made yet to eliminate refuge requirements, but Monsanto and Delta and Pine Land are working together to collect scientific information to convince the government that a refuge requirement is not effective under a small scale farming system. The government of South Africa has been very supportive of biotechnology research and its use, but it is not certain whether it will be convinced to eliminate refuge requirements. No other country has done away with refuge requirements or is considering doing so. The role of a refuge crop has confirmed its worth in most countries, particularly in countries that have reached their area limit.

Local Cotton Varieties

Varieties of foreign origin are being grown in South Africa now, and they were grown prior to the adoption of transgenic cotton. In 1997/98, the most popular varieties were Sicala 32, Tetra, DP Acala 90 and HS 44. South Africa does not have a strong breeding program of its own, and most locally developed varieties have proven to be either low yielding or lower in ginning outturn compared to varieties developed in Australia and the USA.

In the absence of suitable locally developed varieties, South Africa has heavily relied on introductions from other countries. South Africa, being in the Southern Hemisphere, has the additional advantage of serving as a winter nursery for breeders and companies working in the Northern Hemisphere. Thus, varieties developed for cultivation in other countries are checked in South Africa for performance under South African conditions. South Africa does not have to go to the hassle of importing small quantities of seed and arranging performance trials at various locations, rather this is done by international companies for their own use. Companies at their own cost conduct such trials. The record shows that performance trials conducted in South Africa have proven true in other countries.

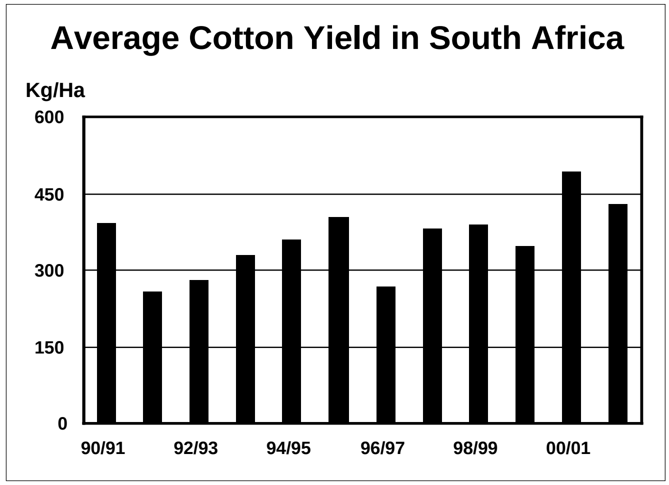
South Africa is divided into eight production regions providing a variety of testing sites with different growing conditions that encourage the interest of private seed breeding companies. Old and new varieties are tested in South Africa. Some of them, developed outside South Africa and which have not even been adopted in their country of origin, have proven successful in South Africa.

There is no private breeding program in South Africa, but a number of large scale international seed companies like Delta and Pine Land Company, Stoneville Pedigree Seed Company, California Planting Seed Distributors, Germain and others, including CIRAD, test their breeding material there. South Africa does not have to go to these companies, rather they come to South Africa to test their material and South Africa, through its relaxed variety registration and approval process, makes use of this offer.

Variety Registration/Approval Process

Varietal registration and approval for general cultivation is granted by the National Department of Agriculture. The Department does not check varietal performance; rather a new variety is checked for its identity. The yield performance data generated by private companies is accepted as base criteria to allow cultivation of that particular variety in South Africa. The varietal registration process makes sure of the identification characteristics of a variety. The Institute for Industrial Crops of the Agriculture Research Council conducts the National Cultivar Trials for two years, while registration trials are conducted for only one year. If a particular variety is found fit for registration, a recommendation is made to the Cultivar Committee for its registration. Under the rules, once a variety has been registered in South Africa, companies can sell planting seed to farmers.

Variety owners submit their reports to the Directorate of Registration of the National Department of Agriculture, but the Cultivar Committee ultimately evaluates the reports. The Cultivar Committee is comprised of members from Cotton South Africa, the Institute for Industrial Crops, ginners, spinners and other segments of the cotton chain. The Committee makes sure that the candidate variety meets the requirements of the textile industry in addition to agronomic requirements and yield performance.



Performance of Bt Cotton in South Africa

The government of South Africa accorded regulatory approval for Bt cotton in the form of Bollgard™ in 1997. On the basis of three years of planting of Bt cotton, from 1998/99 to 2000/01, it was concluded that Bt cotton is more economical to grow compared to conventional cotton. According to a paper presented by Dr. G. D. Joubert, Institute for Industrial Crops of South Africa at the 60th Plenary Meeting of the ICAC held in Victoria Falls, Zimbabwe, from September 16-21, 2001, the following additional conclusions can be drawn about the performance of Bt cotton in South Africa.

- Under irrigated conditions, Bt cotton gave a higher yield for three years over conventional cotton and the differences were statistically significant.
- Under rainfed conditions, the increase in yield of Bt cotton over non-Bt varieties was statistically not significant. This could be due to the fact that farmers did not spray against sucking insects.
- Bt varieties produced a high ginning outturn over non-Bt varieties under rainfed conditions.
- There was no difference in fiber quality, particularly fiber length, strength and micronaire, between Bt and non-Bt varieties.
- Bt varieties currently approved in South Africa reacted to diseases almost in the same way as non-Bt varieties.
- Pest scouting is required in Bt cotton, but the emphasis has changed from bollworms to sucking insects.
- There is a concern that some previously minor pests may become major pests. In this regard, jassid *Amrasca* spp. poses a serious threat. The green vegetable stinkbug *Acrosternum hilare*, which has gone unnoticed for nearly 50 years, reappeared in the second and third year of planting Bt varieties, but, appearance was not confined to Bt cotton only.

Many other conclusions drawn in other countries are common for most situations and they include less insecticide use, environmental safety, lower cost of production, etc. Information from other sources show that in South Africa small-scale farmers have more economical advantage in growing Bt cotton compared to large growers. The reason for this could be the imperfect control of insects by small growers in spite of other good crop management practices. In countries like South Africa, where good quality water is not available in abundance for use in spraying insecticides, Bt farmers had the additional advantage of obviating the need for clean water.

Regulation of Genetically Engineered Organisms

In 1997, the government of South Africa passed an act called the Genetically Modified Organisms Act 15 of 1997 [SAPL4]. The Act was assented in May 1997, but commenced in December 1, 1999, and under it an organizational framework for introduction, testing, commercial utilization and risk management was established. Appropriate procedures for the notification of specific activities involving the use of genetically engineered organisms in general were established, keeping in view the criteria for risk assessment, i.e., that genetically engineered organisms do not present a hazard to the environment. The Act also established various terms used in the production of GE products.

Under the 1997 Act, the government established an executive council and advisory committee which, along with other main points of the Act, are discussed here.

Executive Council

The Executive Council for Genetically Modified Organisms comprises eight members from the National Departments of Agriculture, Arts, Culture, Science and Technology, Environmental Affairs and Tourism, Health, Labour and the Department of Trade and Industry. The main objective of the council is to advise the Minister, National Department of Agriculture, on all aspects concerning the development, production, use, application and release of genetically engineered (GE) organisms, and to ensure that all these activities are performed in accordance with the provisions of the Act.

- Applications are submitted to the Council for a permit to use the facilities for the development, production, use or application, and for the release of genetically modified organisms into the environment.
- Under the Act it is required that inspectors be appointed to visit the facilities where activities for the release of genetically engineered organisms are being undertaken.
- The Executive Council will promote cooperation and enter into agreements between South Africa and other countries with regard to research, development and technology transfer in the field of GE modifications of organisms.
- A registrar, appointed by the National Department of Agriculture, has the important role of making recommendations to the government on the appointment of members to the Committee, if vacancies become available.
- The Act requires that the user immediately notify the registrar of any accident involving genetically engineered organisms. If found necessary, a panel could be appointed to report on the causes of an accident and to make recommendations to the government, with a view to avoiding similar accidents in the future and limiting the adverse impact of such accidents.
- The registrar can authorize an inspector to destroy the GE organisms that do not meet the requirements of the Act, subject to the procedures and other provisions as set out in this Act.
- The registrar will make sure that appropriate measures are undertaken by all users at all times with a view to the protection of the environment from hazards.
- The registrar will receive instructions from the Council and will issue a permit as required or prescribed under the Act.

Advisory Committee

A ten-member Advisory Committee will be appointed by the Minister, National Department of Agriculture, after the recommendation of the council, for a period not exceeding five years. The Advisory Committee will have not more than eight members who shall be knowledgeable persons in those fields of science applicable to the development and release of GE organisms. Two persons shall be from the public sector and shall have knowledge of ecological matters and genetically modified organisms.

- One member of the Committee will serve as chairman.
- The Committee will act as the national advisory body on all matters concerning or related to the genetic modification of organisms.
- The Advisory Committee will make proposals for specific activities or projects concerning the genetic modification of organisms.
- The Committee will also advise on the importation and exportation of genetically modified organisms and propose regulations and written guidelines.
- The Committee will liaise, through the relevant national departments, with international groups or organizations concerned with biosafety.
- The Committee may appoint subcommittees to deal with specific matters as required.

Appointment of Inspectors

- The registrar may appoint any officer as an inspector.
- The inspector shall be furnished with a certificate signed by

the registrar stating that he or she has been appointed under the Act.

- An inspector may conduct an investigation to determine whether the provisions of the Act are being complied with. The inspector can enter any place or facility he or she has reason to believe may be in contravention of the provisions of the Act.
- The inspector can request any information regarding the activity or process in question from the owner or person in charge of the facility. He can also seize any proof of a contravention for criminal proceedings.

Determination of Risks and Liability

Users shall ensure that appropriate measures are taken to avoid an adverse impact on the environment, which may arise from the use of genetically engineered organisms.

The liability for damage caused by the use or release of a genetically engineered organism shall be borne by the user concerned.

Confidentiality

The Council shall decide, after consultation with the applicant, which information will be kept confidential and shall inform the applicant of its decision. However, some basic information like the description of new organisms, name and address of the applicant, purpose of the contained use, etc., will be available to the public.

Appeals

A person who feels aggrieved by any decision or action taken by the Council, the registrar or an inspector in terms of this Act may, within the period and in the manner prescribed and upon the payment of the prescribed fee, appeal such decision or action to the Minister, who shall appoint an appeal board for the purpose of the appeal concerned.

An appeal board shall consist of the person or persons who, in the opinion of the Minister, has or have expert knowledge and who is or are otherwise suitable to decide on the issues of the appeal concerned.

The Cotton Leaf

Leaves are of immense value to the plant. A leaf's role in the life of the plant as a food factory is well known, but there are many more functions that cotton leaves perform which are usually under-appreciated. The cotton plant has two kinds of leaves: cotyledonary leaves and true leaves.

Cotyledonary Leaves

In cotton, the first leaves come from the two well-developed cotyledons. The two cotyledons always form the first green leaves, called cotyledonary leaves or seed leaves. The cotyledonary leaves have a very short life, shortest among all leaves on the plant. The cotyledonary leaves appear to be emerging from a single node, but literature suggests that one is slightly above the other. This might be the reason that both leaves are not shed at the same time. There is a difference of 3-10 days in their age at the time of shedding. There is no specific pattern for which one is shed first, upper or lower one. However, after about forty days from planting both cotyledonary leaves have been shed. The cotyledonary leaves are also smaller compared to true leaves. They are thicker and lack pointed edges. At the time of germination of the seed, two cotyledons are pushed out of the soil without plumule. Thus, further growth in leaves is restricted for the first 8-10 days. In this period, the shoot part, which has given rise to the root, continues to grow and establish the seedling quickly. The cotyledonary leaves give rise to the main stem, while other leaves may give rise to branches or fruit forms.

True Leaves

A shoot emerging from the center of the two cotyledonary leaves forms the basis for true leaves. Therefore, true leaves always follow cotyledonary leaves. The first true leaves may start to appear ten days after planting and from the beginning they have pointed edges and hairs. The first true leaves from the first fruiting node are progressively larger. Many normal leaves may be shed even before they become visible, but naturally they should be staying on the plant and cannot be regarded as shorter living than cotyledonary leaves.

By the time the first true leaf unfolds, 6-7 other true leaves have already been formed. Thereafter, the true leaves continue to be formed at a higher rate. The youngest true leaf on the plant may have as many as 7-11 leaf initials above the youngest unfolded leaf. The cotton plant has a spiral phyllotaxy (arrangements of leaves on the plant) and every new leaf is located at 3/8 turns from the last leaf. The turn could be clockwise or anticlockwise and some references suggest that the twist direction is almost 50:50.

The leaf is the first to be formed and then each leaf axil gives rise to either a branch or a fruiting part. The leaf may or not be physically there, but in all branches, monopodial or sympodial, meristems emerge from a leaf axil. If there is no branch, it is the fruiting part that will show up in the leaf axil. Practically, many leaves on the plant can be seen without a branch or a fruiting point, which means that either a branch, or in most cases a fruiting part, was shed from that spot.

Among all aboveground parts of the cotton plant, leaves have the highest amount of nitrogen. The cotton leaves have the maximum nitrogen at the first square stage, and as the plant grows, the quantity of nitrogen declines by more than 50% by