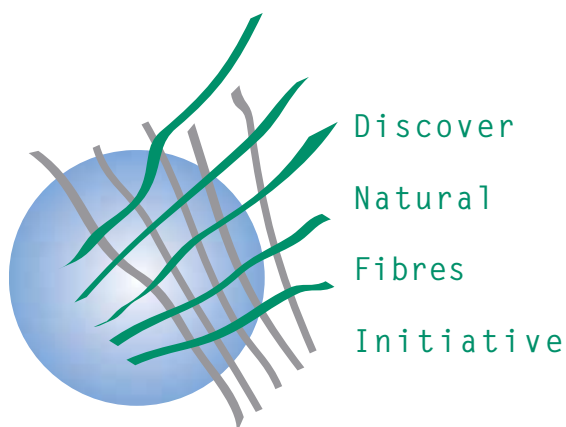




THE ICAC RECORDER

International
Cotton
Advisory
Committee



Technical
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Update on Cotton
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Introduction

The International Cotton Advisory Committee (ICAC) started the world cotton research conferences in the early 1990s, and conferences have been held every four and half years in a different country ever since.

WCRC-1: Brisbane, Australia, 13-17 February, 1994

WCRC-2: Athens, Greece, 6-12 September, 1998

WCRC-3: Cape Town, South Africa, 9-13 March, 2003

WCRC-4: Lubbock, Texas, USA, 10-14 September, 2007

WCRC-5: Mumbai, India, 7-11 November, 2011

The World Cotton Research Conference-5 (WCRC-5) was held in Mumbai during November 7-11, 2011. The Indian Society for Cotton Improvement served as the primary host for the Conference. The Central Institute for Cotton Research (CICR), Nagpur and the Central Institute for Research on Cotton Technology-CIRCOT, Mumbai served as nodal points for receipt of papers, planning of the technical program and

running the Conference. Both institutes belong to the Indian Council of Agricultural Research, which was the main sponsoring agency on behalf of the Government of India. As in the past, the Technical Information Section of the ICAC coordinated international collaboration and facilitated exchanges between the International Committee, Chaired by the ICAC, and the National Organizing Committee in India. A prominent Indian cotton expert, Dr. Charudatta Mayee, Ex Chairman, Agricultural Scientists Recruitment Board of India, served as Chair of the National Organizing Committee.

The ICAC has sponsored the world cotton research conferences since their inception in the early 1990s. CIRAD, France has sponsored each conference since 1998. FAO has also provided support to world cotton research conferences. Support from the private sector in each host country has been a tremendous component in the success of the Conferences.

This issue of the *ICAC RECORDER* is entirely devoted to technical highlights of the papers presented at the WCRC-5.

Notes:

1. Summaries of all the plenary papers are included in the report. However, it was not possible to include highlights of all the papers presented at the WCRC-5 in concurrent sessions. Results from papers that have wide application have been selected for this report.
2. Many researchers have used different words for biotech cotton. Though the ICAC promotes the use of 'biotech' that encompasses all types of cottons developed employing biotechnology, in existence and yet to come, I have not changed the words like Bt, GMO, genetically engineered, etc., to biotech.

Technical Highlights of the World Cotton Research Conference - 5

November 7-11, 2011, Mumbai, India

Mr. Sharad Pawar, Union Minister of Agriculture and Mr. Vilasrao Deshmukh, Union Minister of Science and Technology, Government of India, inaugurated the Conference. 621 delegates from 30 countries attended the Conference. The technical program was comprised of plenary sessions, concurrent sessions, panel discussions and special sessions that included a wide range of topics on the theme of breeding, biotechnology, production, protection, processing and fiber quality. The National Organizing Committee published a book of abstracts covering 150 papers presented orally, and abstracts of 172 papers that were presented as posters. Another book containing 92 full-length papers was also published before the Conference. The five day paper presentation session was followed by a technical tour/visit to the Central Institute for Cotton Research, Nagpur and cotton areas near Nagpur, including a visit to a pilot plant for making particle boards from cotton stalks. This report is focused on technical highlights of the papers presented at the Conference. Shortly, the full-length papers, abstracts, recorded video presentations and list of participants will be available free on the ICAC web page at <<http://icac.org/technical-information/wcrc-conferences>>.

Important Decisions

The world cotton research conferences are the largest international gathering of cotton researchers. The cotton research community made the following important decisions regarding organization of the WCRC:

- The world cotton research community at the WCRC-5 supported a proposal to greatly strengthen international collaboration (training and research) to deliver outcomes in areas of global importance to the industry, in which

no current alternative capacity exists. Researchers acknowledged the critical shortage of trained personnel in many areas of central importance to the long-term competitiveness and sustainability of the global cotton industry and the need for expanded human capacity building to secure the competitive future of cotton. They recognized the need to work towards enhanced outcomes through education/training, partnership, result sharing, networking and collaboration in areas of common importance. As currently envisaged, the networked nodes associated with advanced cotton organizations and institutes will operate as centers for globally accessible, stakeholder-supported specialist training and collaborative research. The WCRC-5 delegates emphasized the need to explore, plan and promote the setting up of such a global network as a matter of priority, and report on the initial activities of the network at WCRC-6 in 2016.

- The cotton researchers at the WCRC-5 decided to form an International Cotton Researchers Association (ICRA). The Technical Information Section of the ICAC will contact researchers to provide additional information and facilitate formation of the ICRA. The main task of the ICRA will be to help organize WCRCs and promote international cooperation on cotton research. ICRA will decide its own mandate.
- The WCRC-6 will be held in the city of Goiania, Goias, Brazil during June 20-24, 2016. The world cotton research conferences have been held only in English, but Brazil will provide and pay for simultaneous interpretation in Portuguese and Spanish. Additional information will become available at <<http://icac.org/technical-information/wcrc-conferences>> in early 2013.

PLENARY PAPERS

Blending Biotechnology and Breeding

Higher cotton yields lie at the intersection of multiple technologies like plant breeding, agronomic practices improvements and biotechnology. Today a suite of enabling technologies helps drive germplasm improvement. Plant breeding is now experiencing a technical revolution that will drive yield improvements while improved phenotyping is critical for maximizing genetic gain. Seed processing innovations, investments in specialized research equipment for cotton enable greater quantity and quality of data, especially for seed quality improvement. Planting, harvesting and data quality improvements help drive genetic gain with

seed processing innovations. Automated phenotyping will be a key enabler of massively parallel gene screening for future traits, molecular breeding to drive genetic gains in cotton, especially for disease resistance traits, nematodes, and high throughput genotyping capacity is required for molecular breeding. The bottleneck of collecting tissue from plants by hand can be reduced with the help of seed chippers and state-of-art robotics to deliver millions of plant DNA marker analysis to breeders around the world. With New Assay Technologies like Nano Fluidic Based Droplet Technology, outstanding repeatability is delivered. Integrated information

technology tools are essential to effectively leverage all of the phenotypic and genotypic data. Targeting drought tolerance and water utilization efficiency in new cotton product concepts would improve yields with drought tolerant biotech cotton. Understanding responses of current varieties and blending technologies into sustainable solutions are essential for increased opportunities. (Roy Cantrell, Global Cotton Breeding Lead, Monsanto Company, USA).

Biotech Cotton: The First Biotech Crop in India

A series of joint activities in the cotton sector in India between 1991 and 2002 led to the release of the first Bt cotton hybrid in the country in 2002. Adoption of Bt hybrids in India emerged as the fastest adopted technology of all times among agricultural technologies. In a span of 9 years since 2002, 93% of the cotton area has gone to biotech cotton hybrids and varieties. Adoption of biotechnology enabled India to become the second largest producer of cotton and a net exporter of raw cotton. Further, the production of cotton seed cake and oil rose to 6.36 and 1.03 million tons respectively. More importantly, higher production helped create a net value of US\$6.3 billion for Indian farmers. The paper also presented a roadmap for future transgenics targeting increased nitrogen use efficiency, tolerance to sucking pests and herbicide tolerance. (Raju Barwale, Managing Director, MAHYCO, India).

Cotton Life Cycle Inventory

Life Cycle Assessment (LCA) is the examination of potential environmental impact and resource utilization of a product, ranging from the raw materials used through disposal. The primary purpose of this study, undertaken in the USA, was to compile a robust and current Life Cycle Inventory (LCI – the database that is used in LCAs) for global cotton fiber production and textile manufacturing. A secondary objective was to use the LCI data to conduct a complete LCA of a hypothetical knit shirt and woven pant to better understand all aspects of the environmental impact of cotton textiles. Overall, the greatest environmental impact occurs in the consumption phase of the LCA (washing); followed by textile manufacturing (spinning had the most energy use); and lastly the agricultural production of the fiber (fertilizer had the biggest impact within this phase). These results can be used to guide future research for minimizing environmental impacts across the entire life cycle of cotton. (Ed. M. Barnes, Director, Cotton Incorporated, USA).

R&D in the Chemical Processing of Cotton

Cotton fiber has achieved an enviable position in apparel textiles and garments because of its hydrophilic properties. Cotton distinguishes itself as a comfort fiber and thus is used for inner garments and also summer wears. However, since it has poor wrinkle resistance, efforts are made to overcome this weakness by finishing it with resins. Formaldehyde

based resins have their own limitations and hence carboxylic acid based finishing agents are used to get such properties. The paper describes the use of a mixture of acids as well as Chitosan in order to get wrinkle resistance as well as antibacterial properties. Another piece of work takes into account energy saving as well as imparting acid debility to cotton material. Acid dyes are only used on protein fibers. Here simultaneous acid dyeability and resin finishing was successfully experimented and the results are very promising. Making cotton hygienic and imparting wellness is today's requirement. When neem oil, peppermint oil, etc., are microencapsulated and then applied on cotton fabric, the finished fabric showed antibacterial properties. The fabric also exhibited mosquito repellency and fragrance or aroma. Acid dyeable antibacterial cotton was also developed using Chitosan. Natural dyeing of cotton is also gaining more and more importance and it requires the use of metal mordents that sometimes are found to be harmful. The research reported in this paper was aimed at screening some of the mordents, which are herbal and were found to be useful in natural dyeing. Cotton is also bio polished by using various enzymes that are cellulosic in nature. The effect of such enzymes on cotton, before and after dyeing, was studied. The pretreatment of cotton with swelling agents and then its influence on bio polishing as well as on dyeing is also reported in this paper. (Mangesh D. Teli, Institute of Chemical Technology, Mumbai, India).

Is Cotton Breeding Really Progressing?

Breeding for upland cotton (*Gossypium hirsutum* L.) lint yield has passed through a series of tremendous gains followed by slow gains. Nearly all scientific studies have shown genetic gains in lint yield over the years and that has not necessarily correlated with grower yields. In recent history, when insect resistance and herbicide resistance were incorporated into existing cultivars, genetic gains slowed compared to the previous phase. The introduction of transgenes has altered the focus of cotton breeders, which may explain the lack of progress in recent years. But more recently gains in lint yield have progressed at a 5% annual rate in many countries. Nearly all the studies of genetic lint yield gains pointed to number of bolls per unit area as a contributing factor. Efforts in cotton breeding have increased at the private level and declined at the public level. Nevertheless the vast majority of parental material used by commercial and private companies is in-house germplasm. Factors affecting genetic gain include genetic diversity, genetic recombination rates and breeding methodology. Identifying the superior phenotype or transgressive segregants is also a factor. Although significant gains have been achieved between near identical parents, broadening the genetic diversity should enhance genetic gains. Besides, the advent of genetic markers could result in continued breeding progress in the next decades. (Daryl T. Bowman, North Carolina State University, USA).

Bt Cotton – A Story to Remember

The story of Bt cotton in India is unique in the global history of cotton. After its introduction in 2002, the adoption rate was unprecedented, and about 7.0 million farmers adopted biotech cotton on about 10 million hectares (the largest in the world). The introduction of Bt cotton and other innovative technologies helped India to improve cotton productivity from 300 kg lint/ha to 503 kg lint/ha (the highest being 560 kg/ha in 2008). Today, Bt cotton contributes US\$7.0 billion to the farm economy. The adoption of Bt cotton altered the species composition, fiber quality profile, cotton seed oil supply, cotton research priorities, the composition of insecticides used and the entire crop husbandry practices. Commercialization of biotech cotton in India radically altered the cotton export-import, quality, trade and processing scenario and helped India emerge as a global leader in cotton. The exponential growth of a national seed industry is reflected in an annual business turnover of US\$400 million (30% of the total turnover of the seed industry). The paper also traced the technology changes over the last six decades, which helped India in breaking yield barriers. (C.D. Mayee, Former Chairman, Agricultural Scientists Recruitment Board, India).

Sustainable Cotton Growing in Conservation Agriculture

Conservation agriculture (CA) involves minimum mechanical soil disturbance, permanent organic soil cover (mulch and residues) and diversified rotations and was recently enhanced with ley farming systems. Zero tillage (CA/ZT) is the preferred technology under this umbrella, pioneered by Brazil in the tropics. Estimates show that lately 25% of Cerrado region cotton was planted under a conservation tillage system and 55% under “semi-direct” system. The principal benefits are erosion control and improved soil health (chemical and physical), with a plethora more accruing over time. Replacing mono-cropping with diverse rotations generates improved profit, while cover crops generate the biomass needed for the multiple mulch functions that differentiate conservation tillage/zero tillage. The paper enumerated rules of engagement and deals with key adoption problems such as initial removal of physical and chemical constraints, altered nutrient regimes, surface lime application, controlled traffic farming, desiccation of cover crops/weeds, allelopathy and other biological controls. The principal challenges are to create positive collaboration between innovative farmers and researchers, weed management of Roundup Ready and Liberty Link volunteers/re-sprouts in the crops following cotton and avoidance of soil compaction. (John N. Landers, Brazil).

Developments in Cotton Breeding Technology in India

The paper contains an overview of the cotton improvement program pursued in India from 1920 to 2010 and the resulting changes in species composition as well as fiber quality. The

introduction of Sea Island Andrews, development of Suvin cotton, the landmark release of the world's first *intra* – *hirsutum* hybrid H4 in 1970, release of interspecific hybrids Varalaxmi and DCH 32 and the adoption of Bt hybrids are important milestones highlighted in the paper. The paper also acknowledged the pioneering role played by the private seed industry and provided a future agenda for the national cotton research program. The agenda included breeding for high yield and optimizing fiber quality components, evolving production technologies to reduce the cost of production and improve net income. Breeding varieties for organic input conditions and development of conventional (non-Bt) hybrids for extra long staple cotton are among the researchable issues highlighted. (V. Santhanam, Consultant, India).

Challenges in Transferring IPM Technologies to Farmers' Fields

The FAO IPM Task Force Report on IPM in 1992 reported ‘disappointing’ results from 20 years of IPM implementation. IPM in rice had considerable success but cotton has proved more refractory with ‘classical biological control’ being almost entirely unsuccessful and a number of other techniques (including the use of pheromones and crop modeling) not living up to earlier promises. ‘Informed intervention’ usually in the form of insecticides has remained necessary. Nonetheless, the proportion of overall variable costs of cotton production globally, which is attributable to insect control, has fallen from 1998 to 2010 by 48% in irrigated cotton and 28% in dryland cotton, with only a modest proportion of this fall attributable to Bt. Cotton IPM is knowledge intensive – which is its major problem. For political/economic reasons, publicly funded extension systems are in decline globally and their agrochemical industry replacements naturally have a different vision of farmer support. Donor driven, short term; programs cannot achieve the requisite scale. Farmer Field Schools in cotton have clearly demonstrated financial, health and economic benefits but not yet the capacity to expand nationally. A more inclusive program like the ‘Better Cotton Initiative’ is generating enthusiasm. While some counties, like Syria, seem able to manage cotton pest, weed and disease control with minimal toxic inputs, globally the unmet requirements remain as they were in 1992. There is a need for - clearly defined targets and well focused programs of intervention pest control strategies suitable for use by small scale farmers, good links between research and extension, adequate infrastructure and availability of trained personnel at all levels of project management. (Derek Russell, Adjunct Professor, Melbourne University, Australia).

Complex Indices for Cotton Fiber Quality Characterization

The cotton classification system is a system of standardized procedures for measuring properties of raw cotton (physical attributes) that affect the quality of processing (spinning) and products (yarns). Specific cotton fiber properties have a

tremendous influence on cotton quality or spinning ability. The difficulty in utilizing these properties for quality characterization is the multivariate character of information, multiplicity of units and lack of transformation to the utility scale. The paper described a complex evaluation of cotton fiber quality (cotton quality index) based on utility value concept. It was found that yarn strength is critically dependent on fiber strength. The simple models for yarn strength prediction based on the reduction of fiber strength by the multiplicative factors from orientation, Poisson ratio and volume fraction combined with linear regression is useful as well. The effects of process parameters are hidden in yarn fineness and are not as important as fiber strength. These results are valid for rotor yarns only and probably will not be directly extendable for other spinning systems. The paper also introduced Q COTTON program written in MATLAB and also evaluated the proposed cotton quality index by comparing it with other quality criteria using two data sets from the US and Czech Republic. Based on preliminary results, it is learnt that problems with cotton varieties having low micronaire due to fineness and relatively

high strength need to be solved. (Jiri Militky, Professor, Technical University of Liberec, Czech Republic).

Cotton Genomics

Genomics has emerged as a multi-faceted suite of sub-disciplines that offer revolutionary inroads into the basis of heredity, the basis of traits, evolution, and many newly perceived relationships among extant organisms. The paper provided answers to a few key issues that relate to the following two questions. "What can genomics do for cotton, cotton production and cotton utilization? Why should those interested in advancing cotton help develop cotton genomics? Specific topics centered on several more specific questions. 1) What is genomics? 2) What is the status of cotton genomics? 3) How can we use genomics to enhance cotton net value? 4) What aspects of cotton genomics need emphasis and investment? 5) How can we push forward the development of cotton genomics in the public sector to the benefit of all? and, 6) What are some prospective derivatives that will benefit cotton? (David Stelly, Professor, Texas A&M University, USA).

PANEL DISCUSSIONS

Biotech Cotton

The number of countries planting biotech cotton increased to 12 in 2010. In 2010, the global biotech cotton area represented 64% of the 33 million ha planted to cotton in the world. The overall acceptance of Bt technology by farmers is highly positive and consistent. The preference to grow Bt cotton, which is measured as a repeat index is almost 10 on 10 that shows farmers preference to grow Bt cotton year after year. India has also witnessed a substantial increase in double gene Bt cotton hybrids over single gene Bt cotton hybrids with an estimation of more than 75% of total Bt cotton hybrids planted with double gene Bt cotton. The impact of Bt cotton is evident and now it is important for India to sustain the upward trend in cotton yields. For achieving this it is imperative to expedite the approval of new generation stacked technologies that combine the best of Bt and herbicide tolerance in the best of cotton germplasm. (Bhagirath Choudhary, International Service for the Acquisition of Agri-biotech Applications- ISAAA, India).

The Bt technology has revolutionized crop improvement and the success story of Bt cotton in India is an example to be emulated in other crops as well. The scientific community should address the concerns raised by different sections of the society. The paper suggested that deregulation of regulatory constraints needs to be deliberated upon while recognizing the success, experiences and social aspects of GM cotton in the country. The Bt technology has raised fundamental concerns in agriculture and the society and therefore, the effective management of science is imperative for all concerned for delivering benefits of the technology to all allied segments of

the industry. (Swapan K. Datta, Indian Council of Agricultural Research, India).

The paper reviewed adoption, progress and impact of Bt cotton in India. The paper cautioned that dominance of biotech cotton varieties/hybrids could lead to elimination or disappearance of traditional cotton grown in India. "Bt cotton cannot be a panacea for everything". There is a need to sustain the success of the Bt technology, introduce new and improved Bt cotton hybrids/varieties that encourages large-scale mechanization of cotton picking. (C. D. Mayee, Former Chairman, Agricultural Scientists Recruitment Board, India).

The Managing Director of MAHYCO, the largest seed company in India, emphasized the role of public private partnerships and vehemently recognized the contribution of the public sector in the commercialization of Bt cotton in India. The paper cited the example of a how different public and private sector institutions and state agricultural universities efficiently worked together for the common goal of ensuring the safety, efficacy and utility of Bt cotton for the benefits of marginal cotton farmers of the country. The whole process of deregulation of Bt cotton took 7 years of partnership that engaged hundreds of scientists from various public and private sector institutions for the evaluation of various regulatory parameters set forth by the regulatory authorities including Genetic Engineering Approval Committee (GEAC), Review Committee on Genetic Manipulation (RCGM), Monitoring and Evaluation Committee (MEC) and Institutional Biosafety Committees (IBSC) of the Ministry of Environment and Forest. Bt cotton as a model of effective partnership between public

and private sector could yield breakthroughs in agriculture. (Raju Barwale, Managing Director, MAHYCO, India).

The cotton cultivation profile has changed in India since the adoption of Bt cotton in 2002. The Bt technology is a magical technology that has proved beyond doubt to be effective, economical, sustainable and safe. The controversy about Bt technology is not justified and rather irrelevant as there has not been any scientifically proven ill-effects of Bt cotton, or any other Bt crops, anywhere in the world. There is a need for aggressive and passionate scientific outreach initiatives effectively designed to reach out to farmers, government officials, policy makers, media, students, faculty and all concerned stakeholders to educate and create adequate awareness on the safety of the technology. The industry and scientists must stand united in upholding the scientific truth and speak in one voice to mitigate the unrelenting opposition on biotechnology. Bt cotton also helped to refine regulatory protocols in India. (T.M. Manjunath, India).

This paper is about future opportunities in biotech cotton with a matrix for organizing future course of action for cotton development. The proposed model/matrix uses Cartesian coordinates where one axis represents the scientific difficulties that are faced while going forward. The other end of this axis is the unexplored scientific territory where it is intended to build drought tolerance and nitrogen use efficiency into cotton. At this juncture the complexity suggests greater difficulty and more scientific hurdles to overcome. The paper suggests that at this point past success experience with traits that confer resistance to insect pests and herbicides can be utilized to advance further. On the other axis of the matrix, other barriers to success including; social, economic, regulatory and political considerations are considered that could block the path forward if they are not reasonably addressed. Ignoring these barriers would most certainly delay scientific progress and potentially even bring research to a halt. The Monsanto Company, along with others, is engaged in the process of searching ways to understand and improve the ability of cotton to respond to hemipteran pests, and environmental stress and efficient use of nitrogen fertilizer—the full range of difficulties along this scientific spectrum. (English Leigh, Monsanto Company, USA).

Brazil is the second country in the world after the U.S.A. to lead in the adoption of GM crops and most of it is represented by soybeans, which accounts for almost 21 million hectares of a total area of 30 million hectares, considering the three major crops: soybeans, corn and cotton. Bt cotton was approved in 2005, and in 2011 there were nine traits available for cotton, two for insect resistance, four for herbicide tolerance and three stack genes (both IR and HT). In 2010/11, around 25% of the cotton area was planted under genetically modified varieties that accounted for around three hundred thousand hectares; most of it represented by herbicide tolerant varieties (115,000 ha) and herbicide tolerant and insect resistant varieties (95,000 ha). In Brazil, with regard to the social, environmental and

economic benefits of GM crops, the biggest benefits were reduced use of fuel, water and insecticide sprays; reduced emissions of CO₂ and additional carbon retention by the soil. Biotechnology is a modern tool in cotton cultivation and further improvement in important agronomic features must be brought which would greatly help in delaying insect resistance and thus help in sustaining the benefits of the remarkable technology. Biotech control to boll weevil is a must to increase biotech cotton adoption in the South American countries. In Brazil, the benefits of biotech cotton among others are positive effects on the environment, positive effects on workers by reducing the risk of contamination by pesticides and lower production costs. According to the paper, Brazil has one of the most modern and safe biotechnology laws in the world. (Haroldo Rodrigues da Cunha, Cotton Grower, Brazil).

Insecticides: What is Next?

All the deliberations in the session emphasized the sustainable (long term) crop protection that will be cost effective with minimal toxicological/environmental impact. Insecticides' footprints since 1940 till date were presented and categorized on the basis of chemical groups of the molecules and their mode of action. From time immemorial mankind has tried to control insects using inorganic compounds (sulfur, mercury, lead, arsenic, etc.), plant extracts (pyrethrum, neem, rotenone, nicotine-sulfur compounds, citronella, etc.), petroleum products (oils, soaps, kerosene, etc.), gases (cyanide, methyl bromide, etc.), and others and some of them are still used. The second generation insecticides or synthetic insecticides that are in use since the mid 1940s and belong to different groups like organochlorines, organophosphates, carbamates, pyrethroids, neonicotinoids, etc. Insect pest management pre and post biotech cotton was compared. Prior to the commercialization of biotech cotton (in countries that have commercialized biotech cotton) pest control had:

- Major dependency on broad-spectrum chemistry;
- Increasing number of applications involved high cost and risk of environmental pollution;
- Resistance problems – Pressure on the insecticide industry for new chemistries;
- Negative impact on yield & quality.

Wide scale use of insect resistant biotech cotton has observed that

- Absence of major bollworms has led to drastic reduction of broad-spectrum chemical usage;
- Increased pressure from sucking pests and bugs increased use of newer insecticides;
- Yield and quality improved particularly in developing countries that adopted biotech cotton.

As far as insecticide market and mode of action are concerned, 50% of the commercial insecticide portfolio is 30 years and

older. The existing insecticides act through 25 different modes of action. Most important are nerve and muscle targets.

It is a matter of concern that development of an insecticide is a lengthy and expensive process. It may take 9-10 years before a product is commercially available and the cost involved in bringing a new product to the market is approximately US\$200-300 million. An interesting fact is that out of 500 odd molecules synthesized, may be one or two molecules can only be launched successfully. There is also a reduction in the number of US - European research-based agro-chemical companies. In 1960, 42 such companies were in existence whereas in 2010, the number has declined to 6-7 companies. The insecticide industry has to focus on newer insecticides because of pressure for new chemistry development, new pest emergence threats, magnified emphasis on human and environment safety considerations, increasingly stringent regulatory measures to safeguard environment and replacements and phase-outs. Trends in new insect control

agents are particularly focused on small classes of chemistry (1-3 compounds) and greater selectivity which points toward improved selectivity of beneficial insects and improved environmental & mammalian safety profiles.

It was indicated that Flonicamid 50% WG (Ulala)- an insecticide to control sucking pests with rapid inhibitory effect on insect feeding is in the process of introduction. Although the treated aphid attached the head of its proboscis to the leaf surface, salivation and sap feeding were strongly inhibited. These results suggest that the main insecticidal mechanism of Flonicamid is starvation based on the inhibition of stylet penetration to plant tissues.

It is also time to popularize 3rd generation insecticides like insect growth regulators, Ecdysones, Pheromones, and Chemosterilants etc. Companies do not have “products sitting on the shelf” and old chemistries cannot meet new standards (safety, efficacy, etc.) It is important to project a scenario of crop cultivation in relation to crop protection issues.

SPECIAL SESSIONS

Cotton Mechanization

Cotton Mechanization – A Journey

The paper titled ‘Cotton Mechanization – A Journey’ covered the evolution and history of cotton mechanization in different parts of the world and also outlined the possible trends in mechanization in non-mechanized regions. Mechanization and yield have symbiotic relationship. Mechanization is a prelude to precision farming, which leads to optimal use of inputs, correct row and plant-to-plant spacing, thus improving productivity and profitability of farmers. Mechanization also leads to better agronomic practices and standardization in these practices and thus helps to eliminate variability in yields and attempts to circumvent vagaries of nature. Mechanization is affected by socio-economic macro trends of the country. The most significant are the scarcity and cost of labor. This is driven by industrialization and migration to urban regions from rural parts of the country. Since the USA was the first country to mechanize cotton, the industry faced challenges that had to be overcome. The challenges were from seed varieties, chemicals for defoliation and growth regulation, equipment and finally agronomic “know-how” for mechanized cotton. Mechanization in China has been driven by labor shortages and government policies. The drivers for mechanization in India are growing labor shortages, increasing labor costs; pressure to improve profitability through higher yields and to reduce the length of the crop cycle to allow double-cropping and competition with food crops for available arable land. Following a value chain approach and adopting lessons learned from other countries, mechanization is very much possible in the time frame of 2-3 years as was done in Turkey. (Ganesh Jayaram, Global Director, Cotton Product Line, John Deere, USA).

Pre-Treatment Approach to Acala and Pima Defoliation in California

A well-timed and effective defoliation with proper choice of harvest aid chemicals can be beneficial for cotton in many ways resulting in improved boll opening and better fiber quality. Early application of harvest aids will be advantageous not only for defoliation but also for advancing the start of harvest and reducing the potential of late season whitefly and aphid infestation. However, no significant yield difference was observed when Ginstar (thidiazuron + diuron) or Ginstar plus Finish (ethephon + cyclanilide) were applied at either the 6 or 4 nodes above cracked boll stage. But lint quality attributes were improved. Though not suitable for most conditions, even better results can be obtained when a farmer plans his defoliation 21 to 28 days prior to the expected harvesting dates. (Steven Wright, University of California Cooperative Extension, USA).

Comparative Analysis of Production Practices and Post-Harvest Handling of Cotton by Smallholder Farmers in Kenya and Mozambique

Cotton is a very important sub-sector in the economies of the Eastern and Southern African countries in terms of household income, employment generation and contribution to the Gross National Product. However, there is decline in cotton production and productivity in the region. The paper reported an analysis of the cotton sector in Kenya and Mozambique, especially of production practices and post-harvest handling with a view to identify constraints and opportunities for improvement. Organization of production and marketing in the two countries are different; Kenya operates a free market

system, while Mozambique uses the concession system. In Kenya, an average of 0.77 ha is under cotton compared to the average size of land holding of 4.25 ha. In Mozambique, the average size of land owning is 3.99 ha with 1.42 ha under cotton. Cotton productivity is lower in Mozambique compared to Kenya and cotton income follows a similar trend. (Daniel Karanja and Richard Musebe, CABI, Nairobi, Kenya).

International Cotton Genome Initiative

This session was organized at the invitation of the officers of the International Cotton Genome Initiative (ICGI). Speakers were also invited by ICGI. Dr. I. Aburakhmonov of Uzbekistan elaborated on 'Marker-assisted selection for improving quantitative traits of cotton.' The emergence of DNA markers opened new opportunities for crop improvement, like a marker-assisted selection (MAS) technology that accelerates crop breeding by several times. Twenty-three major fiber trait-associated DNA markers were selected as a tool to control the transferring of QTL loci during a genetic hybridization. Thirty-seven wild race stocks and variety accessions were chosen from diverse ecotypes as donor genotypes that bear important QTLs for fiber traits. These donor genotypes were crossed with nine commercial cultivars of Uzbekistan (as recipients) in various combinations with the objective of improving one or more fiber characteristics of these recipients. A second generation of recurrent parent backcrossed hybrids (F_1BC_2), bearing novel marker bands and having superior fiber quality compared to original recipient parent (lacking trait-associated SSR bands) were selected. The results showed the functionality of the trait-associated SSR markers detected in association mapping efforts in a diverse set of upland cotton germplasm. Using these effective molecular markers as a breeding tool will pyramid major fiber quality traits into a single genotype of several commercial upland cotton cultivars of Uzbekistan.

The second presentation was by Dr. Sukumar Saha of the

USDA on interspecific chromosome substitution lines from *G. barbadense* and *G. tomentosum* in upland cotton improvement. The objective of the study was to develop chromosome substitution lines from other tetraploid species in *G. hirsutum*. Several *G. barbadense* chromosome or chromosome arm substitution (CS-B) lines were developed. Analogous chromosome substitution lines involving *G. tomentosum* ("CS-T" lines) were also made. Some of the CS-T lines are being characterized. Currently monosomic or monotelodisomic chromosome substitution lines from *G. mustelinum* ("CS-M" lines) are being developed. These materials will provide additional tools in genomic analysis and genetic improvement of upland cotton. The genomic resources of chromosome substitution (CS) lines will compliment conventional approaches of interspecific introgression in upland cotton improvement.

Dr. Vasu Kuraparthi, USA made the third presentation on establishing the cotton breeding and translational genetics program at the North Carolina State University. The objective is to broaden the genetic base of cotton through conservation, efficient utilization of biodiversity using genetic and genomic tools and to understand the genetic basis of fundamental biological processes in cotton. Primary emphasis of the research is on cotton genetics and breeding with the goal of developing germplasm, genetic stocks, mapping and genomic resources for enhancing cotton productivity through improved genetics and breeding. The main focus is germplasm development with a particular interest in the improvement of cotton yield and fiber quality. Developing new breeding methodologies based on molecular and genomic technologies especially techniques directed at the identification and utilization of novel genetic variation is given major emphasis. Current research activities include breeding for improved crop yield and quality, breeding for disease and insect resistance, application of molecular markers in crop breeding, utilization of exotic germplasm and molecular cytogenetics.

CONCURRENT SESSIONS

Biology of Fiber

Dynamics of Transcriptome and Proteome During Cotton Fiber Development

The paper highlighted a large-scale analysis of the structural and functional genome at proteome and transcriptome levels for understanding the fiber development process. It employs a multidimensional approach involving high throughput and hyphenated principles to reveal the proteome dynamics during development, followed by orthogonal/simultaneous validation of the same using Microarray and PCR based strategies. A comparative analysis involving fiber-mutant to identify the genes that are expressed in a stage specific manner and also effect of abiotic stress (water deficit) on the genome response

during fiber initiation, elongation and secondary cell wall synthesis showing the dynamics of fiber transcriptome and proteome during various phases of fiber development are discussed in this paper. (Siva Reddy, India).

Validation of SSR Markers Linked to Fiber Traits in Cotton

The paper deals with validation of the SSR markers known to be linked to fiber related traits. A total of 29 SSR markers were employed to a F_2 population derived from an interspecific cross Sahana (*G. hirsutum*) and Suvin (*G. barbadense*). Based on segregation of marker data four SSR markers were identified. The SSR marker NAU3499 was identified to be associated with fiber strength, NAU3562b with fiber length, BNL2652

with fiber fineness and NAU2238 with fiber elongation. (Ishwarappa Katageri, India).

Cloning and Characterization of Cellulose Synthase Genes from *Arabidopsis thaliana*

This paper dealt with isolation of cellulose synthase genes *rsw1*, and *AthA* from *Arabidopsis thaliana* that are involved in rapid conversion of carbon to UDP glucose (uracil-diphosphate glucose) to facilitate the synthesis of cellulose and/or callose as energy-efficient process. The full length sequence of *AthA* (5.3 kb) and *rsw1* (6 kb) genes were amplified from *A. thaliana*, cloned into pJET 1.2/blunt vector and transformed to *E. coli* (DH5 *Alpha*). The clones were confirmed by restriction analysis, PCR and sequence analysis. BLAST analysis showed homology to the extent of 99% with *CesA2* (*AthA*) gene. In addition, fiber specific promoter ~1.8kb amplicons was isolated from cotton that showed similarity with *CesA4* promoter region. (Ganesan Balasubramani, India).

Identification of Genes Responsible for Fiber Elongation During Early Cotton Fiber Development by Suppression Subtractive Hybridization

Subtractive PCR was performed using cDNA prepared from 10 days post anthesis of *G. arboreum* control (fibered) as tester and cDNA from *G. arboreum* fibreless mutant to identify the genes involved in fiber elongation. Subtracted PCR products were cloned and sequenced. The quality ESTs were assembled into contigs. Blast analysis found that 186 clone sequences were annotated, 53 clone sequences were hypothetical proteins and 192 clone sequences were novel. Real time RT-PCR using 60 annotated genes and qPCR analysis showed that 12 genes were differentially expressed and the genes such as beta-galactosidase, big map kinase, ribosomal protein s8, cytochrome oxidase subunit1, glycosyltransferases were found to be up-regulated in the tester. (Hiremath Vamadevaiah, India).

Genome Wide Transcriptome Analysis of Fuzzless-Lintless Mutant Cotton (*G. hirsutum* L. Cv. MCU5) During Fiber Elongation

In this study genome wide transcriptome analysis was carried out using Affymetrix GeneChip cotton Genome array to understand the genes involved in fiber development by comparing fuzzless-lintless mutant (MCU5) with its isogenic line cv. MCU5. A total of 641 (110 up/531down), 474 (41 up/433 down), 2,727 (1,164 up/1,563 down) and 824 (366 up/458 down) transcripts were found differentially expressed in mutant plants as compared to normal at 2, 5, 10 and 15 days post anthesis (dpa), respectively. More transcripts were down-regulated in mutant plants during initial fiber elongation stages (2 dpa to 5 dpa). Transcripts encoding alcohol dehydrogenase 2b, arabinogalactan protein 2, fiber protein GLP1 (Glp1), endo-xyloglucan transferase, alpha-expansin 1,

proline-rich protein (PRP5), long chain fatty acid elongation enzyme (xl1 gene), aquaporin gamma-TIP, cytochrome P450-like protein (cyP450 gene), alpha-tubulin (TubA2), endo-xyloglucan transferase, acyltransferase-like protein (ACY), zinc finger (C2H2 type) family protein, TCH4 (TOUCH 4), heat shock protein 81-1, pectate lyase, profilin and fasciclin-like arabinogalactan protein 19 (FLA19) were highly down-regulated during fiber development stages in mutant plants. (Mogilicherla Kanakachari, India).

Elevated Heat Units Influence Transition Stage Timing During Cotton Fiber Development Resulting in Increased Fiber Strength

Heat units required for cotton growth and development were recorded for four growing seasons and compared with fiber quality measurements and gene expression data indicative of different stages of fiber development using near-isogenic lines MD 52ne and MD 90ne. Bundle-strength differences were present as early as 20 days post-anthesis and persisted to boll opening and fiber maturity. The study indicated that an earlier entrance into the transition stage of fiber development resulted in increased fiber bundle strength. The paper concluded that the identification of genes associated with early entrance into the transition stage could manipulate fiber development and improve fiber quality. (David Fang, USA).

Analysis of Cotton Fiber Initiation Stage Specific Transcription Factors Under Drought Stress

This paper is on Transcription Factors (TF) involved in normal fiber initiation and affected by drought stress. *G. hirsutum* cv. Bikaneri Nerma was used for the study. RNA, isolated from leaf and zero days post anthesis boll samples, was used for microarray analysis using Affymetrix cotton Gene Chip Genome arrays. Differentially expressed genes and putative TFs were identified comparing cotton Affymetrix consensus sequences with 2,451 protein sequences present in *Arabidopsis* transcription factor database. In total, 206 putative TFs were found differentially expressed in control zero days post anthesis boll, whereas 285 under stressed zero days post anthesis boll. One hundred and fifteen out of 285 TFs showed drought specific expression. (Amol Kumar Solanke, India).

Introgression of High Fiber Strength Trait to Upland Cotton Using Marker-Assisted Selection

An attempt was made to improve fiber strength of *G. hirsutum* by utilizing *G. barbadense* as donor through back cross (BC) and modified back cross (MBC) pedigree breeding methods following marker-assisted selection using SSR markers. The results showed that fiber strength varied from 18.0 to 36.0 g/tex. The heritability and genetic advance for fiber strength was high. In the BC₁F₁ generation, fiber strength varied from 24.4 to 32.7 g/tex and the plants with higher fiber strength

were crossed with the same recurrent parent and also with different *G. hirsutum* parents. Continuous selection was done using fiber strength markers, and selfing was done up to BC₁F₈ and MBC₁F₆ generation to develop the high fiber strength *hirsutum* lines. By using fiber strength markers, four single plant progenies were identified with uniform high fiber strength that ranged 30.0 to 35.7 g/tex and high yield. (Nallathambi Kannan, India).

Temporal Changes in Important Enzymes and Solutes Trigger Epidermal Cell Differentiation Into Fiber Initials in Cotton

Cotton fibers, as one of the longest single-cell seed trichomes, act as an excellent model for unraveling fundamental biological processes such as cell differentiation, cell expansion and cell wall biosynthesis. Temporal changes in the oxidative enzymes and solute content were studied in near isogenic lines of linted cotton (*G. hirsutum*) and lintless mutant. The ovules were quantified for peroxidase (POD), catalase (CAT), ascorbate peroxidase (APX) and superoxide dismutase (SOD) from ten days pre-anthesis to six days post anthesis (DPA). Biochemical analysis of the lintless mutant ovules indicated a marked reduction in the synthesis of reducing sugars, total free amino acids and total soluble protein content. The failure to trigger the production of anti-oxidants and synthesis of solutes at anthesis could be regarded as crucial factors for non-conversion of epidermal cells to fiber initials in lintless mutant, thereby providing enough clues as biochemical determinants for fiber development process in cotton. (N. Gopalakrishnan, India).

QTLs Mapping for Fiber Quality Traits Across Multiple Generations and Environments in Upland Cotton

Identification of stable QTLs of fiber quality traits in multiple generations and environments could facilitate marker-assisted selection (MAS). In the present study, F₂, F₂:3 and recombinant inbred lines (RILs, F₆:8) populations derived from an upland cotton cross between 0-153 and sGK9708 were developed. A total of 5742 SSR primer pairs were used to screen for polymorphism between the two parents. Linkage maps of F₂ and RILs were constructed, containing 155 and 190 loci and with a total map distance of 959.4 cM and 700.9cM, respectively. The fiber quality data of F₂, F₂:3 families and RILs were used to screen the QTLs in multi generation and environments through Composite Interval Mapping. A total of 51 QTLs were identified; 10 for fiber strength, 10 for fiber length, 11 for micronaire, 8 for fiber uniformity and 12 for fiber elongation ratio. 8 QTLs were common in F₂, F₂:3 and RILs. 2 QTLs for fiber strength located on C7 and C25 were detected in all the three generations and four environments simultaneously and each QTL explained 16.67%~ 27.86%, 9.43%~21.36% of phenotypic variation, respectively. The identified QTLs were suggested to be used for marker assisted selection (MAS). (Yuan Youlu, China).

Molecular Genetic Diversity

Genetic Diversity Evaluation of Cotton Germplasm of *G. hirsutum* and *G. arboreum* and Establishment of SSR Fingerprints

Three hundred thirty elite *G. hirsutum* varieties and germplasm lines and 200 accessions of *G. arboreum* were accessed based on agronomic and economic trait surveys, genetic similarity and cluster analysis by using the polymorphic SSR. A digital fingerprinting of some elite germplasm lines was primarily established. The study revealed that the variation of fiber yellowness was higher than the fiber quality traits in *G. hirsutum* while the genetic diversity was extremely abundant in *G. arboreum*. The Un-weighted Pair Group Method with Arithmetic Mean (UPGMA) cluster analysis indicated narrower genetic base distance among the elite germplasm in upland cotton than in *G. arboreum*. In *G. arboreum* germplasm, the phenotypic clustering and molecular results were not consistent, and no apodictic relationships between genetic distance and geographic distance were observed among genotypes. A barcode method was developed called denary numeric string for distinguishing the fingerprints of different germplasm, which was simpler than that of a binary system. (Xiongming Du, China).

Assessment of Genetic Diversity in *G. barbadense* Accessions

G. barbadense is known for superior fiber quality traits. The genetic diversity among 55 *G. barbadense* accessions using multivariate Mahalanobis D² statistics was accessed. Results showed that grouping of accessions into different clusters was independent of the geographical origin of accessions. The analysis of variance showed highly significant differences among genotypes for all the characters. Cluster I was largest consisting of 36 accessions followed by cluster V. The composition of clusters indicated prevalence of a relationship between genetic diversity and geographical distribution. Seedcotton yield, ginning out turn, boll weight, bundle strength and span length were the major characters contributing towards divergence in *G. barbadense* germplasm. (Paul Amala Balu, India).

Diversity Analysis in Core Accessions of Upland Cotton (*G. hirsutum*)

Genetic diversity amongst 94 upland cotton accessions from a set of core collection was analyzed using a total of 55 primers (22 SSR, 14 SRAP, 8 TRAP and 11 RAPD) markers. The 55 primers showed 57.03 percent polymorphism across 94 accessions. The size of amplified fragments ranged from 170 bp to 3kb while the combined marker analysis revealed an overall similarity coefficient (SC) values ranging from 0.70 to 0.94 with an average of 0.82. The dendrogram analysis using similarity matrix data indicated a total of eight major clusters with three accessions as out-group members. Most distinct genotypes from different clusters were identified for

use in breeding and linkage disequilibrium studies. (Vijay N. Waghmare, India).

Genetic Diversity Analysis of Cotton Germplasm

For this study, 192 proprietary inbred lines of *G. hirsutum* that show variable phenotype for traits such as leaf hair density, leaf texture, boll size, plant architecture, fiber quality parameters, maturity group and response to biotic and abiotic stresses were selected and screened with 50 polymorphic microsatellite markers. Forty-seven of the 50 loci were polymorphism with similarity index values ranging from 0.41 to 0.98. A dendrogram showed three major and twelve minor clusters and the results suggest a high degree of genetic diversity in the screened germplasm lines of cotton. (Venugopal Mikkilineni, India).

Genetic Enhancement

Divergent Selection for Yield and Earliness in Cotton (*G. hirsutum* L)

The combined selection for yield and earliness revealed potential for genotype selection combining satisfactory yield, ranging from 45% to 72%, with reasonable earliness by five to seven days compared to the selection for earliness alone, being eight to eleven days. The combination between earliness and yield appears to be possible while the combination between yield and maturity seems to be impossible for the specific genetic material under specific circumstances. (Michalakopoulos Panagiotis, Greece).

Validation of Molecular Markers Against Cotton Bacterial Blight Disease Caused by *Xanthomonas axonopodis*

This paper dealt with identification of resistant source to highly virulent race of *Xanthomonas axonopodis* through artificial screening techniques and genetic inheritance studies for resistance breeding. Isolates were collected from different cotton growing areas and inoculated on ten cotton differentials to identify the *Xanthomonas* races. Among these isolates four races viz. race 6, 8, 15 and 18 were identified. 68 cotton genotypes were screened against most virulent race 18 by syringe infiltration method and two genotypes viz. Ca/H-631 and Ca/H-2046 were found highly resistant. For the genetic inheritance study, Ca/H-631 and Ca/H-2046 were crossed with highly susceptible genotypes viz. Ca/H-658 and Ca/H-551. The resultant F_1 's were inoculated with the race 18 and the same were found resistant, indicating the dominant nature of the gene. 500 plants of each F_2 's were grown and screened for bacterial blight resistance. The segregation fits in a 3:1 ratio for resistance to susceptible. The same populations were also screened with published markers and a perfect correlation was found between phenotype and genotype generated by the markers, indicating a single dominant gene governs resistance. (Gokul V. Shelke, India).

Development of Naturally Colored *Gossypium hirsutum* Cotton Genotypes Suitable for Textile Industry Through Genetic Improvement

Breeding efforts were made to improve the naturally colored *G. hirsutum* cotton genotypes with respect to yield and fiber quality through intra-specific, inter-specific and three way crosses between colored and superior white genotypes followed by selections independently in three populations. Stable genotypes with uniform color, high yield potential and improved fiber qualities were developed. Three of these lines viz., dark brown (DDB-12 with 2,986 kg/ha seed cotton yield), medium brown (DMB-225 with 2,934 kg/ha) and green (DGC-78 with 1,381 kg/ha) reported to have potential for seedcotton yield and quality in the respective color. (S. Maralappanavar Manjula, India).

Creating Novel Diversity and Using Comprehensive Methods for their Further Use in Hybrid Research – An Exercise in *Gossypium hirsutum* L

The paper concluded that a considerable amount of genetic variability can be generated from double crosses, three-way crosses and single crosses derived from highly diverse parents. The diversity generated was assessed through K-means clustering. A simple method called Path-of-productivity analysis was adopted to identify the different paths that the top 12 lines took towards producing higher yields. It was observed that these lines did have differences in paths to higher yield attributable to their differential genetic make-up. In addition, these 12 genotypes fell in five different clusters identified previously. (Rajesh S. Patil, India).

Genetic Transformation of Cotton: Progress and Problems

It is important to increase the conversion of pro-embryos in the callus to globular and torpedo shaped embryos in a very short time by subjecting them to metabolic stress. This can be done by reducing the availability of major and micro-nutrients of MS medium and drying the medium by using a porous tape. Stress from globular embryos produced 33% embryos. Further advancement was made using directly embryogenic callus for transformation with *Agrobacterium*, which enabled direct development of embryo or embryogenic callus. These plants were established as normal plants and transferred to contained facilities for further studies. (S. Leelavathi, India).

Estimation of Genetic Parameters for Yield and Fiber Quality Traits in Inter-Specific Crosses of Cotton (*Gossypium* spp.)

The presence of additive, dominance and epistatic gene interactions for yield and fiber quality traits was confirmed through generation mean analysis carried out using four crosses of different cotton cultivars. Duplicate type of epistasis played a greater role than complementary epistasis for yield and quality traits. (Gunasekaran Mahalingam, India).

Effect of Alien Cytoplasm and Nuclear Genes in Alloplasmic x Euplasmic and Euplasmic x Euplasmic Hybrids in Upland Cotton (*Gossypium hirsutum*)

The paper reported that alien cytoplasm and nuclear genes did not exhibit deleterious effects for fiber quality traits. However, a gain was reported in some of the cytoplasmic male sterility (CMS) based alloplasmic x euplasmic hybrids for 2.5% span length and uniformity ratio over the euplasmic hybrids. The CMS based alloplasmic x euplasmic hybrids expressed their superiority over the genetic male sterility (GMS) based euplasmic x euplasmic hybrids for most of the fiber quality traits. But the average performance of conventional euplasmic x euplasmic hybrids was unambiguously superior over the two types of hybrids for yield and its component traits. (O. P. Tuteja, India).

Elite Cotton Varieties in the Zimbabwean Private Sector Research Program

The yield data indicated that the entry 675-02-1 performed better than others with the average seedcotton yield of 2.33 t/ha under dry-land conditions. Entry 675-02-1 has medium size bolls with very good seedcotton retention and early maturity. Two hundred and sixty four lint samples from the first picking were analyzed on HVI for fiber analysis in terms of fiber length, strength, elongation, maturity and micronaire. The latest maturing entry B81-05-1 had the longest fibers associated with strong and good micronaire values. (J. K. Mandiveyi, Zimbabwe).

TAK FA 84-4: New Jassid Tolerant Cotton Variety

The menace of jassid, especially in a dry period, resulted in yield reduction and increase in insecticide use. A target specific breeding program resulted in the development of a variety Tak Fa 84-4 which has out-standing tolerance to jassid, has good fiber quality and is resistant to the leaf roll disease. (Parinya Seibunruang, Thailand).

Good Characters of New Outstanding Cotton Varieties Developed in Tanzania

After years of testing of several breeding materials, two lines were found to be superior with respect to number of characters and therefore recommended for use by farmers, these are UKM 08 and UK 08. (Tryphon Kibani, Tanzania).

New Cotton Germplasm with Intermediate Cycle Called SP 48114 Developed by National Institute of Agricultural Technology – INTA

A new germplasm SP 48114, which is characterized by greater differentiation of fruiting points on the main stem (5% more) than Guazuncho 3 INTA was developed through the pedigree method. The commercial variety (Guazuncho 3 INTA) is short cycle and has high boll retentions on first fruiting branches. The

selected line SP 48114 maintained boll retention in the interior part of the plant, but continued the process of flowering for more days. The new line is 10 days early in maturity and has improved compensation at the time of water stress. The fiber length is 29 mm and strength 31 g/tex with lint percentage of about 40 %. (Mauricio A. Tcach, Argentina).

Introgression Breeding in Cotton

Tetraploidization of diploid *G. arboreum* using colchicine paved the way to introgress to *G. hirsutum* (for thick lower palisade layer) that confer resistance to sucking pests. Further, improvement in fiber quality (length and fiber fineness) was possible in diploid cottons using *G. hirsutum* as a donor. These introgressed *G. arboreum* genotypes are thought to be the best candidates to substitute *G. hirsutum* as they are inherently resistant to sucking pests. Introgression of *G. arboreum* race bengalense with race cernuum and B genome *G. anomolum* yielded a stable five locule *G. arboreum* (ABC-5) genotype. The distant hybridization of *G. arboreum*, *G. hirsutum* and *G. herbaceum* cotton with *G. austral* resulted glandless seed and glanded aerial parts conferring gossypol free cotton seed oil and resistance to pests and diseases. (Basavaraj M. Khadi, India).

Developing a Transgenic Product for Controlling *Lygus* in Cotton

The paper was on isolation and characterization of a *Bacillus thuringiensis* crystal protein with insecticidal activity towards *Lygus*. The protein expressed in transgenic cotton plants was tested for activity against *Lygus* and demonstrated that transgenic cotton plants expressing this protein caused increased mortality and stunting of *Lygus* nymphs. These results provide a basis for the development of cotton varieties safe from *Lygus* feeding damage. (Kahad Anilkumar, USA).

Development of Biotic Stress Resistance Transgenic Diploid Cotton Utilizing *Agrobacterium* and Shoot Apical Meristem Cells

The paper is on developing diploid transgenic cotton resistant to insect and diseases (*Heliothis* and grey mildew) using *cry* and chitinase genes, independently. Three promising cultivars were used for transformation. The vector containing the Cry1Ac gene was obtained from the National Research Centre on Plant Biotechnology, New Delhi while chitinase gene construct was made at CICR, Nagpur. Shoot tip explants after *Agrobacterium* infection, were co-cultivated on MS medium followed by kanamycin selection to obtain putative transformants. The transformants regenerated shoots rooted on MS supplemented with 0.05 to 0.1 mg/L NAA and 15g/L glucose and rooted plants were acclimatized in liquid MS without hormone followed by their transfer in plastic pot containing soil-rite mix TC. The transformed plants were confirmed as transgenic using PCR, ELISA and Southern blot analysis. (Sukhadeo B. Nandeshwar, India).

Engineering Cotton Leaf Curl Virus Resistance Cotton Through RNA Interference Approach

Most predominant tetraploid hybrids and cultivars are susceptible to cotton leaf curl virus (CLCuV) disease. RNAi-mediated approach was employed to target CLCuV and develop virus resistant transgenic cotton. Primers with engineered restriction sites were designed to amplify five conserved target sequences (MP, CP, AC2, β C4 and β V4), ranging from 109-367 bp, in DNA-A and β -DNA components of the virus, PCR amplified and cloned in pGemT. The five inverted repeat constructs were sub-cloned in two binary vectors pBin-AR and pGreen and introduced in *Agrobacterium tumefaciens* strain EHA 105 by tri-parental mating. The constructs were transformed in two popular *G. hirsutum* cultivars, F846 and HS6 that are otherwise highly susceptible to CLCuV. Evidence of its integration in cotton and generation of siRNA have been ascertained by Southern hybridization and Northern blotting, respectively. (Bipinchandra Kalbande, India).

Crop Production

Cry Toxin Expression in Bt Transgenic Cotton Hybrids Influenced by Soil Depth and Split Application of Nitrogen

Less is known about the effect of soil moisture and N on Bt toxin expression. Expression of Cry toxin was better on deep vertisols compared to shallow soils and was also a function of moisture content. Application of N in 3 splits improved productivity compared to two-split application and farmers practice. In general, foliar supplementation of N did not bring any consistent increase in either the seedcotton yield or the toxin expression. Results indicate split application of N is an option to enhance Cry toxin expression and crop yields under rainfed conditions. (DeSouza Blaise, India).

Which Carbon Footprint Calculator for Cotton?

The purpose of the study was to identify the most appropriate carbon footprint calculator to be used by cotton suppliers to meet emerging sustainability measurement requirements from brand owners and retailers in the textile supply chain. There is a compelling need for an internationally standardized format and methodology for crop-level carbon footprint calculations for the textile supply chain. No common methodology exists in particular for the calculation of soil emissions, and the more accurate processed-based models may be too complex for the industry to use. (Francois Visser, Australia).

Response of Cotton to Bio Boron and its Use Efficiency in Vertic Ustrophept Soils of Tamil Nadu, India

A field investigation was carried out to study the effect of different boron sources on yield and its use efficiency by hybrid cotton. The supply of boron through organic and

inorganic sources produced significantly higher seedcotton yields than boron alone and manure application had a positive influence on increasing the seedcotton yield through the slow and continued supply of boron, along with other nutrients to cotton. The agronomic efficiency was high for the organic boron source treatments. (Janaki Ponnusamy, India).

Effects of Prolonged and Integrated Use of Organics and Inorganics on the Performance of Cotton

A study was conducted to evaluate the prolonged and integrated use of organic and inorganic nutrient sources on leaf reddening and overall performance of hybrid cotton. The anthocyanin content of the leaves decreased from 0.169 mg/g of fresh weight with application of 50% recommended dose of fertilizer (75:37.5:37.5 kg NPK/ha) to 0.0602 mg/g of fresh weight with 100% recommended dose of fertilizer (75:37.5:37.5 kg NPK/ha) + MgSO_4 @ 20 kg/ha, indicating a decrease in leaf reddening with increased nutrition and supply of Mg. Significant increase in organic carbon contents, available P_2O_5 and available potassium was observed with the application of vermicompost @ 2.5 ton/ha and FYM @ 10 ton/ha. Consequently, the improvement in greenness enhanced seedcotton yield significantly. (S. N. Upperi, India).

Cotton Pesticides and Environmental Risk

Research in Australia aimed at this objective has focused on catchment-based environmental risk assessment and development of rapid field test kits for residue monitoring in water. This paper presents a framework sketching this process and allowing desirable environmental benefits to be achieved as part of a participatory social contract in Australia. GM technology process resulted in reduced use of the insecticide endosulfan from 600 tons active ingredient per crop of 200,000 ha to about one-tenth this amount, effectively saving the industry. It is estimated that the 10-year transition from endosulfan to Bollgard II cost \$50 million, but its benefits were well worth the expense. However, herbicides and other agrochemicals remain a significant environmental risk. (Ivan Kennedy, Australia).

Do Foliar Application of Nutrients, PGR's and Insecticides Control Leaf Reddening in Cotton?

Results showed that foliar application of nutrients and hormones did not visibly reduce leaf reddening. It was concluded that Acephate being a safe insecticide might be used in combination with foliar nutrients to effectively control reddening in cotton. (A. H. Prakash, India).

Defining Optimal Application Rate and Timing of Mepiquat Chloride for Cotton Grown in Conditions that Promote Excessive Vegetative Growth

The results showed that less aggressive early bloom strategy

controlled growth similarly to the more aggressive application strategies. However, the modified early bloom strategy may provide growers with some flexibility in adequately controlling growth in situations where timely Mepiquat chloride application to cotton at early bloom is challenging. (Guy D. Collins, USA).

Input Use Efficiency, Productivity, Profitability and Sustainability of Bt Cotton Based Multi-Tier System

This paper is based on a field investigation that was carried out to assess the performance of cotton based vegetables multi-tier systems with different nutrient levels to intercrops during the winter season. The authors found that crop growth characteristics, yield attributes, yield and quality parameters of Bt cotton were not significantly affected by multi-tier systems and nutrient levels. Hence multi-tier planting of Bt cotton + radish + beet root + coriander with application of 100% nutrient to intercrops registered significantly high net profit. (Kaliyakonar Sankaranarayanan, India).

Evaluation of Cotton Genotypes for High Density Planting Systems on Rainfed Vertisols of Central India

In both *G. hirsutum* and *G. arboreum* genotypes, the boll weight and harvest index decreased with increasing plant density. The latter in turn, decreased nutrient utilization efficiency. Nevertheless, in all the genotypes of both species, the nutrient uptake efficiency and partial factor productivity for N increased with increase in planting density. (M. V. Venugopalan, India).

Pruning and Detopping Studies in Bt Cotton

The results indicated that detopping had no significant effect on seedcotton yield when compared with no detopping. Pruning of monopodial branches affected yield negatively. (Suresh S. Hallikeri, India).

Agronomic Evaluation of Bt Cotton Hybrid (RCH 134 Bt) Under Varied Crop Geometries and Fertilizer Levels in Canal Command Area of Northwest Rajasthan

The three-year experiment conducted at Sriganganagar, India showed that seedcotton yield in narrow spacing was statistically at par with wider spacing, and application of 100% recommended dose of fertilizer (150 kg N & 40 kg P₂O₅/ha) was the optimum dose for RCH 134 Bt. (Prem Lal Nehra, India).

Cotton Genotypes Performance Under Rainfed and Irrigated Conditions in Two Regions of Northern Argentina

The paper explains differences in growth, development and yield of two cotton varieties under rainfed and irrigated

conditions at the two government research stations in Argentina. The authors found differences between genotypes in terms of days to crop maturity. However, no significant differences in terms of phenology were found between rainfed and irrigated conditions due to the amount of soil water content available from rainfall for the plant. Both genotypes and moisture levels affected partitioning of reproductive organs. (Marcelo Paytas, Argentina).

High Boll Weight and High Ginning Outturn: The Major Tools for Breaking Yield Barriers in *Gossypium arboreum*

An exploratory and expedition survey of the West Garo Hills in tribal area in Meghalaya of North Eastern Hill Region was conducted in November 2010. The 23 germplasm lines including perennials of *Gossypium* race *cernuum* were collected from the regions where no improved cotton variety or commercial hybrids have been introduced. The collected germplasm possessed high boll weight (8 g) with burst locule length (up to 15 cm) and high locule retentivity. These germplasm lines showed high ginning outturn (up to 50%) and micronaire (7.8, coarse fiber). These collections are important source for genetic improvement of *G. arboreum* cottons in terms of locule retention capacity, boll weight and ginning outturn. (Punit Mohan, India).

Thermosensitive Genetic Male Sterility System in Cotton (*G. arboreum*)

Thermosensitive genetic male sterility (TGMS) is a two-line system of hybrid seed production. In *G. arboreum*, TGMS system has been identified for the first time. The TGMS line remains sterile at temperature above 24°C and showed complete pollen fertility at temperature less than 18°C. TGMS line 1-1 has been characterized and stabilized by continuous selfing. The TGMS line was also tested under phytotron conditions for confirming the phenomenon. Varying minimum/night temperature and a fixed maximum temperature was provided in the phytotron for *G. arboreum* and the phenomenon of reversion to complete fertility at 16°C was confirmed. (Shivaji M. Palve, India).

Insect Pest Management

Influence of Weather Parameters on Population of Mealybug, *P. solenopsis* and its Natural Enemies on Bt Cotton

A team of researchers at the University of Agricultural Sciences, Raichur, India studied the seasonal incidence of mealybug, *Phenacoccus solenopsis* (Tinsley) on cotton. On the basis of two year data from 2008/09 and 2009/10 it was observed that the mealybug incidence started in the month of September (40th Standard week) during both seasons. Upland cotton and hybrids are planted in the Raichur area as late as end of July. A steep increase in the mealybug population was observed after January and reached a peak in March. Maximum

temperature was found positively and significantly correlated with the mealybug population where as other parameters were negatively correlated with the pest population. (Basavaraj Patil, India).

Insecticide Induced Resurgence of Mealybug, *P. solenopsis* Tinsley in Cotton

This paper is about the effect of commonly used insecticides alone and in combination on resurgence of mealybug population on cotton. The work done at the Regional Research Station, Sirsa, India showed that about 15% resurgence in the mealybug population occurred due to Spinosad. Resurgence started after only the 2nd spray of chemicals, which were sprayed on a weekly basis. Resurgence increased in the 2nd year in 2009. The reasons for resurgence like biochemical changes in the plant, changes in insect reproduction physiology or ecological changes could not be traced but need to be confirmed through further studies. (Rishi Kumar, India).

Emerging and Key insect Pests on Bt Cotton- Their Identification, Genetic Diversity and Management

A team of researchers at the Central Institute of Cotton Research, Nagpur, India studied the incidence and damage caused by emerging and key insect pests on Bt cotton, which varied across regions and Bt genotypes being cultivated. Implications for pest management are also presented. Timely taxonomic identification of the mealybug and subsequent molecular studies suggesting narrow genetic diversity led to the development of meaningful management strategies to limit its spread. Two botanical formulations Mealy Kill 50EC (against sucking pests) and Mealy Quit (against mealybug) were identified, developed and validated in multi location trials. (Sandhya Kranthi, India).

Species Diversity, Pestiferous Nature, Bionomics and Management of Mirid Bugs and Flower Bud Maggots: The New Key Pests of Bt Cottons

The work done in India showed that no transgenic Bt cotton variety had appreciable resistance to mirids and the minimum avoidable yield loss is about 21%. Acephate 75 SP at 75g ai/ha was found to be a promising chemical. A new pest called flower bud maggot *Dasineura gossypii* was recorded on cotton for the first time. Sucking pests are becoming an emerging threat due to large-scale cultivation of Bt cottons. (Shashikant Udikeri, India).

Dynamics of Biotypes B and Q of *Bemisia tabaci* in Cotton Fields and Their Relevance to Insecticide Resistance

Researchers at the Agricultural Research Organization, Israel conducted an extensive survey for identifying *Bemisia tabaci* biotypes and monitoring insecticide resistance from 2003 to

2010 in cotton fields. Two biotypes of *B. tabaci*, B and Q, were identified; and some differences in the biotype dynamics were recorded from different areas. The possible reasons for the change in the dynamics of *B. tabaci* biotypes are discussed in this paper. (Rami Horowitz, Israel).

Cotton Pest Management Programs Using Threshold-Based Interventions Developed by CIRAD and Partners in Sub-Saharan Africa

This paper described new crop protection programs using threshold-based interventions developed by CIRAD and its partners in Sub-Saharan African countries, sampling methods and associated intervention thresholds, in addition to the advantages and constraints associated with their adoption. (Pierre Silvie, France).

Development of Meta-Population Approach for Landscape-Level *Lygus hesperus* Management in Texas

Researchers at the Texas A&M System AgriLife Research, USA conducted field marking and capture (FMC) studies using protein markers and enzyme-linked immunosorbent assays to characterize *Lygus hesperus* intercrop movement behavior. The paper concluded that field marking and capture approach can be used to study the effects of various crop management practices on *L. hesperus* intercrop movement and can potentially be applied to other pests and cropping systems. (Megha Parajulee, USA).

Influence of Spatial Cropping Patterns of Cotton Cultivation on Population Dynamics of Mirid Bug, *C. biseratense*

This paper is about the influence of spatial cropping patterns of cotton cultivation on population dynamics of mirid bug, *C. biseratense*. Cotton + cowpea cropping system recorded minimum boll damage (9.06-18.61%) as compared to other patterns of cotton cultivation. The results indicated that cotton + cowpea intercrop with weed free surroundings reduced the mirid bug population and showed promise to be an important component of an IPM package for the management of the pest. (Bhalakrishnan Dhara Jothi, India).

Identification and Characterization of a Novel Source of Resistance to Root-Knot Nematode in Cotton

In an effort to find genetic resistance to the root knot nematode, researchers evaluated a number of *Gossypium* spp., accessions under greenhouse conditions. A highly resistant accession was crossed with a susceptible one to generate F₁ and F₂ plants for further genetic studies. Analysis of the response of these F₁ and F₂ plants to root knot nematode inoculation indicated that resistance is recessive, and controlled by at least one major gene. Analyses using molecular markers associated to known root knot nematode resistance loci showed that the allele(s)

involved are different from those previously described. (Marc Giband, Brazil).

Can Tomato Be a Potential Host Plant for Pink Bollworm?

Tomato *Solanum lycopersicum* is not a recognized host for the pink bollworm. But, in Israel farmers reported pink bollworm larvae inside the processed tomatoes. A lab study was conducted in Israel to find out whether the pink bollworm neonates can penetrate tomato fruits and complete a whole life cycle on them. The pink bollworm eggs were placed on tomatoes along with their vines under lab conditions at 27±2°C, 50% humidity and photoperiod of 14:10 hours light:dark. Tiny holes were found on the upper part of the fruit in 4-6 days. Later on, the pink bollworm larvae were found inside the fruit eating flesh and seeds. Two weeks later exit holes were found and larvae pupated successfully. Adults emerged from the pupae, mated normally and laid fertile eggs. The pink bollworm completed the life cycle on the tomato fruit. (Ariela Niv, Israel).

Can Natural Refuges Delay Insect Resistance to GM Cotton?

Researchers at CIRAD, France used biogeochemical markers to quantify movement of *Helicoverpa armigera* moths from non-cotton hosts to cotton fields throughout the cropping season, in three agricultural landscapes of the West African cotton belt (Cameroon) where Bt cotton was absent. The studies showed that the contribution of non-cotton hosts as a source of moths was spatially and temporally variable, but at least equivalent to a 7.5% sprayed refuge of non-Bt cotton. The paper observed that use of biogeochemical markers provided a valuable tool to evaluate the role of non-cotton refuges in delaying the evolution of *H. armigera* resistance to Bt cotton. (Thierry Brevault, France).

Adaptive Management of Resistance to Bt-Cotton in Australian *Helicoverpa* spp.

This paper from Australia reviewed the history of deploying and managing resistance to Bt cotton in Australia, outlined the characteristics of the isolated resistance that likely impact on resistance evolution, and used a simple model to predict likely imminent resistance frequencies. The paper also discussed potential strategies to mitigate further increases in resistance frequencies, including insecticidal protein Vip3A. The robustness of the Vip3A varieties (anticipated to be released in 2014) will depend on resistance frequencies to Vip3A and to Cry2Ab and efficacy of the Vip3A throughout the season. (Thomas Walsh, Australia).

Insecticidal Toxin Genes from Bacterial Symbiont of Thermotolerant Isolate of *H. indica*

Researchers from the Central Institute for Cotton Research, India reported that they have isolated novel insecticidal toxin

genes from bacterial symbiont of thermotolerant isolate of *Heterorhabditis indica*, entomo-pathogenic nematode. (Nandini Gokte-Narkhedkar, India).

Efficacy of Gene Stacking

Efficacy of Widestrike® Insect Protected Cotton from Dow AgroSciences in Argentina, Australia, Brazil, Mexico, Spain and the United States

WideStrike cotton has a stack of Cry1Ac and Cry1F genes and is deregulated in Australia, Brazil and USA. It has also been tested for efficacy in Argentina, Mexico and Spain. In the USA, WideStrike has performed as well as Bollgard II against heliothine insects. WideStrike is also effective against *Spodoptera* spp., the pink bollworm and the Soybean looper, *Pseudoplusia includens*. WideStrike also qualified for no or natural refugee in the USA due to its dual action genes. The WideStrike cotton varieties/hybrids have been undergoing testing in India since 2004. (Gary Thompson, Dow AgroSciences, USA).

Efficacy of Widestrike Cotton Against Lepidopteran Pests in India

Dow Agro Sciences India Pvt Ltd, Mumbai, India has conducted biosafety research trials with two hybrids and two WideStrike traits WS103 and WS106 since 2008. The trials were conducted in the South and Central cotton zones of India. The efficacy of the WideStrike biotech cotton was checked against *H. armigera* and *Spodoptera litura*. The trials demonstrated that WideStrike cotton provides effective and season-long protection against lepidopteran insects leading to increased crop yields and productivity. The introduction of WideStrike cotton in India will diversify the choice of insect control traits available to Indian farmers and enable effective control of the bollworm complex and *S. litura*. (Rishikant Moudgal, Dow AgroSciences India (Pvt) Ltd, India).

Survival of *H. armigera* on Bt Cotton Hybrids in India - Can We Buy the Interpretations?

This paper is about the survival of target pests on biotech varieties/hybrids. A report in 2004 from Central India claimed a mere 50% reduction in bollworm populations on Bt cotton. A sizeable population of the pink bollworm was recorded on Bollgard II from Gujarat in 2010. In the same year about 9% survival of the American bollworm was recorded in Karnataka on both Bollgard and Bollgard II. The study demonstrated survival and reproduction of the pest for two generations on Bt cotton hybrids. The studies generated considerable national debate on the credibility of the technology. There were many interpretations but in general there were two views about the survival issue. One side of the argument is that there may be less than lethal levels of the toxin produced. The second viewpoint dismisses the low-toxin argument and believed that concentration of the toxin is lethal despite variations across

plant parts. Opinions such as disparities in the environment leading to low toxin production are unsubstantiated and may be rejected. The second-generation survival may be related to hybridization between the bollworm population on the Bt and non-Bt cotton. However, this argument fails to reason out considerable survival of the first generation population. The paper presented views from various schools of thought. (Aralimarad Prabhuraj, India).

Field Performance of F₁, F₂ and non-Bt of BG-II (MRC-7017 Bt) and JKCH-1947 Bt Against Bollworms of Cotton

Results from the comparative performance showed that the lowest damage of terminal bud, fruiting parts, green bolls, open bolls, due to incidence of *Earias* and *P. gossypiella* was recorded on MRC 7017 Bt F₁, JKCH 1947 Bt F₁ and MRC 7017 Bt F₂, as against MRC 7017 non Bt, JKCH 1947 non-Bt and JKCH 1947 Bt F₂. MRC 7017 Bt F₁ also produced the highest yield. The paper also discussed the results vis-à-vis sustainability of Bt cotton in relation to the resistance threat in *H. armigera*. (G. Gujar, India).

Intrinsic Rate of Increase and Life Parameters of Cotton Leaf Eating Caterpillar *S. litura* on Bollgard®II Hybrids

This paper reported on a study conducted during the 2010 season to know the intrinsic rate of increase of *S. litura* on four popularly grown Bollgard II cotton hybrids. Life parameters of the pest were computed in comparison with their counterpart Bollgard and non-Bt hybrids. The results showed that Bollgard II hybrids have significant negative effects on the growth and development of *S. litura*. (Prasad Rao, India).

Disease Management

***Thielaviopsis basicola* - Cotton Interactions Leading to Black Root Rot**

Black root rot is a fungal disease affecting cotton seedlings upon germination. The fungal pathogen, *basicola*, is found in almost every cotton farm in Australia and, while it does not kill the plant, it causes substantial loss in yield. *T. basicola* was successfully transformed using PEG-mediated transformation. Five transformants with different phenotypes were found to have reduced pathogenicity towards the cotton host, and the genes affected in three of the mutants are under investigation. Plants can be categorized as: non-host, (disease) resistant-host and susceptible-host. (Lily Pereg, Australia).

Control of Planting - Seed Deterioration Through Post Harvest Management

This paper suggested an array of seed treatments for mitigating seed deterioration. Delinted cotton seeds with 90% initial germination and 8% moisture content, that were treated with a polymer @ 5 ml/kg, were found to have optimum results

to enhance germination and field emergence. The coating of polymer @ 5 ml/kg or polymer with carbendazim @ 2 g/kg or polymer + carbendazim + imidacloprid increased the germination percentage, seedling vigor and were found effective in controlling sucking pests for up to 45 days. Three treatments alone or in combination prolonged seed viability for a period of sixteen months. Delinted cotton seed when treated performed better for seed viability and seedling vigor. Cotton seed stored at different relative humidity levels for eight months indicated an increase in the storage period when treated than with the control. Progressive decline in viability, dry matter of seedling, vigor, seed oil content, coupled with a rapid increase of seed moisture content, free fatty acid accumulation, electrical conductivity of seed leachate, free sugars and storage fungi were recorded with respect to increases in relative humidity. Results on fuzzy seed are also discussed. (Pulivarthi R. Vijaya Kumari, India).

Changing Scenario of Cotton Diseases in India: The Challenge Ahead

Extensive adoption of Bt cotton in India has also changed the disease scenario. Grey mildew has emerged as the most serious problem on cotton after the leaf curl virus disease. *Alternaria* and bacterial blight are reported from Central and South India while fusarium wilt has become less important as a result of upland varieties' immunity to the Indian race of the pathogen. A disease identified as Tobacco Streak Virus (Tsv virus) transmitted by thrips was observed in the transgenic cotton-growing region of Southern Maharashtra and Andhra Pradesh. Loss estimates and management strategies are also discussed in this paper. (Dilip Monga, India).

VENI VIDI VICI - Cotton Leaf Curl Burewala Virus (CLCuBuV) in Northwestern India

The cotton leaf curl disease (CLCuD) is a major limitation to cotton production on the Indian subcontinent. A few years back the virus mutated and was named as 'Burewala (a city in Pakistan) virus.' Varieties resistant to the cotton leaf curl disease proved susceptible to the Burewala strain. The spread and establishment of the cotton leaf curl Burewala virus CLCuBuV in northwestern India, the variation in the genomic sequence, virulence/infectivity and implications for cotton breeding in India are discussed in this paper. (Radhamani Anandalakshmi, India).

Water Management

The Adaptation of Irrigated Cotton to the Tropical Dry Season

Australia is evaluating growing of cotton in the semi-arid tropics, which is currently largely unutilized for cropping of any species. Experiments found that boll retention and size was correlated ($p < 0.01$) with minimum temperature during flowering. The radiation use efficiency-RUE (conversion of radiation to biomass) was negatively correlated with

average temperature up to first flower a response not reported previously in cotton and explained some of variation in radiation use efficiency measured here and elsewhere. Cool temperatures during fiber development reduced fiber length and strength in March and April sowings. Further screening may identify cultivars with suitable fiber length and strength in these conditions. (Stephen Yeates, Australia).

Managing Saline Sodic Water for Sustainability of Cotton in Semi-Arid Region of Punjab, India

A six-year experiment showed that application of saline sodic water to cotton resulted in a 21% reduction in seedcotton yield as compared to canal water alone. The application of zinc, gypsum, farmyard manure, and a combination of zinc + gypsum + farmyard manure can increase the seedcotton yield. Growing cotton on ridges by pre-sowing irrigation with canal water and all subsequent irrigations with saline sodic water in alternate furrows compensated for the yield decline to the tune of 12% over saline-sodic water. (Gurmeet S. Buttar, India).

A Thermal Optimum Approach to Irrigation Scheduling in Australian Irrigated Cotton

Data showed a single relationship where peak yields occurred at canopy temperature (T_c) of $\sim 28^\circ\text{C}$, validating previous work on the specific optimal temperature of cotton. The stress time (ST) threshold was also investigated. In drip systems, which have the capacity to rapidly supply water at precise volumes, the stress time threshold for peak lint yield was observed at five hours daily stress time. This study provided the temperature threshold and stress time thresholds, as well as a research overview in irrigation scheduling using a thermal optimum approach in a high yield context. (Warren Conaty, Australia).

A Cotton Production Model Developed by Jain Irrigation for Enhancing Cotton Productivity

An agronomic model for high tech production of cotton was tested in Maharashtra state of India at farmers' fields for five years (from 2005/06 to 2009/10), which helped in enhancing cotton productivity to high levels. The model included:

- Specific campaign carried out for drip irrigation and fertilization;
- Teaching growers to perceive cotton as an irrigated crop;
- Agronomical package coupled with efficient drip-fertilization system;
- Pre-monsoon sowing (May 10-June 7);
- Extension of cotton crop beyond normal harvest time to enhance extra flushes.

Farmers harvested 5,000 to 7,500 kg per hectare of seedcotton. The rate of growth of adoption of this model was about 30% every year for the last 4 years. (P. Soman, India).

Comparative Study of Different Weeding Methods on Cotton Crop Under Drip Irrigation System

Chemical weeding was compared with no weeding and hand weeding under drip irrigation systems in Pakistan. The chemical treatment included three chemicals and two combinations. The results showed that three times manual weeding provided better control and produced higher yields than chemical treatments and no treatment. Net profit was also higher in case of hand weeding. (Dil Baugh Muhammad, Pakistan).

Biodegradable Polyethylene Mulching - A New Approach for Moisture Conservation, Weed Control and Enhanced Productivity of Winter Irrigated Cotton-Maize System

Polyethylene film can be made biodegradable by adding a small quantity of a pro degradant additive at the time of manufacturing the poly film. Eight mulch treatments including polyethylene, biodegradable polyethylene, sugarcane trash, maize stover, gunny sheets, sub soil coir waste, surface coir waste and no mulching were tested in a cotton-maize system under three moisture regimes, 0.4 ETc through ip, 0.8 ETc through ip and conventional irrigation. Cotton responded significantly to moisture regimes and mulches. The crop responded up to 0.8 ETc under no mulch condition. However, under mulched situation, the yield started decreasing beyond 0.4 ETc. Among the mulches, polyethylene mulching and biodegradable polyethylene mulching were at par and were significantly superior to the other treatments. Among the combinations, polyethylene mulching with irrigation through drip at 0.4 ETc was at par with biodegradable polyethylene at the same moisture level of 0.4 ETc. The water requirement for the variety under trial was 464, 630 and 800 mm at 0.4 ETc, 0.8 ETc and conventional irrigation respectively. The zero tilled rotation maize grown after cotton harvest was also significantly influenced by the moisture regime and mulch treatments. (P. Nalayini, India).

Drought, Heat and Salt Tolerance

Marker-Assisted Selection for Improving Drought Resistance in Cotton

Quantitative trait loci (QTLs) for yield and drought-adaptive physiological traits (osmotic potential, carbon isotope ratio - an indicator of water use efficiency, and leaf chlorophyll content) were exchanged via marker-assisted selection between elite cultivars of *G. barbadense* and *G. hirsutum*. The resulting near isogenic lines (NILs) were examined in three field trials to test the effect of introgressed QTL alleles on cotton productivity under drought conditions and physiological traits. A considerable number of NILs exhibited the expected phenotypes in term of greater osmotic adjustment, higher carbon isotope ratio, and higher chlorophyll content. (Yehoshua Saranga, Israel).

Applying Technology to Address the Challenges Facing Global Cotton in the Next Decade

The two critical issues currently facing the global cotton industry are rising costs of production and difficulties to increase yields, and both can only be tackled by employing latest technological developments. The author also considers it essential to develop a cotton fiber with new functionalities. This will enable new end uses (like modified permeability, improved durability, shrink and wrinkle resistance, shape retention and fire retardation) that in turn will enhance demand for cotton and stabilize and elevate cotton prices over time. (David M. Anderson, USA).

Cotton Transgenics With DRE-Binding Transcription Factor Gene (DREB 1A) and Zinc Finger Gene (ZF1) Confers Enhanced Tolerance to Drought

Drought tolerant transgenics were developed in elite genotypes LRA 5166 and LRK 516 through *Agrobacterium* mediated transformation with Prd29: DREB 1A and PLEA1:Bc ZF1 gene constructs. Over expression of DREB 1A and ZF1 improved drought tolerance in the transgenic plants by increasing the levels of soluble sugar, phenol and amino acids contents. (Jagannathan Amudha, India).

Cloning and Expression of Two Salt Tolerance Related Genes on Upland Cotton

In this study, two salt tolerance related genes, H⁺-pyrophosphatase gene (GhVP) and S-adenosylmethionine synthetase gene (GhSAMS), were cloned from the salt tolerant material in *G. hirsutum*. The bioinformatics analysis indicated that GhVP protein had a similarity of 90% with *Arabidopsis* and 93% with tobacco, and GhSAMS protein had 91%, 93% and 93% with *Arabidopsis*, *S. salsa*, *O. stiva*, respectively. The authors indicated that under salt stress, GhVP promoted the distribution of Na⁺ in cell, in order to eliminate Na⁺ infection. GhSAMS enhanced the cell-to-cell pathway for water transport and reduced ions uptake, and improved adaptation of cotton to salt stress. (Wuwei Ye, China).

Increased Nutrient Uptake and Salinity Tolerance in AhCMO Transgenic Cotton

The authors found that the transgenic cotton over-expressing a choline monooxygenase (AhCMO) was more tolerant to salt stress and total uptake and contents of main nutrient elements (N, P, K, Ca, Mg, Fe, Mn, Cu, Zn) in CMO4 (a choline monooxygenase line) were higher than those in its wild line (SM3). They suggested that increased salt tolerance of transgenic AhCMO cotton is not only attributed to elevated accumulation of glycine betaine, the resulting protection of the cell membrane and improved photosynthetic capacity, but also associated with more nutrient uptake in CMO4 than its wild line. (Huijun Zhang, China).

Improvement of Partial Root-Zone Soil Environment Increases Salinity Tolerance of Cotton

In this study the authors confirmed the hypothesis that improving at least part of the root-zone environment would alleviate salt injury, since salinity and the related stress originate from the root-zone soil environment. This study concluded that plastic mulching, furrow seedling and early mulching or late-planting with short-season cotton either result in unequal salt distribution, or increased moisture and temperature in the root-zone, thus effectively controlling salt-injury in cotton. (Hezhong Dong, China).

Fiber Quality Testing

Commercial Standardization of Instrument Testing of Cotton - Results from over 4 Years of International Round Trials

The International Cotton Advisory Committee (ICAC) formed a Task Force on Commercial Standardization of Instrument Testing of Cotton (CSITC Task Force) to achieve reliable instrument test results for cotton around the world. A specific Round Trial series for the Standardized Instruments for Testing of Cotton (SITC) often referred to as "High Volume Instruments", was started in order to check the performance of laboratories. Currently approximately 80 laboratories, located on all continents, are participating with more than 120 instruments. It is concluded that data obtained with 18 round trials on five cottons, and 30 test results from each instrument and cotton, is an ideal basis for an intense evaluation, and for coming to concrete applications. The data generated so far on six parameters tested form the best basis for fixing commercial trade limits. (Axel Drieling, Germany).

CIRCOT Calibration Cotton: Standard Reference Material for Fiber Testing

Most labs buy Calibration Cottons from the US Department of Agriculture. The Central Institute for Research on Cotton Technology (CIRCOT), India also provides (to local labs) two sets of standards, one for conventional fiber testing instruments and other for HVIs. The uniqueness of HVI standards from CIRCOT is that the same cotton/standard can be used as International Calibrations Cotton (ICC). The traceability of both the ICC equivalent standards and HVI calibration cotton standards with the USDA standards has been established locally. The repeat orders from the industries and research institutions are an affirmation of the high standards maintained by the Institute in creating and marketing this reference material during the last fifteen years. (Sankar Sreenivasan, India).

The Cotton Length Analysis Using the Length Control

The Length Control is a fiber length measuring device developed by Trützschler GmbH, which can quickly give

information about the distribution of fiber length, the short fiber content (SFC) and the amount of fiber hooks or neps. It can also provide some suggestions to adjust a spinning machine's parameters for optimizing its work. By using this measurement system, it is possible to measure all kinds of fibers, whose length is not higher than 63 mm and which are formed in a sliver from the carding, drawing or combing processes. It can be successfully used for inter-operational control. Results of measurements of cotton length carried out on Length Control were compared with AFIS, which confirmed the accuracy of measurements. (Iwona Frydrych, Poland).

Within-Bale Variability Study on Cotton Produced in Africa

This paper reported on within-bale variability for fiber length, length uniformity, fiber strength, micronaire, reflectance and yellowness. Eight samples per bale were taken from over 400 cotton bales produced in 13 African countries during two crop seasons. Over 3,200 fiber samples were analyzed under controlled conditions using Standardized Instrument for Testing Cotton (SITC). The results showed variation in fiber properties per country, per bale, in some situations, and it was noted that even the gins (saw and roller) also had some effects in relation to within-bale variability. (Everina Lukonge, Tanzania).

Differential Speed Setting Facility for Roller and Beater in Gins for Higher Ginning Rates

In a present-day double roller gin, the rollers rotate with a speed of about 90 rpm, while the reciprocating knives (beaters) make about 1,000 oscillations per minute. Different speed combinations of the rollers and the beaters can produce spectacular changes in the ginning rate (kg/hr). It is not possible to do this in a conventional roller gin because both rollers and beaters are operated by the same drive mechanism. In the modified gin, two independent drives are provided for the rollers and the beaters whereby differential speed adjustment becomes possible. It has been shown that higher roller speeds such as 110 to 140 rpm coupled with a beater speed of 1,000 oscillations per minute can increase the ginning rate by 50-140%. The increase is found to be more in the case of cottons of longer staple length. Interestingly, higher rates of processing do not cause fiber damage. (Krishna R. K Iyer, India).

Exploration of Residual Hazardous Compounds on Cotton Fibers

This paper is about measurement of bioelectrical signals caused by enzymatic inhibition of acetylcholinesterase (AChE) for the detection of carbamates and organophosphorous pesticide chemical on the fiber. Conventional and organic cotton of the variety Giza 86 from Egypt were tested. Biosensor Toxicity Analyzer (BTA) was used for testing, and enzyme activity was determined by acetylthiocholine chloride (ATCCL) as

enzyme substrate. Cryogenic homogenization was carried out for sample pretreatment, and the Soxhlet extraction method (SOX) was used with two different solvents; hexane and dichloromethane. The extracts were concentrated and then injected in the BTA, and the results were also compared with Gas Chromatography equipped with Mass Spectrometry. The results showed that acetylcholinesterase (AChE) can be used to detect pesticides, and the process is easier, faster and cheaper. (Syed Zameer ul Hassan, Czech Republic).

Development of an Automatic Roller Grooving Machine for Making Helical Grooves on Rollers Used in Roller Ginning Machines

The rollers used in double roller gins become smooth due to friction between the roller and knife during continuous operation. Helical grooves are made manually on the rollers after every 16 to 20 working hours to make the roller surface roughs, so that the lint will adhere to the roller at a faster rate. An automatic roller grooving machine was developed that consists of main frame, head stock, tail stock and a cutter assembly mounted on a movable trolley. The rotary motion of the roller and forward motion of the trolley were synchronized. The machine can groove the roller in ten minutes with 18 equally spaced grooves of uniform depth and breadth of 2 mm with accuracy. (T. S. Manojkumar, India).

The Effect of Quarantine Treatments on the Physical Properties Of Cotton and its Subsequent Textile Processing Performance

The quarantine treatments used in Australia to export cotton are either chemical (fumigation), using either ethylene oxide or methyl bromide or radiation (gamma irradiation), using a dose of 25 or 50 kGray. Anecdotal evidence suggests that the prescribed levels of irradiation affect the quality of cotton, particularly fiber bundle strength, although there was little direct scientific information available on the extent of the damage. The work in this paper showed that fumigation treatments by either ethylene oxide or methyl bromide have little or no significant effect on the physical properties of either upland or extra long staple cotton. However, gamma irradiation, from the radioactive isotope Cobalt 60, does have an effect on bundle strength and elongation, length uniformity, short fiber content and to a lesser extent on length and color; with these effects becoming more apparent and significant as the dosage strength increased. The moisture regain as well as the dye uptake of the fiber decreases as the dosage strength increases. The treatment also affected yarn quality. (Marinus van der Sluijs, Australia).

Value Addition and Textiles

Influence of Quality Attributes of Individual Bales on Yarn Quality

The crucial unit operation involved in the value chain is ginning. In India, cotton bales are not individually tagged

with fiber characteristics. This special study was carried out to find out the effect of segregation of bales on the yarn quality, mainly based on fineness after tagging of individual bales according to fiber properties. Results indicated that for high micronaire above 4.5 for a given variety grown in one location, no statistically significant differences in yarn properties are observed. However, for yarns produced from finer cottons of less than 4.0 micronaire, many of the yarn properties were highly influenced by fineness. The study suggested that individual bale tagging with segregation of bales based on fineness could result in better quality yarns, leading to better quality fabrics and garments. (Rajan P. Nachane, India).

The Impact of Cotton Fiber Maturity on Dye Uptake and Low Stress Mechanical Properties of the Fabric

In order to assess the impact of cotton fiber maturity on dye uptake and low stress mechanical properties of a fabric, two groups of cotton samples were collected, i.e. long staple with 33 mm, and extra long staple with 36 mm from different growth areas. The purpose was to have cotton samples with a wide range of maturity values. Yarn and knitted samples were produced from each cotton sample. The K/S (where K is the absorption coefficient and S is scattering coefficient) value of grey and dyed fabrics were different due to the differences in maturity. The knitted fabric produced from the yarn spun from highly mature cotton showed higher compressional recovery, tensile resilience and smoother surface compared to the fabric produced from the yarn spun from low-matured cotton samples. (S. Venkatakrishnan, India).

Studies on Composition of Oil and Fatty Acid in Bt and Non Bt Cotton (*G. hirsutum*)

Cotton seed oil having no cholesterol is a premium quality vegetable oil. On average, the oil content of six Bt hybrids (17.43%) was at par with non-Bt hybrids (17.4%). Further, on average, unsaturated fatty acid of Bt and non-Bt hybrids are at par with each other. The myristic acid in Bt hybrids was numerically superior over non-Bt hybrids, which helps to increase the keeping quality of oil. Considering polyunsaturated fatty acids, two Bt hybrids were numerically superior over non Bt-hybrids. From current investigations, it can be concluded that there is no significant difference in oil percentage and fatty acid composition in Bt hybrids when compared to their non-Bt versions. (Harijan Nagappa and B. M. Khadi, India).

Development and Validation of Cost Effective and Rapid ELISA for Quantitative Assessment of Cry1F Protein in Transgenic Plants

A simple, rapid, sensitive and cost-effective assay for trait validation of Cry1F and screening of genetically modified organisms is required. To develop and validate an ELISA kit for detecting Cry1F protein in transgenic plants, polyclonal

antibodies were raised against the Cry1F protein and adsorbed onto microtitre plate. The one step format allows the formation of the "capture antibody-Cry1F protein-detection antibody" complex. The CV for intra-assay and inter-assay ranged from 1% -11% for non-Bt and positive seed samples. The stability of immunosorbent and immunoconjugate at elevated temperature (37°C) for 7 days and both the components were found to be stable during the shelf life. The assay shows dilutional linearity and specificity. The analytical performance of the Cry1F ELISA indicated that this assay could be used for monitoring traits and genetically modified organisms screening in transgenic seeds and leaves. (K. Jain, India).

An Innovative Biochemical Approach for Low Energy and Less Polluting Scouring of Cotton and Blended Textiles

Application of natural dyes on cotton, by and large, involves the use of chemicals known as mordants to create affinity between the fiber and the dye molecule. The dyeing behavior of six different leaf based natural dyes on cotton using a new eco-friendly mordanting technique was examined. All the six natural dyes were from sustainable resources. The quality of processing water and the mordanting technique employed play a crucial role in determining color strength. Thus the overall study indicates ultra small dye-mordant complex formation under the modified mordanting conditions. The formation of ultra low sized dye-mordant complex could be the reason for the observed increase in the color strength under the new technique. Thus the new technique opens up a new pathway in the dyeing of cotton with natural dyes under environmentally and economically compatible ways. (Perianambi V. Varadarajan, India).

The Use of Cotton Byproducts and Fungal Mycelium in the Manufacture of Biodegradable Formed Packaging and Insulation Panels

The objective of this research was to develop and evaluate various blends of processed cotton-based biomass (CBB) materials as a substrate for colonization of useful fungi in the manufacture of molded packaging material and insulation panels. Tests were conducted to evaluate the physical and mechanical properties of packaging and insulation material produced from six CBB blends. Evaluations were conducted on samples produced using a fungus selected from the *Ganoderma tsugae* group, using two inoculation methods, grain and liquid suspension. Properties evaluated included: density, strength (compressive and flexural), dimensional stability, modulus of elasticity, colonization rate, thermal conductivity, water absorption, and accelerated aging. Results revealed blends that met or exceeded expanded polystyrene and/or customer specifications. One of the higher performing blends was used to launch EcoCradle TM with two Fortune 500 companies. (Gregory A. Holt, USA).

Cotton Stalks - An Additional Raw Material for the Board Industry

A supply chain model comprising collection, cleaning, chipping of cotton stalks, transportation to factories and board manufacturing have been discussed in this paper. Farmers can make money from cotton stalks. Commercial plants using cotton stalks as a raw material for making particle boards are expected to come up soon in India. (Raviprakash M. Gurjar, India).

Mechanism of Plasma Reaction of 1, 3 - Butadiene on Cellulosic Textile

Nano-scale surface engineering of textile substrates by atmospheric pressure plasma reaction is gaining interest in the research community to develop different value added functional textiles such as water and oil repellent hydrophobic, superhydrophobic, permanent hydrophilic, flame retardant, and antimicrobial fabrics. Improvement in dyeing, printing & adhesion may also be obtained by modifying the fiber surface. In the present study, an attempt was made to reveal the mechanism of plasma reaction of 1,3-butadiene (BD) with cellulosic textiles with the aim to impart hydrophobic functionality. Various types of treatments showed that all the physical & chemical modifications took place only on the surface of the fibers at nano-meter level. Plasma reactions, being a dry technology, can be effectively used to impart hydrophobic functionality to cellulosic textiles while addressing environmental issues. (Kartick K. Samanta, India).

Enzyme/Zinc Chloride Pretreatment of Short-Staple Cotton Fibers for Energy Reduction During Nano-Fibrillation by Refining Process

The paper reported on processing short-staple cotton fibers by refining for the production of nanofibrils. The refining process through shear force pumps water into the secondary layer and loosens the compactness of fibrillar structure by disrupting the hydrogen bonding. To enhance the efficiency of the refining process, pretreatments using enzyme/zinc chloride were developed to open up the primary layer. Cellulase enzyme pretreatment hydrolyzed the surface molecules in cellulose while zinc chloride acts as a swelling agent thereby increasing the accessibility to secondary layer. Various process parameters were optimized for both pretreatment and refining; characterization of nanofibrils by atomic force microscopy, scanning electron microscopy, X-ray diffraction; and analysis of degree of polymerization and energy consumption. Nanofibrils of cellulose produced will be evaluated for their use as fillers in biopolymer nanocomposites for use in food packaging. (Nadanathangam Vigneshwaran, India).

Optimal Cotton Covered Jute, Nylon and Metal Core Spun Yarns for Functional Textiles: Production and Characterization

The paper explored producing cotton covered jute, nylon and

metal core spun yarns using a EF-3000 Friction Spinning machine. In the core-sheath yarn, the cotton fibers were optimally used as sheaths by just covering and twisting them around the core components. Fabrics made from cotton-jute core yarn were used for making upholstery fabrics with soft surface feel, better covering and aesthetic improvement with color and design. Cotton-nylon core yarns showed good mechanical properties, with a positive linear relation between the core content and the yarn breaking tenacity. The interface produced by the cotton sheath helped anchor the fabric with rubber matrix without the need of any chemical treatment, such as Resorcinol Formaldehyde Latex (RFL) adhesive treatment. The composite resulted in minimum peel bond strength of 3.11 kN/m between the rubber and the fabric, and is suitable for application in beltings. The cotton-metal core yarn was used to prepare flexible shielding textiles for protection from harmful electromagnetic waves. Such textiles protect not only human being from radiation but also sensitive electronic devices from malfunctioning. (Sajal Chattopadhyay, India).

Efforts to Mitigate Stickiness Problem in Sudan

Researchers at the Agricultural Research Corporation, Sudan, in collaboration with researchers from CIRAD, France undertook studies to develop an objective methodology for separating sticky cotton from non-sticky cotton. The project, which, was financed by the CFC and sponsored by the ICAC, also determined threshold levels for mixing sticky cotton with non-sticky cotton and spin it under different conditions without any major problems. (Abdelrahman Abdellatif, Sudan).

Economics - Production Systems

Total Factor Productivity of Cotton in Gujarat, India

In this study total factor productivity of cotton was estimated in Gujarat state, the largest cotton producing state of India during the period of 1981/82 to 2006/07 using Tornqvist-Theil indexing procedure. The results indicated that the growth of total factor productivity was positive and significant during the period of analysis indicating the sustainability of cotton production. The total factor productivity increased at the rate of 5.9% per annum during the period of analysis, which indicated sustainability of cotton production in the state. Although the total factor productivity growth was positive during all three stages i.e. 1981-1990, 1991-2000 and 2001-2007, the productivity growth was the highest during the last period. Growth of the input index was negative during the first two stages, it was positive during stage 3. (Annareddy R. Reddy, India).

Analysis of Growth and Instability of Cotton Production in India

In this paper growth of cotton area, production and productivity during 1950-2008 in India was analyzed. It was observed

that growth of cotton area was significant during 1950s and 1990s only and growth in cotton production was significant only after 1990 and it was highest during the period 2000-2008. Growth rate of productivity was also the highest during 2000-2008. Instability analysis indicated that cotton area was more stable than either production or productivity. (Anuradha Narala, India).

Economic Impact of Genetically Modified Cotton in India: Welfare Effects and its Distribution Across States

The introduction of genetically modified cotton had a phenomenal impact on increasing yields, reducing pesticide consumption, the real cost of production and cultivation. The highest welfare gain is appropriated by Maharashtra at about 32%, followed by Gujarat (24%), Andhra Pradesh (19%) and Punjab (18%). Increases in pesticide use were recorded in three out of nine states under study, which is perhaps due to the increase in population of sucking insects. The study highlights the need for technology up gradation to counter the dampening effect of the technology depreciation in later years. (Palanisamy Ramasundaram, India).

Climate Change and Adaptation

Climate Disruptions to Fiber Yield Growth

Cotton is ideally suited to tolerate adverse weather due to its morphological plasticity, physiological stress tolerance and high level of farmer expertise. The latest research on climate impacts of cotton production and adaptation were reviewed in this paper. Current examples of beneficial adaptation include: supplemental, high-efficiency irrigation; field drainage; no-till and conservation tillage; cropping systems diversification; community pest management; planting date flexibility; risk management policies; planting seed infrastructure; cotton co-products utilization; and farmer expertise. (Kater Hake, USA).

Effect of Cool Conditions on Cotton Seedlings

Sub-optimal temperatures reduce cotton germination, seedling emergence and early vigor. Cotton is considered sensitive to chilling, and cotton seeds exposed to cold temperature experience slower seedling emergence that can lead to poor and delayed stand establishment. Strategies that provide early season cold tolerance will improve cotton growth when cold temperatures are experienced early or may provide growers with increased flexibility for planting times, especially in cool season regions. Plant growth regulators are a potential option of increasing cotton seedling hardiness against cool temperatures. This paper suggests that plant growth regulators, such as paclobutrazol and trinexapac-ethyl, may have the potential to improve cold tolerance in cotton seedlings. (Daniel K.Y. Tan, Australia).

Industrial-Age Changes in Climate Affect Cotton Physiology and Productivity

Industrial-age changes in climate, rising CO₂ concentration, warming and altered precipitation may have significant impacts on the physiology and yield of cotton (*Gossypium hirsutum*). This paper presents research addressing the challenge to understand how the interaction between increasing temperatures, humidity, CO₂, and changes in water availability (including changes in precipitation and reductions in irrigation water) will impact the physiology and the productivity of cotton. (Katrina Broughton, Australia).

Cotton and Climate Change: Impacts and Options to Mitigate and Adapt

Cotton production is both a contributor to climate change and subject to its impacts. Cotton production contributes to between 0.3% and 1% of global green house gas emissions. The negative impacts of climate change on cotton production relate to the reduced availability of water for irrigation in particular in Xinjiang (China), Pakistan, Australia and the western USA. Heat stress may reduce yields particularly in Pakistan, while some countries could benefit from higher temperatures for plant growth and longer growing season. The impacts of climate change on rainfall will likely be positive around the Yellow River in China, India, the southeastern USA and southeastern Turkey. Impacts in Brazil and Africa are yet unclear. (Peter Ton, Netherlands).

Multi-Level Determination for Heat Tolerance of Cotton Cultivars

This paper is about a multi-level approach to assess whether genotypic differences in morphological, physiological, biochemical and molecular performance under heat stress translated to superior yield performance in the field. This study revealed that cultivar differences ($P < 0.05$) were found at all levels of measurement under elevated temperatures, but the biochemical assays were the most consistent in explaining physiological performance which led to differences in yield. The paper concluded that a multi-level approach incorporating morphological, physiological, biochemical and molecular indicators should be used for screening heat tolerance. (Nicola Cottee, Australia).

Debunking the 'Myths'

In spite of its benefits, cotton has been mischaracterized as having negative impacts on the environment. However, the fact is that in the United States, the environmental impact of producing a pound of cotton has fallen substantially over the last 20 years, there has been 25% reduction in land requirement, 34% drop in soil loss, 49% decline in irrigation water use, 66% reduction in energy and 33% decrease in GHG emissions. Cotton Incorporated, USA, through its funding of agricultural research, is assisting US growers in adopting technologies that conserve natural resources, enhance grower efficiency and continuously work to improve cotton's environmental footprint. (Janet Reed, USA).