Technology, Management and Processing for Quality Fiber

Papers Presented at a Technical Seminar at the 61st Plenary Meeting of the

INTERNATIONAL COTTON ADVISORY COMMITTEE

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Introduction

The Technical Seminar at the 61st Plenary Meeting of the ICAC was held on the topic "Technology, Management and Processing for Quality Fiber." The Seminar was held as an Open Session on Thursday October 24, 2002. Ten researchers from seven countries presented papers.

Low cotton prices have affected production of quality cotton while the demand for quality cotton has increased during the same time. A focus on Bt varieties, climatic changes and subsidies have also contributed to lower quality. According to the paper "Impact of low prices on production practices and fiber quality—A farmer's perspective" by Mr. Mario Rodríguez Rico of Colombia, a number of fiber quality characters have improved over the years, but low prices have affected area, and the number of farmers growing cotton has drastically been reduced in his country.

Genetically engineered cotton is now commercially grown in eight countries in the world: Argentina, Australia, China (Mainland), India, Indonesia, Mexico, South Africa and the USA. Egypt has developed abiotic stress resistant transgenic cotton and is close to its commercialization. The National Biosafety Committee has been established in the country and all other regulatory requirements have been completed. Giza 86 and Giza 87 have been transformed and are ready to be used. Properties and biochemical functions of key factors responsible for fiber initiation and development have been studied and future plans include improving fiber length and strength through genetic engineering.

Though genetically engineered cotton is spreading and covered about one-third of the total area in 2002/03, there is still some controversy on the commercial use of transgenic varieties. The paper from the American Cotton Shippers Association reviewed the impact of transgenic cotton on international trade and concluded that transgenic cottons have been fully accepted in the international cotton trade. According to the paper, criticism in Europe about transgenic products including cotton is driven by misinformation and hyperbole rather than "sound science", because they have proved to cause no negative effects on the environment.

Australia is the highest, or the second highest, yielding country in the world. The average yield has increased at the rate of 23 kg/ha per year since 1964/65. According to Mr. Ralph Schulzé of the Australian Cotton Research and Development Corporation, strategic planning is the key to success and future directions must measure the performance of research. The Australian cotton industry has also made significant progress in environmental safety by reducing pesticide use and river water contamination, adopting best management practices and improving production practices like water use, "Ingard" cotton and minimum tillage. However, there is a need to control production costs.

It is estimated that three-fourths of the total area was planted to transgenic varieties in South Africa in 2002/03. Quality improvement requires interdisciplinary approach. According to the paper by Dr. Dean Joubert of South Africa, 50% of the contribution to fiber quality is based on the genetic ability of the plant, 20% on the pest situation, 18% on agronomic management practices and 12% on the effect of diseases. The contribution of various factors/inputs in the production of quality fiber may vary among countries and even within countries.

Many fiber quality testing methods used in the world are not perfect and need improvement. This is what was observed in the paper from Dr. Iwona Frydrych of Poland. HVI measurement of strength, short fiber content and color need to be improved. Data by the Stickiness Contamination Tester and high speed H2SD do not correlate with the Minicard. However, the work from Sudan does not support such a conclusion. None of the available methods provide information on the reasons for stickiness. The paper suggests that the industry should measure additional characters that are not currently measured, and it should develop portable fiber testing equipment.

The Cotton Arbitration and Testing General Organization of Egypt is one of the oldest institutions on classing and grading of cotton in the world. The paper from the current Chairman Dr. Erfan Rashed stated that quality testing requires measuring good parameters as well as those parameters that have negative impacts on quality like trash, short fiber content and contamination. The paper suggests to establish internationally acceptable moisture and trash standards for commercial cotton trade and introduce a quality assessment system, whereby a ranking could be marked for each property based on its importance for the industry.

The paper from Dr. Mostafa Mohamed Kamal of the Cotton Research Institute, Egypt, explained the need and methodology used in classification of cotton. In order to eliminate the factor of human error, instrument testing should be encouraged. The current manual classification systems around the world give an approximation of the degree of cleanliness, brightness or darkness of its color. These systems in no way provide information on the spinning ability of cotton. The classification of cotton by grade has a value in the pricing system but fiber quality characteristics that reflect its true spinning value must be measured precisely.

Dr. Urania Kechagia of Greece stated that a series of decisions have effects on quality starting from variety selection, a combination of agronomic practices, moisture condition at the time of harvesting, etc., but the paper suggests how seedcotton handling and proper ginning could help to preserve fiber quality. Micronaire is one character which is not affected by ginning. The paper made a number of suggestions for the maintenance of quality during processing.

The role of various fiber quality parameters in the spinning performance of cotton has been reviewed by Dr. Nafia Taha Ahmed of Egypt in his paper entitled “Egyptian cotton yarn quality.” Longer fibers sacrifice minimum strength and produce lesser end breakage, thus resulting in a stronger yarn. Fiber strength is important because it is directly related to yarn strength, which is a combined and true expression of the total of all fiber properties. In addition to processing conditions, fiber fineness, maturity, length uniformity and short fiber content determine yarn evenness.

Dr. C. D. Mayee of India was invited to present a paper at the Technical Seminar. He could come but he sent a paper which has been included in the publication. In India, cotton accounts for 73% of the raw material used in the textile industry and 35% of the total foreign exchange comes from cotton goods. India has developed *G. arboreum* and *G. arboreum* x *G. herbaceum* hybrids that measure 27-29 mm in staple length and are suitable for 40s counts. Recently, India introduced Bt gene through commercial cotton hybrids and plans to shift research efforts toward the incorporation of fiber strength genes from wild species, development of cotton with thermal properties like heat tolerance and identification of genes responsible for biotic and abiotic stresses.

The Committee on Cotton Production Research of the ICAC decided to hold the technical seminar in 2003 on the topic “Effect of Advances in Processing Techniques on Demand for Quality Cotton.”

Impact of Low Prices on Production Practices and Fiber Quality - A Farmer’s Perspective

Mario Rodríguez Rico, Coalcesar Ltda., Colombia

There is a worldwide tendency to establish a general correlation between low international cotton prices and diminished lint quality.

It is also true, as has been reiterated in the past two years at the Beltwide Cotton Conferences, and in a number of trade publications, that some countries, such as the United States, have been decreasing lint quality to the point that industrial buyers have even ventured to offer higher premiums in exchange for a commitment to deliver the quality level they require.

However, a more detailed analysis of the situation shows that it is possible to identify three probable causes, none of which are in any way related to lower prices.

First of all, no new varieties have been developed in recent times to ensure a sustained increase in lint quality. The main thrust of both geneticists and plant breeders has been aimed at innovation by way of introducing genes from other plant or animal species into the cotton plant in order to achieve certain specific effects. This is the case with almost all commercial seed suppliers, who have been simultaneously offering conventional varieties along with those into which they have introduced genes that make them resistant to a given group of insects, such as lepidoptera caterpillars, or a certain herbicide, such as Roundup. The advantage of these modifications is that they help reduce costs and facilitate pest or weed management. So far, however, the altered genetics of these varieties has not had any additional impact on lint quality. However, the increase in the area planted to transgenic varieties coincides with the deterioration in lint quality.

The second factor to be taken into account is that adverse weather conditions prevailing over the past few years have had a negative impact on quality, particularly micronaire. Everyone agrees that environmental conditions have a great deal to do with micronaire. Thus, when production areas are affected by adverse weather conditions during the harvest period, it would not seem to be very likely that the genetic characteristics of production varieties would have much to do with the poor results achieved.

Breeders and researchers are being increasingly pressured to determine whether cultivation and physiological management practices can help keep micronaire levels in a range that is neither too high nor too low. Some researchers have been quick to point out, for example, that the perfect fertilization balance has not been achieved, as evidenced by the fact that the statistics are erratic over time.

The third factor is that, in those countries where there is a prevalence of high subsidy, farmers are sheltered from market oscillations, as well as from the threat of lower income, and are therefore less concerned with factors that might make them more competitive, such as higher agricultural yields, lower production costs, lint quality price differentials or any combination of the aforementioned.

In the most recent version of the Beltwide Cotton Conferences, US cotton farmers expressed their concern over the possibility of a decrease in subsidy levels, and in that connection they stressed the importance of reducing costs and increasing quality. The fact is, however, that subsidy levels were not decreased; on the contrary, in the following months, the United States Government increased subsidies.

There are other factors that may be having a negative impact on prices and income in countries that do not have that kind of protection and distortion and where the unavoidable reduction of production costs in areas such as fertilization, weeding, pest control, harvesting, etc. have been detrimental to lint quality. However, in spite of the above, in many non-subsidized third-world countries whose cotton income has been drastically reduced, lint quality has not only not deteriorated, but has actually improved.

This is the case in Colombia, where cotton farmers have been severely affected by unfair competition from highly subsidized lint, which has driven down international cotton prices and produced a dramatic reduction in the areas planted to cotton and in the number of farmers producing cotton.

According to statistics, in the last 10 years no less than 220,000 hectares were switched to different crops, more than 10,000 farmers gave up cotton production all together, and at least 200,000 persons directly or indirectly employed by the cotton industry lost their jobs.

The onset of this period coincides with the disintegration of the Soviet Union and the entry of former Soviet production into the world market, thereby causing a drop of just over 35% in international cotton prices. It also coincided with the implementation of the economic opening scheme in Colombia and the re-evaluation of the Colombian peso. At the international level, this was also a period that witnessed an increase in agricultural commodity protection and subsidies in the industrial countries, a stagnation of demand for cotton, and a loss of market share to synthetic fibers.

To make matters worse, increased violence and insecurity in rural Colombia was particularly hard on the major cotton producers, leaving production in the hands of small and medium farmers who, unfortunately, had fewer legal options for supporting their families and for whom labor costs — some 30% to 35% of total production cost — had a significant impact on income. Those farmers, obviously, had the least possibilities of achieving scale economies and their lack of schooling made it difficult for them to become familiar with and adopt new technologies.

Efforts at the time in Colombia were geared at offering growers varieties capable of producing the finest qualities. At the same time, agricultural and ginning techniques that decrease costs and increase efficiency were researched, transferred, adapted and adopted. Today, the growers who are still in the cotton business are the ones who have the resources and the knowledge that allow them to be competitive in spite of price slumps, those who have gotten through the income crises by reducing production costs while not only maintaining quality standards, but actually improving them.

Colombia's textile industry, acknowledged throughout Latin America for its high quality products, has for many years demanded high grades of cotton – initially— and subsequently, top intrinsic characteristics as measured by HVI. Curiously enough, now that the producers are offering higher quality, the industry is turning around and asking growers to deliver lower quality and more short staple to produce lower yarn counts and coarser fabrics.

Attempts to convince the industry of the benefits to be derived — for them and for our country — by taking advantage of the excellent quality characteristics of Colombian lint to penetrate market niches for high quality textiles and garments (as countries such as Portugal and Italy, among others, have done) have so far proved unsuccessful.

Manual harvesting of cotton in Colombia and the use of gins with lower speeds and practically zero over-processing, features which were considered to be a disadvantage, have actually become important factors in achieving high quality, allowing for the conservation of what was once called the "virginity" of the lint, reflected in greater uniformity, lower short staple content and fewer neps and naps. Despite the greater costs that these factors entail, especially in harvesting, we are convinced of the convenience of maintaining these high quality levels as a crucial aspect in competitiveness.

Over the past ten years, these quality parameters have remained stable, some of them with a marked upward tendency.

The diagrams on the next pages, containing each of the variables that determine quality, provide the following information:

Staple. The general trend is the stability with up and downs in the averages due to climate conditions, in as much as during the latter years of the decade of the 90s there was a higher frequency of the El Niño phenomenon, which is important as 90% of our cotton production area is rain fed.

Elongation. A glance at the diagram reveals variable performance throughout the period under analysis, but with an upward trend in the last three years.

Uniformity. This is the variable with the best performance, with consistent improvements over the period,

Micronaire. There is no significant upward or downward trend throughout the period under analysis, as the initial and final figures were the same.

Strength. The trend for fiber strength is steady improvement and, together with elongation, it is one of the variables in which our lint performs excellently.

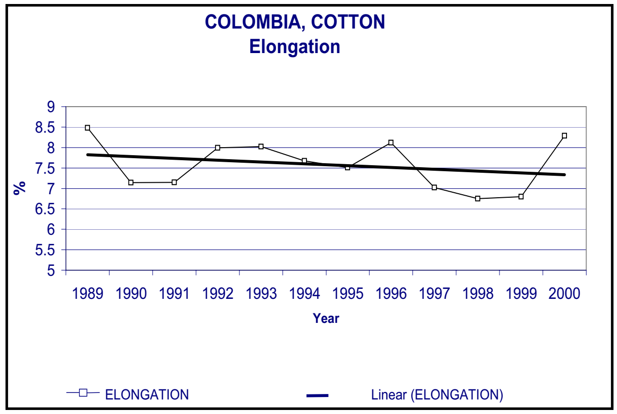
Foreign Matter. The change in this variable is quite noteworthy: from values in the vicinity of 4 in 1995 and 1996, it has been brought down to practically zero.

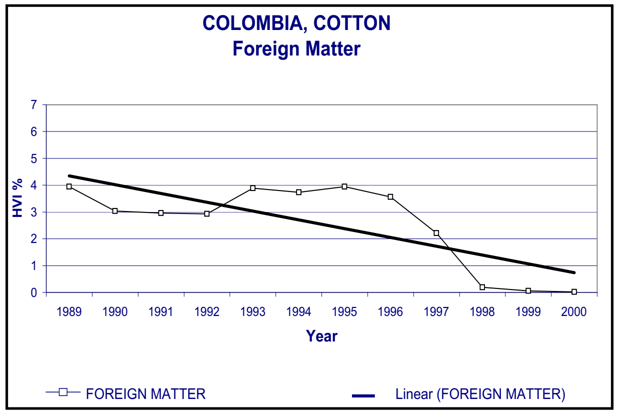
Color. The color factor had been very stable, despite our situation as a tropical country. Its two components, Rd and +b, have very normal characteristics.

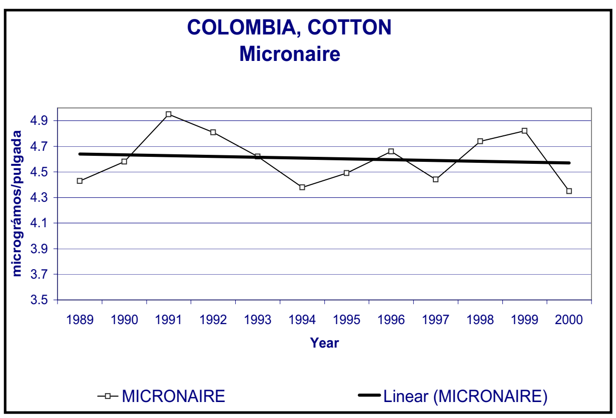
Grade. The average grade of Colombian cottons has been improving year after year and it is presently between MB and SM.

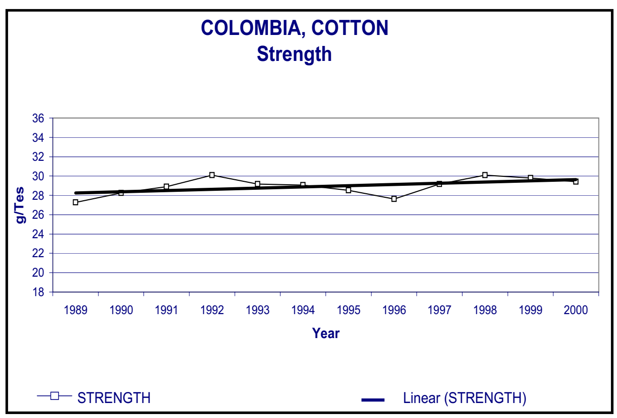
These changes have not taken place by chance; they are, as mentioned earlier, the result of an agreement among producers, their associations, academia and the national government, which has, through the Fondo del Fomento Algodonero (Cotton Development Fund), been doing research that has led to technological innovations, transfers and training.

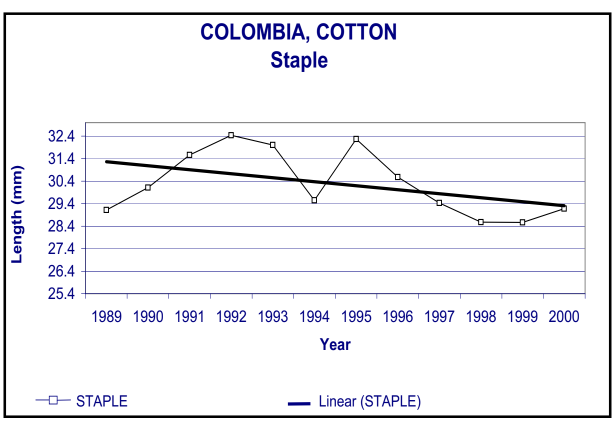
The Fondo del Fomento Algodonero has been developing technological innovations and transfer and training activities through the National Plan for Cotton Research, which is devoted to the generation and implementation

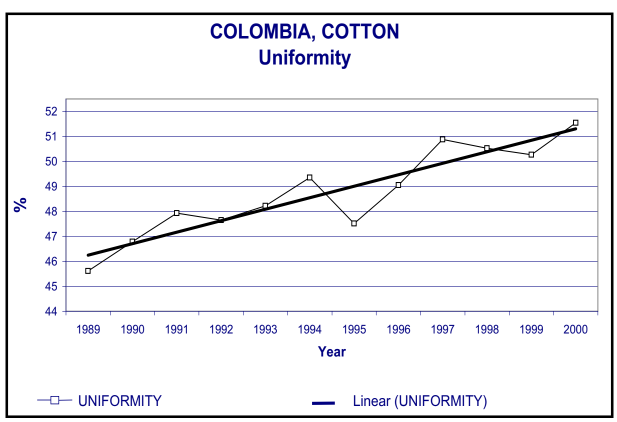


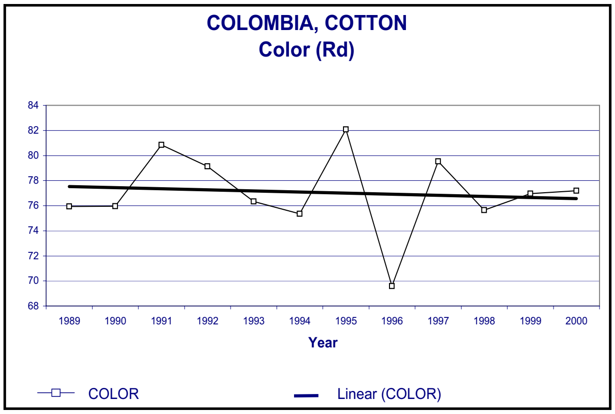


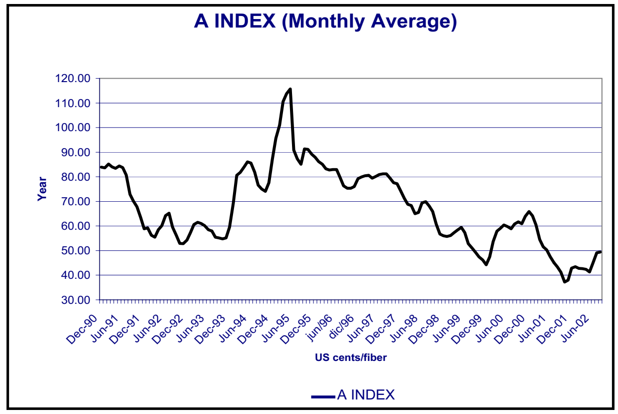


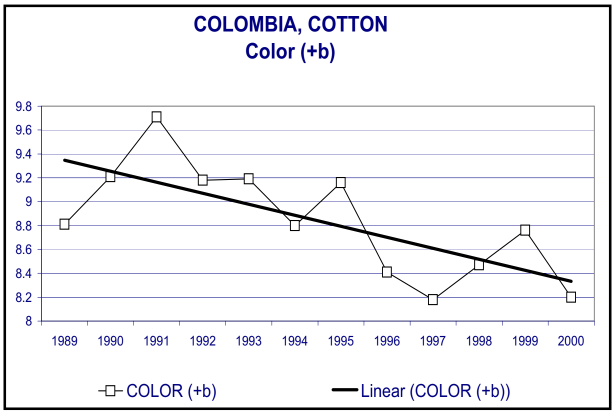


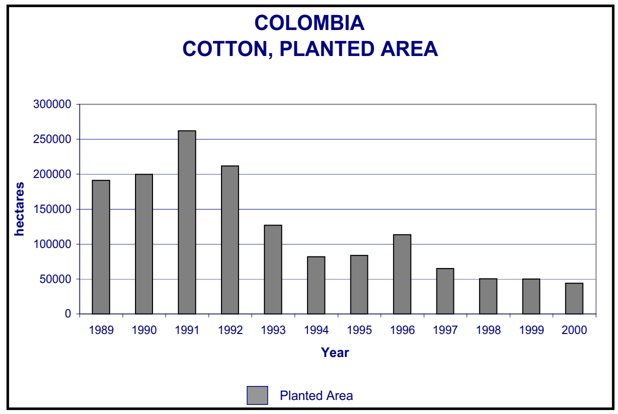












of crop management technologies that will contribute to the sustainability and competitiveness of the cotton production system in Colombia.

The following actions have helped improve the system's competitiveness and sustainability:

- Production of cotton varieties with lint quality characteristics in line with the quality parameters required by the textile industry and adapted to the environmental conditions of the tropical zone.
- Practical implementation of reduced tillage and soil conservation systems in line with conditions in the production areas.
- Implementation of regional pest reduction programs, particularly against the boll weevil, through integrated pest management (IPM) to limit populations to levels below the crop damage threshold in accordance with the ecological characteristics of the production areas.
- Design of an agronomical management package based on the adjustment of planting patterns and growth control to make more efficient use of environmental conditions in each production area.
- Organization of small producers into production units to foster adoption of technological innovations and ensure their impact.

The foregoing have given the country a very acceptable competitive edge thanks to the fact that production costs have been kept steady or even lowered through the following measures:

- The price of domestically produced seed is lower than the seed imported from the United States.
- Modernization of agricultural machinery, particularly in the Sinu valley, has made it possible to reduce the amount of seed per hectare from 25 to 15 kilograms/ha.
- The thinning or spacing work that was formerly done to adjust the final population has been almost eliminated.
- Fertilizers that were spread, often manually, over the fields are now incorporated at the time of planting.
- Over a large part of the area, cotton is planted directly on the remains of the previous crop with no tillage, thus reducing the cost of this operation from some US$50.00/ha to zero.
- Adjustments have been made to the population densities raising them from 35,000 to 80,000 and even 120,000 plants per hectare using the same amount of seed per hectare (15 kg/ha).

- Campaigns have been launched to control migrant populations of boll weevil involving all the farmers in a given region, thus reducing the required number of insecticide applications. In some regions, such as Sur del César, these campaigns have successfully reduced the number of applications against the boll weevil from ten or more to almost two.
- Less expensive generic products with higher marginal returns have been used to control weeds and pests.
- Lint quality has improved thanks to the introduction into the country of varieties with excellent intrinsic quality properties, such as DP Opal, and the increased use of domestic varieties. Selection of the former was done in conjunction with the industry and based on a determination of lint quality parameters in line with the type of yarn to be produced. Thus, all materials that did not meet the established parameters were eliminated. These varieties have the added advantage of performing better in ginning, raising lint yields from 34%-36% by region, to 39% or more when averaged in with the new varieties.

Current Status and Prospects of Transgenic Egyptian Cotton

Osama Ahmed Momtaz, Agricultural Genetic Engineering Research Institute, Egypt

The Egyptian cotton culture and industry started to develop in the 1820s. Improving cotton varieties cultivated in different locations in the delta region and newly reclaimed areas was considered a national priority in 2002. The aim is to increase the profitability of cotton production, and meet the competitive edge with other crops with a major task to increase the total cotton cultivated area in newly reclaimed land in Egypt with maximum cotton quality and quantity production level per hectare.

The target of the cotton biotechnology program is to use advanced recombinant DNA technology to preserve cotton germplasm quality, increase its productivity by resisting biotic factors and tolerating environmental conditions (heat, salt and drought) for the sensitive varieties focusing on producing high quality fiber and maintaining fiber quality and quantity when cultivated in newly reclaimed areas. In coordination with the Cotton Research Institute, new hybrids have been tested in order to select varieties for the improvement of heat and salt stress tolerance using recombinant DNA technology. The Agricultural Genetic Engineering Research Institute (AGERI), the Cotton Research Institute (CRI) of the Agricultural Research Center and the Ministry of Agriculture will supervise final field-testing of the new transgenic cotton hybrids. The following steps have been studied to fulfill this goal:

- Identification and isolation of abiotic stress tolerance genes responsible for heat and salt stress tolerance.
- Development of an eukaryotic vector carrying the indicated gene and selectable marker.
- Creation of an Egyptian cotton transformation system for proven constructs and elaboration of a regeneration system for *Gossypium barbadense* target varieties.

The next step will be molecular studies on transgenic cotton plants at different levels (in the controlled environment, greenhouse and confined field-testing).

The main goal of the cotton biotechnology program at AGERI is to develop new biotechnological approaches to control insects with minimal use of insecticides, a step in this direction is to produce transgenic Egyptian cotton varieties that resist insects and tolerate abiotic stress (heat, salt and drought). Genes, which have the potential to improve cotton quantity and quality, must be identified, manipulated, and genetically engineered into a genotype that cotton breeders can effectively utilize. Identification of genes resistant to insects, and to adverse growing conditions like high temperature, soil salinity and drought and their incorporation into new varieties will have a direct impact on the productivity of the plant. With the transformation process becoming more successful, genetic engineering is going to be a major thrust in cotton research and production.

Main achievements of the program:

1- In vitro regeneration and transformation of Egyptian cotton varieties.

2- Study of key proteins and their genes responsible for salt, drought, heat stress tolerance, and insect resistance (multiple adversity resistant genes).

3- Development of transgenic Egyptian cotton varieties, resistant to insects, using Bt genes molecules, CryI(A)b and CryI(A)c with targeted activities for the pink bollworm.

4- Study properties and biochemical functions of key factors responsible for fiber initiation and development for fiber quality maintenance and improvement.

5- Isolation and purification of megabase size DNA and construction of Egyptian megabase DNA bacterial artificial chromosome (BAC) libraries to be used in gene family identification and map-based cloning.

6- Development of transgenic cotton tolerant to abiotic stress via carbohydrate accumulation via overexpression of manitole dehydrogenase gene and fructane synthase gene for manitole and fructan accumulation and also, via amino acid accumulation using over expression of Delta-1-Pyrroline-5-Carboxylate Synthase gene.

Additional progress in these areas is likely to be achieved in a shorter period of time than before due to new developments in gene identification and transformation technologies. Genomic technologies associated with structural, functional and bioinformatics are being developed under the AGERI biotechnology program targeting the most needed economic traits for Egyptian cotton such as fiber quality, earliness and multiple adversity gene families associated with host plant resistance. Using new AGERI genomic laboratory facilities and BAC libraries that are developed, screening for these traits is carried out. Several genes for stress resistance and fiber modification are being tested in various laboratories. New genes for insect and herbicide resistance are being sought. A strategy to modify fiber using metabolic pathway engineering to produce aliphatic polyester compounds is under development. Particle bombardment technology has been developed to introduce and test genes in elite varieties of cotton, without the need for regeneration or other tissue culture practices and backcrossing. These developments will lead to improved agronomical and fiber traits in cotton and enable the industry to expand its market share.

Impact of Transgenic Cotton on the International Cotton Trade

Neal P. Gillen, American Cotton Shippers Association, USA

Introduction

This paper is presented at the invitation of the International Cotton Advisory Committee, and the material presented documents the reported experiences of the international cotton trade in addition to relying on the available scientific literature documenting the use of insect resistant cotton seeds and Roundup Ready cottons.

Discussion

The controversy generated by the transgenic modification of fruits, vegetables, and feed crops has not affected the international trade in cotton. While some questions were raised by environmental activists in England and Germany at the onset of the use of insect resistant (Bt) and herbicide tolerant (Roundup Ready) cottons in 1996 and 1997, the cotton industry has effectively communicated to the environmental and political communities and to the consumer through sound scientific evidence of benefits to the soil, fauna, beneficial insects, birds, fish, wild life, and the ground and surface water through a substantial reduction in the use of pesticides.

The other important attributes of the new genetic varieties are the significant reductions in costs achieved through reduced use of pesticides and the increase in yields. In 2002, about 25-30% of total world production is transgenic cotton. Based on the increase in the use of the new seeds it is estimated that by 2005 approximately 50 percent of the total world production will make use of the new genetic varieties and the level should encompass two-thirds of production by 2008[1]. The benefits of the new varieties come at a critical time, as they will allow small producers in Africa, China, India, and Brazil to reduce their production costs and be more competitive with producers from the developed nations. The needed breakthroughs have come in two categories, insect resistance and weed control.

Insect Resistant Cotton

Since the transgenic cotton carrying the insect-resistant Bt gene was commercialized in the United States in 1996 the research data[2] documents that Bt cotton has provided 95 percent control of the tobacco budworm; 90 percent control of the cotton bollworm (pre-bloom) and 70 percent control of the cotton bollworm (bloom); and 99 percent control of the pink bollworm. More importantly, yield losses were suppressed. The adoption of Bt varieties was extremely rapid in states that experienced resistance problems (Arizona, Alabama, Georgia, Florida). After a year of very high budworm populations and damage in 1995, growers in Alabama adopted the new technology at an extremely rapid rate, planting over 60% of total acreage to Bt varieties in 1996. The results were astounding and Bt cotton is credited with saving the cotton industry in

Alabama. At the 26th International Cotton Conference in Bremen this year, Hugh H. Summerville, a cotton producer from Aliceville, Alabama reported that prior to 1996, "it was normal to spray a cotton crop about 15 times to control insects and 6 times to control weeds and grass. Over the entire growing season those sprays could include 8 to 10 different insecticides and a similar number of herbicides." Summerville reported that he planted a Bt seed the following year and that in the past six years he has not sprayed his cotton crop with any insecticides. He only uses three Round-Up sprays. "One early spray over the top of the crop and two sprays directed to the base of the stalk. No herbicide is used which leaves any residual in the soil, as was the common practice before Round-Up Ready cotton."

In 2001, 42% of the cotton acreage (over 6 million acres) in the United States was in Bt and Stacked Gene varieties. Adoption has been low in California (5%) because the worm pests are not a problem in the San Joaquin Valley. Adoption has also increased in certain states (Mississippi, Louisiana, Texas, Oklahoma, Arkansas, and Tennessee) due to the implementation of the Boll Weevil Eradication Programs (BWEP) given that producers in BWEP areas are advised to plant Bt cotton due to the negative effects of the weevil sprays on predators of bollworms/budworms. It is estimated that insecticide use was lowered by 1.9 million pounds in 2000 as a result of planting insect resistant (Bt) cotton[3].

Weed Control

In the last sixty years, the rigors of controlling weeds during cotton production advanced from manual labor to the use of herbicides in order to suppress the decline in yields. Up until 1952, the use of the hoe reigned supreme as herbicides were used on only 5 percent of the U.S. acreage. By 1976, the level of use increased to 84 percent. By 1997, the U.S. cotton industry had reached a new era of weed control through the use of Round-Up Ready and Stacked Gene varieties of seed that were utilized on about 70 percent of the planted acreage in 2001 (USDA, AMS). In only four years the amount of herbicide use fell by almost 20 percent. It is estimated (Gianessi, et al.) that in 2001 herbicide use was reduced by 6.2 million pounds from 1997 use due to the decline in use rate per acre, although glyphsoate (RR) (which is much safer than the replaced herbicides) use increased considerably. Also, production costs were significantly reduced. Here, it is important to note that in those cases where herbicide use could not be reduced, the availability of glyphsoate (RR), a much safer material, has proven to be a beneficial improvement. These developments portend great advances in cotton production throughout the world, particularly for producers in the developing nations.

Issues Pertaining to New Genetic Varieties

Three levels of federal regulation administered by the U.S. Food & Drug Administration, the U.S. Department of Agriculture, and the Environmental Protection Agency assure the U.S. consumer of safe food and fiber products. These overlapping jurisdictions govern the use of new seed varieties and the application of chemicals to agricultural products in order to assure that food and fiber are fit for human consumption and utilization and that chemicals or pharmaceutical products applied to agricultural products or fed to poultry and livestock are not harmful to the plant, animal, or environment and most importantly to the ultimate consumer. The basis for the U.S. regulatory process in this area is "sound science". In contrast, in Europe the regulatory process appears to be based on the so-called "precautionary principle." As a result you have in Europe a confusing mix of regulatory rules, which in some instances are dictated by emotional politics. More so than the United States, there are significant political variations both between the various European Union (EU) member states and between the states and the EU institutions. Unlike the United States, Europe is a diverse group of countries; peoples with different cultures and languages making it difficult to reach a consensus on this and other thorny issues.

Moreover, given the trust the U.S. consumer places in the regulatory framework, the new advances in technology, particularly in fruits, vegetables, and feed grain products, have been accepted by the consumer. The U.S. food industry does an effective job of educating its consumers regarding the sound research involved in new product development and the government approval process required to bring these products to market.

Yes, there have been questions raised by environmental organizations, but a full and transparent debate of the subject in the U.S. media established that the concerns expressed had no basis in fact. The U.S. consumer and the U.S. political system reviewed the facts and concluded that based on the principle of "sound science" that transgenically modified food crops are beneficial to the environment and that there is no evidence of any potential harm through their consumption.

Simply put, the debate surrounding agricultural biotechnology has been riddled with misinformation and hyperbole. When confusing and inaccurate information is presented to consumers, it is easy to get a false impression of the attributes of transgenic cotton. As previously noted the U.S. regulatory process is fully focused on the environmental impact and consumer safety and these vigilant government entities have determined that the insect-protected and herbicide-tolerant transgenic cottons are beneficial to the environment and safe for consumers to use. These cottons have all of cotton's consumer-friendly characteristics and people throughout the world have been wearing clothes made with fiber produced from transgenic cottonseed for several years. It is estimated that some 20 billion garments and home furnishings are in use worldwide with no adverse consumer impact[4].

Acceptance of Transgenic Cotton By Textile Mills & Consumers

The case for cotton fiber is even stronger, given that the fiber itself goes through extensive processing phases as it moves from the field, to the gin, yarn production, knitting or weaving, bleaching, and dyeing and finishing before being utilized by the ultimate consumer. Cotton byproducts used in personal care products, and cotton seed oil and meal also go through an extensive processing phase before being consumed as animal feed or utilized as cooking oil, salad oil, or margarine. Thus, transgenic proteins and DNA, which are not toxic or allergic to humans, also cannot be detected in consumer products produced by transgenic cottons.

A review of the scientific and safety literature indicates that transgenic cotton does not pose any different risks to human or animal health than conventional cotton varieties. More importantly, there are no reported instances, other than antidotal in the form a few mill complaints pertaining to fiber quality characteristics, of any problems being incurred in the use and consumption of cotton fiber or any of its seed byproducts.

In the review of the fiber quality characteristics of conventional and transgenic varieties of cotton, the literature[5] discussing fiber analysis concludes that there are no meaningful differences in micronaire, leaf grade, color, length and length uniformity, strength, and elongation. The scientific literature makes it clear that quality variations are due to environmental factors or growing conditions.

While the benefits to the farmer are significant, the U.S. consumer is more impressed with the benefits to the environment with the steady improvement in wild life habitat and the quality of the ground water in cotton producing areas. The new cotton varieties have clearly demonstrated they are environmentally sound and beneficial and this case has been effectively made to the consumers of U.S. cotton in its major export markets throughout the world. No single case is known where the seed variety was questioned or rejected. If anything, there is a growing acceptance of the new varieties. It cannot pinpointed how much of the 11 million bales of U.S. cotton sold in the export market this past season are transgenic cottons, but we estimate it is no more than half given that much of the Eastern U.S. cottons, where transgenic cottons are used to the greatest extent, moves into domestic consumption. Neither do we represent or provide warranties in our contracts that the raw upland cotton being marketed is produced from such seed since we cannot make such a guarantee as the ginner does not provide such information to the buyer. U.S. cotton is sold on the quality terms assigned by the U.S. Department of Agriculture and the only guarantee that U.S. exporters can make pertains to the qualities they merchandise.

Conclusion

There is no problem with the acceptance of transgenic cottons by the world textile industry given there are no differences in the quality characteristics. While there may be perceived problems by uninformed consumers in certain European markets the great majority of the world's consumers of cotton have been fully assured of its safe use and they have readily accepted this positive development knowing of the benefits to the environment. Further, lower production costs associated with transgenic cottons assures the availability of cotton products and byproducts at competitive and affordable prices. Given these reasons transgenic cotton varieties have been fully

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New Directions in Cotton Research Management

Ralph Schulzé, Cotton Research and Development Corporation, Australia

Cotton Research needs to be planned and managed strategically. Gone are the days of ad hoc, disjointed, uncoordinated research, where the only outcomes seemed to be benevolence and continuing employment.

The "New Directions" for research management will be driven by strategic planning. There will be a vision and goals and a plan to reach those goals. And performance indicators will be used to measure success in implementing those plans.

Research funding which is becoming tighter everywhere, will be viewed more and more as an investment portfolio. This needs to be managed to achieve improved returns.

The Strategic Plan

Although these views are influenced by the Australian experience, the principles are universal. Australia has two bodies responsible for coordinating cotton research - the Cotton Research & Development Corporation and the Australian Cotton Cooperative Research Centre. Both work very closely together and share common objectives.

As the first step in formulating (or reviewing) a Strategic Plan, the coordinating bodies seek input and involvement from all sectors of the cotton industry - farmers, field consultants, researchers, industry service personnel, universities, state and federal government agencies, merchants, spinners and the regional community. Collectively we seek a common industry vision.

The process is a robust one and the outcome is a strategic plan for the whole industry. Research is only part of the plan, but it provides the engine room to drive the plan. As part of the process research needs and gaps are identified - and then addressed. Another important outcome is that everyone shares in the ownership of the plan, and generally agree on the need for performance indicators to measure success.

Our Strategic Plan needs to have balance so that we can address short and long term needs. This balance will include fundamental (blue sky), strategic and applied research. It will also depend on a very effective extension effort supported by good communications and decision support tools. As an observation it is to comment that the lack of a well supported extension program is holding more countries back than any lack of academic research. It really gets back to balance and common vision.

The shared vision is to achieve and maintain a successful and sustainable cotton industry. This is to suggest that it is an universal vision with a universal objective - SUSTAINABILITY.

Sustainability and the Triple Bottom Line

A key "future direction" will be to measure the performance of research in addressing each of the components of sustainability - economic, environmental and social. As investors we will need to report against this Triple Bottom Line. For guidance, some of the following examples can be used as performance indicators:

Economic Indicators

Yield

As a simple performance indicator yields can be graphed over time. The Australian example:

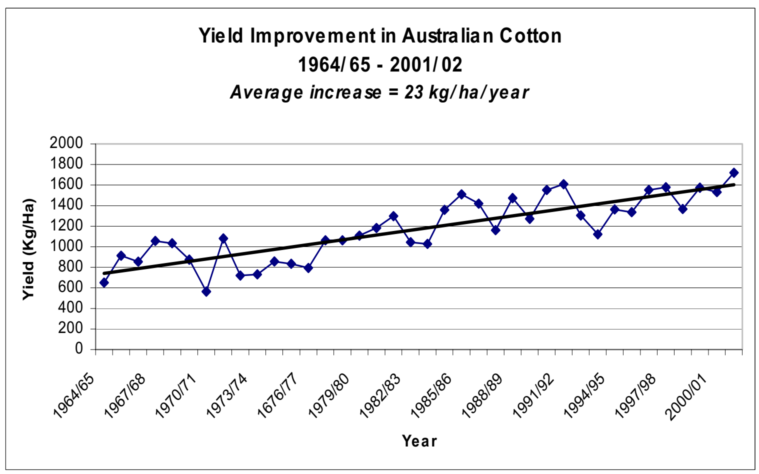


Fig. 1

Studies have separated the components of this progress. Just under half is attributed to plant breeding and the remainder to the adoption of improved production technology, and farming practice.

Key Observation:

The yield increases have been achieved in an unprotected unsubsidized economic environment. As a comparison in the USA, where production is subsidized, yields over this period have plateaued. Why? Probably because there is no imperative to improve and to remain competitive.

Fiber Quality

Again improvements can be graphed over time but because of all the parameters this is difficult to simplify. However, Australian historic data confirm that fiber quality from Commonwealth Scientific and Industrial Research Organization (CSIRO) bred varieties has improved along with yield. CSIRO plant breeders have broken the nexus between improving quality and decreasing yield. However these improvements in fibre are only partly reflected in improved prices for raw cotton. Why?

Key Observation:

Despite the widespread use of HVI and other forms of objective measurement which can better reflect value to a spinner, world trade and world prices are still influenced by outmoded subjective systems such as the USDA classing system.

There is an urgent need for an international collaborative effort to replace these superseded and somewhat irrelevant systems with a more repeatable, relevant, objectively measured and internationally acceptable system. This should help both spinners and farmers, and should be less susceptible to claim and counter claim.

Other Varietal Improvements

Many other improvements can be measured. Increased resistance to diseases like verticillium wilt and bacterial blight can be demonstrated - as can increased earliness, or Host Plant Resistance, or improved agronomic characteristics.

Cost of Production

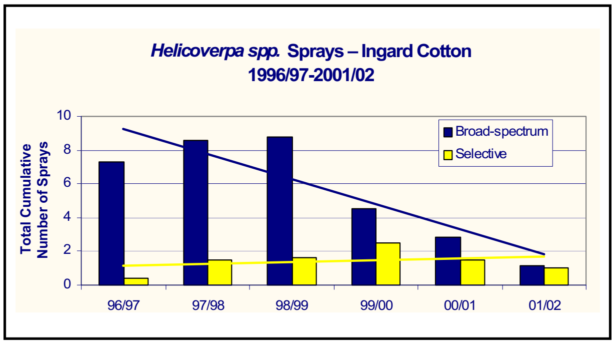
Because these are influenced by so many factors, movements in cost of production are not simple or straightforward performance indicators. It is more meaningful when viewed as cost per kg of fibre rather than cost per hectare.

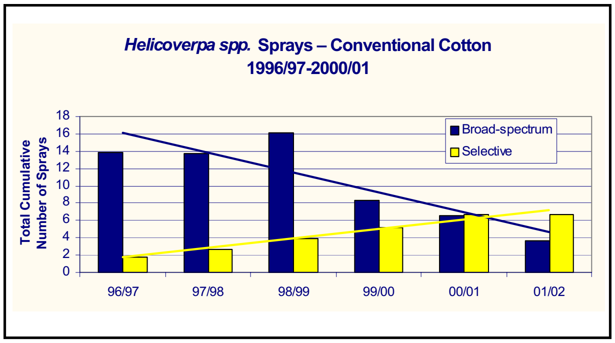
It is in this area that we must admit that we are not winning - we have virtually gone as far as we can go.

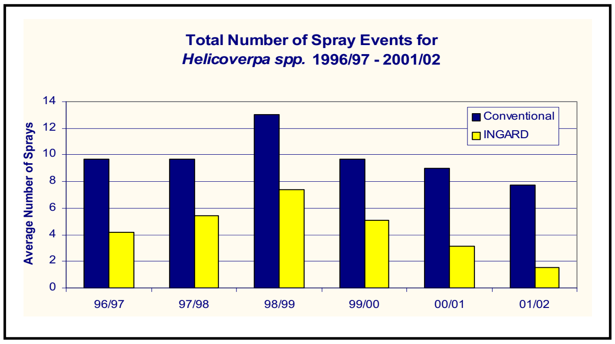
Many inputs are imported, e.g. pesticides and biotechnology, which are strongly influenced by exchange rates. Some are discriminatory and costly. For example the cost of Monsanto's Bt technology to an Australian farmer is higher than it is to an American farmer.

Environmental Performance Indicators

Some societies pay vocal lip service to ecological sustainability - but never practice what they preach. But in cotton we do need to get it right. Then as a sustainably produced natural fibre we can better compete with petro chemical synthetic (and unsustainable) fibres.







To demonstrate progress in a real way, tangible indicators are required. Some Australian examples:

Pesticide Use

To achieve sustainability there is a need to reduce dependence on traditional pesticides. There is a need to achieve balance and tools like integrated pest management, including access to genetically modified host plant resistance, can help us to achieve this. In Australia, regular surveys are used to monitor changes in this area.

Riverine Environment

Measuring riverine contamination (biological and chemical) is a powerful performance indicator. In Australia's cotton regions, the various rivers are continuously monitored-with a rewarding result.

Best Management Practice - BMP

The aim of the Australian BMP program is to protect our natural resources by implementing "stewardship". Essentially BMP is an environmental management system but it also addresses the need to produce "Clean Green Cotton".

We have a robust Audit Program and this measures adoption and progress. This is continuing at a steady pace and we are now past the half way mark. It is this progress which has contributed to the "healthier rivers" graph above.

Improving Farming Practices

Through survey we can measure the uptake of more sustainable farming practices. Minimum tillage, crop rotation, and Heliothis Resistance Management and Area Wide Pest Management strategies, are examples. Another is improvement in water use efficiency and consumption. Currently this averages around 1 megalitre (one million liters) per bale per hectare but research indicates that we should strive for an average of 0.8 megalitres per bale per hectare. This is the equivalent of 80mm or 3.2 inches of rain per bale per hectare - a challenge.

Social Indicators

Social sustainability is the third leg of the Triple Bottom Line. Essentially it is the product of both economic and ecological performance. Social change can be measured e.g. by demographics and family income etc, but it is difficult to isolate the specific contribution of "cotton" to this social change. Some indicators which could be considered include:

- the loss of rural and regional population to congested urban areas

- new jobs and business opportunities created or lost

- the maintenance (or loss) of essential services and infrastructure

- the maintenance (or loss) of family structure and family farm viability.

Key Observation:

A flow on effect from protectionism and subsidisation in affluent societies is damage to the regional social structure in unprotected societies. This raises the issue of what some people call the fourth leg - moral sustainability.

Even in protected societies there is a need to gradually reduce the 'cargo cult' subsidy dependence - as if it happens suddenly, which is the only other alternative, the consequences could be traumatic. A clear choice!

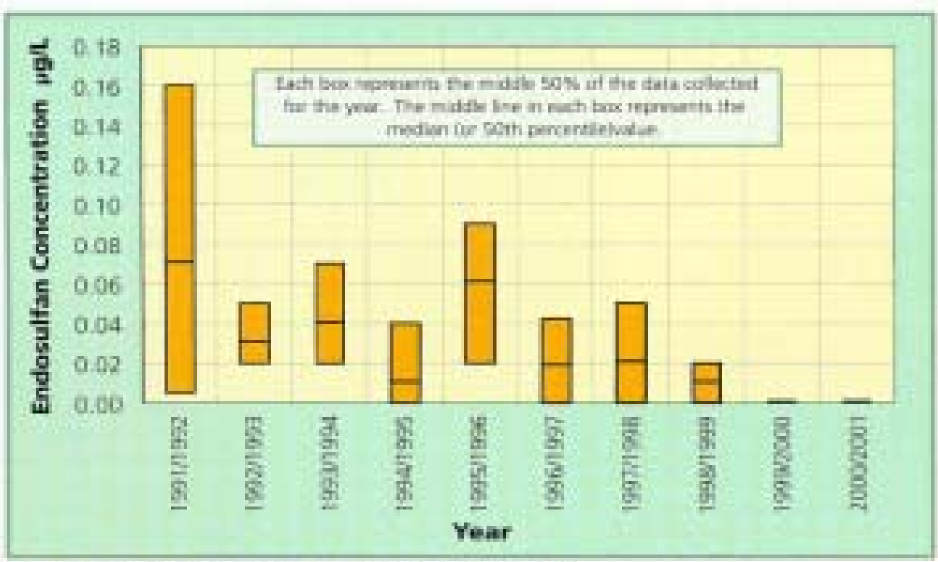
The Fourth Leg - Moral Sustainability

Many of the failures of earlier civilisation - including those in this part of the world - can be attributed to the failure to achieve sustainability. In some cases it has been moral decline which has triggered, or influenced, that failure.

In the international cotton world we do need to consider issues or practices which may not be morally sustainable. Abuse of the sanctity of contracts is an obvious example. Misrepresentation or failure to market 'true to label' is another. Corruption and dishonesty are others.

Key Observation:

The Fiber Max varieties produced in the US are of Australian CSIRO origin. The intellectual property is legally protected by Plant Breeder Rights (PBR), trademarks etc. So why is there 'trade talk' that there is possibly three times as much Fiber Max cotton marketed, as is actually produced?



Endosulfan concentrations detected since 1991.

Another issue which embraces all four legs of sustainability, is international collaboration in research. It is a Win:Win situation when researchers wholesomely exchange views and experience. Hopefully this will be an outcome of the Third World Cotton Research Conference WCRC-3 to be held in Cape Town in March 2003. Researchers should be encouraged to join in and share that experience at WCRC-3.

An Interdisciplinary Approach to the Improvement of Fiber Quality

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Introduction

Cotton is a crop that has been associated with ancient civilizations and that has contributed greatly to the industrial and economic development of many countries. Its great value and the need for cotton products have ensured its survival as one of the world's most widely cultivated and major cash crop, despite the stiff competition it faces from man-made fibers.

Four of the cultivated species are considered to be of major agricultural importance. They produce spinnable lint which is of great value to the textile industry. Two of the four species are diploids (2N = 2X = 26) and are represented by *Gossypium arboreum* and *Gossypium herbaceum* (L). The diploid cotton is still grown in Asia and is often referred to as Asiatic cotton. The other two species are tetraploids (2N = 4X = 52) and are represented by *Gossypium barbadense* (L), often referred to as Sea Island or Egyptian cotton, and *Gossypium hirsutum* (L) or Upland cotton. *Gossypium hirsutum* (L) is by far the most widely cultivated cotton species in the world. It is reported to be contributing over 90% of the total cotton produced worldwide. *G. barbadense* contributes about 5% and diploid or Asiatic cotton also contribute about 5%.

Lint is the most important industrial raw material for which cotton is widely cultivated. It is composed of fibers which are outgrowths from the outer layer of the seed-coat. The fibers increase both in length and thickness, forming lint, which is easily removed from the seed surface by ginning. Lint can naturally be of different colours, but the most widely cultivated cotton produces white lint (Emeetai-Areke, 1999).

Fiber Quality

The following are the main factors that contribute to fiber quality:

Fiber length

This is the length of the fiber or staple length in mm and is one of the fiber quality characters that are important to the textile industry.

Fiber strength

High tensile strength is needed for good spinning, especially with modern fast spinning machines. The strength of the fiber is determined by securing a bundle of fiber between clamps set 32 mm apart and measuring the force required to break the fiber.

Micronaire (fiber fineness)

Cotton fiber may be classified as soft and silky or coarse and harsh. Fineness is expressed in micronaire units. Micronaire is a measure of the rate at which air, at standard pressure, flows through a standard volume of cotton lint. The finer the fiber, the slower the rate of airflow because fine fibers pack more closely together, and hence the lower the micronaire value. This quality characteristic is also important in the selection of fiber that is suitable for manufacturing a particular product.

Uniformity of fiber length

This is also an important lint quality characteristic which is indicative of the maturity of the fiber. The value is taken as a ratio of 50% span length to 2.5% span length of a sample of combed fiber. This value is important in determining the spinning performance and utility of the lint. Higher values are an indication that the yarn spun from such fiber will be uniform in size and strength and that less fiber will be wasted.

The ginning and textile industries are dependent mainly on the fiber quality characteristics mentioned above.

Yield

At the same time, the producer has a different interest, namely yield.

The following aspects determine yield:

Boll size

Boll size, determined by weighing the boll, is indicative of the performance of a genotype. The larger the boll, the heavier the yield expected. Large-bolled genotypes are thus considered higher yielders.

Seeds per boll

Seeds are the units of lint production. Fiber grows from the outer cells of the seed surface. The larger the seed surface, the larger the amount of lint produced. The number of seeds per boll is, therefore, another good indicator of the genotype's yield performance.

Number of bolls

The number of bolls per plant or per unit area is an important indicator of the performance of a cotton genotype (Emeetai-Areke, 1999).

Yield is a high priority for the producer and quality goes hand in hand with yield.

Ginning out-turn

Ginning out-turn is a useful indicator of the performance of a genotype. Ginning out-turn can be described as the percentage of lint obtained from a sample of seed cotton. Genotypes with high ginning out-turn values are thus preferable, because they yield more lint.

Factors That Influence Fiber Quality

The major factors that influence fiber quality are:

- Genetic inheritance
- Growth period
- Moisture
- Fertilizer
- Diseases
- Soil condition
- Pests
- Weed control

Genetic inheritance

Over the last decade, the average strength of US Upland cotton has increased by 3.4 grams/tex, the average staple length has also increased, the average length and uniformity index has increased by nearly one index unit and the percentage of white grades in the crop has increased by over 20 per cent (Raleigh, 1996). In South Africa, fiber properties show an increase in strength, micronaire and length, which reflects the improvement brought about by breeding (Fig 1).

The inheritance of fiber properties in selected varietal types of Upland cotton (*Gossypium hirsutum*) indicated that the heritability estimates for these characters ranged from 0.01 for fiber fineness to 0.62 for fiber strength, or 1 and 62 per cent respectively (Quisenberry, 1973).

A study indicated that the parental differences in fiber length were controlled by one gene, while differences in fiber strength and fineness were separately controlled by two genes.

Only fiber strength is positively correlated with yield. Negative correlations were observed for micronaire and fiber length.

Percentage ginning out-turn, staple length and fiber fineness exhibited low genetic advances irrespective of their high heritability estimates, probably due to non-additive gene effects (Larik, 1997).

Growth period

It is well known that cotton is a warm weather crop, which responds to high heat units.

Fig 2 indicates that a higher temperature regime has a positive effect on micronaire, while in the case of fiber length and strength its effect varies from one season to another.

Moisture

Although the cotton plant can survive severe drought, sufficient moisture is critical at certain growth stages. Re-

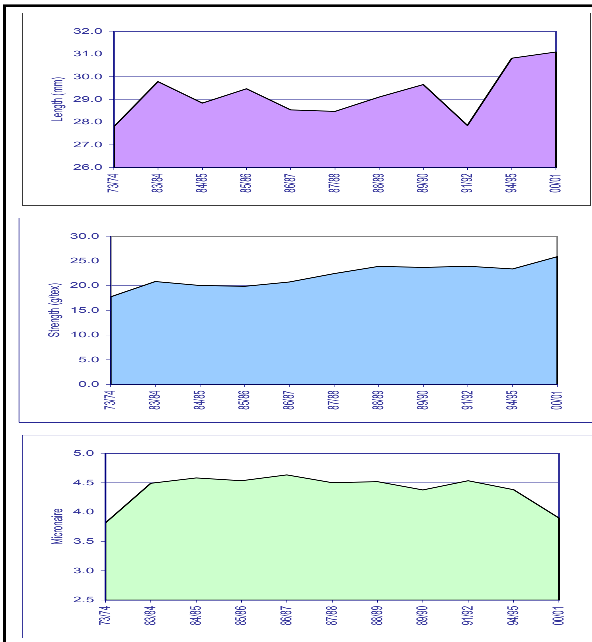


Fig. 1 Fiber properties in South Africa during the past 28 years.

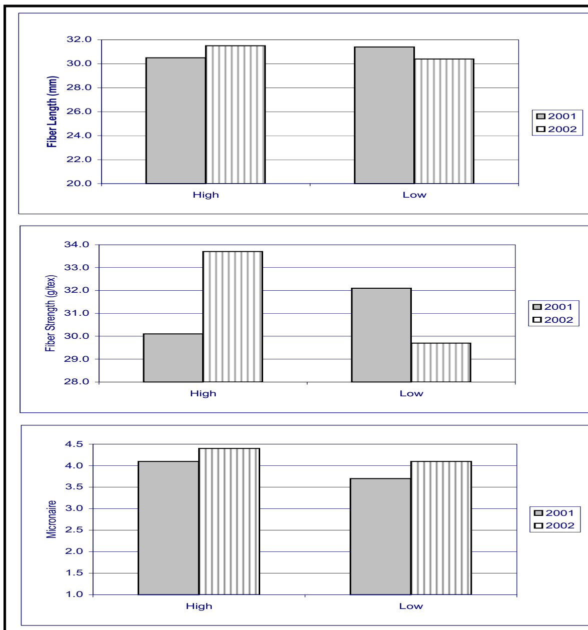


Fig 2. Fiber properties of cotton at different localities with high and low temperature regimes.

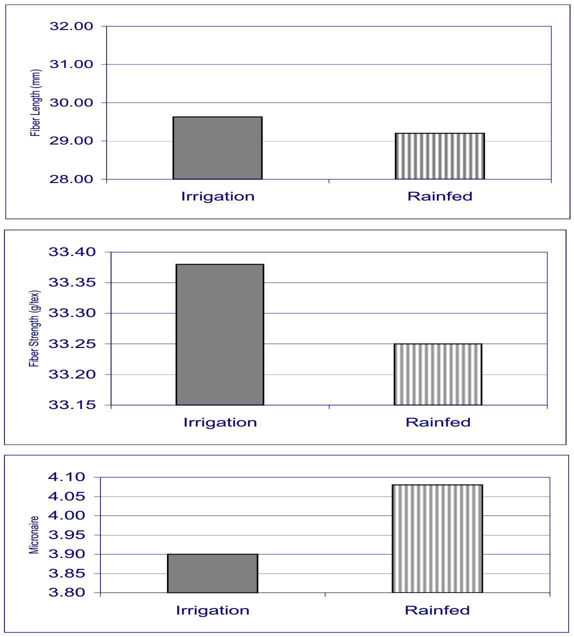


Fig 3. Effect of irrigation and rainfed conditions on fiber properties of cotton.

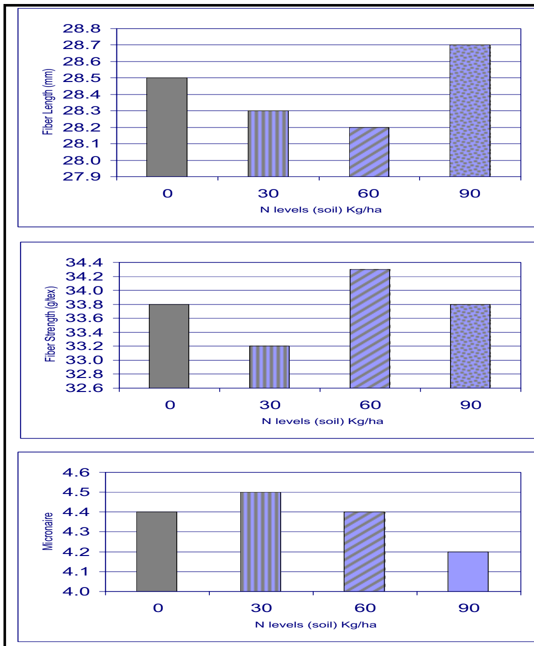


Fig. 4 Fiber properties under rainfed with different N levels.

sults indicate that fiber length and strength will be improved by irrigation, while in the case of micronaire, the opposite is true (Fig 3).

Fertilizer

Results indicated that P had no positive effect on fiber properties, while N and K improved fiber strength. Recent studies, in which different levels of N were applied under rainfed conditions, showed that N had a positive effect not only on strength, but also on length and micronaire (Fig 4).

Diseases

The effect of different cotton diseases on fiber quality was monitored over various seasons and localities and the results indicated that diseases could cause a 10-15% reduction in fiber quality.

Soil conditions

Studies conducted in different cotton-producing areas indicated that soil conditions had a minor effect on fiber quality, but only when all the other growing conditions were optimal. Where different cotton cultivars were grown on clay and sandy soils, the micronaire values were higher on clay soil. The effect of soil conditions on fiber length and strength was not clear (Fig 5).

Pests

The effect of pests on fiber quality was difficult to determine, because in many cases the bolls had been shed or had produced no fiber. Recent results indicate that micronaire can drop by 20% and yield by 50-80% if pest control is inadequate.

Weed control

Proper weed control is extremely important in ensuring a high cotton yield. On the other hand, there was no evidence that weeds had a direct drastic effect on the fiber quality.

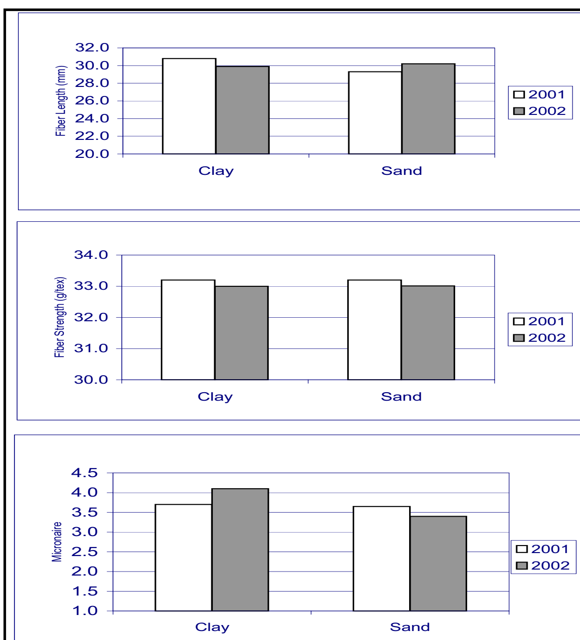


Fig 5. Fiber properties of cotton with a clay and sandy soil.

Disciplines Involved in Improving Fiber Quality

In general, four major disciplines are involved in improving fiber quality, viz. (1) cultivar development, (2) crop science, (3) pest control and (4) plant pathology.

Cultivar development

One must acknowledge the contribution of breeding in the development of Bt and non-Bt cotton cultivars. Calculations made over a long period with different parameters show that the genetic potential of a cultivar can account for up to 50% of the fiber quality.

Crop science

Crop science makes an 18% contribution to fiber quality. The growth period, moisture, correct fertilization and weed control all play a part in the improvement of fiber quality.

Pest control

Although the effect of pests on fiber quality is difficult to determine, studies indicate that pest damage could cause a 20% drop in fiber quality.

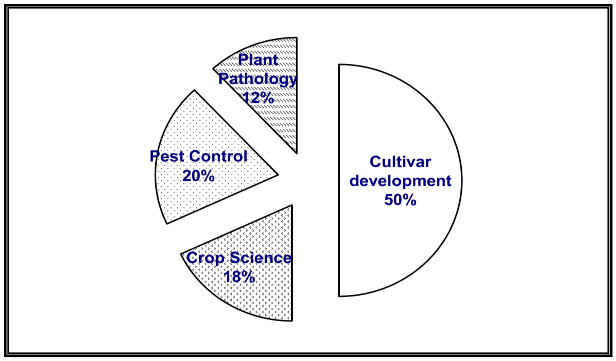
Plant pathology

As indicated, cotton diseases can cause a 12% drop in fiber quality.

Summary

The gene pool makes the highest contribution to the improvement of fiber quality, but the importance of crop science, pest control and plant pathology in achieving and sustaining high fiber quality must be acknowledged. Even the best-yielding cultivar with the best fiber properties will perform moderately, if all the disciplines are not optimized. It is important than an interdisciplinary approach to cotton production is promoted.

Plant breeding has made a huge contribution. It is time for agronomy and plant protection to make their contributions (Fig 6).



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Challenges for Fiber Quality Measurement

Iwona Frydrych[1,2] and Malgorzata Matusiak[1], Institute of Textile Architecture[1],
Technical University of Lodz[2], Poland

Introduction

Cotton as a natural fiber is characterized by a big variance of properties in each lot, as well as by a diversity of particular lots arising from different cultivation regions and from different seasons. Basic cotton fiber properties like: maturity, length, fineness, tenacity, color and so on depend on the cotton variety as well as climatic and soil conditions, in which the cotton plant is growing and maturing. Significant for cotton quality, is also the way of ginning. Saw ginning destructs fibers more than roller ginning. Therefore, we can say that the challenges for fiber quality measurement occur as a result of:

a) variability in cotton fiber measurements (such parameters like length, fineness), and properties like tenacity and strain, color and maturity,

b) changes in fiber processing ability into half-products (yarn) and final products (finished fabrics),

c) changes of consumer predilections - here a big influence have the finishing process and possibility of creating different plastic forms of goods, their roughness and so on.

With regard to a) one may face some serious difficulties, because natural fibers have specific trends in creating their shape and properties. For example, cotton hairs on the seed have different length, fineness and strength. (Similar tendencies are observed also in wool. Also in silk filaments we observe the characteristic changes of their properties.)

Fig.1. Uster® HVI Spectrum

Therefore, a "compulsory" blend of bodies of different morphological and technological properties is created. Assessing specialists face the problem of establishing how a particular feature influences the fiber behavior during processing (b). Chemical fibers play a big help in this area – continuous thanks to the possibility of creating a wide range of dimensions and shape.

All these factors make complex and precise assessment of basic fiber parameters and quality classification a very important problem for cotton cultivation, trade and processing. Efforts are undertaken to improve the existing measurement methods or to develop new ones for a better, comprehensive and objective fiber assessment. During the years, an evolution of quality classification methods has started from a subjective organoleptical assessment done by specially qualified classers into a direction of objective, instrumental measurement methods.

In the field of development of devices and methods of cotton parameter assessment a lot of work has already been done. We have entered the new millenium with many measurement systems at our disposal enabling not only determination of particular parameters, but also complex statistical assessment assured knowledge about the raw cotton necessary for an economical success of cultivation, trading and processing. It has actually a big and still growing significance in a situation of dynamically growing competition with man-made fibers pushing out cotton from some fields of application (especially from the area of the technical textiles).

A lot of work has been done in the field of fiber quality measurement, but for sure not everything. Which parameters should also be measured to make our knowledge about the cotton quality more intensive? How to improve the quality of measurements and credibility of results? Which else challenges are standing in front of the designers and producers of modern measurement systems for cotton assessment?

Measurement Systems and the Measured Parameters

Modern instruments allow determination of bundle or individual fiber measurements not only such basic physical-mechanical fiber parameters like length, tenacity, strain, fineness or micronaire, but also maturity, stickiness, color, trash and nep content. Moreover, the possibility also exists to obtain additional information like mean nep size and nep size distribution or seed coat nep distribution, mean size and distribution of size of trash particles as well as their structure (trash, dust, fiber fragments on MDTA-3).

Fig.2.AFIS

Fig. 3. FCT/ Fiberlab

Improvement of Existing Methods

An important challenge seems to be the exact fiber strength measurement. Cotton fiber tenacity is one of the main factors that affect cotton price. The tenacity measurement has already been done on the HVI line. It is a good measurement only when relative values for a comparison purpose are needed – just to put the examined cottons into an order from the strongest to the weakest. But, if the exact value of breaking force or of tenacity for the purpose of predicting some yarn properties is needed, one need to know the breaking force of single fibers. It is possible to recalculate bundle breaking force into the single breaking force assuming different distributions of single fiber breaking strain, but the values obtained from a different bundle measurement methods represent unfortunately different level of tenacity (Fig. 4) [Frydrych (1996)].

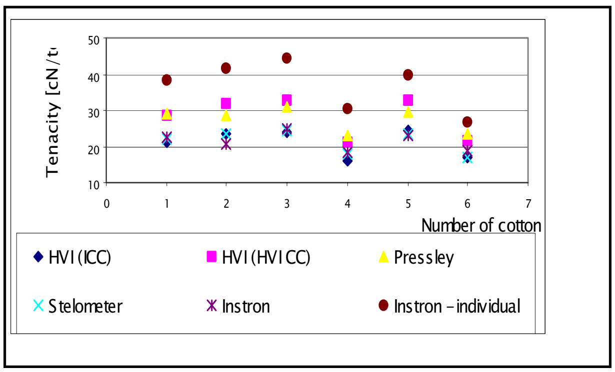

Fig.4a The cotton strength according to the different measurement methods.

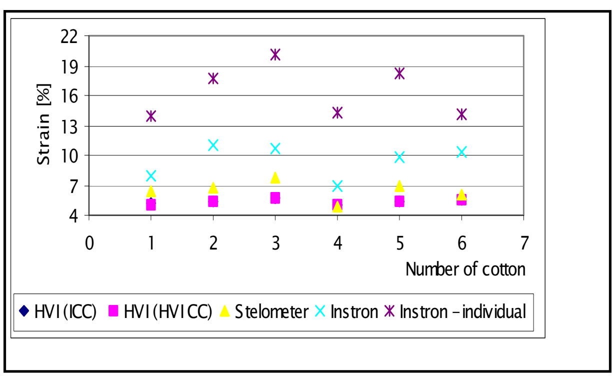

Fig.4b The cotton breaking strain according to the different measurement methods.

As is seen, there are two levels of HVI strength values depending on the kind of calibration standard used. The use of HVI-CCS and ICCS, respectively, leads to two strength levels with associated confusion. Decisions taken at the 1998 International Calibration Cotton standards (ICCS) Committee meeting in Memphis, particularly around the continued supply in the future of only one ICCS calibration cotton ("C" standard) with a length value (in addition to Stelometer strength and elongation and micronaire values), represent an important step towards one HVI calibration level for strength and the elimination of the dual, and confusing, strength levels. In contrast to this, there is still a tendency to produce ICCS-type calibration cottons again. It represents a retrogressive step, unless the normal or calibration values are pitched at the HVI-CCS levels, rather than at the original ICCS levels, or else both values must be given, but the later would still lead to ambiguity and confusion.

It is also a problem to know if the absolute value of the breaking force or tenacity is measured precisely. We should also answer how a sample should be prepared to have results suitable for predicting yarn properties.

The ITMF meeting held in March 2002 in Bremen observed that strength testing is still a problem (Fig. 5 and 6).

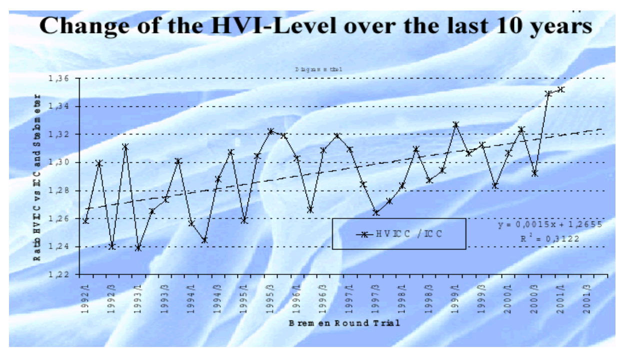

Fig.5. Change of the HVI-Level over the last 10 years

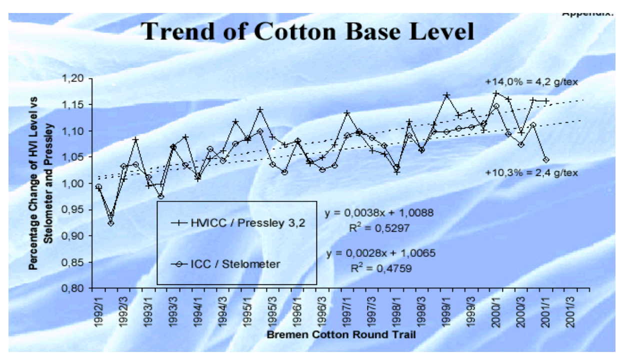

Fig. 6. Trend of Cotton Base Level

The Fiber Institute Bremen tried to elaborate the HVI strength reference testing method. In this reference method there is a special procedure of calculating the bundle fineness, but the graph below shows clear difference between them. It is concluded that no Cotton Standards are needed for calibrating the elongation test device (Fig.7).

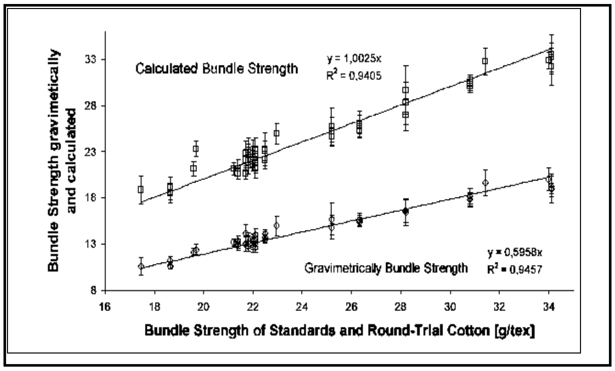

Fig. 7. Measured and Calculated Bundle Strength

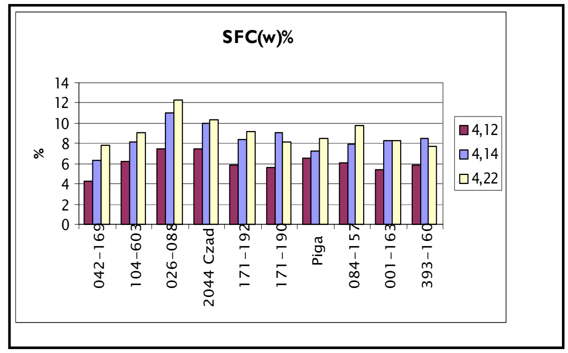

Fig. 8a. Variability of SFC from AFI according to different software.

Considering the HVI line, we can say that the round-tests show a big improvement in CV of strain, but it still takes too high a value (Table 1).

Short fiber content measurement, which is a very important parameter for yarn quality prediction, was evaluated by the USDA during the 2000 classing season from HVI results. The reproducibility remains relatively low at about 58-60%. According to Hunter (2002), the accurate direct measurement by HVI of SFC is yet to be achieved.

SFC assessed on the AFIS system are not precise and it is not credible [Frydrych and Matusiak (2002)] (Fig. 8 and 9). It requires improvement.

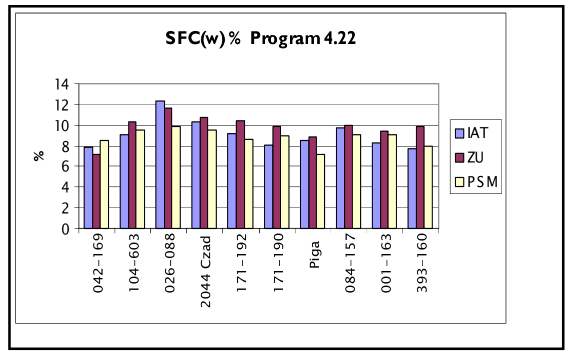

Fig. 8b. Variability of SFC from AFIS placed in different laboratories.

Table 1. Average Interlaboratory variation for laboratory "Stand Alone" instruments and HVI systems (Bremen and USDA Round Trials)

Properties		Average CVs (%)					
		1987 to 2001		1990 to 2001		1995 to 2001	
		Bremen	USDA	Bremen	USDA	Bremen	USDA
Micronaire	Lab.	3,3	3.7	3.3	3.7	3.6	4
	HVI	2,8	2.3	2.8	2.3	2.9	2.4
2,5% Span/Length/ Upper	Lab.	2,4	2.9	2.4	2.9	2.3	2.9
Half Mean Length	HVI	2,1	1.5	2.1	1.5	2.1	1.6
Uniformity Ratio	Lab.	3,7		3.7		3.7	
	HVI	4,0	4	4.1	4.1	3.9	5.1
Uniformity Index	HVI	2,2	1.1	2.1	1.1	2.2	1.1
Strength	Lab.	5,5	7.4	5.6	7.7	5.5	8.9
	HVI	5,9	5	6.2	5	6.4	5.3
Elongation	Lab.	9,1	13.4	9.2	13.3	8.6	12.9
	HVI	**13,8**	**21.4**	**13.6**	**21.6**	**13.6**	**22.4**
Colour Rd	HVI	1,6	2	1.6	2.1	1.7	2.2
Colour +b	HVI	4,1	5	3.9	5.1	4.1	5.1
Percentage Maturity	Lab.	8,1		8.4		8.7	
Maturity Ratio	Lab.	8,6		8.9		9.3	
Fineness	Lab.	8,0		8.2		8.4	

Table 1. Average Interlaboratory variation for laboratory "Stand Alone" instruments and HVI systems (Bremen and USDA Round Trials)

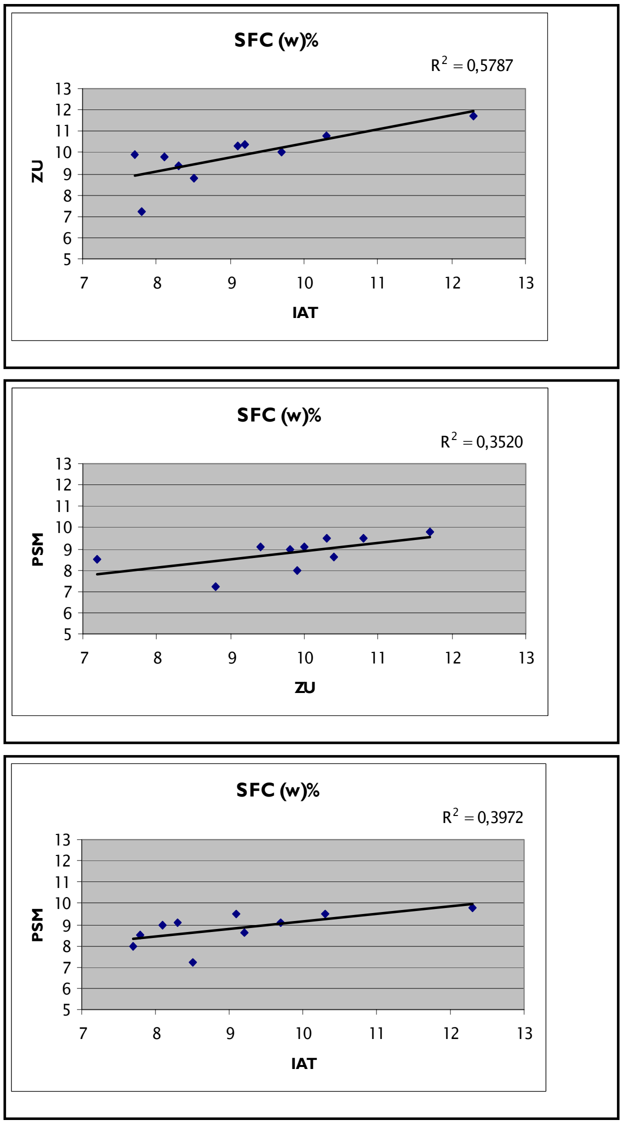

Fig. 9 a,b,c. Correlation between values of SFC obtained in particular laboratories

The other challenge for fiber measurements is their cleanability. It is known that it is well connected with such fiber properties like micronaire, maturity ratio, length, SFC and so on [Peters (1995)]. Such a parameter can be obtained on the MDTA-3 system as:

$$CA = \frac{T_1}{T_2} \cdot 100\%$$

where:

CA – cleanability, which characterizes the technological value of raw material,

T_1 – trash content determined after the first cycle of cleaning on the MDTA-3,

T_2 – trash content determined after the second cycle of cleaning.

Measurement on the MDTA-3 as a gravimetrical one is precise, but it takes time. It would be very valuable, if such a parameter could be obtained in a fast way, for example, on the AFIS system. Nevertheless, so far it is not standardized and recommended by ITMF [Peters(1995)].

The other problem created is also stickiness, which can be determined by different methods: chemical (Perkins) or with the use of thermodetection. Actually, a new international standard for cotton stickiness measurement using a thermodetection principle has been elaborated by CEN TC 248WG19. There will be three parts of the standard:

1. using the manual thermo-detector (SCT) - recommended by ITMF, in 1994. This method was shown to have its limits as a classification tool since it is slow and results were biased by an operator effect (Fig. 10).

2. using the automatic plate thermodetector (H2SD) (Fig.10),

3. using the automatic rotating drum thermo-detector (FCT/ Fiberlab) (Fig.3).

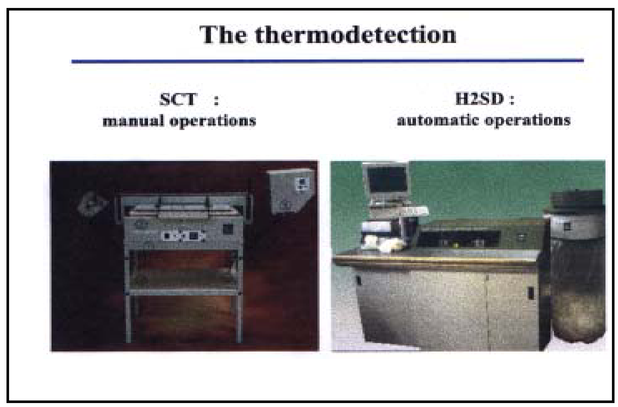

Fig.10. Two detection devices used to measure stickiness in this CFC / ICAC.

As many cottons show stickiness, the development of a rapid method for detecting stickiness is more important than ever. The stickiness of cottons during the spinning process has become a selection criterion in the spinning industry. Therefore, it would be advantageous at the production stage to evaluate the stickiness of each bale.

There is a suggestion to the ITMF Committee on Cotton Testing Methods that the last method (FCT/Fiberlab) should be considered for recommendation by the committee as a method corresponding to the probability of creating problems in the spinning process. Two equally reliable scales have been developed to predict stickiness:

1. 5 categories based on raw counts,
2. 5 categories based on raw counts multiply by arbitrary increasing number to characterize the size of the sticky deposits.

Round tests carried out by 7 laboratories showed that this test is in general reliable for the commercial use, although the statistics of a phenomenon is not so reproducible as for other properties. According to Mor [2002] the reproducibility of stickiness testing is mainly influenced by the nature of the material, not by the system (because CV within the Labs, and between labs are of the same range). The ITMF has not made a decision yet.

Unfortunately, the thermodetection does not indicate the reason of stickiness, which can be caused by:

- white flies (trehaluloze),
- aphids (melezitose),
- plant sugar,
- other sugars, which have not yet been identified (the best method for this purpose is High Performance Liquid Chromatography – HPLC).

It would be useful to know sugar concentration. It is still a problem to determine and distinguish the reason of stickiness. It could be a first step toward making cotton useful or adaptation of the technological process in order to produce yarn without any disturbances, even if cotton has some stickiness.

It was found that trehaluloze produced the largest attachment force, when yarn-to-yarn attachment forces were measured at room temperature; whereas melezitose gave a very low attachment force. Spots coming from aphid contaminated cotton were relatively easy to clean, so readings were much lower at high cleaning pressure (H2SD), whereas those contaminated by white flies were relatively unaffected. The H2SD counts were affected by the pressure applied at the cleaning roll.

It was also found that trehalulose was being preferentially deposited on machine parts. None of the other sugar showed such a tendency. Trehalulose absorbs moisture extremely rapidly and forms a film. There is no correlation between trehalulose content and H2SD counts [Hequet (2002)]. Trehalulose content is a better predictor of processing problems than H2SD counts. Some other authors claim that H2SD is the best for industrial purposes. There is still a challenge to find out, how it is in reality.

The old reference method for stickiness assessment was a minicard. It was shown by Dr. Gamble [Frdrych et al.(2001)] that minicard ratings are not correlated with thermodetector sticky spots (Fig.11). It can possibly be explained on the basis that honeydew droplets had be-

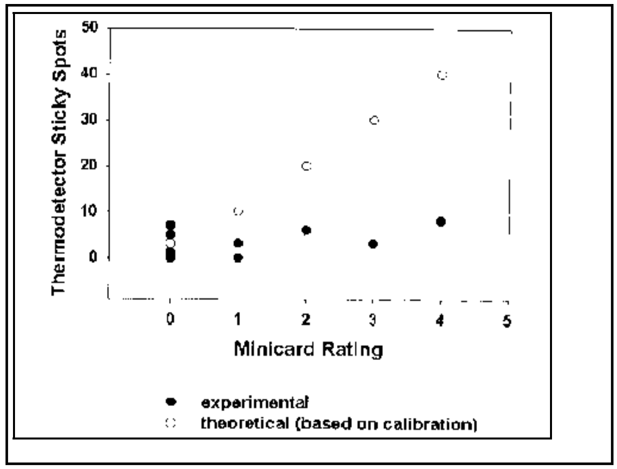

Fig.11. Thermodetector vs. Minicard Ratings for a Series of Whitefly Honeydew Contaminated Samples

come coated with a hard skin and the minicard was able to break the skin due to shear forces at the take-off rolls. According to him minicard is still the most representative method for evaluating stickiness in textile processing. In our experiments [Frydrych(2001)] we have estimated the Spearman's rank correlation coefficient between both methods at 0.8.

Another problem is to create reference standards for stickiness evaluation, which would be stable for a long period of time. It is known that physiological sugar is not stable over time. Up till now it has not been possible to separate physiological sugars from entomological ones in terms of their effect on the spinning process.

A great challenge is to have a reference test method for stickiness based on a simple test instrument for conducting controlled spinning trials. A bale is declared "sticky" if spinning machine performance or final product quality is lower. It should be noted 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.

Very important is also a color assessment. In the past according to the Soviet Standards it was possible to get two cotton samples from bales, which could have different hue (creaminess): blue and creamy. Both samples were of the first grade. Then occurred the problem how to maintain a high quality of yarn production. It confirms how important is a color measurement [Ducket(1997)].

Actually, HVI color is determined by two coordinates: reflectance (Rd) and yellowness (+b). Repeatability of the color measurement on the HVI line is on the level of 80%. Additionally, it was stated that there is 70% agreement between the HVI color assessment and classer assessment. The main difference has a place, when the colorimeter classifies that sample as a white one; whereas the classer thinks that it is light spotted. In 1996, such a disagreement was stated for almost 50% of light spotted cotton cultivated in Louisiana, USA.

The second problem with color measurement is determination of color borders, when values of reflectance Rd and yellowness +b are similarly close to two color classes on the Nickerson-Hunter scale.

The third problem is the fact that the light source in the HVI consists of two lamps lighting the sample from both sides at a 45^0 angle . It causes unevenness of lighting on the sample on the area 6.35 x 7.94 cm^2.

The next problem is the contribution of the third coordinates red-green (a) in the cotton color. It would be in agreement with a chromatic diagram CIE 1976 (L,a,b). The role of these coordinates has been ignored so far during the cotton color assessment. Such a research on introducing the third coordinate was carried out by Duckett [1997] from the University of Tennessee, Knoxvile, TN. Preliminary measurements indicate that coordinate “a” differs for samples of different varieties. A correlation was found between L and Rd values (from spectrometer and HVI) as well as between b and +b. It is also interesting that physical cotton standards in the same color class have the same value of a; but their Rd and +b values are different (Fig.12). It confirms the special role of coordinate a (red – green).

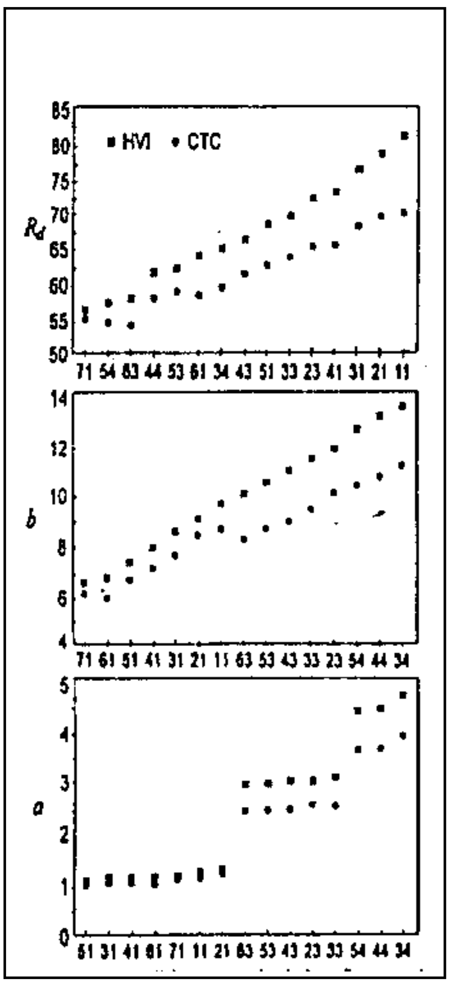

Fig. 12. Cotton color coordinates (Rd, +b, a) for different class of color.

The problems mentioned above suggest that the color measurement technique confined in the HVI should be improved.

New Parameters

The knowledge based on the above mentioned parameters, determined by existing measurement systems, seems to be complete and the range of parameters satisfied. Nevertheless, a deep analysis of all aspects connected with cotton quality, especially problems dealt with the cotton processing and quality of produced yarns, implies some doubts.

Let’s take into consideration only cotton fiber dimensions. Fiber length is the parameter, which influence linear density of the yarn obtained. This relationship deals further with the fiber fineness and maturity. Finding of these relationships took a long time and the solution is not fully satisfactory. It is connected with genetic changes of cotton varieties and outcomes from these changes in fiber morphology and properties (seed fibers).

One of the important problems of cotton yarn quality is its neppiness. Neps and trash contained in the raw cotton used for yarn production are the source of neps in the yarn. Trash can be easily removed up to 90% in the successive stages of the spinning process and is not a danger for yarn quality. Nep problem in raw material is much more complex and dangerous. Increase of the nep number takes place in the ginning and preliminary cleaning/opening processes. It is caused by outer mechanical factors dealt with the pneumatic transport and interaction of machinery work elements.

An increase in the nep number during processing is connected with the cotton tendency from neps [Zurek(1970)]. The tendency of nep formation is intuitively connected with the fiber bending rigidity. Nevertheless, there are not any friendly measurement methods for assessing the bending rigidity of single fibers, and mean bending rigidity of the assessed cotton lot.

Tendency of cotton fiber to nep formation is dealt with their slenderness. In textiles, the fiber slenderness is most often expressed by a ratio of fiber length and fineness:

$$S = \frac{1}{T_{tex}}$$

where:

S – fiber slenderness,

l – fiber length,

T_{tex} – fiber fineness.

Experiments [Zurek(1970)] conducted have shown that this parameter is weakly correlated with the nep number in cotton as well as with the increment of the nep number during processing at the laboratory scale (as well as in the technological process).

Starting from the mechanics of rod [Kurowski(1970)] the expression on a fiber slenderness was proposed as a ratio of the buckling length and a minimal inertia radius of fiber cross-section:

$$S = \frac{l_w}{i}$$

where:

S – fiber slenderness,

l_w – buckling length,

i – minimal inertia radius of fiber cross-section.

An equation has been derived that enables the calculation of minimal inertia radius of cotton fiber cross-section in the function of fiber circularity coefficient (which is a measure of maturity) at the assumption that cotton fiber cross-section has a shape of a flattened ring:

$$i = \frac{D}{2}\left(1-\sqrt{1-\theta}\right)\sqrt{\frac{\frac{1}{4}+\frac{5}{12}\sqrt{1-\theta}}{1+\sqrt{1-\theta}}}$$

where:

i – minimal inertia radius of cotton fiber cross-section,

D – equivalent diameter of cotton fiber cross-section,

– equivalent coefficient of cotton fiber cross-section.

Fiber slenderness determined in this way is better correlated with the increment of the mechanical nep number during pneumatic transport [Matusiak(2002)] than with the slenderness described by the first equation. Nevertheless, in both cases we deal with the mean value of slenderness connected with their mean length, which depends to a big extent on the earlier mentioned short fiber content (SFC) value.

Short fibers and neps are created during ginning and cleaning. Intensive cleaning and ginning cause more neps and fiber damage causing their shortening.

On the basis of mean fiber slenderness, calculated using a mean fiber length, one cannot conclude the cotton tendency to nep formation. There is a need to determine slenderness of individual fibers as well as slenderness distribution in general mass of raw material. Above mentioned possibility for assessment of fiber rigidity would create a base for determination of a so far unknown critical slenderness value.

On line Assessment of Cotton Stickiness

Rapid assessment of the stickiness of cotton can be accomplished with a new, patented apparatus developed at the US Cotton Ginning Laboratory at Stoneville, Missisipi [Anthony(2001)]. 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, on-line monitor in a gin or textile mill. 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 only slightly affected 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. Another challenge is to continue research in this direction, to make the estimation 100% correct.

Fig.13. 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.

Table 2. Fiber Linear Density Measurements by AFIS

	a [mtex]	a_{max} [mtex]	a_{min} [mtex]	R	t variable					
					101-111	101-122	101-133	111-122	111-133	122-133
A	156	157	153	4	1.26	1.49	1.26	**2.53**	0.00	**4.21**
B	174	178	169	9	**5.37**	**3.16**	0.88	**2.00**	**4.68**	**7.37**
C	172	177	166	11	**15.56**	**14.14**	0.00	**2.24**	**15.56**	**31.47**
D	168	174	165	9	**7.02**	**4.88**	**4.43**	0.59	0.71	1.26
E	156	177	141	**36**	**25.71**	**4.24**	**14.53**	**36.77**	**40.25**	**31.47**
F	164	168	161	7	**5.22**	**6.14**	1.49	0.00	**3.73**	**7.90**
G	171	174	167	7	**4.39**	**5.22**	0.54	1.75	**2.35**	**6.32**
H	162	164	158	6	0.00	**3.79**	0.56	**5.26**	0.71	**5.27**
I	164	166	160	6	1.75	**4.47**	1.08	**3.51**	0.00	**4.21**
J	156	177	141	**36**	**18.42**	**5.59**	**16.77**	**22.80**	**31.57**	**15.81**
K	168	172	165	7	2.12	**2.24**	1.90	0.71	**5.26**	**5.53**
L	173	180	166	14	**18.38**	**12.30**	1.12	**2.83**	**19.80**	**18.95**
M	158	160	156	4	1.90	**2.53**	1.32	0.75	0.00	1.05
N	163	164	160	4	1.41	**2.53**	0.00	1.75	1.75	**4.21**
O	171	174	166	8	**2.94**	0.00	1.10	**2.94**	**3.47**	1.90
P	167	172	160	12	**8.77**	**3.35**	1.41	**6.14**	**7.59**	**7.90**
R	173	179	166	13	**16.97**	**8.94**	1.12	**5.66**	**18.38**	**14.21**
S	167	170	164	6	**2.98**	1.49	0.83	1.49	**2.49**	**4.21**
T	156	176	142	**34**	**24.00**	0.00	**22.36**	**21.05**	**34.00**	**15.79**
W	164	168	161	7	1.26	**2.24**	1.68	1.26	**3.16**	**5.53**

where: $R = a_{max} - a_{min}$

Portable Device

In the USA, all cottons sold have the HVI certificate, but cottons cultivated in different regions of the world do not have such a certificate.

Therefore, another challenge is the construction of a portable device, which could be used, for example, by cotton traders during cotton selling transactions. Such a portable device should have an opportunity to measure the following cotton fiber parameters: fineness and maturity, strength and strain and it would be also very valuable if it could measure trash and nep content. The portable device should be light and user friendly.

Quality of Measurements

While describing the quality of measurement, one should pay attention to two problems:

- repeatability and reproducibility of measurements,
- agreement in fiber properties measured by different measurement methods.

Repeatability and Reproducibility

Repeatability is an agreement of results of successive measurements of the same measured parameter carried out by the same technician, in the same measurement conditions. Reproducibility is an agreement of results of successive measurement of the same measured parameter carried out by different technicians in different measurement conditions.

On the basis of many years of experience in the range of interlaboratory comparative measurements (round tests) it can be stated that in the case of modern measurement systems for cotton quality assessment there are not serious problems with repeatability, which is quite satisfactory. It can be influenced only by climatic conditions.

The analogous problem of agreement assessment concerns also the other cotton parameters like for example maturity or short fiber content (SFC). The example is shown in Fig.14.

We can say for sure that reproducibility improvement is one of the important challenges for the measurement equipment producers.

Some doubts are caused by the reproducibility of results [Frydrych(2001)]. Comparative measurements were performed for 20 cotton samples, among which there were also calibration cotton samples for assessment of agreement of mean values. T-Student test was applied. Assessment was carried out for each cotton sample, separately for each pair of measurement systems taking part in the round-test.

Table 2 indicates these cases, for which the differences between mean values of 2 samples were statistically significant. In majority of cases significant differences exist between the fineness mean values. The biggest noted difference is 36 mtex.

Comparability of results from different methods

Many fiber properties can be described by different parameters determined using different methods acting on the basis of different measurement principles. As an example, cotton trash content measurement methods can be divided into two main groups:

gravimetric and optoelectronic.

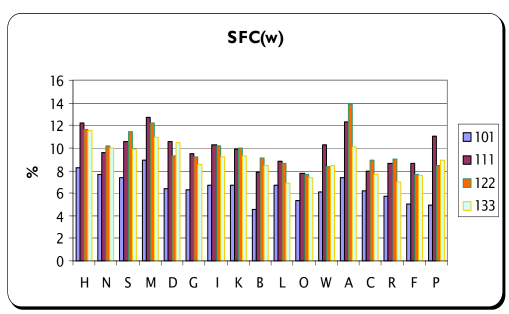

Fig.14. SFC from AFIS reproducibility according to Polish Round-test

By means of gravimetrical methods we obtain information about the percentage of trash in a unit of raw cotton mass.

Results [Schlichter(1995)] showed that there is an agreement of assessment and strong linear correlation relationship between results obtained by gravimetrical methods (Fig 15a).

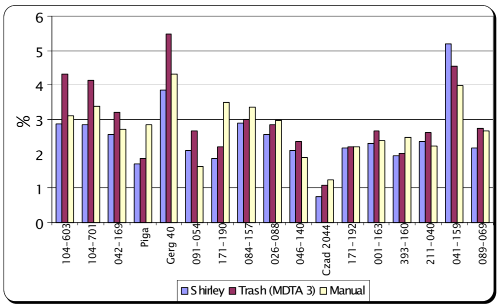

Fig. 15 a. The number of trash particles in cotton according to gravimetrical measurements

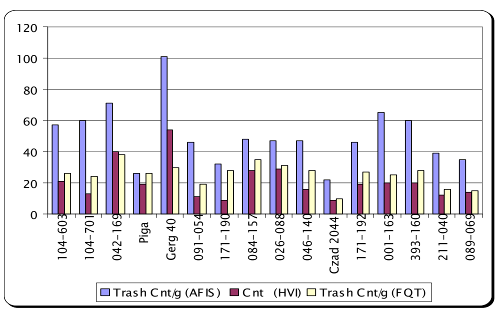

Fig. 15 b. The number of trash particles in cotton according to the optoelectronic measurements

Optoelectronic methods provide information about trash particles in the mass unit (AFIS or FQT) or in the sensor observation field (HVI) and about percentage of visible foreign matters (VFM) on the examined area of sample (HVI).

Optoelectronic methods provide different parameters characterizing trash (Fig.15b), so it is difficult to compare them directly. Nevertheless, the assessment agreement of parameters obtained by different methods was expected. It means that cotton classified by one measurement method as the most trashy should be evaluated in a similar way by the rest of optoelectronic methods. Assessment agreement done by gravimetrical and optoelectronic methods is also required.

Carried out a rank analysis [Schlichter(1995)] confirmed a big coincidence of assessment by the gravimetrical methods W= 0.82244; whereas in the case of optoelectronic methods this agreement is much smaller W= 0.72104. From the optoelectronic methods the best agreement with gravimetrical methods has the HVI line – Trash Cnt (Table 3).

No	Optoelectronic method	W'	k(n-1)W'
1.	AFIS (Trash Cnt/g)	0.72822	46.6061
2.	HVI (Cnt/g)	0.77986	49.9107
3.	FQT (Total area/g)	0.63615	40.7135

Table 3. Set of Kendall's agreement coefficients for four measurement methods: three gravimetrical and one optoelectronic

Application of Information about Raw Material Quality for Industry

Complex cotton analysis provides information allowing a very precise description of cotton quality. Nevertheless, cotton is a consumption good and a raw material, which is further processed. Cotton behavior during the processing, predicted disturbances in the spinning process, and finally a quality of produced cotton yarn is a piece of information, in which the technologists are interested. There is a need to predict cotton yarn quality on the basis of metrological characteristics of raw material. Many researchers have undertaken such a problem of predicting the yarn quality parameters.

Many methods of predicting how the fiber parameters influence the cotton yarn tenacity were elaborated [Frydrych(1995), Hunter et al(2000)]. At the IAT there was a method proposed for predicting nep number in the ring spun cotton yarn [Zurek(1970)]. For the carded yarn the nep number per 1,000 m can be expressed by the formula:

$$N_{UT\,card} = Tt_p \cdot \left[n \cdot (N_b + \Delta N_t) \cdot \left(1 - \frac{NRE_{card}}{100}\right) + u \cdot U_b \left(1 - \frac{CE_t}{100}\right) \cdot \left(1 - \frac{CE_{card}}{100}\right)\right]$$

whereas for combed yarn – by the equation:

$$N_{UT\,comb} = Tt_p \cdot \left[n \cdot (N_b + \Delta N_t) \cdot \left(1 - \frac{NRE_{card}}{100}\right) \cdot \left(1 - \frac{NRE_{comb}}{100}\right) + u \cdot U_b \left(1 - \frac{CE_t}{100}\right) \cdot \left(1 - \frac{CE_{card}}{100}\right) \cdot \left(1 - \frac{CE_{COMB}}{100}\right)\right]$$

where:

Tt_p – yarn linear density,

n – share of neps of a size bigger than the critical nep size for particular yarn linear densities in the total nep number in roving,

N_b – nep number per gram in cotton,

ΔN – increase of the nep number during the preliminary treatment,

NRE_{card} – nep removing efficiency of carding machine,

NRE_{comb} – nep removing efficiency of combing machine.

U_b – trash content in raw material,

u – percentage of trash,

CE_{card} – cleaning efficiency,

CE_{comb} – cleaning efficiency.

Parameters characterizing the cotton raw material and acting efficiency of machinery can be determined using the AFIS system.

There is a need for further research in the direction of predicting the other cotton yarn quality properties based on the fiber parameters like stickiness level to perform the technological process. Some work has been done in this direction.

Stickiness has a significant impact on the yarn evenness and yarn hairiness, even for moderate level of stickiness. The open-end spinning seemed to be less sensitive to stickiness than the ring spinning. It is recognized that the higher the relative humidity, the most numerous the descriptions induced by cotton stickiness and the poorer the quality of the yarn. The number of the yarn disruptions was related to the H2SD stickiness level.

Availability of Measurement Systems

There is a need for cotton fiber measurement and for an appropriate quality of these measurements. Nevertheless, a dissemination of measurement methods is conditioned to a big extent by the availability of measurement systems. The main or even only one obstacle in this field has a price. Modern measurement systems and devices for cotton fiber quality assessment are very expensive.

With the development in other fields of techniques, a relative decrease in prices is observed. It is like production of cars, computers, audiovisual equipment and the other techniques achievements, which not so long ago were difficult to get (were available only for some elites of the society). Actually, in addition to the price decrease there are also some other facilities during purchasing, like discounts, payment by installments and so on.

Unfortunately, in the field of textile metrology the situation looks quite differently than on the common world market. Modern measurement systems are very expensive and therefore, they are not available or available with difficulties, especially for Eastern European countries one of which we Poland represent.

The decrease in prices of measurement systems and therefore, increase of their availability may be a challenge from the point of view of producers of such an equipment. From our point of view, it could also be a great success for the producers, because they could have bigger turnover by selling a bigger quantity of cheaper goods.

Summing up

What the industry expects from producers of measurement systems? The answer is measurement methods must be fast and their measurement principles should assure high preciseness and credibility of results. It is obvious that such a task is difficult to be achieved, but the measurement system developers should intensify their effort in this direction. This is still a challenge for them.

There are many important challenges for producers of measurement systems for cottons. They concern the range of measured parameters as well as the measurement quality. The market situation resulting from the changing preferences of textile consumers will still create new challenges in the field of cotton fiber measurement. Researchers will have different preferences and will like to have more complex and precise information from measurement; other needs should be fulfilled from the point of view of cotton traders (portable device).

It is also significant that producers of measurement systems should reduce production costs and in the same way the price of such equipment. They should cooperate with research institutes in order to recognize the needs and to find the best solutions for the measurement principles.

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A Need for Universal Cotton Quality Standards

El Sayed Erfan Rashed, Cotton Arbitration and Testing General Organization, Egypt

I believe it is time to establish international quality measures for fiber properties to be applied by all parties dealing with cotton activities such as production, trade, manufacture, etc. Especially because we are rapidly developing high-tec facilities that determine all the quality characteristics.

This achievement will allow all parties to follow the same principle in evaluating quality, thus offering better prices and premiums in all cotton handling and processing stages which would be fair for everybody.

Having variation in properties and qualities among each species and variety, and having also variation in the handling of raw cotton as a product and its different manufacturing processes, the parties concerned, dealing with different cotton activities would require accuracy in determining the value of properties and homogeneity. This has become an essential requirement for the manufacturer as it would help him to avoid loss when extracting trash and contamination, which usually cause problems during the process of manufacture and represents imperfections in the quality of the end product, that in addition to the loss in cotton weight along with its price paid.

There are many factors that affect quality:

- Cotton characteristics such as length, strength and fineness,
- Environmental factors such as length of growing season, soil, rainfall, climatic conditions, cultural methods and insect damage,
- Other factors such as picking and packaging, transportation, storage, moisture and trash, cleaning, ginning and pressing.

Hence, the application of a unified quality evaluation system will increase demand by improving the planting system, picking and packaging, ginning and cleaning. One can breed varieties with homogeneuous qualities. The system of maintaining varieties in Egypt as a way of conserving homogeneity is explained. Egypt sells cotton according to the (Type) system, with the determination of characteristics of each lot in terms of length, uniformity, strength, elongation, fineness and maturity.

Egyptian varieties belong to ELS & LS categories, and they possess superior characteristics (strength, fineness, maturity and homogeneity).

Trash percentage, short fiber content, neps, and moisture content are also determined for all cottons.

The Cotton Arbitration & Testing General Organization (CATGO) uses the most updated instruments and issues locally and internationally authorized certificates to Egyptian cotton dealers. Being an Egyptian public body under the authority of the Ministry of Supply & Internal Trade, CATGO has no interest in cotton trade, and so is a neutral technical organization.

CATGO bears the responsibility of supervising all cotton handling processes for seed and lint cotton to maintain purity of commercial varieties and strains against mixing and contamination.

Table 1 **Physical Fiber Properties of Some Egyptian Varieties - 2001/02 (HVI data)**

		VARIETIES			
		ELS		LS	
PROPERTY		G . 70	G . 88	G . 86	G . 89
Upper Half Mean Length	mm	34.9	35.2	32.5	31.7
Length Uniformity	Index	87	88	87	86
Strength	g / Tex	45	44.8	43	39.8
Elongation	%	6.4	6.3	6.5	6.4
Micronaire	u / inch	4.09	4.07	4.41	4.26
Reflectance Degree (Rd)	%	73.1	66.9	76.1	76.1
Yellowness	+ b	9.4	12.2	8.9	8.1
Trash Area	%	1.3	1.1	0.9	1
Trash Count	number	47	39	31	37
Maturity	%	86	85	84	84

The technical departments of CATGO cooperate with all concerned parties dealing with cotton activities in terms of production, ginning, trade, manufacture and export.

This alliance achieves its objectives through:

- Maintaining the properties of current commercial varieties as well as the new better varieties.
- Strict zoning of varieties to prevent mixing or deterioration.
- Cooperation with the Ministry of Agriculture, its different sectors and cotton producers to guarantee comparative privileges to Egyptian cotton.
- Careful hand picking and proper timing for the first and second picks which help pickers to avoid immature and damaged bolls. Seed cotton is picked after 10 AM, allowing dew to evaporate. Damp seed cotton is spread in the sun to dry.

Table 2 **Levels of Physical & Mechanical Properties**

1 - Length

Length in inch		Length in mm		Description
Above	1" 3/8	Above	34.93	Extra Long
1" 1/4	- 1" 3/8	31.75	- 34.93	Long
1" 1/8	- Less Than 1" 1/4	28.58	- Less Than 31.75	Medium Long
"31/32	- Less Than 1" 1/8	24.61	- Less Than 28.58	Medium
"13/16	- Less Than " 31/32	20.64	- Less Than 24.61	Short

2 - Fineness

Micronaire µ / inch	Description
Less Than 3.0	Very Fine
3.0 - 3.6	Fine
3.7 - 4.7	Medium
4.8 - 5.9	Coarse
6.0 and above	Very Coarse

3 - Maturity

Maturity Index	Description
Below 0.70	Un Common
0.70 - 0.85	Immature
0.85 - 0.90	Medium
0.90 - 1.00	Mature
Above 1.00	Very Mature

4 - Length Uniformity

Uniformity	Description
Below 77	Very Low
77 - 79	Low
80 - 82	Medium
83 - 85	High
Above 86	Very High

5 - Short Fiber %

Short Fiber %	Description
Below 6	Very Low
6 - 9	Low
10 - 13	Medium
14 - 17	High
Above 18	Very High

6 - Strength

Strength g / tex	Description
Below 28	Very Weak
28 - 31	Weak
32 - 35	Medium
36 - 39	Strong
39 and above	Very Strong

7- Elongation%

Elongation %	Description
Below 5	Very Low
5.0 - 5.8	Low
5.9 - 6.7	Medium
6.8 - 6.7	High
7.7 and above	Very High

Ref: 1) USTER HVI Spectrum, Application Hand Book, 1999 Zellweger.
2) Internationl Cotton Conference, Bremen, Germany (2002) .

Table 3

Effect of Physical & Mechanical Properties on Different Processes During the Spinning & Weaving

		MIC	MAT	LEN	SFC	Str	Trash	Neps
Spinning Processes	Cleaning	▒	■	■	▒	■	▒	▒
	Waste	▒	■	■			▒	
	Spinning		■	■	▒		▒	
Yarn Quality	Evenness	▒	■	■	▒			
	Imperfections		■	■	▒		▒	▒
	Appearance				▒		▒	▒
	Dye ability	▒	■					
	Hairiness				▒			
	Strength	▒	■	■	▒	■	▒	▒
	Elongation	▒	■	■	▒	■		
Fabric Quality	Appearance			■	▒		▒	▒
	Dye ability	▒	■				▒	▒
	Hand	▒	■	■	▒	■		
	Strength	▒	■	■	▒	■	▒	▒
	Elongation					■		

■ Positive character (maturity-length-strength) directly proportional to quality.

▒ Negative character (short fiber percentage-micronare reading- trash. Neps) inversly proportional to quality.

1. The table indicates the effect of physical properties of cotton fiber on the processing of yarn and textiles.
2. All properties have direct effect on yarn and textiles quality.
3. Quality of raw cotton has direct effect on yarn and textiles quality as it is impossible to obtain fine combed yarn of high quality from short, weak, corse cotton with low quality.

Table 4

Effect of Grade Factors on Processing Characteristics

Quality Factors :	Processing Characteristics Affected
Grade	
Colour	Dyeing, Bleaching
Trash	Processing Waste , Textile Machinery Contamination , Product Appearance, Cotton Dust Levels
Preparation	Processing Waste , Product Appearance

- Using new and good jute sacks sewn with cotton strings for seed cotton.
- Inspection of seed cotton arrivals, seed cotton grades and ginning out - turn are measured in the collecting rings before dispatching seed cotton to ginneries where each grade is stacked separately.
- Avoiding mixing between varieties, or between grades among the same variety, and avoiding foreign matter before ginning.
- Applying 'Taddriba' for seed cotton before the ginning process is done, while immature, diseased seed cotton locks and yellows lint are removed.
- Roller ginning is most suitable for Egyptian cotton varieties (ELS & LS). Hence, strict supervision of adjusting and maintaining ginning stands toobtain good quality cotton.
- Covering cotton bales to avoid contamination, after which the bales are marked (by CATGO) with their variety, certificates are issued bearing properties, trash content and content .
- 'FARFARA' which is applied to assure cleaning and homogeneity before export (a unique Egyptian pro-

Table 5

After the explanation before we can suggest the following

Quality Level	Micronaire	Maturity	Length	Strength	Short Fiber	Level
Very High Quality	Very Fine	Very Mature	Extra Long	Very Strong	Very Low	V.H.Q
	Below 3.0	Above 1.0	Above 34.93	Above 39	Below 6	
Degrees / Points						
High Quality	Fine	Mature	Long	Strong	Low	H.Q
	3.0 – 3.6	0.95 – 1.00	31.75 – 34.93	36 -- 39	6 – 9	
Degrees / Points						
Medium Quality	Medium	Medium	Medium Long	Medium	Medium	M.Q
	3.7 – 4.7	0.85 – 0.95	28.58 – 31.75	32 -- 35	10 -- 13	
Degrees / Points						
Low Quality	Coarse	Immature	Medium	Weak	High	L.Q
	4.8 – 5.9	0.70 – 0.85	24.61 – 28.58	28 – 31	14 -- 17	
Degrees / Points						
Very Low Quality	Very Coarse	Uncommon	Short	Very Weak	Very High	V.L.Q
	6.0 and above	Below 0.70	20.64 – 24.61	Below 28	Above 18	
Degrees / Points						

cess).

- The International Cotton Training Center (ICTC) which belongs to CATGO, conducts training courses at different levels for classers, technical staff and sworn expert panel candidates. These courses include subjects like classification, ginning, trade, marketing, fiber properties and moisture content testing.

Hence, Egyptian cotton varieties are well known worldwide because of their superior fiber properties and homogeneity, and that is why they result in superior quality of yarn and fabric.

The Effect of Moisture Content on Cotton Handling Processes

Commercial Handling on Weight Basis

In accordance with agreements between Egypt and other countries, the moisture content of Egyptian cotton is calculated on the basis of 8.5% in lint cotton, and any percentage above or below that is adjusted accordingly.

Suggestion:
An international agreement could be made on a standard moisture content limit to be applied in cotton trade.

Important Factors that Affect Cotton Quality

During ginning and pressing:

- A high moisture percentage in trash reduces the efficiency of the cleaning process and also allows expelled trash to adhere to sound fibers, causing a high waste percentage.
- This increases the potential of neps and naps.
- Accordingly, lint grades will be lowered, and discoloration occurs.
- Moisture in seeds leads to seed coat fragments and lint waste.
- Moisture increases lint cake formation in bales.
- Heated cotton may occur because of high moisture.

Testing fiber properties:

- High moisture results in misleading readings of strength and elongation and
- Provides a slight increase in fiber length.

Suggestion:
Workshops and conferences should be held to establish an international standard for percentage limits of moisture content as a base for commercial cotton trade.

Moisture Content Levels

Description	%
Very low	
Low	
Medium	
High	
Very high	

Trash

Trash Sources:

- Cotton plants produce shales, burs, pepper and large leaf, stems, sticks, funiculi, motes, seed cotton fragments and whole seeds.
- Foreign matter includes bark, straw, dust sand, oil, grease and sisale fibers.

Trash is measured by a Shirely Analyzer (which measures the trash content of lint cotton in terms of weight)

The HVI Trashmeter measures trash in terms of area occupied and number of particles regardless of type (whether dust, straw, etc.). HVI requires the assistance of a classer.

Suggestion:
Studies on the development of standardized trash levels should be conducted for international implementation.

Research on a definition of trash levels for commercial use should be developed.

Trash Levels

Description	%
Very low	
Low	
Medium	
High	
Very high	

Grade

The art of cotton classification is based on three main factors:

- Color

- Trash
- Preparation (ginning)

Some countries consider micronaire as a fourth grade factor.

Classification systems vary among different cotton groups as well as countries. Each system utilizes grade factors to suit national cotton handling practices and to keep abreast of national economic objectives.

It is necessary for each country to conduct research to design its own national cotton chart based on (Rd%&+b), in addition to specifying the trash factor for each grade. Countries should also prepare their own cotton standard boxes on a scientific basis matching HVI results.

Each fiber property should have a ranking according to importance. The ranking for each property should correspond to internal sublevels that vary according to the importance of each sub level.

Finally, the assessment of cotton quality based on instruments is just as important as that based on the visual assessment provided by a cotton classer. The two levels of assessment (fiber testing by instrument and classification by classers) are complementary to one another and both are essential.

Questionnaire

Finally, it is clear that there are a number of positive characteristics (such as length, strength, fineness, color, and length uniformity) and there are also a number of negative factors (such as trash, moisture, short fibers, etc.).

Now the issues in question here can be summed as follows:

Can we determine the number of properties which are considered positive? And, also the number of factors that are negative.

Having determined a number of degrees for measuring each property, would all properties have the same importance?

If we divide each property into internal levels, would each internal level take the same degree or value?

If, in a positive characteristic, a special variety happens to exceed the maximum level in superiority, should it enjoy a special premium, or would it be left under negotiation?

Finally, if we succeed in dividing all the values into a number of international levels, would there be a corresponding number of grades within the national classification systems?

Cotton Classification by Grade

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Definition

Cotton classification by grade is defined as the art and science of describing cotton quality in terms of grade according to official standards. In fact, grading depends basically on the visual inspection and evaluation of raw cotton quality, since it is accomplished mainly through the sense of sight by integration of the three factors of grade: color, trash content and preparation or appearance of ginned cotton.

Variation in Cotton Quality

Cotton fiber quality characteristics are predominately varietal and controlled genetically. However, it is recognized that environmental conditions, including edaphic, climatic and biological factors, will cause variation in fiber quality within the same cotton variety. Fiber quality properties develop to their full potential when environmental conditions are conducive to good cotton production. By contrast, when cotton is subjected to unfavorable environmental conditions, inferior quality fibers are produced. Generally, variation in cotton quality results from fluctuations in weather conditions, soil fertility, incidence of pests and diseases, extent of care and efficiency of cultural practices, exposure of open bolls before picking and methods of harvesting and ginning. Further, there is variation in quality over the length of the picking season. Later pickings, in particular, usually show a marked fall in quality because these pickings are more likely to have been subjected to boll worms and other insects and diseases, in addition to the detrimental effect of plant senility and adverse environmental conditions. These natural limitations cause an appreciable variation in the quality of cotton within a variety. Different grades are given to the different levels of quality within a variety to indicate their spinning value.

Objectives of Cotton Grading

Cotton is classed to determine its grade, which indicates the spinning value and utility, and hence the market value or the price of cotton. Farmers are interested in the classification of cotton by grade to evaluate production, harvesting and ginning practices, in order to market their cotton profitably. On the other hand, merchants could efficiently buy and sell cotton in accordance with grade. From the stand point of cotton processing, the reasonable uniformity in quality of cotton in terms of grade is essential and required to attain even-running of cotton in processing and to produce yarns of satisfactory performance.

Grade Factors

Color

The main attributes determining the color of raw cotton are brilliance and chroma. Brilliance is the lightness or darkness of color, while chroma is essentially the degree of intensity of yellowness in cotton. Continued exposure in the field to weathering and the action of microorganisms can cause cotton to lose its brightness and become dark and dull. Under extreme conditions, color may become bluish gray. American Upland cotton, in which growth is stopped prematurely by frost or drought, may have a yellow color that varies in depth. Cotton may also become discolored or spotted by insects, fungi and soil stains. Regardless of the cause of discoloration, any deviation from the bright color of normal cotton indicates deterioration in quality.

The varying amount of yellow found in cotton forms the basis for the color classes or groups used in the standards for grading American Upland cotton. These color groups are White, Light Spotted, Spotted, Tinged and Yellow Stained. As the cotton in each color group is exposed to weathering, it becomes progressively darker. The degree of darkness is the principal basis for grade divisions within each color group, and there are seven sub-classes or grades differing in accordance with the amount and nature of foreign matter or trash present. Generally, the clean high grades are lighter and brighter in color while the dirty low grades are darker and duller in color with lower brilliance. However, each grade within a color group also contains some slight differences in chroma or yellowness.

Trash Content

Seedcotton, usually contains various amounts of trash depending on harvesting method; hand-picked cotton is much less contaminated by trash than mechanically harvested cotton. Even when cotton is carefully harvested under ideal field conditions, it is very difficult not to include at least some trash. Although much of the trash is removed in the cleaning and drying processes during ginning, it is impossible to remove all trash. However, trash residues found in raw cotton include dried and broken plant foliage of various kinds such as leaf (large and pepper leaf particles), stems, hulls, bark and bracts, in addition to whole seeds, parts of crushed seeds, grass, sand, dust and motes (undeveloped or immature seeds and ovules).

There is an inverse significant relationship between cotton grade and trash content, where the measured trash tends to increase progressively and consistently as grade decreases. The importance of trash content as a grade factor represents a loss since it must be removed as waste in the manufacturing process, and its elimination is inevitably accompanied by a loss of fiber. Further, the small fine particles of trash that are not removed in manufacturing detract from the quality and appearance of the manufactured yarns and fabrics. In general, cottons which contain the least amount of trash, other conditions being equal, are those with the highest spinning value.

Preparation or Appearance of Ginned Cotton

The classification for grade is influenced by the preparation in such a way that badly ginned cotton will result in a lower grade. However, preparation is the term used to describe the degree of smoothness or roughness with which the cotton is ginned and the relative neppiness and nappiness of the ginned lint. Longer cottons normally will have rougher appearance after ginning than shorter cottons. Neps are small and fairly tight tangles of fibers that are visible as white dots or specks; commonly no larger than a pin head. The removal of neps from the lint is difficult, costly and often impossible. Longer and finer cotton fibers are more prone to form neps than shorter and coarser fibers. However, it is difficult for the classers to detect or evaluate neppiness. Naps are much larger and looser clumps of fibers or matted masses of fibers. Generally the term nappy describes lint that is rough in appearance. The formation of naps is often pronounced when seed cotton is wet and when the seed roll in the gin is too tight causing faulty removal of fibers. Naps are relatively easier for classers to detect, but they are not as detrimental to cotton quality as neps.

Grade Standards

Classification for grade is conducted by the visual assessment of appearance of cotton against standards boxes. Each cotton type has its own grade standards which differ from those of other types.

Grade Standards of American Upland Cotton

The United States Department of Agriculture (USDA) first established standards for American Upland cotton in 1909. Those standards were for 9 grades of white cotton, and their use was made practically compulsory in 1915. In 1953, the two highest grades were discarded (MF and SGM). The other grades still in use, in order from high to low are: 1 – Good Middling (GM), 2 – Strict Middling (SM), 3 – Middling (M), 4 – Strict Low Middling (SLM), 5 – Low Middling (LM), 6 – Strict Good Ordinary (SGO) and 7 – Good Ordinary (GO). The last major revision of grades for American Upland cotton occurred in 1962, but minor revisions have been made in response to changing production patterns since. The 7 grades of white American Upland cotton are represented in physical forms by samples put up in boxes. Each box representing a given grade standard contains 6 – 12 samples or cuts of cotton which show the permissible range in color, trash content and ginning preparation for that particular grade. No standard boxes are supplied for other color categories or classes of Upland cotton, which are defined by verbal description. Below grade Upland cotton (No. 8) is lower in grade than the lowest grade of the official cotton standard, i.e. Good Ordinary (GO).

Grade Standards of American Pima Cotton

Official grade standards for American Pima cotton were first established in 1918. However, Pima cotton is naturally of a deeper yellow color than American Upland cotton, and the trash content of Pima cotton is peculiar to and does not match that of Upland standards. Moreover, preparation is very different from preparation for Upland cotton, where Pima is ginned on roller gins and looks more stringy and lumpy than Upland cotton, which is ginned on saw gins. Nevertheless, there is a set of 9 physical grade standards for which boxes are prepared. Also, there is a tenth descriptive grade to denote very low quality Pima. Grade 1 is the highest grade, and the others are progressively lower, i.e. grade 9 is the lowest grade.

Grade Standards of Egyptian Cotton

In Egypt, there are 7 distinct grades used in cotton classification. These grades, in descending order from the highest to the lowest are Extra (Ex), Fully Good (FG), Good (G), Fully Good Fair(FGF), Good Fair (GF), Fully Fair (FF) and Fair (F). Intermediate or half grade categories are also used. For instance, G/FG denotes cotton of an intermediate quality between the 2 grades Good and Fully Good. Classification for grade is often made to the equivalent of one quarter of a grade and also is attempted to one-eighth of a grade. However, it is doubted that the 1/8 grade classification would indicate a reliable difference in quality, since it is not expected to affect processing efficiency or the quality of end products. Hence, the 1/8 grade difference has no marked practical significance.

The use of grade standards in Egyptian cotton classification began in 1883, and there were only 2 grades, i.e. Fair (F) and Good Fair (GF). Since then, the number of grades has increased gradually in a reflection of improvements in cotton quality due to increased efficiency of cultural practices and in reflection of changes in quality characteristics as new varieties were developed. It is of particular concern, however, that each Egyptian cotton variety has its own set of grades which are annually prepared by the Cotton Arbitration and Testing General Organization (CATGO) in Alexandria.

Use of Instrument Test Results in Cotton Classification

The conventional hand grading procedure is a descriptive means of cotton quality specification, which is subjectively determined by classers depending on the capability of human perceptions, skills and experience. Human inexperience, lack of skill, bias and other vagaries can contribute to inconsistency in the valuation of cotton quality and grade by different classers. Thus, there is a strong justification for the use of instrument measurements of grade, particularly color. Color and grade of cotton are strongly associated with each other to such an extent that the grade is synonymous with color. Nevertheless, the United States Department of Agriculture developed color diagrams to be used in cotton classification by grade on account of the quantitative measurements of color attributes of lightness or darkness in terms of percent reflectance of light (Rd%) and chroma or degree of yellowness in terms of Hunter's scale units of +b.

Color Diagram of American Upland Cotton

The Nickerson–Hunter cotton color diagram shows how color measurements are coded and how they relate to the color of the grade standards. This diagram is based on the current official standards for American Upland cotton. The color scale reflectance, which denotes the lightness or darkness of color in terms of Rd% units, is represented on the vertical axis of the color diagram. On the other hand, the color scale chroma which refers to the degree of yellowness is represented on the horizontal axis of the diagram and expressed in terms of +b units. The scales of Rd % and +b are adjusted so that on the diagram each one inch represents 5% Rd or 2 units of +b. With reference to that color diagram of American Upland cotton, it is shown that there are 5 recognized color classes, i.e. White, Light Spotted, Spotted, Tinged and Yellow Stained. Each color class is divided into 7 sub-classes or grades according to the amount and nature of foreign matter or trash present. For more precise measurement, each single grade is sub-divided into quadrants to denote slight color differences. In the American system of Upland cotton classing, the grades are given numbers and names. Number 1 is the highest grade GM, followed in descending order by 2 (SM), 3 (M), 4 (SLM), 5 (LM), 6 (SGO) and 7 (GO). However, High Volume Instrument (HVI) photodiods absorb light from an illuminated sample, and a microprocessor expresses the results in 3 digitized values. The first value is the lightness or darkness of color as indicated by percent reflectance of light expressed in terms of Rd % units. The second value is the degree of yellowness expressed in terms of +b. The third value combines both lightness and yellowness in the equivalent 3-digit color grade code. This numerical code was proposed by USDA to be used in identifying the grade of cotton, the color classification of equivalent grades and the grade quadrant. Thus, the first digit in the code refers to the grade which ranges between 1 and 7 or 8. The second digit indicates the color designations which varies from 1 to 5. The third digit is an indication of the grade quadrant number, since each single grade is subdivided into quadrants to denote slight color differences within the same grade. Accordingly, the 3-digit code 31 – 2 implies that the grade of the cotton sample is Middling (No.3) and it belongs to the white color class (No.1) and represents the second quadrant (No.2) of the concerned grade (Middling). Likewise the code 54 – 3 indicates that the grade of the cotton sample is Low Middling (No.5) and it has a tinged color (color class No.4) and represents the third quadrant (No.3) of the concerned grade (Low Middling).

Color Diagram of American Pima Cotton

The Nickerson – Hunter Cotton Colorimeter is used to measure color attributes and hence determine the grade of American Pima cotton. This method of testing covers a procedure for comparison of raw cotton color with the color of the official Pima cotton standards established by the United States Department of Agriculture. However, the tested sample should be large enough to cover completely the viewing or the test window, and the surface of the sample should be fairly smooth and free of lumps and folds which cause dark shadows.

The color scale reflectance which indicates color brilliance is represented on the vertical axis of the color diagram and expressed as percent reflectance of light in terms of Rd % units. The color scale chroma is represented on the horizontal axis of the diagram and expressed in terms of +b units. The test procedure begins by placing the cotton sample on the test window making sure that the window is completely covered. Shadows of 2 indicators at right – angles are projected under the translucent screen of the Nickerson – Hunter Colorimeter. One of these indicators moves backwards and forwards to give a measure of color lightness or darkness (Rd%). The other indicator moves sideways to measure the degree of yellowness (+b). However, pressure must be applied on the tested sample untill further pressure does not significantly change the readings of the 2 indicators. The indicators move to a balance point and the color measurements are read directly from the color diagram. The readings of reflectance (Rd%) and yellowness (+b) have to be recorded to the nearest 0.1 scale unit. The point of intersection of the 2 indicators denotes the grade of cotton according to the official cotton standards of American Pima cotton .

Cotton Classification Memorandum Form

It has become well recognized that cotton grade, which is traditionally and subjectively determined by classers, is a mere approximation of the spinning value or utility of cotton. Cotton grades are an entirely qualitative means of determining cotton quality focusing essentially on the degree of cleanliness of cotton and the brightness or darkness of its color. As such, the grading operation does not pay much attention to the character of cotton, which is a complex attribute that can not be judged by any satisfactory standards. The character of cotton refers to fiber properties of length, length uniformity, strength, elongation, fineness or coarseness and softness or harshness. These quality properties in fact play an exceptionally important role in determining the spinning value of cotton. Nevertheless, it seems rational to postulate that cotton grade per se does not wholly define the quality and hence the spinning utility of cotton. As such, other aspects of quality have to be considered to supplement cotton grades in order to obtain uniform lots of cotton having specific fiber quality characteristics. The reasonable uniformity of fiber properties in the supply of raw cotton to spinning mills is important to secure even-running lots during processing and to produce yarns of satisfactory performance. Accordingly, while classification by grade remains essential to the pricing system for cotton, additional measurements of fiber quality properties should be used in commercial transactions to provide accurate, reliable and unbiased characterization of the spinning value of cotton, with minimal reliance on classer grade.

The United States Department of Agriculture developed and adopted the use of the "Cotton Classification Memorandum Form" in cotton classing and marketing. Measurements of cotton fiber quality characteristics, along with classer grade, are recorded on the classification memorandum. The market value of cotton is determined in conformity with the data in that memorandum. It is of particular concern to mention that measurements of cotton quality characteristics are made on High Volume Instrument (HVI). HVI measures all critical parameters defined by the USDA in a proposed cotton marketing system. The measurements of the HVI are fiber length, length uniformity, strength, elongation, micronaire reading, color and trash. These measurements account for more than 85% of the known variation in the spinning performance of cotton. HVI measurements are in accord with the standard test methods of the American Society for Testing and Materials (ASTM).

Maintaining Fiber Quality After Picking

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Introduction

Cotton is the world's most widely used textile fiber, the quality of which is extremely critical for successful textile processing. The choice of the best material for various end-uses has become highly specialized and is based on three major parameters:

- Technological fiber properties
- Non-lint content or waste
- Fiber impurities

All technological fiber properties are imparted during the lifetime of the boll on the plant and are already present when the boll opens. Thereafter nothing can be done to improve characters such as length, strength, elongation, maturity and fineness, and all our efforts are aimed at maintaining these characters in the highest level possible.

However, the spinability of any given cotton is also affected by non-lint content and fiber impurities, mostly introduced into cotton following boll opening.

The fiber quality of the open boll is affected by an array of factors, which can be grouped into two categories; pre harvesting and the post harvesting.

This paper considers all post harvesting factors and subsequent operations involved in handling, storage, seed removal and fiber processing likely to affect fiber quality after picking. Nevertheless, some factors affecting earlier stages are discussed briefly, in terms of their possible influence on the succeeding stages.

Post harvesting practices are further discussed in sequential order along with their effect on particular quality parameters. Yet, post harvest factors can be separated into those having a direct effect on seed cotton quality and those that directly affect lint quality.

Growing and Harvesting for Quality Fiber

Certain actions or omissions during growing or harvesting of cotton are essential for higher performance at the following stages. A series of such prerequisite actions are mentioned below.

- Choice of varieties that mature in a short period of time (synchronously)
- Plant shape adapted to mechanical picking
- Efficient weed control
- Land preparation for harvesting
- Plant preparation with defoliants and desiccants
- Moisture control through proper timing at harvesting
- Proper maintenance of picking machines for high performance
- Experienced machine operators
- Better control of production and harvesting

Improved practices and better harvesters may preserve fiber quality and lower cost.

Post Harvesting Practices for Quality Fiber

Seedcotton Handling

Gin operations should not be delayed by the seasonal nature of harvest and weather conditions, and efficiency depends upon a steady delivery of seedcotton. The volume of seed cotton processed through a gin must be sufficient for profitable operation. Efficient handling must be utilized from harvest until seedcotton is conveyed to the gin. Efficient handling means economical operation and preservation of quality. Seedcotton handling must permit loading, unloading, conveyance and storage with a minimum of infrastructure, equipment and energy.

Seedcotton Storage

Once the bolls have opened, any delay in harvesting means risking quality and loosing quantity from poor weather. Therefore, there is a strong motive to pick the crop faster than it can be ginned, and storage is necessary.

The form in which cotton is stored depends upon many factors. Specific warehouses provide maximum protection. However, field storage is also practiced. Research has shown that seedcotton can be successfully stored if certain precautions are followed.

The most important factors determining the safety of seedcotton storage are moisture, and foreign matter. Clean and dry cotton can be stored indefinitely without deterioration. Cotton must be picked when the ambient relative humidity is lower than 50%. Damp cotton should be ginned immediately. Portable moisture meters used in ginneries do not precise readings, but a high correlation is found between their indications and ambient relative humidity (Fig. 1).

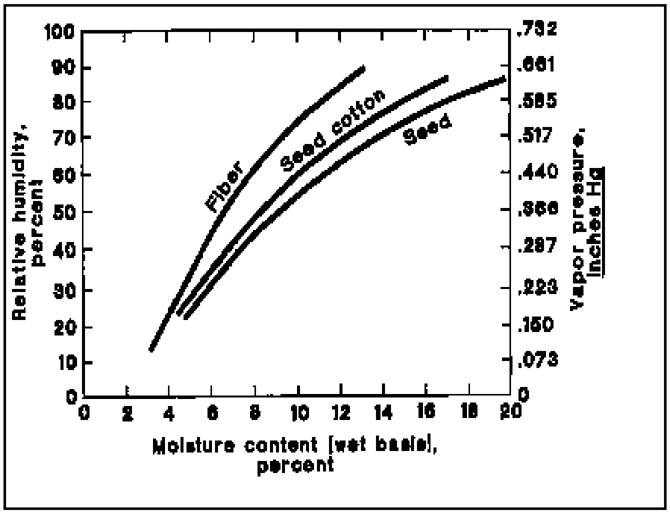

Fig. 1: Equilibrium moisture contents of cotton fiber, seed cotton and seed at different relative humidities at about 70ºF and 30 inches barometric pressure (From Cotton Ginners Handbook, No 503).

Other variables affecting fiber quality include length of storage, amount of high-moisture foreign matter, variation in moisture content throughout the stored mass, initial temperature of the seedcotton during storage, weather during storage (temperature, relative humidity, rainfall) and protection of cotton from rain and wet ground.

Research on quality changes during storage show that the quality parameters most affected are color grade and strength. An increase in light spotting occurs with increased moisture of stored seedcotton from 13% to 15%, while no significant differences in color are noted from 11% to 13% moisture, regardless of the mode of storage.

Changes in the ambient temperature during storage have a moderate effect on yellowness. Thre temperature of seedcotton has to be monitored, since a relative increase indicates high moisture content. Yellowness also increases sharply at moisture levels above 13-14% when the storage exceeds 45 days.

Yellowing is accelerated at high temperatures. Both temperature rise and maximum temperature are important. Temperature rise is probably more related to the heat generated by biological activity than to heat gained from the environment.

Seedcotton moisture of 12% or less will allow safe long-term storage, assuming that production, harvesting and storage guidelines are followed. Higher seedcotton moisture can be tolerated for short storage periods. The rate of lint yellowing, however, begins to increase sharply at moisture above 13% and can increase even after the temperature of a module drops.

Biological activity at high temperatures and moisture is accelerated during storage having a direct and detrimental effect on fiber strength. The deterioration is proportional to the number and kind of microorganisms starting from a slight decrease to a more severe defect called cavitoma. Microbial defection make fibers very weak and not capable of withstanding ginning and spinning.

Ginning

Ginning is an unavoidable, but detrimental, activity.

Assessment of cotton quality cannot be completed unless mill processing techniques and end uses are known. Current classification systems are actually encouraging ginning practices that degrade lint qualities important to textile mills.

A ginner must have two objectives:

- To produce lint of satisfactory quality for the grower's classing and market system.
- To minimize the reduction in fiber spinning quality in order to meet users demands (spinners, consumers).

Optimal ginning is the ultimate preservation of inherent quality characters and can be attained by:

- Proper selection and operation of each machine in the ginning system.
- Monitoring the effect of each machine on weight loss and fiber quality.
- Knowledge of latest technologies in raw cotton fiber testing.
- Careful assessment of each cotton lot and adaptation of appropriate ginning practices.
- Control ginning rates and gin stand speeds that tend to quality reduction.
- Compromise between increased grade, reduced length parameters and reduced turnout.
- Monitoring of moistured content and adapting ginning to the optimum fiber moisture content for any particular process in the gin.

Impact of Ginning on Fiber Quality

The ginning practices that have higher impact on cotton quality are:

- Regulation of fiber moisture during ginning and cleaning.
- The amount of cleaning performed.

Ginning can have a large influence on some quality factors and very little impact on others.

Fiber length and relevant parameters are the quality characters mostly affected by ginning. Length decreases, length distribution undergoes dramatic changes and short fiber content increase. Reliable measures of short fiber content (SFC) are not possible yet, although AFIS gives a close estimation. Constructing of fiber length diagrams is very tedious, nevertheless it gives the best information regarding changes in fiber length parameters during and after ginning. Deterioration is higher when damp cotton is processed, while the lower strength of poorly stored cotton increases fiber breakage (Fig. 2). For each percentage point of reduction in fiber moisture below 5%, length is reduced about 1/100 of an inch and uniformity by 1% (Anthony, 1990).

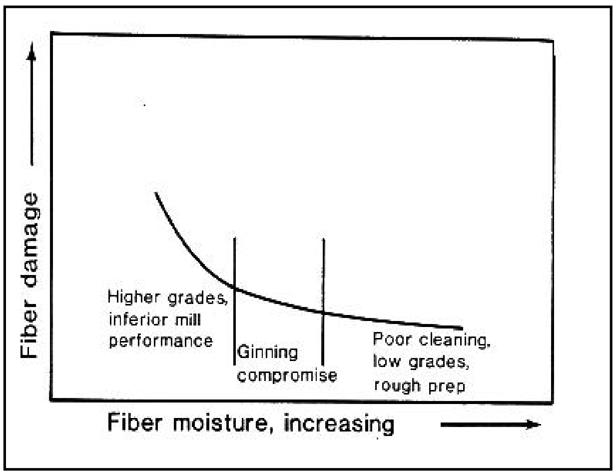

Fig. 2: The acceptable moisture content of cotton being ginned is a compromise between grade level and fiber damage (From Cotton Ginners Handbook, no 503).

Ginning affects grade in regard to preparation and foreign matter but has little effect on the fiber color except in extreme cases. However trash removal changes the perceived color of some samples. Lint cleaning is sometimes blending fibers, so that fewer bales would be classified as “spotted” or “light spotted” (Baker, 1988).

“Preparation” is mainly affected by ginning, especially for wet cotton. Foreign matter or trash has its origin in the variety and is mostly affected by harvesting. Howerver, proper cleaning during ginning may remove trash and improve cotton cleanliness. Excessive cleaning may be tolerated unless fiber breakage is too high thus decreasing length. A compromise between the two characters is the best practice (Fig. 3).

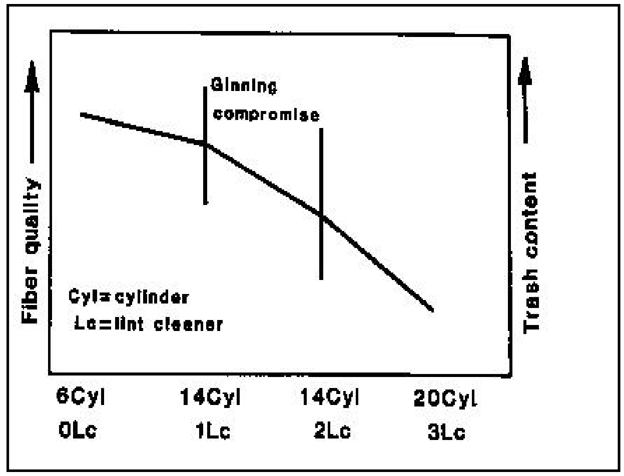

Fig. 3: Cleaning at the gin is a compromise between fiber quality and trash removal (From Cotton Ginners Handbook, no 503).

Ginning has little or no effect on micronaire, although a slight decrease in micronaire values is witnessed. In fact, micronaire affects gin operations because low micronaire cotton is susceptible to entanglement and nepping. Parameters such as maturity or fineness are not practically affected by ginning, while in the case of extreme heating strength may be slightly decreased. Neps on the other hand are the outcome of ginning. Neps are not found in unopened bolls, but their number rapidly increases during ginning. The degree of nepiness is an inherent character, dependent on variety, and ginning has to be adapted to the specific variety needs. The same applies for seed coat fragments. The fiber-to-seed attachment strength varies greatly in different cotton growths, but ginning efficiency may restrict or increase seed coat fragments.

A ginner must produce a quality of lint that brings the grower maximum value while meeting the demands of spinners. Operating gin machinery in accordance with recommended speeds, adjustments, maintenance and sequence while ginning cotton at the optimum moisture level will produce the best possible end product.

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Egyptian Cotton Yarn Quality

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Presented by Abdul Rehman, Cotton Research Institute, Egypt

Yarn is a generic term for an assemblage of fibers laid or twisted together in the form of a continuous strand or filament. It is evident therefore, that fibers are the fundamental units used in the making of yarn. However, it is widely accepted that fiber characteristics are highly transmissible to yarn. Thus, it appears that cotton spinners could realize many practical advantages by being able to steer clear of poor quality cotton. High quality yarns can be obtained from varied combinations of fiber properties.

Therefore, knowledge must be obtained regarding the contribution of each fiber property to yarn properties. Fiber length, strength, elongation and micronaire (fineness and maturity combined) are the principal properties of cotton fibers known to be closely related to yarn properties and end product quality. Generally, cottons with average physical properties are the most popular and functionally useful in most end products. For best textile processing and product quality, industry needs cotton fibers with maximum length and minimum short fiber content, maximum strength, average elongation and average fineness.

Fiber staple length, which is subjectively determined by cotton classers, has traditionally been used as the best criterion of the spinning value of cotton. Fiber length is the principal determinant of yarn strength and of the finest yarn count into which a particular cotton can be spun. The longer the fiber the longer the overlap among fibers in yarn which cohere by means of twist. Therefore, with longer fibers, twist can be less without sacrificing essential strength. As a corollary, the longer the fiber length, the lower the breakage rate, other things equal. However, fiber length does not evince a significant effect on yarn elongation at break.

Fiber strength and yarn strength are known to be positively correlated. Research confirms that stronger cotton fibers produce stronger yarns. Generally, fiber tenacity has the greatest effect on yarn tenacity, followed in order by fiber length and fiber fineness. The contribution of fiber properties to yarn strength is dependent on yarn count and twist. Recent technological advances in the textile industry, where production increases and costs decrease, has focused more on the relationship between spinning performance and both spinning variables and quality of the raw stock. This in turn, emphasizes the need for up-to-date information to guide spinning of cottons differing in fiber quality to utilize fiber properties in the production of maximum yarn quality at maximum rates of production.

Egyptian extra-long staple cottons enjoy the merits of high potential spinning performance because of its high intrinsic fiber properties. In general, long staple cottons are effectively used for the production of high quality fine yarns. Also, it is costly to use them for the production of low count coarse yarns. Sash cottons do not require much twist, because they extend a greater distance and bend themselves better through the yarn than do short staple cottons. Moreover, long staple cottons will give stronger yarns than short staple cottons at the same twist. Commercial cottons, producing lint of essentially equal staple length, differ in the quantity of short fibers due to environmental conditions and differences in their potential to of break during ginning. Short fibers are linearly and inversely related to the upper quartile length, fineness and maturity, yarn strength and spinning performance. The response to increase in short fiber content is much more severe in the 40/1 yarns with low twist than the coarser 30/1 yarn with moderate twist. Fine fiber cotton can be spun into stronger yarns that exhibit a greater average stiffness than do coarse fiber cotton. This advantage is relatively greater with increases in yarn count. Increases in maturity result in increased mean breaking load and decreased breaking load cv.

Fiber strength is correlated linearly with yarn strength. This trend is similar for various yarn counts and twists. In the 27.0 mm staple cotton, higher fiber elongation results in small improvements in spinning performance, yarn strength and yarn elongation. Yarn fineness is expressed by yarn count. In general, no relationship has been found between count variation and yarn count. Yarn count and twist has a greater effect on spinning performance than the range of fiber properties. The number of fibers in a cross-section decreases with increase in yarn count, and this has an appreciable effect on yarn mechanical properties.

The spinning limit is the finest yarn, i.e. count, that can be spun from a cotton. It is determined mainly by fiber length and fineness. Cotton yarn is internationally classed into three categories:

- Coarse yarns: of count up to 24s. Such counts can be spun from (medium staple) and (medium long staple) cottons, to be used for manufacturing cheap fabrics, towels, upholstery fabrics, etc.
- Medium yarns of count 24s up to 42s. Such a yarn

count can be spun from MLS cottons, to be used for manufacturing cheap poplin, knitting fabrics, etc.

- Fine yarns of count 42s up to 60s and above. Such counts can be spun from long staple and extra-long staple cottons, to be used for manufacturing high quality poplin and leno.

According to the international cotton classification mentioned before, both long staple and extra-long staple Egyptian cottons fall in the category of extra-fine, i.e. that group of cottons that could be spun into yarns of count 51s and higher.

However, Egyptian cottons vary among themselves with regard to their spinning limits. As mentioned before, Giza 45 can be spun into very fine yarns, up to 170s and in many cases to even higher counts. Giza 76 comes second followed by Giza 77 and Giza 70. The long-staple varieties have lower spinning limits. In general, longer staple length, lower short fiber content and higher fiber length uniformity, intrinsically finer fibers, or lower gravimetric fineness values (but of normal maturity), higher fiber strength and higher elongation lead to a higher spinning limit. However, fiber fineness and length are usually considered the most important factors that determine the spinning limit, before the irregularity of the yarn becomes so high that the yarn is not strong enough for use on the spinning frame.

Fiber fineness determines the number of fibers in a yarn cross-section, while fiber length determines the number of turns per unit length that a fiber makes a long a length. A minimum number of fibers is required in the yarn cross-section for satisfactory spinning, if the number is below the acceptable level, it results in increases in end breakage, irregularity and poor yarn strength. The minimum number varies with staple length, with longer staple cottons needing fewer fibers in a cross section. For Egyptian MLS, LS, and ELS cottons at 2.5% SL: 28.3, 30.0 and 35.0 millimeters, the minimum numbers of fibers in a yarn cross section have been estimated as 70, 63, and 45 respectively in ring spun yarns. Yarn evenness depends on two sets of factors, the first one is fiber properties, and the second is processing conditions. The important fiber properties that influence yarn evenness are:

- Fiber fineness: the finer the fibers, the higher the number in a yarn cross-section, and the yarn cross section is more regular.
- Fiber maturity: fibers of intermediate maturity usually produce more regular yarns. Higher maturity may result in somewhat lower evenness because of a lower number of fibers in a yarn cross-section. Fibers of a lower maturity produce yarns with lower evenness because of drafting difficulties on spinning frames.
- Fiber length uniformity and short fibers content: drafting rollers on the drawing, roving and especially spinning frames are usually adjusted according to the length of the longer fibers in the cotton being processed. Intrinsically finer cottons of intermediate maturity, and of a higher length, uniformity and lower short fiber content, are expected to produce yarns of highest cross-sectional regularity, i.e. evenness. Yarn strength, and to some extent elongation, are the most important tensile properties of a yarn.

Yarn strength has been regarded for a long time as the true expression of cotton quality as it sums up almost all fiber properties. Also, nebs are the most objectionable imperfections in cotton yarn and fabrics. Nebs cause yarn breakage during spinning and winding, and they cause problems in slashing, weaving, dying and printing.

New Approaches to Improve Cotton Quality in India

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Abstract

Cotton is one of the most important commercial crops grown annually on 8.7 million ha with 15 million bales of average production. However, the productivity (310 kg lint/ha) is amongst the lowest in the world, due to varied agroecological situations in which the crop is cultivated. With over 2,500 mill units, about 4 millions handlooms, 1.7 million power looms and thousands of garment, hosiery and processing units, the textile industry of the country accounts for 35 percent of total foreign exchange. Cotton fiber accounts for nearly 73% of the overall raw material mix of the spinning industry. The cultivated hybrids and varieties viz. LRA 5166, H4, H6, JKHy1, NHH44, DCH32, LH900, MCU5, Suvin, Ankur 651, Banny, have been developed through the efforts of public as well as private systems and are able to meet the quality needs of the textile industry. In the last few years, the national and international scenario has undergone substantial change. With the introduction of high speed spinning machines like rotor and jet spinning, the needs of cotton qualities have also altered. Therefore, the entire cotton improvement strategy is being altered.

Looking into the quality demands of the textile industry, new fiber norms have been fixed. The breeding strategies

are oriented towards meeting the targets. Although, it is realized that there is a limit to every species beyond which improvement is not possible, efforts are made to incorporate the best possible quality parameters in each species group and introgress material for different yarn groups.

Table 1: Area, Production and Productivity in Different States of India

State	2000/01			2001/02		
	Area m.ha.	Production (Million bales)	Productivity Kg/ha.	Area m.ha.	Production (Million bales)	Productivity Kg/ha.
North zone						
Punjab	0.47	0.9	322	0.60	0.9	255
Haryana	0.55	1	306	0.61	0.55	153
Rajasthan	0.51	1.05	350	0.35	0.55	269
Central zone						
Maharashtra	3.08	2.05	113	2.98	3.4	194
Gujarat	1.62	2.4	253	1.69	3.3	333
Madga Pradesh	0.51	1.75	589	0.62	1.7	464
South zone						
Andra Pradesh	1.02	2.5	415	1.00	2.7	458
Karnataka	0.56	0.8	243	0.59	0.75	216
Tamil Nadu	0.26	0.65	429	0.29	0.7	410
Loosecotton		0.9	-	-	0.9	-
Total	8.58	14	278	8.73	15.45	301

Source: Ministry of Agriculture and Cotton Advisory Board

A range of improved *arboreum* and *arboreum* x *herbaceum* hybrids have been evolved with staple lengths ranging from 27 to 29mm which are suitable for 40s count spinning. Currently grown *hirsutums* cater to the needs of the industry to spin up to 60s count yarns.

However, fiber fineness and strength are limitations. The new genetic diversity obtained in these species and interspecies hybrids is remarkable, and new material having micronaire range of 3.5 to 3.7 and strength of 25.4 to 27.9 g/tex have been developed. The *G. hirsutum* x *G. barbadense* interspecies hybrids are popular for spinning at 80s count but they suffer due to low micronaire, higher motes and neps. The new program, therefore, is targeted to these quality parameters, and excellent material is already in the pipeline. Biotechnological approaches are currently restricted to the introduction of a Bt gene into quality cultivars and molecular characterization of released varieties, hybrids and their parents. In the coming plan period, research with shift towards incorporation of fiber strength genes from wild species, development of cotton with thermal properties like heat tolerance, and the identification of genes for biotic and abiotic stresses. An overall strategy has been planned to improve the quality of cotton in India.

Introduction

Cotton is one of the most important commercial crops in India. It is grown on nearly 8.7 millions ha with average annual production of 15 millions bales. Eventhough India ranks first in area in the world, it occupies only third position in production and nearly last position in productivity (310 kg lint/ha). There are several reasons for lower cotton productivity in India. Nearly 65% cotton cultivation is rain-dependent and subject to heavy vagaries of monsoonic rains. Continuous availability of cotton in the subcontinent makes it easy for pests, diseases and other biotic stress agents to survive, multiply and cause uncontrollable frequent epidemics (Mayee, 2002). Despite these reasons, cotton productivity has been improved. The textile industry in the county is one of the most vibrant and accounts for 35% of the total foreign exchange. Cotton fiber accounts for almost 73% of the total raw material mix of the industry. The research programs undertaken by cotton institutes, agricultural universities and the Indian Council of Agricultural Research (ICAR) have led to significant changes in terms of quality and quantity in cotton. The country is able to meet the current demand of different quality cottons through a wide range of hybrids and varieties developed in the system (Cotton: A march towards new millennium, 2001). However, with the introduction of high speed spinning machines and changes in global demand, new norms of quality cotton have been set, and hence the cotton improvement technologies are also getting reoriented. A critical look into some of the quality attributes like fiber maturity, elongation, strength, short fiber content (SFC) and seedcoat fragments (SCF) is necessary. This paper discusses the current issues, textile scenario, quality attributes targeted and improvement strategies adopted in recent years in different species groups to meet the changing demand.

Current Production Scenario

Area, Production and Productivity

In India, cotton is grown mainly in nine states spread over three zones (Table 1). Maharashtra has the largest area under cotton followed by Gujarat. However, Maharashtra has the lowest productivity. The North zone states have higher average productivity, as the total crop is grown under irrigation. Even though cotton consumption by textile mills is the highest in Tamil Nadu (about 3 million bales), the total production of the state is low. An Outbreak of the American bollworm in epidemic proportion during 2001/02 resulted in very heavy damage to cotton, especially in the North zone, which recorded as much as

Table 2: Changes in Species Composition of Cotton in India

	Area (million hectare)					
	1950/51		Current		Projected	
Species	**Varieties**	**Hybrids**	**Varieties**	**Hybrids**	**Varieties**	**Hybrids**
Hirsutum	0.14	Nil	2.7	3.2	2.0	3.2
Arboreum	2.79	Nil	1.6	<0.05	1.8	0.5
Herbaceum	1.39	Nil	0.6	Nil	1.0	Nil
Barbadense	Nil	Nil	Nil	1.0	Nil	0.5
Total	4.32	Nil	4.9	4.0	4.8	4.2

Source: Mayee and Rao (2002)

20-50% reductions in yield compared to the previous year. However, the loss in production in the North zone was more than compensated by above-normal crop in Maharashtra and Gujarat.

Species Composition

India is unique in that all four major cultivated species of cotton are grown commercially. This may be due to the fact that the Indian textile industry requires cotton to spin yarns ranging from as low as 6s counts to superfine yarn of 120s counts. The hybrids, a majority of which are intra-hirsutum, occupy as much as 40% (Table 2). The *hirsutum* varieties occupy 30%, *G. herbaceum* varieties 10% and *G. arboreum* varieties 18%.

Cotton Growing Season

There are wide differences in the agro climatic conditions of the three major cotton growing zones. The North is characterised by extremes of high summer temperature exceeding 44°C. Cotton is sown during summer and harvested before the onset of winter. Soils are mostly alluvial. Rainfall during each cotton season is around 500 mm. Most of the cotton is grown under irrigation. About 22% of the country's total cotton area is in this zone. Large areas are grown under *G.arboreum* and *hirsutum* varieties of medium duration. The Central zone is characterized by a more moderate climate during the crop season, which is usually June to December. This zone accounts for about 55% of the total cotton area, of which nearly 85% is under rainfed condition. Soils are mostly deep to medium black with heavy clay content. Rainfall is variable, varying from 400 to 900 mm. Large areas in the zone are grown with hybrids like H6, H8, H10, NHH44 and JKHY1. A medium staple *G.hirsutum* variety LRA5166 predominates in Maharashtra. The South zone is characterized by a more equitable climate with temperatures ranging from 18 to 35° C. Annual rainfall ranges from 500 to 950 mm. About 35% of cotton in the zone is grown with supplemental irrigation. The soils vary from deep to medium deep black soils and red laterite soils. The soils and climate are ideally suited for growing extra long staple varieties and hybrids like MCU 5 and Suvin. 20% of the total cotton area of the country is in this zone.

Staple wise Composition

At the time of independence, mostly short and medium staple cottons were grown in the country and most of the long and extra long staple requirements of the textile industry were met through imports. There has been a gradual shift in the staple wise production in the country over the years. Today, India produces the widest range of cotton, from 20s count to 120s count (Table 3).

The pattern of cotton consumption by mills during 1996/97 indicates that there has been a sizeable increase in the use of short staple cottons. This is in tune with the increase in production and export of coarse count yarn. There is a decrease in the consumption of extra long staple cotton from 10 to 5%. However, there is no significant change in consumption pattern of other staple groups (Duraiswamy et al. 2000). The quantitative requirements of cotton in different count ranges have been worked out by the Central Institute for Research on Cotton Technology, Mumbai and South India Textiles Research Association, Coimbatore(Table 4) which are used as the basis for research into cotton improvement.

Table 3: Popularly grown cultivars of different count groups

Spinning Counts	< 20	20-30	30-40	40-50	50-60	60-80	100-120
North Zone	RG8 LD327	BN RST 9 F 846 HS6	F 414 H 777 LH 1556 RS 810				
Central Zone	Y-1 Turab Savit AK8704	V 797 Jayadhar AK 235 G.Cot 13	NHH 44 G.Cot.Hy.10 Ankur 651	JK HY.1 LRA 5166 Anjali G.Cot.Hy.8	G.Cot.Hy 6		
South Zone		L 147	LRA 5166 DHH 11	LK 861 Bunny RCH 2	Savith MCU 5VT	DCH 32 TCHB 213	Suvin

Source: Mayee et. al. 2001

Textile Industry vis a vis Production Research

Textile exports constitute about 35% of the total foreign exchange earnings of the country, valued at US$100 billion and provide employment directly and indirectly to around 100 million people. With over 2,500 mill units, about 4 million handlooms, 1.7 million power looms and thousands of garments, hosiery and processing units, the textile industry is the single largest in the country. The spinning capacity in the country has shown tremendous growth. The country had 11 million spindles installed in 1951, and the current capacity is around 36 million spindles. Rotors increased from 0.14 million in 1994 to 0.4 million by 1999. Shuttle looms increased from 0.2 million to 1.5 million during the same period. Spinning requirements vary from as low as 6s counts to as high as 120s counts cotton. (Table 5).

The pattern and production of cotton yarn during the last three years (Table 6) indicate that as much as 90% of cotton yarn production belongs to low count groups of 10s to 40s.

The combination of traditional and contemporary designs have produced a variety of yarn, fiber and home textiles and other textile products sought all over the world. In India, all cotton is hand picked. India is amongst the world's largest reservoirs of the popular fiber. In addition, the available cotton varieties capable of spinning almost any conceivable count adds strength to the industry. Unfortunately, the industry is beset with many problems. Inspite of Indian cotton being hand picked, it is considered the most contaminated cotton in the world due to poor marketing and ginning. The protection provided by the Government from import penetration through high tariff barriers is strong (Mayee *et al* 2002). However, in manufacturing cost, India has a disadvantage in respect of high tariffs, low productivity per spindlage as compared to other competing countries. Further, the high cost of capital in view of the high interest rates in India acts as a disincentive for modernization and technology upgradation.

As long as raw material and human skill were critical for a fine product, the Indian textile industry had a dominant role in the global scenario. However, with the setting up of the World Trade Organisation and a gradual phasing out of quantitative restrictions and the scheduled dismantling of tariff barriers, the textile scenario is undergoing a metamorphosis. In the globalized textile economy, the industry is required not only to fight for its share in international textile trade on an equal footing without guarantee of access through the quota regime under multi fiber agreement (MFA), but also to protect its interest in the domestic market. Already, foreign textiles and garments have started making headway towards the vast Indian market. Competition from man made fiber, unhindered imports of foreign cottons which are directly or indirectly subsidized in the exporting countries, are the major threats to Indian cotton. Hence, the competitiveness of Indian cottons in terms of price and quality assumes great significance.

The research programs undertaken by the state agricultural universities and the Indian Council of Agricultural

Table 4: Requirement of Cotton in Different Staple Groups

Staple length group	Present consumption (1996/97) (Million bales)	Requirement in 2004/05 (Million bales)	
		CIRCOT	*SITRA*
Medium staple	7.29 (48%)	8.8 (46%)	7.8 (38%)
Superior medium staple	2.7 (18%)	2.3 (12%)	3.9 (19%)
Long staple	4.35 (29%)	7.3 (38%)	8.0 (39%)
Extra Long staple	0.70 (5%)	0.8 (4%)	0.80 (4%)
Total	15.04	19.2	20.5

Source: ICMF Annual Report 1997/98

Table 5: Production of Spun Yarn

Year	Total Yarn Production (million meters)			
	Cotton Yarn	Blended Yarn	100% Non Cotton yarn	Total yarn
1997/98	2213	583	177	2873
1998/99	2022	595	191	2806
1999/2000(A)	2205	609	206	3020

Source: Ministry of Textiles, Govt. of India.

Table 6: Count wise Production of Cotton Yarn (in million kg)

Count Group	1997/98	1998/99	1999/2000
1^s – 10^s	503	450	503
11^s – 20^s	508	489	534
21^s – 30^s	427	396	441
31^s – 40^s	542	468	521
41^s – 60^s	144	131	123
61^s – 80^s	52	49	46
81^s and above	37	39	37
Total	2213	2022	2205

Source: Ministry of Textiles, Govt. of India

Research institutes during the past fifty years with the active cooperation of the Central Institute for Research on Cotton Technology(CIRCOT), Mumbai have led to significant changes both quantity and quality, which are closely linked to end use requirements. The hybrid cotton era brought about quantitative improvements in cotton production. Development of hybrids like Hybrid 4, JKHY 1, NHH 44 and DCH 32 brought about a white revolution in cotton. Similarly, the development and release of varieties like LRA 5166, MCU 5, Suvin and hybrids like DCH 32, H 6 and Savitha brought about a qualitative change in Indian cotton.

However, the multiplicity of varieties grown in a given agro ecosystem and the mismatch between production of different fiber quality groups and the markets driven demand by the consuming industry, leading to mixing at the farm and/or ginning level, has posed new problems in cotton development. Therefore, during the tenth five-year plan period (2002/07), the Cotton Advisory Board under the Textile Commissioner (Government of India) has recommended a reduction in the number of cotton varieties from the present level of about 125 to about 30 (Table 7).

Apart from reducing the number of varieties/hybrids to those which are most suitable for different agro-ecological zones, new cultivars are recommended, specifically as improved replacements for earlier ones. The new varieties should meet the new fiber quality parameters standardized by CIRCOT in consultation with the industry.

The changing national and international textile scenario with high speed spinning machinery and the availability of quality cotton with better fiber properties in other parts of the world, is making new standards for fiber quality in breeding programs. Hence, it has become necessary to look critically into some quality attributes.

New Fiber Quality Norms

Traditionally, ideal cotton fibers are said to be as white as snow, as strong as steel, as fine as silk and as long as wool. However, it is difficult to incorporate these specifications favoured by the textile industry into a breeding programme or to set them as quantitative goals for cotton producers. Growers think about fiber quality only when their produce is rejected by the buyer for being substandard and the processors think about it only when they incur costly disruptions in yarn spinning. No post harvest mechanisms are available to improve intrinsic fiber quality.

Long term planning of varietal improvement research requires precise information on the requirement of the Indian textile industry both in quality and quantity. Keeping in view the yarn production plans of textile mills, international demand and supply, the availability of varying qualities of cotton in the world, the Indian textile industry and the CIRCOT have prescribed quality norms for the important fiber characteristics (Table 8).

The plant breeding strategies are to be reoriented towards meeting these targets, so Indian cotton could regain world competitiveness.

Table 7: Varieties Identified by Cotton Advisory Board for Retention

0-20s < 25 mm	21s-40s 25-29 mm	41s-80s 29-34 mm	81s and above > 34 mm
RG.8	LRA 5166	Bunny	DCH 32
LD.491	AKA 8401	H 6 / S 6	MCU 5
B N /F 1378	NHH 44	MCU 5	Suvin
LH 1558	NHH 302		Surabhi
H 1098	H 8		
Jawahar Tapti	G Cot 16		
G Cot 17	DHH 11		
G Cot 21 / V 797 / G Cot 13	LRK 516		
Jayadhar	S.6		
Suyodhar	Sahana		
	LHH 144		

Improvement of Cotton Quality

Improvement of *G. arboreum* cotton

Ever since independence, there has been a gradual shift in the species composition of cotton in India. The traditional *desi* varieties, which occupied as much as 80 percent of the total cotton area, gradually gave way to the American tetraploid cottons. Even though the tetraploid cottons brought about a sea change in total cotton production, both in terms of quantity and quality, it also brought with it more pests and diseases. The recent outbreak of whitefly, *Helicoverpa* and leaf curl disease points to the dangers of crop uniformity. Hence, the present species composition of 17 percent of *G. arboreum* and 8.0 percent of *G. herbaceum* varieties need to be stabilized at the present level at least to avoid further erosion of genetic resources like tolerance to biotic and abiotic stress. The *G. arboreum* varieties have an inherent ability to resist major pests and diseases and can withstand moisture stress. Under irrigated conditions in the North zone, they record higher yields than the tetraploid cottons. However, these cottons, though belong to the medium staple group, because of their short fiber length, high micronaire and low fiber strength can not spin beyond 20s count. Hence, attempts are being made to introgress superior fiber quality characteristics of *G. hirsutum* into *G. arboreum*. These efforts, along with conventional breeding approaches, have resulted in the evolution of several long lint quality cottons capable of spinning up to 40 counts(Table 9).

Table 8: New Norms for Breeding for Fibre Quality

YARN/COUNT RANGE	2.5% Span Length (mm)	Micronaire	Strength g/tex. (3.2 mm)	Count Strength Product (CSP)
101s – 120s	36 to 38	3.2 – 3.4	30 to 32	3400
81s – 100s	36 to 38	3.2 – 3.4	30 to 32	3200
61s – 80s	33 to 35	3.2 – 3.4	28 to 30	3000
51s – 60s	31 to 33	3.3 – 3.5	27 to 28	2900
41s – 50s	30 to 31	3.5 – 3.8	25 to 27	2800
31s – 40s	28 to 30	3.8 – 4.5	24 to 25	2600
21s – 30s	26 to 27	3.8 – 4.8	22 to 23	2500
6s – 20s	22 to 25	4.0 – 5.0	20 to 22	2400

Improvement of *G. herbaceum* Cotton

G. herbaceum cotton has great potential in marginal and submarginal areas with very scanty rainfall. However, its long duration, low yield and poor fiber qualities make it unattractive for farmers and buyers. Current research indicates that the interspecific hybrids of *G. herbaceum* x *G. arboreum* are eminently suited to change the coastal agro ecosystem scenario.

Trials conducted at five centres under the Coastal Agro Ecosystem have shown that the interspecific hybrid G.Cot.DH 7 was superior to *G. herbaceum* varieties in seed cotton yield by over 50%. The hybrids were also early and recorded better fiber properties, which indicates their suitability to spin up to 30s count (Table 10).

Concerted efforts are needed to produce these hybrids in large quantities and to cover more *G. herbaceum* area with these superior fiber quality hybrids.

Improvement of *G. hirsutum* Cottton

Gossypium hirsutum is being grown widely and caters to the needs of the textile industry to spin up to 60's count yarn. However, the varieties and hybrids released under this category, though meeting the fiber length standards set by the industry, fineness and strength need improvement. Some of the cultures and hybrids being tested in various projects indicate the availability of various genotypes with the revised quality standards (Table 11).

The recently released hybrids like LHH 144 for the North, RCH 2 and Bunny for the South zones are a distinct im-

Table 9: Mean Performance of Quality G. arboreum Cultures

S. No.	Cultures	Seed Cotton Yield (q/ha)	Ginning Percent	2.5% Span Length (mm)	Micronaire	Fiber Strength (g/tex)	Microspinning	
							Nagpur (Mah)	Mudhol (AP)
1	PA 255	8.76	37	27	4.3	22	2291	2356
2	PA.183	7.72	37	27.3	4.7	20.7	2212	2269
3	PA.464	9.43	37	25.9	4.8	21.2	2037	2066
4	PA.402	8.13	37	25.1	4.9	21	2208	2304
5	DLSA 17	9.27	36	25.1	5.1	20.6	2190	2005
6	MDL 2463	8.8	35	26.4	4	21.6	2248	2407
7	G.hirsutum (check)	5.25	36	24.8	4	19.3	2320 (Anjali)	2250 (Narasimha)

Standard CSP at 40s Count = 2208 Source: Deshpande, et. al. 2000

Table 10: Performance of Desi (G. herbaceum x G. arboreum) Hybrids (Seedcotton yield in kg/ha)							
S. No.	Cultures	Bramhavar, Karnataka	Khapat, Gujarat	Kovilpatti, Tamil Nadu	Pattu kottai, Tamil Nadu	Konanki, Andhra Pradesh	Mean
1	G.Cot.DH 7	8.20	10.20	9.10	11.80	12.80	10.50
2	G.Cot.DH.9	8.30	8.60	8.10	12.20	13.30	13.30
3	G.Cot. 21 (c)	3.70	6.70	6.30	1.10	10.60	10.60
4	Digvijay (c)	3.20	4.70	-	2.10	6.80	6.80

Quality Parameters									
Culture	2.5% S.L (mm)			Micronaire			Fiber Strength (g/tex)		
Location	Kapat	Kovil	Konan	Kapat	Kovil	Konan	Kapat	Kovil	Konan
G.Cot.DH 7	23.5	22.7	24.1	5.6	5.2	3.4	18.1	19.2	19.3
G.Cot.DH.9	27.8	28.0	26.2	4.2	4.4	3.1	17.1	25.0	20.7
G.Cot. 21 (c)	25.0	18.9	22.6	5.4	5.0	3.1	15.5	15.7	20.5
Digvijay (c)	25.6	-	22.6	4.6	-	3.8	20.9	-	20.8

Source : NATP. G. herbaceum Annual Report- 2000/01

provement over the existing hybrids in terms of fiber quality.

Interspecific (*G.hirsutum* and *G.barbadense)* Hybrids

The requirement of the textile industry to spin 80s count yarn is exclusively met from the interspecific hybrids of *G. hirsutum* and *G. barbadense*. DCH 32 in the state of Karnataka and TCHB 213 in Tamil Nadu are the only two hybrids grown on a commercial scale. Eventhough both the hybrids possess adequate length and strength, they suffer from low micronaire and higher motes and neps. Proper selection of the parents is necessary to overcome this problem. Proper selection of hybrids with superior fiber properties in the initial stage of testing itself is a prerequisite (Table 12).

Improvement *of G. barbadense* Cotton

The development and release of Suvin is a significant milestone in Indian cotton improvement. Due to a combination of factors like instability in yield, competition from hybrids, increased pest damage and other market related problems, the area under Suvin has declined to less than 5,000 hectares. A strong breeding program for the improvement of *G. barbadense* varieties and the development of intra-barbadense hybrids should receive attention.

Biotechnological Approaches for Quality Improvement

The development of Bt cotton itself is likely to bring about a big improvement in fiber quality. Due to reduced pest damage, better retention of first formed bolls, absence of secondary growth and late formed bolls and early harvest is likely to improve the quality of lint harvested from Bt cotton plants. Recent studies indicate that Bt cotton hybrids were superior in quality than their counter non-Bt hybrids (Table 13 and 14), particularly with regard to micronaire, uniformity ratio, tenacity and naps.

Some wild species like *G. thurberi* and *G. raimondii* carry higher fiber strength genes than cultivated species. If these genes cannot be transferred to cultivated varieties by conventional breeding techniques, the gene blocks could be transferred to desirable genotypes through genetic engineering techniques. It would be easy to adopt such a transgressive population rather than adopting a non-cotton genetic material in the cotton genome. Genes responsible for fiber strength have been identified and up to 25 to 50% increases in fiber strength have been

Table 11: Superior hirsutum Cultures Available for Further Exploitation in the

S.No.	Cultures	2.5% Span Length (mm)	Micronaire	Fiber Strength (g/tex)
1	(M5 x Z.2) 1211-1-4	32.5	3.4	26.3
2	72 (M5 x Z.2) 7351	32.0	3.5	25.4
3	H.84	29.4	3.7	27.9
4	H 87	30.7	3.7	27.2
5	MCU.5 (C)	33.5	3.2	22.2

Ref: Annual Report- TMC Project: 2001/02

Table 12: New Interspecific Hybrids under Testing

S. No.	Hybrids	2.5% S.L (mm)	Uniformity Ratio (%)	Micronaire	Bungle Strength (g/tex)
1	H 45 x B 26	36.6	44	2.9	27.8
2	H 50 x B 26	35.9	40	3.5	25
3	H 45 x B 22	38.1	45	3.4	27.5
4	G1 x P26	36.3	43	2.5	31.2
5	TCHB 213 (c)	34.2	47	3.1	25

Table 13: Mean Values of Some Fiber Properties of Bt and non Bt Cotton Hybrids

Hybrid	2.5% SL(mm)	UR%	Micronaire	Tenacity (g/tex)
MECH 12 Bt	29.0	47.2	3.9	21.6
MECH 12 NBt	29.3	45.7	3.6	21.0
MECH 162 Bt	25.3	48.4	4.0	19.3
MECH 162 NBt	25.4	49.0	3.5	19.5
MECH 184 Bt	27.4	49.0	3.4	21.4
MECH 184 NBt	27.9	48.8	3.5	20.6
NHH44(Check)	24.4	48	3.4	18.3

Source: Sreenivasan.S and Bhama Iyer, 2002.

Table 14: Comparison of Fibre Properties Measured by AFIS

Hybrid	L (W)	SFC (W)	L(n)	SFC(n)	Fineness (m tex)	IFC (%)	Naps/g	**SCN/g**
MECH 12 Bt	25.5	7.5	20.6	23.7	156	9.9	106	11.4
MECH12 NBt	26.1	7.1	20.9	23.7	153	10.4	119	9.7
MECH162 Bt	22.9	9.5	18.4	26.5	158	10.1	116	11.7
MECH162 NBt	22.6	9.9	18.1	28.0	152	11.2	156	9.3
MECH184 Bt	25.2	7.0	20.5	23.3	151	124	133	15.3
MECH184 NBt	25.7	7.1	20.7	23.8	152	115	156	13.7

Source: Sreenivasan, S and Bhama Iyer,P (2002)

reported by incorporating these genes in *G. hirsutum* back ground. Sucrose synthase (SuSy) genes are known to be involved in epidermal cell initiation and efforts are on to use them for higher fiber yield.

The synthesis of new biomaterials in fiber, depending upon the biopolymer selected and its level, is likely to alter fiber quality traits. Some progress has been achieved in this regard, and transgenic cotton with thermal properties like heat tolerance have been realised. There are a number of fiber specific mRNAs that have exclusive and critical functions in the development and architecture of fiber cells. These could be exploited effectively without affecting other plant characteristics.

The use of molecular markers enables cotton breeders to connect the gene action underlying a specific genotype with the distinct region of the genome in which the gene resides. Molecular markers will allow direct selection of genotypes, thereby providing an efficient means of selection for fiber properties. Once markers for an interesting trait like fiber development or for a specific structural property of fibers are established, these should allow prediction of fiber characters in individual off spring derived from a cross solely by the distinctive pattern of markers in the off spring genome.

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