THE ICAC RECORDER

International
Cotton
Advisory
Committee

Technical
Information Section

VOL. XXVI No. 4
DECEMBER 2008

Update on Cotton
Production Research

Discover
natural
fibres
2009

Contents

Introduction

The Technical Information Section of the ICAC has a mandate to facilitate communication among cotton researchers. The objective is achieved through world cotton research conferences and regional networking. Currently, the ICAC is sponsoring meetings of four networks, Interregional Cooperative Network on Cotton for the Mediterranean and Middle East Regions, Latin American Association for Cotton Research and Development (ALIDA), Asian Cotton Research and Development Network (ACRDN) and Southern and Eastern African Cotton Forum (SEACF). Three of the four networks organized meetings in 2008. This issue of *THE ICAC RECORDER* is devoted to the Fourth Meeting of the Asian Cotton Research and Development Network held in China (Mainland) from September 23-26, 2008. The Chinese Cotton Research Institute, Anyang, Henan hosted the meeting. Over 80 researchers attended, including delegates from India, Indonesia, Iran, Kazakhstan, Myanmar, Pakistan, Syria, Tajikistan, Thailand, Turkey, Vietnam, FAO Sub-regional Office for Central Asia, CABI, ICAC and a large number of participants from China (Mainland). In addition to ICAC, FAO Sub-regional Office for Central Asia, CABI and Organic Exchange sponsored the meeting. Twenty-two papers covering all aspects of production research were presented. A summary of these papers provides the contents of this *RECORDER*. Full papers are available on the ICAC web page at <http://www.icac.org/tis/regional_networks/asian_network.html>.

It is a tradition of the Network that the host country takes over chairmanship of the Network until the next meeting. The meeting elected Dr. Jingyuan Xia of China (Mainland) as the new Chairman of the Network.

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The next meeting of the Network will be held in 2010 in Kazakhstan.

Cotton Production Practices

The Technical Information Section publishes a report *Cotton Production Practices* every three years. The latest report, published in November 2008, included data from 34 countries. The 118-page report provides information on varieties grown and their characteristics, seed supply and planting methods, farm size and soil types, rotations followed in cotton production systems, soil preparation and irrigation, fertilizer application timing and doses, insect pests and control measures, chemicals used to control pests and number of sprays. The report also includes information on how cotton is harvested (by hand or machine) and ginned in various countries. For easy understanding of French and Spanish speaking researchers, all text has been translated into French and Spanish. A hard copy or an electronic version of the publication can be ordered from the ICAC at <publications@icac.org>.

Technical Seminar Papers

The 67th Plenary Meeting of the ICAC was held in Ouagadougou, Burkina Faso from November 17-21, 2008. During the Plenary Meeting, a one-day Technical Seminar on the topic 'Improving Sustainability of Cotton Production in Africa' was held on November 20. Six papers were presented, including a paper on organic cotton as a sustainable production system. The six papers plus two papers that could not be presented at the seminar are available free at <http://www.icac.org/cotton_info/publications/samples/tech_seminar/english.html>.

The 2009 Technical Seminar will be held on the topic 'Biosafety Regulations, Implementation and Consumer Acceptance', during the 68th ICAC Plenary Meeting in Cape Town, South Africa, September 7-11, 2009.

The ICAC RECORDER (ISSN 1022-6303) is pulbished four times a year by the Secretariat of the International Cotton Advisory Committee, 1629 K Street, NW, Suite 702, Washington, DC 20006-1636, USA. Editor: M. Rafiq Chaudhry <rafiq@icac.org>. Subscription rate: $195.00 hard copy, $160.00 electronic version.

Cotton Facts

The ICAC has arranged reprints of the book *Cotton Facts*. Orders can be sent to <publications@icac.org>. The price is US$50.00 including shipping. Bulk order of more than 10 copies has a discounted price.

Award – ICAC Cotton Researcher of the Year

The ICAC has decided to honor a distinguished cotton researcher each year beginning in 2009. An Award Panel consisting of five recognized experts located in at least four countries will choose the outstanding Cotton Researcher of the Year. The Award Panel will be anonymous and known only to the chairman of the Award Panel and the ICAC Secretariat. The Award Panel will be independent in its evaluation and will select one outstanding researcher in cotton each year, in any discipline related to production research, and award him/her with an honorarium of US$1,000.00, a certificate, and the title "ICAC Cotton Researcher of the Year." A procedure to select the distinguished researcher has been formulated. All details, including how to apply, and where to apply are available on the ICAC web page <http://www.icac.org/tis/researcher_of_the_year/english.html>.

Fourth Meeting of the Asian Cotton Research and Development Network

Chinese Cotton Research Institute, Anyang, Henan, China (Mainland)
September 23-26, 2008

The Technical Information Section of the ICAC has a mandate to bring researchers together and facilitate communication among them. This objective is achieved through world cotton research conferences and regional networks. The world cotton research conferences are well recognized in the cotton research community. Through its Technical Information Section, ICAC is currently supporting four regional networks of which the Asian Cotton Research and Development Network is the youngest.

This network was started in 1999 at a meeting held in Pakistan on insecticide resistance management. The network held its second meeting in Uzbekistan in 2002, and its third meeting in India in 2005. The Fourth Meeting of the Network was held in China (Mainland) on September 23-26, 2008. The meeting was hosted by the Chinese Cotton Research Institute of the Chinese Academy of Agricultural Sciences, Ministry of Agriculture and co-sponsored by ICAC, the National Science Foundation of China, under the Ministry of Agriculture, the FAO Sub-regional Office for Central Asia, CABI and the Organic Exchange. The meeting was attended by delegates from India, Indonesia, Iran, Kazakhstan, Myanmar, Pakistan, Syria, Tajikistan, Thailand, Turkey, Vietnam, the FAO Sub-regional Office for Central Asia, CABI, ICAC and a large number of participants from China. Kyrgyzstan, Turkmenistan and Uzbekistan were also invited to the meeting but their delegates were not able to attend. The list of participants is attached.

Mr. Xiaodong Zhang, Mayor of the Anyang City Government, was the Guest of Honor at the opening ceremony of the meeting. Dr. Huajun Tang, Vice President of the Chinese Academy of Agricultural Sciences, delivered the keynote address during the opening session. Mr. Fawzi Taher of the FAO Sub-regional Office for Central Asia, Dr. Julie Flood of CABI, Dr. M. Rafiq Chaudhry of the ICAC, Dr. Jingyuan Xia, Director General of the Ministry of Agriculture of China, Dr. Shuxun Yu, Director General of the Chinese Cotton Research Institute and Dr. Dilip Monga of India (on behalf of Dr. B. M. Khadi, Chairman of the Network) also spoke at the opening session. Speakers emphasized the importance of cotton for the countries in Asia and recalled that networking among the cotton researchers of the region was both useful and necessary. In addition to the opening session, the program consisted of six substantive sessions, plus a concluding session wherein administrative issues regarding future activities of the Network were discussed. Over 20 papers were presented during two days. Participants also visited cotton fields, a seed delinting plant and biotechnology labs of the Chinese Cotton Research Institute. A summary of papers presented in the meeting is povided here.

Cotton Breeding

Genetic Improvement of Colored Cotton in China

Dr. Xiong-ming Du
Chinese Cotton Research Institute, Key Laboratory of Cotton Genetic Improvement, Anyang, China

In the last 20 years, China has achieved a number of breakthroughs in the genetic improvement of yield, fiber quality and in the disease and insect resistance traits of colored cotton by applying interspecific hybridization, heterosis and transgene biotechnology. Twenty-one new colored cotton varieties and more than 50 lines were bred in China in recent years. The yields of colored cotton lines such as B2K8, CCRI 51and S9B11 were raised to that of white cotton, and the fiber quality of colored cotton was improved with a 10-15% increase in fiber length and a 25-45% increase in fiber strength. The fiber length and strength of several commercially grown colored cotton lines were as high as 30.9 mm and 33.5 cN/tex, respectively. The lint percentage reached more than 37%, i.e., 8% higher than the colored cotton germplasm.

Some Bt transgene colored cotton varieties have also been developed: CCRI 51, B2K8, G88, Zong 970818, TC-03, Bingcai No.1 and Bingcai No.2., but it was, Zongxu No.1, the first modern colored cotton line used in China, that paved the way for colored cotton in the country after it was brought into production. Now China is the world leader in colored cotton breeding, production and textiles.

The stability of fiber color was studied based on wax content. The literature shows that the wax content of white cottons accounted for 0.4-0.7% of fiber weight, but that in green cotton wax can be as high as 14-17%. A positive correlation was found to exist between brightness and the surface wax content of cotton fiber. High wax affects fiber color and the quality of fabrics, so it was necessary to work on the wax content of green cotton to try to achieve improvement in color through genetic means. Workers at the Key Laboratory of Cotton Genetic Improvement of the Chinese Cotton Research Institute analyzed forty-eight colored cotton lines and F_1 hybrids for wax content, cellulose content and fiber quality. Green cotton was found to have the highest wax content followed by dark brown cotton, with a figure two times greater than that of white cotton. However, the Chinese researchers also found some green lines with relatively lower wax content.

The genetics of different color cotton lines was extensively studied in China. The findings indicated that two pairs of major genes, acting independently of each other, controlled the inheritance of brown lint and brown fuzz. The recessive gene for fuzz inhibited the expression of the dominant brown lint gene. Two pairs of major independent genes controlled the inheritance of green lint and fuzz. One pair controlled color in fuzz and the other in lint. Researchers found a genetic interaction between the genes coding for green lint and fuzz, i.e. the recessive gene for fuzz inhibited the expression of the dominant green lint gene. They also found that fiber color was not controlled solely by the dominant fiber color genes; it was also affected by the dominant white fiber genes. Different white fiber lines and varieties were found to contain different pairs of dominant genes-the greater the number of major genes coding for white fiber, the whiter the resulting fiber. The genetic diversity of colored cottons was also studied based on SSR markers and it was found that the genetic diversity of brown cottons was greater than that of green cottons. Twenty-three specific loci from 9 primers related to brown fiber were found, compared to 4 specific loci from 2 primers in green fiber.

Progress in the Development of High Yielding Cotton Varieties in Indonesia

Dr. Emy Sulistyowat
Cotton Breeder, Indonesia Tobacco and Fiber Crops Research Institute, Indonesia

The focus of the cotton improvement program is to strengthen the competitiveness of cotton against other crops by increasing productivity and to improve fiber properties in order to meet the requirements of the textile industry, which is export oriented in Indonesia. The cotton improvement program at the Indonesia Tobacco and Fiber Crops Research Institute (IToFCRI) has released 15 new varieties since 1983. Some of them, Kanesia 1 and Kanesia 15 are not only high yielding but also are resistant to jassids, such as *A. biguttula*, have better fiber properties and are more tolerant to drought. The cotton-breeding program at the Indonesia Tobacco and Fiber Crops Research Institute has resulted in a simultaneous genetic improvement in terms of productivity, resistance to insect pests, especially jassids, as well as in fiber properties.

Cotton production in Indonesia is limited by the lack of good quality planting seed, a lack of irrigation facilities, the lack of financial support to growers, greater emphasis on cash crops than on cotton, a low level of farmer acceptance of new technologies, and a lack of support from the relevant support agencies. Farmers are not inclined to invest strongly in cotton farming because of the high risk of disasters in rainfed areas. Consequently, productivity at the farmer level is less than one ton of seedcotton per hectare. Elimination of the abovementioned constrains could boost cotton production in Indonesia where local production currently meets only 2% demand. Indonesia, introduced commercial production of insect resistant biotech cotton in 2002/03, but has given it up in the last few years. Cotton researchers are trying to convince the government to reintroduce biotech cotton through local varieties. Researchers are also exploring the possibility of growing commercial cotton hybrids using male sterile lines.

Earliness Component Analysis Through Diallel Cross Method

Mr. Farshid Talat
West Azerbaijan Agricultural and Natural Resources Research Center, Iran

Researchers agree that it is difficult to study quantitative traits for a number of reasons: 1) their expression is dependent on environmental and management variations, 2) most characters are controlled by multiple genes, 3) the expression of an individual gene is often influenced by the expression of other genes, 4) linkages are difficult to break, 5) the optimum genotype for a given environment-management system may require gene contribution from diverse sources and 6) the optimum genotype for a given environment-management system is likely to be different from that of another system.

Early maturity is an important objective of all cotton breeding programs. Mr. Talat conducted his research using five early-maturing parents and a standard cultivar. He started work in 2003 by making all possible crosses among the six parents, without reciprocals. Field evaluation of the six parental genotypes and the 15 F_1 was done in 2004 in a randomized complete block design with four replications. Of the 13 earliness components studied, all characters except days to first square, vertical flowering interval, boll maturation period, and production rate index showed significant additive genetic variance. Heritability estimates ranged from 0.08 for the production rate index, to 0.45 for days to first open boll. Correlation analysis showed that a smaller number of nodes to the first fruiting branch generally produced shorter plants, initiated early squaring, early flowering, and early boll opening. Mr. Talat concluded that the use of the number of nodes to the first fruiting branch as a indicator to select rapid-fruiting and early maturing genotypes could be misleading, as the small additive variance for this trait resulted in a narrow sense heritability of only 0.14. On the other hand, plant height showed a relatively high heritability (0.44), suggesting that selection for this attribute would be moderately effective. The date of first square, as a selection criterion, has the benefit of being closely associated with several other components and indicators of earliness. The date of first flower is easy to work with and also showed association with many other earliness factors.

Cotton Breeding in China

Dr. Shuxun Yu
Director General, Chinese Cotton Research Institute, China

Cotton production plays a very important and irreplaceable role in the national economy of China where cotton is planted on only about 3% of cropland but accounts for over 10% of the output value of the country's industry. In addition to a series of biotech varieties carrying Bt and Bt plus CPTI genes, great advances have been made in cotton breeding for essential characteristics such as high yield, high fiber quality, low gossypol content, early maturity, resistance to diseases and pests, tolerance to drought, salinity, chilling, and high temperatures, and colored cotton. "Project 973," is a national high-tech key project on the functional genomics of cotton fiber quality and its molecular genetic improvement. Since its inception in 2004, new methods have been developed to efficiently separate proteins for proteomic analysis of developing cotton fibers to clarify a simplified model of the regulatory mechanism controlling the cotton fiber cell. A simplified model was established to depict the regulatory mechanism controlling formation of cotton fiber. A high-density genetic linkage map was constructed with a perennial F_2 population of *G. hirsutum* × *G. barbadense*. High performance transgenic technology systems have been developed including an agro-bacterial transformation system, a pollen-tube mediation system and a gene-gun bombardment system. A series of genes such as *SOD* and *Ghcysp*, which encode a *cysteine* proteinase, have been isolated from senescent cotton tissues. In connection with fiber development, several functional genes have been cloned, 7 of which were associated with fiber quality.

Transfer of Virus Resistance from *G. arboreum* and *G. anomalum* into *G. hirsutum*

Mr. Muhammad Arshad
Director, Central Cotton Research Institute, Multan, Pakistan

The leaf curl virus disease has created havoc in cotton production in Pakistan since the disease appeared in the early 1990s. The disease affected about 35,000 hectares in 1991 and by 1993/94 more than 889,000 hectares were damaged. The disease spread to Sindh province in 1997, NWFP in 1998 and Balochistan in 2001.The leaf curl virus disease is caused by a white fly-transmitted begomovirus (cotton leaf curl virus) and characterized by either upward or downward curling of leaves. ICAC has published a number of reports on this disease and also sponsored a five-year project in Pakistan, the UK and the US with funding provided by the Common Fund for Commodities. The project characterized the virus and designed a protocol to develop genotypes immune to the virus.

The Central Cotton Research Institute screened the available genetic stock and discovered that three exotic cultivars, CP-15/2, LRA 5166 and CEDEX showed high resistance to this disease. As a result of hybridization of these exotic cultivars with local varieties, virus resistant varieties, CIM-1100, CIM-448, CIM-443, CIM-446, CIM-482 and CIM-473 were developed and commercialized in the Punjab. These varieties covered about 80% of the area in the Punjab in 2001, and yield losses decreased from 360,000 tons in 1996 to 14,000 tons in 2001. Unfortunately, a new strain, known as the Burewala strain, of the cotton leaf curl virus (CLCuV) appeared, and none of the original CLCuV varieties escaped from damage by this strain. The leaf curl virus disease spread into India and was also detected in China and Uzbekistan but never became a problem. Cotton in Pakistan is still severely affected by the new strain, but India is safe from it for now. The whitefly is the only important vector of CLCuV, but it is difficult to eliminate whitefly as a pest on cotton. The virus has about 118 alternate hosts in Pakistan that are helping the virus to survive when there is no cotton in fields. After the emergence of this new strain of virus, yield losses started increasing. The hot spots of this disease (those requiring treatment) increased from 2.4% of fields to 73.4% from 2001 to 2007. Similarly, the area affected by this disease also increased from 4.45% in 2007 to 70.26% in 2007/08. The Central Cotton Research Institute screened 30 Gossypium species and found that diploid species of cotton viz. *G. herbaceum, G. arboreum, G. anomalum, G. captis viridis, G. gossypioides, G. laxum, G. stocksii, G. reysianum, G. somalense* and *G. longicalyx* were resistant to the Burewala stain of the cotton leaf curl virus. Researchers defined resistance as a mechanism preventing colonization, effective growth and reproduction of a pathogen entering the host plant. *G. arboreum* and *G. anomalum* were found resistant rather than immune to cotton leaf curl virus.

The following methodology was adopted to transfer diploid resistance to *G. hirsutum*.

- *G. anomalum Wawra et. Payer*(2n= 26)-B1 was crossed with *G. hirsutum Linn*(2n=52)(AD)1 as female. The resultant triploid hybrid was treated with 0.2% aqueous solution of colchicine for 72 hours using the seedling dip method for doubling the chromosomes. The hexaploid was further crossed with *G. hirsutum* to make a pentaploid which was further back crossed four times to get a stable tetraploid.
- *G. anomalum Wawra et. Payer*(2n=26)-B1 was crossed with *G. arboreum*. *Linn*(2n=26)A2. The resultant diploid inter-specific hybrid was treated with 0.2% aqueous solution of colchicine for 72 hours using the seedling dip method for doubling the chromosome. The resultant tetraploid hybrid was crossed and backcrossed with *G. hirsutm.*

Researchers grafted 2,431 hybrid plants in a green house with tissues from the varieties showing acute virus symptoms. The 342 plants that showed no disease symptoms were transferred to the field. Sixty-one plants showed no disease symptoms until harvest. The material reached the F_3 generation in 2008/09 but still requires genetic purification and improvement of its fiber quality parameters. However, diploid resistance has been successfully transferred to a tetraploid base.

Biotech Cotton

Biotech Cotton: Issues for Consideration

Dr. B. M. Khadi
Director of Post Graduate Studies, University of Agricultural Sciences, Dharwad, India

India is the only country in the world where all cultivated species of cotton, intra and inter specific tetraploid hybrids and diploid hybrids, are grown on a commercial scale. Insect-resistant biotech cotton, mostly in the form of commercial cotton hybrids, occupied 75% of cotton area in 2008/09. Cotton production regions and their varietal composition in India is shown in the following table.

The average national productivity showed a remarkable increase after the adoption of biotech cotton in 2002/03, going from 303 kg lint/ha in 2001/02 to 560 kg lint/ha in 2007/08 and the expected yield in 2008/09 is 590 kg/ha. There are three types of bollworms that attack cotton in India: American bollworm (*Helicoverpa armigera*), pink bollworm (*Pectinophora gossypiella*) and spotted bollworm (*Earias vitella*). India needed a strong defense against these worms. Prior to introduction of Bt cotton, about half of all the insecticides used in India were sprayed on cotton. Planting seed production is almost entirely in the hands of the private sector, and private seed companies have utilized eight different sources of biotech genes, including Cry1Ac, Cry1Ac+Cry2Ab, Cry1Ab+Ac fusion (China), Cry1Ac modified (IIT Khargpur), Vip3A+Cry1Ab, Cry1Ac+Cry1F, Cry1C, Cry1Aa3, Cry1F, Cry1Ia5, Cry1Ab and Cry1Ec.

In the public sector, the Indian Council of Agriculture Research (Ministry of Agriculture) and the Department of Biotechnology (Ministry of Science and Technology) have entrusted the development of transgenic cotton varieties to a group of institutions: the Central Institute for Cotton Research, Nagpur, the National Research Centre on Plant Biotechnology, New Delhi, the National Biotechnology Research Institute, Lucknow, International Centre for Genetic Engineering and Biotechnology, New Delhi and the University of Agricultural Sciences, Dharwand. The Central Institute for Cotton Research developed a Bt detection kit that is extensively used in India. The Institute has also concluded that Cry1Ac expression declines with the age of the plant, the highest concentration being about 19 µg/g in the leaves at 75 days after sowing. The varietal factor plays a role in the quantity of the toxin and in the decline of the quantity of the toxin. On average, Cry1Ac expression in the eight Bt-cotton hybrids tested was found to be adequate for bollworm protection at least until the first 100~120 days after sowing.

India is pursuing a vigorous resistance management strategy in connection with biotech cotton. Conventional seed is sold along with the biotech seed, and producers are encouraged to

Cotton Regions and Varieties Grown in India

Zone/States	Share		Irrigated Area/Species/Hybrids	Rainfed Area/Species/Hybrids
	Area %	Production %		
North Zone (Punjab, Haryana and parts of Rajasthan and Uttar Pradesh)	16	20	100% *G. hirsutum* *G. arboreum* Intra *hirsutum* hybrids & diploid hybrids (*G. arboreum* x *G. arboreum*)	-
Central Zone (Primarily Madya Pradesh, Maharashtra and Gujarat)	68	60	23% *G. hirsutum* Intra *hirsutum* hybrids	77% *G. herbaceum* *G. arboreum* *G. hirsutum* Intra *hirsutum* hybrids diploid hybrids (*G. arboreum* x *G. arboreum*)
South Zone (Andhra Pradesh, Karnataka and Tamil Nadu)	15	18	40% *G. barbadense* *Intra hirsutum* hybrids Inter *specific* hybrids (*G. hirsutum* x *G. barbadense*)	60% *G. arboreum* Intra *hirsutum* hybrids Inter *specific* hybrids (*G. hirsutum* x *G. barbadense*) diploid hybrids (*G. arboreum* x *G. arboreum*)

plant five rows of a non-biotech hybrid/variety around every biotech field. The stochastic model 'Bt-Adapt,' developed at the Central Institute for Cotton Research, Nagpur, to understand and predict the rate at which *H. armigera* develops resistance to Cry1Ac-based Bt cotton showed that with 40% Bt cotton area in India, it would take at least 11 years for the frequency of Cry1Ac-resistant allele in *H. armigera* to reach 0.5, the threshold at which it would begin to cause significant difficulties in pest control on Bollgard Bt cotton. However, a number of factors are counter productive to the resistance management strategy. The area under biotech cotton is increasing every year, it is almost double what it was at the time of the resistance study on a lab population. Many more genes have been approved, and illegal biotech cotton is being grown on significant areas where refuge requirements are not observed. Apart from the threat of resistance developing to biotech cotton, sucking pests are increasing on biotech cotton. Mealy bugs, *Phenacoccus solenopsis*, and mirids, *Creontiades biseratense*, are emerging as potential threats to the biotech-dominated production system in India.

Problems and Prospects of Cultivation of Bt Hybrids in the North India Cotton Zone

Dr. Dilip Monga
Head, Central Institute for Cotton Research, Regional Station, Sirsa-125 055, Haryana, India

Biotech cotton was adopted in the North Zone comparatively late compared to the other two zones. The major bio-physical constraints identified prior to the introduction of biotech cotton were: inadequate crop stand (stemming from poor emergence resulting from crust formation caused by rains just after sowing); seedling burn (due to prevailing high temperatures at emergence); alkalinity and salinity problems; less turn-around time; rising water-table and depletion of water table in some pockets; rains during September coinciding with flowering and fruit setting and incidence of pests, such as cotton bollworms.

However, since the introduction of insect resistant biotech cotton in the North zone, there has been a gradual increase in production and productivity. A study conducted by this regional station in Haryana and Rajasthan during 2007/08 found that the yield gain due to biotech cotton over traditional varieties averaged 20% in 2006/07 and 25% in 2007/08. The study also found that producers were able to reduce insecticide sprays by 40% in Rajasthan and by 33-42% in Haryana. Biotech hybrids/varieties start fruit setting early and thus mature early. Development of early-maturing biotech cotton varieties made it possible to implement a one-year cotton-wheat cropping system which helped to improve cropping intensity by almost 100% giving a boost to the economy in the zone.

In 2005, six Bt cotton cultivars were approved for cultivation in the North zone of India and eight new Bt cotton cultivars were approved for this zone in 2006. With the approval of eighteen more Bt hybrids in 2007 and twenty one in 2008/09, there will be a total of 53 Bt cotton hybrids approved for cultivation in the northern zone of the country. These Bt hybrids have four major events: Cry1Ac gene (Bollgard-I), Cry1Ac gene (Event 1) sourced from IIT Kharagpur, Fusion genes (Cry1Ab and Cry1Ac) known as GFM event, sourced from China, Stacked Cry (Cry1Ac and Cry2Ab) genes and Event MON 15985 or BG-II sourced from Monsanto. By 2008/09, in the short span of three years, almost 50% of the cotton area in north zone was planted to biotech hybrids. A detailed survey on the cultivation, adoption and performance of Bt cotton conducted by various agencies revealed significant multiple benefits. These include: increases in yield, decreased production costs, and reductions in insecticide applications, resulting in substantial environmental and health benefits to farmers, along with significant social and economic benefits. Dr. Monga suggested that genes for new insecticidal toxins with different target sites should be developed to manage a wider spectrum of insects and slow the pace of resistance development. The Bt gene developed by the public institutes in India will be available in pure line varieties of cotton, freeing farmers from having to purchase Bt hybrid seed every year. With the development and release of new transgenic events, the probability of resistance developing in the bollworm complex has been significantly reduced. Dr. Monga went on to explain that the research agenda needs to address the following areas with particular reference to cotton in the North zone:

- High vulnerability and extreme weather conditions in the northern cotton zone of India. High temperatures, rains and hot winds during sowing and seeding in May and June result in a poor plant stand in some fields, thus requiring re-sowing; hence technology to maintain proper plant stand of Bt hybrids needs to be evolved.
- Insufficient knowledge of the agronomic requirements of different Bt cotton hybrids. As a result farmers are not able to achieve the maximum yield potential of these hybrids. The state agricultural universities could evolve location- or region-specific agronomic packages to further advance the technology and derive the maximum benefits it has to offer.
- High sucking insect incidence. There is an urgent need to select parents (for hybridization) that are tolerant to or resistant to sucking pests, especially jassids *Amrasca devastans*, thrips *Thrips tabaci*, mealy bug *Phenococcus solenopsis* and white fly *Bemisia tabaci*.
- Resistance threat. The stacking of more than one gene and the use of more events could go a long way toward minimizing this threat.
- Use of illegal seeds. The area planted to spurious/unofficial hybrids of Bt cotton and even F_2 seed of Bt cotton hybrids is quite high, thus creating a favorable environment for the development of insect-pests and diseases. Hence, there is a need to create awareness among farmers that they should not grow unapproved hybrids of Bt cotton if they hope to harvest the full benefits of this technology.

Dr. Monga also acknowledged that the incidence of the mealy bug (*Phenococcus solenopsis*) is on the increase in the region and may become a big threat to cotton production in the North zone.

Cotton Breeding and Biotechnology in Vietnam

Mr. Trinh Minh-hop
Vice Head, Nhaho Research Institute for Cotton and Agricultural Development, Vietnam

Over three million farmers are directly and indirectly involved in the cultivation of cotton in Vietnam. At present, cotton growing is mainly concentrated in the northern highlands, central highlands, the coastal central and eastern regions of the south. More than 95% of cotton area is planted to commercial cotton hybrids, mainly intra-specific (*G. hirsutum* x *G. hirsutum*) hybrids. Seed is produced by hand emasculation and pollination. The Genetic Male Sterility (GMS) system was tried using natural vectors such as honeybees and insects as pollinators, but hand emasculation and pollination is still the only commercial method employed to produce F_1 hybrid seed. Cotton area in Vietnam has been affected by the outbreak of the cotton bollworm *Helicoverpa armigera* in the early 2000s. Spurred by heavy bollworm damage, in 2004 Vietnam launched a program to develop biotech cotton resistant to lepidopteron insects. In four years, Vietnam has tried regeneration via somatic embryogenesis and achieved some encouraging results. Gene transfer into cotton through *Agrobacterium* involves the development of an efficient regeneration system from transformed tissues. Regeneration through somatic embryogenesis is preferred over organogenesis for the regeneration of large numbers of plantlets from cotton genotypes, but the problem is that the success rate in cotton has been lower than with other major commercial crops. Regeneration efficiency via somatic embryogenesis has improved recently, but genotype dependent response, prolonged culture period, high frequency of abnormal embryo development, low rate of conversion of somatic embryos into plantlets and a lack of shoot elongation continue to plague cotton regeneration efforts.

The Nhaho Research Institute for Cotton and Agricultural Development has worked with upland variety SSR60F. Callus was induced from hypocotyls explants on medium MSB (MS basal salt with B5 vitamins) containing 2,4-D and kinetin. The optimal 2,4-D and kinetin concentrations for callus induction were both 0.1 mg/l. Hormone free MSB medium promoted the proliferation of embryogenesis callus. The best medium for the differentiation, maturation and germination of somatic embryos was MSB with 1.9 g/l KNO3, MSB supplemented with 1.0 g/l glutamine and 0.5 g/l asparagines and 1⁄2 MSB, respectively. The Institute has successfully developed an efficient protocol for the production of high frequency somatic embryogenesis and plant regeneration of a cotton cultivar. The work done so far in Vietnam has shown that plants may be regenerated through somatic embryogenesis from hypocotyls explants within 8-9 months.

Regeneration via multiple shoots from zygotic embryo protocol was developed in 2005 using variety LRA 5166 and C 118. The method involved (i) transformation of regenerable cells or callus tissues that were derived from Coker lines, (ii) regeneration of putative transgenic plants through somatic embryogenesis, (iii) collection of transgenic T1 seeds and advancement of the desired traits into an agronomic background by plant breeding techniques.

Zygotic embryos were isolated from cotton seeds and passed onto multishoot induction, multishoot formation, shoot elongation and root formation media. The MS medium containing 0.1 mg/l 2,4-D, 2.0 mg/l BAP and 0.1 mg/l NAA seemed to be optimal for the induction stage of multishoot formation. A combination of 0.5 mg/l BAP and 0.05 mg/l NAA drove the continuously dividing cells derived from the former event to form shoots, giving rise to a shoot mass from each original zygotic embryo. The subsequent absence of phytohormons facilitated the elongation and root formation of the shoots. Transferring the *in vitro* rooted plantlets into soil succeeded to verify the whole plant regeneration procedure. A complete plant may be regenerated via multiple shoot from zygotic embryos in 4-5 months, but back crossing to bring back the characteristics of the original variety takes many years. An efficient protocol for the production of a relatively high rate of shoot mass formation could be used for genetic transformation in cotton.

With regard to the genetic transformation system, Agrobacterium-mediated transformation (AMT) and Pollen Tube Pathway (PTP) transformation have been tried in Vietnam. Scientists have developed other techniques such as particle bombardment, electroporation, microinjection, ultrasonic, carborundum, etc., but Agrobacterium-mediated transformation is the most used technique in cotton in the world. In Vietnam, after developing an efficient protocol for the production of high frequency somatic embryogenesis and plant regeneration of cotton cultivar SSR60F, scientists at the Nhaho Research Institute for Cotton and Agricultural Development have applied a protocol to transfer the Cry1Ac gene into this cotton cultivar by Agrobacterium-mediated transformation since 2006. As a result, a reliable and highly efficient system of transforming embryogenic callus mediated by *A. tumefaciens* was developed. *Agrobacterium tumefaciens* strain C58 harboring the pC1300-Ubi-Cry1Ac plasmid containing the hpt gene as a selection marker, was used for the transformation. Hypocotyls were excised from 7-day old seedlings and cut into 5-6 mm segments. Hypocotyls explants were first inoculated with the *A. tumefaciens*. Infected hypocotyls explants were co-cultivated in callus induction medium with 200 mg/l Acetosyringone for two days at 21^0C and were then moved on to callus induction medium with 10 mg/l hygromycin for 45 days. After that, the hygromycin resistant calli were subcultured in embryogenic callus proliferation medium with 10 mg/l hygromycin. Transformed embryogenic calli were then transferred to MSB with 1.9 g/l KNO3, MSB supplemented with 1.0 g/l glutamine and 0.5 g/l asparagines and 1⁄2 MSB media, respectively for differentiation, maturation and germination of somatic embryos. Putative transformed plants were confirmed by PCR and Southern-blot analysis. Forty-five regenerated plants were successfully transferred to soil, of which 12 proved to have the active Cry1Ac gene. Insect resistance will be tested by bioassay during the next season.

The Pollen Tube Pathway (PTP) transformation is a method that delivers foreign genes directly into germ line cells. It has been proved that the pollen tube pathway developed by Chinese scientists is an efficient and convenient way for gene delivery, particularly for cotton. Great progress has been made in recent years in China and numerous transgenic cotton cultivars or lines have been bred, that are now widely used in cotton production. The advantages of this method are that breeders can (i) avoid somaclonal variation and genotype dependence, (ii) expand the range of recipient species for plant transformation, (iii) avoid the use of marker genes or reporter genes, (iv) shorten the duration of the whole transformation process, and (v) the technique is simple and easy for breeders to handle. It is particularly suitable for large-scale transformation to obtain large populations of transformants.

In addition, since molecular analysis and agronomic trait selection of transgenic plants can be done at the same time, genetic engineering may ideally be combined with conventional breeding to enhance the efficiency of cotton improvement. In Vietnam, researchers designed and artificially synthesized Cry1Ac and VIP3 genes in 2004. Since 2005, scientists at RICOTAD, have introduced those genes by PTP into three cultivars of *G. hirsutum* L: C118, LRA5166 and TM1. As a result, a reliable and high efficiency transformation system was developed. Transformed plants were tested for Cry1Ac and VIP3 genes by Polymer Chain Reaction (PCR) analysis. The result (based on the calculation of positive PCR seedlings out of the total geminated seedlings) was that 0.96% of the seedlings expressed a positive PCR. Plants have yet to be analyzed by Southern, Northern, Western blot and bioassay.

While Vietnam has successfully established somatic and genetic regeneration systems, it has not been able to utilize genetic male sterility for producing commercial cotton F_1 seed. Open pollination through enhanced honeybee activities resulted in 48.3% boll setting, which is enough to lower cost of hybrid cottonseed by 14-41% in comparison with hand emasculation and pollination techniques. Commercial viability over multiple years has yet to be tested.

Development and Use of Transgenic Bt Cotton in China

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In China (Mainland), damage by pests is one of the major factors limiting the country's cotton production. Over 100 pest species have been recorded as predators of cotton. The key pests are seedling diseases, boll diseases, *Fusarium* wilt, *Verticillium* wilt, cotton aphid, red spider mites, cotton bollworm and pink bollworm. The yield loss due to damage from those pests is estimated to be 10-15% of the production potential, and even as much as 30% at peak outbreak periods. Chemical control is one of the major measures for cotton pest management. Heavy dependence on application of pesticides leads to the serious problem of the three Rs (resistance, resurgence and residues). Breeding for host-plant resistance has been considered the most effective and economical approach to cotton pest control. It is understood that conventional breeding is a slow process by which to develop an ideal cultivar for production.

Biotechnology is thought to be the most efficient way to breed crop varieties highly resistant to target pests. So far, several genes have been constructed, such as the single gene (Bt), the double genes (Bt+CpTI), and the triple genes (Bt+CpTI+Go, Bt+CpTI+GNA, Bt+CpTI+herbicide resistance, Bt+CpTI+male sterile). Three methods of genetic transformation have been applied in China, including *Agrobacterium*, pollen-tube pathway and gene gun, with a transformation efficiency of 5%, 2% and 8%, respectively. Over 20 Bt cotton cultivars have been released for commercial production, and the area under biotech varieties reached over 4 million hectares in 2007/08 accounting for over 70% of the nation's total cotton area. Transgenic Bt cotton exhibits high resistance to lepidopteran pests (especially to the bollworm), but has less of an impact on sucking pests like the cotton aphid, red spider mites, and so on. Transgenic cotton increases the abundance of predator populations, while decreases that of parasitoids.

China has established a Bt cotton-based IPM system with bio-ecological regulation early and late in each season, and chemical control in mid-season. A monitoring system for Bt toxin resistance has also been established, including in-lab screening and testing in the field. The results of resistance monitoring show that there is a high potential for the cotton bollworm to develop resistance to the Bt toxin in lab, while, so far, no evidence of resistance has been detected in the field.

The dissemination of transgenic Bt cotton has brought about significant economic, social and ecological benefits. In terms of economic benefit, savings from reduced insecticide applications amount to US$120-150 per hectare, and earnings from increased yields amount to US$150-200 per hectare. In terms of the social benefits, labor use is reduced by 20-30%, and poisoning incidents from spraying fell by over 90%. In terms of the ecological benefits, the abundance of beneficial species has increased by 20-40%. Thanks to the introduction of transgenic biotech varieties, cotton production has stabilized in China, the varietal structure has been optimized, and competitiveness has improved a great deal. On future prospects for biotech cotton, Dr. Xia suggested that improvement efforts should stress increased resistance to insects, along with time and tissue specification expression. The application aspect should focus on establishment of an efficient system for biotech gene resistance management.

Biotech Cotton in China

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China has made tremendous progress in cotton biotechnology. Dr. Zhang summarizes it as follows:

Transgenic research - Cotton is the first major crop in which commercialization of a biotechnological initiative by the private sector provided various forms of plant protection through the use of transgenic technology. So far, many important genes have been expressed in cotton cultivars. These genes included those responsible for insect resistance such as Bt, GNA, CpTI etc, as well as resistance to herbicides, disease, drought and cold. Among the commercial cultivars that have been transformed successfully, transgenic Bt and/or Bt+CpTI insect-resistant cotton has achieved the greatest popularity in China. In the meantime, studies on genetic mechanism and expression features of time and space on foreign genes in receptors have also been carried out.

DNA marker screening - Many DNA markers such as Restriction Fragment Length Polymorphism (RFLP), Random Amplified Polymorphic DNA (RAPD), Simple Sequence Repeat (SSR), Inter Simple Sequence Repeat (ISSR), Amplified Fragment Length Polymorphism (AFLP), etc., have been used to construct cotton linkage maps, screen molecular markers linked with genes coding for important agronomic traits in cotton, and to study heterosis mechanisms. Many SSR/ISSR markers have reached advanced stages. Three genetic maps have been constructed by segregation mapping populations such as direct hybrids, F_2 and BC_1, etc. Based on these map, DNA markers associated with disease resistance, fertility restorer gene, QTLs for fiber quality, pubescence, lint percent and other yield components have been identified.

Cotton regeneration and transformation - Regeneration of limited cotton genotypes may produce large genetic vulnerability and risk in cotton production. So, research continues to focus on the problems of regeneration and transformation, especially in the development of transgenic technology. Several commercial cultivars have been isolated and are being used in Agrobacterium-mediated transformation, so that a gene that is to be inserted can be used directly. Additionally, genotypically independent pollen tube transformation was developed and used to transfer many genes to commercial cotton cultivars in China. It is estimated that cotton has about 70,000 functional genes. Many studies of these genes have been carried out using DNA markers, maps and gene transfer procedures. However, this is not enough. Bacterial Artificial Chromosome (BAC) libraries with a size of 150kb or greater have been constructed and contigs identification is being done using genetic markers with known chromosome positions. Additionally, genetic markers and DNA sequences from the physical map that are linked with the targeted agronomic traits will be used directly for marker assisted selection and gene isolation. These techniques appear to have a promising future in cotton genomics.

New Developments

Recent Progress in Cotton Research in China

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The cotton production system in China (Mainland) is diversified, and farmers are focusing more and more on increasing income and improving cropping intensity; this is the driving force behind cotton research in the country. The mono-crop cotton production system is decreasing, and cotton intercropping with watermelon, peanuts, wheat and rapeseed is gaining ground at a rapid pace. Thus, both cotton and food crop production are benefiting. The cotton transplantation technology is going through an innovation process. As the use of hybrid cotton spreads and the price of hybrid cotton seed rises, planting density is decreasing. Farmers are striving to achieve a one-to-one seed-to-plant ratio to cut back on their seed costs and they cannot do that without an innovative transplanting technique. Dr. Zhang reports that researchers in China are working to produce nursery seedlings on a soft mixture substrate from which the plantlets can be transplanted to the fields, with or without substrate mixture clinging to the roots. The technology is being perfected to scale it up for commercial mechanized farming, but manual use of the technique is already spreading throughout the cotton production areas.

Cell engineering is another area where China has achieved substantial success. Work in this field is currently underway at many institutes and universities. They have surveyed hundreds of cotton varieties and found several cultivars that easily tolerate embryogenesis and regeneration. Plant regeneration from wild cotton species and cell fusion, a further step forward in cell engineering, were first achieved in China. To be able to supply greater quantities of transgenic cotton plants for breeding purposes, China has employed highly skilled personnel and extensive funding to develop efficient cotton transformation systems. Recent results confirm that a number of laboratories have successfully used cell engineering techniques to produce transgenic plants on large scale. Pest, disease and drought resistance genes, as well as some genes that influence fiber development, have been spliced into the cotton genome.

Many kinds of molecular markers were developed to help improve breeding selection. In some labs coupling expressed sequence tag (EST) isolation with EST-SSR enriched the amount of SSRs available for cotton map construction. Meanwhile, SRAP and AFLP markers were also used in structural cotton genomics. A number of maps were published; some of them incorporate more than 1,000 markers. These maps were used to identify economic traits in cotton that are believed to be useful for future breeding programs. Findings seem to indicate that molecular biology assisted selection is very useful in the transfer of traits from wild cotton species to cultivated species.

Functional genomics work has also attained significant progress in China. Researchers have systematically analyzed the expression profiles involved in cotton fiber development and they have found that many pathways take part in the fiber development process. Ethylene was revealed to play a major role in fiber cell elongation; later they found that saturated very-long-chain fatty acids promoted cotton fiber elongation by activating ethylene biosynthesis. A group of researchers at Zhejiang University found a new mechanism for pest control, i.e., an RNAi structure from a P450 gene was introduced into the cotton genome and found that it provides the plant with pest resistance by interfering with the development of the pest. Based on the SSH method, Dr. Zhang investigated the genes controlling the development of Sea-Island (*Gossypium barbadense* L.) cotton fiber, somatic embryogenesis, and cell wall regeneration. He found that a complex gene network participated in somatic embryogenesis. Many key functional genes were involved in the function test. Workers are hopeful that these results will contribute to cotton gene manipulation efforts in the future.

The use of hybrid cotton is spreading, and Bt cotton has played a pivotal role in the production of hybrid cotton. Close to 90% of the cotton area in Changjiang and 50% in Huanghe was planted to hybrid cotton. Naturally sterile lines still do not work well in hybrid cotton seed production because of their low yield or the appearance of sterile plants in the F_1 generation, so most of the hybrid cotton varieties have one Bt variety as a parent and are produced by hand emasculation. The work done so far, and the encouraging results achieved, indicate that with the development of more functional genes and smart tools for detecting economic traits, the dream of a 'super cotton' with simultaneous expression of multiple improved traits may come true.

Cotton Production, Breeding and Biotechnology Research in Kazakhstan

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In Kazakhstan, cotton is grown in the South Kazakhstan Region where climatic conditions are characterized by comparatively warmer weather, a frost-free winter and sunny days. However, cooler temperatures during spring and autumn provide a short period of optimal conditions for cotton production. Soils are rich in nutrients and irrigation water is usually available in sufficient quantities. Most cotton is irrigated by the drip method; about 20% by sprinklers with a pivot system. Cotton production declined in 2006/07 and 2007/08 because of a shortage of irrigation water. The shift in farmer priories to growing more food crops also has a negative impact on cotton, both in the availability of irrigation water and in fertilizer applications, resulting in lower yields. Verticillium and fusarium wilts are commonly occurring diseases. Thus, in addition to high yield and better fiber quality, the primary objectives of cotton breeding in Kazakhstan include short duration and resistance to wilt diseases. Resistance to insects, particularly bollworms, is not a high priority, but insect-related losses have been increasing over the last few years. Researchers will ultimately have to divert their attention to obtaining host plant resistance to bollworms and sucking insects.

Cotton biotechnology research in Kazakhstan is still in its early stages of development. The Cell Biology Laboratory of the Institute of Plant Biology and Biotechnology has used various recipient systems and approaches for transformation of Kazakh cotton varieties. Kazakh researchers have focused their efforts on using a technique that is not genotype dependant. In order to overcome genotype dependence, researchers have used the strategy of revealing the morphological type of primary calli that are shared by various local genotypes and that appear to be promising from the point of view of morphogenesis. The type I (grayish – white callus) from three types of primary tissues was found to be the most typical for all seven investigated genotypes and two types of explants (hypocotyls, cotyledons). This common tissue type was very responsive to changes in media composition and was used as a source for the induction of long-term friable embryogenic calli for two cultivars (Maktaaral-4005 and Maktaaral-4006). The same approach is currently in development and embryogenic callus lines are being induced from other local genotypes.

Long-term embryogenic calli of Maktaaral-4005 were bombarded with plasmid pAHC25 containing reporter gene *ß-glucuronidase* (GUS) and a selective marker gene, Bar, for phosphinotricin resistance. Pollen transformation was carried out according to the Chinese protocol (vacuum infiltration) on Maktaaral-4005. Pollen was transformed by using an Agrobacterium strain containing a plasmid with reporter gene GUS and selective marker gene nptII. The treated bolls were produced from flowers that had been emasculated the previous day and pollinated by transformed pollens. Seedlings produced from these treated bolls were tested for GUS-gene expression. Nineteen bolls were produced from 140 pollinated flowers; 600 seeds were obtained from those bolls and 25 of them produced plantlets with positive reaction to histochemical GUS-assay. Research is under way and the progeny will be tested for GUS-gene expression and molecular biological evidence of foreign gene insertion.

Cotton Quality and Use

A Study of the Skills Gap along the Cotton Value Chain: Garments Segment

Mr. Ghulam Ali
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Mr. Ali undertook a study of the cotton value chain in Pakistan to analyze inputs and outputs to, a) identify key stakeholders, b) define the role of knowledge and skill gaps in determining the likelihood of poverty at the level of each sub-system, c) assess the knowledge and skills of key stakeholders, d) study the existing knowledge systems, and e) develop an action plan based on the results achieved.

He focused on the garment sector. Using a purpose designed questionnaire, data were collected during June-July 2008 directly from garment factories, government departments and agencies and many secondary sources. He observed that a US$7 billion investment in the textile sector from 1998 to 2008 led to the creation of 454,000 new direct jobs. Owing to low skills and knowledge, the difficulty of finding the right people, or *Head Hunting* is rated at 78 in Pakistan compared to zero in India, 11 in China (Mainland) and 44 in Bangladesh (a higher rating means greater difficulty) . The study identified several knowledge gaps at the firm or business level. Owners and top management are not fully aware of developments in modern information technology and consequently are unable to make use of the contribution that information technology can make to enhance productivity.

The garment industry is lacking in skilled personnel managers and in training and development opportunities for improving existing skills. Another weakness of the garment industry is the shortage of trained dye masters. The study detected several knowledge gaps at the firm or company level. Creative design adds substantial value to the price of garment products, and the lack of creative design in Pakistan is also harming the garment industry. The study identified eight different types of process and material losses in the garment sector, particularly in production, cutting, rejection, recall, stitching, etc. Those losses were due mainly to ineffective process and materials management, but weaknesses were also identified in product marketing and quality management. That notwithstanding, there were some notable successes; upgrading of the skills of managers and employees involved in materials and process management made a significant contribution to the profitability of the organization. Based on his study, Mr. Ali was able to make a number of suggestions to improve the value chain, particularly the garment sector, in Pakistan. Some of the more important recommendations were:

- The garment industry must recruit qualified personnel. The government should initiate and encourage target-oriented initiatives for capacity building among garment factory owners, factory managers and technical employees.
- Employers and employees must be educated in existing labor legislation. That kind of training might appear to work against the interests of the business community but in reality, the productivity of employees is more likely to increase.
- The garment industry must focus on branding various products to win the trust of international buyers.
- Cotton value chain stakeholders must improve information sharing, vertically and horizontally.
- Export-oriented manufacturers should be given incentives linked to quality manufacturing and export earnings per unit product.
- The government of Pakistan must design a clear-cut power policy for the textile industry.

The Cotton Standardization System and Market Failures in the Turkish Cotton Market

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In Turkey, the General Directorate for Standardization, under the administrative control of the Under Secretariat for Foreign Trade, is responsible for implementing the cotton standardization policy. All seedcotton, un-pressed cotton, linters and fiber waste are subject to mandatory classification and controls. The system is based mainly on the traditional classification of cotton produced in different regions of the country. In this system, cottons are classified according to their production region. The existing system of traditional pricing favors the cotton from the Ege region of Western Anatolia in the market. The Cotton Laboratory of the Regional Directorate of Western Anatolia under the Undersecretariat for Foreign Trade prepares sample boxes for different cotton types and supplies them to all commercial exchanges in Turkey and abroad, as well as to a group of foreign trade standardization inspectors. The standard boxes are compared to HVI data in order to rule out human error. About 2% of the total number of bales produced in the country is analyzed on a single-bale basis, so that only a limited number of bales are opened and physically tested. Thus, most spinners have to retest their cotton on HVI before processing. Mr. Sözümert also addresses, at length, the problems arising from this obsolete system: sample based sales result in high transaction costs; interested parties have to buy their own HVIs, which remain idle most of the time; HVI data from different sources are not uniform or repeatable, and farmers are not paid based on quality (no incentive for quality production). These shortcomings are complemented by the disparity among cottons produced in various regions.

The paper suggests that the cotton marketing system in Turkey should be based on a sound mechanism for fiber quality testing by an independent authority directly responsible for actually performing the tests. The information on fiber quality for particular cotton should be based on the tested quality of the cotton itself and not on the region where it was produced. The General Directorate for Standardization plans to adopt a single-bale testing method. Qualified experts will draw lint samples at gins, and all samples will be tested by HVI according to international standards. The Izmir cotton fiber analysis laboratory of the General Directorate for Standardization for Foreign Trade has already started work along these lines. The Directorate plans to establish a fiber analyses laboratory this year in Sanlıurfa province, one of the major cotton production areas in the GAP-Southeastern Anatolia Region. Once the irrigation projects are fully implemented, this region is expected to become the main cotton production area in the country. The biggest obstacle to the full implementation of the single-bale method using HVI analysis appears to be the high number of gins throughout Turkey. There are over 700 gins in the country. Initially, the General Directorate of Standardization for Foreign Trade intends to apply the single-bale method and HVI classing to the cotton bales produced in the ginning facilities that already have the necessary equipment for automatic sampling. This way, some factories will be excluded by default, but at least the process will be under way.

Organic Cotton

Organic Cotton Production in Syria

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Syria has excellent conditions for growing organic cotton because less than 1% of the cotton area is treated with insecticides. The program to eliminate insecticides from the cotton production system was started almost three decades ago, but the foundations for organic production were laid almost 10 years ago when a biological control method was introduced to eliminate the last remaining uses of insecticides. Cotton in the field is closely monitored in Syria through crop surveying at weekly intervals and by means of pheromone traps. Adopting a single variety per zone, as well as planting and harvesting cotton as recommended by the experts, further enhanced conditions for growing organic cotton in Syria.

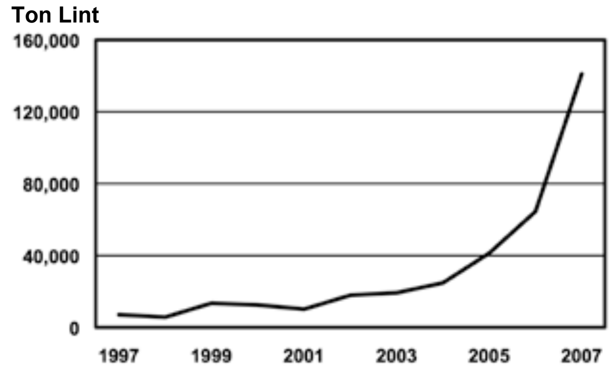
Syria initially started with 372 hectares under organic production methods, and in less than three years converted another 10,000 hectares to organic production. These areas were either not planted to cotton before or had had zero insecticide applications on cotton two years in a row. Syria selected an elite group of educated technical farmers whose cotton fields were most suitable for organic production. In 2006/07, *Trichogramma principium* eggs and *Bracon brevicornis* larvae were used on 5,271 hectares to control any insects appearing in the area. International certifiers were invited to certify the organic growing and ginning of the cotton. Organic production efforts were made jointly by the research wing, the Cotton Research Administration, and the Cotton Marketing Organization of Syria, which is responsible for sales of Syrian cotton. Consequently, Syria produced 8,185 tons of organic cotton in 2006/07 and organic production increased to about 26,000 tons in 2007/08.

Organic Cotton Production in the World

Dr. M. Rafiq Chaudhry
International Cotton Advisory Committee

Organic production is a labeling term and, for any cotton to be labeled organic, it must be certified as a recognized certifying agency. In order to claim that a given textile is organic, it must be made from certified organic cotton processed according to organic fiber processing guidelines. Organic cotton production totaled over 140,000 tons in 2007/08. A number of new projects started in India, and the country emerged as the largest producer of organic cotton in the world in 2007/08. Over 90% of the world's organic cotton is now produced in Asian countries. It may be concluded that conventional and organic production can co-exist, and that both can be sustainable. Biotech cotton has hurt organic cotton, at least in the USA, where the biotech cotton area reached 95% of total area planted to cotton in 2008/09. However, organic production will continue to exist as a niche market and may increase in selected countries.

Organic Cotton Production in the World



Pest Control

CABI'S Expertise in Cotton with an Emphasis on Asia

Dr. Julie Flood
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CABI has a staff of over 400 people located in 16 countries, but most of the work on cotton is focused in China (Mainland), India and Pakistan. CABI's main mandate is to improve people's lives worldwide by providing information and applying scientific expertise to solve problems in agriculture and the environment. CABI has done a lot of work on technology transfer and on building capacity for a wide range of stakeholders. Many of our initial projects in Asia involved studying the biology and field behavior of natural enemies of major pests such as pink bollworm *Pectinophora gossypiella* in Pakistan. This project was funded by USAID. Studies were made on the biology, phenology and behavior of parasites and predators against the pest. A limited scale augmentation of *Bracon gelechiae* (a braconid wasp) as a predator was done, and the impact of its releases was studied. *Bracon kirkpatrickcki* and *chelous blackburni* were also imported, bred and released against *P. gossypiella.* Pesticide spraying and its impact on predator populations were also investigated to understand the ecological interactions of the pest-predator relationship and the effect on that relationship of pesticide spraying.

CABI implemented a project titled 'Asian Regional Cotton IPM' from 1992-96 in China (Mainland) and Pakistan. The validation trials showed that IPM plots required half the number of sprays compared to the conventional approach. CABI implemented a project called 'Freshwater Management in Cotton Ecosystems through Farmer Field Schools.' The project studied the qualitative and quantitative impacts of cotton production on the freshwater ecosystem and identified good management practices to ensure sustainable cotton production with minimum threats to the freshwater ecosystem. This work included determination of the water requirements of the cotton plant, and farmers studied water use patterns on cotton. CABI was also involved in the EU/FAO project 'Integrated Pest Management Program for Cotton in Asia' (2000-2004) and many other projects involving cotton. Currently, CABI is collaborating with the National Agro-Tech Extension and Service Centre (NATESC), of the Ministry of Agriculture, in China, on a project funded by the Department for International Development (DFID) of the UK to investigate the initial benefits of Bt cotton and the sustainability of these benefits over the long term. The goal is to identify risk factors associated with Bt resistance in cotton bollworm in China. CABI is managing a project in Pakistan to control mealy bugs. The project is funded by the Government of Pakistan and will run through 2008-11. The project is exploring commercial utilization of the mealy bug destroyer, *Cryptolaemus montrouzieri*, introduced from Australia, as a biological mealy bug control agent.

Mirid Menace: An Emerging Potential Sucking Pest Problem in Cotton

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Large-scale adoption of biotech cotton in India has reduced insecticide use against target bollworms by about 80%. Farmers have also moved toward selective insecticides. Changes such as the shift in insecticide use in India have resulted in increased populations of sucking pests: mirids, aphids, white flies, thrips and mealy bugs. Mirids are on the increase year after year and pose a big threat to cotton production in India. Mirids, some times also known as true bugs, are small terrestrial insects, usually oval-shaped or elongated, measuring less than 12 mm in length. The pest has a huge host range and it is appearing in biotech fields more prominently than in non-biotech cotton areas. Dr. Udikeri undertook a project in Karnataka state on the species complex, bio-ecology, yield losses and management aspects of mirids. Data were recorded on mirid populations and predators at fortnightly intervals from July to December in four districts. Separate experiments were designed to assess avoidable losses and damage management linked to mirid bugs.

Five different species of mirids have been reported to affect Bt cotton in China, but in Karnataka (India), *Creontiades biseratense* (Distant) is the only reported species of mirid detected so far. Current reports mention two new species of mirid, i.e., *Hyalopeplus lineifer* (Walker) and *Compylomma livida* (Reuter). This is the first formal report on the incidence of these species on Bt cotton in India. Symptoms and the nature of the damage caused by these species on cotton were similar to those described earlier by many researchers. Nymphs and adults feed on squares and small developing bolls. During feeding the mirids pierce the plant tissues with their stylet. The affected area rapidly turns dull, then blackens and ultimately the cells in affected areas die. Mirid damage may result in heavy shedding of medium-sized squares and small bolls. More developed squares, if affected or damaged, may result in the formation of deformed or partially filled bolls. If the infestation is severe in older bolls, the damaged locks may not develop properly or lint may be stained. Consequently, yield losses are significant. Mirid populations ranged from 18 bugs/25 squares to 66 bugs/25 squares and reached their peak at all locations in September and continued until December.

A total of 59 biotech hybrids and four non-biotech hybrids were studied. The results showed that mirid attack was not genotype-dependent, although mirids were found in slightly higher numbers on interspecific biotech hybrids. As far as yield loss is concerned, untreated plots averaged a yield of 2,480 kg/ha of seedcotton compared to 2,770 kg/ha in plots treated against mirids. Among the various treatments, acephate 70SP was best in reducing mirid infestation, followed by acetamiprid 20SP and imidacloprid 200SL. Other treatments included dimethoate 30EC, thiamethoxam 25WG, chlorpyrifos 20EC, neem oil + nirma powder, nirma powder, *Verticillium leccani, Beauveria bassiana* and *Metarhizium anisopleae.* In Australia, recent trials have shown that reduced rates of indoxocarb or fipronil combined with salt provide effective control of mirids with reduced negative effects on beneficials. The studies are continuing during 2008/09.

Research and Development

Basic Problems and Perspectives of Cotton Sector Development in Tajikistan

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Cotton production in Tajikistan has been declining for the last few years and only about 420,000 tons of seedcotton, or 130 tons of lint, was produced in 2007/08, i.e., below 50% of what was produced in 1990/91. Cotton was planted on 237,000 hectares in 2008/09, and total production was expected to be close to 110,000 tons of lint. Cotton makes up 8% of the GDP and accounts for 15% of export earnings. It is estimated that the cotton farming sector accounts for about 60% of all agricultural production and 75% of the rural population is engaged in cotton production. Taxes and duties collected from the cotton sector make up 27% of the country's annual budget.

It is estimated that 53% of the cotton area has assured irrigation, while the rest is rainfed. Cost of production data show that on the average US$500-650 are spent to grow and harvest a hectare of cotton. In the past, the banking system in Tajikistan was not developed properly, and farmers could not get credits. The Government invited foreign investors to assist in the development of the cotton growing sector. During the last few years, cotton growers have accumulated huge debts because of their inability to pay back the loans received from foreign companies. Unpaid debts have become a big issue in Tajikistan and the following factors are responsible for farmer defaults:

- Cotton production requires heavy investment, and the cost of processing and transportation is also quite high.
- The inputs used by farmers are not appropriate for the requirements. Thus, yields are low and farmer income is also low.
- Farmers are depressed and do not see a way out without the help from the Government.
- Soil condition is continuously deteriorating, thus affecting other crops grown in rotation with cotton.
- Agricultural machinery is old and does not match the agro-technical requirements of modern farming.
- Some local authorities continue to interfere in the management of private farmers' activities.
- Legislation is not suited to the new private farming environment, particularly with respect to the market economy.
- Low international cotton prices and high fuel costs have also affected Tajik growers.

Lately, the Government of the Republic of Tajikistan decided to provide loans to farmers via local banks. The investment in the 2008 crop as of August 1, 2008 was US$81.6 million, of which 67% was disbursed through banks and 33% through private investors. The reimbursement of debts hinges on the problem that the land still belongs to the Government and the farmers cannot use it as collateral. Farm assets are quite limited and cannot be used as collateral either. If the land could be used as collateral, commercial banks could get more actively involved in the process of providing credits for the country's cotton sector. The Government of Tajikistan has undertaken the following additional steps as part of the economic reforms to deal with the situation. Hopefully, the cotton situation will improve after 2008/09.

- The 'State Order' to produce cotton was cancelled.
- The state organization 'Glavkhlopkoprom,' which had a bad reputation in the cotton sector, was liquidated.
- Both internal and external trade has been liberalized.
- Gins were privatized.

Cotton Research and Development in Thailand

Dr. Parinya Sebunruang
Senior Cotton Breeder, Nakhon Sawan Field Crops Research Centre, Thailand

Thailand is a cotton importing country, and cotton production has been declining for the last few years. Cotton was planted on 12,478 hectares in 2005/06. That figure declined to only 4,679 hectares in 2007/08. Thus, 398,840 tons of cotton fiber had to be imported in 2007/08 for the textile industry. The decrease in the growing area is due to low seedcotton prices and the high cost of pest control, especially insecticides. In 2007/08, the number of cotton growers was 10,589, as against 13,540 in 2005/06. Most farmers grow cotton on less than one hectare for their own use in hand-crafted textiles. In the last three years, government policy has encouraged farmers to grow high-profit crops, such as sugarcane and cassava. Therefore, more than 95% of the total demand for cotton fiber had to be met through imports, mainly from the USA, China, Australia and India.

At present, most domestic cotton cultivars have medium staple fiber, but some farmers in some areas in the north of Thailand still grow short staple fiber cultivars belonging to *G. arboretum*. Most short-staple fiber is used in the hand-crafted textile industry for small articles such as scarves and pillowcases, etc. The cotton research and development work under way to develop suitable *G. hirsutum* varieties has been carried out at the Nakhon Sawan Field Crops Research Center (NSFCRC) since 1989. The first locally developed variety, Tak Fa 2, was released for production in Thailand in 2001. This cultivar has good resistance to the cotton leaf curl virus disease common in Thailand.

Fiber quality is very good: fiber length = 31.8 mm; strength = 34 g/tex; and micronaire = 3.4. However, cotton growing areas in Thailand are still too few because cotton requires intensive care and effective insect pest control management, especially to control the cotton bollworm *Helicoverpa armigera*. The competing crops are sugarcane, cassava and maize, as they need less management than cotton. The cotton breeding program at the Nakhon Sawan Field Crop Research Center is also endeavoring to develop naturally colored cotton varieties for use in textile handicrafts and in making local cotton products. Breeding for colored cotton cultivars began in 2000, the long-staple variety Tak Fa 2 was crossed with a green short-staple cotton cultivar. Then, selection for characteristics similar to those of Tak Fa 2 and backcrossing continued for four generations. In each backcross, the seed was collected in bulk from green lint cotton plants exhibiting the plant type of Tak Fa 2. The seeds of BC_4F_1 - BC_4F_5 were then sown for pedigree selection. In 2007, 20 lines with good uniform green-lint fiber and plant type were selected and will be evaluated for yield potential before release for commercial use.

Cotton Research in Myanmar: An Overview

Mr. Tu Win
Research Officer for Cotton Farms, Cotton and Sericulture Department, Myanmar

Cotton research in Myanmar was originally focused on developing *G. arboreum* varieties. *G. hirsutum* varieties were introduced from the USA and the former USSR during the 1950s and now upland varieties occupy 76% of the 314,000 hectares planted to cotton in 2007/08. Currently, the Cotton and Sericulture Department is responsible for research and development, extension and training work on cotton. Two other institutions involved in cotton research in collaboration with the Cotton and Sericulture Department are Yezin Agricultural University and the Department of Agricultural Research of the Ministry of Agriculture and Irrigation, Myanmar.

Ngwe chi 1, Ngwe chi 2, Ngwe chi 3 and Ngwe chi 4 are commercial varieties planted on about 90% of the upland area. All of these varieties have ginning outturns of close to 35%. Breeders have developed new varieties with 40-41% ginning outturn and their fiber quality characteristics are comparable to the Ngwe chi types. The new varieties are close to being released in various regions. Breeders are also trying to find an economical way to produce commercial hybrid cotton seed for large-scale production. The recommended fertilizer formulations include NPK at 57 kg of nitrogen/ha, 28 kg phosphorous/ha and 26 kg/ha potassium. The sandy soils are seriously deficient in boron and three applications of home-made boron applied at first square, first flower and full bloom stages have resulted in up to a 60% increase in yield. There is a drastic variation in the fertilizer doses applied by growers. To deal with that, the Cotton and Sericulture Department is perfecting the recommended plant stands adapted to various levels of fertilizer doses. Researchers have observed that growers also need specific advice on the use of growth regulators, particularly if cotton is grown on fertile sandy loam soils. Farmers have concluded that it is not economical to grow cotton as a sole crop; thus, it is officially recommended that green chick peas, sesame or chilli should be intercropped with cotton.

Helicoverpa armigera and *Pectinophora gossypiella* inflict the greatest damage on cotton production, although sucking insects always remain a threat. Biotech cotton against Lepidopteron insects has been tested on a small scale, but the biosafety and legal frameworks needed to commercialize biotech cotton are not available yet. About 25% of the cotton area, mostly under diploid varieties, is not sprayed at all; the rest is treated with insecticides, at 4-6 sprays per season. Biological control of a serious sucking pest aphid *Aphis gossypii* is being aggressively pursued through the use of the ladybug beetle *Menochilus sexmaculatus* Fabricius. A method to mass rear the ladybug has been developed and the predator is constantly released at the cotton research and seed farms. Research efforts are also under way to mass rear another potent predator, a bug of the genus *Eocanthecona furcellata*. The biological control lab of the Myanmar Agriculture Service is taking the lead in this work and test release studies have already been completed. *Cynodon dactylon* and *Cyprus rotundus* are major weeds that appear constantly in cotton fields. Herbicides are still not being used, but labor scarcity is becoming a problem.

The future program includes intensified efforts to undertake research on the physiology of the cotton plant in Myanmar's production conditions to improve output efficiency in proportion to the inputs used. The Cotton and Sericulture Department is seriously working to develop techniques to enhance seed setting efficiency and improve the seed quality of commercial cotton hybrids. The ultimate objective is to produce F_1 hybrid planting seed at a low cost. The need to study the biology and ecology of the cotton stem weevil *Pempherulus affinis* is increasing because of the frequent occurrence of damage in cotton fields at early stages of growth. Currently, the problem seems to be prevalent in fields where cotton is grown in a monoculture cropping system year after year. Myanmar will continue its emphasis on optimization of input use and enhancement of the profitability of cotton against competing crops.

Administrative Issues

The meeting elected Dr. Jingyuan Xia of China (Mainland) as the new Chairman until the next meeting of the Network.

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The participating countries decided to hold the next meeting in two years' in Kazakhstan. Papers on the economics and marketing of cotton will also be invited.

The meeting considered changing the name of the network to Asia and Pacific Cotton Research and Development Network, but decided not to. Despite the decision, the meeting decided to invite Australia to future meetings.

The FAO Sub-regional Office for Central Asia will continue to support the network's activities/meetings.

More details about the meeting and papers are available at http://www.icac.org/tis/regional_networks/asian_network.html.

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