Improvement of the Marketability of Cotton Produced in Zones Affected by Stickiness
Seminar of the project ‘Improvement of the marketability of cotton produced in zones affected by stickiness’
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Organizing Committee of the seminar in Lille, France: CFC - ICAC - CIRAD - IFTH - SCC – ARC.


Edition: GOURLOT J.-P.

Edition of external pages: Dist, Service des éditions, CIRAD.

Impression: CIRAD.

Cover picture: Bruno Bachelier: Opened cotton boll.

Produced by CIRAD, France.

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Introductory notice

This document includes the proceedings of the communications that were presented during the final seminar. Communications from external speakers from the Project CFC / ICAC / 11 are given in extenso under the author’s responsibility. All communications relating Project results are presented in the form of the titles of the presentations. The general conclusion extracted from the Technical Report N°17 is recalled here.

Most of the technical information and results of the project are given in the following book in English language:


The same report exists in French under the following title:

– Rapport Technique n° 17.

More details can be found in the book:


Finally, the French version of these proceedings is given in the book:

– Proceedings of the Final Seminar.

All books are available at the Common Fund for Commodities or at Cirad.

This report has been produced by the project. The views expressed here in are not necessarily stored by the Common Fund for Commodities.

General abstract of the book

This seminar gave the opportunity to present all the acquired results up to now on the project labeled Improvement of the Marketability of Cotton Produced in Zones Affected by Stickiness funded the Common Fund for Commodities and the International Cotton Advisory Committee.

The Sudan Cotton Company, the Agricultural Research Corporation, the Institut Textile de France, and the Cotton Technology Laboratory of CIRAD-CA have been partners to accumulate all the results which were shown

Stickiness of cotton fibers is an important problem in economic terms for the cotton business, from the grower to the transformation stages in the textile industry. The ongoing researches were able to define, for the first time, the importance of the problems which occur during spinning. Clear effects of stickiness on the productivity of an industrial mill have been shown. The quality of the yarns, obtained through ring spinning or open end spinning is sensitive to stickiness.

The classification of the bales produced using the H2SD (High Speed Stickiness Detector) seems to be a valid solution, both in technical and economical terms at the production stage.

Some other solutions exist to suppress the effect of stickiness, but were not studied during this project. However, the effect of relative humidity and the effect of mixing sticky cotton with non-sticky cottons were studied at the laboratory scale.
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This report was prepared by Mr. Jean-Paul Gourlot, Dr. Richard Frydrych, Dr. Omar Fonteneau-Tamime, Dr. Abdin Mohamed Ali from SCC, Dr. Ahmed Fadlala from ARC, Dr. Bruno Bachelier, Dr. Eric Gozé, with the help of Mr. Gérard Gawrysiak, Dr. Jean-Philippe Deguine, all researchers from Cirad.

Our special thanks go to the ICAC for sponsoring the project and to CFC for financing this project. Many thanks go to Dr. Rafiq Chaudry from ICAC and Dr. Sietse van der Werff from CFC for their involvement in the practical organization of this research work and for their assistance throughout the project.

We would like to thank Dr. Abdin Mohamed Ali from SCC who rendered all the experiments possible within his company with the help of ARC. We also wish to thank M. Abdallah (SCC), Mrs Fatma Shoke and Mr. Habiela Doudo (SCC) for their excellent work in Sudan. Many thanks to Mr. Mutasin Yousif (SCC) for fruitful contributions about statistical data analysis.

Most of the experiments in ‘Component A’ were undertaken by ARC, Wad Medani. We would like to thank Dr. Ahmed Fadlala, Mr. Abdelahmane Latif and their colleagues for their tremendous work on this project.

All the real-scale spinning experiments in ‘Component B’ were conducted at Institut Textile de France (now called Institut Français du Textile et de l’Habillement) in Lille, France. Many thanks for their work and for the availability of Dr. Bernard Deltête, Mr. Jacques Edmée, Mr. Marc Derradji, Mr. Thierry Le Blan and their staff in the workshops. Thanks also to Mr. Alain Dobat, accountant in IFTH for the financial follow-up during the project.

Many thanks to Mr. Christian Lebrun and Mr. Bernard Lebrun from SERCOM in Montpellier and Mr. Michel Giner from Cirad for their contribution in improving the measuring devices.

Many thanks are also due to Mr. Pierre Bouschet from ANVAR for funding development research on the measuring equipment.

We would like to thank the Caulliez Frères spinning mills for allowing us access to their combing facilities in order to complete specific experiments in the project.

We would like to thank Mr Mike Watson and his staff from Cotton Incorporated for their contributions in this project, and for the help they provided with stickiness measurements.
Our special thanks to Dr. Dean Ethridge and Mr. Eric Hequet for the HPLC testing they ran at their International Textile Center in Lubbock, Texas, USA.

We would like to thank Pr. Hubert Manichon, Pr. Alain Capillon and Dr. Jean-Philippe Deguine (Cirad-ca) for their unfailing support throughout the project.

The other experiments were conducted at the Cirad Cotton Technology Laboratory. We would like to thank Mr. Serge Lassus, Mr. Jean-Charles Nieweadomski, Mr. Philippe Francalanci for their work on the micro-spinning experiments and stickiness testing. Many thanks also to Mrs. Michèle Vialle, Mrs. Chantale Brunissen, Mrs. Sandrine Duplan for the fiber testing they performed on the samples collected in the course of the processes. Our gratitude also goes to Mrs. Hélène Guillemaund and Mrs. Dominique Braye who took care of the secretariat activities. Our accountants Mr. Hervé Gace, Mr. Benoit Cervello, Mrs. Annie Di Malta also deserve our thanks for the help they provided in drawing up the semestral and annual reports. We also would like to thank M. Claude Freud for his support during the economic studies.

We have not forgotten that everything was initiated thanks to Mr. Eric Hequet who started this project back in 1995. The project was also conducted for one year by Mr. Jean-Luc Chanselme who also deserves our thanks.
Opening Session
Opening session

JEAN-PAUL GOURLOT

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Ladies and Gentlemen,

In the name of the organising committee, I am most honoured to open this seminar which is devoted to presenting the results obtained in the course of the research project known as ‘Marketability of the Cotton Produced in Zones Affected by Stickiness’.

This corresponds to the conclusion of an immense, 4-year effort in daily co-operation between the ‘Sudan Cotton Company’ represented by Mr. Abdin, the ‘Agricultural Research Corporation’ represented by Mr. Fadlala, the ‘Institut Textile de France’ recently renamed the ‘Institut Français Textile Habillement’ represented by Mr. Deltête and Cirad, represented by Mr. Déat.

The work undertaken was rendered possible thanks to joint funding by the 'International Cotton Advisory Committee' represented by Mr. Townsend and the ‘Common fund for Commodities’ represented by Mr. Boehnke.

Four years. That seems like a long time, but when the work involves fascinating research with many people making complementary contributions, time seems to pass so rapidly.

All the research scientists and technicians from the different institutes participating in the project wanted to be sure of their results. They wanted to check and refine them to provide you with the best possible understanding of this cotton fibre contamination problem that manifests as stickiness. Over these three days, the orators are going to attempt to give you some perception of the gigantic amount of work that has been performed.

The main objectives here are to:

- increase planter returns through the development of effective methods for measuring the sticky potential of bales produced;
- establish an operating threshold for the processing of contaminated cotton;
- increase the price of sticky cottons;
- increase the amount of cotton on the market.

For effective management, the project was divided into three sectors, the principal objectives of which were to determine:

- The technical feasibility of stickiness grading, i.e. commercial grading of cotton bales by HVI analysis (High Volume Instrument) accompanied by mixing into batches of homogeneous quality as already performed for parameters such as length, micronaire, etc. Is this possible when fibre
stickiness is studied? The main results expected concern the type of method for possible recommendation, the evaluation of intra-bale and intra-batch stickiness variations and the development of a sampling method.

– At what level of stickiness are problems encountered in spinning? Until this project was started, no-one was aware precisely of the effects of stickiness on the different cotton processing steps and the consequences for productivity and quality. In the course of this project, we therefore made a particular effort to focus on this point. In addition, we attempted to determine the stickiness threshold, or thresholds, at which major problems emerged during fibre processing. This threshold, demonstrated using spinner criteria, was then used to separate cotton bales depending on their stickiness and thus assisted the first part of the project in establishing a commercial grading system.

– What is the economic feasibility of stickiness grading? In view of the threshold established and the grading costs, the mixing into batches, potential discounts imposed on sticky cottons, etc. an economic study was conducted to determine the feasibility of such a commercial grading system for a given cotton company in its everyday operations. Furthermore, two specific studies were conducted on the impact of relative humidity and the effect of diluting the stickiness by mixing sticky and non-sticky cottons. I should add here that it was also planned in this study to bring you all together today to inform you of all the results obtained.

This project is part of a more overall vision concerning the importance of cotton fibre quality for the entire industry. Defending cotton's market share against artificial and synthetic fibres necessarily requires improved control of cotton fibre quality. Here, in the face of this competition (SLIDE), all the players in the cotton industry are called on to find the right balance between a quality product, competitive productivity and profitability. This balance will inevitably require some measure of economic and qualitative compromise (SLIDE) imposed by the starting material and its naturally very variable characteristics, by the machines and their ever faster evolution and finally by consumer needs.

Thanks to the efforts made and the technological innovations that have taken place in the cotton industry over the last few decades both in terms of production (cropping methods) and in textile processing, this fibre today remains one of the most widespread on the market. As well as being of major economic importance for many countries, the irreplaceable qualities of cotton fibre have encouraged all the players in the industry to meet new challenges and satisfy market requirements.

The variable characteristics of cotton fibres constitute one of the main challenges facing the cotton industry. Cotton fibre quality is highly dependent on the appropriate development of the cotton plant. This quality is therefore dependent on environmental factors that are in part uncontrollable. However, the constitution of homogeneous batches needed for the production of quality yarn has become an explicit requirement expressed by spinners. Faced with this variability, research into cotton has provided the industry with new techniques to characterise fibre quality. These allow the fibre to be graded and homogeneous batches can thus be constituted for processing under the best possible conditions. The considerable capacity of HVI lines can cope with the systematic grading of all the cotton bales produced, as is notably the case in the USA. Since 1991, all cotton produced in this country (approximately 200 million bales) has been evaluated and graded by HVI. In December 1997, approximately 1100 of these HVI lines were operating world-wide. Nevertheless, this type of grading is still insufficiently employed in certain cotton-producing countries of the South where traditional methods remain in force.

The presence of impurities in the cotton fibre is a problem encountered increasingly frequently. This contamination reduces productivity and affects the quality of the finished product. The spinners, who are aware of the problems caused by contaminants, are increasingly strict as concerns the cleanliness of their starting material. Thus, discounts of varying magnitudes are applied to cotton contaminated by foreign matter. In addition, people working in the cotton industry are increasingly confronted with problems caused by more specific contaminants that require a precise determination of the nature and origin of each type of impurity encountered in the cotton fibre.
The measurement of total foreign matter content, irrespective of origin and as practised today, is no longer appropriate for the qualitative needs of the cotton industry. Indeed, the problems encountered by the spinner, caused by different impurities, and the means required for their neutralisation, may differ. It has therefore become necessary to identify the nature and origin of each type of impurity in order to evaluate the risk of disturbing subsequent processing and reducing the quality of the finished product. Such a possibility would allow all the players in the industry to envisage possible solutions, if solutions in fact exist, and this right from the very start of the process. If this is not done, as the cotton passes through the different steps in its processing, the economic losses caused by undetected contaminants are amplified because of the value added to the product at each step.

Although contaminants of artificial origin are a worrying problem for the cotton industry, they remain minor in comparison to those posed by impurities of natural origin. In fact, natural impurities are derived from the plant or its environment and because of this are more difficult to avoid. This second category includes particles of different origins that may behave differently during processing and have varying effects on the quality of the finished product.

These impurities include insect-derived contaminants that cause stickiness-related problems which manifest throughout processing to the yarn.

Fibre stickiness is due to the presence of large quantities of sugars and, less frequently, other non cellulose-related substances, e.g. oily or fatty substances. The sugars present on the fibre may be divided into two categories depending on their origin: physiological sugars produced by the plant, and entomological sugars secreted primarily by two insects: the aphid *Aphis gossypii* and the whitefly *Bemisia tabaci*. Here, it should be noted that, according to the literature, contamination by insect honeydew is the most prevalent. The resulting stickiness causes major disruptions during spinning and results in production losses and the introduction of defects into the yarn.

The project to be described here therefore aimed to clarify the commercial relationship between fibre producers and users in the difficult context created by the presence of varying degrees of stickiness. The magnitude of the annual effect of the stickiness problem is a major difficulty and has marked consequences on seller / purchaser relations. Some years are "sticky", others not. To this should be added the impact of the type of insect infesting the fields. Here, it would seem that the effects on cotton processing are different depending on the type of insect contaminating the fibres.

An incidental consequence of these difficulties is that the producing country may acquire a poor commercial image and reputation following stickiness problems. By accepting to work in this project, Sudan has demonstrated its willingness for transparency through all the efforts made to restrict the problem, and thus meet spinner requirements. The approach established by this research work could become a world-wide standard in terms of stickiness grading. Your future strategies that will decide this.

It is of capital importance here to mention that this project was set up and supported by Eric Hequet in 1995/96, and for this reason the Cirad-ca Cotton Technology Laboratory bore considerable scientific responsibility for the project. Jean-Luc Chanselme subsequently took over this responsibility. Then, as the director of this laboratory for the period during which the research was conducted I, in collaboration with our partners, was required to take certain decisions that led to doubling or even tripling certain specific studies. As you will see in the course of these three days, these decisions sometimes reoriented the project in different directions from those initially planned.

In all this research work, we started with hypotheses that required validation by experimentation and the gathering and comparison of information, etc. I would like to underline that all the results and conclusions presented here are based on knowledge acquired over the years; knowledge that was used as the foundation of our studies conducted to address the questions you have raised in the different sectors of the cotton industry. Questions that we converted into research objectives.

It should be noted that each person in the different sectors – producer, ginner, shipper or dealer, grader, spinner, equipment manufacturer, researcher – may have his own vision of the problems posed by sticky cottons.
If we wish to resolve these problems, we need information from you. This information, which is often technical, was always provided to us unless it gave its holder a certain technological advantage – and I'll come back to this point. The information received served as the base of our work and was used to put forward working hypotheses for the conduct of our studies.

However, like for all experimental work, the conclusions we shall be presenting are based on these hypotheses and are restricted to a given field of validity. There is always therefore the risk of using our conclusions in contexts other than that presented, or the risk of forgetting the context. I therefore ask you to be our ambassadors for all those using these results in the future. I ask you to explain that if considered outside the field of validity, a result or conclusion is no longer valid, or should be viewed with caution.

To come back to the question of technological advantage: as I already stated a few moments ago, technical solutions can be communicated fairly easily. By contrast, other information is inaccessible. As an example, research was conducted into the economic feasibility of a commercial grading system based on the measurement of cotton stickiness. Equations were used here for modelling purposes. They employed certain parameters that are readily accessible: production volumes, salaries, fixed costs, etc. On the other hand, these models also require information about prices and this appeared to be very "sensitive" and can nearly be considered as top secret. The same may be said for the price of traded materials. Given that the starting materials used by a spinner account for 50 to 60% of his costs, it is evident that even the smallest price advantage over a competitor corresponds to an undeniable advantage on the current market and that this information was not made available to us. In view of this, the results we shall be presenting on the economic side of this project have extremely limited fields of validity and the simulations made are founded on very broad hypotheses. However, the discussions that have been organized over these three days will be the opportunity for us to share our experience and knowledge, and could therefore serve to better calibrate the model through any information you consider it appropriate to provide.

This project also involved a University dimension: in partnership with the Ecole Nationale Supérieure de Industries Textile in Mulhouse, represented by Mr. Renner, a school that is part of the Université de Haute Alsace, and here Cirad assisted Mr. Omar Fonteneau-Tamime throughout his thesis work which he presented in June 2000.

I would like to take advantage of this introduction to thank the experts delegation, represented by Mr. Afzal. This delegation audited the project in April 2000. They validated our working hypotheses and approved the results that are to be presented here. On the basis of the work already conducted by April 2000, they also approved the conclusions and perspectives we presented at that time.

Another quick word to thank all the orators who have come here to present their work on the methods used to control stickiness world-wide.

Thanks are therefore due to the Common Fund for Commodities and the International Cotton Advisory Committee for their active support in this research work.

Many thanks also to all those who have come from far away to participate in this sharing of our results. I wish you all a very agreeable stay in Lille and a seminar rich in instructive exchange.
Talking points in Lille

TERRY TOWNSEND

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World cotton situation

World cotton prices are not expected to return to their long run average levels in the next several years, making efforts to lower production costs and improve quality all the more important. The decline in cotton prices during 2001 is forcing a reevaluation of basic expectations about the structure of the world cotton market.

The ICAC recognized as early as 1994 that the world cotton yield was not increasing, and investigation showed that yields in many countries had actually leveled or even begun falling in the late-1980s. The importance of rising yields is underscored by the fact that all of the gain in world cotton production between 1950/51 and the early 1990s resulted from increases in yields. Therefore, with the world yield no longer climbing in the 1990s, it seemed that world production would not expand. With economic growth and increases in population leading to a rise in cotton use, the expectation was that demand would climb while supply did not, resulting in above-average cotton prices in most seasons.

This basic view of world cotton fundamentals [stagnant supply confronting rising demand, resulting in above-average prices] seemed accurate in the mid-1990s when the Cotlook A Index climbed to more than $1 per pound. The decline in prices during 1995/96, 1996/97 and 1997/98 seemed justified by the rise in production after 1994/95, and few expected that the exceptional prices of 1994/95 would continue. When cotton prices continued lower in 1998 and 1999, the fall was rationalized by the Asian financial crisis that began in Thailand in 1997, by additional currency devaluations in Russia and Brazil in 1999, and by lower imports by China (Mainland). The basic view of tight supplies still seemed justified, and cotton prices were surely expected to climb in 2000/01. And indeed prices did rise in 2000, climbing to 66 cents by December and seeming to validate the expectation that prices would be above average in most years. But the sharp decline in prices in 2001 has carried the A Index to less than 50 cents per pound, forcing a questioning of the basic assumptions that world supply was stagnant while demand was rising.

The expectation that stagnant supply would confront rising demand was half right; world cotton demand rose to a record of 19.8 million tons in 1999/00, and additional growth is expected over the next two seasons as world economic growth improves and current cotton prices encourage increased cotton use. However, the expectation that supply is stagnant does not seem to be valid. While world production remains at about 19 million tons in 2000/01, cotton area is forecast to rise in 2001/02 and production is forecast to increase to 20 million tons, despite prices near the lowest levels in 25 years. In economic terms, the world cotton supply curve seems to be moving to the right, meaning that even at current prices, production is rising.
Four factors seem to be influencing the rise in cotton area despite low prices: improved technology, the strength of the US dollar, expansion into new cotton area and government measures. The most visible of the new technologies is genetic engineering (GE). GE cotton already accounts for 16% of world cotton area and is the most rapidly adopted technology in the history of agriculture. GE varieties may lead to higher yields. However, the primary impacts of the technology are to reduce risks and costs, thus leading to higher area and greater production. Incremental advances in proven technologies such as irrigation management, pesticide formulations and pesticide applicators, low till and no till production systems, crop rotations and other management techniques are also contributing to lower production costs and expanded cotton production, despite three consecutive seasons with average prices of less than 60 cents per pound.

The strength of the US dollar is encouraging increased production in those countries where currencies have depreciated. The US dollar has risen by one-third against the Australian dollar in the past three years, by 90% against the Brazilian reais, by one-fourth against the currency of Francophone Africa, and by 500% against the Turkish lira. Thus, while cotton prices measured in US cents per pound are among the lowest in 25 years, prices in the currencies of producers outside the USA are somewhat more attractive. It is instructive to note that in Argentina, where the peso is pegged to the US dollar, the cotton industry is not expanding.

The development of new areas for cotton in Brazil and Turkey are contributing to the rise in world production. Production costs in Mato Grosso, Brazil are estimated at 35 US cents per pound for well-managed enterprises, and production has climbed from 30,000 tons to 450,000 tons in Mato Grosso since the mid-1990s. The expansion of irrigation in East Turkey is well documented, and the GAP region now accounts for 450,000 tons of production, compared with 164,000 tons in 1994/95 when the Cotlook A Index averaged more than 90 cents per pound. Together, Mato Grosso and East Turkey are accounting for an additional 700,000 tons of world cotton production that is still expanding, even at current prices, and that did not exist in 1994/95.

Measures by governments to support farmers and domestic production during periods of economic stress are also affecting the world cotton supply. The US, the EU, China (Mainland), Mexico, Brazil, Egypt and Turkey programs that support cotton farmers. In total, the measures by governments are boosting world production by an estimated two million tons over what would be produced at current prices in the absence of the measures.

One implication of rising world production is that a recovery in prices to average levels is not likely soon. Secretariat estimates of season averages of the Cotlook A Index remain below 60 cents per pound over the next several seasons. Obviously, weather can and will change the outlook for prices from season to season. But rather than an underlying expectation that cotton prices will tend toward levels of 80 cents per pound, it now seems more likely that the average level of prices will tend to less than 70 cents per pound, compared with the average since 1973/74 of 73 cents. Low prices will ultimately benefit consumers, and the rate of growth in world cotton consumption may return to approximately 2% per year, as was common prior to the mid-1980s. However, continued low prices are obviously going to put additional pressures on producers, leading to less intensive input use, continued efforts to lower costs through technology and sharpening diplomatic conflicts over government measures.

This means that the work of the Common Fund for Commodities to finance projects that directly benefit producers in least development countries will become ever more important.

**Stickiness affects one-fourth of world production**

Stickiness affects one-fourth of world production, and much work has been completed on the nature of sugar contamination. However, the solution to stickiness lies in the elimination of the insects responsible for causing stickiness in the first place. A project with this objective has been undertaken with CFC funding, and a presentation of results will be given in the next session.
Extraordinary projects

The current project has made extraordinary advances in knowledge regarding the segregation of sticky cotton from non-sticky cotton, and in techniques to spin blends of sticky and non-sticky cotton. The entire cotton community, from producers through to textile manufacturers will benefit from the results of this project.

ICAC: The International Commodity Body for cotton

The ICAC was identified as the International Commodity Body for cotton in 1991, and there has been a strong and cooperative relationship in the decade since. Through the efforts of the CFC, there are 9 cotton projects valued at over $50 million that are contributing to the improvement of the world cotton economy. I want to thank Dr. Boehnke and the member countries of the CFC for making these resources available for the improvement of commodity markets. I also want to thank the organizers of this Final Workshop for their efforts in making this meeting as productive as possible.
Statement of the Common Fund for Commodities – Cooperation for Development - on the occasion of the final workshop for the project “Improvement of the Marketability of Cotton Produced in Zones Affected by Stickiness”

DR. ROLF W. BOEHNKE

Managing Director, Common Fund for Commodities, Willemshuis, Stadhouderskade 55, 1072 AB
Amsterdam, The Netherlands

Mr. Chairman, Dr. Terry Townsend, Executive Director of ICAC, Dr. Abdin Mohamed Ali, CEO of Sudan Cotton Company, Distinguished Participants, Ladies and Gentlemen: May I welcome you to this Workshop in Lille, a city which has been and is well known for its link to the textile industry.

It is a pleasure for me to be here at this workshop and to be able to share with you some of my thoughts on this project, its background, its implementation and the expectations on the outcome. I will not go into details of the technical issues which will be much better covered by the many highly qualified experts later on.

Instead, I will limit myself to a brief account of the mandate and activities of the Common Fund for Commodities and subsequently I will touch upon some salient aspects of the project.

As most of you will be aware, the Common Fund for Commodities (CFC) is an autonomous intergovernmental financial institution established within the framework of the United Nations in 1989. The Fund forms a partnership of 104 Member States and three intergovernmental organizations.

The Common Fund’s mandate is to enhance the socio-economic development of commodity producers and to contribute to the development of society as a whole. In line with its market-oriented approach, the Fund concentrates on commodity development projects financed from its resources, which are capital subscription by Member Countries, voluntary contributions and interest earned. Through cooperation with other development institutions, the private sector and civil society, the Fund endeavors to achieve overall efficiency and impact in commodity development.

The focus of the Common Fund is on commodities and this has good reasons. Many developing and least developed countries are heavily dependent on commodities which form the backbone of their economies and account for the bulk of their export earnings. It is estimated that around 1 billion people derive a significant part of their income from the production of export commodities. This
number would substantially increase if production for domestic or national use would be taken into account. It should also be noted that it is frequently the poorer strata of the population which is involved in commodity production. The Common Fund, therefore, deals with a core question of development in many regions of the world.

The Common Fund operates under the novel approach of commodity focus instead of the traditional country focus. Commodity focus means concentrating on general problems of commodities affecting several countries. The activities of the Fund mainly comprise commodity development measures aimed at improving the structural conditions in markets and at enhancing the long-term competitiveness and prospects of particular commodities. They include: research and development; productivity and quality improvements; transfer of technology; diversification and processing; and improvement of marketing and product development. Secondly, the Fund supports commodity market development activities which assist Developing Countries and, in particular, the Least Developed Countries (LDCs) but also Countries in Transition, to function effectively in a liberalized global economy. Projects in this field include: physical market development; enhancement of market infrastructure; facilitation of private sector initiatives, and commodity price risk management.

The Common Fund concentrates on low cost, high impact projects which have the potential of becoming self sustainable and the Fund involves, whenever possible, the private sector. By May of this year, the Fund had approved 96 regular projects, with a total cost of about US$ 290 million. Of this, CFC finances approximately 45%, the balance comes from other donors and the participating institutions through counterpart contributions. This high co-financing ratio is testimony of the catalytic role played by the Fund in commodity development. The average project size is around US$ 3 million and the duration is between two to five years. In addition to the regular projects, 20 so-called Fast Track projects have been approved. These Fast Tracks are small projects with a maximum CFC contribution of up to US$ 60,000.

The Common Fund for Commodities is a financial institution and as such does not develop its own projects. Projects are submitted by 24 so-called International Commodity Bodies, which are intergovernmental organizations, such as the International Cotton Advisory Committee, specializing in particular commodities. Besides cotton, the Common Fund for Commodities can support projects for about 60 other commodities.

Let me now come to the project which is the focus of our discussions at this workshop.

Stickiness in cotton is one of the major concerns of cotton producers as well as consumers. Stickiness affects both the quality of the lint as well as its processability. The increasing use of high-speed industrial spinning equipment adds to the importance of having clean lint of uniform quality without any irregularities that disrupt the spinning process. While most forms of contamination can be detected by visual inspection prior to the spinning process, stickiness often only becomes noted during spinning when frequent breakages occur. Timely, reliable detection and magnitude assessment can thus reduce problems in spinning, and enable spinners to better use their machine capacity at higher speed and to produce higher quality.

Of course, it would be better to prevent contamination and to produce clean cotton and clean lint. Cotton being a natural product, however, cannot always be protected against contamination. As you may be aware, the Fund has financed a recently concluded project on integrated pest management of cotton, with specific reference to the protection of the crop against aphids and whitefly, which are the main agents causing stickiness in cotton. During this workshop, there will be a presentation by Mr Gadi Forer, highlighting the main findings and recommendations of the whitefly project which was based in Israel, Egypt, Ethiopia and Zimbabwe; the results of this project have been summarized in two technical publications, which are available through the Fund and the International Cotton Advisory Committee.

We note with satisfaction that in the current project on stickiness the Project Executing Agency is based in a Least Developed Country, supported by co-operating agencies in a developed economy. The project has shown to be an important example of co-operation between the project teams in Sudan and Europe. When I visited the project sites in Khartoum and Wad Medani during a mission to Sudan in February 1999, I was very impressed by the professional work done by the project team.
Mr. Chairman, may I suggest that in the presentations and the discussions during the coming days, we should reflect on how the project results can be made operational and become cost effective, and also to reflect on what remains to be done. A crucial consideration will be whether the proposed equipment and methods will convince buyers of cotton that the level of stickiness reported is correctly estimated and that this will be reflected in a price premium for producers.

I wish the workshop successful proceedings.

Thank you, Mr Chairman.
The Sudan Cotton Company - The Project Executing Agency (PEA) - Project CFC / ICAC / 11

DR. ABDIN MOHAMED ALI

General Director, Sudan Cotton Co., P.O. BOX 1672, Khartoum, Sudan

Ladies and Gentlemen:

It is a great pleasure to be here today and to welcome you all to this final workshop of our project « Improvement of the Marketability of Cottons Produced in Zones affected by Stickiness ». I really feel honored by having such a group of eminent scientists and distinguished businessmen among this great audience, coming to share with us the experience we gained during the last three years of hard work, both, in the Sudan and here in France.

The Sudan was greatly honored by having the Common Fond for Commodities (CFC) and the International Cotton Advisory Committee (ICAC) endorsing this project to be executed in our country. We in the Sudan Cotton Company (SCCL) were specially privileged by being appointed as Project Executing Agency (PEA). Please, let me take this opportunity, on behalf of the SCCL, the PEA, to thank you all for coming and being with us here today.

I would like also, as PEA, to take this opportunity and thank all the parties who were involved in the various project activities: CIRAD, IFTH and ARC, and express my admiration to the marvelous cooperation and team work spirit among them. This spirit was the key factor that helped reaching the results which will be displayed during this and the coming two days.

On the side of the project outcomes, we now, at least, have an objective methodology, in place of the previous subjective ones, by which we can measure cotton stickiness, thanks to modern technology. This was not available just ten years ago, and the array of the subjective methods which dominated in the past, were utilized more cleverly by some "people" and were of very limited use to the original producer.

It is, however, true the results were short of our intentions and ultimate aspirations, yet they are still of great importance to cotton producers, particularly in the developing countries. For practical reasons, if was not possible to establish firm and internationally accepted thresholds for the various levels of stickiness. It was very clear such thresholds would be extremely difficult to establish because any level of stickiness, however small that level was, proved to have a negative effect on efficiency or quality or both. Yet, still, this technology and methodology can be used to very successfully stratify the cotton production into categories of known levels of stickiness. Also, these levels can be fairly guaranteed if variation could be controlled- Prices could, accordingly, be negotiated on farmer grounds, and such guaranteed levels are equally important for the merchant and the spinner as they can decide better, knowing what they are actually buying.
The benefits for us in the Sudan Cotton Company and the cotton sector in the country- as a whole are great and worthwhile. A well trained core staff of cotton scientists and technicians, who were well exposed and connected with international research and technology centers, like CIRAD and IFTH is a great asset.

We all feel better now in abilities to deal with our number one cotton problem, stickiness. The technology is at home now. With the very effective scientific and technical know-how made available by this project we are ready to move forward and work towards providing our customers, worldwide, with cotton not only of the best fiber quality they know, but also contamination and stickiness free.

Thank you again
Agricultural Research Corporation and its cotton programme

DR. AHMED S. FADLALLA

Agricultural Research Corporation, GEZIRA research station, Cotton Research Program, Wed Medani, Sudan

Good morning, Ladies and Gentlemen, and warm greetings from Sudan.

Actually the part of ARC has been covered very well by Dr. Abdin. I will give some definitions of ARC and Cotton Research Program and how we came in.

The issue of the stickiness is very central and very important to us in ARC because we are the body who is mandated to conduct investigation and do research for all the problems which are related to agricultural productions and marketing distorting problems. The ARC is an autonomous body within the Ministry of Agriculture of the Sudan, now it has been moved to a new Ministry called The Ministry of Science and Technology but that really is not important and it does not change anything on the mandate of the ARC. It has been established back in 1902, 100 years ago, and it continued development of technologies and issuing recommendations for the improvement of productivity and quality of the various crops in the Sudan.

The cotton research program is the largest and most important research program in ARC and it has been like this for quite a long time. It is still very important and very big. Cotton is grown in the Sudan for almost 800 years. This is a very well known fact. Commercial production as mentioned by Dr. Abdin, has started back in 1867.

Cotton research has started with the start of ARC also in 1902. During this period, 100 years, tens of varieties are counted up to 39 commercial varieties, were generated in the cotton research program and were developed for the various ecological zones in the country and for the agricultural systems rain fed and irrigated. These varieties addressed all the production constraints of bacterial blight, leafcurl, Fusarium wilt, early maturity, insect pest, weeds and field tolerance. It addressed all kinds of biotic and abiotic stresses and issued relevant technologies recommendations.

The stickiness problem actually started and continued and remained the major concern of the cotton research program. The problem really started as a serious one in 1960 and in a very short time it was identified by the researchers as the outcome of sugary secretions of the honeydew secreted by the white fly and the Aphids. Post control research was intensified accordingly and considerable success was achieved at the research level in controlling those insects. But unfortunately the problem remained because application was lagging behind research for some reason. In all cases, the insect population and the stickiness level were remarkably reduced. But unfortunately this reduction was not reflected in the price.
The national production remained stigmatized and stamped as sticky in the minds of buyers and the international market. Our own evaluation in our cotton technology lab revealed that annually there is a considerable portion of our cotton which is either free or having very little stickiness which should have a price comparable to clean cotton but it did not. That portion was in most cases above 50%.

But the market attitude did not change. The development of methods to separate a sticky of a non-sticky cotton objective and recognize the international market was a great idea for us that came in time. ARC could only accept to take its part in the project with pleasure in order to develop the sampling methodology and to do the stickiness evaluation with the SCT. That is what we did and we were very pleased to do that.

Thank you for your attention.
Institutional and technical communications
Cotton contamination survey 1999, ITMF

HERWIG STROLZ

Am Schanzengraben 29, Postfach, CH 8039 Zurich, Suisse

Abstract: The International Textile Manufacturers Federation organizes a survey among its members every two years. This survey records the spinner's perception concerning main cotton origins. This presentation relates the results of the 1999 survey and compares the results to previous surveys.

Note: M. Herwig Strolz, not being available at the dates of our seminar, was very nice to provide us with the slides he presented in Bremen conference. Jean-Paul Gourlot, who was attending this conference, did the presentation. The following text was prepared by M. Herwig Strolz.

Some of those present in this room will recall from past presentations to this conference that ITMF started over 20 years ago to regularly survey spinners around the world on their perception of contamination they have experienced with the processing of cotton. In 1989, the survey was put on a new methodological basis, the 1999 edition released in October of last year being the sixth and last in the new series.

Before entering the analysis of the results of the 1999 report, I would like to make two observations in response to questions which have been raised in the past. The first relates to what this report is all about. As I have said earlier, it is a reflection of spinners’ perception of contamination. It is not a scientific pronouncement on a cause and effect relationship we feel is neither necessary nor feasible. Spinners are buying cotton with the record of perceived contamination in mind and not on scientifically-founded evidence. Producers would therefore be well advised to take the results of the survey seriously and think about proper strategies to correct the problem.

The second point I would like to make relates to the question whether the survey is a true reflection of the extent of the contamination phenomenon. The most important precautionary measure we have taken to avoid distortions consisted in the elimination in the report of all growths that have been evaluated less than five times. From a statistical probability point of view this would seem to ensure as true a reflection of the real situation as possible. Because of this limitation, of the 87 growths (figure 1) which were evaluated by the spinning mills that participated in the 1999 report only 58 (figure 2) or two thirds were considered in the survey.

Let me now turn to the results of the 1999 report.

Participation

As far as participation is concerned, the number of reporting spinning mills decreased (figure 3) slightly from 297 in 1997 to 283 in 1999 as did the number of participating countries which fell from 27 to 24, the most notable absentee being Pakistan whose industry ceased to be a member of the Federation two years ago. Lower participation was partly responsible for a fall in the total number of...
samples evaluated which decreased from 1,800 in 1997 to 1,500 in 1999 (figure 4). The other reason for a lower sample level lies in the fact that in 1999 a particularly large number of participating mills were from cotton producing countries such as India and the US which limited the number of evaluated growths as spinners in these countries use mostly domestic varieties (figure 5). Thus the 43 participating US spinning mills evaluated 160 samples, a relationship of 1 to 3.8 whereas the 14 participating mills in the Czech Republic evaluated 78 samples (1 to 5.6).

Overall Contamination

The really bad news of the 1999 survey (figure 6) is that contamination overall deteriorated, showing the second steepest rise in a two-year period after the one from 1993 to 1995. The cottons evaluated in 1999 were in 21% (18% in 1997) of all cases found to be seriously or moderately contaminated (figure 7) by 16 different sources of foreign matter mentioned in the questionnaire, leaving only 79% (82% in 97) insignificantly or not at all contaminated. As the summary data are arithmetic averages, the extent of contamination is fully illustrated only by the results for the individual contaminants (figure 8) which range from a mere 4% for “tar” (unchanged from 1997) to no less then 39% of all cottons evaluated being moderately or seriously contaminated by “organic matter”, i.e. leaves, feathers, paper, leather, grass and bark, etc. (+ 5% compared to 1997). Other serious contaminants were strings and pieces of fabric made of jute/hessian, woven plastic and plastic film.

Contamination by Country/Region

When we look at contamination by countries/regions (figure 9), we see a worsening situation in 1999 in nearly all major producing areas, one of the few exceptions being Argentina. Countries/regions showing the most pronounced deterioration were West Africa (+ 56% compared to 1997), Pakistan (33%) and India (+ 16%). It must be stressed however that despite the large increase in percentage terms, West Africa remains an area with an overall low level of contamination compared to India and Pakistan. Even model countries such as Australia and Zimbabwe had a higher contamination record in 1999 although they still remain on top of the list of the world’s least contaminated growths.

The longer-term development covering the period from 1989 to 1999 shows a mixed picture of deteriorations and improvements (figure 10). Limiting myself to the major growths, Central Asia remains the area with the worst record showing an increase in 1999 of nearly 160% over the contamination level of 1989. Egypt follows in second position (+ 127% since 1989) but exhibits the steepest rise in the last 2 years. In third position amongst the larger producers comes the United States (+ 46%) which exhibits a slight acceleration since the mid-Nineties. With an average degree of contamination of 12.6% US cottons range however at the lower end of the scale. West Africa which has performed best between 1989 and 1997 has not been able to continue on the same track, the deterioration in the last two years being the second largest in this group of countries after Egypt. India and Turkey, two countries which started out with very high contamination levels in 1989 have recorded some improvement last year, Turkey’s overall contamination level in 1999 being however still 24% higher than 10 years ago whereas India’s remained unchanged from what it was at that time. Brazil’s overall contamination level finally shows a slight deterioration compared to 1997, but still a marginal improvement over what it was 10 years ago.

The ITMF report does not only cover sources of contamination proper but also such problem areas as stickiness and seed-coat fragments.

Stickiness

As far as stickiness is concerned, occurrence overall for the 58 growths evaluated has fallen in 1999 to about the same level as in 1995 and was marginally better than in 1989 (figure 11). This has come as a surprise to some and was the result of a significantly lower occurrence mainly in US and Central Asian growths which, thanks to their high consumption and hence evaluation levels, have a considerable weight in the overall picture (figure 12). Countries where the situation has slightly
deteriorated are India and some West African descriptions. There was only one country where stickiness has risen sharply in 1999, namely Mexico.

Of the more important growths (figure 13), Sudanese cottons remain the most affected with nearly 75% of all those having used these origins experiencing stickiness, followed by the average of all growths of West Africa (33.5%), Central Asia (25.3%), India (21.9%) and the US (18.6%). At the lower end of the scale follow Turkey (9%), Australia (9%) and Argentina (5%). No stickiness was reported from Paraguay.

**Seed-coat Fragments**

After a drop of 16% in 1997 (figure 14), seed-coat fragments flared up again in 1999, 38% of all evaluations indicating the presence of this particularly nasty problem for spinners. As a result, the longer-term trend is now clearly in an upward direction whereas it pointed downwards for the 1991-1997 period (figure 15).

In the league of the most affected growths (figure 16) are those from Pakistan (67% of all evaluations indicating the presence of seed-coat fragments), the average of all growths from Turkey (61%) and from India (59%). In the middle range the average of all growths from Central Asia and West Africa (34% each) and from the United States (26%). Nearly free of fragments were cottons from Australia (5%).

**Outlook**

According to the International Cotton Advisory Committee, the share of cotton in total fibre consumption has fallen to under 42% in 1999 from 50% in 1986 and is forecast to go down further to 40% five years from here. Even if consumption of cotton will grow in absolute terms, it will rise much more slowly than the competing man-made fibres.

There are several ways open to combat this potentially dangerous course, one of them being the improvement of quality, contamination-free cotton remaining the number 1 priority of any spinners. All the mechanical and electronic devices that have been developed in recent years to eliminate contamination in the spinning process should not lead to believe that technology alone will eventually take care of the problem and make contamination soon a subject of the past. Spinners whose mills have been equipped with these devices look at them as a safeguard of last resort. Only contamination-free cotton (figure 17) allows them to run their mills at the highest levels of productivity which is so essential for success in today’s competitive textile world.
Cotton Contamination Survey 1999 Evaluations

87 growths evaluated

Figure 1: Number of evaluations.

Cotton Contamination Survey 1999 Evaluations

58 growths considered

Figure 2: Number of evaluations considered.
Figure 3: Number of participating companies.

Figure 4: Number of samples.
### Cotton Contamination Survey 1999
#### Mill Location vs Sample Volume

<table>
<thead>
<tr>
<th>Country</th>
<th>Particip. Mills</th>
<th>Samples</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>43</td>
<td>160</td>
<td>1/3.8</td>
</tr>
<tr>
<td>Czech Rep.</td>
<td>14</td>
<td>78</td>
<td>1/5.6</td>
</tr>
</tbody>
</table>

Figure 5: Sample representativity.

### Cotton Contamination Survey 1999
#### Degree of Contamination

Figure 6: Degree of contamination.
Figure 7: Trend of the contamination level.

Figure 8: Contamination by origin.
Figure 9: Cotton contamination by country.

Figure 10: Evolution of the contamination by country.
Figure 11: Evolution of stickiness.

Figure 12: Evolution of stickiness by country.
Figure 13: Stickiness by country.

Figure 14: Evolution of seed coat fragments.
Figure 15: Global trend of seed coat fragment contamination.

Figure 16: Seed coat fragment by country.
Contamination-free Cotton = Number 1 Priority

Figure 17: ITMF need.
Presentations made by the Chairman of the ITMF stickiness working group at the Bremen conference (from February 28 to March 3, 2000)

MIKE WATSON
Cotton Incorporated, 6399 Weston Parkway, Cary, North Carolina 27513, USA

Abstract: The International textile manufacturers federation is organised into working groups. The working group concerned with sticky cottons is headed by Mr. Mike Watson who relates here the information presented in Bremen in March 2000. The source of the stickiness is explained along with various methods used to characterize this contamination. The Cirad Sticky Cotton Thermodetector (SCT) is the method recommended by ITMF for the measurement of stickiness on the fibres. Requests for recommendation have been received this year for the Lintronics Fiber Quality Tester (FCT) and the Cirad High Speed Stickiness Detector (H2SD) with a view to replacing the SCT recommendation. An international test will be organized to decide between the candidates.

NB: Since Mr. Mike Watson was not available for the seminar, he was kind enough to supply us with the slides he presented at the Bremen conference. Jean-Paul Gourlot who was present at this conference made the presentation. The text provided below is simply a brief outline of the presentation made by the author in Bremen.

Cotton stickiness generally manifests at points in the fibrous matter where pinching occurs. Figure 1 illustrates this phenomenon during the drawing step. Several studies, including that presented by Mr. Héquet, ITC USA, demonstrate the involvement of stickiness in breakages occurring during yarn production.

What causes stickiness?

Whereas sugars have for many years been considered to be implicated in stickiness, all recent research has shown that sugars do not necessarily induce fibre stickiness during processing. Sugars may be derived from several sources.

They may come from the plant and are thus called physiological sugars. These sugars are always present and are evenly distributed in the fibres. They generally have a glucose, fructose and sucrose base and can be detected by means of simple chemical tests (Perkins test, Fehling test). They tend to create chronic problems during spinning.

Sugars may also be secreted by insects present on the crop. These entomological sugars contain monosaccharides (glucose, fructose) and polysaccharides (sucrose, melezitose, trehalulose). They are not always present in the fibre and are not evenly distributed in the fibre mass. They cannot be detected by simple chemical means, but by HPLC. They cause "immediate" problems during spinning.
This source of stickiness has therefore been the subject of careful study by different research teams. Two insects are the main source of these sugars: whitefly (figure 2) and aphids (figure 3).

**Different methods of detection**

The reference method is that using the mini-card (figure 4) which has the advantage of measuring the stickiness potential of the fibres under conditions that are almost identical to those encountered in industry. However, this method is subjective where the operator evaluates the cotton on a scale of stickiness.

Since 1994, ITMF has been recommending the method based on the Sticky Cotton Thermodetector (SCT) (figure 5) where points of sticky material are deposited by heating and pressure onto a sheet of aluminium. These points are then counted and their number determines the contamination of the sample tested.

Over recent years, an increasingly pressing need has been felt for a rapid and automated stickiness test. In response to this, Cirad (France) developed a prototype, the High Speed Stickiness Detector (H2SD) (figure 6) and this has now led to the production of an instrument available on the market (figure 7).

Lintronics (Israel) has produced the Fiber Contamination Tester (FCT) (figure 8) and the Fiber Quality Tester (FQT) (figure 9) that both integrate a stickiness measurement module.

**How valid are the chemical tests?**

Figure 10 gives the results of HPLC assays of sugars derived from the two main insects responsible for stickiness. The percentage contents of the different sugars, as measured by ITC, are different depending on whether the contamination of the cotton crop is due to one or the other of the insects.

**Prevention of stickiness**

Prevention programs have already been implemented in the USA where advice is given in terms of cropping methods (figures 11 and 12). These primarily deal with recommendations for controlling the insects. These programs recommend specific cropping conditions depending on the stage of pest development (figures 13 and 14).

**Meeting of the ITMF "stickiness" working group**

At the meeting of the ITMF working group, Mike Watson reiterated the need to standardize the terms stickiness, honeydew and sticky points.

Then Mr. Uzi Mor and Mr. Jean-Paul Gourlot asked ITMF to recommend their methods, i.e. the FCT/FQT and H2SD (figure 15) respectively.

Mr. Shlomo Peles, Israeli Cotton Board, provided his results on the use of the FCT in Israel.

Mr. Hequet, ITC, USA, presented his latest results concerning the effects of stickiness on spinning by using H2SD data obtained from tests conducted on industrial-scale spinning equipment.

Mr. Mike Watson presented the rules to be respected by the instruments put forward for recommendation in terms of measurement repeatability, precision etc. (figure 16).

**Conclusion**

As a conclusion of the discussions held by the working group, the committee considered that both methods are under examination (figure 17) and that inter-laboratory testing will be organized. The operating procedures for the different methods will be circulated to group members for comment.
Figure 1: Stickiness occurring during drawing.

Figure 2: Photograph of a whitefly.
Figure 3: Photograph of a leaf infested with aphids.

Figure 4: Mini-card test
Figure 5: SCT instrument.

Figure 6: Prototype H2SD.
Figure 7: Commercial H2SD.

Figure 8: FCT instrument.
Figure 9: FQT instrument.

Figure 10: Results of HPLC assays of sugars derived from contamination by two different insects.
Figure 11: Prevention of insect infestation in the field.

Figure 12: Some advice for the prevention of insect infestation in the field.
Figure 13: Two stages in the development of whitefly.

Figure 14: Two stages in the development of aphids.
REQUESTS FOR COMMITTEE RECOMMENDATIONS

- Dr. Uzi Mor - Lintronics, Ltd. for approval of FCT/FQT as a recommended test for stickiness
- Mr. Jean-Paul Gourlot - CIRAD for approval of H2SD as a recommended test for stickiness

Figure 15: Requests for recommendation of measurement methods.

2. The method should yield information on one or more of those fiber properties which are important for cotton processing or for quality assessment of cotton yarns or fabrics

Figure 16: One of the important rules for candidates seeking an ITMF recommendation for measuring instruments.
The committee considers both methods as “test methods under examination” and a round test will be organized by the chair. The draft protocols for the round test will be circulated to the members by mail for review and comment. Final protocols will be initiated and final reports distributed to the committee members.

Figure 17: Decision taken by the ITMF working group.
History and objectives of the CFC / ICAC / 11 project

RAFIQ CHAUDHRY

Technical Information Section, International Cotton Advisory Committee, 1629K Street, NW, Suite 702, Washington DC, 20006, USA

Good morning, Ladies and gentlemen,

I will briefly explain to you the history of this project, how we came up to the current situation of this project, how Sudan came in, when the project started and how the project objectives were revised to the current objectives. At the ICAC, I was responsible for this project from the very beginning and I am proud to say that this was one of the most smooth running project we had so far. The collaborators were open and frank to each other and there was a very good cooperation and collaboration among the collaborators.

In November 1993 the Standing Committee of the ICAC approved the project for three years and the title of this project was slightly different from the current title; the project was called “Sticky cotton: possible controlled matters from plant to yarn”. And, Cameroon and CIRAD were involved in this project. The project had four objectives:

– to eliminate causes of stickiness in the field,
– to forecast stickiness by assessing the insect damage in the field,
– to separate sticky cotton from non sticky cotton,
– to develop matters to treat sticky cotton so that it could be spun smoothly.

The project was submitted to the Common Fund for Commodities and in January 1994 the Consultative Committee of the CFC considered this project and made three decisions on the project:

– The Consultative Committee of the CFC accepted that the objective 1 and objective 2 were already covered in the other project. The project was in Israel, Egypt, Ethiopia and Zimbabwe. The title of that project was “Integrated pest management of cotton” and it was assumed that the first two objectives “control of stickiness in the field” and “assessment of stickiness based on the pest damage” were covered in the Israeli project. And, this is one of the reasons that we have invited Dr. Gadi Forer from Israel to present results of that project.
– The Consultative Committee accepted that objectives 3 and 4 could be considered for approval.
– The Consultative Committee also decided that there is a need to add a component on dissemination in the project.
In July 1995, a revised project was submitted to the CFC with a number of objectives reduced to two instead of four. The title of the project was accordingly revised: “The improvement of the marketability of cotton produced in zones affected by stickiness”. I must say that there was no component on dissemination, however the Consultative Committee recommended those two objectives should be approved and dissemination component should be added. And still Cameroon and CIRAD were planned to work on this project.

In December 1995, all of a sudden Cameroon decided not to participate in this project. The reason was that the cotton company was being privatized and the Company could not commit for a long term to work on this project. So we started looking for possible collaborators. In March 1996, I arranged a meeting between the Sudan Cotton Company and the CIRAD-CA representatives in Bremen and we decided that the representatives of CIRAD will go to Sudan and visit the facilities and meet the future collaborators and see if they can work together. Mr. Eric Hequet who was at that time Head of the Cotton Program went to Sudan and submitted a report to the ICAC that concluded they were willing to work in the project with the Sudan Cotton Co. So this is the time that we handed over the project to Sudan Cotton Co. to revise accordingly and also add the component of dissemination of information. So the current project has three main objectives:

– testing and evaluation of method for establishing the degree of stickiness,
– development of a threshold which enable economical processing of sticky cotton,
– evaluation of financial viability that is economical to evaluate cotton commercially and then disseminate this information to cotton producing countries and consuming countries.
Producers and Sellers’ Perspective

DR. ABDIN MOHAMED ALI

General Director, Sudan Cotton Co., P.O. BOX 1672, Khartoum, Sudan

Historical Background

Cotton Production in the Sudan

Cotton production in the Sudan has its roots as early as 1839 when it was introduced by Mumtaz Basha, a Turkish governor of Tokar district during the Turkish colonial rule in Sudan. In 1904 an American investor (Leigh Hunt) was granted a concession at Zeidab area - subsequently the Sudan plantation syndicate, a private company, was authorized to begin experiment with cotton production in 1911 in Tayba which was to become a nucleus for the prospective Gezira scheme. The construction of Sennar Dam in 1925 signaled the real take off for commercial cotton production in Sudan and in that year 80,000 feddans (virtually acres) were irrigated and expansion of area since then progressed in steady rates in Gezira and alongside Blue Nile and White Nile Banks.

Quality of Sudan Cotton over time

It is worth mentioning here that the early experience of cotton production in Sudan, coupled with technology – know-how borrowed from international pioneer companies helped to establish sound agricultural practices and a well educated and dedicated cotton farmers. It was not surprising that Sudan cotton was one of the best qualities in the world and the export from ELS cotton reached a peak of about 1.3 million bales in 1971 amounting to about 40% of the international trade on that type of cotton at that time (up to that time Sudan and Egypt used to export about 90% of the international exports of ELS cotton).

The emergence of stickiness problems in Sudan cotton

The problem of stickiness in Sudan was felt since the late seventies. This is the same date for the international outbreak of the problem. The phenomenon, stickiness, which was of little importance in the beginning of the 80s seems to have become widespread both in Sudan and the world. It is not my intention in this short comment to explain the reasons for the outbreak of stickiness in the Sudan as the reasons are similar to those in other countries facing the problem.
Stickiness problem in the Sudan

Farmers perspective

For Sudanese cotton farmer stickiness problem means the following:

- More efforts in the field (picking) ...;
- Higher cost of production (as more spraying has to be done for Aphids and white fly);
- Lower yield;
- Lower prices and ultimately lower income: Hence their attitude towards the problem must be a mixture of dismay, feeling of injustice and bitterness.

For the marketing organization

Stickiness is number one problem in marketing Sudan cotton. Although currently we don’t have carry over from previous years, sales volume and value could have been much higher with wider geographic distribution has it not been for stickiness problem. For marketing organization a lot of effort and resources are put to push sales and to convince non traditional buyers that our cotton possesses intrinsic value which outweighs the stickiness stigma. Stickiness also means lower prices, tougher competition and higher preparation costs. A study in the Sudan in the early 80s proved that roller ginning for sticky cotton is more expensive than non sticky cotton (low productivity due to frequent stop pages).

Applying for international help in dealing with stickiness cotton:

The efforts of Sudanese scientists to mitigate or eradicate the stickiness phenomenon are dealt with in a separate paper prepared by Prof. H. Khalifa. However the contribution of the national scientists had to be supported and complemented with international expertise. The studies done could pinpoint many factors as contributing to the stickiness. Some of them are as follows:

- the number of insecticide treatments applied and date of the last treatment;
- difficulty in reaching the insects as they are positioned on the lower side of the leaves;
- occasionally the early onset of the dry season in rain fed conditions, which is reputed to favor Aphids;
- effect of the plant population in the irrigated conditions;
- plant vegetation being more or less dense at the end of the season depending on the variety used;
- effect of sowing date;
- late harvesting leaving the cotton exposed to contamination for a longer time.

The non-exhaustive list of factors given above illustrates the complexity of the problem and the need for a global approach to solve it. The stickiness problem cannot be eliminated as long as the Aphids and white fly remain a problem. The problem can, however be controlled through various approaches in the field. Once sticky cotton is there, one of the more encouraging approaches would be to learn how to live with the problem: has to isolate the sticky cotton from the non-sticky one and hereby saving unnecessary and, indiscriminate economic tosses. Early identification of the problem will not only save the growers from discounts but will also alert spinners to be ready to spin such cotton through adjustments in their machinery or through mixing. Such type of thinking encouraged us in the marketing organization to try and share the experience of the international cotton community in living with the problem.
The objectives of the SCCL sought in the project

When SCCL contacted the ICAC and CFC in 1995 to sponsor and finance the project we had the following motivation:

To improve our sales of Sudanese cotton by establishing an internationally agreed upon method for grading sticky cotton.

It is our belief that pricing of our cotton is influenced by stickiness stigma rather than a real physical existence. Indiscriminate discounting lowers the income to cotton farmers. Previous studies of stickiness in Sudan cotton proved that contamination with stickiness is partial and of various levels, some growths are found to be even almost stickiness free but still discounted based on the well established reputation for stickiness. Therefore our objective in joining this project was to find an internationally accepted methodology for grading cotton for stickiness. We also meant to increase our sales by establishing an international threshold for dealing with various levels of stickiness in spinning.

Before concluding this comment I would like to state that the decision to join the project was not an easy one for us: simply, to do that we had to admit the existence of this sort of contamination in our cotton: very simple to say but very difficult to do. Eventually we had the courage to admit it and the reward is very obvious. We possess now the appropriate technology to measure and grade stickiness, we have the competent personnel and scientists who are thoroughly trained to do it and above all we have regained confidence in our cotton.

Thanks for listening.
The ‘Institut Français du Textile et de l’Habillement’

BERNARD DELTETE

Directeur général, IFTH, 2 rue de la Recherche, B.P. 637, 59656 Villeneuve d’Ascq Cedex, France

Ladies and Gentlemen,

I am very happy to welcome you in Lille. I have fifteen minutes for a quick overview of the Textile Institute. Slides are in English and my talk will be in French.

The industrial technical centre has a special legal structure that was created in France in 1948. This gives it a status that is neither private nor public. The centre is provided with a budget and is given a number of tasks to perform; tasks that I am going to present here.

The board of directors is made up of representatives from both the textile and clothing industries, and from the State, notably representatives from three ministries: Industry, Research-Development and Education and Finance. Our budget consists of funds from two principal sources: private resources which, in fact, correspond to the invoicing of certain services, e.g. tests, professional training, and a budget allocated by the State directed by contracts relating to research programs that are selected generally to run for a period of four years, and finally other programs in which we participate, e.g. the program we are discussing here today.

Who are we? Several of you have perhaps already encountered the Institut Textile de France and another organization called CETIH, i.e. devoted to work with the clothing industry. These two organizations, both of which are industrial technical centres, merged last year at the State’s request to become IFTH (Institut Français du Textile et de l’Habillement) which thus covers the entire sector. We are therefore able to work in the development of the entire textile industry, from fibre to retailing.

And, as you already known, textile retailing in Europe and in France – and more particularly in this region – is of major economic importance through mail-order companies and specialized retail chains.

We have a workforce of about 365 employees, nearly half of whom are engineers and PhDs.

We have 11 sites in France that do not all have same objectives or the same workforce structure. The workforce at the 11 sites (see map) can be divided into two groups: the first is made up of a few highly operational centres, such as that in Lille (the 6 black points on the map correspond to sites equipped with laboratories and major technical facilities). The others are composed of offices and administrative or commercial bodies. Each of these centres possesses certain specialisations. Here in Lille, in particular, we possess expertise in all aspects of fibre technology, both for natural and chemical fibres, the technologies involved in the processing of these fibres, woven and non-woven technologies, technologies involving the application of certain technical products, notably those related to enduction, and substantial development in processes involving information technologies though imaging and robotics.
The Troyes region, close to Paris, has since time immemorial been specialized in the development of products based on knitting and stitching. Mulhouse, in Alsace, close to the German border, has always been specialized in dyeing and finishing processes, particularly in dyeing and printing. Lyon is a major centre that has been greatly influenced by its chemical industry and also works on application technologies and technical textile products, notably in the fields of public health, protection, comfort, touch etc. Mazamet, in south-west France, is situated in a wool-dominated environment. It used to be a centre for wool and carding. Today, it has turned more toward water processing and the production of feathers and duvets derived from specialist breeding centres well known in the south-west. Cholet is a far more specialized unit that focuses on all aspects concerning the development of software and organizations, information and management. This centre focuses more particularly on all types of clothing applications.

As mentioned earlier, our budget is derived from three major sources. Approximately half comes from services rendered to industry in exactly the same way as any private company. About 30% of the budget is drawn from the budget of the Ministry of Industry, and this is therefore allocated to certain tasks and programs. The rest is obtained from programs that are either regional, national, European or international.

What are our principal missions? Three fields: innovate, qualify, transfer. What does this mean?

1) With our expertise, we can provide assistance on a national level, and increasingly internationally through co-operation, for studies, technical advice, technological development, research and all other forms of partnership through international organizations. Our natural task is obviously to help in the development of the industrial sector, i.e. to assist commercial companies by helping them improve the control they have over the products they use, notably as concerns their quality, standardisation and certification, and by all test processes.

The presentations we have seen today have clearly illustrated to what extent the development and control of these products and qualification methods is of great importance for products such as cotton.

2) We seek to improve technological processes and provide technical assistance, i.e. accompany the development of new processes or their control in companies.

3) Finally, we assist in the transfer of knowledge through training, expertise or economical or technical intelligence, i.e. monitoring of new technological developments.

To do this we possess 7 laboratories, 6 primary pilot plants or pilot workshops which, in particular, are fitted with equipment very similar to that used by companies, even if these naturally do not have the same production capacity. We work under similar conditions to those used in industry. This has been our approach, notably in the case of the cotton program which is currently in development and which will be presented to you. If you have the possibility or the desire to come and visit our site, you will have the chance to see for yourself the equipment installed in our laboratories, and particularly that in the pilot plant.

As an example of the processing and measurement capacity our laboratories can devote at any point in cotton processing, why was Lille so deeply involved in the Sudan cotton project? Because we possess the tools, the technical control means and a sufficient numbers of experts. Also, this is one of the specialities covered by the different sites in the national institute. Knowledge about cotton is also something very important for us. Thus, we set up a specialist laboratory which opened last November in Dunkirk. This laboratory is entirely devoted to the control of cotton products using modern techniques. At the same time, it has developed processes to study relations between cotton characteristics and performance during production, and the final specifications the spinner must provide to his clients. The laboratory is involved in checking compliance with quality specifications and with productivity which again is extremely important. But this presentation also illustrates the fact that increasingly we are developing tests for markets with greater added value, or for the consumer where feel, comfort, safety, health and care are important factors, or in sectors where applications concerning technical textiles or environmental questions are also essential. As far as our industrial
testing instruments are concerned, these cover the entire sector from fibres, yarns, woven, non-woven, etc. up to assembly and the making up of clothes.

It is perhaps interesting to add here that currently, a great deal of new development is being conducted on processes. Major innovations are more particularly affecting aspects of product enhancement, i.e. dyeing, printing or processing, and it is therefore particularly in this field that new tests are being developed and you have here an illustration of the types of technique on which we have been working for some time at all institute sites. So-called digital printing techniques should also be mentioned as these are starting to develop on the market and therefore supersede traditional printing techniques based on flat or rotary frames.

Therefore, few technological changes have occurred in traditional weaving processes, but, in my opinion, this will become a major challenge in the future, but few real changes in the current state of affairs. By contrast, we are working increasingly in the form of an international network in partnership. This is being built up with other technical centres, other research centres or with laboratories similar to our own. It also involves professional bodies and engineering schools. These networks are in place on national and international levels and concern other fields as well as the textile industry. Increasingly, we are working in partnership with non-textile specialist laboratories and research centres. For example, in electronics, nano-technologies, the life sciences and with organizations such as the Pasteur Institute, CIRAD, INRA and other similar bodies internationally.

Two main thrusts to our research programs aim to develop the new products required by the market.

– Efforts aimed at developing textiles for the public, both fashion wear and for home decoration. Today we are talking about new functions that can be presented in 5 categories: improved comfort, improved protection for the person or the environment, improved health or hygiene, and finally the entire field of beauty where we have created links with the cosmetics industry.

– The second major thrust in a sector that is undergoing development particularly in Europe and the USA, but is also emerging in a number of other countries, concerns applications generally known as technical textiles where you have here the illustration of a few of the larger markets where natural materials must reach extremely high performances in terms of insulation, filtration, mechanical resistance, fire resistance, etc.

I shall close by pointing out that we of course have a number of large clients: approximately 3000 both in France and abroad. Here is a list of some countries with which we work, more or less regularly, and a certain number of development programs.

I shall finish here simply by underlining why the Sudan cotton program is important to us:

– firstly, through the knowledge we have acquired, as I already pointed out, we are very familiar with fibres and spinning processes;

– secondly, our position in the sector leads us more and more frequently to attempt to create a link between the starting material and the consumer. This approach is increasingly important in order to focus efforts and attempt to ensure that the entire sector is involved in developments, not simply such and such a section that seeks simply to improve its own lot, without necessarily worrying about what is happening upstream or downstream.

I believe that future challenges should also be met with this type of project development approach. Thank you for your attention.
Cirad and its Cotton program: outline of its research and development objectives

ALAIN CAPILLON

(Represented by Michel Deat)

Director of Cirad-ca, TA 70/01, 34398 Montpellier Cedex 5, France

Ladies and Gentlemen,

Alain Capillon, the director of Cirad-ca, greatly regrets that he is unable to come to Lille today for this seminar because of ill health. The honor, but also the pleasure, therefore falls to me to talk to you today about Cirad's research and development objectives and describe the technological activities conducted in its cotton program.

Firstly, I would like to describe Cirad and its mandate. The term Cirad stands for "Centre for international co-operation in agricultural research for development". Cirad is a public organization with an industrial and commercial character. It aims to contribute to development in tropical areas of the world by co-operation with partners in the North and South. Its initiatives take the form of research, development support and training. Cirad expertise covers agriculture, animal breeding and forestry, but also social sciences, economics and agri-food affairs. It has a workforce of about 1800, half of whom are scientists. Approximately 320 researchers are based in more than 50 countries worldwide.

Cirad is divided into 7 departments covering 28 programs, some of which constitute "sector" programs. These are a reflection of the fact that research can only be finalized when integrated into an economic activity. Products generated by the research efforts are therefore negotiated not only with our researcher partners in other countries, but also with the users and all players in the sector. This means that we share objectives but also that we work on many major international problems through projects that impact on food safety, sustainable agriculture, environmental conservation and the maintenance of or increase in farmer revenues.

Secondly, I should underline that the French have been involved in cotton research for more than 50 years. The fact that the cotton program today is part of Cirad's department of annual crops is due to the fact that it is the successor of I RTC (Institut de Recherche du Coton et des Textiles Exotiques) set up after the Second World War. Traditionally, researchers in the cotton program, and therefore in IRCT, liaised with French organizations responsible for textiles. In IRCT, we worked to lend support to the sector, notably in Africa, and this both for the farmer and for fibre production and processing. Cotton-related activities have always been conducted with close collaboration between different fields, primarily agriculture, genetics, integrated pest control, economics, technology and biotechnology, and its challenges are market-related, environment-related and concern sustainable agriculture. Some
operations in Africa were, or still are, conducted in co-operation with cotton companies or private operators. But today, the African situation has changed and the Cotton program is no longer restricted to Africa since we also work with private operators in Latin America and Asia.

This change in the situation prompted us to reflect on the manner in which we were assisting the different players in the sector produce the best possible cotton under conditions that ensured the most sustainable agriculture. Changes in economic conditions, adjustments to local production conditions – whether these be due to the environment, the price, the market or simply the type of agriculture we were dealing with – led us to diversify considerably the advice we gave farmers concerning their cropping methods.

Now, I would like to describe the role played by the cotton technology laboratory at Cirad. Cirad made what at first sight seems to be a simple wager: that of banking on quality. This requires the evaluation of technological characteristics but also improvements in both quality and the tools used to measure quality. The development over the last few years of new instruments, including HVI lines, is the clearest example of this and we are now progressing towards a more detailed and exhaustive characterization of the fibre produced throughout the world.

In this context, Cirad set a triple objective for its technologies.

– Firstly, we wished to be at the cutting edge when evaluating cotton quality. We consider that some of our traditional partners, particularly those involved in the cotton industry in Africa, have everything to gain from evaluating and demonstrating the quality of the fibre they produce. Although the current manner in which the price is set does not depend on quality, we believe that demonstrating and claiming high quality will be advantageous for African cottons. In consequence, various studies were conducted by Cirad to evaluate the technological quality of cotton fibre. These studies led to the development of appropriate and transferable evaluation tools, notably in the fields of stickiness and seed coat fragments.

– Secondly, the need to equip the sector, and particularly our partners in the South, with these tools – thus enabling them to evaluate the technological characteristics of their cotton – had an impact on our approach to cotton cropping since it placed this technology at the centre of our strategy. The underlying challenges here consist of correcting positioning errors in relation to the traditional fibre sector and highlighting the origin of the cotton or the batches of cotton perfectly suited to certain spinning conditions. The quantitative and reliable measurement of new characteristics seems more than ever necessary today. This is particularly true for stickiness which must henceforth be integrated into any quality assessment. Stickiness is now, and has been for several years, one of the most critical problems encountered in the processing industry. Chronologically, and logically, requests first issued from the processors because of the quantitative and qualitative consequences of this phenomenon on their production. They informed the cotton producers of their problems and these turned to research for a solution. Today, all parts of the sector are concerned to one degree or another. This is why Cirad was called in by its partners. Here, it should be recalled that it was at Cirad that the first technological research was conducted on stickiness, started by Mr. Massat, Mr. Gutknecht, Mr. Fournier, Mr. Bourely and Mr. Frydrych in the 1980s. This research, a few years later, led to the filing of several patents and the development and marketing of the two stickiness detectors you are familiar with.

– Finally, work on stickiness, and also on all aspects of quality – as envisaged by Cirad – cannot be restricted to a single technological field. Here, in its central role as an evaluator of quality and the factors that affect quality, technology can call on other disciplines for an overall approach to quality right from the very first steps in cropping (genetics, entomology, agriculture, agrophysiology). Some of the results obtained using this global approach will be presented here this afternoon. This powerful strategy adopted by the cotton program in the practical application of its research is based on a multidisciplinary approach. Cirad has made substantial investments in this field in terms of labor, funds, time and means and continues to do so.

In the logic of our approach to this problem, the commitment made by Cirad to the project "Improvement of the marketability of cotton produced in zones affected by stickiness" from its very conception and implementation up to the seminar here today, clearly demonstrates our wish to seek
and discover solutions to stickiness with our partners both in the South and the North. This project also enables us to increase our knowledge and expertise in this field and we can now share this knowledge with all cotton operators. For this reason, I hope that in the course of this seminar, the results presented to you and the discussions and exchanges between the different sector players present here today will enable us all to obtain practical information to help us reduce the effects of stickiness.

Thank you for your attention.
Integrated Pest Management for Cotton with a focus on Whitefly and Aphids

GADI FORER

Chief Entomologist, The Israel Cotton Production & Marketing Board Ltd., Israel

CFC / ICAC / 03 project was an international joint effort conducted by the Israel Cotton Board, involving Egypt, Ethiopia, and Zimbabwe. The project aimed at developing integrated methods for control of whitefly and cotton aphids, both of which cause stickiness to cotton. The broad objectives included the production of high quality non-sticky cotton; increased profitability for both raw cotton producers and processors; and reduction in damage to the environment.

The project developed new target-oriented, environmentally compatible pesticide formulations and their application methods; promoted biological pest control; developed guidelines for economic use of these methods; and disseminated the project findings to extension staff of participating and other countries.

The project comprised five main components:

Development of novel target-oriented pesticides

Target-oriented insecticidal formulations, based on vegetable oils, were developed and tested under controlled conditions. This included: characterization of different species of Vegetable Oils (VO) according to their bioactivities vs. Bemisia and their phytotoxic tendencies; accumulating knowledge on the formulation-function relationship of VO as control agents; formulation and scaling up of prototype VO formulations for field application under semi-commercial conditions; development of a laboratory setup for adaptation and quality assurance of formulations based on VO of local origin; and production of experimental formulations of VO for field research by the cooperating groups.

The kind of tested VO, all of major commercial importance, showed a similar activity repertoire, which included toxicological and behavioral components. However, different oils varied in potency, speed of action and bio-persistence, in such parameters as: residual activity against adult and immature Bemisia, spray toxicity to larval stages, and modification of adult’s behavior expressed by settling and oviposition deterrence. Among the eight tested VO, groundnut, castor and cottonseed oils showed the most prominent activities. Coconut oil was the most phytotoxic and castor oil was the safest to the crop.

Systematic study of the effects of formulation variables on control-related properties of VO resulted in several promising formulating procedures. Among these, two formulation lines, one based on cottonseed oil (No 4) and the other based on castor oil (No III), gave the most promising results for all the studied kinds of VO. Both experimental and field versions of “optimized” and “stabilized”
formulations retained VO activity towards the target pest and had minimal phytotoxicity. The formulations made only of non-toxic and environmentally friendly ingredients, were proven to be consistent and stable, to exhibit good dilution stability and were easy to dispense and apply. In addition, a simple laboratory setup was developed and suggested as a model for development and preparation of similar formulations from local VOs in the target countries.

At the beginning of the project, the material based on cottonseed oil applied with a long drop-tube sprayer (2 treatments at 2-week intervals), caused a reduction of 71.5% on the average infestation level of whitefly immatures on the Acala variety and 50% reduction on the Pima variety. However the long drop-tube sprayer had to be withdrawn due to the damage it caused to the cotton plants, and it was replaced by the Tornado sprayer that was developed within the framework of the project.

66 novel materials were tested in 5 stages, along the course of the project. After each stage, the superior materials were sent for repeat tests to Egypt, Zimbabwe and Ethiopia.

**Stage 1**

Phytotoxicity was tested and 21 materials were disqualified at this stage.

**Stage 2**

The remaining 45 materials were tested for their effect on whitefly control, under ideal spray conditions with complete coverage of the underside of the leaves. In this series of tests it was determined that material III gave the best results.

**Stage 3**

Materials No. III and No. 4 were compared using knapsack and tractor mounted sprayers under standard field conditions. In all of the cases, the results of material No. III were superior to those of No. 4.

**Stage 4**

Application methods were tested. It was found possible to reduce spray volume from 500 l/ha to 200 l/ha with material No. 4 if the amount of active material remained constant. In addition, both materials, three tractor-mounted sprayers were compared: the long drop-tube sprayer, the air-sleeve sprayer and the Tornado sprayer. The long drop-tube sprayer had the best results, with no difference displayed between the air-sleeve and Tornado sprayers. Various knapsack sprayers, such as the knapsack drop-tube sprayer, the standard knapsack sprayer and the motorized knapsack sprayer also had good results.

Two applications of material No. III at 2-week intervals with the Tornado sprayer caused a reduction of average infestation by 55.7% compared with 13.3% obtained under similar spray applications with material No. 4. An additional improvement was obtained with material No. III by switching to 4 applications at weekly intervals between treatments. Of the three different sprayers (the air-sleeve, the Tornado and the knapsack drop-tube), a reduction of 74% in average whitefly population was obtained in comparison with the unsprayed control under similar conditions. The standard treatment, 2 applications of Diafenthiuron, reduced the population by 86%. There was no difference between the Pima and Acala cotton varieties sprayed by the air-sleeve or the Tornado sprayers.

In a series of four trials in Zimbabwe under various coverage conditions, it was found that a set of novel materials had good aphid control if the underside coverage of the leaves was complete. Under standard field conditions using the knapsack sprayer with a tail-boom there were no satisfactory results concerning aphids.
Stage 5

Examining the effects of the materials on beneficial insect populations under field condition will discuss later (in this page).

**Design of criteria for cotton sprayers and design of new spray techniques**

Three manual sprayers and one tractor-mounted were developed and tested by the engineering groups from Egypt, Zimbabwe and Israel. The sprayers were developed in an effort to achieve very high uniformity of spray deposition, as required for whitefly control with the nontoxic pesticides developed in the present project.

Two motorized knapsack sprayers were modified for application of the nontoxic pesticides in small farms, one by the group from Egypt and one by the group from Zimbabwe. The group from Israel developed an electrically powered sprayer for the same purpose. Field tests of the manual sprayers showed higher uniformity of spray deposition for all of the newly developed sprayers as compared with commercially available machines.

The tractor-mounted sprayer was developed with a high ground clearance in order to provide high uniformity of spray deposition, while still enabling operation in fields where branches cross from one row to the next. The application tests gave better results than any commercial sprayer known to the researchers, but also gave lower uniformity and lower quantities of pesticides on the targets as compared to an earlier model with very small ground clearance.

**Biological control**

Our main goal here was to understand the dynamics of the pest and its natural enemies in order to facilitate optimal pest management. This was achieved by determining:

1. The pest biology and population dynamics;
2. The natural enemies’ (parasitoids and predators) identity, biology, dynamics and impact - how important are they, and when are they important?
3. The effects of insecticidal (commercially used materials and new preparations) treatments on natural enemies - does it cause damage to control efforts and how can such damage be decreased?
4. The impact of neighboring crops – how do they influence the levels of B. tabaci populations?

Whiteflies were found in all countries throughout the warm seasons. In most cases populations were lowest when cotton was young and rose with the season; a sharp rise in Egypt and Israel occurred in late July or August. Maximal levels in untreated fields were as low as 2.5/leaf [1997 report, p.194] but also reached as high as 68/leaf [1998 report, p.162 5]. In Ethiopia, high populations were observed early in the season due to their development on alternative hosts from which they had moved on to cotton [1997 report, p.221]. In Zimbabwe, both Trialeurodes vaporariorum and Bemisia tabaci were active, but did not cause damage in most cases.

In Egypt and Israel Encarsia lutea Masi and Eretmocerus mundus (Mercet) were the predominant whitefly parasitoids [1995 report, p. 101]. In Ethiopia and Zimbabwe Encarsia transvena and Eretmocerus mundus or a very similar species, were found. Rates of parasitization often rose with the season and reached levels up to 90% [1992 report, p.95; 1998 report, p.199]. The 5-year averages for Israel and Egypt were between 65-70%, while for Ethiopia, the one reported year averaged 47% parasitism. No correlation was found between % parasitism and whitefly population. The use of insecticides did not affect % parasitism in1998 but it reduced parasitism significantly in 1997. The high percentages of parasitism indicate that parasitism alone prevents a significant increase in whitefly populations. This is especially significant in the light of quick resistance build-up in whiteflies resulting from successive treatments with insecticides.
Many predator species were found. Most coincided among the countries and locations but some did not. The more generally occurring ones were Chrysoperla carnea, Orius spp. Deraeocoris pallens (In Israel), Campilomma spp., Coccinella spp., Hippodamia variegata, Scymnus spp., spiders of various kinds and predaceous mites, esp. Amblyseius swirskii (studied only in Egypt). Since none of these are either specific to, nor regular predators of whitefly, we established methods to evaluate their value in our context, drawing correlation between predator abundance and that of whitefly populations, and conducting specific behavioral observations. The only predators showing overall correlation with the whiteflies were species of Orius. Studies conducted with A. swirskii in Egypt also indicate that the abundance of this species may be linked with that of the whiteflies. Direct observation of predators on plants in relation to whiteflies showed that predators frequent whitefly infested plants. Although this relationship does not always give a clear picture of their activity, the Heteroptera, and probably also the mites, do seem to be important controlling factors of whitefly populations.

Predators were more sensitive to insecticides than the parasitoids. acetamiprid appears to be one of the more harmful insecticides to both parasitoids and predators, with the exception of the predacious mite A. swirskii in Egypt. Non-conventional insecticides (e.g. jojoba and mineral oils), and the IGRs: diafenthiuron, pymetrozine and pyriproxyfen usually did very little damage to enemy populations while killing high proportions of the pest. Similar results were obtained with flufloxuron, kemesol (summer mineral oil) and National (winter mineral oil). The same trend was noticed when using natural (vegetable) oils, bemisstop and buprofezin. Of the insecticides usually used in the cotton field, we found monocrotophos to be more harmful than endosulfan. These tests should be continued for more materials and under more varied field conditions.

Materials number 4 and III (developed during the course of the project) were tested by treating selected fields that abounded in natural enemies. Material 4 was relatively innocuous to predators. Material III showed detrimental activity to some of the enemies in the lab and in the field. In the latter case, the damage to natural enemies seemed short lived. The fact that the various materials were found less harmful to natural enemies while still able to control the whiteflies can suggests them as important tools for the control of the pest, especially early in the season.

We did not find any advantage in growing corn near the cotton. The main predators therein, Orius spp. did not seem to migrate into the cotton. Sunflowers were found to harbor few natural enemies and at times, a lot of whiteflies. Thus at best, the proximity of sunflowers will not cause a whitefly outbreak, but we should not rely on this crop to be a refuge for natural enemies.

Establishment of economic thresholds

Seven field trials were conducted in which a total of 30 populations of whitefly were examined. Each population was counted twice weekly during the 60-day period before 80% boll opening (defoliation day) in the field. Finally, each population was characterized according to the average number of larvae (stage 2 or more, including pupae) per maximum leaf for the entire period. There was a follow-up of the effect of each population on the final yields, yield components, lint quality, sugar level and stickiness. From these populations it was found that the damage threshold for yield and quality averaged between 15 to 20 immatures per leaf (1999 report, p. 105 Table 15).

Gerling et al found migration into the field early in the season, but the main increase in population later in the season results from build-up within the field.

Reproduction within the field is dependent on 3 factors:

– initial population size;
– oviposition and survival of the various stages;
– number of generations.

Within the framework of the project, the effect of initial treatment timing which determines the initial population, and the effect of various chemical treatments on survival were studied in relation to very large whitefly populations.
It was found that a series of various treatments reduced the average population throughout the entire counting period at different percentage (Table 2).

Advancing the time of the first treatment, even if the population was very small at that stage, (average of 1.8 immatures/leaf) reduced the population level throughout the entire counting period and average reduction was about 45% for the whole season (1999 report, p. 112 Table 18).

From these results the following conclusions may be drawn:

- In fields in which whitefly build-up (migration and development within the field) is slow and can be controlled by 1-2 treatments, a threshold level of 15-20 larvae and pupae may be used.
- In fields in which the rate of whitefly build-up is high, one should speak in terms of “control strategy” and not in terms of a fixed threshold. The aim of this strategy is to ensure that the average population will not rise above 15-20 nymphs/maximal leaf as an average for the entire season. The strategy would include a series of treatments (date and chemical) at varying thresholds (from low at the beginning to a higher threshold later on) in order to achieve these results at a minimal cost, while adhering to the correct policy for preventing future pest resistance to the various chemicals. In order to improve preparation of these strategies, this particular study should be continued.

**Knowledge dissemination**

Knowledge dissemination efforts took place throughout the project and its finalization.

- a) Two out of the four PCC meetings that took place in Egypt and Israel in the summers of 1996 and 1997, included demonstrations of field trials conducted in the two countries. Extension staff and growers from the two countries attended those demonstrations in addition to the research staff from Zimbabwe and Ethiopia. Field demonstrations of the developed sprayers took place in Israel, Egypt and Zimbabwe during the PCC meetings.

- b) Two workshops for extension staff and growers were conducted: one in 1998 in Ethiopia (1998 report, p. 263-272) and the second in 1999 in Egypt (1999 report, p. 141-144, abstract booklet).

- c) Two courses for participants from Egypt and Ethiopia were conducted in Israel during the summers of 1997 & 1998.


- e) Five annual professional reports and a final project report were published, including technical appendixes describing the preparation methods for the new insecticides as well as descriptions and assembly instructions for the new sprayers.

- f) A guideline manual of the methodology developed was prepared.
Historical background on cotton stickiness in the Sudan

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Introduction

Cotton is one of the main cash crops in the Sudan. The main three types of cultivated cotton, the long and the extra long staple (\textit{Gossypium barbadense}), the medium and short staple cotton (\textit{G. hirsutum}) are grown under irrigation and rain-fed.

Cotton in the Sudan is grown under different ecological regions and different cultivation and agronomic practices. All seed-cotton is hand picked following successive picks. The seed-cotton of long staple cotton and part of the medium staple cotton are exclusively roller ginned. The short staple cottons are usually saw ginned.

A number of insect pests infest cotton and the main control measures are insecticide spraying and some cultural practices. The whitefly (\textit{Bemisia tabaci} "Genn") is one of the most serious pests on cotton. It has a wide range of host plants, where it breeds and later migrates and infest cotton. It has an adverse effect on cotton yields and quality. It secretes sugary substances known as honey-dew which is the main causative agent of cotton stickiness in the Sudan.

The problem of cotton stickiness is just one of the many other limiting factors affecting cotton production and marketing in many countries. But it is the most serious one compared with other quality factors confronting the modern cotton industry. Unfortunately, the producers are still using the same practices of picking, cleaning, ginning and baling. They have not kept pace with the rapid changes that have taken place in the modern textile industry.

Research Programs

The National Research Committee on Cotton Stickiness in the Sudan launched a number of coordinated research programs relating to the solution of this problem. These programs include:

1- Identification of the type of sugars causing cotton stickiness and their origin.

2- Establishment of reliable and quick methods for grading cotton stickiness and correlate the grade to the spinning performance.

3- Correlation between the degree of cotton stickiness, the ginning efficiency of seed-cotton and the spinning performance.

4- Screening and evaluation of different insecticides for the control of whitefly, together with the formulation of integrated pest management package.

5- Effects of different cultivation practices and plant type on the life cycle of the whitefly infestation.
6- Breeding of cotton varieties tolerant to whitefly infestation.

**Causes of Cotton Stickiness**

Research programs were undertaken to find out the factors involved in causing the cotton stickiness. These factors include honey-dew secreted by whitefly and Aphid (Aphis gossypii "Glov"), physiological sugars originating from plant nectaries, foreign matters such as trash, immature fibers and broken seeds.

Numerous factors were suspected of causing cotton stickiness have been reported in the literature. Some of these factors are, insects such as whitefly and aphid, microorganisms decomposing cellulose, sugary substances from the plant, broken seed fragments and immature fibers during ginning and growing conditions. All these factors may directly or indirectly affect the grade and the spinning performance of cotton.

The problem of cotton stickiness appears right at the picking of seed-cotton and aggravated in ginning, baling and spinning operations. At the picking time the old leaves are usually, contaminated with honey-dew, which enhances contamination of seed-cotton. Troubles caused by sticky seed-cotton include, the amount of waste at ginning, cleaning point, jamming of roller gins, proneness to roll ups, sliver and yarn properties, ends down rates, draw frame lap ups and waste of time. The yarn produced from sticky cotton is usually weak, irregular, nappy and poor in appearance. Such yarn causes the subsequent trouble in weaving.

Chemical analysis of whitefly and Aphid honey- dew and plant exudates revealed both whitefly and Aphid honey-dew contained both reducing and non reducing sugars, but there is one type of unknown sugar found in whitefly secretion and not found in others. Plants exudates have no significant role, as they are inactive at the time of boll maturity.

Whitefly was found to be the major cause of cotton stickiness. They might migrate from host plants to the cotton plants and starts to breed rapidly and form a peak at the time of boll development and maturity, (Fig. 1). The figure also depicts the differences in the maturity and whitefly peak between G. barbadense and G. hirsutum (Khalifa 1980).

The presence of mold, immature or crushed seeds in the lint, immature fibers can cause cotton stickiness in pressing. This is usually found in low-grade cottons or cotton picked late in the season. It has been reported that adverse weather conditions at boll maturation period may result in immature fibers and some remaining sugars on the lint.

**Methods for Stickiness Grading**

There are two methods for the evaluation of cotton stickiness.

**The physical method**

In order to evaluate stickiness grade using the physical method, random samples of seed-cotton were collected from different of picked seed-cotton. They were mixed and ginned and 40gm of heaps lint were run twice through the miniature carding machine. The deposits of sticky material and adhering fibers and foreign matters in the calendar roller were collected and weighed. The total weight of the deposits mg/100gm of lint was obtained and stickiness grades were classified into 5 grades, 0, 1, 2, 3 and 4 representing free or trace, light, medium, heavy and very heavy stickiness respectively. This method is quick and subjective.

**The chemical method**

Ali and Khalifa (1980) established a quick chemical method to determine the grade of stickiness in lint samples. Both reducing and non-reducing sugars were evaluated. The non-reducing sugars found in the whitefly honey-dew were more important in causing stickiness in cotton lint. Ten samples each of
2gm were used in the analysis. The total amount of reducing and non-reducing sugars in gm/100gm of lint were determined and classified into 5 grades 0, 1, 2, 3 and 4.

**Variation of Cotton Stickiness**

The abnormal distribution of honey-dew contaminating the lint whether within the same plant or in the bale poses the main constraint to obtain a reliable estimate of the cotton lint stickiness grade.

Experiments were carried out to detect the variation of honey-dew contamination within the same plant, the same field, cotton variety, picks, location and lots.

The results indicate that distribution of honey-dew within the same plant was variable (Table 1). The grade of cotton stickiness was higher in lint collected from the bottom and middle of the plant compared with the top (Khalifa 1982). This was expected because the whitefly usually prefers humid, warm and shady conditions, as well as protection from wind found in the upper part of the plant canopy later in the season (Gameel 1982). Therefore, it was recommended to follow the conventional practice of having successive picks instead of overlapped picks, and seedcotton from each pick should be bulked separately.

As to variation of cotton stickiness within the same field, it was found that the distribution of whitefly population within the same field was variable. The southern part of the field was the most affected part due to the north wind driving the whitefly to the southern part of the field. The east and west margins showed relatively higher concentration of honey dew compared with the center of the field, the coefficient of variation was 28% and 26% in case of picks (Table 2). It was also found that the medium staple cottons (G. hirsutum) showed higher stickiness grade compared to (G. barbadense) varieties (Table 3). This is mainly because hirsutum varieties are hairy, bushy and hence more susceptible to whitefly infestation. It can also be added that their maturity period coincides with the peak of the whitefly (Fig. 1), Khalifa (1982). The variation due to the location was evident when comparing Rahad and Gezira cotton, as whitefly infestation is higher in Rahad.

In order to find out the variation of honey-dew within the same bale, it was essential to determine the sampling procedure to get reliable estimates. Khalifa (1982) found that the optimum number of bales for sampling was 25-30 bales per lot (Fig. 2).

Bales were selected from one lot (300). Five to 60 bales of 420 lb were selected at random. Then lint samples were taken from 6 positions in the bale. The results indicated that there was high heterogeneity within the same bale, especially in medium staple varieties. This was mainly due to mixing of sticky and non-sticky cotton (Table 4).

**Correlation between the Degree of Cotton Stickiness to Ginning and Spinning Performance**

During ginning sticky seed-cotton created a lot of trouble by jamming of roller and then the gin was to be cleaned. The spinning tests of sticky cotton samples gave varying degrees of trouble at the card, draw frame depending on the degree of cotton stickiness.

**Screening and Evaluation of Different Insecticides**

The main control measure practiced to control whitefly was by the use of insecticides. This practice has a lot of drawbacks. A number of systemic insecticides resulted in pollution of environment and hazardous to human beings and animals. It will also reduce the chance of biological control as most of the parasites and predator’s population will be reduced, it is also expensive.

**Effects of Cultural Practices**

An experiment on cotton defoliation was carried out. The main objectives were to get rid of the contaminated dry leaves and also to reduce leaf area. This practice under Sudan conditions was found
to be effective during picking time and will facilitate picking of clean seed-cotton. It was also effective in eliminating the last 2 sprays.

Plant population in relation to whitefly build up was studied. It was found that the optimum plant population was 125,000 plants/ha, which showed lower whitefly population compared to 150,000 plants per ha.

It was also found that there was a significant positive correlation between plant canopy and number of all stages of whitefly. Varieties with open plant canopy have low whitefly population.

**Breeding of Cotton Varieties Tolerant to Whitefly**

The main objectives of the breeding program were to manipulate the morphological and physiological characteristics of the cotton plant in such a way to create unfavorable conditions for the whitefly build up to allow for biological, cultural control and efficient insecticide control.

The plant characters, okra-leaf, glabrous plant body, nectariless flower and leaf and high gossypol content where transferred singly and in combination to *G. hirsutum* varieties using the back-cross method of breeding (Khalifa 1982).

The synthesized lines together with the standard varieties as control were tested for three successive seasons in the Gezira Research Station in RCB design, to compare whitefly infestation and the degree of cotton stickiness. The experiments were carried out in isolation plots with no application of insecticide. Whitefly counts were taken at weekly intervals for about 8 weeks and the data was transformed and analyzed statistically (Khalifa and Gameel 1982). The result indicated that the line with okra-leaf shape, glabrous plant body, nectariless flower and high gossypol content showed significantly lower number of whitefly population compared to the other controls (Fig. 3).

This result was substantiated by the lower stickiness grade. This line was later released as a commercial variety by the name "Sudac-k".

More tests showed that there was a positive correlation between hair density and low number of whitefly adults per leaf, scales and pupae per unit area, low hair density played a major role in the mechanism of tolerance to whitefly and together with the okra-leaf shape showed for more than 60% of tolerance.

Parasitization in Sudac-k was 30% higher compared to Barac (67) B. The build up of whitefly in Sudac-k did not exceed 200-300 adults per 100 leaves, while in case of the standard varieties peaks of more than 1000 adults per 100 leaves were evident.

Scale Parasitization was 30% higher in Sudac-k compared to Barac (67) B as host searching and attack by whitefly parasites are known to be more successful on glabrous foliage than in hairy ones. Sudak-k has an open plant canopy with less total leaf area and more sunlight penetration as compared to Barac (67) B. This open plant canopy resulted in lower relative humidity and higher temperature. It is well known that the dry hot conditions create unfavorable microclimatic conditions for the breeding of whitefly (Sippell, Bindra and Khalifa 1983). The advantage of open plant canopy in Sudac-k was that it allows far better and more efficient insecticide penetration, especially at the later stage of plant growth, while the plant canopy of Barac (67) B was almost closed (Fig 4). Gossypol renders the cell sap in high concentration unpalatable this will result in antibiosis type of resistance to sucking insects, which will result in starvation and in some cases eventual death of the feeding juvenile or adult stages of the whitefly.

In another experiment Sudac-k and Barac (67) B were tested to evaluate the response of spraying on whitefly build up and grade of stickiness. Counts of whitefly population were taken at pre and post spraying. Table 5 shows that there were significant differences between Barac (67) B and Sudak-k, indicating low counter for both pre and post spraying. This result was reflected in low stickiness grades for cotton stickiness in Sudak-k. It was also found that only 4 sprays in a season were enough to control whitefly infestation. Barac (67) B required 6-7 sprays in the growth season (Fig. 4).
Table 5 shows the efficiency of spraying in Sudac-k compared with Barac (67) B. It is very clear that in surveying the agronomic characters of Sudac-k the seedcotton yield was not statistically different from Barac (67) B, but it was 5-10% less compared to Barac (67) B. This difference in low yield can be compensated by a higher price for non-sticky cotton. The difference in 2-3 sprays compared to Barac (67) B is also added to compensation in low yields. Sudac-k has the same boll weight and fiber characteristics compared with Barac (67) B.

**Bibliography**


<table>
<thead>
<tr>
<th>Position</th>
<th>Total soluble sugars mg/100 gm lint</th>
</tr>
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<tbody>
<tr>
<td>Top</td>
<td>501</td>
</tr>
<tr>
<td>Middle</td>
<td>587</td>
</tr>
<tr>
<td>Bottom</td>
<td>621</td>
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</table>
Table 2: Variation of cotton stickiness with picks and locations within the same field, CV. “Barakat”.

<table>
<thead>
<tr>
<th>Location</th>
<th>Cotton stickiness Mg/100 gm lint</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>602</td>
<td>1</td>
</tr>
<tr>
<td>North</td>
<td>473</td>
<td>0-1</td>
</tr>
<tr>
<td>East</td>
<td>521</td>
<td>0-1</td>
</tr>
<tr>
<td>West</td>
<td>577</td>
<td>0-1</td>
</tr>
<tr>
<td>Center/s</td>
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<td>0-1</td>
</tr>
<tr>
<td>Center/n</td>
<td>455</td>
<td>0-1</td>
</tr>
<tr>
<td>S.E =</td>
<td>+ 28</td>
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<tr>
<td>Pick I</td>
<td>468</td>
<td>0-1</td>
</tr>
<tr>
<td>Pick II</td>
<td>427</td>
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<tr>
<td>Pick III</td>
<td>539</td>
<td>0-1</td>
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S.E = + 26

Table 3: Variation of cotton stickiness with cultivar and location.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Turabi Mg / 100 g lint</th>
<th>Grade</th>
<th>Hag Abdalla Mg / 100 gm lint</th>
<th>Grade</th>
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<tr>
<td>Long-staple:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Barakat</td>
<td>476</td>
<td>0-1</td>
<td>727</td>
<td>1</td>
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<tr>
<td>VSA</td>
<td>532</td>
<td>0-1</td>
<td>622</td>
<td>1</td>
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<td>Huda</td>
<td>563</td>
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<td>Maryould</td>
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<td>0-1</td>
<td>746</td>
<td>1</td>
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<td>Medium-staple:</td>
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<td></td>
<td></td>
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<tr>
<td>Barac (67) B</td>
<td>797</td>
<td>1</td>
<td>922</td>
<td>1</td>
</tr>
<tr>
<td>Barac (69) 2</td>
<td>767</td>
<td>1</td>
<td>783</td>
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<tr>
<td>Mean</td>
<td>594</td>
<td></td>
<td>754</td>
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</tr>
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S.E. =

Table 4: Dispersion of honey-dew within the same bale, CVS. Barakat and Barac (67) B.

<table>
<thead>
<tr>
<th>Position</th>
<th>Barakat Total soluble Sugars (mg/100 gm lint)</th>
<th>Barac (67) B Total soluble Sugars (mg/100 gm lint)</th>
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<tr>
<td>Top</td>
<td>753</td>
<td>839</td>
</tr>
<tr>
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<td>722</td>
</tr>
<tr>
<td>Right</td>
<td>694</td>
<td>902</td>
</tr>
<tr>
<td>Left</td>
<td>672</td>
<td>654</td>
</tr>
<tr>
<td>Front</td>
<td>656</td>
<td>933</td>
</tr>
<tr>
<td>Rear</td>
<td>636</td>
<td>688</td>
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Table 5: - Response of insecticides of “Sudac-k” and “Barac (67)B”, 1982/83: Mean whitefly adults on 100 leaves: Data transformed to $\sqrt{x}$: Actual means in parentheses.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average of 5 counts before spraying was commenced</th>
<th>Pre-sprayed counts; average of 8 counts (one before each of the 2nd to the 4th sprays.)</th>
<th>Post-spray count; Average of 4 counts (one after each of the 1st to the 4th sprays)</th>
<th>General performance through the season (average of 20 counts from 11 Sep. 1982 to 9 Jan. 1983)</th>
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<tbody>
<tr>
<td>Barac (67)B sprayed</td>
<td>13.76 (189.8)</td>
<td>22.27 (496.8)</td>
<td>11.8 (140.8)</td>
<td>18.3 (333.8)</td>
</tr>
<tr>
<td>Barac (67)B unsprayed</td>
<td>14.5 (209.5)</td>
<td>53.37 (2851.0)</td>
<td>43.2 (1871.3)</td>
<td>40.8 (1668.7)</td>
</tr>
<tr>
<td>Sudac-k sprayed</td>
<td>8.00 (64.0)</td>
<td>15.35 (236.3)</td>
<td>6.6 (43.3)</td>
<td>11.6 (136)</td>
</tr>
<tr>
<td>Sudac-k unsprayed</td>
<td>6.88 (48.5)</td>
<td>24.88 (620.5)</td>
<td>23.5 (522.0)</td>
<td>20.6 (426)</td>
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The effect of shocking treatment on cotton seeds before sowing by electrical current on cotton (*Gossypium hirsutum l.*) stickiness and some fiber traits under Kahramanmaras conditions

SEFER MUSTAFAYEV, LALE EFE, FATIH KILLI

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Abstract: In this study carried out in 1999-2000 at Kahramanmaras 5 cotton cultivars which belong to *Gossypium hirsutum L.* (Maras-92, Sayar-314, Cukurova-1518, Nazilli-87 and the mutant cotton variety of Agdas-3 that was obtained by mutation breeding in Azerbaijan) were used as a material. High voltage electrical current (30 KV/30 sec.) was applied to the seeds of above-mentioned cotton cultivars before sowing without soaking by using the shocking instrument called “CORONA” which was brought from Azerbaijan. In both years, field experiments were established according to the experimental design of split plots with four blocks using the shocked and unshocked (control) seeds of the cultivars. Fiber properties of lint samples were determined by using HVI analyser but the stickiness counts were determined by FCT (Fiber Contamination Tester). According to two years’ results, stickiness values of the cultivars were found low in this region. For all investigated traits the shocking treatment were not statistically significant in Kahramanmaras conditions. In spite of the effects of the shocking treatment were found statistically insignificant on stickiness, it was determined that the shocking treatment had decreasing stimulative effects on sticky spots the all varieties.

Introduction

The cotton is one of the most raw materials of the textile industry. At the same time, Turkey is one of the most important cotton producing countries. Today, cotton has been sown in Turkey in the total area of 719.294 ha. and Turkey’s lint cotton production is 791.298 tons and lint cotton yield is 110 kg/da. In Kahramanmaras which is one of the cotton regions of Turkey cotton has been sown in the area of 15.300 ha. and lint cotton production is 16.983 tons, and seed cotton yield is 293 kg/da and lint cotton yield is 111 kg/da in this province (Anonymous, 2000).

Cotton fibers contain natural plant sugars and may also contaminated with insect honeydewproduced by aphids and whitefly (Chun and Brushwood, 1998; Crompton and Frydrych, 1998). Sticky cotton can causes quality problems at the various stage of production and processing of cotton lint in the textile industry (Mart et al., 2000; Abbasi, 2000; Gencer and Gormus, 1992; Gencer and Gormus, 1993; Gourlot et al., 1998; Gormus, 1997; Gormus, 2000). Increasing in nepness and irregularities occurs with sticky cotton and the quality of the yarn decreases and efficiency is affected adversely (Crompton and Frydrych, 1998).
Since 1974 sticky cotton can also have been a serious problem in Turkey depending on years and regions. However Turkish cottons are among the most quality cottons which belong to Upland Cottons of all the world because its trash content is low dependig on not using defoliants and chemicals for boll opening and harvesting by hand (Gencer and Gormus, 1993).

Cotton varieties cultivated were treated with high voltage electrical current in order to obtain higher yielding and higher quality fiber. According to the literature review, high voltage electrical current and the other physical factors have stimulative effect on plant growth, yield and some quality traits. Some researchers have reported that the shocking of the cotton seeds by gamma radiation (200-300 gray) has provided stimulative earliness of 5-8 days and increasing yield of 13% in Uzbekistan (Ibrahimov, 1961; Egamberdiyev and Ibrahimov, 1968). Similarly, Gavrilov (1972) has noted that shocking treatments have shown stimulative effects on potato plants when potato knots were shocked gamma radiation of 50 gray before sowing. Furthermore, Mustafayev (1980; 1989; 1997) and Mustafayev et al., (1999) have reported that complete treatment of electrical current and temperature on cotton seeds before sowing causes mutations but the only electrical current treatment has stimulative effects on earliness and yield of the cotton plants. The shocking instrument called “CORONA” which was used for shocking of the seeds with high voltage electrical current was developed by Prof. Dr. Hammed Gozelov and Prof. Dr. Sefer Mustafayev et al. in Azerbaijan Sciences Academy, Physical Institute and they took a patent for this instrument in 1987 in Moskov. The above mentioned instrument was brought from Azerbaijan to the University of Kahramanmaras Sutcu Imam, Agricultural Faculty in 1996.

The aim of the study was to investigate wheather the treatment of high voltage electric current to the cotton seeds causes stimulative effect on stickiness and some fiber traits of the cotton cultivars.

Material and methods

In this study carried out in 1999-2000 at Kahramanmaras 5 cotton cultivars which belong to Gossypium hirsutum L. (Maras-92, Sayar-314, Cukurova-1518, Nazilli-87 and the mutant cotton variety of Agdas-3 that was obtained by mutation breeding in Azerbaijan) were used as a material. High voltage electric current (30 KV/30 sec.) was applied to the seeds of above-mentioned cotton cultivars before sowing without soaking by using the shocking instrument called “CORONA” which was brought from Azerbaijan. In both years, field experiments were established according to the experimental design of split plots with four blocks using the shocked and unshocked (control) seeds of the cultivars. The seeds were sown in four row’s plots at planting space of 65 cm. by using experimental planter and each row was 10 m in length. Then plants were thinned 20 cm in rows. After the plants were cultivated under normal maintanence conditions, the samples of 20 bolls were taken from each plot at harvesting time. Fiber properties of lint samples were determined by using HVI analyser but the stickiness counts were determined by FCT (Fiber Contamination Tester). Obtained data were analysed over two years according to experimental design of split plots with four blocks in the package program of SPSS and the means were compared using Duncan test (Bek and Efe, 1998).

Results and discussion

Fiber Length

According to the two years’ results for fiber length of the investigated varieties in this study, varieties, years and year x variety x treatment interaction and year x variety interaction were statistically significant (P< 0.01). The two years’ mean values belonging to fiber length of the varieties and arised groups were given in Table 1. When Table 1. was looked over, it has been seen that there were no differences between the treatments over two years and that fiber lengths varied between 29.4 mm and 28.3 mm. Moreover fiber length values were 28.7 mm in shocking treatment and 28.8 mm in control. When the values belonging to treatment x variety interaction were examined, it was determined that the varieties of Maras-92 and Sayar-314 had the longest fibers in control. When also the variety means were investigated over two years, it was observed that Maras-92 and Sayar-314 had the longest fibers.
(respectively 29.1 mm and 29.2 mm). This result is similar to the result of Mustafayev et al. (1999). From Table 1, while the shocking treatment had a positive stimulative effect on some cultivars, whereas this treatment had a negative stimulative effect on some cultivars.

**Fiber Strength**

For fiber strength of the investigated varieties in this study, varieties and years were statistically significant ($P < 0.05$). The two years’ mean values belonging to fiber strength of the varieties and arised groups were given in Table 1. When Table 1 was looked over, it has been seen that there were no differences between the treatments over all years and that fiber strength were 30.2 gr/tex in the shocking treatment and 30.4 gr/tex in control. When the values belonging to treatment x variety interaction were examined, it was observed that the all varieties were at the same group. When also the variety means were investigated over two years, it was determined that Sayar-314 (31.8 gr/tex) gave more strength fibers than the other varieties. This variety were followed by Agdas-3 (30.4 gr/tex) and by Maras-92 (30.8 gr/tex).

**Fiber Fineness**

For fiber fineness of the investigated varieties in this study, years ($P < 0.01$) and year x variety interaction ($P < 0.05$) were statistically significant. The two years’ mean values belonging to fiber fineness of the varieties and arised groups were given in Table 1. When Table 1 was looked over, it has been seen that there were no differences between the treatments over all years and that fiber fineness ranged between 4.66 and 5.5 micronaire. When the values belonging to treatment x variety interaction were examined, it was observed that Maras-92, Sayar-314 and Cukurova-1518 had the most fine fibers in the treatment of shocking. When also the variety means were investigated over two years, it was determined that Sayar-314 and Cukurova-1518 gave more fine fibers than the other varieties. From Table 1. While the fibers of Maras-92, Sayar-314 and Cukurova-1518 have got thinner with the shocking treatment, the fibers of Agdas-3 and Nazilli-87 have become thick. It can be sad that the cultivars’ responses were different to the shocking treatment for fiber fineness. Mustafayev et al., (1999) also reported similar results.

**Uniformity Rate**

According to the two years’ results for uniformity rate of the investigated varieties in this study, varieties, year x variety interaction and year x variety x treatment interaction were statistically significant ($P < 0.05$). The two years’ mean values belonging to uniformity rate of the varieties and arised groups were given in Table 2. When Table 1 was looked over, it has been seen that there were no differences between the treatments over two years and that uniformity rates were 84.2% in shocking treatment and 84.5% in control. Furthermore from Table 1, it was seen that uniformity rates ranged 83.5% and 84.9%. When the values belonging to treatment x variety interaction were examined, it was determined that the varieties of Agdas-3 and Maras-92 had the most uniform fibers in control. When also the variety means were investigated over two years, it was also observed that Agdas-3 and Maras-92 had the most uniform fibers (respectively 84.8% and 84.6%).

**Stickiness**

For stickiness of the investigated varieties in this study, varieties, years and year x variety x treatment interaction and treatment x variety interaction were statistically not significant. The two years’ mean values belonging to stickiness of the varieties and arised groups were given in Table 2. When Table 1 was looked over, it has been seen that there were no differences between the treatments over two years and that stickiness values have varied between 7.7 and 26.0. But in shocking treatment the all stickiness values of the varieties over two years were lower than ones in control (respectively 13.3 and 16.2). When the values belonging to treatment x variety interaction were examined, it was determined that the variety of Agdas-3 had the lowest value of stickiness in the shocking treatment (7.7). When also the variety means were investigated over two years, it was observed that Agdas-3 and Cukurova-
1518 had the lowest values of stickiness (respectively 10.3 and 12.1). In all varieties stickiness values were lower in shocking treatment than ones in control. From Table 2, for stickiness it can be said that the cultivars’ responses to the shocking treatment were similar. Furthermore coefficient of variation in stickiness was calculated more higher than the other traits. This situation may be because of two reason. First reason; stickiness data may be very variable. Second reason may be working system of instrument for stickiness.

**Conclusion**

According to two years’ results, for all investigated traits the shocking treatment were not statistically significant in Kahramanmaras conditions. The cultivars’ responses were different in the all investigated traits except stickiness. Especially for stickiness the shocking treatment had similar effects in all cultivars. Generally stickiness values of the cultivars were found low in this region. In spite of the effects of the shocking treatment were found statistically not significant, it was determined that the shocking treatment had decreasing stimulative effects on sticky spots the all investigated varieties.

**Bibliography**


Table 1. The Two Years’ Mean Values Belonging to Fiber Length, Fiber Strength and Fiber Fineness of the Investigated Varieties and Arised Groups (1999-00)

<table>
<thead>
<tr>
<th>Traits</th>
<th>Fiber Length (mm)</th>
<th>Fiber Strength (gr/tex)</th>
<th>Fiber Fineness (micronaire)</th>
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<tr>
<td>Varieties</td>
<td>Shocked Control</td>
<td>Shocked Control</td>
<td>Shocked Control</td>
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<tr>
<td>--------------------</td>
<td>------------------</td>
<td>-------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Agdas-3</td>
<td>28.3 b 28.5 b</td>
<td>28.4 b</td>
<td>30.3 a 30.5 a</td>
</tr>
<tr>
<td>Maras-92</td>
<td>29.0 ab 29.2 a</td>
<td>29.1 a</td>
<td>30.4 a 31.1 a</td>
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<tr>
<td>Sayar-314</td>
<td>29.0 ab 29.4 a</td>
<td>29.2 a</td>
<td>31.0 a 31.0 a</td>
</tr>
<tr>
<td>Cuk.1518</td>
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<td>28.5 b</td>
<td>30.0 a 29.3 a</td>
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<tr>
<td>Nazilli-87</td>
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<td>29.4 a 30.1 a</td>
</tr>
<tr>
<td>Means</td>
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<td>28.8 a</td>
<td>30.2 a 30.4 a</td>
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<tr>
<td>CV (%)</td>
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<td>5.165</td>
<td>5.081</td>
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Table 2. The Two Years’ Mean Values Belonging to Uniformity Rate and Fiber Stickiness of the Investigated Varieties and Arised Groups (1999-00)

<table>
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<tr>
<th>Traits</th>
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<th>Fiber Stickiness (Counts of Sticky Spots)</th>
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<td>Shocked Control Means of Varieties</td>
<td>Shocked Control Means of Varieties</td>
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<td>Agdas-3 84.6 ab</td>
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<td>84.8 a</td>
</tr>
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<td>Sayar-314 84.4 abc</td>
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</tr>
<tr>
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<td>84.5 a</td>
<td>13.3 a</td>
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<tr>
<td>CV (%)</td>
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</table>
Current situation concerning cotton cropping methods and their effect on stickiness

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Abstract: The COTONS model simulates the growth and development of a plot of cotton plants defined by specific soil and climatic conditions, the variety cropped and the cropping techniques applied. This model provides a 3D image of an average plant corresponding to the plot in question. It is also possible to view the vegetative condition of the plant when the bolls start to open and therefore evaluate stickiness potential in relation to plant vegetation. This presentation describes the effects of the variety and cropping practices on stickiness potential. Earliness constitutes a varietal advantage in reducing the risk of stickiness. Different cropping techniques may result in very varied stickiness potential in the same variety even though seed-cotton yield remains constant.

The COTONS model uses and integrates functions and concepts drawn from mechanistic and architectural approaches. The system may be considered as coupling a "plant" model with a tool for the 3D viewing of the simulation results. This system greatly improves the interpretation of test results and can be used prior to experiments, or even as a substitute.

As an example, when attempts are made to evaluate the potential stickiness of cotton fibre, it is essential to determine the exuberance of the foliage when the bolls start to open. The COTONS model is able to do this by comparing diverse situations that are simulated then displayed on the computer screen.

The first illustration (figure 1) shows 2 cotton varieties cropped under the same conditions: same soil, same climatic conditions and same cropping technique. This means that the sowing date, spacing between the rows and between the plants in the row, mineral fertilizer, protective measures, etc. are identical. The least early variety (FULL) is 20% smaller than the earlier variety (EARLY). It also has substantially more foliage and therefore an enhanced risk of suffering from stickiness since the insects responsible for stickiness will find a more favorable environment here (young turgescent leaves) at the critical moment when the bolls start to open.

In the second illustration (figure 2), the same variety (MID) is cropped using 2 different techniques. In the first case, the sowing is denser, less nitrogen-containing fertilizer is used, damage by parasites if more pronounced and a growth regulator is applied. As illustrated in the simulation below, the plants show very different configurations at boll opening despite the fact that their end of cycle yields are identical.
Figure 1: First simulation.

Figure 2: Second simulation
A basic outline of the insect-related stickiness problem and its management in cotton

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Summary: The honeydew-producing insects in cotton are whiteflies, aphids and mealybugs. Fiber stickiness is caused by the swarming of these insects at the end of the cotton growing cycle, when bolls are open. They have been increasing in number over the last few years because of changes in climate and cropping practices, pesticide resistance and probably also because of the appearance of new biotypes. Direct chemical control is often ineffective at the end of the cotton cycle. It is preferable to adopt an integrated approach involving cultural practices and an accurate varietal choice, seeking to increase natural control and to eliminate or at least reduce the support provided by the leaves that persist at the end of the cycle.

Introduction

Drops of honeydew deposited onto cotton fiber are the excretory products of sucking insects belonging to the insect Order Homoptera: whiteflies, aphids and mealybugs. Once these insects have ingested the elaborate sap that circulates in the phloem vessels, they excrete the excess carbohydrates after having modified their chemical structure. This physiological particularity can be used to confirm the entomological origin of the honeydew on the fiber because of the presence of trehalulose and melezitose which are not sugars naturally present in the plant. The problems posed by sticky cottons increased in the course of the 1980's and today constitute a major hazard in most cotton-producing countries.

The insects responsible

Three species or groups of species are encountered frequently on cotton plant at the end of the season: the aphid Aphis gossypii Glover, the whiteflies - mainly Bemisia tabaci Gennadius, but also B. afer and Trialeurodes spp. - and the mealybugs Ferrisia virgata and Pseudococcus filamentosus. However, only the first two have a major economic impact. These insects present common biological characteristics: high multiplication capacity (a generation every 15 days for whiteflies, but every seven to nine days for aphids) and localization under the leaves. In addition to producing honeydew, they also cause trophic damage because of their substantial consumption of sap which normally nourishes the plant. They are also vectors of viral diseases that affect cotton plants ("Blue disease" carried by aphid, Mosaic and "Leaf curl" by whitefly).
Assumed origins of the current situation

Fiber stickiness has been known for many years. Honeydew contamination was often attributed to the whitefly B. tabaci.

It was suggested that repeated applications of DDT-based formulations, widely used on cotton from the 50', were responsible, because DDT and its metabolites were considered as enhancing whitefly egglaying. Meanwhile organophosphates, more specifically directed against sucking insects, progressively lost their effectiveness because of the development of resistance.

More recently (in the 80'), whiteflies and aphid populations have been seen to increase in almost all cotton producing countries. According to cultivation practices, reasons for this may be:

- the introduction and use of pyrethroids to control bollworm and which, while being ineffective against sucking insects, destroy beneficials;
- recourse to low volume spraying techniques (through aerial ou ground ULV equipement) that are unable to coat the inner surface of the foliage;
- increased dosages of nitrogen which favor the vegetative growth of the cotton plant; while increasing sap-sucking by the insects;
- the apparition of new biotypes.

The problem in Africa also includes the increased production since this has created a labor shortage and led to late harvesting.

Improving honeydew-producing insect management

Three approaches are possible in an attempt to reduce the incidence of honeydew on cotton fiber:

- remove the fiber from contamination roots;
- reduce the insect population;
- remove the vegetal support on which the insect population is likely to develop.

Removing the fiber from possible contamination in fact means harvesting the bolls as an when they open. Obviously, this measure requires labor availability that is not always easy to organize for small-scale producers, as well as financial incitement to pick early.

Reducing the number of insects that produce honeydew is possible through a set of cultural practices and varietal choices and by respecting natural enemies before implementing direct control methods:

- as far as cropping practices concerned, the farmer has to choose sowing date the less favorable for the sucking insect populations, and plant the rows further apart, reduce the dosage of nitrogen and use growth regulators to restrict the exuberance of the vegetation;
- as far as varietal measures are concerned, attention has to be focused on selecting morphological or physiological traits of the cotton cultivar capable of slowing population growth as well as developing a plant growth pattern at the end of which the plant dries out very rapidly and losses its leaves;
- as far as the encouragement of natural factors is concerned, practices could be conducted to enhance the action of beneficials (predators and parasites) which decimate aphid and
whitefly populations. Insect pathogens efficacy will be enhanced by indirect measures (modifying crop microclimate);

– finally, direct control measures consist of the judicious choice of chemicals (specific products, with systemic effects), combined with effective spraying methods (sufficient volume to coat the entire canopy), possibly in combination with varietal traits controlling leaf morphology ("okra" leaf).

The most promising measures today seem to be those removing the leaf as a support where the insect populations grow and multiply. Three research routes are proposed:

– breeding of varieties of determined growth that lose their leaves at maturity,
– use of defoliants,
– manual topping of the cotton plants at the end of the cycle.

We have also to take into account that the honeydew-producing insect management has to be planned not only inside the cotton plot, but also at the agrosystem level, where other crops are refugia for cotton pests, when adults escape pesticide applications or host-plants for populations during the dry season.

Conclusion

The struggle against honeydew-producing insects draws on various techniques but all enter into the concept of Integrated Crop Management. Mastering the situation will only be achieved at the agrosystem level, and by combined efforts in cropping methods, varietal selection and a rational use of chemicals in the cotton plot.

Bibliography


The influence of the plant on *Aphis gossypii*.

Some results of research conducted in Cameroon

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Abstract: Studies were conducted in Cameroon in the 1990s to evaluate the development of populations of *Aphis gossypii* Glover on different types of host-plant belonging to the Malvaceae family. Several host-plant characteristics may affect aphid infestation. Firstly, the influence of several varietal morphological characteristics is interesting. This is the case of the okra leaf character as leaf areas are soon saturated in case of aphid pullulation. However, this morphological character implies changes to certain components of the crop management sequence. Plant chemical composition is another interesting pathway for the control of *A. gossypii*. The levels of certain components such as amino acids and sugars may partially determine the development potential of *A. gossypii*. These varietal control methods can be envisaged in integrated control programmes and their study deserves to be continued and completed.

Introduction

The aphid *Aphis gossypii* Glover has become a serious pest on cotton in central Africa, as in most of the other cotton production regions in the world (LECLANT & DEGUINE, 1994).

Aphid population dynamics results from favourable factors corresponding to the hatching of aphids and unfavourable factors causing death (ROBERT, 1981). The balance between these factors causes the increase or decrease in their numbers. The nature of the plant itself may have an effect on the dynamics of *A. gossypii* by changing its capacity for development or reproduction. The studies described below were conducted in Cameroon from 1989 to 1994 and were aimed at studying aphid development on different types of host-plant belonging to the Malvaceae family.

Four levels of comparison were designed. First, *A. gossypii* were monitored under both natural and laboratory conditions on cotton and okra, the two host-plants most seriously infested in Cameroon (EKUKOLE, 1990). The two cotton species most commonly cultivated in the world, *Gossypium hirsutum* L. in rainfed cultivation and *Gossypium barbadense* L. in irrigated cultivation, were then compared. Fibre stickiness was then studied in different varieties of cotton that can be extended in Cameroon. Finally, okra leaf, a varietal character often mentioned as having advantages for the control of *A. gossypii*, was studied.

Material and methods

Generic study

Observations concerning infestation of cotton and okra were performed in 1993 at three locations: Maroua, Mokong and Touboro. Okra plants at the edge of unprotected cotton plots (half-hectare) were
observed weekly. The number of aphids on 20 cotton plants and 20 okra plants were counted at each observation.

Study at species level

'Wild' cotton varieties (species or races not grown in farms) are grown for decorative purposes close to the offices of the IRA Research Station in Maroua. The species or races are as follows: G. hirsutum (punctatum race), Gossypium arboreum (soudanense race) L., Gossypium herbaceum (acerifolium race) L. and G. barbadense. These species are harvested in northern Cameroon, generally for crafts purposes (SEIGNOBOS & SCHWENDIMAN, 1991). Two plants of each species sown side by side in August 1992 in an area 3 m by 7 m were irrigated in the dry season and thus kept 'green'. These cotton plants were the main material used in the experiment.

Field observations

Field observations first consisted of counting the aphids on all the leaves of each decorative cotton plant during pullulation (23 December 1992). Subsequently, after qualitative evaluation of aphid infestation of six barbadense cultivars in the field in August 1993, cultivar 1284 was chosen for the following studies. Thus, a trial comparing aphid infestation of the species G. hirsutum (latifolium race, IRMA BLT variety) and G. barbadense (cultivar 1284) was sown on 5 September 1993 at Maroua. It was a twin trial with five repetitions. The elementary plot consisted of a 5-metre row. The cotton plants were not sprayed and were watered after the end of the rainy season. Twenty-three observations consisting of aphid counts on the five terminal leaves of five consecutive cotton plants in each row were performed twice a week (from 20 October 1993 to 13 January 1994).

Fertility tests

Fertility tests on A. gossypii were performed in the laboratory in August 1993 for each of the four plant species and for the extended species G. hirsutum (latifolium race, variety IRMA BLT). This species was sown on 10 June 1993 near the others. The purpose of these tests was mainly comparative and they were performed in the following way. Five terminal leaves were collected from each cotton species in the morning. Fine tweezers were used to remove the aphids from the leaves. Temperature (25°C), relative humidity (55.5%) and lighting (12 h per day) were kept constant in the laboratory. After wrapping of the petiole in moist cotton wool, each leaf was placed lower face upwards in a Petri dish. Fifteen adult aphids of the third generation of aphids reared in the laboratory were then placed on each leaf. The operation was carried out with adult apterae and alatae. A count of the larvae produced on each leaf in 24 hours was performed on the following day. The observations were repeated nine times from 19 to 30 August 1993 using different leaves and aphids. The results of the fertility tests were subjected to analysis of variance using Fisher blocks with five objects (Gossypium species) and nine repetitions (observation dates).

Chemical analysis of leaves

These field and laboratory studies were completed by the analysis of certain chemical substances in cotton plant leaves. The species hirsutum (IRMA 1243) and barbadense (1284) were used. The analyses concerned protein substances (amino acids) and carbohydrates (sugars) because these are particularly important for the development of A. gossypii (SLOSSER et al., 1989). For this, two small plots of each species were sown at Maroua on 10 August 1994. These received chemical protection (so as not to assay substances in arthropod excreta and in particular in those of A. gossypii and B. tabaci, whose honeydews are particularly sugary). Fifty leaves of each variety were collected on 13 October 1994 (from the 10th node counting from the base of the plant).

The leaves were kept fresh after collection (placed between two moist pads and petiole sealed with wax) for the analysis of amino acids. The analyses were performed at the CIRAD-GERDAT UR BIOTROP laboratory. Preparation consisted of grinding the leaves in liquid nitrogen. The dry weight was measured after heating at 105°C for 24 hours. Free amino acids were extracted from 5 g dry matter with 20 ml
sodium citrate 0.2N pH 2.3. Protein hydrolysis was performed with hydrochloric acid 6N at 110°C for 24 hours. After evaporation, the aliquots were resuspended in sodium borate buffer 0.4 N pH 9.5. The amino acids were then analysed by HPLC (High Performance Liquid Chromatography) using the following method. After derivatisation of the amino acids on a pre-column with orthophthaldialdehyde, separation was performed on a C18 grafted silica column. Amino acids were detected by fluorescence (excitation at 360 nm, emission at 455 nm) and calibrated according to the PIERCE 20290 standard.

Analysis of the sugars in dried leaves was performed at the CIRAD-GERDAT URA laboratory. The preparation used was a simple dilution after grinding at 200 µm. A 1 g to 3 g fraction was removed. The ion chromatography method was used, based on anion exchange followed by pulsed amperometric detection. The method is described in detail by PESCHET & GIACALONE (1991). Sugar analysis was performed twice.

**Study of the okra leaf character**

**During the vegetative cycle**

Three experiments concerning the progress of the season were used. First, two trials were set up in 1992, one at Gaklé and the other at Djalingo, with the aim of studying the behaviour of an okra leaf variety under on-farm conditions, provided information about the effect of the okra leaf character. At each location, a quarter-hectare plot was divided into two. One half was sown with IRMA 1234 (normal leaves), the extended variety and the other half with the IRMA BOKA variety (okra leaves). The two varieties are isogenic, apart from the okra leaf character. All the cultural operations recommended by SODECOTON were applied to the elementary plot and crop protection was by staggered control (an approach combining thresholds and specific pest targeting) (DEGUINE et al., 1993). Secondly, a comparison of the varieties IRMA 1243 and IRMA BOKA was undertaken in a 500 m² unprotected plot at Maroua in 1994. This consisted of two elementary plots with no repetition. Observations were performed twice a week in both cases and concerned 50 cotton plants per plot (25 plants along each of two diagonals) in 1992 and 15 plants of each variety in 1994. On each plant examined, 15 leaves (five at the top, five in the middle and five at the base) were observed in 1992 and all the leaves were observed in 1994. Aphids were counted on each leaf.

**At the end of the season**

The end of season study was performed at Maroua in 1992 in a propagation plot that had previously received conventional ULV crop protection spraying. Aphid infestation was very severe at this time in spite of prior protection. Two varieties were studied, the conventional extended variety IRMA 1243 and an 'okra leaf variety', IRMA Z332 (IRMA 1243 x IRMA B1F4 Okra). The two varieties have common genealogy, are close and differ essentially in the okra character. The study set-up was not statistical; the two 100 m² plots were contiguous and had the same cultural and soil-climate conditions. Observations performed from 26 November to 5 December 1992 consisted of counting, leaf by leaf, the aphids on 63 cotton plants of each variety.

**Analysis and presentation of the results**

The results of the tests with statistical layouts were subjected to analysis of variance. The figures presented in the tables are the real averages, with the transformed averages in brackets. The other criteria presented are F1 (Fisher test for the treatments), CV (coefficient of variation), Proba (test significance) and SD (standard deviation). Transformations (T) of the variables were performed if necessary (% , log) to homogenise variance. Object classification was performed using the Newman-Keuls test and letters awarded in descending order of interest.
Results and discussion

Infestation of okra and cotton

Comparative evolution of the populations of the two plants are given in Figures 1, 2 and 3. The dynamics was the same on both and the pullulation at the beginning of the season occurred at the same time.

The difference in population during this phase varied from one location to another. When cotton was sown well before okra (Maroua), its larger leaf area harboured a greater number of aphids. Conversely, at Mokong, infestation of okra was more marked because seedling emergence was earlier. An intermediate situation was observed in Touboro (close emergence dates).

Furthermore, counts of aphids infected by parasites or fungi and of predators give identical results on cotton and okra (DEGUINE, 1995).

Development and reproduction on G. hirsutum and G. barbadense

Table 1 gives a comparison of the aphid population sizes observed on 23 December 1992 on the four decorative species. The differences in infestation between G. hirsutum punctatum and the other species are very marked. Detailed results for G. hirsutum punctatum and G. barbadense, whose appearance in the field is contrasted, are shown in Table 2. Leaves of the second species are much larger than those of the first. These results were confirmed by observations performed in 1993/1994 comparing cumulated aphid numbers on G. hirsutum latifolium (cultivated) and G. barbadense in the inter-season (Table 3).

The results of the laboratory fertility tests on the decorative species and on G. hirsutum latifolium are shown in Table 4. A. gossypii reproduction was significantly inferior on G. barbadense and better on G. hirsutum latifolium.

Chemical analyses (Tables 5 and 6) revealed that the levels of free amino acids and sugars were approximately twice as high in G. hirsutum leaves than in the other leaves. The amino acids obtained by hydrolysis of cotton leaves are equivalent in the leaves of the two species (22.2% for G. hirsutum and 19.8 for G. barbadense).

The results of these experiments all display the same trend. A. gossypii develops and reproduces better on G. hirsutum than on G. barbadense, confirming the results of prior comparisons in Africa (KHALIFA & SHARAF-EL-DIN, 1964; GHOVANLOU, 1976; SILVIE & DEGUINE, 1987). Even if it is still a research hypothesis, these studies would indicate a possible effect of the substances studied in cotton leaves. Given the recognised role of these substances in A. gossypii development (SLOSSER et al., 1989; LECLANT, 1990), their relatively low level in G. barbadense leaves may partially account for the lower aphid infestations observed. If it were to be confirmed, the hypothesis would allow the search for a genetic answer to the aphid problem. It would thus be possible to envisage considering the genes or groups of genes involved in the amino acid and sugar metabolism. This requires the prior finding of molecular markers. However, other substances (flavanols, flavonols and tannins), whose importance was demonstrated by SLOSSER et al. (1989), should also be taken into account in the future. Likewise, certain substances are known to reduce the biological capacities of A. gossypii.

The okra leaf character

The okra leaf character is indeed very special and seems to meet the necessary—but insufficient—condition mentioned above. Indeed, two varieties differing only in the okra character have very different appearances and the lesser leaf area resulting from the character should a priori result in less severe infestation, as is the case for whitefly (DEGUINE & LECLANT, 1997).

Figures 4, 5 and 6 show the population dynamics during the 1992 season at Gaklé using three observation criteria. No difference in the percentage of plants or leaves infested was observed during pullulation early in the season (4 August 1992) between the two varieties. In contrast the aphid counts on leaves showed a considerable difference that was significant given the number of leaves observed (750 per object).
same remark can be made for the Djalingo test in 1992 (Figure 7). It was also noted that aphid number on
the okra leaf plot at this location stopped increasing before the peak of pullulation and 'stagnated' for
several days (27 July to 4 August 1992). A similar observation (13 to 17 July 1994, Figure 8) was made in
the 1994 Maroua trial. Shortage of space probably caused this stagnation during this phase of very strong
infestation.

The leaf area may therefore be the limiting factor for aphid numbers during spatial saturation of laminae.
Leaf area measurements performed on 4 August 1992 at Gaklé shows that okra leaf area was 61.2% of
that of conventional cotton (data from the Programme Cultures Cotonières Paysannes, IRA Maroua).
This percentage is very close to the ratio of aphid numbers on okra leaf cotton to aphid numbers on
conventional cotton on the same date (60.7%). This tends to confirm that pullulation in terms of aphid
number is limited by the spatial saturation of populations.

Inversely, when the populations become small in the middle of the season (when aphid infestation is not
of great importance), the curves of the aphid numbers are very similar for the two varieties whereas those
of the infested plant percentages display differences. Indeed, the small numbers of aphids tend to spread
more on the surface of the plants and plants with leaves with a larger area (the conventional variety) are
therefore more strongly infested.

These observations performed during the season lead to concluding that the okra leaf character reduces
populations of A. gossypii during the pullulation phase, if one uses the most suitable criterion (aphid
counts). The conclusion is different according to the more classic and more commonly used criteria
(percentage of infested plants or leaves). This is in agreement with the results of the studies performed to
date on cotton growing in Francophone Africa and where no direct effect of the okra leaf character on
aphids has been found (RENOU et al. (1984) in Cameroon; SILVIE & DEGUINE (1986) in Chad;

The average end-of-season figures for the leaf area of leaves and plants, for aphids and stickiness are
shown in Tables 10, 11 and 12. The leaf area is smaller in the okra variety (33 cm² instead of 55 cm² on
average). At the plant scale, the presence of a larger number of leaves (34 instead of 26) compensates (and
partially erases) the leaf difference (126 cm² instead of 1428 cm²) in comparison with conventional
cotton plants. Aphid numbers depend firstly on the area that they can occupy during pullulation and
therefore follow the same trend, with an average of 253 instead of 292 aphids per leaf (as many as
658 aphids on a single leaf has been attained on a cotton plant at the edge of the plot!), but 8,577 against
7,541 per plant.

Finally, under the conditions of the study and under the A. gossypii pullulation conditions at the end of the
season, the use of okra leaf varieties alone does not significantly reduce fibre stickiness. It should
nevertheless be noted that the incorporation of the okra leaf character in cotton requires the adapting of the
crop management sequence components (density, fertilisation, weed management and pest protection).

**Conclusion**

These studies show that several host-plant characteristics can affect infestation by aphids.

Furthermore, the levels of certain substances such as amino acids and sugars may partially affect
A. gossypii development potential. Genetic research should thus be envisaged to modify the composition
of these substances.

A varietal character that results in a change in the aphid development conditions in the field may limit
populations. This is the case of the okra leaf character, which limits the area available on the leaf.
However, this effect is not sufficient to reduce the intensity of the nuisance caused by A. gossypii. This
would also seem to be the case of the leaf hairiness character, as the absence of hairs on leaves is known
to reduce the protection of A. gossypii from its natural enemies (KHALIFA & SHARAF EL-DIN, 1964;
VAISSAYRE, 1970; ULLAH, 1978; CASTELLA et al., 1992). Nevertheless, the same conclusion as for
okra leaves (inadequate effect) would probably be made for smooth leaves.

Thus, in varietal control of A. gossypii, research on the composition of the plant in different substances is
a line that should be followed instead of the study of varietal morphological characters whose effects are
inadequate. However, the latter pathway can accompany other methods within the framework of true integrated protection against the cotton aphid. Indeed, it is known that the juxtaposition of several techniques that are inadequate when applied singly can give agriculturally interesting results when used simultaneously (LECOQ & PITRAT, 1983).

**Bibliography**


EKUKOLE G., 1990- Effect of some selected plants on the fecundity of Aphis gossypii Glover under laboratory conditions. Coton et Fibres Tropicales, 45, 263-266.


Table 1. Comparison of aphid numbers per plant for the four 'wild' *Gossypium* species. Maroua (23/12/1992); observations of two plants of each species.

<table>
<thead>
<tr>
<th>Gossypium species and race</th>
<th>Aphids per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hirsutum punctatum</td>
<td>3 698.5</td>
</tr>
<tr>
<td>arboreum soudanense</td>
<td>37.7</td>
</tr>
<tr>
<td>herbaceum acerifolium</td>
<td>252.5</td>
</tr>
<tr>
<td>Barbadense</td>
<td>343.5</td>
</tr>
</tbody>
</table>

Table 2. Comparison of the infestation of two 'wild' *Gossypium* species. Maroua (23/12/1992); observations of two plants of each species.

<table>
<thead>
<tr>
<th>Cotton plant number and average per species</th>
<th>Number of branches</th>
<th>Number of leaves</th>
<th>Percentage of leaves infested on the plant</th>
<th>Number of aphids average per leaf</th>
<th>max per leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant 1</td>
<td>33</td>
<td>129</td>
<td>82.2</td>
<td>3634</td>
<td>28.2</td>
</tr>
<tr>
<td>Plant 2</td>
<td>29</td>
<td>122</td>
<td>86.9</td>
<td>3763</td>
<td>30.8</td>
</tr>
<tr>
<td>Average</td>
<td>31</td>
<td>125</td>
<td>84.5</td>
<td>3698</td>
<td>29.5</td>
</tr>
<tr>
<td>G. hirsutum punctatum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant 1</td>
<td>28</td>
<td>268</td>
<td>43.7</td>
<td>436</td>
<td>1.6</td>
</tr>
<tr>
<td>Plant 2</td>
<td>28</td>
<td>252</td>
<td>36.5</td>
<td>248</td>
<td>1.0</td>
</tr>
<tr>
<td>Average</td>
<td>28</td>
<td>260</td>
<td>40.2</td>
<td>342</td>
<td>1.3</td>
</tr>
<tr>
<td>G. barbadense</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Comparison of infestation of *G. hirsutum latifolium* (IRMA BLT) and *G. barbadense* (1284) during the inter-season. Maroua (23/10/93-10/01/94); irrigated field. Analysis of variance in a pair test (5 repetitions). Observations of 25 leaves per plot.

<table>
<thead>
<tr>
<th>Gossypium Species and race</th>
<th>Aphids on 25 leaves (23 observations cumulated)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Hirsutum latifolium</em></td>
<td>340.7 (2.51) b</td>
</tr>
<tr>
<td><em>Barbadense</em></td>
<td>136.2 (2.11) a</td>
</tr>
<tr>
<td>F</td>
<td>35.24</td>
</tr>
<tr>
<td>CV</td>
<td>5.1</td>
</tr>
<tr>
<td>Proba</td>
<td>0.2%</td>
</tr>
<tr>
<td>SD</td>
<td>0.05</td>
</tr>
<tr>
<td>T</td>
<td>log</td>
</tr>
</tbody>
</table>

Table 4. The fertility of *A. gossypii* on several *Gossypium* species. Maroua (9 observations from 19/08 to 30/08/1993). Analysis of variance performed using a Fisher block layout with 5 objects (species) and 9 repetitions (number of tests).

<table>
<thead>
<tr>
<th>Gossypium Species and race</th>
<th>Number of larvae produced per day per 75 adult apterae</th>
<th>per 75 adult alatae</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Hirsutum latifolium</em></td>
<td>227.3 (2.34) c</td>
<td>167.2 (2.20) c</td>
</tr>
<tr>
<td><em>Arboreum soudanense</em></td>
<td>171.3 (2.19) b</td>
<td>131.2 (2.09) b</td>
</tr>
<tr>
<td><em>Herbaceum acerifolium</em></td>
<td>212.2 (2.30) c</td>
<td>156.1 (2.17) c</td>
</tr>
<tr>
<td><em>barbadense</em></td>
<td>124.3 (2.07) a</td>
<td>104.4 (1.99) a</td>
</tr>
<tr>
<td><em>Hirsutum punctatum</em></td>
<td>227.7 (2.34) c</td>
<td>167.4 (2.21) c</td>
</tr>
<tr>
<td>F</td>
<td>25.79</td>
<td>12.01</td>
</tr>
<tr>
<td>CV</td>
<td>3.1</td>
<td>3.7</td>
</tr>
<tr>
<td>Proba</td>
<td>&lt; 0.01%</td>
<td>&lt; 0.01%</td>
</tr>
<tr>
<td>SD</td>
<td>(0.02)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>T</td>
<td>log</td>
<td>log</td>
</tr>
</tbody>
</table>
Table 5. Comparison of free amino acid contents in the leaves of *G. hirsutum* (IRMA 1243) and *G. barbadense* (1284). Maroua (1994); leaf collection on 13/10 (approximately 60 days after emergence); unit: cg per 100 g dry weight (%).

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Content (%)</th>
<th>G. hirsutum</th>
<th>G. barbadense</th>
</tr>
</thead>
<tbody>
<tr>
<td>aspartic acid</td>
<td>267.4</td>
<td>191.2</td>
<td></td>
</tr>
<tr>
<td>glutamic acid</td>
<td>81.2</td>
<td>113.1</td>
<td></td>
</tr>
<tr>
<td>asparagine</td>
<td>558.1</td>
<td>273.3</td>
<td></td>
</tr>
<tr>
<td>serine</td>
<td>57.9</td>
<td>33.1</td>
<td></td>
</tr>
<tr>
<td>glutamine</td>
<td>16.8</td>
<td>16.0</td>
<td></td>
</tr>
<tr>
<td>histidine</td>
<td>50.7</td>
<td>26.6</td>
<td></td>
</tr>
<tr>
<td>glycine</td>
<td>12.0</td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>threonine</td>
<td>55.2</td>
<td>21.0</td>
<td></td>
</tr>
<tr>
<td>arginine</td>
<td>70.1</td>
<td>38.2</td>
<td></td>
</tr>
<tr>
<td>alanine</td>
<td>37.8</td>
<td>15.7</td>
<td></td>
</tr>
<tr>
<td>gamma-aminobutyric acid</td>
<td>14.2</td>
<td>7.8</td>
<td></td>
</tr>
<tr>
<td>tyrosine</td>
<td>43.4</td>
<td>17.1</td>
<td></td>
</tr>
<tr>
<td>methionine</td>
<td>1.1</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>valine</td>
<td>31.6</td>
<td>16.1</td>
<td></td>
</tr>
<tr>
<td>phenylalanine</td>
<td>75.3</td>
<td>42.1</td>
<td></td>
</tr>
<tr>
<td>isoleucine</td>
<td>23.9</td>
<td>13.8</td>
<td></td>
</tr>
<tr>
<td>leucine</td>
<td>12.5</td>
<td>6.9</td>
<td></td>
</tr>
<tr>
<td>lysine</td>
<td>29.1</td>
<td>16.5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1438.2</td>
<td>856.7</td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Comparison of the sugar contents in the leaves of *G. hirsutum* (IRMA 1243) and *G. barbadense* (1284). Maroua (1994); leaves collected on 13/10 (approximately 60 days after emergence); unit: cg per 100 g dry weight (%).

<table>
<thead>
<tr>
<th>Sugar</th>
<th>Content (%)</th>
<th>G. hirsutum</th>
<th>G. barbadense</th>
</tr>
</thead>
<tbody>
<tr>
<td>sorbitol</td>
<td>0.25</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>galactose</td>
<td>0.17</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>glucose</td>
<td>0.65</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>xylose</td>
<td>0.14</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>fructose</td>
<td>0.24</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>melibiose</td>
<td>0.79</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>sucrose</td>
<td>1.02</td>
<td>0.51</td>
<td></td>
</tr>
</tbody>
</table>
Table 7. Comparison of the area of conventional and okra leaves and comparison of the numbers of aphids that they harbour. Maroua (26/11 to 05/12/1992). 1 631 conventional leaves (IRMA 1243 variety); 2 121 okra leaves (Z 332 variety).

<table>
<thead>
<tr>
<th>Leaf area (cm²)</th>
<th>Variety</th>
<th>Average</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>1st quartile</th>
<th>Median</th>
<th>3rd quartile</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRMA 1243</td>
<td>54.76</td>
<td>32.27</td>
<td>2.05</td>
<td>28.43</td>
<td>53.17</td>
<td>75.58</td>
<td>184.22</td>
</tr>
<tr>
<td></td>
<td>Z 332</td>
<td>33.43</td>
<td>21.08</td>
<td>1.13</td>
<td>17.32</td>
<td>30.67</td>
<td>46.04</td>
<td>170.05</td>
</tr>
<tr>
<td>Number of aphids</td>
<td>IRMA 1243</td>
<td>292.22</td>
<td>202.21</td>
<td>0.00</td>
<td>120.00</td>
<td>269.00</td>
<td>434.00</td>
<td>1411.00</td>
</tr>
<tr>
<td></td>
<td>Z 332</td>
<td>253.49</td>
<td>171.83</td>
<td>0.00</td>
<td>120.00</td>
<td>225.00</td>
<td>359.00</td>
<td>1040.00</td>
</tr>
</tbody>
</table>

Table 8. Comparison of the leaf area of conventional and okra leaf cotton plants and comparison of the numbers of aphids harboured. Maroua (from 26/11 to 05/12/1992). 63 IRMA 1243 cotton plants; 63 Z 332 cotton plants.

<table>
<thead>
<tr>
<th>Cotton plant</th>
<th>Variety</th>
<th>Average</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>1st quartile</th>
<th>Median</th>
<th>3rd quartile</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of leaves</td>
<td>IRMA 1243</td>
<td>25.97</td>
<td>7.57</td>
<td>11.00</td>
<td>20.00</td>
<td>26.00</td>
<td>30.00</td>
<td>49.00</td>
</tr>
<tr>
<td></td>
<td>Z 332</td>
<td>33.67</td>
<td>8.83</td>
<td>12.00</td>
<td>28.00</td>
<td>33.00</td>
<td>38.00</td>
<td>58.00</td>
</tr>
<tr>
<td>Leaf area (cm²)</td>
<td>IRMA 1243</td>
<td>1428.37</td>
<td>644.18</td>
<td>458.74</td>
<td>903.58</td>
<td>1389.61</td>
<td>1726.63</td>
<td>3724.96</td>
</tr>
<tr>
<td></td>
<td>Z 332</td>
<td>1125.71</td>
<td>488.49</td>
<td>326.85</td>
<td>684.21</td>
<td>1155.21</td>
<td>1500.92</td>
<td>2018.44</td>
</tr>
<tr>
<td>Number of aphids</td>
<td>IRMA 1243</td>
<td>7541.54</td>
<td>2963.50</td>
<td>2184.00</td>
<td>5328.00</td>
<td>7349.00</td>
<td>9226.00</td>
<td>16872.00</td>
</tr>
<tr>
<td></td>
<td>Z 332</td>
<td>8577.13</td>
<td>3866.59</td>
<td>1009.00</td>
<td>5682.00</td>
<td>8587.00</td>
<td>11627.00</td>
<td>18475.00</td>
</tr>
</tbody>
</table>
Figures 1 (Maroua, 1993), 2 (Mokong, 1993) and 3 (Touboro, 1993). Evolution of aphid number on cotton and okra. 20 plants observed.

Maroua: emergence on 18/06 (cotton) and 20/07 (okra)
Mokong: emergence on 26/06 (cotton) and 18/06 (okra)
Touboro: emergence on 14/07 (cotton) and 17/07 (okra)
Figures 7 (Djalingo, 1992) and 8 (Maroua, 1994). Evolution of aphid numbers on convective and okra leaf cotton plants.

Djalingo (1992): 750 leaves observed
Maroua (1994): 15 cotton plants observed
On line Assessment of Cotton Stickiness

W. STANLEY ANTHONY

Abstract: Rapid assessment of the stickiness of cotton can be accomplished with a new, patented apparatus developed at the US Cotton Ginning Laboratory at Stoneville, Mississippi. The apparatus essentially consists of an infrared-based moisture sensor, a resistance-based moisture sensor, a compression mechanism, and a computer equipped with special software. The apparatus may be used either as a stationary laboratory device or as a continuous, online monitor in gin or textile environments. The infrared moisture meter responds to the level of natural sugar, insect sugar, and moisture that is contained within the sample whereas the resistance moisture content is affected only slightly by the insect sugars. Results of several studies involving a number of cottons grown across the US cotton belt indicated that the instrument can correctly estimate stickiness over 75% of the time.

Introduction

Cotton yield as well as cotton processibility at the gin and textile mill are severely degraded by the presence of excessive insect sugar on cotton lint. Some cotton production areas are penalized monetarily because of their reputation for sticky cotton. In extreme cases, cotton production has been severely curtailed in response to stickiness problems. Operational problems become apparent when certain contaminants present on the cotton fibers begin to interfere with the smooth operation of textile processes such as carding and spinning. At the gin, reduced ginning rates and poor operation can occur as a result of sticky cotton. These effects are less pronounced at the gin than those that occur during textile processing.

Sugar is a colloquial term used to describe certain members of the class of compounds called carbohydrates. Sugars have hydrophilic properties. These molecules possess several hydroxyl groups, which can interact with water molecules; in essence, they take up water. The physiological or natural sugars that occur in cotton can be subdivided into those originating as (a) cellulose precursors and as (b) nectary-secretions. Insect sugars, usually referred to as honeydew, cause 80 to 90% of all cases of cotton stickiness (Sisman and Schenek, 1984). The main honeydew producing insects attacking US-grown cotton are the sweet potato whitefly Bemisia tabaci Gennadius and the cotton aphid Aphis gossypii Glover (Rimon, 1982).

Whiteflies and aphids are both plant sap-sucking insects, which feed by inserting their slender mouthparts (stylets) into the leaf tissue. Sap is then drawn up into the insect along the stylet food canal. Phloem sap is generally rich in sugars but poor in the amino acids which are essential for insect growth. Whitefly and aphids therefore have to ingest large amounts of sap in order to obtain sufficient amino acids for growth. The insects do only a little digestion and the residual solution is stored in the dilated rectum before ejection to the exterior in the form of a droplet of honeydew. The honeydew droplet released is rich in excess sugars. The droplets are intact on seed cotton but the combing and
blending action of lint cleaners spread each droplet over a larger area. These droplets create problems during mechanical processing at the gin and textile mill, and should be mitigated or eliminated.

The first step toward solving the stickiness problem is identification of the cotton that is contaminated with insect sugars. Several laboratory methods to identify stickiness but they are generally time-consuming and subjective. Online detection systems for stickiness have the potential to influence mitigation during gin and mill processing.

New Online System

As a result of the need to rapidly evaluate the stickiness of cotton, a new apparatus referred to as the "Stickiness Tester" was developed and patented (Anthony and Byler, 1997). The laboratory version of the apparatus essentially consists of a cabinet, an infrared-based moisture sensor, and a resistance-based moisture sensor operated in conjunction with a compression platen (Figure 1). The infrared moisture meter responds to the level of natural sugar, insect sugar and moisture that is contained within the sample whereas the resistance-based sensor is affected only slightly by the sugars. The device predicts the stickiness of cotton correctly about 75% of the time and requires less than 5 seconds to analyze the sample. This device can be integrated into a gin or mill system as shown in Figure 2 to provide a mechanism to regulate additives and procedures to reduce stickiness. Successful implementation of this device will identify and mitigate stickiness and thus improve the market potential for cotton. The present invention provides a system and method for determining the stickiness of contaminated cotton. One moisture sensor measures resistance or capacitance of a sample to define a reference moisture level. The resistance sensor may include a sensor array having a plurality of electrodes for measuring resistance and/or capacitance, a pressure sensor, and a temperature sensor. The pressure sensor ensures that the sample surface is adequately compressed to achieve accurate readings. The temperature sensor provides a means to correct the resistance readings for temperature differences. A second moisture sensor based on infrared technology is responsive to the presence of both moisture and sugars. This is used to determine a sugar-based moisture content in the sample. A computer program is then used to determine the stickiness of the sample by analyzing the variation between the reference and sugar-based moisture contents.

Testing is accomplished by pressing the sample against the sensing surfaces of the moisture sensor to a degree that ensures that an accurate measurement is made--this degree is measured by the pressure sensor imbedded in the resistance moisture sensor. The pressing means may be accomplished by a platen as discussed earlier for the laboratory model or by a paddle or a ram or any similar device. Several methods of collecting, compressing and releasing samples in commercial gins and mills are shown in Figures 1-4 (Anthony 1992).

The Stickiness Tester, in addition to providing operator-based laboratory measurements, can be operated in an automatic and continuous fashion. Automated operation may be accomplished at gins or textile mills or laboratories. For the automated version, a device such as a "paddle sampler" collects, compresses, analyzes and releases a sample as it travels through a conduit in a gin or processing mill (Figure 2). It can be used at any stage of processing. For example, the system can be used to measure the stickiness of cotton as it is harvested, module, ginned, graded, cleaned, carded, etc.

Review of Research with Stickiness Tester

Numerous studies were conducted from 1994 - 2000 to validate the Stickiness Tester on many different types of cotton. Comparisons were made with the thermodetector and the Minicard.

Initially in Study 1, comparison of the infrared and resistance readings of samples combined with oven moisture readings indicated that cottons were usually sticky if the resistance-based moisture differed from the infrared-based moisture by 0.8%. Samples with high natural sugar also appeared to be called sticky. When the oven-based moisture differed from the infrared-based moisture by 0.6%, and the resistance-based moisture differed from the infrared-based moisture by 0.8%, it appeared that these samples had a high sugar content but were not sticky--it appeared that the sugar in this lint was due to
physiological or natural plant sugars. Thus by combining these three measurements of moisture content, samples could be separated into three categories: sticky, nonsticky, and high natural sugar. Further analysis of these data using the Discriminate Analysis procedure by the Statistical Analysis System (SAS, 1996) indicated that the samples could be divided into categories of 0, 1, 2, 3, and 4 regardless of the natural sugar by using only the resistance and infrared methods (Anthony, et al., 1994).

For study 2, which involved numerous sticky and non-sticky lint samples with stickiness levels ranging from 0 to 4 (based on the thermodetector method) and conditioned and tested in a laboratory environment, 74% of the nonsticky samples were placed into the correct category (Anthony, et al., 1995). For the sticky samples, 67% of the level 1 samples, 83% of the level 2 samples, and 100% of the level 3 and level 4 stickiness samples were correctly identified.

In study 3, seed cotton samples similar to those before any gin processing were evaluated in addition to the resulting lint samples after ginning. Two levels of stickiness were used based on Minicard readings from lint taken from the seedcotton--0 and 4. For the samples of seed cotton for study 3, 100% of the samples were correctly identified by the Stickiness Tester. This increased precision for seed cotton was likely due to the fact the insect sugar droplets were still intact on the surface of the cotton and had not been broken up, combed, and blended as would occur during normal ginning and lint cleaning operations.

In study 4, Anthony (1999) conducted three separate tests with the Stickiness Tester by taking one reading on each of four sides of the sample and averaging the results. Stickiness was predicted by the Stickiness Tester from infrared and resistance moisture measurements. For seed cotton, 100% of the non-sticky samples were correctly identified. For stickiness levels 1, 2 and 3, respectively, 0%, 89%, and 100% were correctly identified. Only 1 of 21 seed cotton samples were incorrectly categorized as non-sticky; no non-sticky sample was incorrectly identified as sticky. For lint cotton, 91%, 64%, 88%, and 100% were correctly identified for stickiness levels 0, 1, 2, and 3, respectively.

For study 5, 78% of the non-sticky seed cotton samples were classified correctly as non-sticky compared to 50%, 55% and 50% for stickiness levels 1, 2 and 3, respectively. For lint data, those numbers were 80%, 34%, 78%, and 60%. When the lint and seed cotton data were considered in the same database, these numbers were 76%, 30%, 70%, and 14%. For a similar study with different samples (Study 6), stickiness levels were correctly predicted 50%, 43%, and 75% of the time, respectively, for levels 0, 1, and 2.

In study 7, Anthony (2000) further evaluated the Stickiness Tester using 500 reference samples that were evaluated with a standard thermodetector as well as an automated thermodetector (H2SD) at other laboratories. In this study, samples were classified into level of stickiness from 0 to 3 based on the thermodetector as the reference method. Both thermodetectors (standard and H2SD) differed from each other as to level of stickiness about 80% of the time and misclassified the samples as to sticky or non-sticky 22% of the time. By using the discriminate analysis technique, the new device correctly identified 76% of the samples as either sticky or non-sticky when compared to either but not both thermodetectors. The time elapsed (1-2 years) between the various measurements of stickiness may have degraded the results. It does appear, however, that the Stickiness Tester can be trained to predict the results of the minicard, manual thermodetector, or H2SD.

Summary

Cotton yield as well as cotton processibility at the gin and textile mill are severely degraded by the presence of excess insect sugar on the cotton lint. Whiteflies and aphids secrete globules of a concentrated sugary mixture on cotton that makes it "sticky". Some cotton production areas are penalized monetarily because of their reputation for sticky cotton. As a result of the need to rapidly evaluate the level of stickiness of cotton, a new apparatus referred to as the "Stickiness Tester" was developed and patented to rapidly assess cotton stickiness. The apparatus essentially consists of an infrared-based moisture sensor, a compression platen, and a resistance-based moisture sensor. The infrared moisture meter responds to the levels of natural sugar, insect sugar and moisture that are contained within the sample whereas the resistance moisture content is affected only slightly by the
sugars. The device predicts the stickiness of cotton correctly about 75% of the time and requires less than 5 seconds to analyze the sample. This device can be integrated into a gin or mill system to automatically classify seed cotton and lint samples as to degree of stickiness, and thus provide a mechanism to regulate additives and procedures to mitigate stickiness. Successful implementation of this device could improve the market potential for cotton.

Disclaimer

Mention of a trade name, proprietary product, or specific machinery does not constitute a guarantee or warranty by the US Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available.

Bibliography


Figure 1. Stickiness Tester configured to operate in a laboratory environment. The infrared sensor is inside the cabinet and its processor is located in the upper left hand corner. The sample under evaluation is in the center of the cabinet top underneath the compression platen that also contains the resistance-based moisture sensor.

Figure 2. Stickiness Tester configured to operate automatically and continuously to collect lint samples in a cotton gin or mill. The sensors are in the cabinet on the right. The compression platen that collects the sample is shown in the closed position in the center of the photograph.
Figure 3. Stickiness Tester configured to operate automatically and continuously to collect seed cotton samples in a cotton gin. The infrared sensor is mounted on top of the sampler and the resistance sensor is inside the cabinet and mounted to the compression platen that collects the sample.

Figure 4. Stickiness Tester configured to operate automatically and continuously to collect lint samples in a cotton gin or mill. The sensors are in the cabinet on the left and the multisided, rotating compression mechanism is on the right in the raised position.
Cotton stickiness – A marketing and processing problem

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Introduction

Cotton at its cleanest is produced by nature. It is, however, contaminated by both organic and inorganic matter as well as by insects and humans.

Contamination by aphids and white fly is called honeydew. The definition of honeydew as stated by the Textile Institute, Manchester is,

The result of infestation of growing cotton by “aphids or white fly”. It takes the from of more or less randomly distributed droplets of highly concentrated sugars causing stickiness.”

Hector and Hodkinson (1989) have reported that the term honeydew and stickiness is used interchangeably by the industry. It must, however, be noted that stickiness in cotton is not necessarily due to honeydew alone.

During the last decade, honeydew has spread to many cotton producing countries, which is a cause for concern. Up till now detection of honeydew and its level had been done subjectively. Recently objective testing has become available and it is hoped that it will result in more accurate testing.

ITMF contamination surveys

ITMF regularly conducts surveys for contamination. The latest survey was conducted in 1999. Names of the participating countries, number of respondents and the number of samples/evaluations are given in Table 1.

Sources and degree of contamination as a result of 1999 survey are given in Table 2.

Summary of ten years (1989 to 1999) survey results are given in Table 3. These results are shown graphically in Fig 1.

From the data presented in Table 2 it appears that jute/hesian (both strings and fabrics) has emerged as one of the major sources of contamination. It passes through spinning and weaving but manifests itself in dyeing and causes quality problems. Perhaps time has arrived to consider discontinuation of hessian as a material for cotton bale wrapping.

It is proposed that cotton fabric may be used for wrapping cotton bales. It is evident from data presented in preceding paragraphs that cotton strings and fabrics also contaminate cotton. Although contamination from this source is low, however, it should be reduced to a level approaching ZERO.
According to Ansari et al. (1998) cotton is a better wrapping material than either hessian or polypropylene. Affect of weather on the above three materials was studied and the results are plotted in Fig. 2.

SEED COTTON FRAGMENTS (SCF): ITMF surveys point out the fact that SCF are a problem, which is perhaps, more serious then honeydew. It may not only be a source of stickiness but can also cause disruption of forces acting on yarn during its ballooning during spinning. It can cause yarn breakages not only during spinning but during weaving as well. If SCF pass through all these processes, they may still be quality problem for fabrics.

There are two main causes of SCF biological and mechanical. Immature and/or small seed (biological cause) can get caught between roller and knife or ribs and saws of the ginning machines. Secondly, ginning machines with defective settings, high speed, blunt or defective saws can also result in SCF. Ginning machines, therefore, merit closer attention. Anthony (1985) has rightly stated that, “One way to increase cotton fibre quality is to reduce trash and SCF”.

Detection and determination of level of stickiness

If sticky cotton is not detected and is allowed to be processed it will choke various machines and efficiency will drop to a level where further running of machines would no longer be economical. It is, therefore, essential to detect stickiness and take corrective measures. Several methods like Elsner’s heating method, rotor ring test, mini card test, Shenkar test and thermo detector are available and have been discussed by Hector and Hodkinson (1989).

Determination of level of stickiness is also important. In other words, it is essential to determine the THRESHOLD LEVEL.

THRESHOLD LEVEL: It appears that it is difficult to establish threshold level. Fixation of number of sticky points with relation to yarn breakages and/or yarn quality is possible. However this needs in-depth study as yarn breakages due to stickiness will have to be differentiated from normal yarn breakages. Ends down as well as yarn imperfections have been studied by CIRAD. However, further studies are needed to arrive at an acceptable threshold level.

Economics of stickiness

Sticky cotton will naturally sell at a discount depending upon the level of stickiness. Prior to the development of H2SD no objective method for estimation was available and the discount was based purely on buyers’ whims. In this respect, Sudan’s example can be quoted. Khalifa (1982) estimated loss of US$ 15 million every crop year due to stickiness. Present days loss to Sudan is estimated at US$ 30 million.

Honeydew is more prevalent where only ONE picking is the rule. This practice provides plenty of time to white fly and aphids to sit on the opened bolls and secrete sugar. Two or three pickings will deprive the white fly of the time to contaminate. More than one picking would naturally cost more, but surely the higher price of lint will more than offset the cost of extra pickings.

Pakistan’s example can be quoted where three and some time four pickings are customary. Although white fly is a problem, however, due to multiple pickings the incidence of honeydew is minimal rather non-existent.

Effect of stickiness on ginning

Sticky Cotton tends to clog/choke the ginning machines. Khalifa and Gameel (1982) have reported that stickiness reduces roller gin production by 10 to 15 pounds of lint per hour. Carlson and Mohammad (1986) reported losses at ginning stage due to extra payment to workers for frequent changing of blades/saws and reduced production. Financial losses due to frequent replacement of blades/saws are in addition.
USE OF ADDITIVES: According to Hector and Hodkinson (1989) several reports are available describing the use of chemical additives before ginning to reduce/eliminate the effect of sugar. The chemical additives are supposed to coat the fibres thereby covering the sugar. While the additives may tend to increase gin stand production by reducing fibre to fibre and fibre to metal friction, the disadvantage is increased cost. However, it is claimed that the extra cost is more than covered by less energy consumption, increased production and enhanced lint quality.

**Effect of stickiness on spinning**

Stickiness tends to create problems not only for the ginner but for the spinner as well. Stickiness will cause lint to stick to card clothing and draft rollers in subsequent processes.

Sticky fibres even if they pass through the spinning back process will create extra centrifugal forces during ballooning causing the yarn to break. In the OE frames stickiness will clog the turbine. No matter how we look at stickiness it will reduce efficiency and production to a considerable extent during spinning.

LOW HUMIDITY SPINNING: Low humidity will dry the sugars and they will cease to be sticky. If, however, humidity is allowed to rise, sugars will become sticky again. CIRAD has carried out experiments at different levels of humidity and have established that lower the humidity better the processing of honeydew-infested cotton. Gutknecht (1988) has also studied the affect of humidity on the processing of sticky cotton. However, humidity can be lowered or regulated by refrigeration, which is expensive.

MIXING: Mixing sticky cotton with non-sticky cottons is another option. Experiments conducted by Gutknecht and Fournier (1988) indicated that low sticky cottons could be mixed upto 20% in the blend with non-sticky cottons, which would then spin at an acceptable level of efficiency. Hector and Hodkinson (1989) have quoted some Italian experiments, which were reported in Bremen Report (1988).

ADDITIVES: Perkins (1986) and others reported by Hector and Hodkinson (1989) have stated that some American mills used additives to control processing problems caused by honeydew. Hughes et al (2000) has reported that certain chemicals when applied at the gin stage not only improved ginning but also facilitated processing during spinning as well.

**Effect of stickiness on weaving**

Stickiness has minimal effect on warp as it is usually sized and the sugar present gets either dissolved in the hot size mix or is covered by it. However, in weft, sugar starts building up in shuttle, gripper or air jet and weaving efficiency drops to a level where it becomes uneconomic to continue weaving. Frequent cleaning of wefts passage would, therefore, be required. This is time consuming and expensive.

**Epilogue**

It was Sudan, ICAC, CFC, CIRAD, ITF and ITMF who drew world attention to the problems caused by honeydew. CIRAD from the above organizations deserves praise and commendation for carrying out research for objective detection and determination of level of honeydew. This pioneering work by the above organizations has also helped in the marketing and processing of honeydew contaminated cotton.

Efforts should, however, be made to eradicate white fly and aphids. Consideration should also be given to more than one picking thereby denying the above insects the time to settle on opened bolls and secretes sugar. It must, however, be remembered that “plants are fixed in soil and cannot walk away from calamities”.

Seed coat fragments are another source of stickiness and their magnitude is higher than that of honeydew. Perhaps time has arrived to pay narrow focus attention to this problem.
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Khalifa, H. and O. I. Gameel (1982) Control of cotton stickiness through breeding cultivars resistant to white fly (Bemisia tabaci) IAEA Vienna.

Table 1: ITMF’s contamination survey – 1999.

<table>
<thead>
<tr>
<th>Countries</th>
<th>Number of Respondents</th>
<th>Number of Samples/Evaluations</th>
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<td>2</td>
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<tr>
<td>Austria</td>
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<td>2</td>
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<tr>
<td>Belgium</td>
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<td>23</td>
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<tr>
<td>Brazil</td>
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<td>59</td>
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<td>Czech Rep</td>
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<td>78</td>
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<td>Egypt</td>
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<td>1</td>
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<tr>
<td>Korea Rep</td>
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<td>162</td>
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<td>TOTAL</td>
<td>283</td>
<td>1521</td>
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Source: ITMF

NOTE: Divided among 87 cotton descriptions
Table 2: Contamination survey results. All countries / all growths. Number of samples – 1521.

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<tr>
<th>Source of Contamination</th>
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<td>Non-existent/ insignificant</td>
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<td>1. Fabrics Made of</td>
<td>Woven Plastic</td>
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<tr>
<td>2.</td>
<td>Plastic film</td>
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<tr>
<td>3.</td>
<td>Jute/Hesian</td>
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<tr>
<td>4.</td>
<td>Cotton</td>
</tr>
<tr>
<td>5. Strings made of</td>
<td>Woven Plastic</td>
</tr>
<tr>
<td>6.</td>
<td>Plastic film</td>
</tr>
<tr>
<td>7.</td>
<td>Jute/Hesian</td>
</tr>
<tr>
<td>8.</td>
<td>Cotton</td>
</tr>
<tr>
<td>9. Organic Matter</td>
<td>Leaves, feathers, leather etc</td>
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<td>10. Inorganic matter</td>
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<tr>
<td>11. Rust</td>
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<td>12. Metal wire</td>
<td>84</td>
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<tr>
<td>Oily substances /</td>
<td>Grease/Oil</td>
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<td>Chemicals</td>
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<td>14. Rubber</td>
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<td>15. Stamp color</td>
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<td>16. Tar</td>
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<td>Average of 1-6</td>
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Source – ITMF
Table 3: Summary of 1989-1999 results.

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<th>Year</th>
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<th>Stickiness%</th>
<th>Seed-Coat Fragments%</th>
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<tr>
<td>1999</td>
<td>79</td>
<td>15</td>
<td>6</td>
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Source – ITMF

Figure 1: Degree of contamination (1989 – 1999). Source – ITMF

Figure 2: Affect of atmospheric exposure on fabrics (Bursting Strength – Kg/Cm²). Source: Ansari et al 1998.
Chemical measurement of total soluble sugars as a parameter for cotton lint stickiness grading

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Abstract: Stickiness in seed cotton is mainly caused by the honeydew excreted by the two insects whitefly (Bemisia tabaci) and aphids (Aphis gossypii). Stickiness is the most serious problem confronting the textile industry at both the ginning stage and the subsequent spinning and weaving processes. The sugar constituents of the honeydew are the reducing monosaccharides glucose and fructose and the non reducing oligosaccharides sucrose and melezitose. The concentration of the monosaccharides did not seem to change with the increase in the stickiness grade while the concentration of the oligosaccharides as well as that of the total soluble sugars when taken together also increased with increasing stickiness. The degree of honeydew contamination vary at the field level, within the bale and even within a single plant. For reasons of specificity and precision, measurements of total soluble sugars can be adopted for cotton lint stickiness grading. The method is suitable for mixing sticky cotton with clean cotton in a calculated ratios to have a mixture which can be processed. The method is also suitable for spinable threshold determination as well as calibration of instruments constructed for physical stickiness grading. The reagents used in this method are rather stable at room temperature and do not require daily preparation. The chemicals are not expensive and the equipments are rather simple.

Introduction

Honeydew contamination is one of the most important factors detrimental to cotton fibre quality. This can reduce the efficiency of the ginning machine and adversely affect spinning and weaving processes.

The honeydew which causes contamination of cotton fibre was found to be excreted by the two insects whitefly and aphids (Gameel, 1969). The sugar constituents of the honeydew were identified by thin layer chromatography and were found to be the reducing monosaccharides glucose and fructose and the non reducing oligosaccharides sucrose and melezitose (Rutherford and Ali, 1977). Melezitose was not detected in the cotton leaf sap on which the insect feeds and was believed to be synthesized by the insect from the monosaccharide pool. This is mainly for efficient excretion of the extra sugars sucked by the insect (Ali, 1988).

Because of the impact of stickiness on cotton marketing and processing physical and chemical methods were developed to grade stickiness in cotton. Some of the physical methods include the mini-card, shanker and recently thermodetector, while most of the chemical methods depend on measurements of reducing sugars (Perkins, 1992). The honeydew contamination is not homogenous and for this reason due consideration should be made for taking a representative sample for stickiness grading whether physically or chemically.
Based on mini-card stickiness grading of cotton lint, a chemical method was developed (Ali and Khalifa, 1980). This was later modified to suit commercial application (Ali, 1998). The main objective of the modification is to shorten the time for running the test as well as to reduce the amount of chemicals to be used. With adequate laboratory facilities, this chemical test can be made fast enough to cope with the textile industry need.

**Materials and methods**

Different samples necessary for this study were collected as previously described (Ali, 1978 and Ali and Khalifa, 1980). The soluble sugars of the samples under investigations were qualitatively identified and quantitatively determined as previously described (Rutherford and Ali, 1977).

A chemical method for cotton lint stickiness grading based on total soluble sugars concentration was developed which was later modified to suit commercial application. A detailed account of this modified chemical method is as follows.

(1) Preparation of reagent

- Oxalic acid (2%): This is prepared by dissolving 20g oxalic acid in 1L distilled water.
- Sodium hydroxide (0-11 N: This is prepared by dissolving 4.4g NaOH in 1L distilled water.
- Copper reagent: Prepared by dissolving 6.0g hydrated cupric sulphate (CuSO₄. 5H₂O) in distilled water.
- Hardings reagent: Prepared by dissolving 12g potassium sodium tartrate, 20g sodium carbonate (Na₂CO₃) 25g sodium bicarbonate (NaHCO₃)in 1L distilled water.
- Nelson reagent: Prepared by dissolving 50g ammonium molybdate in 900 ml distilled water, to this 42 ml conc. H₂SO₄ were added slowly, then 6g hydrated sodium arsenate were dissolved in 50ml distilled water and this solution was then added to the first solution. This mixture should be aged for 3 days and kept in brown bottle.
- Glucose standard: Stock solution prepared by dissolving 1g glucose in 1L distilled water. Aliquots containing 20, 40, 60, 80 and 100µg glucose were taken in a final volume of 1ml and these are used for constructing the standard curve.

(2) Extraction and hydrolysis of sugars

- Weight 2g x 10 for each of the cotton lint samples and put each weight in a separate clean dry test tube.
- Add to each test tube 10 ml of 2% oxalic acid. Cover the tubes with aluminum foil or glass ball to reduce evaporation and heat the tubes in boiling water bath or heating block for 25 minutes which is sufficient for the extraction of sugars and hydrolysis of oligosaccharides to monosaccharides.
- After cooling, take from each test tube 0.2 ml oxalic acid extract and pool in one test tube to make a final volume of 2.0 ml (10 sub samples) and to this add 3 ml of 0.11 N NaOH for neutralization. Aliquots from this can be taken for total soluble sugars determination spectrophotometrically (Nelson, 1944).

(3) Determination of reducing sugars

- In clean dry test tubes pipette aliquots from the glucose standard or the oxalic acid extract of the sample under test containing 20-100 µg reducing sugars in a final volume of 1.0 ml
– Then add ml copper reagent.
– Then add 1ml Harding’s reagent and mix well.
– Then heat the tubes in boiling water bath or heating block for 10 minutes and cool.
– Then add 1ml Nelson reagent, agitate and leave for few minutes for complete colour development.
– Then add to each test tube 6 ml distilled water to make a final volume of 10 ml, mix well and read absorbance at 600 mm in 1cm cuvette against a blank not containing reducing sugars.

(4) Calculations

Let the aliquot taken for reducing sugars determination be X ml containing Y µg reducing sugars as taken from the glucose standard curve. Then the amount of reducing sugars (RS) in mg per 100g cotton lint can be calculated as follows:

\[
\text{Mg RS/100g lint} = \left( \frac{Y \times 5 \times 10 \times 100}{X \times 2 \times 2 \times 1000} \right) = (1.25 \frac{Y}{X})
\]

From the above value the degree of stickiness can be determined according to the following ranges:

<table>
<thead>
<tr>
<th>Mg RS/100g lint</th>
<th>Degree of stickiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-499</td>
<td>0 free of stickiness</td>
</tr>
<tr>
<td>500-699</td>
<td>1 light stickiness</td>
</tr>
<tr>
<td>700-899</td>
<td>2 moderate stickiness</td>
</tr>
<tr>
<td>900-1100</td>
<td>3 heavy stickiness</td>
</tr>
<tr>
<td>Over 1100</td>
<td>4 very heavy stickiness</td>
</tr>
</tbody>
</table>

Cotton lint samples with variable degrees of honeydew contamination were chemically and physically tested for stickiness. The chemical test was performed as described in the text. The physical test was conducted at the ARC Fibre Testing Lab. using the CIRAD Sticky Cotton Thermodetector (SCT), 2.5g cotton lint sample worked as a thin film was placed between two sheets of aluminum foil. The SCT device applies heat and pressure to the sample and as a result, sticky spots were fixed on the upper and lower sheets of the aluminum foil. Spots were then counted by directing a light beam to the aluminum foils.

**Results and discussion**

Physiological sugars may constitute up to 0.3% of the total cotton fibre weight. This is equivalent to 300mg RS/100g lint and that is why cotton free of insect infestation contains sugars of physiological origin (Brown and Ware, 1958).

Table (1) shows the amount of total soluble sugars which include reducing sugars (RS) and non reducing sugars (NRS) for samples collected from different sources. With the exception of cotton leaf gland, the concentration of the NRS in the investigated samples constituted 44-70% of the total soluble sugars while that of the reducing sugars constituted 30-56% of the total soluble sugars. From these results it could be concluded that the NRS are very important with respect to stickiness problem and due consideration should be given to these sugars when stickiness grading based on sugars determination is to be adopted.

The total soluble, non reducing and reducing sugars were extracted and estimated for cotton lint samples with different stickiness grades as assessed by the mini-card method and the results are shown in Table (2). The amount of reducing sugars did not seem to change with increasing stickiness grade, while that of non reducing sugars and total soluble sugars did increase with increasing stickiness grade. This table constitute the basis for this chemical method. Measurements of reducing sugars as reported by others (Perkins, 1992) cannot reflect the true honeydew contamination of cotton lint and hence not of value in chemical stickiness grading. Since the concentration of non reducing sugars and total soluble sugars showed an increase with increasing stickiness grade, measurements of these sugars can reflect the actual degree of contamination and therefore can be both adopted for chemical
stickiness grading. For ease of manipulation, measurements of total soluble sugars was adopted in this chemical method of stickiness grading. The 2% oxalic acid solution used for the solubilization of sugars and hydrolysis of oligossaccharides is a weak organic acid and has no effect on the cotton fibre. Also 25 minutes of heating are quite sufficient for the hydrolysis of oligossaccharides to their constituent monosaccharides.

The whitefly was reported to prefer the lower shady moist portion of the cotton plant (Gameel, 1968). As a consequence, cotton lint produced from the lower portion of the plant is expected to be more contaminated with honeydew. To investigate this, seed cotton from top, middle and lower portions of the cotton plant were separately picked and ginned. The total soluble sugars in each sample were then chemically determined and the results are shown in Table (3). As seen in the table there is a contamination gradient increasing from top downwards the cotton plant. Baling is the final stage of seed cotton ginning process and one bale is approximately 187 kg cotton lint. To assess the degree of contamination within a bale, cotton lint samples from the different sides of the same bale were taken. The total soluble sugars of these samples were chemically determined and the results are shown in Table (4). The results presented in Tables (3) and (4) indicated clearly the heterogeneity of honeydew contamination of cotton lint even within the same plant or at the bale level. As a result, it is very essential to take a representative samples for stickiness grading physically or chemically. For a bale this can be achieved by taking sub samples from the different sides of the bale and mixing these together thoroughly.

Table (5) shows the results of physical and chemical tests for 15 cotton lint samples. It is apparent that a relationship may exist between the spot counts and sugar concentration. The establishment of this relationship requires further work.

In this chemical method of stickiness grading, 10 sub samples are taken and the average of these is then considered as a measure of stickiness for a single sample. This greatly reduced the effect of variation resulting from uneven distribution of honeydew in seed cotton. Because of specificity reliability and precision, this chemical method is valuable in mixing clean cotton with contaminated cotton in an accurately calculated ratios to give a mixture that can be processed without troubles.

The method is also suitable for determining the spinable threshold with respect to honeydew contamination. Using this chemical method, stickiness grading can be based on the commonly known five grades (0-4) or based on the concentration of total soluble sugars in cases where there are no differences between these five grades when comparing two or more cotton lint samples with regard to honeydew contamination. The method can be used to calibrate other subjective methods adopted for stickiness grading. Through adequate laboratory facilities, the time for running this chemical test can be greatly reduced to cope with textile industry needs.

References


**Table 1:** Total soluble sugar (TSS), reducing sugars (RS) and non reducing sugars (NRS) from different sources.

<table>
<thead>
<tr>
<th>Source</th>
<th>%RS</th>
<th>%NRS</th>
<th>%TSS</th>
<th>%RS of TSS</th>
<th>%NRS of TSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whitefly honeydew</td>
<td>16</td>
<td>22</td>
<td>38</td>
<td>42</td>
<td>58</td>
</tr>
<tr>
<td>Aphid honeydew</td>
<td>0.8</td>
<td>1.9</td>
<td>2.7</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Cotton leaf extract</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
<td>33</td>
<td>67</td>
</tr>
<tr>
<td>Cotton leaf contaminant</td>
<td>25</td>
<td>20</td>
<td>45</td>
<td>56</td>
<td>44</td>
</tr>
<tr>
<td>Cake from ginning machine</td>
<td>30</td>
<td>30</td>
<td>60</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Cotton leaf gland</td>
<td>30</td>
<td>5</td>
<td>35</td>
<td>86</td>
<td>14</td>
</tr>
</tbody>
</table>

**Table 2:** Soluble sugars (mg/100g) of cotton lint samples with different stickiness grades.

<table>
<thead>
<tr>
<th>Stickiness grade</th>
<th>RS</th>
<th>NRS</th>
<th>TSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (free of stickiness)</td>
<td>358</td>
<td>47</td>
<td>405</td>
</tr>
<tr>
<td>1 (light stickiness)</td>
<td>520</td>
<td>93</td>
<td>613</td>
</tr>
<tr>
<td>2 (medium stickiness)</td>
<td>507</td>
<td>262</td>
<td>769</td>
</tr>
<tr>
<td>3 (heavy stickiness)</td>
<td>590</td>
<td>317</td>
<td>907</td>
</tr>
<tr>
<td>4 (very heavy stickiness)</td>
<td>530</td>
<td>1092</td>
<td>1622</td>
</tr>
</tbody>
</table>

**Table 3:** Variation in honeydew contamination within a single plant (medium staple cotton).

<table>
<thead>
<tr>
<th>Position</th>
<th>TSS (mg/100g lint)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td>501</td>
</tr>
<tr>
<td>Middle</td>
<td>587</td>
</tr>
<tr>
<td>Bottom</td>
<td>621</td>
</tr>
</tbody>
</table>
Table 4: Variation in honeydew contamination within a single bale (long and medium staple cotton).

<table>
<thead>
<tr>
<th>Position</th>
<th>Long staple cotton</th>
<th>Medium staple cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td>753</td>
<td>839</td>
</tr>
<tr>
<td>Bottom</td>
<td>733</td>
<td>722</td>
</tr>
<tr>
<td>Right</td>
<td>694</td>
<td>902</td>
</tr>
<tr>
<td>Left</td>
<td>672</td>
<td>654</td>
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<tr>
<td>Front</td>
<td>656</td>
<td>933</td>
</tr>
<tr>
<td>Rear</td>
<td>636</td>
<td>688</td>
</tr>
</tbody>
</table>

Table 5: Comparison between the chemical and physical tests for stickiness.

<table>
<thead>
<tr>
<th>No.</th>
<th>Chemical test (mg sugar/100g lint)</th>
<th>Physical test (spot count)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>163</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>188</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>700</td>
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<td>4</td>
<td>725</td>
<td>6</td>
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<tr>
<td>5</td>
<td>775</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>838</td>
<td>47</td>
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<tr>
<td>7</td>
<td>850</td>
<td>37</td>
</tr>
<tr>
<td>8</td>
<td>900</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>913</td>
<td>74</td>
</tr>
<tr>
<td>10</td>
<td>1113</td>
<td>36</td>
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<td>46</td>
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<tr>
<td>12</td>
<td>1270</td>
<td>84</td>
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<tr>
<td>13</td>
<td>1575</td>
<td>80</td>
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<tr>
<td>14</td>
<td>1588</td>
<td>73</td>
</tr>
<tr>
<td>15</td>
<td>1625</td>
<td>70</td>
</tr>
</tbody>
</table>
Relationship between sugar properties and stickiness measurements

E. HEQUET (1), N. ABIDI (1), M. WATSON (2)

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(2) Cotton Incorporated, Cary, North Carolina, USA

Abstract: Cotton contaminated with excessive amounts of sugars causes serious problems in spinning mills. During the yarn manufacturing process, the machinery is contaminated to different degrees depending on the processing stage. The contaminants are mainly sugar deposits produced either by physiological or entomological sugars. It was shown that among the sugar present on the contaminated cotton, only trehalulose accumulated on the textile equipment. The accumulation of trehalulose could be related to the changes in the properties of sugars during fiber processing because of the increase of the temperature due to the frictional forces involved in the textile processing. The thermal properties of individual sugar present on contaminated cotton show that trehalulose has the lowest melting point, being around 48°C. In addition, hydration kinetic of trehalulose is very fast. All the indications gathered show that the accumulation of trehalulose is due to its low melting point and highly hygroscopic character. Therefore, humidity and temperature would have an effect on stickiness measurements. One hundred and fifty cotton bales representing a wide range of stickiness and different types of contamination were selected and tested on the H2SD under different conditions. The results obtained demonstrate that by testing at lower relative humidity (55% RH instead of 65% RH), the H2SD readings were significantly lower, 23.2% in average (on the square root transformed data). By testing at high temperature, nearly all the contaminated cottons become sticky, even the one having little-to-no trehalulose. At low temperature, only the cotton having significant amount of trehalulose were sticky. This shows that the H2SD principle needs to be revisited.

Introduction

Cotton stickiness caused by excess sugars on the lint, from the plant itself or from insects, is a very serious problem for the textile industry - cotton growers, cotton ginners and spinners - (Hequet et al., 2000; Watson, 2000). During the transformation process from fiber to yarn of the contaminated cotton fibers, i.e. opening, carding, drawing, roving and spinning, the machinery is contaminated to different degrees depending on the processes involved and the locations within the machines. This affects the efficiency as well as the quality of the products obtained. Stickiness is essentially due to sugar deposits produced either by the cotton plant itself - physiological sugars - or the feeding insects -entomological sugars - (Hendrix et al., 1995). The latter is known to be the most common source of contamination (Sisman et al., 1984). The analysis of honeydew from Aphis gossypii Glover and Bemisia Argentifolii Bellows and Perring [= B. tabaci (Gennadius) strain B] has shown that the aphid honeydew contains around 38.3% of melezitose plus 1.1% of trehalulose, while the whitefly honeydew contains 43.8% of trehalulose plus 16.8% of melezitose (Hendrix et al., 1992).
Gutknecht (Gutknecht et al., 1986) reported that stickiness caused by honeydew depends on the relative humidity, which is function of both air water content and temperature, in which the contaminated cotton is processed. Price (1988) noticed that sticky cotton dried would probably not stick to the spinning equipment; however, increased rigidity of the fiber will intensify the friction forces thus static electricity (Morton and Hearle, 1993). Therefore, it will require more energy to draw the lint. Furthermore, Miller (Miller et al., 1994) demonstrated that stickiness is related to the type of sugar present on the lint. The authors showed that highly concentrated solutions of trehalulose and sucrose, both disaccharides, are the stickiest when added to clean cotton while melezitose (trisaccharide), glucose and fructose (both monosaccharide) solutions were relatively non-sticky.

In all these studies, it appears that there is no quantitative analysis on the effect of the relative humidity on the individual sugars as well as on the structural stability of the sugars during the textile process. In fact, it seems that stickiness is not only due to the quantity of total sugars present on the lint, but also to the presence of some specific, highly hygroscopic sugars, along with their non-even distribution in the form of droplets of honeydew. In addition, the stage of the transformation process involved is also extremely important (Hequet et al., 2000). During the fibers-to-yarn transformation, the flow of lint is submitted to different friction forces; consequently, the temperature of some mechanical elements may increase significantly. This affects the thermal properties of the sugars present on the contaminated lint. Once a sugar becomes sticky because of its relatively low melting point and high hygroscopicity, the other sugars present on the lint as well as other substances such as dusts, silica, etc. will stick on it. This could lead to unevenness in the flow of lint being drawn, such as rolling up on the rolls, nep-like structures, and ends-down.

The objective of this work was to investigate the effects of relative humidity and H2SD hot plate temperature on stickiness measurements.

**Procedures**

**Individual sugar properties**

Trehalose, inositol, fructose, glucose, sucrose, trehalulose and melezitose were selected for the investigations on hygroscopic and thermal properties.

The selected sugars were first dehydrated under vacuum for 48 hours. Then they were immediately weighed. The recorded weight was referred as to m0 at time t0 = 0. Since the stickiness tests were achieved at 65± 2%RH and 21±1°C, the sugar samples were stored at these conditions and weighed (weight m_t) over time until the weight gain remains constant (approximately four weeks). The percentage of adsorbed water on each sugar was then calculated as [(m_t-m_0)/ m_0]*100 and plotted against time.

The DSC (Differential Scanning Calorimetry) technique is widely used to examine and characterize substances. The principle of this method is based on the measurement of the heat flux between the sample and a reference while the temperature is rising. The sample and the reference are deposited in two different pans and heated at the same rate. In this work, the reference was an empty pan. The analysis of the DSC profiles indicates the thermal properties of the substances being tested; specific values such as melting point and decomposition point are obtained. The DSC profiles were recorded by heating at the rate of 5°C/min between 25°C and 250°C.

**Stickiness measurement**

One hundred and fifty cotton bales representing a wide range of stickiness and different types of contamination, i.e. from whitefly, from aphis and from physiological sugars, were selected. The samples came from 3 different growing regions. Fifty bales were from Area 1, known to have important whitefly populations and very little to no aphis. Fifty bales were from Area 2, where both types of insects coexist. Fifty bales were from Area 3, where large populations of aphis exist and very little to no whiteflies. In addition, for Area 3 mainly, high physiological sugar contents could be obtained after a freeze.
The bales were sampled (2 samples per bales), and the samples tested on the High Speed Stickiness Detector (H2SD).

The H2SD is based on the Sticky Cotton Thermodetector principle (Crompton et al., 1998). First, a sample of cotton weighing between 3.0 and 3.5 g is opened using a rotor type opener. The mass of opened fiber is then shaped into a rectangular, even pad of fibers. This pad is deposited by the system on aluminum foil. Then, the sample passes successively in front of 4 stations. A hot pressure is applied to the sample (53°C, 30 seconds). This renders the honeydew sticky. The sticky points in contact with the aluminum are then fixed in place by a pressure exerted at ambient temperature. The loose cotton fibers are then removed using a vacuum then a cleaning roll. The sticky spots still adhering to the aluminum foil are counted and sized by an image analyzer.

As shown previously (Hequet et al., 1997) the H2SD readings within a sample follow a Poisson-like distribution; therefore, a square root transformation is adequate to normalize it prior to statistical analysis. Consequently, all the statistical analyses were done on the square root transformed data.

The effect of a lower relative humidity on the stickiness readings was achieved at the following conditions 55±2%RH, 23±1°C and 65±2%RH, 21±1°C. The H2SD instruments and the samples were conditioned for 96 hours prior to testing.

The normalized manufacturer setting for the hot plate of the H2SD is 53°C. The measurements were done at this temperature. Then, this setting was modified to perform the tests at the following temperatures: 27°C, 34°C, 40°C, and 67°C. These tests were done in standard laboratory conditions at 65±2%RH and 21±1°C.

Results and discussion

Since sugars belong to the carbohydrate class, they are hydrophilic because of several hydroxyl groups (-OH), which interact with water molecules, and many hydrogen bonds could be established. Thus, the quantity of water adsorbed on each sugar at 65±2%RH and 21±1°C, as well as its kinetic, were evaluated. (Abidi and Hequet, 2001) Figure 1-a shows the weight gain in % during the first 12 hours of hydration. No sugar shows any significant variation within this time period except trehalulose, which picks up about 12% of moisture corresponding to 2 molecules of water per molecule of trehalulose. Then, the weight gain of the sugar samples continued to be recorded until the plateau was reached. Trehalulose and fructose continued to pick-up moisture (figure 1-b). The hydration kinetic was very fast for trehalulose, with the equilibrium being reached after 80 hours, but slow for fructose, with the plateau being reached after 500 hours. The total amount of weight gain corresponds to 3 molecules of water per molecule of trehalulose and 3 molecules of water per molecule of fructose.

This suggests a relationship between water content of the raw material and stickiness (Hequet and Abidi, 2001). Figure 2 shows the relationship between the H2SD readings (square root transformed) performed at 55±2%RH, 23±1°C and 65±2%RH, 21±1°C with the standard hot plate temperature setting (53°C). It indicates that, when the relative humidity was lowered from 65±2%RH to 55±2%RH, the square root transformed H2SD readings were in average 23.2% lower. As shown in table 1, a significant interaction between cottons and relative humidity is noticed. This means that, depending on the cotton, this percentage can vary considerably (from 7% higher to 74% lower).

No significant interaction between the Area and the relative humidity is noticed (table 2). This means that the origin of the contamination does not seem to have an effect on the stickiness measurement when the fibers are in the equilibrium with the laboratory environment.

Then, DSC was performed to study the thermal properties of the selected sugars. The DSC profiles were recorded between 25°C and 250°C with a heat rate of 5°C/min. Each sugar has two characteristic peaks corresponding to melting points and decomposition (or carbonization) points (table 3). The melting points obtained are similar to those given in the Merck Index (1989), except for trehalulose, which seems to be absent from the literature. Among the selected sugars, trehalulose has the lowest melting point (48°C). It begins to melt as soon as the temperature starts rising (figure 3). The other sugars remain stable when the temperature rises until it reaches 98°C (melting point of trehalose).
Therefore, any increase in the temperature of the textile processing equipment will first affect trehalulose.

As shown on this DCS profile, trehalulose begins to melt around 25°C. Therefore, we can hypothesize that the honeydew droplets having a high percentage of trehalulose would be sticky at any temperature above 25°C, and that lower the trehalulose percentage is in those droplets, lower would be the “sticky potential”. Therefore, when testing cotton for stickiness at 53°C (recommended manufacturer setting for the H2SD) the trehalulose, which is mainly present in whiteflies honeydew, should melt while the other types of sugars should remain unchanged.

To confirm this hypothesis, the H2SD hot plate setting was modified to perform the stickiness measurement at different temperatures.

Figure 4 shows the relationship between hot plate temperatures and the average H2SD readings for the 3 areas tested. A significant interaction between these two parameters is apparent (table 4). To elucidate this interaction it was decided to plot the H2SD reading at each temperature against the readings at the reference level (53°C).

Figures 5 to 8 show the relationship between the H2SD readings (square root transformed) performed at 53°C and the readings performed at 67°C, 40°C, and 27°C for the Area 1, Area 2, and Area 3.

**Hot plate temperature setting at 67°C**

The three Areas seem to follow the same trend; the relationships were not linear, revealing a probable saturation phenomenon. The image analysis software does not seem to be able to separate 2 merging sticky spots. When the number of sticky deposits on the aluminum foil is very large, the probability for 2 sticky spots to merge is high, which lead to the inability for the image analysis software to count accurately above 60 sticky spots, of course this number needs to be adjusted depending on the size of the sticky spots. The statistical analysis does not show a significant interaction between temperature setting and Area (table 5). At 67°C the readings averaged 31.8% higher than at the reference level.

**Hot plate temperature setting at 40°C**

For the three Areas, the relationship between the readings at 40°C and 53°C was linear. The statistical analysis does not show a significant interaction between temperature setting and Area (table 6). The H2SD readings at 40°C averaged 29% lower than the readings obtained at 53°C.

**Hot plate temperature setting at 34°C**

The relationship between the readings at 53°C and 34°C was also linear, with the Area 3 reacting differently as reflected by a highly significant interaction between temperature and area (table 7). The H2SD readings at 34°C, on average, were lower than the readings obtained at 53°C: 35.8% lower for Area 1 (mainly contaminated by white-flies), 40.9% for Area 2 (mix white-flies and aphis contaminations), and 60.9% for Area 3 (mainly contaminated by aphis).

**Hot plate temperature setting at 27°C**

The relationship was also linear with the Area 3 reacting clearly differently as reflected by a highly significant interaction between temperature and area (table 8). The H2SD readings at 27°C, in average, were lower than the readings obtained at 53°C: 46.4% for the Area 1, 54% for the Area 2, and 68.7% for the Area 3. This seems to confirm our hypothesis; trehalulose is sticky even at low temperatures while melezitose is not.

Figure 9 summarizes the H2SD readings at 27°C and 53°C for the three Areas. This figure shows that for Area 1, all the cottons that tested sticky at the reference level of 53°C were also sticky at the lowest temperatures. For Area 2, most of the cottons testing sticky at 53°C were slightly sticky at lowest temperatures. However, for Area 3 nearly all the cottons testing sticky at 53°C were not sticky at
27°C. These results demonstrate clearly an effect of the hot plate temperature of the H2SD on the stickiness readings. They also confirm, as hypothesized earlier, the different behaviors of the honeydew deposits depending upon the origin of the contamination (white-flies vs. aphis).

Figure 10 shows the H2SD readings for two types of cotton contaminated with whiteflies and aphis based on the HPLC tests. The two cottons have nearly the same number of sticky spots at 53°C (respectively 72.8 and 71.7 spots). However, by lowering the hot plate temperature from 53°C to 27°C, the two cottons react differently. Cotton contaminated with whiteflies remains sticky even at low temperature, while the cotton contaminated with aphis is not sticky. Therefore, it is possible to discriminate between the types of the insect contamination by varying the temperature of the stickiness measurement.

Conclusion

These results demonstrate that by testing at high temperature, nearly all the contaminated cottons become sticky, even the one having very little trehalulose. The temperature of the spinning equipment is well below 53°C (the recommended manufacturer setting of the H2SD), therefore the higher the number of sticky deposits at low temperature; the worse will be the problems at the spinning mills. The differential between two or more readings at different temperatures may be used to reveal the type of contamination; thereby allowing yarn spinners to better predict processing troubles in the mill and to use this information for bale management.

Bibliography


Acknowledgments

This project was supported by Cotton Incorporated and the Texas Food and Fibers Commission. The authors wish to thank P. Williams for her valuable technical assistance.

Table 1: Variance Analysis on square root transformed data: Effect of relative humidity on H2SD readings.

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>F</th>
<th>Probability</th>
<th>H2SD reading (SQRT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bales</td>
<td>149</td>
<td>71.37</td>
<td>0.0000</td>
<td></td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>1</td>
<td>672.94</td>
<td>0.0000</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td>3.701 b</td>
</tr>
<tr>
<td>65</td>
<td></td>
<td></td>
<td></td>
<td>4.820 a</td>
</tr>
<tr>
<td>Bales x Relative Humidity</td>
<td>2</td>
<td>2.10</td>
<td>0.0000</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>1500</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Variance Analysis on square root transformed data: Effect of Area and relative humidity on H2SD readings.

<table>
<thead>
<tr>
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<th>H2SD reading (SQRT)</th>
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</thead>
<tbody>
<tr>
<td>Area</td>
<td>2</td>
<td>6.20</td>
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<td>1</td>
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<td></td>
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<tr>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td>4.820 a</td>
</tr>
<tr>
<td>65</td>
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<td>Area x Relative Humidity</td>
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<tr>
<td>Error</td>
<td>294</td>
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</tr>
</tbody>
</table>
Table 3: Melting and decomposition points of selected sugars

<table>
<thead>
<tr>
<th>Sugar</th>
<th>Melting point (°C)</th>
<th>Decomposition point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trehalose</td>
<td>98</td>
<td>208</td>
</tr>
<tr>
<td>Inositol</td>
<td>225</td>
<td>215</td>
</tr>
<tr>
<td>Fructose</td>
<td>116</td>
<td>178</td>
</tr>
<tr>
<td>Glucose</td>
<td>152</td>
<td>210</td>
</tr>
<tr>
<td>Sucrose</td>
<td>184</td>
<td>215</td>
</tr>
<tr>
<td>Trehalulose</td>
<td>48</td>
<td>193</td>
</tr>
<tr>
<td>Melezitose</td>
<td>152</td>
<td>225</td>
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</tbody>
</table>

Table 4: Variance Analysis on square root transformed data: Effect of hot plate temperatures on H2SD readings.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Df</th>
<th>F</th>
<th>Probability</th>
<th>H2SD reading (SQRT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bales</td>
<td>149</td>
<td>126.92</td>
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<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>4</td>
<td>3718.05</td>
<td>0.0000</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td>2.075 e</td>
</tr>
<tr>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td>2.569 d</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td>3.418 c</td>
</tr>
<tr>
<td>53</td>
<td></td>
<td></td>
<td></td>
<td>4.820 b</td>
</tr>
<tr>
<td>67</td>
<td></td>
<td></td>
<td></td>
<td>6.345 a</td>
</tr>
<tr>
<td>Bales x Temperature</td>
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<tr>
<td>Error</td>
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</table>

Table 5: Variance Analysis on square root transformed data: Effect of Area and hot plate temperature setting (67°C) on H2SD readings.

<table>
<thead>
<tr>
<th>Source of Variation</th>
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<th>H2SD reading (SQRT)</th>
</tr>
</thead>
<tbody>
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<td>5.735 a</td>
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<td></td>
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<tr>
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</tr>
<tr>
<td>53</td>
<td></td>
<td></td>
<td></td>
<td>4.806 b</td>
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<td>6.339 a</td>
</tr>
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<td>Area x Temperature</td>
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<td>0.9161</td>
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</tr>
<tr>
<td>Area 1 - 53°C</td>
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<td></td>
<td></td>
<td>4.923 bc</td>
</tr>
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<td>Area 1 - 67°C</td>
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<td></td>
<td></td>
<td>6.547 a</td>
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<tr>
<td>Area 2 - 53°C</td>
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<td></td>
<td></td>
<td>5.745 ab</td>
</tr>
<tr>
<td>Area 3 - 53°C</td>
<td></td>
<td></td>
<td></td>
<td>5.340 abc</td>
</tr>
<tr>
<td>Area 3 - 67°C</td>
<td></td>
<td></td>
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<td>6.723 a</td>
</tr>
<tr>
<td>Error</td>
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</table>
Table 6: Variance Analysis on square root transformed data: Effect of Area and hot plate temperature setting (40°C) on H2SD readings.

<table>
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</thead>
<tbody>
<tr>
<td>Area</td>
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<tr>
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<td></td>
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<td>0.2052</td>
</tr>
<tr>
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<td></td>
<td>4.923 ab</td>
</tr>
<tr>
<td>Area 1 - 40°C</td>
<td></td>
<td></td>
<td>3.803 bc</td>
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<td>Area 2 - 53°C</td>
<td></td>
<td></td>
<td>4.155 abc</td>
</tr>
<tr>
<td>Area 2 - 40°C</td>
<td></td>
<td></td>
<td>3.099 c</td>
</tr>
<tr>
<td>Area 3 - 53°C</td>
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<td></td>
<td>5.340 a</td>
</tr>
<tr>
<td>Area 3 - 40°C</td>
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<td></td>
<td>3.345 c</td>
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<tr>
<td>Error</td>
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</table>

Table 7: Variance Analysis on square root transformed data: Effect of Area and hot plate temperature setting (34°C) on H2SD readings.

<table>
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<tbody>
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<td>3</td>
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<td></td>
<td>3.718 ab</td>
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<tr>
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<td></td>
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<tr>
<td>53</td>
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<td></td>
<td>4.806 a</td>
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<td>Area x Temperature</td>
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<td>Area 1 - 34°C</td>
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<td></td>
<td>3.161 bc</td>
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<tr>
<td>Area 2 - 53°C</td>
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<td></td>
<td>4.155 ab</td>
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<td>Area 2 - 34°C</td>
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<td>2.456 c</td>
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<td>5.340 a</td>
</tr>
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<td>Area 3 - 34°C</td>
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<td></td>
<td>2.096 c</td>
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<tr>
<td>Error</td>
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</table>
Table 8: Variance Analysis on square root transformed data: Effect of Area and hot plate temperature setting (27ºC) on H2SD readings.

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</thead>
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<td></td>
</tr>
<tr>
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</tr>
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<td></td>
<td></td>
</tr>
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<td>158.69</td>
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<td>2.076 b</td>
</tr>
<tr>
<td>53</td>
<td>2</td>
<td></td>
<td></td>
<td>4.806 a</td>
</tr>
<tr>
<td>Area x Temperature</td>
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<td></td>
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</tr>
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</tr>
<tr>
<td>Error</td>
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<td></td>
</tr>
</tbody>
</table>

Figure 1-a: Hydration kinetic of selected sugars at 65 ± 2% RH and 21 ± 2ºC
Figure 1-b: Hydration kinetic of selected sugars at 65 ± 2% RH and 21 ± 2°C

Figure 2: Effect of relative humidity on H2SD readings
Figure 3: DSC profile of trehalulose

Figure 4: Effect of H2SD hot plate temperature on H2SD readings (square root transf.)
Figure 5: H2SD readings at 67ºC vs. H2SD readings at 53ºC (square root transf.)

Figure 6: H2SD readings at 40ºC vs. H2SD readings at 53ºC (square root transf.)
Figure 7: H2SD readings at 34°C vs. H2SD readings at 53°C (square root transf.)

Figure 8: H2SD readings at 27°C vs. H2SD readings at 53°C (square root transf.)
Figure 9: Comparison between H2SD readings at 27°C and 53°C for 150 bales

Figure 10: Effect of the type of honeydew contamination on H2SD readings
The heat induced degradation of melezitose and trehalulose

GARY R. GAMBLE

USDA, ARS, Cotton Quality Research Station, Clemson, South Carolina 29633, USA

Abstract: A cotton sample heavily contaminated by whitefly honeydew is subjected to heating conditions commonly found at the gin, and subsequently analyzed for melezitose and trehalulose content as a function of heating time. As a result of thermochemical processes, the concentrations on the surface of the cotton are observed to decrease exponentially. Reaction mechanisms are elucidated by heat treatment of pure melezitose and trehalulose with subsequent analysis of the resultant reaction products. The rate of thermochemical degradation in the case of trehalulose is of sufficient magnitude that its concentration on the cotton surface may be substantially decreased under controlled conditions of heat and time. The rate of degradation of melezitose is nearly an order of magnitude smaller, and its concentration on the cotton surface is not substantially affected under similar conditions. Rates of thermochemical degradation are accelerated by the addition of an organic acid catalyst. Results indicate that it may be possible to influence honeydew levels at the gin through optimization of reaction conditions.

Introduction

Melezitose is a primary constituent of both aphid and whitefly honeydews [2], and trehalulose is the most prevalent sugar in whitefly honeydews [2], though present in aphid honeydew only in relatively small amounts. Both trehalulose and melezitose have been implicated as major contributors to cotton stickiness, and because of this the presence and amount of one or both of these saccharides has been used as a measure of correlation with cotton stickiness arising from insect honeydew contamination. Screening of cotton samples for melezitose and trehalulose as indicators of stickiness is normally performed after the cotton has been ginned. During the ginning process cotton may be heated to temperatures of up to 200°C for several seconds. The effect of this heating upon individual sugar components of insect honeydew has not been addressed, and this work attempts to elucidate the rate and mechanism by which both trehalulose and melezitose degradation occurs.

Heating monosaccharides, disaccharides, and oligosaccharides leads to a variety of products as a result of thermal decomposition reactions. These reactions include thermolysis of disaccharides and oligosaccharides into constituent monosaccharides, and the dehydration of monosaccharides to form non-carbohydrate products. In the presence of amino acids, the Maillard reaction occurs with the formation of melanoidins [1]. Without the presence of catalysts, one of the primary initial products formed by the thermal dehydration of glucose and fructose is 5-(hydroxymethyl)-2-furaldehyde (HMF)[3]. HMF will further undergo thermally catalyzed reactions in the presence of saccharides to yield a variety of polymeric products including caramel [4]. The sequence of thermal dehydration reactions of saccharides is a process termed caramelization, and may be effected by heat alone or catalyzed under acidic or basic conditions. The presence of organic acids, amino acids, or mineral salts
on the surface of cotton fibers or in insect honeydew may affect the thermochemical degradation of physiological plant sugars and sugars present due to insect contamination [4].

**Methods**

High performance anion exchange chromatography (HPAEC) was performed on a Dionex DX-500 using pulsed amperometric detection and two Dionex CarboPac PA-1 (4 x 250 mm) columns connected in series. Elution was carried out at 0.75 ml/min using 200 mM NaOH as the mobile phase and a sigmoidal gradient of 0 to 500 mM NaOAc.

A cotton sample exhibiting high amounts of melezitose and trehalulose due to whitefly honeydew contamination was obtained from the Western Cotton Research Laboratory, USDA-ARS, Phoenix, AZ. The sample was ginned at ambient temperature in order to avoid prior subjection of the sample to heat. The sample was divided into 0.100 g subsamples which were formed into ~4 sq. in. webs. These webs were subsequently placed into a forced draft oven at 200°C for varying time increments. The resultant webs were then extracted into 10 ml deionized water and injected directly onto the HPAEC column.

Melezitose (α-D-Glucopyranosyl-[1→3]-β-D-Fructofuranosyl-[2→1]-α-D-Glucopyranoside) hydrate, 99+%%, was purchased from Sigma Chemical Co., St. Louis, MO and used as received. Samples of 0.0100 ± 0.0005 g were placed in glass vials and heated in a forced draft oven for times ranging from 0 to 40 min. The resulting product mixtures were then dissolved in 20 ml deionized water. The UV-vis spectra of these solutions were analyzed for 5-hydroxymethyl-2-furaldehyde (HMF) using a Beckman DU-7 spectrophotometer, and the absorbance at 283 nm was recorded. HMF (99%) purchased from Sigma Chemical Co. was used as the absorbance standard. 25μL of this solution was subsequently injected onto the HPAEC column and analyzed for melezitose and its saccharide reaction products.

Trehalulose (α-D-Glucopyranosyl-[1→1]-D-Fructofuranoside) was obtained as a 90.4% pure syrup (dry weight basis) from Dr. Wolfgang Wach (Südzucker Ag, Mannheim/Ochsenfurt, Germany) and was used as is. Samples of 0.100 ± .005 g of the syrup were placed in glass vials and heated in a forced draft oven for times ranging from 0 to 10 min. The resulting product mixtures were then dissolved in 1 L deionized water. 25μL of this solution was injected onto the HPAEC column and analyzed for trehalulose.

Melezitose samples of 0.0100 ± 0.0005 g were placed in glass vials with varying amounts of malic acid, ranging from 0 to 20% on a molar basis. The two ingredients were thoroughly mixed by repeated folding. The samples were then heated to 200°C for 6 min in a forced draft oven and the resulting product mixtures dissolved in 20 ml deionized water. The resulting solution was analyzed by HPAEC for melezitose and its carbohydrate degradation products. Trehalulose samples of 0.100 ± 0.005 g were similarly treated with malic acid ranging from 0 to 20% on a molar basis.

**Results and Discussion**

Figure 1 shows the concentration vs. time profiles for melezitose and trehalulose extracted from cotton webs heated for varying times at 200°C. The concentration of each component decreases exponentially, with resultant rate constants k_M = 0.131 min^-1 (R^2 = 0.58) and k_T = 1.196 min^-1 (R^2 = 0.82). The implication of this behavior is that it may be possible, under controlled conditions, to selectively remove these sugars through a thermochemical process, possibly resulting in a concomitant decrease in stickiness level. Preliminary to determination of these controlled conditions, it is necessary to first establish the reaction kinetics of the individual sugars and whether these kinetics may be influenced by the presence of other constituents present on the cotton surface, such as organic acids.

Pure melezitose was heated at 200°C in a forced draft oven for 20 minutes. The resulting melt was dissolved in water and the non-polar components separated using a C_{18} SPE column. The resulting water solution was then fractionated by HPAEC, and a wide variety of saccharide reaction products were obtained. Melezitose is present at 10% of its’ initial concentration, and glucose is the predominant reaction product. Turanose is also present as a relatively minor component, and a number
of larger oligosaccharides are apparently formed by rearrangement reactions. These components have yet to be characterized, and therefore the detector response cannot be correlated with concentration. However, when account is taken of a 7% (w/w) water loss due to dehydration reactions which occur on heating, 40% (w/w) loss on the C\textsubscript{18} SPE column, 10% unreacted melezitose, and 10% (w/w) glucose formed by degradation, it appears that the rearrangement products may account for as much as 33% (w/w) of the melt.

Figure 2 shows the concentration vs. time profiles for melezitose, glucose, and 5-hydroxymethyl-2-furaldehyde (HMF) resulting from the heating of pure melezitose at 200°C. The initial 5 minutes shows the concentration of each component to be constant, due to a period during which the temperature of the glass vessel and its contents are equilibrated with the oven. Following this equilibration time, the concentration of melezitose decreases exponentially. The resultant rate constant is $k_M = 0.129 \text{ min}^{-1}$ ($R^2 = 0.97$). This is in agreement with the value obtained for the contaminated cotton, indicating that the melezitose present in whitefly honeydew degrades without the catalytic influence of other components present in the honeydew or on the surface of the cotton fiber. Glucose is the primary reaction product observed upon degradation of melezitose. Fructose is not observed due to the fact that it degrades essentially instantaneously upon formation, due to its low melting point. The concentration vs. time behavior of glucose is consistent with a consecutive first order reaction scheme where melezitose is hydrolyzed to form 2 parts glucose and one part fructose, which subsequently degrade by various thermal decomposition mechanisms to form non-carbohydrate components, including HMF.

Concentration vs. time behavior for 90.4% trehalulose (not shown) also indicates exponential decay. The resultant rate constant is $k_T = 0.65 \text{ min}^{-1}$ ($R^2 = 0.99$). The reaction produces a relatively small amount of glucose as compared with the reaction of melezitose, indicating that the degradation of trehalulose may involve direct decomposition to non-carbohydrate products, as is the case with glucose and fructose. The observed value of $k_T$ for the 90.4% trehalulose syrup is significantly smaller than that obtained for trehalulose on honeydew contaminated cotton. The presence of a catalytic agent either in the honeydew droplets or on the surface of the cotton fiber itself may account for this rate difference. Possible candidates for such a catalytic agent include organic acids, found in substantial quantity on the fiber surface.

In order to elucidate the effect of an organic acid catalyst upon the rates of degradation of both melezitose and trehalulose, each was mixed with varying amounts of malic acid and subjected to heat for a fixed amount of time. Figure 3 shows the results of malic acid catalysis on the thermochemical degradation of melezitose. Melezitose was subjected to a temperature of 200°C for 6 minutes (1 minute following the end of the temperature equilibration period) at varying relative concentrations of malic acid. As the initial malic acid concentration is increased from 0% to 20% relative to the initial concentration of melezitose, the melezitose concentration decreases exponentially with a resultant value of the catalytic rate constant $k_{c,M} = 34920 \text{ (mol/L)}^{-1} \text{ min}^{-1}$ ($R^2 = 0.99$) at $T = 200°C$. Small relative amounts of catalyst therefore increase the rate of degradation of melezitose significantly. Similar treatment of trehalulose syrup yields $k_{c,T} = 2389 \text{ (mol/L)}^{-1} \text{ min}^{-1}$, more than an order of magnitude smaller than that of melezitose. Based on this evidence the effect of any organic acid catalyst present either in the whitefly honeydew or on the surface of the cotton fibers is expected to be much greater on melezitose than on trehalulose. The degradation of melezitose present in whitefly honeydew is an un-catalyzed reaction. Trehalulose, however, does appear to be at least mildly catalyzed by some agent, possibly an organic acid. It is probable that the observed catalytic effect is related to the extremely hygroscopic nature of trehalulose, allowing the catalytic agent to be preferentially trapped by trehalulose as opposed to melezitose.

The temperature dependence of the non-catalyzed thermochemical degradation of melezitose was studied by observation of the concentration vs. time profile at 170°C. In addition to a five minute period in which the sample and glass vessel equilibrate with the oven, an additional period of approximately 35 minutes elapses before the sample begins to degrade at a substantial rate. Subsequent to this period, the concentration of melezitose decreases exponentially with $k_M = 0.02 \text{ min}^{-1}$ ($R^2 = 0.99$), nearly an order of magnitude smaller than at 200°C. The thirty-five minute period preceding the onset of degradation is consistent with an autocatalytic mechanism whereby a relatively
minor byproduct of the initial thermal degradation may serve as a catalyst. Small amounts of species such as levulinic acid may be formed as byproducts of the dehydration reaction of glucose to HMF [10], and the subsequent fragmentation of HMF. When malic acid (10% w/w) is added as a catalyst at 170°C, the concentration of melezitose decreases to 30% of its initial value after 6 minutes time (one minute following the end of the temperature equilibration period), indicating that the presence of organic acid catalysts will lead to substantial degradation of melezitose when heated for a short time at 170°C.

Conclusions

When cotton heavily contaminated by whitefly honeydew is subjected to a temperature of 200°C the trehalulose content is substantially degraded to non-saccharide components on a timescale of seconds while the rate of degradation of melezitose present in the honeydew is nearly an order of magnitude slower. These results suggest that it may be possible to optimize conditions for the alleviation of trehalulose present on the cotton surface without concomitant degradation of the fiber itself. Results using malic acid as a catalyst suggest that proper application of a suitable chemical catalyst to the fiber surface prior to heat treatment may lead to a substantial alleviation of melezitose levels as well as other oligosaccharides present in insect honeydew.

Currently, most screening for stickiness potential takes place after the cotton has been subjected to heat at the gin. The conditions of this heat application vary widely depending upon many factors, and the extent of thermochemical degradation occurring at the gin is therefore unpredictable. The effect this degradation has upon observed stickiness potential may depend upon the method used for screening. For instance, reducing sugar content as measured by the ferricyanide method should be correlated with trehalulose content, due to the reducing nature of trehalulose. The results of the reducing sugar test may, however, be dependent upon the ginning conditions previously applied.

Bibliography


Figure 1: Concentration of trehalulose and melezitose extracted from whitefly honeydew contaminated cotton webs heated at 200°C as a function of time.
Figure 2: Concentration of melezitose and the degradation products glucose and 5-hydroxymethyl-2-furaldehyde (HMF) heated at 200°C as a function of time.
Figure 3: Concentration of melezitose and the degradation products glucose and 5-hydroxymethyl-2-furaldehyde heated at 200°C and t = 6 min (one minute after temperature equilibration period) as a function of malic acid concentration.
Comparative analysis of the stickiness assessment methods

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Abstract: Different methods of the cotton stickiness assessment are studied. At the first stage a comparison of Perkin’s method with manual thermodetection by SCT and adaptation of Fixotest and iron for purpose of thermodetection for 15 cotton samples of different origin was performed. At the second stage the Perkin’s method was compared with manual thermodetection with SCT, hot press KIKO and mini-card test. The data obtained show that the chemical Perkin’s method does not correlate with thermodetection methods. The results of cotton stickiness measurement by the thermodetection using different devices (SCT, Fixotest, iron, hot press) are not coherent.

Introduction

The cotton susceptibility to stickiness in the spinning process results from various types of contamination. The most frequent and serious reason of the cotton stickiness is its contamination by honeydew, sugars produced by the aphid *Aphis gossypii* and the white fly *Bemisia tabaci* [1]. There are two types of sugars:

- reducing monosaccharides – glucose, fructose,
- non reducing polysaccharides- sucrose, malezitose, trehalulose [1].

Other reasons of cotton stickiness are:

- contamination by plant fragments such as leaves, stalks,
- presence of natural waxes,
- presence of physiological sugars connected with the plant vegetation,
- immature fibres,
- presence in cotton traces of oil from the harvesting machines or ginning equipment [1-5].

The phenomenon of cotton stickiness has brought the negative economic effects. It has caused a decrease the yield (kg/ha) in the production process, a decrease of the selling price, an increase of cultivation care costs. In the processing it has determined a reason of the frequent machinery downtime due to dirt build-up. The consequence of the cotton stickiness is also the decreasing of yarn quality and yarn unevenness [1,6].

There is a number of the cotton stickiness assessment methods. To the direct of them belong: mini-card test, rottering method, Shenkar’s test, test using FCT (Fibre Contamination Tester) or new its
version FQT (Fibre Quality Tester), thermodetection method using SCT (Sticky Cotton Thermodetector) and H2SD (High Speed Stickiness Detector) \[1,7-10\]. The determination of the cotton stickiness in these last methods (SCT, H2SD) relies on the counting of sticky points onto aluminium foils after the previous subjection of the sample to the pressure and/or heat.

The indirect methods permit to determine the level of reducing sugars or all kinds of sugars in cotton. There are: chemical methods (Perkins’, Benedict’s, Molisch’s), chromatographic tests (HPLC), infra red spectroscopy measurement \[6\].

In the polish cotton industry, the commonly applied method in order to determine the cotton susceptibility to stickiness was the Perkins’ method, which describes the stickiness criterion on the basis of the level of reducing sugars: \(\leq 0,2\%\) - non sticky, \(> 0,3\%\) - there is a dangerous of stickiness \[6\].

However, according to Hequet \[11\] the cotton stickiness is an extremely complex phenomenon and a simple chemical test cannot bring enough information to conclude about the stickiness potential of specific cottons.

In the recent years, as reference method for assessing honeydew cotton stickiness, recommended by ITMF was adapted the thermodetection method, which is in the middle of the standardization process now.

In this paper, the comparative analysis of different cotton stickiness assessment method: the chemical Perkins’ method, thermo-mechanical thermodetection method using SCT and simplified thermodetection using iron, Fixotest or hot press is presented. For some selected cotton samples the mechanical method using mini-card Platt was applied.

**Materials and methods**

At the first stage, 15 samples of cotton from Central Asia (14 from Uzbekistan and 1 from Kasachstan) were selected to the research. These cotton samples were characterized by the different content of reducing sugars, determined by means of Perkins’ method according to the polish standard PN-89/P-0675/07.

The determination of reducing sugars in cotton relies on the reaction of yellow ferricyanide potassium solution with reducing sugars extracted from cotton. A cotton specimen (weight 0,5 g) after purification by hands is immersed in the distilled water with the addition of adequate amount of ferricyanide potassium, then is heated to the boiling temperature and held in this temperature for 3 min. Then the specimen is taken out and the colour of solution is assessed. Remaining yellow colour means that the sugars confined in the cotton sample did not reduce completely the ferricyanide potassium. Light yellow colour of solution means the balance point, the content of reducing sugars in cotton sample corresponds the amount of ferricyanide potassium in the solution.

For all the samples, the stickiness susceptibility by the thermodetection method was assessed. The following variants were applied:

Thermodetection by means of the SCT thermodetector: temperature 83°C, hot pressure time 12 s, cold pressure time 120 s, the surface area 0,66 m\(^2\), force applied: about 1300 N for aluminium hot plate and about 600 N for an upper wooden board.

For each cotton lot, 3 specimens weight of 2,5±0,5 g, were tested. The samples were conditioned (about 24 hours) in atmosphere: 20°C±2°C and 65%±2% RH. The cotton web was prepared with the mechanical opener. The sticky points onto aluminium foils were counted after 60 min.

Thermodetection by means of iron with thermostat and Fixotest (Hanau GmbH): temperature 110°C, heating time 30 s, cooling time 180 s, the surface area 0,012 m\(^2\), force applied: 0,55 kPa for iron, 4 kPa for Fixotest.

For each cotton lot 3 specimens of weight of 2,5±0,5 g were tested. The samples were conditioned (about 24 hours) in atmosphere: 20°C±2°C and 65%±2% RH. The cotton stickiness to the aluminium
foil was assessed according to the following scale: S – sticky (a lot of stuck fibres), W – questionable, single stuck fibres, N- non sticky.

At the second stage, 9 cotton samples were chosen. For these samples, the amount of reducing sugars by Perkin’s method and susceptibility to stickiness by means of SCT thermodetector and hot press were determined.

Thermodetection by means of hot press Kiko: temperature 110°C, heating time 30 s, cooling time 180 s, the surface area 0,012 m², force applied 3 kPa , the specimen weight 3 g.

The samples were conditioned (about 24 hours) in atmosphere: 20°C±2°C and 65%±2% RH. The cotton stickiness to the aluminium foil was assessed according to the following scale: S – sticky (a lot of stuck fibres), W – questionable, single stuck fibres, N- non sticky.

Moreover, for samples chosen at the second stage mini card test at the ambient temperature was carried out. The sample weight amounted 10 g. The samples were conditioned (about 24 hours) in atmosphere: 20°C±2°C and 65%±2% RH. The stickiness was assessed in a scale from 0 to 4 ( non sticky ÷ very sticky).

**Results**

The results of cotton susceptibility to stickiness in the spinning process obtained by means of individual method are shown in Table 1 and 2.

The correlation coefficient between the content of reducing sugars, determined by means of Perkin’s method and the amount of sticky points given by SCT at both stages of investigation was calculated. The following data were received:

\[ R_{xy} = -0.0013 \] for cottons tested at the first stage;

\[ R_{xy} = 0.02213 \] for cottons tested at the second stage.

The obtained values of correlation coefficient show that does not exist a linear correlation relationship between these two methods (Fig. 1). Moreover, one should affirm that in general with the growth of content of reducing sugars decreases the amount of sticky points determined by SCT.

This lack of correlation can result from the fact that the compared methods provide diverse information about the cotton susceptibility to stickiness. The thermodetection method permits to conclude directly about the stickiness caused by honeydew contamination, while the chemical Perkins’ method determines only the level of reducing sugars in cotton. Thanks to this it permits to predict indirectly the cotton susceptibility to stickiness in the spinning process.

**Discussion**

In order to assess the compatibility of individual methods of the cotton stickiness determination, the obtained results were ranked in the rising order. There were assigned the suitable ranks to each cotton lot (Table 3 and 4). The first rank was assigned to the cotton lot, which according to the appropriate method displayed the lowest susceptibility to stickiness and adequately the greater susceptibility to stickiness, the higher rank.

The analysis of compatibility of results of the cotton susceptibility to stickiness obtained by means of applied different measurement methods was carried out by counting of Kendall’s compatibility coefficient according to the equation:

\[
W = \frac{12 \cdot \sum_{i=1}^{n} \zeta_i^2 - 3k^2n(n+1)^2}{k^2n(n^2-1) - kT}
\]  \hspace{1cm} (1)

where:

\[ \zeta_i \] – the rank sum for tested feature,
The obtained values of compatibility coefficient, successively equal to

\[ W'_1 = 0.2281, \]
\[ W'_2 = 0.2574, \]

suggest that does not exist the compatibility between applied methods of the cotton susceptibility to stickiness. In order to verify the significance of Kendall’s compatibility coefficient, the following zero hypothesis was advanced: between k assessment values does not exist the compatibility. Thus,

\[ k(n-1) W'_1 = 12,774 < \chi^2_{0.95;14} = 23,685 \]
\[ k(n-1) W'_2 = 5,148 < \chi^2_{0.95;5} = 11,070 \]

It shows that the zero hypothesis should be accepted.

The Kendall’s compatibility coefficient was also calculated for different thetmodetection methods, applied at the first stage of investigations. The value \( W' = 0.285 \) was obtained. It shows that the compatibility of assessments of the cotton stickiness by means of three methods based on the thermodetection using different devices: SCT, iron and Fixotest does not exist. The lack of compatibility can be caused by different conditions of tests: the pressure, the weight of used specimen.

In order to compare the individual methods applied for the cotton stickiness assessment, the Spearman’s correlation coefficients of rank were calculated basing on the ranks assigned in Tables 3 and 4, according to the equation:

\[
\rho_s = 1 - \frac{6 \sum (u_i - v_i)^2}{n(n^2 - 1) - (T_S + W_S)}
\]

(2)

where:

\[ T_S = 0.5 \sum t(t^2 - 1) \]
\[ W_S = 0.5 \sum w(w^2 - 1) \]

\( t \) – a number of identical ranks for feature, for which the \( u_i \) ranks were attributed,
\( w \) – a number of identical ranks for feature, for which the \( v_i \) ranks were attributed,
\( v \) – a number of combination for ranks \( v_i \),
\( u \) – a number of combination for ranks \( u_i \).

The data obtained were shown in Table 5.

In order to verify the Spearman’s coefficient, the zero hypothesis was advanced: between two assessment values observed does not exist the correlation. The zero hypothesis is accepted if \( |\rho'_s| < \rho_s (n;\alpha) \). As can be seen in Table 5, this hypothesis can be rejected only in two cases. This means that
there exists the correlation between the assessment of the cotton stickiness by means of thermodetection method using iron vs. Fixotest and the Perkins’ method vs. thermodetection using Fixotest. The comparison of the cotton stickiness results received for iron and Fixotest permits to conclude that the application of other apparatus at simultaneous maintain of the others test conditions causes a slight discrepancy of evaluation results.

In the recent years, as a reference method for assessing honeydew stickiness of cotton recommended by ITMF the thermodetection method by means of SCT was adapted, so the other methods shown in this paper were compared with this one. On the basis of the obtained data it can be affirmed that there is a good enough relationship between the assessment values of the cotton stickiness by means of the thermodetection using SCT vs. hot press Kiko and SCT vs. mini-card Platt (Table 5).

**Conclusions**

Recommended in the recent years by ITMF method of thermodetection using SCT correlates quite well with thermodetection using hot press Kiko and mini-card test, recommended earlier by ITMF.

The commonly applied method in the polish cotton industry in order to determine the cotton susceptibility to stickiness (the Perkins’ method) does not correlate with thermodetection using SCT. It results from the fact that the cotton stickiness phenomenon is caused by various types of contamination, but not only by reducing sugars, which content is determined the Perkins’ method.

The research of the cotton susceptibility to stickiness by means of thermodetection using different devices (SCT, Fixotest, iron, hot press) give discrepant results. It can result from the differences in the test conditions (temperature, pressure, weight of specimens). There is necessity of precise and unambiguous determination of the test condition and procedure.

**Bibliography**


Table 1. The cotton stickiness assessment result determined by means of Perkins’ method as well as thermodetection using SCT, iron and Fixotest.

<table>
<thead>
<tr>
<th>No</th>
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<th>Stickiness assessment by means of iron</th>
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Table 2. The cotton stickiness assessment results determined by means of Perkins’ method, thermodetection using SCT, hot press Kiko and mini-card test.

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Table 3. The cotton stickiness assessment results determined by means of Perkins’ method as well as thermodetection using SCT, iron and Fixotest put into ranks.

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Table 4. The cotton stickiness assessment results determined by means of Perkins’ method, thermodetection using SCT, hot press Kiko and mini-card test put into ranks.

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Table 5. The comparison of the Spearman’s correlation coefficients of rank for individual methods of cotton stickiness assessment.

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<td>0,89</td>
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<tr>
<td>11.</td>
<td>Perkin’s vs. hot press Kiko</td>
<td>-0,84</td>
<td></td>
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<tr>
<td>12.</td>
<td>Perkin’s vs. Nimi-card</td>
<td>-0,41</td>
<td></td>
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</table>

*N = 15 AT THE FIRST STAGE, N = 6 AT THE SECOND STAGE;

Fig. 1. Correlation relationships between cotton stickiness assessment results determined by means of Perkins’ method and thermodetection by SCT.
Separating sticky and non-sticky cottons - Stickiness measurement and bale management system

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Introduction

Cotton stickiness was fully recognized in the early 1960’s (or probably earlier), but was of little importance until the beginning of the 1980s when it became generalized. It is now reported in most, if not all, the cotton producing countries. For cotton yarn makers sticky cottons cause disruptions along the whole line of the spinning process and lead to the production of poor quality yarn.

There are various factors contributing to this cotton stickiness, but the entomological sugars secreted by sucking insects (honeydew) are the most important. In Sudan, however, the most common source of cotton stickiness is the honeydew secreted by the two major pests, whitefly (Bemícia tabaci, Gen.) and aphids (Aphis gossypii).

Chemical control strategies and others (agronomic, physiological and morphological traits), developed and executed to impart resistance against these two insects during the last three decades, were never fully successful; control was always partial. Such cottons are always labeled sticky on basis of their place of origin and are downgraded accordingly; it became clear a new strategy had to be followed.

It was, therefore, decided that some way of separating the clean cotton from the sticky one should be found, inorder to sell them separate, each for its due price. This could be done only through having an objective and standard stickiness measurement methodology. Being unavailable at the time, international help was sought for providing means of developing such a methodology. The Sudan Cotton Company (SCCL) submitted the request for such help in due time, and it was supported by the International Cotton Advisory Committee (ICAC). A project, originally drafted for somewhere else, was finally endorsed by the Common Fund for Commodities (CFC) to be executed in the Sudan. The SCCL became the Project Executing Agency (PEA), and it contributed effectively to the total cost of the project. Other contributors, who executed the research, were CIRAD CA (France), ITF (France) and ARC (Sudan).

The objectives of the project were 1) to develop a standard method to measure the level of stickiness in cotton bales, and 2) to establish operational thresholds for making use of, and the processing of sticky cotton.

Achieving these goals would serve the dual purpose of: a) protecting growers against unjustified price discounts and b) enable spinners to spin such cottons through adjustments in the machinery and factory conditions or through mixing in certain proportions with non-sticky cotton.
This project was coined with these considerations in view. It satisfied the conditions of the Common Fund for Commodities as it had its central objective of increasing the returns on a commodity (cotton) to producers through the development of objective methods to determine the level of stickiness in cotton bales. It also served another important objective of establishing (under factory conditions) of operational thresholds for the processing of contaminated, sticky cotton. The development of such processes to successfully deal with the problems of stickiness in cotton would not only raise prices of cotton in currently affected regions but would also increase their quantity of marketable cotton.

The project, however, bypassed the control of the causal organisms, which was the mandate of another project elsewhere. It focussed on the post harvest stage of production and measures to deal with sticky cotton. Main targeted outputs were to:

(1) Develop a method to separate sticky from nonsticky cotton using the industry standard (at the time) Thermodetector (SCT) developed by CIRAD-CA of France.

(2) Establish threshold levels of stickiness, for contaminated cotton, which when mixed with known amounts of nonsticky cotton would spin without problem.

(3) Disseminate information and results to member countries.

The reported study summarizes the work carried out at ARC in Sudan. It describes the sampling technique and development of the stickiness evaluation methodology using the SCT.

**Materials and methods**

**Sampling Technique**

For the purposes of this investigation, in the first year (season 1996/97), cotton samples were drawn from one hundred Blocks out of the one hundred and thirteen Blocks of the Gezira. 50 of these Blocks were roller ginned and the other 50 were saw ginned. [In the Agricultural Production Corporations of the Sudan the Block is the smallest administrative unit. The Block has an average area of nearly 4000 hectares divided into Numbers each with an area of about 36 hectares. The Number is divided into tenancies and each farmer grows about 2 ha. of cotton]. There are one hundred and thirteen Blocks in the Gezira grouped into eighteen Groups. One hundred of these blocks were ear marked for this study; 50 blocks roller ginned and 50 blocks saw ginned. For this study only, the cotton coming from each Block was graded and ginned separately. This is not the normal practice, as the commercial produce is usually sorted and ginned on grade basis. The ginned cotton of each grade is subdivided into lots of one hundred bales each, (lot = 100 bales) and is offered for sale in these lots.

In order to be practical the lots and bales to be sampled in each lot must be decided in advance by their numbers. It is not practical to keep someone all the time up on the lint slide to collect samples; some whole lots might not be needed for sampling.

The number of bales and the number of samples to be taken must be arbitrary at this starting step of the study. It was decided to take ten bales from each block and take one sample from each of the sixteen press layers of the bale.

Therefor, sixteen samples were drawn out of each one of the ten bales chosen randomly from the cotton coming from each one of the 100 Blocks. Each one sample represented one layer of the sixteen layers of the bale drawn at the lint slide along the pressing period. The sample weighed between 80 and 100 grams of lint. This sample was put in a plastic bag and clearly labeled with the gin, lot, bale and sample numbers. The total number of samples under test was 16,000.

**The Thermodetector**

The SCT thermodetector developed by CIRAD-CA is a thermo-mechanical device that applies pressure and heat to a cotton sample contained between two plates covered with aluminum foil. The heat releases water out of the cotton, which is taken up by the honeydew droplets, and become moist
and sticky. The applied pressure will fix these sticky droplets to the plates. The sticky spots can then be counted.

Details of the procedure start off with a pre-heating phase after which an aluminum foil sheet is placed on the lower copper plate of the SCT. A mass of a known weight (in grams) of cotton fibres is opened, spread and homogenized by a specific fibre blender that comes with the machine. The fibre mass is thus spread into a web; this web is put on top of the aluminum foil on the lower plate of the SCT. A second sheet of aluminum foil is put on top of the web forming an ensemble. The heating device is placed over this ensemble for a preset time. At the signal the ensemble is left under ambient temperature and pressure for another preset period of time, after which it is removed and stored for a certain period to cool. After this period the upper aluminum foil is removed and a special brush is used to remove the cotton web and the attached fibres from the lower and upper aluminum sheets. The sticky spots can then be counted with a counting pen under high illumination.

The samples must be conditioned and measurements taken at standard temperature and relative humidity.

**Stickiness measurement**

The cotton sample for the SCT stickiness evaluation weighed 2.5 g, and the test was run at standard conditions of relative humidity (65%) and temperature (21°C). The sample was opened on a manual opener and was spread to form a web with a density of 30g/m. The web was contained between the two aluminum plates the ensemble of which was then placed on the lower plate of the SCT. Heat and pressure were applied for 12 seconds, followed by pressure alone for 2 minutes at ambient temperature. The whole ensemble of the aluminum sheets together with its contents were then removed and left for one hour. After this one hour the cotton web was removed with a special pad impregnated with mineral oil. The spots (sticky points) on the upper and lower plates were then counted under high illumination. The test was repeated three times for each sample and the average of the three readings was recorded.

**Bale samples for spinning test**

Sixty bales were selected from the national production of the 1996/97 crop representing Barakat (roller ginned), Acala (roller ginned) and Acala (saw ginned), twenty bales for each type. The 20 bales representing each type had the following levels of stickiness: 2 free, 8 light, 8 medium and 2 heavy.

Typically, these bales should have been chosen after stickiness measurement with the SCT thermodetectors. However, due to late arrival of thermodetectors the levels of stickiness of these bales were assessed on minicard, but still, a sample was taken from each bale, and these sixty samples were sent to CIRAD-CA, France for confirmation of stickiness level. The 60 bales were later shipped to France for spinning tests by ITF (Instiut Textile de France) to provide information for the second main objective “dealing with sticky cotton in spinning”. Cotton with varying levels of stickiness would be mixed with varying amounts of nonsticky cotton under different machine and factory adjustments to define thresholds for spinning sticky cotton.

**Results and discussion**

**Potential Stickiness**

The main objective behind the above sampling and stickiness evaluation was to find a sampling and a stickiness measurement methodology by which it would be possible to categorize the country’s cotton production into sticky and nonsticky bales. This would allow the nonsticky bales to be sold at a higher price in the cotton international market. In other words we were seeking the development of an objective method to determine the potential stickiness of the cotton bale. By this it should be possible for the producer to offer the spinner lots of cotton that are guaranteed trouble free during processing.
This potential stickiness needs to be qualified. At the very outset, a classification of just two categories: sticky and nonsticky might come to the mind. This is what can be termed qualitative classification in which the division is based on a fixed value termed the ‘critical stickiness threshold’. Another form is the quantitative classification in which the bale is given a guaranteed stickiness score, (e.g. 10 sticky spots). It could be seen easily that such a quantitative classification, although might be technically possible, yet it involves considerable cost in constituting and managing bales of homogeneous stickiness. On the other hand, a qualitative classification system can determine the grade of a very sticky bale after a single measurement, thus restricting the number of measurements per bale and reducing the classification cost. This was the one recommended and would be based on the use of a critical stickiness threshold. This critical stickiness threshold, of course, should relate to the spinnability limit of the sticky cotton, and as such can extend beyond the mere number of sticky spots to include the spot size and, possibly, the types of the sugars contained in them. The spinnability limit with this definition was attempted to be determined at the ITF (France) using the 60 bales mentioned above. The results of that study are reported elsewhere (Final Project Documents or Proceedings of the Final Project Workshop). As for the second consideration, of the sticky spot size and sugar type, the SCT model used for this analysis was not equipped to do more than the number of the sticky spots. That is because it was the only model available for the industry, and the CFC, at the time of approval and inception of the project. Therefore, the critical stickiness threshold referred to, hereafter, was defined solely by number of the sticky spots measured by the SCT.

Analysis

Distribution of the sticky spots

An effective classification of the cotton bales into sticky and nonsticky lots necessitates the rigorous evaluation of the within bale variance of the sticky spots. This was the reason behind the sampling and measurements detailed above. In order to decide on the number of samples per bale and the guaranteed trouble free stickiness level, (bale management system), this within bale variance, and the statistical law governing it, must be determined.

The statistical laws governing the distribution

The number of sticky points in a cotton sample is a discrete variable that is counted, rather than a continuous variable that is measured. On basis of a hypothesis of a fully randomized distribution, and a homogeneous density of sticky points within a cotton bale, the number of sticky points in any sample from that bale follows the Poisson’s distribution law. On the opposite hypothesis (not following Poisson’s law) the probability distribution is over-dispersed, compared to Poisson law. The choice between these two hypotheses is possible by a unilateral Chi² test. In the case of Poisson’s distribution the ratio of the sum of squared deviations (SSD) from the mean of n measurements asymptotically follows a Chi² law with n-1 degrees of freedom. For p bales and nᵢ measurements per bale, giving a mean xᵢ, the following equation gives the expression of the observed Chi² (χ²obs) with \[ \sum_{j=1}^{p} (nᵢ-1) \] degrees of freedom.

\[ \chi^2_{\text{obs}} = \sum_{j=1}^{p} \left\{ \frac{SCE}{x_j} \right\} \]

A probability of a Chi² higher than that of the chosen type one error suggests the presence of a Poisson’s distribution. In the opposite case the ratio of the Chi² to its number of degrees of freedom gives an estimate of the over-dispersion compared to Poisson’s law.

In order to fit such an over-dispersed distribution to some other statistical law we resort to the relationship between the variance and the mean. This relationship seems quadratic when observing the regression logarithm of the variance to the one of the mean. Such a relationship can correspond to a
negative binomial law. The negative binomial law has two parameters: the mean $m$ and the shape factor $k$, and can be written as follows:

$$P(X=x) = \frac{\Gamma(k+x)m^x k^k}{\Gamma(x+1)\Gamma(k)(m+k)^{k+x}}$$

(1)

With gamma $(\Gamma)$ being the generalized integral defined by $\Gamma(k) = \int_0^\infty x^{k-1} \exp(-x) \, dx$

and its expectation is $E(X) = m$, and variance is $V(X) = m + \frac{M^2}{K}$.

Estimation of parameters $m$ and $k$ for the negative binomial distribution

The arithmetic mean $M_j$ is a good estimate of the parameter $m_j$. On the other hand, the shape factor $k$ can be estimated using different ways among which the method of maximum likelihood is the most precise. This method mainly consists of evaluating the maximum of function $L$:

$$L = \prod_{j=1}^p \prod_{i=1}^{n_j} \frac{\Gamma((k + x_{ji})/k)}{\Gamma(x_{ji}+1)\Gamma(k)(x_{ji} + k)^{k+x_{ji}}} L$$

In practice, it is easier to estimate the inverse of $k \left( \frac{1}{k} \right)$ and, indeed, the estimation of the quantity $\alpha = \frac{1}{k}$ is less biased and gives more symmetrical confidence intervals around $\alpha$.

A Chi² test, based on the ratio of the maximum likelihood, allows to check the homogeneity of the $k$ coefficients within a group of $p$ bales. Indeed, if $L$ is the maximum of likelihood obtained, considering that all the bales have the same $k$ coefficient, and $L_j$ one obtained with a $k$ for every bale taken separately, then the quantity $-2(\log L - \sum \log L_j)$ is a Chi² with $p-1$ degrees of freedom the probability of obtaining a higher value of which, for a type 1 error, permits concluding the $k$ coefficient is homogeneous.

All the statistical analysis of the data was carried out at CIRAD. Prior to the statistical analysis, Block means and variances were log transformed, and plotted in a scatter diagram. This scatter plot of log(variance) versus log(mean) showed the variance was increasing with the mean. If the distribution of the sticky points within each bale was random, a Poisson distribution would have been obtained. Such a hypothesis of a Poisson distribution was rejected according to the (Chi²) dispersion test at 0.0001 probability.

Among the over-dispersed distributions the negative binomial is frequently encountered, and has already been observed for stickiness counts in other countries collaborating with CIRAD. The negative binomial distribution with parameters $k$, $m$, is the distribution of the variable $X$ given in equation (1):

$$P(X=x) = \frac{\Gamma(k+x)m^x k^k}{\Gamma(x+1)\Gamma(k)(m+k)^{k+x}}$$

(1)

($K$ is the dispersion parameter, $m$ the mean and the variance is $\sigma^2 = m + m^2/k$)

However, the scatter diagram of log transformed variance against log transformed mean for this particular data (Fig 1) did not satisfy a negative binomial model, either.

Also, in the scatter plot two clouds of points could be observed; one of them was over-dispersed and lied above the other which, on the other hand, has such low dispersion that is commonly not expected in random distributions.

The low (under) dispersion can result in situations were the stickiness measurements for one bale are read successively by one and the same person, and is attributed to ‘observer memory’. Here, each time
the points are counted the operator remembers the counts he/she has just determined for other samples from the same bale.

The upper cloud covered the most variable measurements. It was separated from the lower cloud by an over-dispersion test with an alpha type-1 error of 1%. This over-dispersion of the upper cloud might have resulted from sticky points being distributed as clumps, or may be due to incomplete mixing of the fibbers during ginning.

After assuming the measurements in the upper cloud were not affected by operator memory another attempt was made to adjust a negative binomial distribution for the points showing significant over-dispersion in the upper cloud alone. This adjustment was also not satisfactory.

So, the data obtained from the 1000 bales did not show clearly what kind of statistical distribution was followed by the sticky points in the bale, and it was not safe at this stage to draw any conclusions concerning the probability distribution of the SCT counts based on this data. Further work was necessary.

However, with such bias introduced by operator effect in the results, big doubts grew about the SCT being the most suitable machine for the job. This was specially true after studies showing that the stickiness potential is not determined by the number of sticky points only (the size of the points is important), the whole procedure must be reconsidered.

The 480 samples experiments

Towards this end, there were two other experiments conducted at CIRAD on subsets of the same thousand bales under study. The first experiment involved the first thirty bales (without random choice) and the other one involved another thirty bales taken at random. In these two experiments the 16 samples from each bale were distributed at random between two operators in one experiment (the random experiment), and were measured by a single operator in the other (the first nonrandom one). In the measurements made and scatter plots drawn, overdispersion was more pronounced in the random experiment than in the nonrandom one. It should be noted that the results obtained at ARC were even less dispersed than the nonrandom experiment at CIRAD. This showed clearly that the operator memory introduced considerable bias into the results.

A negative binomial distribution model could easily be fit for the variance/mean relationship in the case of the randomized experiment data. This is true in both cases of estimating the k parameter by nonlinear regression or by maximum likelihood. Thus, although a likelihood ratio test showed that the k parameter was heterogeneous, a negative binomial distribution of parameter k = 10.8 was the best approximation that could be established by the data.

Bale Management System

The final goal of the project was to classify the commercial produce into sticky and nonsticky bale lots. This would be based on counting the sticky points using the thermodetector (SCT). The efficiency of separating the sticky from the nonsticky bales will be based on the results of adjustments of within bale sticky points distributions. The variability of the measurements made determines the risk involved in commercial classification and this is the risk that the purchaser will classify a bale, classified as nonsticky by the seller, as sticky. This risk must be reduced to a minimum level by classifying more strictly.

A bale is classified by reference to a classification threshold, and the bale is stamped sticky or nonsticky according to whether the stickiness is less or greater than the threshold. However, the different measurements made for the same bale would not always give the same result, as already noted in the variability study. Therefore, the same bale could be classified at some point as nonsticky and at another as sticky. This is a potential cause of legal disputes between the seller and the purchaser.
If, for example, the stickiness classification threshold was set, arbitrarily, at 10, then bales with 11 points and more would be classified as sticky. For a bale with a true potential stickiness mean \((m) = 12\) sticky points and showing negative binomial distribution, it would be possible to calculate the probability of observing exactly \(X = 0, 1, 2, 3, \text{ etc.} \) sticky points. If these values were plotted in a chart it will show very clearly that the probabilities of classifying a bale as sticky and as nonsticky are almost equal. In this particular example, if the purchaser adopted the same classification threshold and the same number of measurements, he will have a probability of 0.591 (1-0.409) of classifying the same bale as sticky. From the same chart the probability of the seller classifying the same bale as nonsticky = 0.409. To avoid disputes, both the seller and purchaser must classify the bale as nonsticky; the probability of this happening equals the product of the two independent events, that is: 0.409 x 0.591 = 0.24. This is the risk value that can have serious economic consequences and is, therefore, unacceptable. It can be demonstrated that this risk can reach a maximum of 0.25. This happens when the classification threshold is exactly equal to the distribution median. This result is independent of the probability distribution.

**Minimizing the risk**

The risk for any given threshold is not always a maximum, it varies in relation to potential stickiness of the bale, as shown in figures 2 and 3.

In actual case the potential stickiness of the bale is unknown when it is classified. If \(r(m)\) is the risk of litigation in relation to the potential stickiness of the bale, and \(f(m)\) is the probability density of the potential stickiness for the entire production being classified, then the overall risk (GR) for the produce patch will be given by the following formula:

\[
GR = \int_{0}^{\infty} r(m) f(m) dm
\]

But \(f(m)\) is unknown, and, therefore, no calculations can be made based on such an overall risk. However, we do know that its upper limit is the maximum risk. On that basis, even though we are unable to base calculations on the overall risk, we can use the maximum risk which we can set at a value of our choice in order to lower the chances for a litigation.

Being more stringent in classifying categories, which should always be beyond the evaluation figures is one way of minimizing the risk. We can actually guarantee an evaluation of the bales that will never give a stickiness reading higher than the limit required by the buyer (called the evaluation threshold) and that is by classifying the bales using a lower threshold (called the classification threshold). For example, if the evaluation threshold was set at 11 sticky points but the classification threshold was set at 4 sticky points, the litigation risk for a bale with potential stickiness of 12 points would only be 0.0146x(1-0.409) = 0.0086, i.e. less than 1%.

The maximum risk was calculated for both the classification and evaluation thresholds with one or two replicate. Figures 4 show isolines for this risk in relation to the classification and evaluation thresholds.

**Additional confirmational experiments**

**The 1600 sample Experiment**

The approximations and results given above were obtained at rather special sampling conditions, and were decided to be confirmed by a larger experiment involving 100 bales with randomized sample measurements among SCT operators. The results of this experiment should provide a more precise description of within bale stickiness distribution, and demonstrate whether or not the operators have a significant impact on the results.

One hundred bales were sampled this way in the second season (1997/98) crop in Sudan, and the degree of stickiness was evaluated at ARC laboratory using SCT and on a parallel set of samples at CIRAD using H2SD. The ARC data confirmed a presence of a further complication of “operator X
bale” interaction effect. The inevitable conclusion here is that the operator effect cannot be corrected because it depends on the particular bale being analyzed. This showed the SCT couldn’t be used with any success to establish a dependable bale management system for stickiness.

The results obtained by CIRAD staff with the H2SD showed the ability of the improved machine to eliminate the drawbacks of human intervention. It was possible to draw conclusions about the distribution and its parameters by which it is possible to deduce the stickiness threshold with known confidence limits. However, these results were, still, drawn from rather restricted data (from 100 bales) and it was decided to sample a larger portion of the commercial crop in 1999.

The 7680 sample Experiment

Repeating the first season experiment in the third year’s crop was thoroughly negotiated between CIRAD, SCCL and ARC and was agreed to. The number of samples was reduced to about half and the sampling involved selected ginneries.

30 lots (of 100 bales each) were sampled in 8 ginneries in the Sudan. Two bales were randomly chosen from each lot, and 16 samples were taken from each bale, which brings the total of samples to 7680. The stickiness in these samples was evaluated in France by CIRAD staff using the H2SD. The results were reported in a separate paper.

Application to the National Crop

As the SCT measurements turned out unsuitable for constructing a litigation free bale management system, the H2SD was endorsed as the more suitable machine to be used for commercial classification purposes. But the SCT, with its limitations, could still be used to classify bales on basis of number of sticky spots, rather than potential stickiness.

On basis of this assumption, and inorder to apply the methodology on large scale the whole national crop (Gezira, Rahad and Halfa) was sampled during seasons 1997/98 and 1998/99. 5% of the bales of each lot (one lot = 100 bales) were taken at random and two samples (each weighing 80 to 100 grams) were taken from each bale (10 samples per lot). Stickiness was measured on the SCT in the same way described above. The figures obtained for each lot were averaged to give one value for that lot.

In order to separate the sticky from the non-sticky cotton bales an arbitrary classification scale was constructed according to the number of sticky spots as follows:

<table>
<thead>
<tr>
<th>Range of Sticky Spots</th>
<th>Stickiness Grade</th>
</tr>
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<tbody>
<tr>
<td>0 – 5</td>
<td>Free</td>
</tr>
<tr>
<td>6 – 15</td>
<td>Light</td>
</tr>
<tr>
<td>16 – 35</td>
<td>Moderate</td>
</tr>
<tr>
<td>36 – 50</td>
<td>High</td>
</tr>
<tr>
<td>Above 50</td>
<td>Very High</td>
</tr>
</tbody>
</table>

This classification can serve the purposes of the producer, in as far as stratifying his crop on basis of stickiness levels, and for providing his customers with less sticky cottons. It must still be backed with price discounts, but probably less than in case of ‘blind’ deals in which there are no indicators for stickiness levels.

In table 1, figure 5, it is clear that in all locations (Maringan, Hassahisa and Bageir) and in both seasons (1997/98 –99), between 70 and 90 per cent of the Barakat crop was free (<5 sticky points), or with light (>5 to<15 sticky points), grade of stickiness. Bale lots having high or very high stickiness levels never constituted more than 3% of the total crop. Percentages will vary for varieties, locations and seasons, but considerable proportions of the crop will annually be obtained in the various categories, with very effective portions in the lower stickiness levels.
Such information about the crop stickiness level, arbitrary as it is, will be of good help in framing the pricing policy.

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KHALIFA H., GAMEEL O.I., 1982. Control of stickiness through breeding cultivars resistant to whitefly (Bemisia tabaci Genn) infestation. Improvement of oil seed and industrial crops by induced mutations. IAEA, 181-186.
Table 1: SCT classification of Sudan cotton (variety Barakat), seasons 1997/8-99

<table>
<thead>
<tr>
<th>Variety, Ginning type, Location and Season.</th>
<th>Number of Bales</th>
<th>Level of Stickiness</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td>Free</td>
</tr>
<tr>
<td>Barakat, Roller Ginned</td>
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<tr>
<td>Maringan 1997/98</td>
<td>9183</td>
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<tr>
<td>Bagier 1998/99</td>
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<td>6899</td>
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</table>

Within-bale Distribution

![Mean-Variance Relationship](image)

Figure 1: Relationship between within bale variance and bale mean on SCT measurements on 1000 bales sampled from 1996 production of 100 Blocks of the Sudan Gezira Board. The solid line shows the theoretical variance x mean relationship for negative binomial distributions with a common k estimated on all the bales.
Figure 2: Negative binomial probability distribution of number of sticky points; mean = 12 and k = 11.

Figure 3: Litigation risk when classification threshold = evaluation threshold = 10 sticky points. Negative binomial distribution, k = 10.8, 1 replication.
Figure 4: Maximum litigation risk on bale classification with 1 measurement / replication/bale as a function of classification and evaluation thresholds. Negative binomial distribution.

Figure 5: SCT classification of Sudan Cotton (variety Barakat), seasons 1997/98-99.
List of Presentations Made Concerning the CFC/ ICAC / 11 Project

Most of the technical information and results of the project are given in the following book in English language:


However, the general conclusion is given here after the list of the communications related to the Project to highlight its main results.

The same report exists in French under the following title:

- Rapport Technique n° 17, available at the Common Fund for Commodities or Cirad.

More details can be found in the book:

Standardization procedure for the stickiness measuring instruments used within the CFC / ICAC / 11 project

RICHARD FRYDRYCH, JEAN-PAUL GOURLOT, GÉRARD GAWRYSIAK, CHARLES FONTENEAU-TAMIME, ERIC GOZÉ, AHMED FADDLALA AND A. H. ABDELATIF

Extend and variability of stickiness within Sudan, 1998 crop, using SCT and H2SD devices

CHARLES FONTENEAU-TAMIME, FRANCK LANGLOIS, RICHARD FRYDRYCH, JEAN-PAUL GOURLOT, AHMED FADDLALA AND A. H. ABDELATIF
Presentation of the equipment used for these researches. Effect of relative humidity on stickiness effects during spinning. Some specific experiment made at low humidity within IFTH workshop

RICHARD FRYDRYCH, CHARLES FONTENEAU-TAMIME, JACQUES EDMÉ, THIERRY LE BLAN, JEAN-PAUL GOURLOT, BRUNO BACHELIER, SERGE LASSUS, JEAN-CHARLES NIEWEADOMSKI, PHILIPPE FRANCALANCI AND GÉRARD GAWRYŚIAK

Proportionality between percentage of sticky cotton and H2SD results, non-evidence of drift along time and independence between successive H2SD measurements

ERIC GOZÉ, RICHARD FRYDRYCH, JEAN-CHARLES NIEWEADOMSKI, FRANCK LANGLOIS, PHILIPPE FRANCALANCI AND SERGE LASSUS
Presentation of the equipment used in the project within IFTH, sampling procedure during spinning

THIERRY LE BLAN AND JACQUES EDMÉ

Full scale carded ring spinning experiment: effect on productivity and on quality

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What is the actual best indicator of stickiness?

CHARLES FONTENEAU-TAMIME, JEAN-PAUL GOURLOT AND ERIC GOZÉ
Economic viability of quantitatively grading cotton bales for stickiness measured by H2SD

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Final conclusion of the CFC / ICAC / 11 Project

It would appear that stickiness is on the increase. Many authors in the bibliography give different reasons for this increase e.g. changes in insecticides, possible resistance to insecticides, changes in processing machines etc. Many producing countries are affected by stickiness, and ICAC decided to sponsor a first project in 1993 to control insect-induced stickiness in the field. The project was known as « Sticky cotton: possible control methods from the plant to yarn ».

In parallel, some kind of stickiness evaluation was required to assess bale quality for commercial purposes. Thus, a new project, entitled « Improvement of the Marketability of the Cotton Produced in Zones Affected by Stickiness » was designed to address some of the basic questions and develop a method for characterizing stickiness.

This project, also sponsored by the International Cotton Advisory Committee, and funded by the Common Fund for Commodities, was carried out by ARC and SCC in Sudan, and by IFTH and Cirad in France with the support of ICAC.

The central objective of the project was to increase cotton producer revenues through the development of reliable methods to evaluate the stickiness of cotton bales, and determine (under factory conditions) the operational thresholds for the processing of contaminated sticky cotton.

A bale is declared as “sticky” if, during a processing step, e.g. spinning, its stickiness disrupts the spinning process, reduces spinning machines performances or decreases final product quality.

It should be noted here that classification requires a measuring tool, appropriate conditions for that tool, and good cotton production organization. All these conditions will impact on the success of such a classification system.

**Qualitative classification of stickiness**

In this part of the project, we investigated methods intended to manage the cotton and establish make a classification for its marketing.

As planned in the project, the SCT thermodetector, which was shown to be a good predictor of problems encountered during spinning and is the measuring device recommended by the International Textile Manufacturers Federation, was used to separate the sticky bales based on the number of sticky points. This method was shown to have its limits as a classification tool since it is slow and the results were biased by an operator effect. In the second part of the project, it was decided to use the H2SD instead of the SCT as it proved to be more reliable and faster.

The bales can be classified for stickiness in several manners, i.e.:

- a quantitative classification, namely each bale is labeled with a number of H2SD sticky points, and its associated confidence interval (tolerance);
- separation into two categories, “sticky” and “non sticky”, according to a determined threshold called the “crucial stickiness threshold”.
Both these methods require knowledge concerning the within-bale distribution of sticky points. The qualitative classification of the cotton bales was chosen to be more suitable for the situation.

From a specific experiment, it was shown that the sticky points were distributed in an aggregated manner: the number of sticky points in the tested bales followed a binomial negative statistical distribution whose shape factor and homogeneity was estimated for all the bales.

The aim of any classification is the guarantee a certain quality for a given bale. However, since fiber characteristics showed within-bale and within-lot variability, samples from one single bale or a single lot could show different results and this could result in complaints. This would be particularly awkward when producer results and purchaser results are different for the same bale.

When classifying stickiness, at least qualitatively, this risk of complaints being made (i.e. risk of litigation) must be evaluated and sampling / classification conditions must be managed accordingly.

This is why tables were established on the basis of simulations that took account of:

- the statistical distribution observed
- producer requirements in terms of cotton production constraints
- the classification and grouping together of bales of homogeneous quality
- purchaser requirements
- and part of the economical cost of the operation.

Under these conditions, the classification method used by the producer must be based on a lower threshold than that employed by the purchaser, and thus reduce the risk of litigation.

The extent of stickiness was also evaluated within Sudan. Several thousand samples, produced by eight ginning plants located in different geographical zones were analyzed using the H2SD. The results showed that some zones are more affected by stickiness than others. It is therefore possible to consider developing a strategy for the follow-up and assessment of stickiness by concentrating the measurements on the zones where the classification is the most useful.

**Stickiness measurement and relationship with technical hitches during spinning**

Part of this study focused on the spin-ability of sticky cottons by processing several sticky cottons bales covering a wide range of stickiness. During the spinning of each of these bales, the breaks, stops and technical hitches were noted and used to calculate the output of each spinning machine.

Some cotton samples, taken from the opening of the bale up to the sliver, were used to monitor changes in cotton stickiness in the course of the processing. Different methods were used to measure the stickiness: SCT thermodetector, H2SD and HPLC chemical method. The sliver, roving-yarn and yarn quality were also monitored by analyzing samples taken at the different performed stages from cotton to yarn.

The spinning tests were performed in carded cycle for the two main types of spinning (ring and open-end spinning), under the temperature and relative humidity conditions usually recommended for processing in the absence of stickiness.

Some relationships were noted between the different stickiness levels and the production and quality criteria and were used to define the best indicator of stickiness, namely the number of sticky points measured by the H2SD fast detector.

This device, in addition to providing the result that correlated the most closely with the production criteria (breaks and output) and quality criteria (regularity, imperfections and properties of yarn strength) is the fastest and the most suitable for industrial application in the detection of stickiness in cotton bales.
The other measurements methods studied, i.e. SCT and sugar percentages measured by HPLC, were often correlated to the production and quality criteria, but the coefficients of determination ($R^2$) did not generally equal those obtained with the number of sticky points given by the H2SD. Moreover, the HPLC chemical measurement is unsuitable for an industrial application because it is costly and time-consuming.

The results of this study showed that the rowing frame was the most sensitive machine to stickiness. Considerable efficiency could be lost depending on the degree of stickiness because of breaks and the rolling-up of fibers around the rollers.

The open-end spinning seemed to be less sensitive to stickiness than the ring spinning. The loss of efficiency due to stickiness is gradual with a relatively gentle slope while the rate of breaks in the ring spinning process increased rapidly with stickiness potential.

Another noticeable difference between these two types of spinning processes concerned the yarn quality. Whereas the quality of ring spun yarn (coefficient of variation for mass, imperfections, tenacity) greatly depended on stickiness and deteriorated when stickiness increased, the properties of open-end yarn were only slightly sensitive to this problem.

It should be remembered that this experiment was conducted to determine a threshold to separate non-sticky and sticky bales. However, because of this gradual increase in the rate of incidents with stickiness, it was not possible to determine a single, overall threshold where spinning problems become too important.

In fact, the threshold depends on the number of incidents accepted by the customer. Also the rate of incidents remains rather variable from one bale to another for a same number of H2SD sticky points.

In view of the extensive work that would be necessary to list the incidents for every bale, the small number of bales could be used to establish only a rather imprecise relationship between the acceptable rate of breaks and the stickiness threshold.

Some tests on combed spinning were conducted in order to study the relationships between stickiness and disruptions of the specific machines used in this type of spinning process: the combing machine and the lap top machine. However, as the range of stickiness was rather limited, the study was conducted in a set of bales that all showed low stickiness potential.

Nevertheless, the few tests conducted showed that the combing machines we used in the project seemed to be very sensitive to stickiness, inducing a relatively large number of registered breaks. This proves that stickiness may be damaging for production in modern spinning mills.

**Financial viability of a classification**

The cost of grading all bales produced in Sudan was assessed along with the actual financial gains from such an operation, taking into account the discounts applied to cottons with the reputation of being sticky and the proportion of bales in the whole production. The results of this economic assessment showed the cost of grading to be about 1.5 $US per bale (almost 50% of this price for sample shipment to the testing laboratory since sample collection is not yet centralized) for an analysis cost of 0.388 $US per sample. A grading system is only economically viable if it results in some financial gain and this depends on the discount applied and the proportion of non-sticky bales. This study was conducted on the basis of many assumptions that need to be checked since it was almost impossible to obtain price and discount information from the market.

**Solutions to reduce the consequences of stickiness**

It is recognized that the higher the relative humidity, the most numerous the disruptions induced by cotton stickiness and the poorer the quality of the yarn. This negative effect was confirmed by reducing the relative humidity to 40% in a specific spinning experiment.
Three levels of relative humidity (40, 45, 55%) were tested to evaluate impact on productivity and the yarn quality in micro-spinning. Some tests conducted in an industrial spinning confirmed that very sticky bales which could be spun or were very difficult to spin under normal relative humidity (RH) conditions were spin-able without much disruptions at 38% RH. The quality of the yarns produced was also improved. Decreasing the relative humidity would appear to be a solution for the processing of sticky cottons.

In the scope of this study where each bale of cotton was spun individually, it was shown that the number of disruptions was related to the H2SD stickiness level. In industrial processing, cottons from different origins are often mixed together.

The linearity of H2SD counts in mixtures of sticky and non-sticky cottons was checked in samples containing 25, 50, 75 and 100% sticky cotton.

The stickiness of the mix was determined to be the mean stickiness of each constituent weighted by the proportion of this constituent in the mix (if the sticky cotton contains no more than 50 H2SD sticky points).

Though there is no doubt that this observation needs to be confirmed in an extensive industrial spinning process and with respect to the quality of the yarn produced, it seems reasonable to imagine that mixing some sticky with some non sticky cotton could reduce the incidence of technical problems in the mill to an acceptable level.

**Perspectives**

Controlling stickiness requires a global approach where improvements in breeding, agronomy, pest control and technology have to be made in a parallel manner. Classification is one of the tools used to combat stickiness. Measurement results can help, through mapping, to make progress in all other ways to reduce stickiness, such as breeding new varieties, developing new ways to manage the crops through integrated pest management programs, managing the seed-cotton flow, etc.

On a long term basis, the classification tool should be economically viable, and would insure an improvement of the image of Sudanese cotton.
Economical Viability of the Proposed Solutions
An economic appraisal of testing and marketing Sudanese cotton according to levels of stickiness

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Abstract: Sudan Cotton Company (SCC) in collaboration with other international agencies, interested in researches on cotton stickiness launched an interdisciplinary project to test and evaluate methods for establishing the degree of stickiness in Sudanese cotton (b) develop a threshold to enable economical processing of sticky cotton and evaluate financial viability of the project. On bases of the results of testing and classification of exported cotton according to different thresholds it was found that a high percentage of Barakat cotton was free from stickiness and the other types are lightly affected. The discounted current prices are revised to cater for free and lightly affected cotton. On bases of these the project is found financially viable and the testing for stickiness is recommended to continue but on commercial bases using more sophisticated testing equipments and testing charges to be levied on the agricultural corporations.

Introduction

Cotton (Gossypium barbadense L.) and (G. hirsutum L.) is a fibre crop which includes many cultivars differentiated by the length of their fibres, length of maturation period characteristics of plant leaves and canopy in addition to other biological and morphological characteristics. It is produced all over the world under different modes of irrigation depending on the type of soil, weather conditions, amount, duration and intensity of rainfall, and availability of irrigation water. Four types of cotton cultivars are produced. These are extra long staple cotton represented by Giza and Barakat, long staple cotton represented by Pima, medium staple cotton represented by Acala and short staple cotton represented by upland cotton. Most of the world cotton is produced in Asia. Four Asian countries account for more than 50% of the world production in 1998 and 1999. China (Mainland) is the largest world producing country followed by USA., India, Pakistan and Uzbekistan. These five countries account for more than 75% of the world production.

Consumption of cotton is affected by synthetic fibres consumption. In recent years cotton consumption has declined from 66% to 58% as a result of expansion in purchases of synthetics resulting from higher incomes in developing countries (CFC). Nevertheless textile industries in developing countries were expected to expand. The developed countries on the other hand have become recently more conscience to natural goods and are expected to become a source of raw material to the developing countries.

Consumption of cotton fibre is seriously limited by cotton stickiness. However cotton stickiness is not new to producing and consuming countries. Many causes were reported contributing to this problem. Among these causes are insect excretions, plant exudates, environmental conditions and varietal
differences, in addition to an endless list of factors. Stickiness caused by whitefly (*Bemisia tabaci*) and Aphids (*Aphis gossypii*) is the most serious one. Chemical analysis revealed that both insects excretions are very rich in monosaccharites compared to that from plant exudates. It poses serious problems at spinning and results in considerable financial losses. Because of these high losses, spinners purchase sticky cotton at discount prices. For a producing country like Sudan the losses incurred from selling at discount rates may be considerable especially the country depends mainly on cotton export proceeds for its foreign currency. This problem faces almost 20% of the world producing countries. Because identification of levels of cotton stickiness is not possible at the field and ginning factories, it is therefore very important to establish cotton stickiness classification system in order to allow discounts to be attributed in a more rational manner. An early identification of the problem will not only save cotton producers from discounts but also warn spinners to be ready to make necessary adjustments in machinery and spinning conditions to avoid unnecessary delays, breakages and ultimate financial losses. But many of these countries lack research capacities and financial means to solve key problems.

**History of stickiness in Sudan**

Sudan grows four types of cotton ranging from extra long to short staple cotton. Of these the medium staple cotton (Acala) is mostly affected. This is related to the nature of the crop. Acala plant is hairy, short, bushy and forms a close plant canopy which encourages white flies to hide in the lower parts of the plant thus avoiding insecticides from reaching them. Moreover, the maturation period of the plant coincides with the peak of the white fly infestation. Hence, the open cotton bolls are subject to more contamination with honeydew the more they remain on the plant in the field.

Khalifa in his review on cotton stickiness stated that the white fly infestation does not only cause cotton stickiness but also leads to an inferior fibre characteristics such as low maturity ratio, reduction in fibre length, micronaire value, fibre weight per cm, and yarn strength.

The National Research Committee on cotton stickiness in Sudan had launched a number of coordinated research programmes which aimed at establishing reliable methods for grading cotton stickiness, investigating the effect of different cultural practices on the life cycle of the white fly and breeding cotton cultivars resistant or tolerant to white fly infestation. These programmes were accompanied with routine cotton tests for stickiness using minicard testing machines. The results of the total production showed that 50% of the extra long staple cotton (Barakat) was free of cotton stickiness and 25% of it was considered light. These results are not surprising because the maturation of Barakat commences after the infestation peak of the white fly thus avoiding being contaminated.

Sudan cotton is offered for sales in different quantities (lots) and is purchased by different dealers originating from different parts of the world. Stickiness of Sudan cotton although not mentioned but is well taken care of. Each of these purchasers or consumers already have developed their own technique to deal with Sudan cotton. In doing so, they have calculated the costs and benefits and based on these they normally offer their bids. It is believed that in absence of an official classification system, the entire production reputed to be contaminated may have to be discounted whereas, in fact, it only contains a small fraction of truly contaminated cotton. This is very true with Barakat. It is therefore, believed that large amounts of foreign currency is lost because of this.

**Action taken by Sudan**

Sudan Cotton Company Ltd being the cotton sole marketing agency in collaboration with Agricultural Research Corporation (ARC), (Sudan) Common Fund for Commodities (CFC), International Cotton Advisory Committee (ICAC) International Textile de France (ITF), and Centre de Cooperation Internationale en Recherche Agronomique pour le Development (CIRAD), launched a multidisciplinary stickiness testing research project to investigate the following:
To test and evaluate methods for establishing the degree of stickiness in Sudanese cotton produced in affected areas.

To develop a threshold to enable economical processing of sticky cotton.

To evaluate the financial viability of the project.

**Materials and Discussion**

The implementation of the project was carried by ARC, ITF and the author for analyzing the financial viability.

ARC collected samples of cotton produced in season 1997/98 and 1998/99 from the Gezira scheme, Rahad and New Halfa Agricultural Corporations. The samples were stratified according to location of production, type of cotton and type of ginning (roller/saw). The testing was carried out using stickiness cotton thermodetector which is developed by CIRAD and recommended by the International Textile Manufacturer Federation (ITMF).

The results of the testing is arranged in Tables 1 to 3 for each type of cotton according to a given stickiness threshold. The stickiness thresholds are developed by ITF using the same cotton samples used by ARC in Sudan, but using more sophisticated equipment such as high speed stickiness detector (H2SD). The range of stickiness thresholds developed by ITF was lowered by ARC to avoid litigation charges. The threshold levels used in this study are as follows:

- free cotton up to five sticky points.
- light cotton between six and fifteen.
- moderate cotton above fifteen to thirty, and
- high above thirty.

ITF has set maximum limits of 10, 20 and 30 for the above three thresholds respectively.

According to the above sticky threshold levels Sudan cotton for 1997/98 and 1998/99 is classified as follows:

**Barakat roller gin**

The Gezira scheme is the only scheme producing Barakat and all the produce is roller ginned. Table (1) gives the levels of stickiness and percentage of sticky points of tested samples in each level for the two crops according to location of gin.

The table indicates that more than 80% of Barakat cotton has less than 16 points which according to Tamime et al is considered for some spinning machine as non-sticky or free. The location of the ginning factories indicates that North and North West Agricultural Groups have less sticky cotton (Bageir) than the Centre Agricultural Group (Hassheisa) and the Southern Agricultural Groups (Maringan). The Centre and Managil Agricultural Groups are relatively more infested. However the comparison between seasons indicates that 1997/98 is better than 1998/99.

**Acala roller gin**

The Gezira scheme is the only scheme which uses roller gins for Acala cotton. About 87% and 68% of the Gezira production of this crop was roller ginned in 1997/98 and 1998/99 respectively. The remaining quantities were saw ginned. Table (2) gives the percentage of Acala cotton according to the level of stickiness and location of ginning (roller) for seasons 1997/98 and 1998/99.

Table (2) indicates that Acala cotton is more contaminated with stickiness than Barakat, which calls for more measures to be taken at the field. The percentage of free and light cotton in both seasons was
less than 40%. Comparison between seasons indicates that the levels of stickiness in 1997/98 were much higher than 1998/99.
Acala cotton saw gin

Acala cotton produced in Rahad and New Halfa is totally saw ginned in addition to the proportion left from Gezira. Of the total saw ginned, Gezira Acala accounts for 26% in 1997/98 and 40% in 1998/99. It is worth noting that 1998/99 production in Rahad was only 58.5% of that produced in 1997/98. Similarly the production of New Halfa in 1998/99 was also 67% of that produced in 1997/98.

Table (3) gives the percentages of Acala cotton (saw) according to the levels of stickiness thresholds and location of scheme for 1997/98 and 1998/99.

In 1997/98 the cotton infestation was very heavy in all schemes. Moderate and high levels accounted for 88% in Gezira, 92% in Rahad and 73% in New Halfa. However the situation became less intense in 1998/99 season. The moderate and high levels dropped to 64% for Gezira, 16% for New Halfa and remained at their high level in Rahad (91%). For the Sudan as a whole some producers with free and light sticky levels received less than they ought to receive because the cotton of other producers in other corporations was highly contaminated. Of the three cotton producing corporations the Rahad should give more attention and the present production practices need to be seriously revised. Early picking should be encouraged as well as effective measures on the side of crop protection should be taken.

Financial analysis

To calculate the financial benefits the average prices currently received for each variety are upgraded by 10% for free cotton, 5% for light, zero % for moderate and furtherly discounted by 5% for high. The upgrading is only arbitrary. It can be more or less than the above levels. However its impact will be felt when the resulting returns are compared with the existing returns (with and without).

Also the production of 1997/98 and 1998/99 is classified according to type of cotton and levels of thresholds obtained from testing. Table 4 gives the distribution of cotton according to above criteria.

The prices received under the existing situation (without project) for the different types of cotton in 1998/99 per bale were $ 322.3 for Barakat, $ 240 for Acala roller and $ 224.1 for Acala saw with a weighted average of $ 263.4/bale.

The corresponding upgraded prices per bale for each type of cotton according to each threshold level are as follows:

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Barakat</th>
<th>Acala (R)</th>
<th>Acala (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free</td>
<td>$ 354.5</td>
<td>$ 264</td>
<td>$ 246.5</td>
</tr>
<tr>
<td>Light</td>
<td>338.4</td>
<td>252</td>
<td>235.3</td>
</tr>
<tr>
<td>Moderate</td>
<td>322.3</td>
<td>240.0</td>
<td>224.1</td>
</tr>
<tr>
<td>High</td>
<td>306.2</td>
<td>228</td>
<td>212.9</td>
</tr>
</tbody>
</table>

Applying these prices to amounts in bales in 1998/99 of each type of cotton, the following results are obtained in thousand US $.

Without project:

Barakat $ 38496.8
Acala R $ 25303.2
Acala S $ 26009.5

Total returns $ 89809.5 and an average price of 263.4.
With Project:

<table>
<thead>
<tr>
<th></th>
<th>Barakat</th>
<th>Acala R</th>
<th>Acala S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free</td>
<td>$8045.0</td>
<td>1948.3</td>
<td>3147.1</td>
</tr>
<tr>
<td>Light</td>
<td>25060.2</td>
<td>9033.2</td>
<td>9012.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>6544.3</td>
<td>11892.5</td>
<td>7542.7</td>
</tr>
<tr>
<td>High</td>
<td>731.5</td>
<td>2884.7</td>
<td>6671.6</td>
</tr>
</tbody>
</table>

Total returns $92513.1 and an average price of 271.3.

The overall upgrading is only 3%.

The net benefits for each type are 1882.2 for Barakat, 455.5 for Acala (R) and 363.9 for Acala (S).

Total net benefits equal $2701.6 of which Barakat gained 69.67%, Acala roller 16.86% and Acala saw 13.47%.

The gain on bases of bale for each type was $15.76 for Barakat, $4.32 for Acala roller and %3.13 for Acala saw.

The cost of testing was estimated at $231.6 thousand leaving a net financial benefit of $2470 thousand for the producers.

From the above analysis it is clear that marketing cotton on bases of levels of stickiness is financially awarding. The total capital cost needed for the purchase of testing equipment and materials is given at $194.35 thousand. The rate of return to capital is estimated at 2470 / 194.35 = 1271%

The benefit cost ratio is estimated at 2470 / 231.6 = 1066%

**Conclusion**

The project is financially viable and SCC should commence testing and marketing at least Barakat type on bases of levels of stickiness. Agricultural Corporation growing Acala are encouraged to secure enough finance for picking operations and especially Acala type should be picked between waterings in order to obtain cotton free of stickiness. If ARC charges one dollar/bale for testing, ARC is expected to gain about 110 thousand dollars. The financial analysis for ARC indicate that the rate of net return to capital would be 56.6% and the benefit cost ratio would be 147%.

**Recommendations**

- Agricultural Corporations should be encouraged to test their produced cotton for stickiness annually and market it accordingly.
- The testing of cotton should be expanded using more sophisticated equipment such as H2SD and operated on commercial bases.
- Agricultural Corporations currently facing high levels of stickiness are advised to take immediate measures to reduce such levels.
- SCC is encouraged to convene a workshop to discuss and demonstrate the advantages of marketing cotton on bases of levels of stickiness.

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Table 1: Percentage of Barakat cotton according to levels of stickiness threshold and ginnery for seasons 1997/98 and 1998/99. Source: ARC.

<table>
<thead>
<tr>
<th>Levels of stickiness</th>
<th>Free</th>
<th>Light</th>
<th>Moderate</th>
<th>High</th>
<th>Total bales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maringan</td>
<td>45</td>
<td>21</td>
<td>45</td>
<td>65</td>
<td>10</td>
</tr>
<tr>
<td>Hasshaesia</td>
<td>31</td>
<td>14</td>
<td>52</td>
<td>60</td>
<td>17</td>
</tr>
<tr>
<td>Bageir</td>
<td>49</td>
<td>32</td>
<td>44</td>
<td>63</td>
<td>6</td>
</tr>
<tr>
<td>Total Gezira</td>
<td>37</td>
<td>19</td>
<td>49</td>
<td>62</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 2: Percentage of Acala cotton according to level of stickiness threshold and location of ginning roller for season 1997/98 and 1998/99. Source: ARC.

<table>
<thead>
<tr>
<th>Levels of stickiness</th>
<th>Free</th>
<th>Light</th>
<th>Moderate</th>
<th>High</th>
<th>Total bales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maringan</td>
<td>3</td>
<td>9</td>
<td>9</td>
<td>39</td>
<td>31</td>
</tr>
<tr>
<td>Hasshaesia</td>
<td>2</td>
<td>2</td>
<td>23</td>
<td>25</td>
<td>44</td>
</tr>
<tr>
<td>Total</td>
<td>2.6</td>
<td>7</td>
<td>15</td>
<td>32</td>
<td>36.6</td>
</tr>
</tbody>
</table>
Table 3: Percentage of Acala cotton according to levels of stickiness thresholds and location of scheme for season 1997/98 and 1998/99.

<table>
<thead>
<tr>
<th>Location of ginnery</th>
<th>Free</th>
<th>Light</th>
<th>Moderate</th>
<th>High</th>
<th>Total bales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gezira</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td>Rahad</td>
<td>1</td>
<td>9</td>
<td>7</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>N.Halfa</td>
<td>1</td>
<td>30</td>
<td>26</td>
<td>54</td>
<td>49</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>11</td>
<td>19</td>
<td>33</td>
<td>46</td>
</tr>
</tbody>
</table>

Table (4). Distribution of exported cotton bales according to level of stickiness.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Without project</td>
<td>60000</td>
<td>119444</td>
<td>183000</td>
<td>105430</td>
<td>102000</td>
<td>116060</td>
</tr>
<tr>
<td>With project:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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Some remarks and ideas to better understand the links between stickiness and prices

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Abstract: At present, the “sticky cotton” reputation is the criteria taken in account by buyers. But only a scientific analysis could allow to classify the bales, then to identify and to certify the non-sticky ones. The discount applied today to sticky bales depends on the level of supply of cotton on the market and on the level of modernity of the spinning mill using them. But over fifty sticky points, a cotton cannot be processed pure and is no more bought. In the Sudanese conditions, the financial evaluation of a classification has to be based on economical data, not yet all available.

Cotton reputation

The discount on the cotton sales price is linked to the reputation of cotton stickiness, this reputation not being established on a scientific analysis of the percentage of sticky cotton in the delivered lots, but is founded on the customer’s perception of the stickiness characteristic of the cotton origin. It is difficult to remove an acquired reputation; thus, cotton from Cameroon which acquired the reputation of a sticky production and undergoing some discounts, was unable to get rid of this reputation in spite of the success they got in fighting against stickiness. Nowadays, mean discounts of 5% are still in use compared to cotton from Mali though their stickiness levels are not different.

Cotton classification on its stickiness level could solve the problem, if a renowned certified body certifies that bales are homogeneous, otherwise traders will not take the risk of this certification by their own. Mixing lots from different origins, as it is done in Sudan, is not the proper way. It would be better to identify free zones and make certified by ICAC that this is coming from a non-sticky certified production zone, otherwise customers’s reticences will be maintained and the non-sticky cotton from Sudan will continue to be subject of discounts.

Discount level as a function of the cotton quotation

The discount level is more or less important depending on the excess of supply over the demand or the contrary. The discount level is lower when the supply is in deficit, it is higher when the supply is in excess. Consequently, knowing that, when the supply is in excess then the quotation is lower, and conversely when the supply is in deficit then the quotation are high, the effect of the discount is cumulative. Thus, the discount level was 0.50 FF/kg when the cotton price was 7 FF / kg and was only 0.30 FF/ kg when the cotton price was 10 FF / kg. In the first case, the discount level was 7% whereas it is 3% in the second case.
Discount level as a function of the customer’s origin

The price discount on sticky cotton is linked to the fact that cotton fouls up production machines, which induces yarn breakdown and machine stops. The cost of these immobilizations is not the same in modern mills with high productivity and a high labour level compared to lower productivity mills and low labour level. The discount level to be applied by the customer using high productivity mills will be higher than the lower productivity mills.

The use of sticky cotton in the industry

Sticky cotton having more than 50 sticky points cannot be used because it prevents the production of machines. There is no more discount in this case, this becomes a refusal of purchase. In France, it even seems that cotton having more than 20 sticky points is not accepted.

In the countries with modern machinery and high labour, when the supply is in excess, the industry refuses cotton having more than 2 sticky points, it does not buy discounted cotton. When the supply is in deficit, it could buy sticky cotton, to mix it with non-sticky cotton, but it cannot pass its own given stoppage level, and one can assess that it cannot mix more than 5% of that sticky cotton. It would prefer to pay a premium for non-sticky cotton than use a discounted sticky cotton for mixing, that induces a storage of this sticky cotton to be gradually mixed and induces extra-handling. There is no market for Sudanese sticky cotton in France in any case.

In countries using low productivity equipment, the machines often run with sticky cottons with given levels. If the Sudanese production is separated into sticky and non-sticky batches, the stickiness level of the sticky part will automatically increase. If this level is too high, would the customer continue to purchase it?

Comment on M. A. Ahmed’s financial analysis of the Sudanese cotton

This evaluation do not take in account some variability aspects in some factors:

- The stickiness level per crop:. Keeping the cost hypothesis made by M. A. Ahmed to be applied on 1997 crop, the raw profit of the operation drops from 2,764 million dollars down to 0,501 million dollars, and the net benefit from 2,470 million dollars down to 0,270 million dollars.

- The discount level for sticky cotton following the quotation levels, if the discount level in low quotation period remains around 10 and 5% for non-sticky and low sticky cotton, but goes to –5 and - 10% for moderate to highly sticky cottons, the gross benefit of the operation becomes a loss of 2,346 million dollars.

To know what would have been the consequences of a classification process for the Sudanese cottons, the following information is required:

- a complete list of purchasing countries,
- the amount in weight that has been acquired by every purchaser,

- the discount level that was applied to the Sudanese cotton (at the exact quotation mentioned in the contract compared to the ICAC quotation the same day) by every purchaser for the past years 1995,1996,1997,1998,1999,
- the price that every purchaser would have paid its cotton at each stickiness level.
Closing session
General conclusion for the CFC / ICAC / 11 project

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Introduction

This study, financed by the Common Fund for Commodities and the International Cotton Advisory Committee, entitled « Improvement of the Marketability of the Cotton Produced in Zones Affected by Stickiness » was carried out by ARC and SCC in Sudan, IFTH and Cirad in France with the support of ICAC.

The central objective of the project is to increase the income on cotton to producers through the development of reliable methods to estimate the level of stickiness in cotton bales, and the assessment (under factory conditions) of the operational thresholds for the processing of contaminated, sticky cotton. Consequently, it is necessary to find a methodology to manage the cotton production allowing to separate the sticky bales from the non-sticky ones.

A bale is declared “sticky” if during the transformation process, for example spinning, its stickiness level disturbs the spinning process, leading to a lower performance of the spinning machines or decreasing the quality of the final products. To assess stickiness, it is necessary to have a reliable and rapid measurement device, whose results are well correlated with the efficiency, the breakage incidence in an industrial-scale spinning and the quality of the yarn. In this study, we propose a methodology to manage the production and make a classification for the marketing.

Stickiness measurement and relationship with technical hitches during spinning

In a part of this study, the spinnability of sticky cottons was studied by transforming several sticky cottons bales, covering a wide range of stickiness. During the spinning of each of these bales, a follow-up of the breaks, the stops and the technical hitches was carried out, permitting to calculate the output of each spinning machine. Some cotton samples, taken from the opening of the bale up to the sliver, allowed to follow the evolution of cotton stickiness level during the transformation with several methods of measurement: SCT thermodetector, fast detector H2SD and HPLC chemical method. A follow-up of sliver, wick and yarns quality was carried out too, by analyzing the samples taken along the different transformation stages from cotton to yarn.

The spinning tests were done, in carded cycle for the two main types of spinning (ring and open-end spinning), under the conditions of temperature and relative humidity usually recommended for a good progress in spinning process in the absence of stickiness contamination.
Some relationships between the different measurements of stickiness and the production and quality criteria led to choose the best indicator of stickiness, namely the number of sticky points measured by the fast detector H2SD. This device, in addition of providing the measurement the best correlated with the production criteria (rate of breaks and output) and of quality (regularity, imperfections and properties of yarn strength) is the fastest and the best fitted to an industrial use for the detection of stickiness in the cotton bales. The other measurements studied, SCT and percentages of sugars measured out by HPLC, are often correlated to the production and quality criteria, but the coefficients of determination ($R^2$) do not generally equal those obtained with the number of sticky points given by the H2SD. Moreover, the HPLC chemical measurement is not adapted in an industrial context because too time and money consuming.

The results of this study of spinnability in carded spinning process show that the flyer is the most sensitive machine to stickiness; the losses of output could be high according to the degree of stickiness, due to the breaks and coil of fibers around the rollers. The open-end spinning seems to be less sensitive to the stickiness level than the ring spinning. The loss of its output due to stickiness is gradual with a slope relatively low while the rate of breaks on the ring spinning increases quickly and highly with the potential of stickiness.

An other noticeable difference between these two types of spinning process concerns the quality of yarn. Whereas the quality of classical yarn (coefficient of variation of mass, imperfections, tenacity) depends greatly on stickiness and deteriorates when stickiness increases, the properties of open-end yarn are slightly sensitive to this problem.

Because of this gradually increase of rate of incidents with stickiness, it was not possible to determine a universal range threshold: the threshold depends on the rate of acceptable incidents by the customer. Besides, the rate of incidents remains rather variable from one bale to another for a same number of H2SD sticky points. Taking into account the extensive work necessary to list the incidents on every bale, the low number of tested bales only allow to establish a rather imprecise relationship between the acceptable rate of breaks and the threshold of stickiness.

Some tests on combed spinning were achieved in order to study the relationships between stickiness and disruptions of the specific machines for this type of spinning process: the combing machine and the lap top machine. By lack of a range of different level of stickiness, this study was only achieved on some bales showing a low number of sticky point. Nevertheless, the few tests made show us that the combing machines seem to be very sensitive to stickiness since, with some little sticky bales (ten sticky points on H2SD), the number of breaks registered is relatively important and proves to be damaging for the production criteria of modern spinning mills.

**Solutions to reduce the consequences of stickiness**

It is known that the higher the relative humidity, the most important the disruptions misled by stickiness of cotton and the worst the quality of the yarn. We could confirm this negative effect on the expression of stickiness by reducing the relative humidity to 40%. Three levels of relative humidity (40, 45, 55%) permitted to evaluate this impact on the running of the mill and the quality of yarn, in the conditions of a micro-spinning. Some tests, achieved in an industrial spinning mill around 38% of relative humidity, confirmed that some very sticky bales, impossible to spin in normal spinning conditions, could be spun with this relative humidity. The quality of the yarns produced was improved too. A decrease of the relative humidity seems to be a solution for the transformation of the sticky cottons in spinning process.

In the scope of this study, where each bale of cotton was spun individually, it was shown that the number of disruptions created follow the intensity of the H2SD stickiness level. In the industrial surroundings, it is frequent to mix cottons. In order to know what represents the measurement H2SD on a mix of cottons, we have tested its linearity according to a very well definite proportion (25, 50, 75, 100%) between a sticky and non sticky cotton. As a conclusion, the H2SD stickiness of such a binary mix may be considered as the product of the proportion of sticky cotton by the H2SD stickiness
level of this cotton. Generally speaking, the stickiness of a mixture is the mean of stickiness of its constituents weighted by the proportion of each one.

Though there is no doubt that this observation needs to be confirmed in an extensive industrial spinning process and on the quality of the yarn produced, it seems reasonable to think that mixing some sticky with some non sticky cotton could reduce the rate of technical hitches in the mill to an acceptable value.

**Qualitative classification of stickiness of the cottons with the fast H2SD thermodetector**

In parallel to the spinning tests, the management of the bales after their ginning was studied. As planned in the project, the thermodetector SCT was used in order to separate the sticky bales according to the number of sticky points. This measurement for the classification showed its limits of use because the SCT is slow and the measurement depends on the operator making it, as this occurred during this study. In a second part of the project, it was decided to use the H2SD instead of the SCT as measurement device.

The bales management (so-called classification) according to they potential of stickiness can be made by several ways, whose main ones are:

- a quantitative classification, namely each bale is accompanied with a number of H2SD sticky points, guaranteed with confidence interval (a tolerance);
- a qualitative classification, where the bales are separated in two categories, “sticky” and “non sticky”, according to a determined threshold called “crucial stickiness threshold”.

Both of these methods require the knowledge of the distribution inside bale of the number of sticky points. The qualitative classification of the cotton bales were chosen as the best adapted. By a study of sampling, it was shown that the distribution of the sticky points is an aggregated one. The number of sticky points of the tested bales follows a binomial negative law of which the parameter of shape could be estimated as well as its homogeneity for all the bales.

This result was applied to the classification by a probabilistic approach joining the number of measurements done on a bale, the stickiness threshold required by the purchaser and the risk tolerated by the seller of cotton. The classification method proposed permits the producer to guarantee the stickiness of these bales to the threshold required by his customer, while controlling the risk of litigation.

The cost of a classification of the whole bales in Sudan was assessed as well as the profits of such an operation, taking in account the discounts applied to the price of cottons having a reputation for being sticky and the proportion of the bales really non sticky in the whole production. The results of this economical assessment show a cost of classification around 0.75 SUS per bale (this price includes the sampling and transportation of the samples to the laboratory that accounts for half of this amount), with a real profit in some conditions of discount and of proportion of non sticky bales in the totality of the production to classify.

In order to complete the studies carried out, it was decided to evaluate the effect of the importance of stickiness according to the geographical zones. Several thousand of samples, produced by eight ginning plants located in different geographical zones, were analyzed with the H2SD. The results showed that some zones are more affected by stickiness than others. It is therefore possible to consider the development of a strategy of follow-up and assessment of stickiness of the production by concentrating the measurements on the zones where the classification is the most profitable. The final objective is to valorize the non sticky production and to permit the users to manage their purchase according to stickiness as the other technological characteristics.
Let me first make one comment on the dissemination of the results of this project. Mr. Gourlot said what has been done so far on the project. We are not going to stop here, we will continue our efforts to disseminate the results in different forms. One of them will be a technical report at the end of the project that will be published in English and French languages. Hard copy will be available in both languages and electronic versions of this report will also be available on the ICAC and CFC web pages and may also be on the CIRAD web page. The final report will also be available free and access to the Internet report will be free.

We will also do a small brochure particularly for the spinners. We discussed the possibility of such a brochure yesterday and will see what kind of information will be available in this brochure. The brochure will be done by SCC and CIRAD and many copies will be published particularly keeping in view the spinners significantly affected by stickiness.

The third thing which I think is important for Sudan is to establish a reliable system to negate the image that Sudanese cotton has some stickiness, Sudan has to do something by themselves. They have to establish their credibility and develop a system and establish the credibility in the system on how to label their cotton, as no sticky, slightly sticky, highly sticky. They should prove that this system has a credibility in the international community and unless this is not done I think it will be difficult for Sudan to make use of this information or avoid the discounts on cotton because of stickiness. Sudan has to develop a system not only to isolate sticky from non sticky cotton but also establish a credibility in that system that the international community recognizes and has a good confidence in it.

Regarding the issue that I have been asked to speak on: there is no change in the ICAC policy about this project, we will continue to welcome projects from all the member governments. But let me say that there is a strong need for international collaboration on cotton. It is just unfortunate that there is no international institute on cotton. Many of you probably know that IRRI, CIMMYT are international institutes on food crops. The Consultative Group on International Agriculture Research (CGIAR) has 18 international research centers. They work on all crops. There is no institute on cotton. This is just unfortunate that such an important crop has no international institute and consequently there is minimum collaboration on cotton research in the world. ICAC, every three years, undertakes a survey of research projects on cotton in the world and for the first time last year, I included information on international projects, each country has how many international projects and who are the country they are working with and what are the issues they are focusing. I tell you that the information I receive is very discouraging: almost no collaboration, except if we take all the ICAC/CFC projects there is no collaboration. ICAC is not supposed to undertake research on cotton, we do not have that mandate. But we do have the mandate to facilitate communication among researchers. We try to bring researchers together and we try to do it in different ways:
– we have regional networks where we bring researchers, help researchers to come together and discuss research on cotton, some of them are more efficient than others,

– and since 1994 we have also started World Cotton Research Conferences; this is another opportunity for researchers from various countries to come together and exchange information.

As seen from the ICAC, we have tried to have such an international institute, but it did not work out for many reasons. About 4-5 years ago we pursued the CGIAR very strongly, but we failed. We tried to convince them that they should include cotton in the mandate. Their response is that cotton is not a food crop, we do not work on fiber crops. You all know that cotton is just not only a fiber crop, but is also a food crop. There is a need for an institute on cotton.

Regarding the CFC – ICAC collaboration, it is not a contractual assignment. ICAC is recognized international commodity body with the CFC and we will continue our efforts to bring more projects and convince the CFC on behalf of governments to have more collaborative work.

I think these projects are well used far beyond the objectives. It is not only we focused these specific objectives and bring people like here together and it is not only to discuss the project. We will have for instance the opportunity to visit the IFTH facilities today and I am sure that in the last three days you made some new friends and this will contribute to enhance the collaboration in various aspects.

ICAC is always open to new ideas, new projects and I encourage researchers in various countries to come up with new projects. I can assure you that at the ICAC Secretariat, we are ready to help you to formulate proposals and put them in the acceptable form for the CFC. You are the researchers, you are the capabilities to come up with new ideas which I think is very important. Projects of conventional nature developing high yielding varieties, developing IPM system will not be welcome by the CFC. The projects have to be “problem oriented”, specific in nature, multinational in application. We are ready to help you to formulate your idea in the form of a proper proposal. On behalf of the ICAC, I thank you all for your participation in the workshop and I will encourage you to come up with new ideas and develop new proposals. Thank you very much.
On the cooperation between the Common Fund and the ICAC

SIETSE VAN DER WERFF

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Mr. Chairman,

In the opening remarks made on Monday, Mr Rolf Boehnke, the Managing Director of the Common Fund, has already mentioned that the Common Fund for Commodities is covering a broad range of commodities. Currently, the Fund has designated 24 organizations, representing commodity producing and consuming countries, as so-called International Commodity Bodies, or ICB’s. This designation implies that they can submit project proposals to the Common Fund for possible financing. This is the only routing for project proposals to be formally submitted to the Fund. By channelling all proposals through an ICB, the founders of the Common Fund wished to ensure that proposals financed by the Fund, indeed represent the interests of all producing and consuming countries, or that at least the support for a specific project has obtained the approval of the member countries of that commodity organization. In this manner, it is avoided that possible Fund financed activities in one group of countries go against the interests of other countries producing that same commodity.

Furthermore, the Fund has the practice that all results obtained from its projects, are made available to other member countries which have an interest in those projects. These results are made available through direct publication of technical reports, open workshops, publication of reports through its web site and/or through the web site of the commodity body concerned.

I must say that I am pleased to be able to state that the co-operation with the commodity organization representing the cotton sector, the International Cotton Advisory Committee, has been, and still is, a productive and efficient one. The number of cotton projects financed by the Fund is currently nine, leading to a share of cotton projects in the Fund’s project portfolio of 16% (only by-passed by coffee), with a total financial commitment from the Fund of almost US$ 22 million.

The types of projects supported by the Common Fund range from cotton sector country studies, via projects on crop protection against major cotton pests, to projects on developing improved marketing structures in selected countries and testing price risk management instruments for use in developing countries, for the benefit of smaller cotton producers. Consultations are ongoing between the ICAC and the Fund to develop more projects that qualify for Fund support.

Let me briefly touch upon some of the completed and ongoing projects.

Financed by the Fund, the World Bank has undertaken a study into the cotton sector in nine countries, namely Brazil, China, Egypt, India, Mali, Mexico, Pakistan, Tanzania and Uzbekistan. The results of
the cotton sector study have been published in 1995 as a World Bank Technical Paper entitled Cotton Production Prospects for the Next Decade.

Five projects focus on crop management and the development of sustainable methods of crop protection against major cotton pests. The project Integrated Pest Management for Cotton was implemented in Israel and Egypt, with field activities in Ethiopia and Zimbabwe. You have been informed about this project earlier during this workshop. A three-country project in Argentina, Brazil and Paraguay is concentrating on a major pest in the America’s, namely the cotton boll weevil. The final workshop has taken place last week in Brazil. A project based in Pakistan, the UK and the USA is focusing on determining the causal agents of diseases like the cotton leaf curl disease, and the development of virus-resistant varieties. This project is also in its final stage with a closing workshop scheduled for 12 – 15 November of this year in Faisalabad, Pakistan. The fourth project in this field has recently started and is related to the origin, impact and countermeasures against the cotton bollworm. This latter project is based in China, India and Pakistan. A related project is still in its preparatory phase and will have a focus on the prevalence of cotton bollworm in West Africa, and what can be done about the increasing resistance of this pest against currently used pesticides.

In Uganda and Tanzania, a project is being implemented on the development of an improved marketing and trade system for cotton, having as core activity the testing of a warehouse receipts system as a basis for production and trade financing for small producers and traders using the warehouse receipts as a collateral. In a way related to that project is a recently approved project with a focus on testing market-based instruments to reduce price risks for small cotton producers in developing countries. The start-up modalities for this project (which will focus on Tanzania, Uganda and Zimbabwe) are currently under discussion between the Fund and the ICAC.

As you may have noted, some projects are currently either just being completed or will be completed during this year. There certainly is thus scope for new project ideas to be submitted to the ICAC for initial consideration and possible submission to the Fund. It is up to the member countries of the ICAC and the ICAC Secretariat to make the first move in this respect, based on assessed priorities for support to the cotton sector in the developing countries, and in particular in the least developed cotton producing countries.

In doing so, project proponents should take into account the priorities set by the ICAC and that the Fund supports only projects which provide solutions to general problems of the commodity concerned and thereby normally involve a number of commodity producing developing countries, in particular the least developed among them. Single country based projects are the exception and should be pilot projects with replicable results for other developing countries. The majority of our projects so far are grant financed, but there is a move towards more loan-financed projects, provided they have an adequate financial return. Also investment related 'national based' projects would need to be loan financed. Loans would need to be guaranteed by the government of the country concerned, or by an entity acceptable to the Common Fund.

Mr Chairman, I will close my remarks by expressing the hope that the continuation of the productive co-operation between the Common Fund and the International Cotton Advisory Committee, as reflected in our current project portfolio, will have corresponding results in strengthening the position of cotton as a commodity of great importance to both producers and consumers, in developing and developed countries alike.

Thank you Mr. Chairman.
Agenda