THE ICAC RECORDER

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Information Section

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Update on Cotton
Production Research

Contents

Introduction

The International Textile Manufacturers Federation (ITMF) undertakes a survey of the level of stickiness in cotton in the world every second year. According to the report published in 2001, 18% of world production has some level of stickiness, the lowest since the initiation of the stickiness surveys in 1989. In some countries, the stickiness problem is worse than in others, and Sudan is one such country. Stickiness is mainly caused by whitefly, and Sudan has achieved considerable success in controlling the whitefly but the consequent impact on the stickiness level in cotton produced in Sudan has not been realized. Like Sudan, other countries produce some sticky cotton, but all their production is alleged to have the stickiness problem. Cotton from these countries suffers stickiness price discounts, though in fact much cotton may not be sticky or may only be slightly sticky and could be spun without problems. Accordingly, in collaboration with the CIRAD-CA of France, Sudan implemented a project to test and evaluate methods for establishing the degree of stickiness, to develop a threshold for economical processing of sticky cotton, and to evaluate the financial viability of the process developed under the project. The Common Fund for Commodities (CFC) funded the project in addition to the local organizations. The project is finished and the first article in this issue of *THE ICAC RECORDER* has a summary of the results. Reports of the project are available in English and French free on line at http://www.icac.org/icac/Projects/CommonFund/ Stickiness/english.html.

South Africa is a cotton producing country but requires more cotton than it is able to produce to meet the needs of the textile industry. During 2001/02, South Africa needed 72,000 tons of cotton for the local textile industry, out of which 40,000 tons was produced locally. In 2002/03, South Africa is expected to import about 50,000 tons of cotton. South Africa commercialized production of Bt cotton in 1998/99, and it is estimated that three-fourths of the total area was planted to genetically engineered varieties during 2001/02. Herbicide resistant Roundup Ready varieties were planted on a commercial scale for the first time in 2001/02. In South Africa, transgenic varieties have been grown by large as well as by small growers, but the adoption rate has been much higher among small growers. The differences between Bt and non-Bt varieties were significant for yield under irrigated conditions but not under rainfed conditions. Quality remained unaffected, and disease incidence was also the same between Bt and non-Bt varieties for three years. There are indications that jassid and green vegetable stinkbug are on the increase. Much more information on the experience of South Africa with Bt cotton, including regulations, is given in the second article.

The cotton plant has two kinds of leaves. The cotyledonary, or seed leaves, live for not more than forty days and then fall off. One cotyledonary leaf is located slightly above the other, and they are also shed at different times within a margin of 3-10 days. They are thicker than true leaves and lack pointed edges. The true leaves initiate from the center of the cotyledonary leaves and even small true leaves have pointed edges. All true leaves in the cultivated species have hairs, but the level of hairiness varies significantly among varieties. Dense and longer hairs provide good control against jassid, but hairy leaf varieties are preferred by whitefly and bollworms. Leaves serve as a food factory, indicator of nutrient deficiency, storehouse of certain nutrients, indicator of pest attack symptoms and perform many more functions that are crucial for the cotton plant. Leaf shape, how they are arranged on the plant, why they are shed and many more aspects of the cotton leaf are discussed in the third article.

The Technical Information Section of the ICAC has updated its database on cotton production practices, which includes information on all aspects of cotton production from soil types, seed, etc., to harvesting and ginning of cotton. The printed report, *Cotton Production Practices*, can be ordered from the ICAC Secretariat at publications@icac.org.

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The World Cotton Research Conference–3 will be held in South Africa from March 9-13, 2003. All information is available on line at http://www.cottonconference3.co.za and http://www.icac.org. The Internet sites have more detailed information than the printed brochure, which can be requested from Dr. G. D. Joubert, Local Organizing Committee, at director@nitk1.agric.za. Important dates are

- October 31, 2002 — Notice to delegates on the acceptance of papers
- December 31, 2002 — Early bird registration
- February 28, 2003 — Final date for registration (on site registration will be available)

Personalized invitation letters can be requested from the Local Organizing Committee or from the ICAC at Rafiq@icac.org.

Improvement of the Marketability of Cotton Produced in Zones Affected by Stickiness

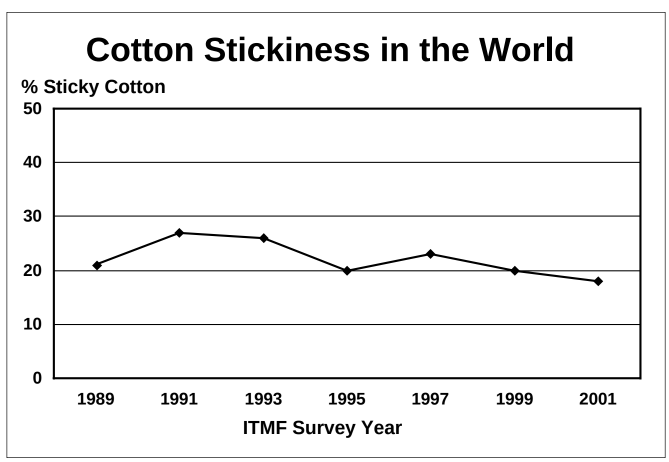
Note: This article is based on results from the ICAC project sponsored by the Common Fund for Commodities and local institutions in France and Sudan. The ICAC Secretariat, on behalf of the member governments, in particular the participating countries, would like to thank the Common Fund for Commodities for its support of this project.

The International Cotton Advisory Committee (ICAC) is the recognized International Commodity Body on cotton with the Common Fund for Commodities (CFC). As such, the ICAC can sponsor projects for funding from the Fund. In the last ten years, a number of projects on various aspects of cotton production research and marketing have been approved by the ICAC for financial support from the CFC. The project, “Improvement of the Marketability of Cotton Produced in Zones Affected by Stickiness,” was specifically related to the serious problem of cotton stickiness caused by sucking insects, whitefly *Bemisia tabaci* and aphids *Aphis gossypii*. Whitefly is a notorious pest that has been spreading to many countries, lately to Australia and Uzbekistan, and has a high potential to develop resistance to insecticides. Aphids, though not a serious threat to cotton production in many countries, are responsible for stickiness and unfortunately often exist in extremely high numbers. A high whitefly population at the time of boll opening remains the dominant factor for stickiness. Every three years, the Technical Information Section of the ICAC undertakes a survey of cotton production practices wherein information on pests is collected. The latest data show that there is hardly any cotton producing country in the world where one of the two is not a pest on cotton, thus making cotton vulnerable to the stickiness problem.

Status of Stickiness in the World

It is not known what percentage of the world cotton production has stickiness problems because this information at national levels is not available. The International Textile Manufacturers Federation (ITMF), an association of the world’s textile industries, tries to keep its world-wide membership constantly informed about the evolution of the industry’s basic raw materials and their application, with the overall objective of creating growth and prosperity in all aspects of the industry. The objectives are fulfilled through surveys, studies and publications, and through annual conferences and specialized committees. In 1982, the ITMF decided to undertake a survey on cotton contamination in the world; since then, the survey has been undertaken biennially, the latest being in 2001. Reports have been published regularly, but stickiness was not added to the survey studies until 1989.

The methodology employed by the ITMF for collecting information on stickiness and other sources of contamination in cotton is not based on science. Spinning companies are sent a questionnaire asking if they have used a particular type of cotton originating from a specific country. The number of samples taken into account to grade cotton contamination is not uniform, and it is entirely dependent on the respondent to react. No lab testing is used to categorize sticky cotton. The stickiness response is either “yes” or “no” while for contaminants like plastic, rubber, dye, sand and others the respondent is asked



to describe contamination as serious, moderate, or insignificant/non-existent.

The ITMF data, though not perfect, is the only source of information on contamination in cotton at the international level. According to the surveys undertaken by the ITMF, stickiness in cotton has ranged from 18% to 27% of total production in the world. In 2001, 18% of the world production was found to have at least some level of stickiness, the lowest since the initiation of the survey in 1989.

Stickiness in Sudan

Cotton research in Sudan is a century old. Since regular breeding efforts started in 1902, a number of high-yielding varieties resistant to insects have been developed for Sudanese conditions, characterized by hot and dry weather during the cotton growing season. Whitefly remained a pest for many years, but stickiness started emerging as a serious issue in the 1960s. Researchers soon realized that honeydew secreted by whitefly and aphids was causing the stickiness problem in Sudan. Accordingly, research programs were implemented to tackle the insect problem and reduce stickiness and considerable success was achieved in minimizing the problem of whitefly and aphids. However, since the initiation of the ITMF survey, Sudan has been on the top of the list of countries producing sticky cotton. According to the *Cotton Contamination Survey 2001* of the ITMF, 100% of Barakat, 100% of Acala and 91% of other Sudanese cotton varieties had at least some level of stickiness.

In addition, international price discounts on the cotton produced in Sudan did not reward the efforts and achievements of Sudanese cotton researchers. Sudanese cotton remained stigmatized and stamped as sticky in the minds of international buyers. It is known from work done in many countries that whitefly distribution on the plant is not uniform, and that the whitefly population is also not uniformly distributed within a field. In Sudan, during the cotton season, wind blows from north to south and the southern parts of the fields always have a higher whitefly population (Khalifa Hassan, 2001). As whitefly is the main insect responsible for stickiness, the stickiness problem should also vary in the field. Work done in Sudan has proved that there were years when more than half of the total production had no stickiness problem. But this fact was never recognized, and Sudan's entire production has continued to suffer price discounts.

Project Objectives

Sticky cottons cause disruptions in the spinning process, fouling the cards, brush tables, feed trays and rotors in open-end spinning. Apart from the frequent stoppages that require cleaning of the machines, these honeydew deposits also cause irregularities in the card web, slivers and threads, and lead to the production of poor quality yarn. But, because stickiness is usually detected at the time of spinning, discounts are applied indiscriminately to all cotton originating from any area considered affected. This is what has been happening in Sudan.

The central objective of the project was, therefore, to increase the return on cotton to producers through the development of reliable methods to establish the level of stickiness in cotton bales, and the establishment (under factory conditions) of operational thresholds for the processing of contaminated, sticky cotton. The project comprised the following three main objectives:

- Testing and evaluation of methods for establishing the degree of stickiness in cotton.
- Development of a threshold for economical processing of sticky cotton.
- Evaluation of the financial viability of the process developed under the project, training, and dissemination of project results through presentations, publications and technology transfer.

Project Implementation

With respect to the work undertaken in this project, four main collaborators contributed to its success: The Sudan Cotton Company Ltd., the Agricultural Research Corporation of Sudan, the Cotton Technology Laboratory of CIRAD-CA, France, and the French Textile and Apparel Institute (IFTH), which at the start of the project was called French Textile Institute (ITF). Some stickiness testing was done at the fiber quality laboratory of Cotton Incorporated in the USA without any charge to the project. The French Textile and Apparel Institute also arranged large scale testing of sticky cotton bales at commercial mills. The Sudan Cotton Company Ltd. had the overall responsibility of executing the project. The project started in January 1997 and concluded at the end of June 2001. ICAC served as the supervisory body.

Project Results

Testing and Evaluation of Methods for Establishing the Degree of Stickiness in Cotton

The main objective of this component was to estimate the level of stickiness, assess the extent of variability within bales and lots, devise a sample procedure to test stickiness on a large scale, and design a methodology for testing all cotton production in Sudan. For this purpose, two types of machines, i.e., the Stickiness Cotton Thermodetector (SCT) and the H2SD were used, and a number of experiments were conducted on roller-ginned and saw-ginned cotton produced in different growing regions of Sudan. At the time of initiation of project activities in 1997, SCT was recognized by the ITMF International Committee of Cotton Testing Methods as a reference method. H2SD was not yet available for full scale testing and use in the project's work. With both SCT and H2SD, aluminum foil is used to which the sugary spots stick after melting under high temperatures.

In the first year, 16,000 samples were evaluated for stickiness using SCT. Those samples were collected from 500 saw-ginned bales and 500 roller-ginned bales, taking 16 samples from each bale (one sample from each of the 16 layers of the bale). Also, 5% of the total Sudanese production was tested on SCT. 15,885 bales, with two samples drawn from each bale, were subjected to stickiness testing. The total number of samples tested was 31,770, but only one reading was taken on each sample. However, five production regions and both ginning systems were represented in the sample of bales.

Results showed significant variation among bales within a lot, with one exception. This means that a lot cannot be considered homogeneous for stickiness and that the separation between sticky and non-sticky cottons must be made bale by bale rather than lot by lot. These results could also be used to identify high stickiness zones, low stickiness zones and no stickiness zones. However, when data from two crop years were compared where the same sampling procedure had been applied, year to year variation was very erratic. The average number of sticky points on the aluminum foil per sample on the 1997/98 crop was 40 against an average of only 20 points on the 1998/99 crop.

Originally, it was planned to use SCT throughout the project duration. But work done in 1997 (the 16,000 sample experiment and two smaller experiments using subsets from the same material) showed that the measured level of stickiness was highly dependant on the person who was counting the sticky spots on the aluminum foil and even sometimes resulted in variations within a bale. Consequently, in 1998, it was decided to use H2SD for all testing. SCT is time consuming while in H2SD sticky points are counted by image analysis. Sample sizes of 3.0-3.5 grams and testing conditions, i.e., 65% relative humidity (RH) and 21°C, are the same for both machines. The use of image analysis with the help of a camera in H2SD allows the completion of one test in 35 seconds, much faster than with SCT. It was concluded that H2SD was not only efficient, but also more suitable for ascertaining variability within bales as it eliminates the chances of operator variation.

Sixteen samples were drawn from each of 50 roller-ginned and 50 saw-ginned bales to understand the variation within bales and the feasibility of commercial classification using H2SD. The most important consideration was that commercial testing of cotton for stickiness does not result in litigation. It was concluded that a single classification threshold might lead to a maximum of 25% litigation risk for the borderline bales. Therefore it was determined that one threshold of, say, ten points per sample should not be fixed when sometimes a nine-point sample could also produce ten or more points on retesting. One option is to lower the classification threshold compared to the evaluation threshold so that the litigation risk is minimized. The project worked on some statistical tables designed to estimate the risk of litigation depending upon the two thresholds, but no concrete recommendations could be drawn. Within-bale variation with H2SD was found, but differences remained insignificant.

The project concluded that a wide range of stickiness could be recorded on cotton coming from various ginning factories in Sudan. It was based on the assumption that cotton produced in the surrounding areas was only ginned at a particular gin factory. The fundamental reason for variation is the varietal difference in the sensitivity to insect infestation and location effects. Some areas are more conducive for whitefly and aphid attack than others. Based on this information, a country map of the cotton growing areas could be drawn on the basis of stickiness produced in various production regions. If a particular area is badly affected by stickiness year after year, appropriate agronomic measures could be undertaken to reduce the insect population responsible for stickiness.

The project concluded that SCT is not suitable for stickiness classification because of human error involved in counting sticky spots and spot size. H2SD could be successfully employed for the kind of work done in the project.

Development of a Threshold for Economical Processing of Sticky Cotton

Sticky cotton disrupts the spinning process by sticking to various parts of the spinning machines. The machines must then be stopped and cleaned. Researchers have developed methods to neutralize stickiness in cotton without affecting quality parameters, but it is not always economical to use these methods. Mostly, the cost of additional processing to get rid of stickiness after production is uneconomical. The second aspect of the project is related to dealing with sticky cotton at a mill. All the work on spinning in the project was carried out in France at the French Textile and Apparel Institute. Cotton bales with known levels of stickiness were brought to France to study the effects of stickiness on the spinning process and yarn quality, establish stickiness thresholds for spinning, study the effect of RH on the processing of sticky cotton and recommend various blends of sticky cotton with non-sticky cotton to eliminate problems during spinning.

Various types of sugars are responsible for producing stickiness. High Performance Liquid Chromatography (HPLC) was used to identify types of sugars in Sudanese cotton. The work done in the project concluded that inositol, trehalose and glucose contents did not correlate with sticky points measured by SCT and H2SD. Fructose was only lightly correlated, while melezitose, trehalulose and saccharose were highly correlated with the number of sticky points. The presence of melezitose and trehalulose showed that stickiness in these bales was predominantly caused by whitefly infestation. While the physiological sugars disappear with time, the type of sugars in honeydew indicates the source of contamination, either whitefly or aphid.

Cotton was prepared and carded at 25°C and 47.5% RH and was spun at 25°C and 57.5% RH. The following conclusions were drawn, which should be used carefully as the types of machines, brand, settings, ambient conditions, automation level, etc., affect the way stickiness could impact the spinning process.

- The stickiness points measured by SCT and H2SD can be correlated with productivity parameters. H2SD results provided higher correlation coefficients with spinning performance compared to SCT. The High Performance Liquid Chromatography results did not provide any additional information on the level of stickiness that could be better correlated with spinning performance.

- Sticky points on aluminum foil show up in various sizes. Though the size on the foil is not the actual size in the untested cotton, classification of the sticky points based on size did not explain the problems encountered during spinning of sticky cotton. The difference in the actual size in cotton and the measured size on the foil paper could be responsible for not having any relationship with the productivity performance. Activities will continue on this aspect beyond the project duration.
- Breakage incidence and machine efficiency are correlated with trehalulose, melezitose and sucrose, but not for all spinning machines. Fifty sticky points on the aluminum foil, measured by H2SD, almost stopped spinning at the card. Lower levels seriously affect efficiency. The roving frame is the most sensitive to stickiness.
- Relative humidity plays an important role. Cotton with 50 sticky points could be processed successfully by lowering RH to 40% instead of 57.5±2.5%.
- Carding and drawing frame output was reduced by stickiness, but stickiness had no effect on sliver quality. It was only from the roving frame onward that stickiness affected regularity. Ring spinning was more susceptible to stickiness defects than rotor spinning.
- In yarn, the number of thin and thick places and neps was affected the most by stickiness. The ring spun yarn showed a significant increase in the number of thin places even at low levels of stickiness. The trend remained the same even at varying levels of RH if sticky points were more than 20, and lower humidity worsened the effect. The same was true for the number of neps. Even if cotton is only slightly sticky, a high number of neps are produced if spun at 40% RH compared to 45 and 55% RH. The tensile properties of ring-spun yarn are correlated with the level of stickiness measured in terms of sticky points. Yarn hairiness was affected the most in rotor spun yarn.
- No detailed studies were undertaken on the combing process, but indications are that a difference of only a few sticky points will affect productivity and quality parameters of combed yarn.

The project concluded that mixing various levels of sticky cotton with non-sticky cotton for smooth processing of sticky cotton is an appropriate solution. No solid recommendation was made on mixture levels and it was suggested that the effects of binary mixes under local conditions, which vary from mill to mill, should be checked.

Evaluation of the Financial Viability, Training, and Dissemination of Project Results through Presentations, Publications and Technology Transfer

It was envisaged in the beginning of the project that financial analysis would be undertaken to look into the practical possibility of commercial testing of all cotton in Sudan and thus in any other country alleged to produce sticky cotton. The work discussed above clearly showed that stickiness testing at the national level should be done in Sudan. But, how much will it cost to test the whole production and what will be the economic benefit of extending testing to the whole crop? Large scale testing will require a number of operations from sample collection, transportation of samples, buying many H2SD machines, actual testing, data compilation and above all establishing credibility of such testing. Each operation has a cost that may accumulate to more than the anticipated benefit.

Data from the U.S. showed that on average it costs $1.50 to test a bale of cotton. This calculation is based on two H2SD readings per bale and includes depreciation of the machines, labor, consumables and spare parts. Based on the assumptions that 500,000 bales are produced in Sudan, that two samples from each 191-kg bale are drawn, and that only one reading is taken on each sample, the economic evaluation of testing the whole crop showed that the cost would be $1.52 per bale. Additional costs over the U.S. estimate are included in the table below.

Additional assumptions not mentioned in the table are that two teams would work for 26 weeks, eight working-hours per day, five working-days per week, and standard cotton samples with known levels of stickiness would run every two hours for calibration of machines. This cost is based on current Sudanese conditions.

The estimated cost of $1.52 per bale is negligible per kg, but it is based on the assumption that all cotton has some level of stickiness. All production may not be sticky every year; ac-

Estimated Cost of H2SD Testing of Sudanese Crop for Stickiness

Item	Unit Price US$	Total Cost US$	Cost/Bale US$
Seven H2SD machines (depreciation based on 5 years)	90,000	126,000	0.252
Aluminum foil	120	36,240	0.073
Maintenance and spare parts		30,000	0.060
One air conditioning system (depreciation based on 10 years)	100,000	10,000	0.020
Energy bills	0.35	45,500	0.091
Workforce wages:			
30 technicians	420	97,200	0.194
Two team managers	700	1,400	0.003
Two engineers	1,100	2,200	0.004
Sampling (shipment, handling)		367,000	0.734
Data processing and communications:			
Computer, phone, fax, etc.		20,000	0.040
Standard cotton (21 kg)	200	4,200	0.008
Miscellaneous (2.7% of total)		19,920	0.040
Total			1.520

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/Common Fund/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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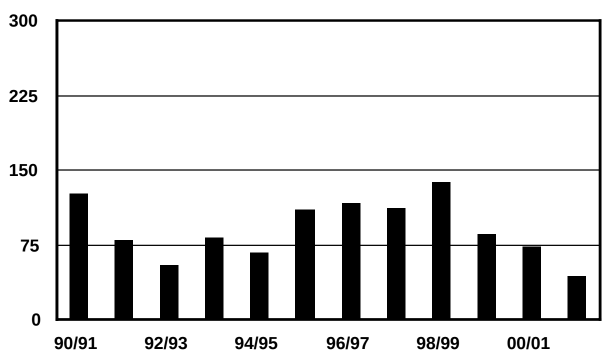
Transgenic Cotton in South Africa

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.

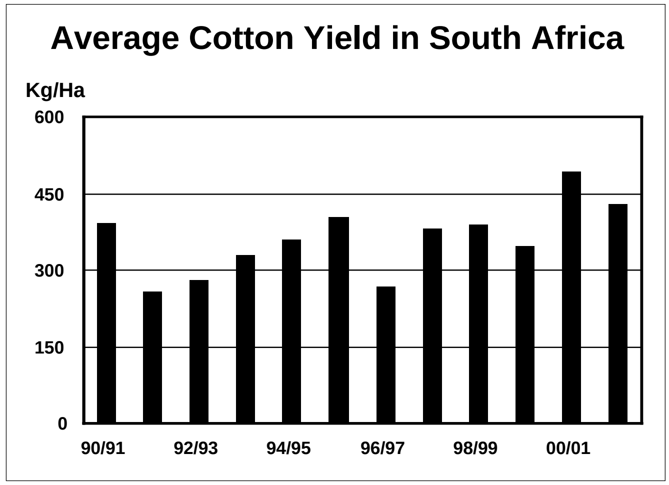
South Africa is divided into eight production regions providing a variety of testing sites with different growing conditions that encourage the interest of private seed breeding companies. Old and new varieties are tested in South Africa. Some of them, developed outside South Africa and which have not 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 the full maturity stage. This is the stage when the nitrogen content in leaves is lower than in the seed. The reason for the decline in nitrogen content in leaves could be nitrogen translocation to fruiting parts.

Both sides of the leaf have stomata, but the upper side has 2-3 times more stomata than the lower surface. The average number for a normal variety may be 100-130 stomata per mm^2 on the upper surface compared to 40-50 stomata on the lower surface.

Leaf Shape

The cotton plant has a palmate leaf shape, and leaves are green in a variety of shades. Normal healthy leaves may be lighter or darker than average. Most varieties belonging to *G. hirsutum* have 3-5 lobes in the leaf. The cuts may be deep as in the case of most *G. arboreum* varieties or they may be only half cuts or even smaller cuts, as is the case in most varieties of cultivated tetraploid species. Deeper cuts provide a smaller leaf area index, lower photosynthesis and lower evapotranspiration per leaf, but narrow leaves are desirable because they provide better aeration of the crop. Better aeration not only provides enough light to the bottom bolls but also avoids boll rot and reduces the chances of fungi growth. Better aeration in the area close to the soil surface avoids creating humid conditions and lets bottom bolls mature normally. Deep cut leaves in *G. hirsutum* are usually called okra and super-okra types. Super-okra leaves are strap-shaped, almost looking like a composite leaf. Such varieties are grown on a commercial scale in Australia. Okra leaf types are thought to create unfavorable conditions for some insects. The leaf type is a heritable character.

A full-grown true leaf in cotton is 12-15 cm in length and width with a long petiole. *G. barbadense* has in general broader leaves, and the color is also slightly darker than other cultivated species. The leaf shape varies greatly in the non-cultivated species, from almost no cuts to much smaller in size compared to cultivated species. There is not a strong correlation that could be proved over a wide range of genotypes, but some references in the literature suggest that broader leaves have higher staple length than normal leaves.

The cotton leaf may have a nectary on the underside on the main mid-rib or it may be nectariless. The nectary secretes a sugary compound and bollworms feeding on these nectaries produce a larger population than nectariless varieties. The nectariless character is considered desirable and nectariless varieties for commercial production have been developed in many countries. Among many special plant characters used in host plant resistance, nectariless is one of the few that does not have a negative effect on yield or fiber quality.

The leaves can be red in addition to green. Red is a factor for lower pest population, but not many red colored varieties have been put into commercial production. The reason could be lower yield potential and also an effect on quality.

Effect of Temperature

Leaves are formed at a faster rate at optimum minimum and maximum temperatures, and lower temperatures negatively impact plant growth and thus the rate of formation of leaves. Higher temperatures may also affect growth negatively, but the effect is different. At higher temperatures, leaves are formed at shorter intervals. It is comparatively difficult to overcome the effect of low temperatures, but the effects of high temperature on growth can be partially avoided through additional irrigation and better plant nutrition. The rate of leaf formation will depend on a number of factors but variety and location effects are more pronounced than others. The genotypic constitution will also determine the total number of leaves and hence the rate of leaf formation. Though the situation is specific to one set of genotypic constitution, work under lab conditions has shown that time taken to form a set number of leaves was three times higher at 18°C compared to 30°C. That particular variety had an average plastochron (days between successive organs) of 2.2 days at 30°C.

Effect of Fruit Formation on Leaf Formation

The rate of formation of leaves is not constant throughout the life of the cotton plant. Leaves are formed at a much higher rate just before and, mostly, during the early fruit formation stage. The plant continues to form leaves at a higher rate, even if it has started forming buds, flowers and bolls. But, as the plant enters into an intense fruit formation phase, the leaf formation ability is affected and plant leaf formation slows to divert energy toward reproductive growth.

Reasons for Slower Growth in Leaf Formation

Leaves cannot be formed in unlimited numbers. The rate of leaf formation is slow in the beginning, reaches its peak during the season and slows with slower plant growth. At some stage, leaf area begins to exceed the capability of the root system to explore new soil, acquire enough nutrients and water and transport them to leaves for stomatal conductance. When this condition is reached depends on a complex interaction of factors. These factors can be manipulated to delay the occurrence of this stage. Water and nutrient stress conditions, if created due to a lack of inputs, can be corrected through proper additions.

Nitrogen nutrition has significant effects on the number of leaves as well as on the size of leaves, although the effects are dependent on other factors. The portioning effect of nitrogen between vegetative growth and reproductive growth is known, and that is a major change that affects leaf formation and growth. Higher nitrogen supply increases leaf area, but do not add proportionately to leaf dry matter. In the case of water stress, leaf expansion is inhibited more than photosynthesis. But any stress in the form of nutrient or water deficiency results in more aggravated effects on the number of leaves rather than in the size of leaves.

Cotton is claimed to be a salt-tolerant crop and work in various countries shows that increases in the concentration of various salts up to certain limits have no effect on yield. However, an increase in salinity reduces photosynthesis and transpiration, proving the effect of salinity on stomatal conductance. The conclusion that the salinized plants had lower water-use-efficiency indicates the greater effect of salinity on CO_2 uptake than on transpiration.

Leaf Functions

The cotton leaf has a number of important functions to perform for the plant and its fruit:

- The cotton plant absorbs water, nitrogen and other nutrients from the soil. Leaves transform them from inorganic form to organic substances through photosynthesis.
- The highest demand for potassium in cotton is at the time of boll maturation. The plant continues to take up potassium from the soil and store it in leaves even if it is not needed. When the demand for potassium increases and the plant is not able to meet potassium needs from the soil, the cotton leaves volunteer excess potassium for boll development and maturation.
- Water evaporates through leaf cuticles, but the evapotranspiration rate depends on many factors. Whatever the rate may be, high or low, a stage is reached when the crop needs additional irrigation. Various methods are used to determine that it is time to irrigate. Leaf drooping at mid-day is one indicator. Various more refined techniques have been established, like pressure bulb where a leaf is placed upside down in a shaded chamber and nitrogen gas is pumped into the chamber. The water seen at the petiole as a result of backward pressure reflects the amount of pull or tension the plant was experiencing at the time of testing. Leaves are the strongest indicator of a need for irrigation.
- Young leaves reach functional maturity in about twenty days and begin to support other growth organs on the plant including bolls. On average, leaves maintain this support for almost forty days. If leaves are not healthy, their support to newly formed buds and bolls is affected.
- Hairy leaves provide protection against jassid, which has difficulty laying eggs on a hairy surface. Thus, hairy leaves help the plant to escape insect damage and, depending upon hair density and pest pressure, 1-3 sprays can be saved by growing profusely hairy varieties in some countries.
- The cotton leaf is a strong indicator of pest damage. Many disease effects can be recognized from their symptoms on leaves, like leaf curl, leaf crumple, etc. Similarly, pest damage due to jassid, whitefly, thrips, etc., can be identified from its effect on leaves. The damage from these and other sucking insects sends strong messages to the plant to adjust the rate of fruit forming/retention, and the plant abides by such instructions.
- The cotton leaf also serves as an indicator of nutrient deficiency from the beginning to the end of the crop. At later stages, when it is not possible to get certain nutrients, particularly potassium and nitrogen from soil, leaves take nutrients from foliar applications and deliver them to the plant system for use by other parts of the plant.
- Leaves also absorb systemic insecticides to save the plant from pest damage.

Why Leaves Are Shed

There are three types of leaf shedding in cotton: premature leaf shedding, normal or age leaf shedding and forced leaf shedding induced through defoliants or extreme weather/growing conditions like stress, starvation or frost. There are two major theories about why flower buds are shed in cotton. First, as the plant retains more and more flower buds, flowers and bolls, the balance between the auxin and anti-auxin hormones is disturbed, resulting in fruit shedding. The other theory is that with the growth of fruit, the carbohydrate supply is limited, forcing the plant to shed a higher number of fruiting forms. Most leaves formed by the plant stay on the plant, while most fruiting forms are shed.

Only a small number of leaves are shed naturally, and such leaves never develop into full-grown leaves. The number of leaves continues to grow and reaches its peak at peak flowering time. Thereafter, the number grows but shedding increases, thus reducing the number of leaves on the plant. Thus, there is premature shedding and normal shedding that come with age. Premature shedding is affected by a number of factors and has drastic effects on fiber quality. Even under ideal conditions, leaves reach their maturity and must be shed. At one stage, leaves must be shed to lower the leaf area index and to enhance boll opening. In the case of natural/age shedding, leaves continue to accumulate carbohydrates in the leaf tissue and an abscission layer, which is carbohydrate in nature, continues to be formed between the leaf petiole and mainstem/branch. The abscission layer serves as a filter to block the supply of food to leaves, thus leaves start loosing chlorophyll and showing age signs. Consequently, the abscission layer turns from a filter to a blockade, and leaves start turning yellow and are ultimately shed.

While premature leaf shedding and age leaf shedding are natural processes and must occur sooner or later, temperature, soil moisture and nutrient supply, alone and in combination with themselves and with other growth factors have a significant effect on leaf shedding. These factors enhance the formation of an abscission layer and reduce the life of a leaf. But abscission layer formation can also be enhanced through chemical sprays called defoliants. Chemical defoliation technology is almost sixty years old and has been accepted as a pre-requisite for machine picking. Defoliation is a cultural practice that induces abscission of cotton foliage earlier than normal and enhances crop maturity, but it is done at a crop stage such that it has no negative effects on fiber quality. The effect of defoliation on yield and quality has been studied extensively in many countries, particularly in those where machine picking has been adopted. But other countries where machine picking has not yet been adopted have also looked into the possible loss in yield or quality, though not in so much detail. There is no doubt that even if cotton is picked by hand, defoliation results in less trash in cotton if defoliated before picking.

The membranes that divide cell compartments go through complex physiological changes. In young healthy leaves, membranes permit efficient transport of material from one compartment to the other. But with age, the membranes begin to leak, and powerful enzymes capable of dismantling the cells are activated. Several physiological processes are upset and chlorophyll molecules that harvest the sun's energy also begin to break down. Ethylene production is also affected, and changes in the ratio of auxin hormone to ethylene across the separation layer initiate the abscission process. Auxin plays a major role at a joint between the leaf petiole and stem, and ethylene complements the activity of auxin.

The cotton leaf has an area near its base that is structurally different and characterized by a line of weakness where abscission occurs. The change in the hormone activity in the leaf blade triggers hormone changes in the abscission zone. Thus, the abscission process is controlled by hormone interaction initiated in the leaf blade and transmitted to the target area close to the stem or branch. The hormone changes cause the cells within the abscission zone to secrete hydrolytic enzymes that degrade the cell wall. As the process goes on, the leaves proceed toward their detachment from the plant, but the weight of the leaf blade causes it to fall even before the process is complete.

Defoliant chemicals induce their own way of aging and killing leaves by altering the hormone levels. Contact type defoliants induce abscission by stimulating the production of naturally occurring ethylene. Some are related to the naturally occurring hormone cytokinin.

Leaf Hairiness

Cotton leaves always have hairs on their upper side as well as on their underside, but the level of hairiness varies among varieties. The upper side always has lesser hairs compared to the underside. Profusely hairy varieties may have over 400 hairs per cm^2 on the underside. In countries where jassid is a problem, profusely hairy varieties are recommended in order to save them from jassid attack. Dense and lengthy hairs do not allow oviposition thus reducing the multiplication rate of jassid. The level of hairiness decreases with increases in the height of the plant and also with the delay in the planting of cotton. As leaves get older, they shed hairs, but not all hairs are shed and hairy leaves never turn into non-hairy or sparsely hairy leaves.

Some other references suggest that leaf hairiness is at its full expression on leaves on the 12^{th} node. However, there is no doubt that 20-22-day old leaves have the highest expression of number of hairs and length of hairs. In countries where jassid *Amrasca devanstans* is not a serious pest, varieties with profusely hairy leaves are promoted, but in others it is recommended to grow less hairy varieties. In some countries where jassid does not exist as a pest on cotton, less hairiness is considered a plus factor in varieties. Sometimes less hairy varieties are incorrectly claimed as glabrous. No cultivated cotton varieties have hairless leaves, but the density can be very low.

Cotton researchers in South Africa in the early 1920s discovered that hairy varieties resisted jassid attack. But the observation was used very little in the beginning. In was during the 1940s and after World War II that jassid resistant hairy material spread in the world and was first used as a defense strategy. Hairiness is a multigenic quantitatively controlled character, and varieties with highly dense hairs have been developed. Densely hairy varieties like velvet and much shorter in length (pilose) are also known to exist, but no such varieties have been adopted on a commercial scale. Hair density alone has proved to be unsuccessful in controlling jassid. So, both density and hair length are required for proper control of jassid.

The most common approach used in testing breeding material for resistance to jassid is not the counting and measurement of hair numbers and length in the lab, but the growing of such genotypes under unsprayed conditions and observing deformation of leaves. This approach needs to be improved to a scientific basis, counting hair density and length and the number of jassids per square leaf area under unsprayed conditions.

While leaf hairiness is a desirable character to control jassid, it can encourage other pests. The most serious competition has been the whitefly. Experience in many countries, particularly first in Sudan and then in Pakistan, proved that high hair density converted whitefly into a serious pest on cotton in both countries. The whitefly adults prefer hairy leaves and multiply at a much slower rate on glabrous leaves, thus, researchers have to choose which pest—whitefly or jassid—they would prefer to control through host plant resistance, and which they would control through other means, including insecticides.

Some bollworms may also establish better on hairy leaves compared to glabrous leaves. But the hairiness effect on trash contents is well known. Hairiness is an undesirable character because hairy leaves have a higher tendency to stick to open cotton bolls while falling at maturity.

Okra-leaf Does Not Favor Whitefly

The sweet potato whitefly *Bemisia tabaci* is a serious pest on cotton in many countries. It is also difficult to control and there is a need to find both economical and environmentally acceptable methods to control it. Experiments conducted in Sudan show that okra and super-okra leaf varieties offer considerable reductions in whitefly populations. But, since these varieties were not commercialized in the affected countries, the results have not been utilized. The misconception that okra and super-okra leaf varieties are lower yielding compared to normal leaf varieties also inhibits adoption. This perception has been disproved with the adoption of okra and super-okra leaf varieties in Australia. These varieties have also spread to other countries, like South Africa and the USA.

Experiments were conducted to assess the effect of leaf shape on whitefly population in western USA for five years, from 1996 to 2000. Experiments showed that the mean number of whitefly adults, eggs and nymphs was significantly lower on okra leaf varieties compared to normal leaf varieties. According to Chu et al., (2002), many varieties planted at one location in California and one location in Arizona from 1996-2000 showed that the number of adults/leaf were 7.2 vs. 9.6 and eggs were 14.2 vs. 18.0/cm^2 of leaf on okra and normal leaves respectively. The number of nymphs/cm^2 of leaf was also significantly lower on okra leaf varieties. The mean leaf area index was also measured in the last two years at one location, which was 49.6 vs. 59.0 and 55.3 vs. 64.9 cm^2 in 1999 and 2000 for okra and normal leaf respectively. The mean length perimeter was much higher in okra leaf, i.e., 62.1 vs. 41.4 and 73.4 vs. 46.4 cm^2 in 1999 and 200 respectively.

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Short Notes

• Bt Cotton in India

In the last issue of *THE ICAC RECORDER*, a note was published on the approval of genetically engineered Bt cotton hybrids in India. The Genetic Engineering Approval Committee granted the approval with the condition that a refuge crop be planted along with the Bt seed. The Genetic Engineering Approval Committee stipulated that fields where Bt hybrids are grown must be surrounded by a non-Bt variety of the same origin. The refuge crop will comprise five rows or 20% of the area, whichever is more, of the non-Bt hybrid of the respective Bt hybrid. The Bt hybrid seed has been sold in small packets for planting in 2002/03. It has been learned that Mahyco-Monsanto Biotech Ltd. sold 105,000 packets containing 450 grams of Bt seed and 120 grams of non-Bt seed. The price of each packet was US$32 (1,600 Indian rupees). Bt cotton was planted in six states in India on a total area of 42,052 hectares: 3,400 hectares in Andra Pradesh; 6,532 hectares in Gujrat; 6,714 hectares in Karnataka; 3,638 hectares in Madhya Pradesh; 16,685 hectares in Maharashtra; and 5,083 hectares in Tamil Nadu. The initial approval is valid for three crop years, from April 2002 to March 2005. Farmers are no doubt very enthusiastic about the use of the first genetically engineered crop in the country, but the performance of Bt hybrids versus their non-Bt isogenic hybrids has to be seen. However, the company plans to produce one million packets of Bt seed for distribution during 2003/04, which could affect yields in the six states. India is the eighth country to approve commercial production of Bt cotton.

• Additions in the Universal Cotton Standards

The Cotton Program of the USDA carries out a crop survey and other special studies in the USA to determine if any changes are needed to grades or other standards for correctly describing cotton quality. The primary objective of the standardization program run by the Cotton Program of the USDA is to develop, prepare, and distribute grade standards and calibration standards of cotton in order to ensure uniformity in grading and enhance the worldwide marketing of cotton. Many cotton associations in the world are signatories to the Universal Cotton Standards Agreement, and when a revision or change in standards becomes necessary, the USDA notifies the overseas signatory associations and all major U.S. cotton industry groups of the proposed changes. Such changes are presented to a Universal Cotton Standards Conference, held every three years in the USA. Under the agreement, changes accepted in a conference are submitted to the Advisory Committee on Cotton Standards, which submits its recommendations to the U.S. Secretary of Agriculture. The changes become effective after a year, only if approved by the Secretary.

Currently, twenty-four cotton merchant and spinners associations in twenty-one countries in Europe, South America, and Asia are signatories to the Universal Cotton Standards Agreement. The agreement provides for (1) the adoption, use, and observance of the Universal Standards in the classification of U.S. upland cotton; and (2) the preparation, distribution, and protection of copies of the Universal Standards. The last Universal Cotton Standards Conference was held in Memphis, Tennessee, USA on June 8-9, 2002 and the following changes to the Universal Cotton Standards were recommended.

- Addition of two Universal HVI Micronaire Calibration Cotton Standards:
  - √ The proposed standards will represent the high

(5.5) and low (2.6) ends of the American Upland micronaire range.

√ The six International Calibration Cotton (ICC) Standards for micronaire will continue to be available.

√ The proposed standards are on the same measurement level as the ICC Standards.

√ The proposed standards are intended for verification and/or calibration of the HVI micronaire measurement.

• Additional changes in the Universal HVI Cotton Color Standards and Universal HVI Cotton Trash Standards were also considered, but they were not approved for recommendation.

• The Universal Cotton Standards Conference also proposed that the USDA publication, "Guidelines for HVI Testing" be referenced to provide accepted procedures and practices for standardized HVI testing. These guidelines are available free at http://www.ams.usda.gov/coton/cnpubs.

• Subsidy to Cotton Production

The U.S. government has passed a new farm bill called "Farm Security and Rural Investment Act of 2002," which became law on May 13, 2002. The new farm bill replaces the "FAIR Act of 1996" and will be effective for the next ten years. The main objective of this farm bill is to support agriculture production in the country. The overall farm bill budget has been calculated on a ten-year basis at $180 billion. In 2002/03, cotton was grown on 5.2 million hectares in the USA, and production is expected to be 3.8 million tons with an average yield of 725 kg/ha. It is estimated that about 30,000 farmers grow cotton in the USA. They are all eligible for cash payments in three different forms but there is an addition to the new bill that limits maximum payment to any single farmer to US$360,000 per year.

Fixed decoupled payments: People who own land on which cotton was grown in the past receive a set payment of 6.67 cents per pound for each pound of average past yield. In most cases, current cotton farmers own or lease the land they farm. Yet, in at least some cases, the payments will go to people who no longer produce cotton.

Loan deficiency payments (LDPs): Cotton farmers are paid the difference between the "loan rate," fixed at 52 cents per pound, and a local "market" price estimated by the U.S. administration. The loan deficiency payments are "counter-cyclical" in nature: more is paid when prices are low and vice versa.

Counter-cyclical payments: These subsidies are paid when the overall income of farmers for cotton (i.e., the market return, plus the fixed decoupled payment, plus the LDP) falls below the "target price" of 72.4 cents per pound. However, this payment is made on the basis of what a farmer grew in the reference period, irrespective of what is grown on the farm in the current year. There was no provision for this third level of subsidy under the 1996 FAIR Act. Nevertheless, from 1998 the government introduced annual "emergency packages" in response to low prices. The new counter-cyclical payments provide a guarantee that the extra finance provided until now by "emergency" payments will be available every year. Farmers must either farm the eligible land or put it to a "conservation use." However, they do not need to plant cotton to receive the counter-cyclical payments.

It is generally believed that direct subsidies to production result in lower international prices and unfair competition among exporting countries. The ICAC has done extensive analysis of the situation and published many reports and papers. In addition to the USA, a number of other countries also provide direct support to farmers as below.

Assistance Provided by Governments to the Cotton Sector

Country	Assistance in U.S. Cents/Pound Lint 2001/02
Brazil	3
China (Mainland)	10
Egypt	3
Greece	59
Mexico	9
Spain	76
Turkey	3
USA	24
Argentina	4
Benin	5
Colombia	16
Cote d'Ivoire	2
India	9
Mali	3

For more details on the issue refer to the ICAC publications, *Production and Trade Policies Affecting the Cotton Industry*, July 2002, and *COTTON: Review of the World Situation*, May-June 2002. Both publications can be ordered from the ICAC at publications@icac.org.

• Emergence of a New Cotton Leaf Curl Virus Strain in Pakistan

Pakistan is the fourth largest cotton producing country in the world. Since 1992, an epidemic of cotton leaf curl virus has severely affected cotton production in the country. The Asian Development Bank estimated losses in production from 1993-97 at about 1.3 million tons amounting to US$5 billion. International funding by donor agencies like the Asian Development Bank, the Food and Agriculture Organization, and the Common Fund for Commodities/International Cotton Advisory Committee, in addition to federal and provincial governments' special efforts and well-focused aggressive research done in the country, enabled Pakistan to control the leaf curl virus problem. Pakistan production rose to more than 1.7 million tons during the last three years and the government's plans to strengthen research and extension services have contributed to the gains in cotton production. The leaf curl causing geminiviruses were extensively studied at various national institutes and collaborative efforts resulted in the development of many leaf curl resistant varieties. In Pakistan, cotton varieties require government approval for commercial seed production and cultivation. The variety approval rate was more than double compared to the rate prior to the appearance of the disease in 1992.

Recently, a new variant of the cotton leaf curl virus, a complex geminivirus, has been reported from Burewala, a place in the center of the cotton belt of Pakistan, The new virulent strain appears to have overcome resistance both in the commercial varieties as well as in the sources of resistance that were used for breeding virus-resistant varieties. Disease incidence and severity are increasing and it is feared that it could lead to serious losses in the next few years if proper steps are not taken now. Cotton experts and research managers are concerned with the new situation and they have already started the process of critically analyzing the problem. The Ministry of Food, Agriculture & Livestock of the government of Pakistan has already allocated additional funding to manage the new strain. Research conducted so far at various research institutes/stations revealed that this is a geminivirus with the same symptoms observed in the previous epidemic. Isolation and molecular characterization have already been taken up. A search to find new sources of resistance from the available germplasm in the country and also through genetic engineering has also been taken up on a war footing. Pakistan has the expertise and the experience to tackle the problem. (*Contributed by Dr. Yusuf Zafar, National Institute of Biotechnology and Genetic Engineering, Faisalabad, Pakistan.*)

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INTERNATIONAL COTTON ADVISORY COMMITTEE

The International Cotton Advisory Committee is an association of governments having an interest in the production, export, import and consumption of cotton. It is an organization designed to promote cooperation in the solution of cotton problems, particularly those of international scope and significance.

The functions of the International Cotton Advisory Committee, as defined in the Rules and Regulations are

- To observe and keep in close touch with developments affecting the world cotton situation
- To collect and disseminate complete, authentic and timely statistics on world cotton production, trade, consumption, stocks and prices
- To suggest, as and when advisable, to the goverments represented, any measures the Advisory Committee considers suitable and practicable for the furtherance of international collaboration directed towards developing and maintaining a sound world cotton economy
- To be the forum for international discussions on matters related to cotton prices

Membership of the Committee, which represents the bulk of the world's production, trade and consumption of cotton, now comprises the following forty-two governments:

Argentina
Australia
Belgium
Brazil
Burkina Faso
Cameroon
Chad
China (Taiwan)
Colombia
Côte d'Ivoire
Egypt
Finland
France
Germany
Greece
India
Iran
Israel
Italy
Japan
Korea, Rep. of
Mali
Netherlands
Nigeria
Pakistan
Paraguay
Philippines
Poland
Russia
South Africa
Spain
Sudan
Switzerland
Syria
Tanzania
Togo
Turkey
Uganda
United Kingdom
USA
Uzbekistan
Zimbabwe

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