# SIXTH MEETING OF THE ASIAN COTTON RESEARCH AND DEVELOPMNET NETWORK

**Dhaka, Bangladesh**
**June 18- 20, 2014**

# BOOK OF ABSTRACTS

**COTTON DEVELOPMENT BOARD**
**MINISTRY OF AGRICULTURE**
**BANGLADESH**

**SIXTH MEETING OF THE ASIAN COTTON RESEARCH AND DEVELOPMNET NETWORK**

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**ABSTRACTS**

## A. BIOTECH COTTON

### 1. ENHANCED GENE EXPRESSION IN DROUGHT TOLERANT TRANSGENIC COTTON (*Gossypium hirsutum.L)*

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*Gossypium hirsutum* the most important textile crop Worldwide, often encounters water stress. Molecular mechanism of water regulation in cotton plants were regulated by stress responsive genes. The expression of dehydration-inducible genes has shown that at least four independent signaling pathways function in the induction of stress-inducible genes in response to dehydration: two are ABA dependent and two are ABA independent.Dehydration responsive element (DRE) or C-repeat (CRT), a *cis*-acting element, plays an important role in regulating gene expression in response to stress in an ABA independent manner. Drought tolerant transgenics were developed in elite genotypes LRA 5166 and LRK 516 with *Prd29: AtDREB 1A* and *PLEA1: Bc ZF1* gene constructs through *Agrobacterium* mediated transformation with both the gene constructs. The regenerated shoots were screened in the kanamycin medium (MS) and were transformed in the MS medium containing auxin 1mg/l and cytokinin 1mg/l. Molecular confirmation for the presence of the gene was done by PCR using specific gene and *npt II* primer. RT-PCR study was carried by isolating mRNA from transgenic plants and cDNA was synthesized and amplified with npt II primer,*DREB 1A, ZF 1* gene specific primer produced the 700 bp, 540 bp fragments and 480 bp respectively.

To evaluate the gene expression of candidate genes for drought tolerance, transgenic plants and wild type were grown in the pots and drought stress was subjected to the plants during square formation stage (55–60 days old plants) and boll developmental stage without watering for maximum 15 days for drought stress treatment. Fresh young leaf from the main terminal branch and root samples were collected from drought stressed plant at square formation and boll developmental stage and used for RNA isolation. Transgenic events of *G. hirsutum* variety LRK 516 carrying *DREB 1A* gene were analyzed for gene expression by qPCR during square formation stage showed average of 5 fold increase of transgene expression during stress period and the proline content was also found 3-fold increase during stress condition in transgenic plant when compared to the wild type and the drought tolerant variety 28 I. The transgenic plants were subjected for drought stress and physiological and biochemical studies viz., PEG (polyethylene glycol), proline, reducing sugar, amino acid, protein and phenols were carried at regular interval.Transgenic plants showed higher levels of relative water content (RWC), leaf water potential (LWP) along with increasing levels of water stress than the wild type plants. The leaf discs from non-stressed plants of both transformed and wild type were placed on PEG medium with varying degrees of stress (0, 0.4, 0.6, and 0.8 MPa). The biochemical changes induced due to stress were quantified at 0, 7 & 15 days after stress treatment. The data showed that there was an inherent tolerance developed in transgenic plants due to *DREB 1A*. The control plants showed a immediate burst in synthesis of reducing sugars, amino acids and proline but declined by seven days, while the transformed plants showed a gradual increase in solute accumulation and maintained high even after 7 days. The non-transformed discs produced very high phenolic's, which led to death of the tissues with stress. The transgenic plants were subjected to different water treatment regimes of 100%, 75%, 60%, 45%, 30% revealed that in 100% regime, total water requirement was higher in wild type when compared to the treatments. The weather parameter was observed that under 100 % water regimes, at the top of plant the relative humidity was higher and at the base of plant it was lower. The vapour pressure deficit under high amount irrigation water regimes was minimum as compared to low amount of water applied to the plant.

## 2. MOLECULAR MARKER-ASSISTED SELECTION AND PYRAMIDING EFFECT OF MAJOR QTLs FOR COTTON FIBER STRENGTH

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Plenty of QTLs for cotton fiber quality had been mapped, which provides an opportunity for molecular marker-assisted breeding in cotton fiber quality., It is necessary to pyramid a few QTLs to improve cotton fiber quality, because there is small effect to fiber quality for single QTL.

In this research, three elite fiber quality lines (HS427-10, 7235 and 0-153), and two commercial cotton cultivars (TG41 and sGK156) were used as parents to develop three double-cross $F_1$and $F_6$ populations of （sGK156×HS427-10）× (0-153×7235),（TG41×HS427-10）× (0-153×7235)and（sGK156×0-153）× (sGK156×HS427-10). Thus, the pyramiding effect of major QTLs of cotton fiber strength by molecular marker assisted selection was studied.

For QTL-1, QTL-2 and QTL-3, linked to marker NAU1262, CM67 and TMK19, MUSS034, respectively, there was significant genetic effect. In three double-cross F1 populations, the average fiber strength of individuals whose genotype denoted as "+", was 31.00~33.35cN/tex, and 31.00~33.39cN/tex for the individuals denoted as"+-". Selection effects of single marker were 0.80-1.51cN / tex. In three double-cross $F_6$ populations, the average fiber strength of individuals detected by molecular markers was higher than that detected by no markers, and existed significant or extremely significant difference in at least one population. The average fiber strength of individuals whose genotype denoted as "++/+", was 31.99~33.46 cN⁄tex. Selection effects of single marker were 0.36~2.47 cN/tex.

QTL-4, QTL-5 and QTL-6 were linked to marker BNL1694, NAU1048 and BNL1421, respectively. In three double-cross $F_6$ populations, the average fiber strength of individuals detected by molecular markers was higher than that detected by no markers, and existed significant or extremely significant difference in at least two populations. The average fiber strength of individuals whose genotype denoted as "++/+" was 30.89~33.06 cN⁄tex, and 30.74~32.56 cN/tex for the individuals denoted as"+-". Selection effects of single marker were 0.13~1.48 cN/tex.

In three double-cross $F_1$ populations, 26 combinations were produced through comparing the average fiber strength of pyramiding two QTLs with that of pyramiding one QTL. Of 22 combinations (84.6%), the average fiber strength of individuals with two QTLs was higher than that of individuals with one QTL. Of 11 combinations (42.3%), it reached to significant or extremely significant level. The average fiber strength of individuals with two QTLs was 31.69~33.52 cN⁄tex. The selection effect was 0.63~1.74 cN⁄tex compared to the individuals without QTL; and 0.20~1.18cN⁄tex compared to one QTL.

In three double-cross $F_6$ populations, 75 combinations were produced through comparing the average fiber strength of pyramiding three of six QTLs with that of pyramiding two QTLs. Of 63 combinations (84.0%), the average fiber strength of individuals pyramiding three QTLs was higher than that of individuals pyramiding two QTLs. Of 13 combinations (17.3%), it reached to significant or extremely significant level. The average fiber strength of individuals pyramiding three QTLs was 31.40~36.55 cN⁄tex. The selection effect was 0.77~6.10 cN⁄tex compared individuals pyramiding none of the three QTLs; 0.04~6.41 cN⁄tex for pyramiding one of the three QTLs; and 0.01~4.74 cN⁄tex for pyramiding two of the three QTLs.

Therefore, cotton fiber quality could be effectively improved by pyramiding multiple QTLs.

## 3. GENE DISCOVERY FOR IMPROVEMENT OF FIBER STRENGTH IN COTTON

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Modernization of textile industry with high speed spinning technology demands long and strong cotton fiber. Hence, genetic improvement of cotton fibre quality is essential to meet the growing demand of the textile industry. Advances in cotton biotechnology research have helped to decipher molecular mechanisms involved in fiber development process that includes initiation, elongation, secondary cell wall synthesis and maturation. Significant efforts to understand the fundamental molecular mechanisms involved in fibre development resulted in generation of large number of expressed sequence tags (ESTs) governing fiber quality traits. In addition, next generation sequencing technology has also registered remarkable progress in genomic resource generation which can be targeted for genetic improvement of economic traits in cotton. Second generation sequencers such as, 454 GS FLX, HiSeq 2000, SOLiDv4, performing sequencing based on pyrosequencing, sequencing by synthesis, ligation and two-base coding mechanism, respectively on comparision with Sanger 3730xl which uses dideoxy chain termination created sea changes in the area of cotton genomics. Taking advantage of these scientific and technological progresses, diploid progenitor cotton *G. raimondii* genome was successfully sequenced independently in 2012 by two research groups. With the above genomic resources available, molecular mechanism for fibre elongation is well understood for cotton. However, the information available about the genes responsible for fibre strength is scanty. Exploration of high strength genotype/ germplasm lines/ near isogenic lines (NILs) for fibre strength using high throughput gene expression profiling studies revealed putative candidate genes associated with fibre strength. Bioinformatics analysis of 9240 ESTs of 20 days post anthesis fibre from public database (NCBI) resulted in identification of 63 uncharacterized contigs showing differential expression in secondary wall synthesis stage. Further gene expression analysis through quantitative PCR in high and low strength RIL mapping population resulted in identifying candidate genes associated with fibre strength. The identified genes showed homology with actin binding proteins having role in elongation and transcription factor for phenylpropanoid biosynthesis and glycoproteome with a role in secondary wall synthesis and fibre strength. The targeted expression of the identified candidate genes driven by strong fiber specific promoter is under progress which will pave the way for the development of GM cotton with improved fiber strength in the near future.

## 4. *In Planta*GENETIC TRANSFORMATION OF DOMESTIC COTTON VARIETY

**I.I. Umbetayev[1], I.R. Guseinov[1], A.K. Amirova[2], B.E. Yertaeva[2], A. Bilyal[2] and N.K. Bishimbayeva[2]**

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Advantages of *in planta* genetictransformation are overcoming the problem of genotype dependence in plant regeneration process and avoiding the time-consuming steps of tissue selection in sterile conditions during the genetic transformation *in vitro.* The purpose of this study was to optimize conditions for *in planta* transformation of local cotton variety using agrobacterium strain carrying a plasmid with the reporter glucuronidase gene (*GUS*-) and the marker gene neomycin phosphotransferase (*nptII*-). Pollen of flowering plants and shoot apexes were used as recipient systems for transformation. Local commercial variety Maktaaral-4005 was used as an object of investigation.

In optimization of *in planta* transformation of flowering plants, pollen was transformed by co-cultivation with agrobacterium cell suspension; then flowers were pollinated with the transformed pollen. As a result, 19 bolls and 600 set seeds of putative transformants of T0 generation were obtained from 250 pollinated flowers. For 25 of them we obtained histochemical proof of GUS- gene expression in T1 generation, which is 4.2 % of the total amount of putative transformants. For 13 of the GUS- positive plants we obtained molecular biological confirmation for introduction of nptII and GUS- genes by PCR method, which is 2.2 % of the set seeds. In the course of *in planta* apex transformation, apical buds of 14-day old seedlings were co cultivated with agrobacterium cell suspension with the exposure to vacuum infiltration. As a result of optimization, 6 transgenic plants were obtained from 101 apexes, in which the amplification products of *nptII*- and *GUS*-genes were detected, representing 5.6 % of the transformed apexes.

Conditions were optimized for the production of transgenic plants from local cotton varieties using reporter and marker genes, which will allow introducing "useful" genes responsible for economically valuable traits into their genome. Transgenic plants of local commercial cotton variety expressing reporter GUS- gene have been generated. The authors are thankful to Prof. Dr. A. Mitra of the Nebraska University, Lincoln, USA for providing plasmid constructs and agrobacterium strains containing *nptII*- and *GUS*-genes. This work was done under the projects STP MES RK 01.01.08.03.R1 (2006-2008), and 02.2.03.P4 (2009-2011).

## 5. RED LEAF IN COTTON- A MOLECULAR PERSPECTIVE

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Cotton plant, withstands extreme harsh environments during its life cycle in the form of various abiotic and biotic stresses to produce the white gold wrapped around the seeds which is essential for species survival. Despite the fact that cotton is grown as a forced annual plant, it exhibits the inherent perennial nature in terms of adaptation to its external environment. Be it any kind of abiotic or biotic stress, one can observe cotton plant emerging strong during its recovery phase producing at least few flowers and bolls to perpetuate its life cycle like any other perennial tree does. Red leaf disorder in cotton is an effect induced by various internal and external factors *viz.,* mobilizing the nutrients from older leaves to younger leaves or developing bolls thus turning older leaves or subtending leaves red, protecting the photosynthetic apparatus from photo-oxidative damage due to various abiotic stresses by accumulation of red pigments called anthocyanins, leaves turning red during cooler nights followed by brighter days as occurring in perennial trees during autumn, reddening due to sucking pests etc., Rather than ignoring this malady which is causing panic among farmers and the policy makers who pay subsidy to farmers for the same, by considering red leaf disorder as a natural phenomenon, the cotton plants are endowed with as an adaptive strategy, the underlying cause in the accumulation/ visibility of anthocyanins by degradation of chlorophylls during stress induced senescence can be redressed. An insight into the complex molecular interaction of various abiotic stresses in a plant that induce the accumulation of anthocyanins is worth considering for developing strategies to ameliorate the red leaf disorder in cotton.

## B. GENETICS AND BREEDING

### 6. DEVELOPMENT OF DROUGHT TOLERANT VARIETY OF COTTON BY USING MODERN TECHNIQUES

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The research work was carried out with an objective to develop a drought tolerant variety of cotton having high yield under minimum irrigation conditions. Four cotton lines known to be drought tolerant viz.FH-942, RH-510, CIM-1100, PB-899 and eight testers (FH-113, FH-4243, FH-114, FH-214, CIM-496, MT-002, MT-007 and FH-2015) were crossed in LxT (line x tester) mating design at Cotton Research Institute, Faisalabad during 2010. $F_1$ of these crosses were raised in glasshouse conditions for generation advancement and $F_2$ in field during 2011. Seed of each $F_1$ cross was pooled and large population of $F_2$ (1000 plant/cross) were sown in field. Selection criteria from $F_2$ to $F_6$ bye modified pedigree selection on the basis of morphological traits, CLCuV (%), plant yield and fiber quality. Fifteen promising selected lines were tested at six different ecological zones of Punjab province, during 2013-14. The data were recorded for morphological, CLCuV, physiological, biochemical, molecular, yield and fiber traits. These lines were preliminary screened under PEG-6000 stress at germination and seedling stage. Root/shoot parameters of these lines were also measured 60 days after sowing by using the PVC pipes and sand media. Out of seventeen, one line FH-326 showed encouraging results for all the parameters studied during these trials and have been studied on the basis of stability of yield and other parameters calculated by genotype x environment method. This line has been selected for testing in Provincial Coordinated Cotton Varietal Trial (PCCT)at sixteen locations and registration, during 2014-15.

### 7. BREEDING FOR DROUGHT TOLERANCE IN COTTON (*Gossypium hirsutum)*FOR RAINFED CONDITION

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Drought is one of the major factor limiting crop production and quality globally especially in arid and semi- arid areas of the world. Approximately 64 per cent of the world's soils are located in the desert or in areas with limited water availability and that 57 per cent of the potentially arable area is located in soils for dry land crop (FAO, 2000). Water availability at various phenological phases of development affects both seed cotton yield and quality of the fibre produced in cotton crop. Genetically uniform plant population when subjected to water stress has shown yield reduction of up to 50 per cent when compared with those under irrigated condition, particularly when the stress is imposed during flowering and fruiting stage (boll development stage). Presently, water

availability for use in agriculture is limited and expensive due to meeting the demand for urbanisation and increasing population, creating impetus for research projects that can identify genotypes with more efficient use of water or better tolerance to water stress conditions needs to be addressed.

Researchers have shown and discussed in detail about physiological, cellular, molecular and biochemical basis of drought tolerance. Various approaches to incorporate drought tolerance, traits involved and screening methods that can be adopted have described. In order to address this issue a focussed programme for development of drought tolerance was initiated in *G. hirsutum*. The process revolved around screening, identification and effecting crosses to incorporate the drought features of the donors into the existing breeding gene pool. Considering the holistic approach viz., physiological, biochemical and yield per se,has resulted in evolution of a new spectrum of drought tolerant cultivars better adapted to water deficit regions. These cultures were specially designated as DTS cultures. Many of the existing DTS cultures have outperformed the prevalent existing high yielding cultivars when subjected to drought situation. These cultures also exhibited stable expression across the years under drought situation. Classification of these drought tolerant cultures as per their performance at different phenological stages could make them more adaptive for specific soil and rainfall pattern. Special emphasis for breeding for drought tolerance under target environment could lead to development of genotypes for specific drought situations. In view of the anticipated climate change process these cultivars bred for abiotic stress tolerance could play a pivotal role in catering to the specific environmental hazard.

## 8. DEVELOPMENT OF COTTON MUTANT LINES TOLERANT TO *Verticillium dahlia Kleb*AND SOIL DROUGHT

**Khalmanov Bakhtiyor Abdurashidovich[1], Glukhova Lyudmila Aleksandrovna[2]and Muminov Kakhramon[3]**

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Researches on creation of cotton mutant lines tolerant to *Verticillium dahlia Kleb* and soil drought are important. Because, every year farmers meet theses difficulties in many cotton growing countries.

The present researches are implemented under the frame of the National Project UZB 5005 “Development of cotton mutant lines tolerant to disease, drought and salinity” of TCD/IAEA/Vienna/Austria and conducted under the different soil and climatic conditions of Uzbekistan taking into account of aboitic and biotic stresses existence.

In 2007, four medium staple (*G.hirsutum L.*) varieties and three long staple (*G.barbadense L.*) varieties induced with the different doses of gamma rays at the Gamma Facility of the Nuclear Physics Institute of Academy of Sciences of the Republic of Uzbekistan. Among $M_2$ plants were selected several cotton mutant forms, which were superior then parental ones by the complex traits. In the following years they were subjected to the multiple selection under the concrete stresses condition. The first year researches have been conducted under the naturally wilt infested areas. Since 2008 the $M_2$, $M_3$ and $M_4$ lines were tested for soil drought taking into account less water holding capacity of soil.

Studying for tolerances of cotton mutant accessions to the main cotton pathogens of $M_6$ and $M_7$ have been investigated under the naturally infested fields for *Verticillium dahlia Kleb* $M_6$ generation were studied under the greenhouse conditions. *Verticillium dahlia Kleb*stamps were taken from the Institute of Genetics and Experimental plant biology (IGEPB) under the Academy of Sciences.

In 2013, two mutant lines were given (MT-70 and MT-71) to the small stationary testing plot of CBSPARI. Both the mutant lines were superior by the complex traits concerning to the standard cotton cultivars (C-6524 and Namangan-77) which registered to the Tashkent province.

At present in 2014, MT-70 as a medium staple cotton variety C-2530 is cultivating at 8 hectares in "Surkhan" experimental plot, Djarkurgan district, Surkhandarya province.

## 9. INTROGRESSION OF DESIRABLE CHARACTERS FOR GROWING COTTON IN CLCuV PRONE AREAS

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Cotton crop faces both biotic and abiotic stresses. Keeping in view the emerging problems of cotton in Pakistan, a breeding programme was initiated to develop cotton varieties which can withstand under changing environment especially at high temperature and Cotton leaf curl virus (CLCuV) conducive conditions. A series of experiments were conducted to select parental lines, which can contribute for high temperature tolerance, low input requirements, earliness, good fibre quality traits, CLCuV tolerance and plants suitable for high density planting. A comprehensive crossing programme was initiated to combine desirable characters in resulting breeding material. Screening of breeding material was carried out in CLCuV hot spot areas. During selection in early segregating generations fibre quality, earliness and high yield were also taken in consideration. For low input requirement varieties like FH-113 and FH-942 were developed. For heat and CLCuV tolerance 24 Lines were developed. Some of the lines like MNH-886, FH-142 and MNH-456 showed promising results in this respect. For high density planting of cotton, the line FH-114 showed good performance at densities of 10,0000 plants per hectare. It was recommended that for late sowing of cotton, plant-to-plant distance of FH-114 may be reduced to 12cm to achieve maximum possible yield per unit area. The varieties developed during this programme exhibited the highest yield with good fibre quality in CLCuV hit areas. The high seed cotton yield in these lines becomes possible due to introduction of tolerance to CLCuV. It is expected that in future more improved *germplasm* with improved characters will be available which will enhance the productivity of cotton in Pakistan.

# 10. BREEDING OF COTTON HYBRIDS WITH HIGH (+) - GOSSYPOL IN SEEDS

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It is known that using of cottonseed as a feed for animals is limited by the presence of gossypol. Gossypol helps protect the plant from pests. However, most researches toward breeding of cotton varieties without gossypol were unsuccessfully due to susceptibility of them to insects.

Gossypol occurs in two stereoenantiomers referred to as (+)- and (-)-gossypol (Jaroszewski et al., 1992). Most of the toxicity of gossypol resides in the (-)-enantiomer (Wu et al., 1986).

To develop a cotton varieties with high (+)-gossypol in seeds combining high positive parameters of agronomic valuable traits we have initiated breeding program which was supported by a grant from the USDA, ARS under project No. CRDF Uzb2-31001-TA-08 and local project of QXA 8-119.

The objective of our research is to develop a cotton variety with a high percentage of (+)-gossypol and good agronomic and fiber qualities, tolerant to some insects and pathogens.

Research results showed that cotton progenies developed among the F7BC$_3$S$_1$-47-8-1-17 x S-6530 and F7BC$_3$S$_1$-47-8-1-17 x S-6532 with (+)- gossypol >90,0% were tolerant to *Rhizactonia saloni* with the respective susceptibility 1.23% and 5.63%.

It was determined comparative tolerances to *Helicoverpa armigera* such progenies as F$_5$BC3S1-47-8-1-17x S-6532, F$_5$BC3S1-47-8-1-17x S-6524, F$_5$BC3S1-1-6-3-15x S-6530, F$_5$BC3S1-1-6-3-15x S-6532, F$_7$BC3S1-1-6-3-15x S-6524, F$_7$BC3S1-47-8-1-17x S-6524, F$_7$BC3S1-1-6-3-15x S-6530 with the respective susceptibility 1.0%, 2.0%, 2.5%, 2.5%, 3.5%, 4.0% and 4.5%.

The obtained dates confirmed that selected progenies with a high level of (+)-gossypol in seeds has high agronomic traits such as early maturity, weight of one boll and 1000 seeds, fiber turnout and length. As results of conducted researches it was developed some cotton breeding materials such as S-7300, S-7301, L-7302, L-7303 and different progenies that exhibit the high (+)-gossypol trait in seeds, good agronomic traits and fiber properties, which are tolerant to some diseases.

Thus on the base of research results it may be concluded effectiveness of cotton breeding program for high level of (+)-gossypol in seeds combining high positive parameters of agronomic valuable traits

## 11. EFFECTIVENESS OF INTERSPECIFIC HYBRIDIZATION OF COTTON TO IMPROVE SOME AGRONOMIC TRAITS

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An actual problem of modern cotton genetics and breeding is using of different hybridization methods. Intraspecific hybridization is one of leading methods of reaching genetic improving of cotton varieties. However, for increasing of cotton production it necessary to develop cotton varieties which has early maturity, high yield, good fiber quality, as well as tolerance to diseases, pests, and stress factors. Therefore, it is necessary to increase the genetic variability of agronomic traits of cotton, by involving wild and semi wild species.

In the laboratory "Cotton Genetics and Cytology" of The Cotton Breeding, Seed Production and Agrotechnologies Research Institute for many years conducting researches to identify effectiveness of different intra- and interspecific hybrid methods. By crossing of genetically different initial forms and investigation of genetic aspects at segregation progenies of composite intraspecific cotton hybrids developed genetically enriched breeding material with high levels of complex agronomic traits.

The objective ofthisstudy wasto report of results ofbreeding methods usedby scientists in this laboratory.

It was shown effectiveness of interspecific hybridization by using of such composite hybrids as $F_{1}$(*G.thurberi* Tod. x *G. raimondii* Ulbr.) x G. hirsutum L., $Ғ_0$($Ғ_1$K-28 $Ғ_1$G.thurberiTod. x G. raimondii Ulbr. x G.arboreum L.) x S-4727 (G. hirsutum L.), $Ғ_0$($Ғ_1$ K-28 $F_1$G.thurberiTod. x G. raimondii Ulbr. x G.arboreum L.) x S-6524 (G. hirsutum L.). Particularly, were developed:

-by participant 3 cotton species cotton varieties Sulton, Jarkurgan, S- 7276, S-7277;
- by 4-5 specific and backcross hybridization introgressive lines- L-578/07, L-578/07 L-485/07; L-534/07; L-485/07, L-578/07, L-534-/07, L-485/07.

Thus, it was shown effectiveness of interspecific hybridization due using of amphidiploids for practical cotton breeding.

## 12. EFFECTIVENESS OF CONVERGENT HYBRIDIZATION IN COTTON BREEDING

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In practical breeding developed many unique cotton varieties by using of widespread hybridization methods. However, some commercial cotton varieties do not meet the requirements of agriculture and the textile industry. This requires a combination of a new genotype of positive attributes of different accessions from the gene pool of cotton using various hybridization techniques.

Nowadays, one of the main objectives is to provide a selection of new early maturing, high yielding, quality fibers cotton varieties.

For many years in breeding of grain crops, various methods of convergent hybridization are widely used. Convergent method used to incorporate genes controlling several traits and fixing these genes in genotypes commercial cultivars. This method contributes to a more favorable hybridization gene recombination controlled traits that an effective approach to the transfer of donor properties of the parents to recurrent varietes.

In the laboratory of "Cotton Genetics and Cytology" of Cotton Breeding, Seed Production and Agrotechnologies Research Institute, conducted breeding of cotton by using convergent hybridization for the first time. Conducted preliminary researches on study of the genetics of quantitative traits of convergent hybrids synthesized on the basis of transgressive recombination under local projects. There are developed such cotton lines as KS-1/05, KS-1/08; KS-1/18; KS-1/35; KS-1/51; KS-1/77 which has high yield and fiber quality, productivity, which are also has disease and pest tolerances.

On the base of research results it is concluded effectiveness of convergent hybridization and best cotton lines recommended for the practical cotton breeding.

## 13. SUPPRESSION SUBTRACTIVE HYBRIDIZATION (SSH) TO IDENTIFY DIFFERENTIALLY EXPRESSED GENES DURING FIBRE DEVELOPMENT IN DIPOID COTTON (*Gossypium spp.*).

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Cotton fibre is the most prevalent natural raw material used in the textile industry and it serves as one of the mainstays for the global economy with more than 50% share of raw material supply. Fibre development consists of four overlapping stages viz. initiation, elongation, secondary cell wall biosynthesis, and maturation that are defined on the basis of the number of days post-anthesis (dpa). These differentiation processes, which typically last at least 60 days, directly determine cotton fibre quality characteristics. The goal of this work was to identify differentially expressed genes at two different stages during cotton fibre development i.e. 0 dpa and 10 dpa. The techniques, suppression substractive hybridization (SSH) and qRT-PCR were followed using the isogenics representing *FL* (Fuzzy linted) and *Fl* (Fuzzy-lintless) linesof *G.arboreum*. The scanning electron microscopy (SEM) revealed no difference in the fibre initials except for the fuzz development in *Fl* (Fuzzy-lintless) line which is due to the down-regulation of the some genes necessary for the fibre development. In SSH, based on the putative functions of genes preferentially or specifically expressed in fibre elongation stage in cotton fibre development BLAST results showed that many novel genes were contained in forward library and a few had been previously reported. On the basis of previous reports and the putative functions of the genes which are involved in fibre development and how those genes regulate fibre growth were reported in the database. This include actin depolymerizing factor 2 (ACT2), acyl- oxidase 1 (ACO1), beta-galactosidase (β-galactosidase) from Ricinus communis. There were contigs showing the homology to the beta-glucanase (β-glucanase), β-ketoacyl-Coa synthase family protein, beta-tubulin 19 (β-tubulin 19), elongation factor 1 (EF1), glucose-6-phosphate 1-epimerase, malate dehydrogenase, xyloglucan endotransglucosylase hydrolase protein 32 (XTH32/XET32). Genes like calcineurin b-like protein (CBL), calmodulin binding (CaM), mitogen-activated protein kinase 16 (MAPK/ MPK16), diacylglycerol acyltransferase (ACY) Phospholipase-C (PLC), phosphatidylcholine transferases (PCY), Phospholipase-C (PLC) were also found in the database and attempt was made for some of this genes to validate by the Quantitave real-time PCR which confirmed the chance of the undergrowth of the fibre in the *Fl* line. Comparative analysis fibre specific genes between tetraploid and diploid cotton is made to specify genomic location of these genes.

## 14. Tak Fa 86-5: GREEN-STAPLE COTTON CULTIVAR

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Cotton improvement for natural-color fiber is not only adding value to fiber product, but is also environmental friendly in reducing nature pollution from a dying process. Thus in 2000, the long stable (fiber or lint) Takfa 2 cotton was crossed a green-short staple cotton variety; thereafter (2001-2002), backcrossing to Takfa 2 and selection for good green-lint yielding cotton plants for four generations was made. In each backcrossing, seed (after ginning or separation from seed cotton) was collected in bulk from individual green- lint cotton plants exhibiting the plant type of Takfa 2. The seeds of $BC_4F_1$ were then sown in 2003, plants with green fiber or lint were selected and their seeds were used for planting as $BC_4F_2$ in 2004 for pedigree method of selection. From all planted $BC_4F_2$ plants, 574 plants were individually selected from this generation. Then 574 families of $BC_4F_3$ seeds or lines were used for further planting for selection (in the plant-to-row pattern) in 2005.

Two hundred and eight green-lint yielding rows with the plant type or canopy similar to Takfa 2 were selected, in which 675 plants were selected for fiber quality examination. Sixty-six plants (from 30 rows) had a standard fiber quality with the average of 24% ginning out turn fiber percentage), 1.24-inch fiber length, 18.3 g $tex^{-1}$ fiber strength, 47 uniformity and 0.9 micronaire fiber fineness. In 2006, seeds of 66 selected plants were then planted as 66 rows (plant-to-row) and 96 rows (boll-to-row) of $BC_4F_4$ families or lines. Only 27 rows or lines with good plant type uniformity were selected. The bulk-collected seeds of 27 individual lines were planted as $BC_4F_5$ lines in 2007. Only 20 lines with good uniformity green-lint yield and plant type were selected their mean fiber qualities were 24% ginning out turn, 1.24 inch fiber length, 23 g $tex^{-1}$ fiber strength, 49 uniformity and 2.0 micronaire fiber fineness. The lines with uniformity in good plant type and green fiber quality were evaluated for yield potential in 2008-2011. The promising, Tak Fa 86-5 was a selection as outstanding in green-stable quality, high yield and leaf roll disease resistance.

## 15. EXPLOITATION OF HETEROTIC GROUP THROUGH RECIPROCAL SELECTION FOR COMBINING ABILITY IN COTTON (*Gossypium hirsutm* L.)

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Exploitation of heterosis through hybrids has led to improvement in productivity of both selfand cross pollinated crops. In cross pollinated crops hybrid breeding program is supported by population improvement schemes aimed at improving combining ability. There are very few studies on grouping genotypes based on heterotic pattern and exploiting them in self pollinated crops. At Dharwad, efforts are made to constantly observe most potential crosses and understand the basis of complementationcausing high heterosis. These efforts have lead to formation of different heterotic groups like Stay green x Compact, Robust x Compact, Robust x Higher RGR and Stay green x high RGR which in general give potential hybrids.Further efforts are alsomade to identify elite combiners within each group and utilize this knowledge to exploit these groups by Patil (2013).

In an attempt to exploit these diverse heterotic groups, attempts are made to enhance genetic distance between opposite heteroticpopulations following modified reciprocal recurrent selection scheme between opposite populations. The main objectives of the present study were framed on creation of recombinational variability for combining ability and assess the nature and magnitudes of variability released for combining ability in $F_4$ generations and explore possibility of improving combining ability as a trait in developing better hybrids.

The experimental material was constituted by a HeteroticBox involving two diverse single cross $F_1$s *viz* DSC-7x DSC-68 from compact heterotic group and DSMR-10 x DSG3-5 from robust and stay green heterotic group which were identified as base populations through the principal of predicted double cross performance.. These crosses were advanced to $F_4$ generation and seventy four lines of DSC-7 x DSC-68 and thirty seven lines of DSMR-10 x DSG3-5 were randomly selected and were utilized in this study on reciprocal selection for combining ability. The crosses involving the $F_4$ lines with opposite testers were referred to as derived $F_1$s. These derived $F_1$s were compared with commercial check as well as bench mark cross. Ten elite combiner lines of compact cross DSC-7x DSC-68 were identified based on performance of their derived F1s involving reciprocal testers *viz*., DSMR-10 and DSG3-5. Similarly ten elite combiner $F_4$ lines of Robust stay green group of DSMR-10 x DSG3-5 were identified as the top ten combiners.

The derived $F_1$s of these lines were very productive and superior to commercial check, Mallika and superior bench mark crosses. Attempt is made to cross these 10 elite lineseach from opposite heterotic groups as the crosses resulting in this manner are genetically expected to be potential because of increase in the genetic distance between them. The genetic basis of transgressive segregation for combining ability is explained. The nature and magnitude of variability for combining ability is assessed for each testers and compared.

## 16. COTTON BREEDING AND ITS IMPROVEMENT IN GUDDU BARRAGE AREA GHOTKI SINDH PAKISTAN

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Ghotki is important Cotton growing area its production was maximum in upper sindh. Guddu Barrage area is quite distinct from other parts of sindh and characterized by very high temperature (50˚C) salinity, rison water table and humidity during the cotton growing season. High potential varieties K-86/9 & Shaheen of this area were eliminated due to CLCV disease. Reversal trend was observed in the cotton production during the year 1996 due to severe outbreak of CLCV in upper sindh. The production of cotton was decreased per acre gradually. All though the damage of CLCV minimize the yield but as a result of development of New CLCV tolerant strains viz: GH-106, GH-110, GH-111, GH-115, GH-116, GH-117, GH-118, GH-119 and Bt. Strains GH-140 to GH-155 has improved the yield per acre of seed cotton under this climatic conditions. It is hope that the commercial cultivation of the new approved varieties from the above promising strains in future contribute to the overall increase in the per acre yield of cotton production as well as to earn more foreign exchange through export of raw cotton with better quality characteristics.

## 17. CHINESE TECHNOLOGY FOR LONG-STAPLE HYBRID COTTON AND THE FEASIBILITY OF ITS APPLICATION IN ASIAN COTTON PRODUCING COUNTRIES

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The author has long engaged in breeding long-staple hybrid cotton and high yield production technology in China. The paper introduces the characteristics of Chinese varieties of long-staple hybrid cotton; the drought-resistant water-saving cultivation technology for high quality and high yield which is widely applied in Xinjiang

Autonomous Region, China; and, the result of these variety tests in Yunnan Province of China and Myanmar. Then, the paper analyses the main reasons for the low yield of cotton in Asian cotton producing countries. Based on this, it explores the feasibility of applying Chinese varieties of long-staple hybrid cotton and the drought-resistant water-saving cultivation technology for high quality and high yield in Asian cotton producing countries. The conclusion is that the technology is adoptable to Asian cotton producing countries and of great economic value.

## 18. REVISING CONVENTIONAL BREEDING APPROACHES FOR CHANGING NEEDS OF COTTON

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During Bt era in cotton over 90% of Indian continent is under hybrids and there is need for enhancing genetic diversity for maximizing heterosis. The pattern of complementation for plant features has given rise to Robust versus Compact groups. The stay green types combine well better with high RGR types, compacts and types with high harvest index (HI), based on this information opposite heterotic groups are defined. The genetic diversity seen between plant type groups robust and compacts, Stay Green and High RGR types etc., are utilized in forming heterotic groups. The principle of identifying heterotic box involving two elite combiners of each group and exploiting recombinational variability for combining ability in segregating $F_4$ lines and deployed in reciprocal selection for combining ability are discussed. Progress of work on developing broad based populations is given rise to very useful Heterotic populations that are ready for sharing and exploitation among cotton breeders.

In varietal development, segregating generations derived from hybridization reveal high proportion of plants containing nearly 50:50 proportion of alleles from the two parents. If the two parents share equal proportion of desirable alleles or yield components (roughly) between them, Pedigree/Bulk/SSD methods are ideal choice of breeding methods When wild species with bad genetic back ground are used for transferring simply inherited characters the target genotype becomes 98:2 or 99:1 and the back cross breeding increase the frequency of 98:2 types. If there is unequal distribution of desirable alleles (yield traits) between the parents say then the target genotype may be 70:30 or 80:20 and hence these three methods of varietal improvement are not appropriate because the frequency of 70:30 or 80:20 is considerably reduced in segregating generations. This explains why at times these methods fail to give desired success as the target genotype is not correctly understood and a wrong approach is followed. It is necessary to understand what is the pattern of distribution of desirable alleles between the parents chosen for hybridization as this determines the target genotype sought to be developed from the combination of parents hybridized. Attempt is made to explain how limited back cross method of breeding will be helpful in such cases to increase the frequency of say 70:30 to 80 :20 types in limited back cross derived populations. Determining target genotype is possible by comparing $F_2$ with the two backcross populations B1 and B2 for potentiality and frequency of transgressive segregants . The results of such studies and the inferences

derived on handling segregating generations by maximizing frequency of target genotype are discussed.

Revisiting wild species for importing genes for stable restoration of CGMS system, resistance to pests and diseases threatening cotton cultivation, enhancing drought tolerance to meet the challenges of climate change fibre quality etc., is necessary. Breeding options available for such objectives are discussed.

Excessive focus on hybrids has led to exploitation of loci showing high degree of dominance and reduction in emphasis on exploiting loci showing additive gene action to complete dominance. Emphasis on developing compact variety under high density planting and the breeding efforts need on fulfilling this requirement are discussed.

## 19. THE EFFICIENCY OF INTRASPECIFIC HYBRIDIZATION IN COTTON BREEDING

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It is known that using the cotton selection methods of cotton plant and improving them, conducting of selection works by focusing on the achievements of science, effectively employing of exist any cotton plant's wild and cultured species of transferring of wild species unequal traits on cultivating species and getting genetically enriched intra-species, unequal hybrids and also carrying out complex researches on them are important in developing the new cotton plant varieties.

Interspecific hybridization is being one of the progressive methods in the cotton plant selection and possibility of transferring of valuable traits existing in the cotton plants wild and semi wild species through interspecific hybridization on cultivated species genomes have been proved well in the practices of the world. In the result of number sous years have been elaborated synthesis of cotton plants polygenome hybrids, getting over the sterility occurring on the hybrids and the transfering ways of unique traits of the wild and semi wild species on the genomes of cultivated species picked out genetically enriched, unique recombinants and even brought to variety states. This work is the indissoluble lasting of above comments and have been analyzed on the basis of data of complicated and backcross hybridization as the efficient method with the participation of several cotton plant species possessing the different genome structures.

## 20. PRE-BREEDING APPROACHES FOR GENETIC IMPROVEMENT OF YIELD AND FIBER QUALITY TRAITS IN*Gossypium hirsutm*UNDER RAINFED SITUATION

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Many germplasm accessions have been accumulated over the years in our National gene bank for all the four species in CICR, Nagpur.In order to support and also exclusively deal with unused *G.hirsutum* germplasm, an ambitious programme on 'pre breeding" was initiated by introducing available trait specific genepool in our working collections. Initially in 2002, 7 trait specific donors for boll weight and GOT (%) were incorporated in 10 selective existing elite cultivars from three cotton growing zones of India (North,Central and South). The methodology adopted was (1) Incorporation (2) Backcross. Single crosses followed by intermating of selective F1s was adopted to incorporate specific traits .Inbred backcross method was used in developing improved backcross lines. Fifty six improved lines have been generated in F8 generation. Productivity was expressed in terms of high boll no. upto 35-40 bolls perplant and seed cotton yield of 2000 kg/ha was recorded.Trait specific improvement in advanced backcross improved lines was noted in PKV-081 and H-777 for boll weight (3.8 g) from an initial base value of 2.9 g; GOT( %) in case of Rajat from an initial value of 35% to 41 %; Staple length ( 27 mm) from an initial base value of (23 mm) in case of RS 810 , a north zone cultivar and seed cotton yield in PKV-081 upto 2200 kg/ha.Interestingly in the sixth cycle of advanced generation of intermating lines ,high productive lines with large boll weight upto 4.7 g have been evolved.Fibre strength upto 23.8 g/tex and staple length upto 30 mm have been recorded . Also in 2004, a set of crosses were developed involving new donors to broaden the genetic base.These are in F6 stage and a big boll weight line upto 5 g has been identified in which LRA-5166 has been the female parent which was once a popular variety in the non-Bt era. Also LRA-5166 has been made sucking pest free and more productive.Thus these material holds promise for further use in breeding programme in rainfed situation.Presently ideal plant types are being explored in germplasm through prebreeding.

## 21. GENETIC RESOURCES OF *Gossypium*

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Plant genetic resources are the foundation and basic material of any crop improvement program. Central Institute for Cotton Research, Nagpur, Maharashtra (India) holds a rich repository of geographically and genetically diverse cotton germplasm with 11345 accessions belonging to four cultivated species of *Gossypium* (*Gossypium hirsutum* - 8265), (*Gossypium barbadense* - 305), (*Gossypium arboreum* - 1936) and (*Gossypium herbaceum* - 565) besides a number of races Hirsutum – 7, Barbadense – 1, Arboreum – 6 and Herbaceum – 1, Wild species – 26, Interspecific Derivatives – 40 and land races and perennials – 193.

The above gene pool is conserved in short, medium and long term cold storage at CICR, Nagpur and also at National Bureau of Plant Genetic Resources, New Delhi. As a result of continuous evaluation and collection of new genetic material from within the country and abroad, the current germplasm repository has been broadened in its genetic base to a very significant extent. Seven thousand one hundred eighty five (7185) accessions were evaluated under multilocation evaluation trial of germplasm at three locations viz., North Zone – Sirsa (Irrigated), Central zone – Nagpur (Rainfed) and South Zone – Coimbatore (Irrigated) for major economic characteristics. 119 elite germplasm accessions were identified for individual traits viz., Seed cotton yield, Boll weight, Ginning outturn, Fibre length and Fibre strength for utilization in breeding programme.

The 40 unique genetic stocks (*G.hirsutum*-24, *G.arboreum*-10 and Introgressed derivatives-6) coupled with novel traits were registered with NBPGR, New Delhi during 2009-2013 to protect the sovereignty of cotton genetic stock resources in the country.

## 22. GENETIC DIVERSITY AND UTILIZATION OF THE WILD COTTON GERMPLASM

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Conservation of wild germplasm along with other genetic stocks forms an integral part of a meaningful breeding strategy in cotton improvement. Effective transfer of desirable and important genes from wild relatives into the cultivated background is a potential way of conservation as this can circumvent the problem of genetic erosion. The continuous improvement of cultivars to meet the demand of a more profitable cotton farming and even changing needs of the textile industry can be achieved through the careful use of these delicate genetic resources. The species of both diploid and tetraploid cotton provide the most intriguing but difficult sources of genetic variability for cotton variety improvement. Difficulties in the use of species arise from chromosome structural differences and differences in chromosome complements between wild diploids and the tetraploids. Fertility relationship among the species are highly variable and only about two thirds of the interspecific hybrids produce fertile $F_1$'s. Even though interspecific hybridization presents considerable problems, its use offers intriguing possibilities.

In Gossypium, out of the 50 known species, 4 are cultivated and remaining 46 are all wild. The wild species form an important reservoir of genetic variability for various economic characters such as disease and insect resistance, tolerance to abiotic stress, increased biomass etc. Several barriers, which operate at various levels, prevent the successful gene transfer from wild to cultivated species. Several pre-zygotic and post – zygotic barriers are known to limit the production of hybrids between distantly related species. So far, it is the species from the primary and secondary gene pool which have been utilized in direct hybridization while the use of species from the tertiary gene pool has been very limited owing to their low level of genetic recombination. At CICR, Nagpur; out of the conserved 26 wild species, 14 species have been successfully utilized in introgression breeding programmes. More than 400 introgressed derivatives with improved fibre properties have been developed. At the molecular level, isolation of DNA from cotton which is high in secondary isolated compound sometimes is problematic and the yield of DNA is often low and the quality can be poor. A modified rapid method for extraction of DNA from the wild species of Gossypium was also standardized while working with SSR markers for genetic diversity among wild species and introgressed derivatives. Pre-breeding efforts have been strengthened and species from tertiary gene pools have been utilized to develop mapping populations for traits like fibre strength and fibre fineness. Six introgressed genotypes were registered as genetic stocks with the National Bureau of Plant Genetic Resources located at New Delhi. Thus, use of wild species has lead to the development of promising elite cultivars enriched with rare useful genes.

## C. CROP MANAGEMENT FOR HIGHER PRODUCTIVITY

### 23. PERFORMANCE OF COTTON UNDER AONLA BASED MULTISTORIED AGROFORESTRY SYSTEM IN TERRACE ECOSYSTEM OF BANGLADESH

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The study was conducted at the Bangabandhu Sheikh Mujibur Rahman Agricultural University experimental farm from December 2008 to April 2011 to know the morphological behavior, yield and yield contributing characters of cotton variety on multistoried agroforestry system in the terrace ecosystem of Bangladesh. Experiments were carried out in ten years old aonla orchard, which was considered as upperstorey crop, while two minor fruits namely carambola and lemon were used as middlestorey crop. Cotton varieties were used as lowerstoried crop. Three cotton varieties ($V_1$ =CB 9, $V_2$ = CB 10 and $V_3$ = CB 11) were tested following Randomized Complete Block Design (RCBD) with three replications. Three different combinations were $T_1$ = Aonla only, $T_2$ = Aonla + Middlestoried tree species (Carambola and Lemon), and $T_3$ = Open Field (control). Among the cotton varieties (CB 9, CB 10 and CB 11) most of the yield and yield contributing characters i.e., sympodial branch, number of boll per plant, weight of single boll, and yield were influenced significantly by the combined effects of trees and varieties. The CB 10 produced the maximum number of sympodial branches per plant at all agroforestry systems and open field condition in both the cropping seasons. The longest duration was recorded in $T_2V_1$ and the shortest duration was found in $T_3V_2$. The maximum number of bolls per plant and seed cotton yield was observed in CB 10 variety at open field condition ($T_3V_2$) in the both cropping seasons, whereas the minimum number of bolls per plant and the lowest seed cotton yield was recorded in $T_2V_3$ treatment in both the growing seasons produced the highest GOT and the maximum PSI were found at cotton variety CB 10 at all agroforestry systems and open field condition in both the

cropping seasons. Therefore, Cotton variety (CB 10) would be cultivated in aonla based multistoried agroforestry system for terrace ecosystem of Bangladesh to have better production and additional income.

Key words: Cotton and Agroforestry systems

## 24. EFFECT OF PLANTING PATTERN ON THE PRODUCTIVITY OF COTTON+MUNGBEAN INTERCROPPING SYSTEMS

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The cropping intensity in the high and medium high lands of Bangladesh are maximum, where cotton crops has been facing competition with other high value crops. Intercropping is an important strategy to increase the domestic production as well as maximize the benefit from cotton production. Intercropping cotton with mungbean will be a best option for increasing productivity and profitability from cotton cultivation. The appropriate spatial and temporal arrangements in cotton+mungbean intercropping systems therefore need to be determined. To achieve the objectives two experiments were conducted during 2009-2010 and 2010-2011 cropping season at the Cotton Research Farm, Sreepur, Gazipur. Both the experiments were laid out in RCBD with three replications. Cotton variety CB-10 and mungbean variety BU mung-4 were used as test crop. Performance of eight different spatial arrangements, such as 1, 2, 3 and 4 rows of mungbean in between single row of cotton and 4, 5, 6 and 7 rows of mungbean in between paired row cotton were compared against sole single and paired row cotton and sole mungbean in the first experiment. In the second experiment, five relative sowing dates i.e. mungbean sown 15 and 30 days before and after cotton sown and simultaneously sown were assessed against their sole cropping.

Increasing mungbean density between cotton rows decreased the plant height and dry matter accumulation in cotton, while that was reverse in mungbean. Cotton and mungbean under sole cropping was more efficient in light utilization and photosynthetic ability with higher LAI, CGR and RGR compared to intercropped condition. Density of component crops in intercropping system reduced individual yield of cotton and mungbean compared to their sole cropping but increased equivalent yield of both cotton and mungbean. The highest seed cotton (2951 kg $ha^{-1}$) and mungbean (3373 kg $ha^{-1}$) equivalent yield was recorded from the spatial arrangement of paired row cotton+4-row mungbean. The land equivalent ratio (LER) of the same combination indicated 31% yield advantage over sole cropping. Also the highest gross return (118039 Tk $ha^{-1}$), net return (60220 Tk $ha^{-1}$) and BCR (2.04) were recorded from the same pattern. Positive values of monetary advantage index (MAI) showed yield advantage of cotton+mungbean intercropping system and the highest value (27670) was achieved from paired row cotton+4-row mungbean. Higher values of relative crowding coefficient (RCC) of cotton than mungbean indicated that cotton was more competitive and dominant over mungbean in cotton+mungbean intercropping system.

Relative sowing dates of mungbean in cotton+mungbean intercropping system affected growth attributes and photosynthetic ability of both cotton and mungbean. Cotton under the treatment of simultaneous sowing and mungbean sown 15 and 30 days after cotton showed better performance compared to mungbean sown 15 and 30 days before cotton, but it was opposite in case of mungbean. Both cotton and mungbean as sole crop showed better performance compared to intercrop condition in growth attributes and photosynthetic ability. Relative sowing dates of mungbean in intercropping system decreased both cotton and mungbean individual yield than sole cropping. Under intercropping higher seed cotton yield was recorded when cotton and mungbean was sown simultaneously and mungbean sown after cotton but reduced in the treatments when mungbean sown before cotton. Land equivalent ratio (LER) and monetary advantage index (MAI) showed an advantage in intercropping under simultaneous and mungbean sown after cotton, but disadvantage at mungbean sown before cotton. The highest LER (1.22), MAI (23380), seed cotton equivalent yield (2199kg $ha^{-1}$) and mungbean equivalent yield (2095kg $ha^{-1}$) was obtained from simultaneous sowing. Higher relative crowding coefficient (RCC), competitive ratio (CR) and positive aggressivity (A) showed dominancy of cotton over mungbean at simultaneous sowing and mungbean sown after cotton, while mungbean become more dominant when it was sown before cotton. The highest RCC (5.01) from simultaneous sowing determined more competitive and dominance over all the treatments. The highest gross return (131965 Tk $ha^{-1}$), net return (71830 Tk $ha^{-1}$) and BCR (2.19) were recorded from simultaneous sowing. Considering intercrop productivity, efficiency and competition indices, it was concluded that paired row cotton+4-row mungbean sown simultaneously could be the best combination among all other arrangements.

## 25. PROFITABILITY, INPUT USE EFFICIENCY OF TRANSGENIC Bt COTTON INTERCROPPING

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Novel intercropping systems were tested in different soil and climates across India during 2004-2011 in hybrid cotton to improve the profitability on *insitu* rain water conservation, pest and nutrient management. Four fertilizer management practices and two inter plant spacings in seven intercropping systems were evaluated in split plot design during 2010, 2011 seasons in Vertisols at Central institute for Cotton Research, Nagpur, India. Present *refugea* recommendation of pigeon pea stripcropping in determinate Bt hybrid cotton (2:8) reduced Bt hybrid cotton yield by 69%, therefore rejected by farmers, instead of it, *Tagetus sp*. or *Dolichus lab lab* are advocated as *refugea* with economic advantage of US $ 600 $ha^{-1}$ with C:B ratio of 1:2.8. Roselle or soybean intercropped with Bt hybrid cotton alongwith conservation furrow double the profitability of US $768 and 662 $ha^{-1}$ with a C:B ratio of 1:3.7 and 1:3.0 compared to US $ 350 only with C:B ratio of 1: 2.5 in sole Bt hybrid cotton despite of aberrant weather conditions. Hybrid cotton Bt or non Bt needs only 90:20:37 kg N:P:K $ha^{-1}$instead of higher recommended dose 113:24:47 kg N:P:K $ha^{-1}$ advised for Bt hybrid with cotton. Additional 14:13:0 N:P:K kg $ha^{-1}$is required wherever cotton is intercropped soybean. Any nutrient deficiencies arising out of abnormal weather or sub optimal fertilizer applications need to be corrected with two foliar sprays of 2% urea + 0.2% Mg + 0.06% soluble Boron at 45-60 days. Intercropped soybean and roselle with Bt hybrid cotton significantly improved nutrient uptake and fertilizer use efficiency. Incessant rains and extended monsoon, permits extended weed growth. Continuous application of pendimethalin pre plant incorporation or layby application and pyrithiobac as early post emergence spray resulted in some weeds population that were difficult to control under such a situation spray of glyphosate and graminicides respectively besides two late interculture operations and one hand weeding is effective and improves the efficiency inputs.

## 26. COTTON CULTIVATION IN RICE FALLOW IN SUNDARBANS IN WEST BENGAL (INDIA)-PROBLEMS AND PROSPECTS

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The southern coastal region of West Bengal(India) is characterized by saline sandy loam and clay loamsoil with heavy rains known as Sundarbans has a geographic area of 0.9 million hectares and cultivable area of 0.4 million hectares. While rice is grown in the entire cultivable area during June-December, it remains largely fallow during December-May due to limited irrigational potential and lack of knowledge and technology for rice fallow crop production.

Agro climactic conditions of the region however afford scope for cultivation of a second crop after the harvest of rice.Several crops were tested and cotton with its deep tap root system was found to be most suitable.State government with aid from Central government launched cotton cultivation programme in the 1970's.Several farmers were attracted to the crop. However inadequacy in the choice of variety and the crop's vulnerability to bollwormcomplex**,** it got a setback

In the eighties and nineties Ramakrishna Mission Farm Science centre, Nimpeeth with the aid of state government and Sundarbans Development Board took up rice fallow cotton cultivation seriously which got a fillip when Cotton Corporation of India joined the programme with funds and expertise .I was involved then.

Technologies were fine-tuned.Short duration high yielding varieties H777, LRK516,LRA 5166 were shortlisted , spacing and fertilizer dose determined and appropriate pesticides to combat bollworms identified .Awareness programmes and training programmes to attract farmers and to guide them to get a good yield began in a big way in both mainland & islands of Sundarbans. The result was visible. From a small number of 120 farmers during 1983-84.It rose to 4387 during 1999-00.Currently more than 22000 farmers are growing cotton in rice fallows with direct sowing in mainland and transplanting and direct sowing in rice fallows in islands. Progressive farmers are harvesting 3 quintals of seed in a bigha, or 22 quintals/hectare, with a net profit of Rs 5000 per bigha or Rs 37,000 per hectare.

After testing in the research farm of Nimpeeth, two genotypes of University of Agricultural Sciences , Dharwad Karnataka namely PL 190 and 370 with a duration of 125 days and high yield have been identified .Technologies, particularly high density planting system with reduced spacing of 45 X 15 cm and higher fertilizer dose are being developed to maximize yield.

However with rain becoming scarce during rice fallow cotton crop period, availability of sweet water fro irrigation is a big challenge .The prospect of rice fallow cotton cultivation will largely depend on how we tackle this problem.

I had interactions with a large group of cotton farmers the other day and found them to be very enthusiastic to cultivate cotton.

The interest of farmers , technologies in place , harnessing sweet water and the commitment of Cotton Corporation of India to purchase the cotton at remunerative prices , will it is hoped go a long way in promoting rice fallow cottons in Sundarbans and improve socio economic status of its farmers.

## 27. OPTIMIZING INPUT USE FOR ENHANCING PRODUCTIVITY AND ECONOMIC VIABILITY IN COTTON: PHYSIOLOGICAL APPROACH

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Cotton physiology has seen significant changes in last decade. These changes are more visible in terms of large scale cultivation of Bt cotton hybrids, emergence of physiological disorder like leaf reddening, parawilt and nutritional stress which adversely impact many aspects of the physiology of plant. Bt cotton hybrids are similar to non-Bt hybrids upto squaring. At early boll development Bt hybrids exhibit faster growth and higher photosynthesis over non-Bt because of a high demand for assimilates due to more synchronized boll development. Plants with higher boll load are the most sensitive to stresses (moisture) due to increased requirement for photosynthesis. Maintenance of positive carbon balance during stress is of significant importance to avoid yield penalty. Alternatively, manipulation of plant architecture using plant growth regulator can be physiological strategy for obtaining high yield in rainfed. Use of phenotyping screen to select genotype for abiotic stress tolerance from a large collection of cotton germplasm has been discussed. High-throughput phenotyping technologies will be particularly important for studies of drought and water-logging. These stresses are highly complex and require dissection of responses into a series of component traits. Information about the physiological changes in response to drought over time is vital in order to identify and characterize the different drought-tolerance mechanisms. Cotton will only continue to be produced if it is economically viable for farmer. However, an improvement is needed in understanding basic cotton physiology affected by different soils, plant population, and environments. Improving nutrient use efficiency is an essential pre-requisite for expansion of cotton crop production into marginal lands with low nutrient availability. Besides transgenic approach, screening of available germplasm, and induced mutants growing better at low input of nitrate and phosphate could be exploited. Additional research is needed to identify more indicators to select cotton cultivars with higher acclimation response to drought stress, heat stress, water-logging and salinity. Such plant types will be extremely important because they will dramatically increase the stability of

production in drought situations. Cotton physiology work at CICR has been reviewed in the context of current trends in cotton physiology in management and research.
Key Words: Cotton, physiology, drought tolerance, water-logging, phenotyping

## 28. COMPARATIVE STUDY OF VARIOUS WEEDING METHODS ON COTTON CROP UNDER BED-FURROW PLANTING TECHNIQUE IN PUNJAB, PAKISTAN

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Effective and economic weed control is essential as weeds are the most efficient users of resources due to their different kinds, intensity and fast growth habits. In bed-furrow cotton planting technique, application of irrigation for cotton seed germination, emergence and seedling growth, weeds germinate more in number and grow much faster than cotton. Studies were conducted in two consecutive years (2011 to 2013) to evaluate the effect of different weed control methods on weed intensity, seed cotton yield and its components. Treatments comprised pre-emergence sequence with Dual Gold 960EC (s-metolachlor @ 2.0 lit ha$^{-1}$), Panida Grande (Pendimethaline 43.5EC @ 2.0 lit ha$^{-1}$) and post emergence Glyphosate 490G/L @ 4.7 lit ha$^{-1}$, Dual Gold 960EC + Glyphosate 490G/L, Panida Grande + Glyphosate 490G/L, Mechanical inter-culturing, Manual weeding (thrice), Mechanical inter-culturing + Manual weeding and Untreated check. Treatments were arranged in randomized complete block design with four replications. Cotton cultivar CIM-499 was dibbled manually at experimental area of CCRI, Multan on silt loam soils. Results indicated that all chemical and mechanical weeding methods increased seed cotton yield and its components over untreated whether applied alone or in combination. Anyhow, combination of Panida Grande (pre-emergence) + Glyphosate (post-emergence) and Dual Gold + Glyphosate gave 113.7% and 120.5% increase in seed cotton yield over untreated respectively. Moreover, combination of mechanical (inter-culturing) + Manual (hand weeding once) gave maximum increase in yield i.e. 125% over untreated. All weeding methods mechanical or chemical gave significantly broad leaves and narrow leave weed control over untreated. Data recorded 60 days after planting showed that combination of pre- and post-emergence weedicide i.e. Panida Grande + Glyphosate gave 92.36 broad & 86.15% narrow leave weeds control and Dual Gold + Glyphosate showed 96.75 broad & 98.28% narrow leave weeds control over untreated. Moreover, Mechanical + Manual weeding (once within plants) at 60 days after planting provided 98.87 broad and 97.59% narrow leaves weed control over untreated, respectively.

## D. AGRONOMIC IMPROVEMENTS

# 29. SIMPLE HYDROPONIC VARIANT FOR SCREENING COTTON GENOTYPES FOR SALINITY TOLERANCE

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A simple, reusable, economic, reproducible and reliable laboratory hydroponic system was designed for screening a large number of cotton genotypes (about 300 genotypes/frame/tray in one go) for salinity tolerance. The wood used was the left out pieces of carpentary. The cost of one complete system (wooden frame and the plastic tray) was Rs. 325/-(USD 5.5 approx.). The system was arrived at by working through thermocole tray design, transparent glass design and thermocole glass design. The system consisted of double wooden frames holding a nylon net in between. The size of the wooden frame depended on the size of the plastic tray holding the nutrient solution. The frame was partitioned into six compartments, each compartment could hold fifty genotypes. Practically the system did not require air stones for aeration of the nutrient medium and the leaves themselves prevented the light penetration into the nutrient solution. The EC and pH of the solution was checked regularly and maintained by changing the solution every week. Six *arboreum* genotypes viz. LD 1026, LD 1027, LD 1019, LD 1037, LD 1029 and LD 949 along with RAHS-14 as check, were screened for salinity tolerance via four different hydroponic designs at EC 18 and 21 dS/m with ½ Hoagland medium as the nutrient supplement. The glass experiments and the thermocole tray design produced large variability in the survival percentage due to small sample size (4-6 seeds/replication) and often cross bred nature of cotton. However, the wooden frame design which could hold large sample size gave more accurate and repeatable results and hence the same is being recommended for hydroponic screening of cotton genotypes. In the final selected design, maximum survival percentage was observed with LD 949 (~40 %) followed by LD 1037 (~39.5%) and was least in LD 1019 (~4%) and LD 1029 (~5%) at 21 dS/m. The survival percentage of RAHS-14 was 35% at 21 dS/m. Based on the survival percentage data, LD 949 showed more salinity tolerance (at 21 dS/m) and LD 1037 was comparable to RAHS-14 for salinity tolerance at seedling stage under hydroponic conditions. As regards the growth parameters, the control samples of LD 949 at 15 DAG had longer root length (RL) and more root and shoot weights (RW, SW) than the check (LD 949: RL 17.0cm, SL 6.7cm, RW 0.07g, SW 0.55g; RAHS-14: RL 10.8cm, SL 6.0cm, RW 0.05g, SW 0.39g). However, the decrease in root length (0.55cm) and shoot weight (0.07g) in RAHS-14 in 21 dS/m at 15 DAG was less than in LD 949 (5.1cm, 0.28g respectively). The decrease in shoot length (2.8cm) and root weight (0.03g) was same (2.8cm) in both the genotypes. The selected hydroponic design proved very simple, economic, reusable, reproducible and easy to use.

## 30. *IN VITRO* SCREENING FOR SALT TOLERANCE IN COTTON

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Drought and high salinity are the two major environmental determinants of plant growth and productivity (mainly limits the fiber development). About 50 – 80 per cent of the maximum potential yield is lost by these "environment or abiotic stresses" which is approximately 10 times higher than the loss by biotic stresses. Among several activities, the development of abiotic stress tolerance in crop plants and the identification of salt tolerant genetic resources through screening is most important. Screening for salt tolerance under natural condition is difficult because of nonavailability of uniformly salt affected fields and also it is time consuming and labour intensive, which is reducing breeding efforts in improving salt tolerance in crop plants. Through *in vitro* technique it is possible to develop less labour intensive, short duration oriented and more efficient screening method for abiotic stresses by manipulating salt concentrations to induce salt stress.

A laboratory experiment was conducted during 2009-10 in the 'Tissue culture laboratory' of Agriculture Research Station, Dharwad Farm, University of Agricultural Sciences, Dharwad to study the effect of *in vitro* induction of salt stress on growth parameters, osmoprotectant and two enzymes belonging to the class of oxido-reductases in three cotton genotypes viz. Bikeneri Nerma, female parent of NHH44, a popular cotton hybrid for rain-fed situation, AC-738, male parent of same hybrid and Jayadhar, a diploid cotton cultivated under rain-fed conditions. The salinity stress was induced by incorporating different concentrations of salts to generate EC 0, 2, 4, 6, 8 and 12 referred to as $T_0$ to $T_5$, respectively. The experiment was laid out in completely randomised design with three replications. Reduction in seedlings fresh weight, shoot length, root weight, root length and root dry weight was significantly less in Bikaneri Nerma under salt stress as compared to Jayadhar and AC- 738. Salinity stress led to significant increase in proline content in shoots and roots of Bikaneri Nerma when compared to Jayadhar and AC-738. Bikaneri Nerma showed significantly increased Nitrate reductase (NRA) and Peroxidase (POD) in shoots from treatments $T_1$ to $T_{5,}$ whereas in roots the activities of NRA and POD increased up to $T_2$ and $T_3$ onwards the activities declined. The differential protein expression was studied by SDA-PAGE in all the three genotypes under control and at EC level of 6. The Bikaneri Nerma and Jaydhar genotypes found differentially producing protein under salt stress only. Polymorphic difference was also observed among the genotypes. The genotypes studied differed widely in their response to salinity exhibiting thereby that different genotypes may have different adaptation levels against salinity stress.The information generated from the present investigation reveals that the genotypes Bikaneri Nerma and Jayadhar may be better suited for salinity stress conditions. Technique of invitro screening may be widely used.

## 31. MODELLING COTTON STRUCTURE TO OPTIMIZE YIELD, QUALITY AND LIGHT INTERCEPTION

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Cotton (*Gossypium hirsutum* L.) has indeterminate growth. The growth regulator mepiquat chloride (MC) is used worldwide to restrict vegetative growth and promote boll formation and yield. The effect of MC is modulated by complex interactions with growing conditions (nutrients; weather) and plant population density. Hence, the effects of MC on plant form are incompletely understood and difficult to predict, and its use is difficult to optimize.To explore crop response to plant density and MC, a functional-structural plant model (FSPM) for cotton (CottonXL) was designed, calibrated with field data, and validated by using two additional years of detailed experimental data on the effects of MC and plant density in pure cotton and in intercrops of cotton with wheat. CottonXL simulates development of leaf and fruits (square, flower and boll), plant height and branching. Crop development is driven by thermal time, population density, MC application and topping of the main stem and branches. The FSP cotton model was used to explore light interception, fiber quality, and yield formation responding MC, population density, row configuration and cropping systems.

The validation of the model showed good correspondence between simulated and observed values for leaf area index with an overall root mean square error of 0.50 $m^2$ $m^{-2}$, and for number of bolls, plant height, number of fruit branches and number of phytomers with an overall prediction error less than 10 %. The light interception of FSP cotton model was validated and showed a good agreement ($R^2$=0.8) with field measurements. Canopy structure became more compact with the decrease of leaf area index and internode length due to the application of MC. Moreover, MC did not have a substantial effect on the boll density but increased the lint yield at higher densities.

Scenario analysis of FSP model at plot level showed that faction of light interception (FLI) were much affected by strip intercropping by means of changing row length density (RLD) and less affected by plant population density, only when it was lower than a certain threshold. Intercropped cotton intercepted less light comparing to the sole cotton with same plant distance and population density. Even in more homogenous sole cotton, the light extinction was different in relation to the capacity of canopy closure. Light extinction coefficient (*k*) of sole cotton increased by RLD before a threshold was reached, 1.5 rows $m^{-1}$ at 4 plant $m^{-2}$ and 2.0 rows $m^{-1}$ at 8 plants $m^{-2}$.

Scenario studiessimulating a range of management practices predicted that delaying topping times can significantly decrease fiber quality, while sowing date and film mulching had no significant effect. We conclude that CottonXL may be used to explore options for optimizing cotton fiber quality by matching cotton management to the environment, taking into account responses at the level of the individual fruits. The model may be used at plant, crop and regional levels to address climate and land use change scenarios.

## 32. IDENTIFICATION AND EFFECT OF GROWTH RETARDANT (MEPIQUAT CHLORIDE) ON PERFORMANCE OF GENOTYPES PLANTED UNDER HIGH DENSITY PLANTING SYSTEM (HDPS) IN IRRIGATED CONDITIONOF SOUTH ZONE

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Afield experiment was conducted at Central Institute for Cotton Research, Coimbatore in 2012/13 and 2013/14 with objective for identification of suitable genotype and also to assess the effect of growth retardant (mepiquat chloride) on performance of genotypes planted in high density planting System (HDPS) under irrigated condition of South zone. The *hirsutum* genotypes viz., Anjali , KC-3, NH615, MCU 7, SVPR-3, LH 900, PKV081, and Suraj planted at HDPS (planted at 45 X 15 cm) and compared with RCH 2 BG II ( planted at 90 x 60 cm) . The selected genotypes were super imposed with and without mepiquat chloride @25g ai/ha at 45 and 60 -days after sowing (DAS) were tried in factorial randomized block design with three replications. Significantly highest no of sympodia (14.6), no of node (20.4), sympodial length (24.4 cm), no of bursted bolls (20.1), single plant yield (90.5 g) and boll weight (4.5 g) were recorded with RCH 2 BG II, planted at normal spacing of 90x 60 cm. The planting of RCH 2 BG II at normal spacing might have avoided inter plant competition and produced higher biometrics. Application of mepiquat chloride @ 25 g ai/ha at 45 and 60 DAS reduced significantly plant height (54.4 cm), no of sympodia(12.1),no of nodes(17.7),LAI (2.0),sympodial length (18.3 cm),and dry weight (5893 kg/ha) but improved the boll weight (3.5g) .

Genotypes, KC 3 (31.9 q/ha), Anjali (30.8 4q/ha), Suraj (28.8 q/ha) and NH615 (28.8 q/ha) were harvested significantly higher seed cotton yield and the least one with RCH2 BGII (16.0q/ha ). High density plantinghad helped to produce higher biomass by increased photosynthetic efficiency thus ultimately resulted in 1.42 to 2.0 fold increase of seed cotton yield as compared to RCH2 BGII .Application of growth retardant, mepiquat chloride @ 25 g ai/ha at 45 & 60 DAS was harvested on par yield (25.9 q/ha) as compared to without application (25.8 q/ha). The highest 2.5 % span length (31.1 mm) fibre strength (23.1 g/tex),fibre quality index (367), estimated count(54),count strength product(2225) were recorded with Suraj. PKV 081,NH 615 and KC 3 were counted significantly the least jassid population. Gross return (Rs.1, 36, 904/ha), net return (Rs.87,995/ha), benefit cost ratio (2.67) were maximumwith Suraj. Agronomic advantage of HDPS, high yielding potential and better quality parameters linked with Suraj fetched high market price and ultimately leads to higher economic return.

# 33. IDENTIFICATION OF IDEAL PLANT TYPE IN COTTON SUITABLE FOR HIGH DENSITY PLANTING SYSTEM IN INDIA

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Globally, India ranks first in area under cotton cultivation. Production wise, India ranks second next to China. In India, almost two third of area under cotton cultivation is rain dependent and the cotton productivity got stagnated during the past five years at around 500 kg lint /ha. This is mainly because of the fact that a large area (more than 90 per cent) is being cultivated with Bt cotton hybrids at a wider spacing of either 120 cm x 90 cm or 90 cm x 90 cm with a plant population of 9,000 to 12,000 plants per hectare even under rainfed situations. Preliminary experiment with released semi-compact genotypes under high density planting system with a plant population of around 150,000 per hectare indicated possibility of breaking the yield barrier, especially under rainfed conditions. These experiments indicated that productivity of more than 1000 kg lint/ha are possible even in marginal shallow soil under rainfed situation. Hence, efforts were made to develop and identify high yielding compact *Gossypium hirsutum* genotypes suitable for high density planting system with better fibre quality. These genotypes were developed by following pedigree method of selection.

Twenty eight compact genotypes were evaluated in a three row plot at a closer spacing of 45 cm between rows and 15 cm between plants in a completely randomized block design with two replications during *kharif*, 2013-14 at Central Institute for Cotton Research, Regional Station, Coimbatore along with three semi compact released varieties. Of these, 21 genotypes had normal palmate leaf while seven other genotypes had super okra leaf. Data were recorded on plant height at maturity (cm), number of monopodia, number of sympodia, sympodial length at $5^{th}$ node from ground, boll number per square meter, boll weight (g), seed cotton yield (kg/ha), lint yield (kg/ha), lint index, seed index and ginning outturn. The fibre quality parameters *viz*., 2.5 % span length (mm), uniformity ratio, micronaire (µg/inch) and tenacity at 3.2 mm gauge (g/tex) were analyzed in High Volume Instrument at Central Institute for Research on Cotton Technology, Regional Unit, Coimbatore using the pooled lint samples from all the replications.

Analysis of data indicated significant differences among the studied genotypes for seed cotton yield and other characters. The highest seed cotton yield of 3642 kg/ha was recorded in the genotype PI 36-2-4-1 among normal leaf genotypes. Among super okra leaf type plants, the highest seed cotton yield was recorded in Surabhi x MM02-16-5-2-4. Fibre quality wise, the genotype Surabhi x MM02-19-1-8-2 was the best with 30.0 mm of 2.5% span length and 23.3 g/tex of tenacity. Correlation and path coefficient analysis was carried out to find the direct and indirect effects of various characters on seed cotton yield.

The super okra type genotypes were found to be highly compact and hence they were even amenable for further closer spacing. Hence, such genotypes are being further evaluated at a spacing of 37.5 cm between rows and 10 cm between plants, thus accommodating more than 250,000 plants per hectare during the summer, 2014.

# 34. AN INSIGHT INTO THE PLANT TYPE OF COMPACT COTTON MAKING IT SUITABLE FOR DIFFERENT SITUATIONS OF COTTON CULTIVATION

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Historically cotton cultivation in Asian continent has witnessed interesting changes in the choice of species and plant types. The era of hybrids has seen increased productivity coupled with robustness of cotton and thus lead to increase in number of pickings of cotton. Even though these robust hybrid plant types have contributed to increase in boll number and thus increase in seed cotton yield the remunerative value of robust hybrid cotton plant type has at times taken a beating because of increase in hybrid seed cost, increase in harvesting cost associated with manual picking of cotton, lower per day productivity. There is a need for developing compact cotton types suitable for high density planting which can reveal high productivity/day and can be fitted in double cropping situation to increase the total revenue of cotton based cropping system.

Evaluation of Dharwad compact hirsutum varietal lines was taken up during kharif (at Dharwad) and summer situation in Karnataka (Sirsi) and sunderban region of West Bengal (rice fallow situation). When tested under high density of over 1 lakh population per ha, some of the compact varietal lines have revealed productivity (seed cotton yield) higher than that of Bt cotton hybrid checks. More importantly these compact cotton varieties reveal early maturity making them suitable for double cropping situation.

The popular robust cotton varieties requiring normal duration of over 150 days are caught in incessant rains at the time of maturity and are thus unsuitable for rice fallow situations. The results clearly indicate that by introducing early maturing compact varieties it is possible to commercialize compact cotton varietal cultivation in summer situation after paddy and enhance remunerative value of this double cropping system and bring prosperity in west Bengal, Bangladesh and other eastern regions of the continents .Compact varietal lines revealing gradation of compactness have been compared for their relative genetic potentiality and this has given vital indications about what could be the ideal compact types capable of enhancing cotton productivity in normal kharif season .

Seed industry is restricting to the option of introducing hybrid technology for every emerging situation including that of cotton in high density or machine picking situation. Attempt was made to evaluate intra hirsutum compact hybrids at varying population density levels such as 17500plants/ha,35000plants/ha and the highest density level of 54,450 plants /ha .Some compact hybrids revealed increased productivity but they still fell short of the productivity level attained by super compact varietal lines tested under density of 1,15,000 plants /ha. It indicates that present day hybrids cannot be exploited under very high population density.This raises the question about the limit up to which the stature of the hybrids can be reduced to fit them in high density planting situations. A comparison of compact varieties differing in the extent of horizontal and vertical growth was made and this study gave an insight in to the ideal plant types of compact variety whose yield can be maximized under high density planting situations.

## 35. EVALUATION OF NEW STRAINS OF *G. hirsutum*FOR SEED COTTON YIELD AND FIBRE QUALITY UNDER HIGH DENSITY PLANTING SYSTEM

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In India, all four species of cultivated cotton *Gossypium arboreum* and *G. herbaceum* (Asiatic cotton), *G. barbadense* (Egyptian cotton) and *G. hirsutum* (American cotton) are grown in three distinct agro-ecological regions of the country. *Gossypium hirsutum*occupies about 90 % of the area under hybrid cotton cultivation in the country. Approximately, 65 % of the India's cotton is produced on rainfed areas. The productivity of Indian cotton remained stagnant around 500 kg lint per hectare which is far below to the world average productivity. Thus, in view of this the present investigation was initiated on evaluation of new hirsutum strains under high density planting system for finding their suitability under rainfed situations. These strains were sown with plant population of 1,11,110 plants per hectare at Central Institute for Cotton Research, Nagpur, India in 2012 under rainfed conditions. The experimental design was completely randomized block design with three replications. Plot size was four rows of 4.5 m length with row to row distance of 45 cm. The distance between plants in a row was 20 cm.

Of the 18 strains evaluated, four strains CNH 7008-1, CNH 7012-13, CNH 7012-6, and CNH 7012-11 recorded higher seed cotton yield with good fibre quality. The higher significant seed cotton yield of 2954 kg/ha was recorded by strain CNH 7008-1followed by CNH 7012-13 (2842 kg/ha), CNH 7012-6 (2816 kg/ha) and CNH 7012-11 (2741 kg/ha) over the local variety LRK 516 (1081 kg/ha). Strain CNH 7012-13 showed 2.5 % staple of 27.9 mm and fibre bundle strength of 23.7 g/tex. Strain CNH 7012-11 recorded staple of 29.3 mm (Long staple category) and fibre bundle strength of 23.3 g/tex. The strain, which recorded highest seed cotton yield also exhibited good fibre quality of 26.4 mm with 22.4 g/tex (superior medium staple category) with strength to length ratio of 0.85. Strain CNH 7012-13 recorded 2.5 % staple of 27.9 mm and fibre bundle strength of 21.5 g/tex. These strains will be evaluated under multilocation testing over the years for seed cotton yield and fibre properties for finding their suitability for releasing as a variety with recommended agronomic package of practices under rainfed cultivation in the country.

# 36. EARLINESS COMPARISON OF SUNCROP GROUP'S NEW Bt COTTON LINES

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Four Bt cotton genotypes (Leader-1, Sun-1, Tahfuz-1, and Leader-3) developed at Suncrop Group's Research Farm were compared for their earliness against a commercial cultivar MNH-886 developed at Cotton Research Station Multan in a trial having randomized complete block design replicated three times during the years 2012 and 2013. The earliness parameters studied were: first sympodial node number, days taken to form first square, days taken to open first flower, days taken to open first boll, number of bolls formed at 90 dap (days after planting), number of bolls formed at 120 dap, number of bolls formed at 150 dap, number of bolls opened at 120 dap and number of bolls opened at 150 dap. The earliness of the above varieties was also compared by using Bartlett's Earliness Index (BEI), which explains that higher the BEI, the earlier would be the variety.

Statistically, significant differences were observed among the genotypes for all the parameters under study. The results revealed that Bt cotton variety Leader-3 had lowest (5.2) sympodial node number followed by Leader-1 (6.6), whereas, the highest sympodial node number (7.9) was recorded in SUN-1 followed by Tahfuz-1 (7.4). Again Leader-3 took fewer days to form its first square (26.0) followed by Leader-1 and Tahfuz-1 (26.9), MNH-886 took more days in forming its first square (28.2) followed by SUN-1 (27.1). As regards opening of first flower, Leader-3 took minimum days (43.2) to open its first flower followed by Leader-1 (44.9), it was MNH-886 which took maximum days to open its first flower (46.6) followed by Tahfuz-1 (45.3). Similarly, for the parameter days taken to open fist boll, Leader-3 took minimum days (80.0) in opening its first boll followed by Leader-1 (80.4), whereas, Tahfuz-1 took maximum days (81.2) in opening its first boll closely followed by MNH-886 (81.1). As regards to formation and opening of bolls at specific time intervals (90, 120 and 150 dap), Leader-3 formed and opened maximum number of bolls per plant. When the earliness of the above varieties was compared by applying Bartlett Earliness Index formula, it was the Leader-3 variety which recorded highest earliness index thus was recorded as earliest variety.

Considering the results of present study, Leader-3 was assessed as an early genotype as compared to other varieties included in the test.

## E. NUTRIENT MANAGEMENT

### 37. PERFORMANCE OF UREA DEEP PLACEMENT (UDP) ON THE YIELD AND YIELD CONTRIBUTING CHARACTERS OF COTTON

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To determine the performance of Urea Deep Placement (UDP) on the cotton yield and yield Contributing Characters,experiments were carried out at three cotton research farms located in, Sreepur, Gazipur; Jagadishpur, Jessore and Sadarpur Dinajpur during the period of 2013-14. The number of treatments were five viz. $T_1$ = Recommended dose of nitrogen (80.5 kg N/ha) from prilled urea.$T_2$ = Recommended dose of nitrogen (80.5 kg N/ha) from urea supper granule (USG) T3= Recommended dose of nitrogen (72.45 kg N/ha) from USG $T_4$ = Recommended dose of nitrogen (64.40 kg N/ha) from USG and $T_5$ = Recommended dose of nitrogen (56.35 kg N/ha) from USG. The experiment was conducted in RCBD with three replications. The interaction between treatment × locations was found significant. The highest seed cotton yield at Sreepur farm was obtained by applying prilled urea while at Jagadishpur and Sadarpur Farm the highest seed cotton yields were obtained from the USG. Economic analysis showed that the highest return (132917 Tk/ ha) was obtained from the treatment $T_1$ (80.5 kg N/ha from prilled urea) that also gave the highest benefit to cost ratio (2.14).

### 38. EFFECT OF N P K S ON SEED COTTON YIELD OF THE VARIETY CB-12

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A field experiment was conducted at three Cotton Research Farm Sreepur, Jagadishpur and Sadarpur during kharif season in 2012-13 to determine the effect of NPKS on seed cotton yield of the variety CB-12.Yield, yield contributing parameters and economics of the new cotton variety CB-12 were used. The experiments were set up in RCB design with three replications. Highest seed cotton yield of 3650 kg/ha when the crop was fertilized with125:50:125:25 kg NPKS/ha respectively. The lowest yield of 1576 kg/ha was produced where no chemical fertilizer was applied. The yield contributing parameters plant height, monopodial branches/plant, sympodial branches/plant, number of boll/plant and single boll weight were significantly influenced by the highest fertilizer levels. Economic analysis showed that the highest level of fertilizer 125:50:125:25 kg NPKS/ha gave the highest gross margin (158040 Tk./ha) with the highest benefit cost ratio and the lowest gross margin (50480 Tk./ha) with the lowest benefit cost ratio were recorded from treatment (control) $T_1$ were 2.59 and 1.14, respectively

## 39. EFFECT OF FOLIAR NITROGEN, POTASSIUM AND BORON FERTILIZATION ON SEED YIELD AND QUALITY OF COTTON

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Field and laboratory experiments were conducted at Central Cotton Research Farm, Shreepur, Gazipur, Bangladesh to determine appropriate concentration of foliar nitrogen, potassium and boron (NKB) on growth, yield, fibre properties and seed quality of cotton. The concentrations of foliar NKB were (i) 7.50-40-0.75, (ii) 7.50-40-1.00, (iii) 7.50-50-0.75, (iv) 7.50-50-1.00, (v) 9.00-40-0.75, (vi) 9.00-40-1.00, (vii) 9.00-50-0.75, (viii) 9.00-50-1.00 g NKB $L^{-1.}$ water and (ix) untreated control. Foliar fertilizations were made for thrice beginning at first flowering stage, at ten days interval, continued till boll development stage of cotton. The crop was also fertilized with 2 ton cow dung and 78, 37, 33, 20.5, 4.60, 2.2, 1.90 kg N, P, K, S, Zn, B, Mg $ha^{-1}$ respectively, applied as general dose in soil. It was observed that foliar application of 7.50-50-1.00 g NKB $L^{-1}$ water produced the highest seed cotton yield (1.39 t $ha^{-1}$) consistent with better fibre properties and seed quality. This combination of three foliar inputs also increased fibre length (12.19 mm), microniare value (4.65), uniformities (46.30) and strength (84.88 PSI) over the untreated control cotton plants. Furthermore, increased seed index and nutrient content in seed under this foliar fertilization with NKB enhanced seed quality as it was evident from its highest germinability (88.09%), seedling growth along with lowest electrical conductivity (106.50 $\mu Scm^{-1}g^{-1}$) value. Therefore, this study demonstrates that cotton plant needs supplement foliar NKB fertilization during reproductive stage for its improvement in yield, fibre properties and seed quality.

## 40. EFFECT OF POULTRY MANURE AND INORGANIC FERTILIZER ON THE PRODUCTIVITY OF COTTON IN BANGLADESH

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Cotton cultivation in Bangladesh depends on high quantity of inorganic NPKS fertilizers that should be reduced by organic sources. Poultry manure contain many essential plant nutrients, but its effect on cotton (*Gossypium hirsutum L.*) yield and yield contributing characters in Bangladesh has not been investigated in the field.The objective of thisresearch was to determine the effect of poultry manurecombined with inorganic NPKS fertilizers at the rate of deficient to recommended to excessive on cotton yield and yield contributing characters. The experiment was conducted at three cotton research farms located at Sadarpur, Dinajpur and Sreepur, Gazipur in 2012-13 growing period. The performance of six treatments viz. 1.without fertilizer, 2.recommended doses of inorganic fertilizer ( 104-45-138-22 kg NPKS $ha^{-1}$ respectively), 3. 75% of recommended

doses of inorganic fertilizer, 4. 75% of Treatment 2 + 2 t $ha^{-1}$ poultry manure, 5. 75% of Treatment 2 + 4 t $ha^{-1}$ poultry manureand 6. 75% of Treatment 2 + 6 t $ha^{-1}$ poultry manurewere investigated in RCB design with 3 replications. The main effect of treatment was found significant for vegetative branch, fruiting branch and plant height at harvest, boll number and seed cotton yield. While, the location effect was found significant on vegetative branch, fruiting branch and plant height at harvest, boll number, individual boll weight and seed cotton yield. The interaction effect of treatment × location wasfound significant for boll number and seed cotton yield. Application of poultry manure significantly increased the cotton yield and yield contributing characters. The highest seed cotton yield at Sreepur and Sadarpur farms were obtained from 2 t $ha^{-1}$ poultry manure and at Jagadishpur farm from 4 t $ha^{-1}$ poultry manure together with 75% recommended dose of NPKS fertilizers. With the increase of poultry manure rate the seed cotton yield decreased.Besides, the NPKS use efficiencies and benefit cost ratio varied from location to location for different treatments.

## 41. ENRICHED COTTON STALK COMPOST AS A COMPONENT OF INTEGRATED NUTRIENT MANAGEMENT FOR IRRIGATED COTTON

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In India about 400 million tones of agricultural waste are produced annually of which 29 million tones are cotton stalk. High inorganic inputs for crop cultivation and improper management of solid wastes result in environmental pollution. Microbial conversion of agricultural waste into well humified compost is not only reduces environmental pollution but also acts as an important source of nutrients for carbon deficient agricultural lands of India. The use of Farm Yard Manure (FYM) as a component of Integrated Nutrient Management (INM) is recommended for sustainable cotton farming. However, its use is declining year by year due to non availability of good quality FYM and high cost. We attempted to produce nutrient rich cotton stalk compost to be used as substitute for FYM in Cotton production. To accelerate the composting process, aerobic (5liters) and anaerobic microbial consortium (5liters) were added to the cotton stalk at the time of initiating the composting process. The aerobic culture includes *Phanerocheate chrysoporium*, *Pleurotus flabellatus* and *Bacillus stearothermophilus*.The anaerobic culture used was CIRCOT anarerobic consortium. Two types of cotton stalk compost were prepared with and without adding microbial consortium and evaluated under field condition consecutively for two years during 2012-13 and 2013-14 cropping season( August – February)under irrigated agro ecosystem of Coimbatore in randomized block design with four replications using RCH 20 BG II cotton hybrid as test cultivar. The cotton stalk compost was analysed for nutrients content at 45 days after initiation of composting process and before applying to cotton field. The results revealed that the compost prepared using microbial consortium recorded higher total nitrogen (0.72 %),total phosphorus(0.125 %),total potassium(0.55%) and calcium(340ppm)as against

0.65 % total N,0.08% total P ,0.52% total K and 280 ppm of calcium recorded in the compost prepared without adding microbial consortium. while the nutrients like magnesium, sodium and sulphate were higher (142 ppm,65ppm and 82ppm respectively) in compost prepared without addition of microbial consortium as compared to 135 ppm,46ppm and 73ppm in the microbial consortium added cotton stalk compost. The field evaluation of cotton stalk compost prepared with and without adding microbial consortium at two doses of 2.5 t and 5t/ha along with recommended NPK of 90:45:45kgs/ha revealed that addition of organics either as FYM or as cotton stalk compost is significantly superior to inorganic fertilizer alone in recording higher number of bolls ranging from 52.2 to 55.7 bolls as compared to 43.2 bolls recorded under inorganic fertilizer alone. The boll weight was not significantly altered due to organics, inorganics or their combination. The seed cotton yield was significantly reduced (2041 kgs/ha) due to inorganic fertilizers alone without combining organic source of nutrients. Application of cotton stalk compost prepared either with microbial consortium or without microbial consortium at 2.5t/ha along with recommended NPk resulted in on par seed cotton yield as that of recommended NPK +12.5 t/ha of FYM in soil with low available N ,medium P and high K content.

## 42. SYNTHESIS OF NANOENCAPSULATED ZINC FERTILIZER BY USING BIOPOLYMERS AND ITS EFFECT ON COTTON

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A pot culture experiment was conducted to study the effect of nanoencapsulated zinc fertilizer on cotton growth parameters. Nanoencapsulated zinc fertilizer in with or without zein polymer coating was synthesized as a novel slow or controlled release fertilizer through ionic gelation process in which biopolymer chitosan was used to interact with crosslinking agent sodium tripolyphosphate (TPP) to produce chitosan nanoparticles for encapsulation of water soluble micronutrient fertilizer like zinc sulphate. The newly synthesized nanoencapsulated zinc fertilizer was characterized for confirmation of size, shape, zeta potential, crystalline nature and elemental composition using particle size analyser, scanning electron microscopy with EDAX, X-ray diffraction and FTIR. Results of the synthesized nanofertilizer size ranging beween 70 – 86 nm for Zn loaded CS/TPP nanoparticle whereas size of zinc loaded CS/TPP nanoparticle with zein was 80 to 300 nm. Shape of the Zn loaded chitosan nanoparticle in with or without zein coating was spherical with smooth surface and homogenous in diameter. Surface charge, *ie*., zeta potential of zinc loaded CS/TPP nanoparticle in with or without zein coating was found to be positively charged, which indicates medium stability of nanoparticle. The characterized nanoencapsulated zinc fertilizer were foliar sprayed at 50 ppm concentration on leaf of 30 day old cotton (var: suraj) plants. A significant improvement was recorded on plant height (15 cm), number of leaves (13.3) and root length (14.5 cm) by application of nanoencapsulated zinc with chitosan and zein (0.1 %) as compared to plant height (13.5 cm), numbers of leaves (10) and root length (13 cm) of nanoencapsulated zinc with chitosan but without zein in 7 weeks old plant. It was followed by normal recommended dose of zinc fertilizer ($ZnSO_4$) and control.

# 43. PERFORMANCE OF COTTON HYBRID AND INBRED VARIETIES AT DIFFERENT NUTRIENT LEVELS

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A field study was conducted at Cotton Research Training and Seed Multiplication Farm, Sreepur, Gazipur from July 2011 to February, 2012 to investigate the influence of different levels of fertilizer on a number of hybrid and inbred varieties of cotton in respect of growth, yield components and yield, and fibre quality attributes. The experiment comprised three cotton genotypes (i) HSC-4 (hybrid), (ii) DM-2 (hybrid) and (iii) CB-12 (inbred) variety and five levels of fertilizers (i) Control (without fertilizer), (ii) 25% less than recommended dose, (iii) Recommended dose (RDF: 120, 52, 131,27:N,P,K,S $kgha^{-1}$), (iv) 25% higher than recommended dose and (v) 50% higher than recommended dose. The experiment was laid out in a Randomized Complete Block Design (factorial) with three replications. The results revealed that seed cotton yield, bolls $plant^{-1}$, ginning out turn differed among the varieties. The highest seed cotton yield and ginning out turn were obtained in hybrid HSC-4 and that of the lowest received from CB-12 variety. Increasing levels of fertilizer maintained higher values of all the parameters except days to first flowering, lint index and ginning out turn. The tallest plant (111cm) and maximum days to boll opening (129.3), number of no.of bolls $plant^{-1}$ (27.08), seed cotton yield (2174 kg $ha^{-1}$), lint yield (953$kgha^{-1}$), seed index (9.49), staple length (1.2inch), micronaire value (4.3), fibre strength (83.70 psi), uniformity ratio (48%) were observed in the plot where 50% higher than RDF was applied. Plant height, bolls $plant^{-1}$, individual boll weight, lint yield and ginning out turn showed higher value with the interaction of HSC-4 x 50% higher than RDF. The highest seed cotton yield (2406 kg $ha^{-1}$) Gross return (144360 tk $ha^{-1}$) Gross margin (75358Tk $ha^{-1}$), BCR (2.09) and seed index were obtained with the combination effect of CB-12 x 50% higher fertilizer than RDF. For economic point of view, the results indicate that CB-12 inbred variety x 50% higher fertilizer than RDF was more profitable than any of the other treatment combinations.

## F. INSECT PEST MANAGEMENT

### 44. DIMENSIONS AND CHALLENGES cf ALTERED INSECT PEST SCENARIO UNDER THE INFLUENCE OF BT COTTON

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Adoption of Bt cottons expressing *CryIAc* worldwide was inevitable to contain surmounted insecticide resistant bollworm problem. From 2002 commercial cultivation of Bt cottons started in India with 0.038 m ha. Within few years the area increased drastically and by 2019 India became largest grower in the world crossing 100 m ha. The ruling events have *CryIAc* either as single or stacked event; however the majority area is under Mon-15985 event (BG-II) expressing *CryIAc* + *CryIIAb*. Bt cottons have given the expected benefits all over world including India with enhanced production and reduced pesticide usage. The incidence and damage due to bollworms (especially *Helicoverpa armigera)* has been almost negligible in Bt cotton era particularly after cultivation of BG-II genotypes. The insecticide reduction experienced immediately after introduction of Bt cotton was said to be about 40%. The reduction in use of pyrethroids and several conventional insecticides on Bt-cotton especially after introduction of BG-II is presumed to have led to an enhanced infestation of non-target species such as mirid bugs, mealy bugs, thrips *Spodoptera* etc. As in Australia, China and US mirid bugs are assuming key pest status in India with the introduction of Bt cotton, particularly BGII.

The problem of emerging / new pests as well as increased incidence of sucking pests viz., leafhoppers, aphid and thrips is increasing now. Since 2005mirid bug *Creontiades biserratense*has emerged key pest in Karnataka as well as other South Indian States and Maharashtra. Both adults and nymphs suck the sap from squares and tiny bolls while hiding leading severe shedding of squares and tiny bolls. Initially established as causing 28% avoidable loss it has now crossed 65% . The farmers are using minimum two sprays targeting this pest exclusively. An ETL of 5.0 bugs/pl has been recommended recently. Another dreaded mirid bug tea mosquito *Helopeltis bradyi* is turning to be a regular pest of Bt cotton since 2009 expanding its host range. The estimated loss due to this pest is > 80 %. Re-appearance of flowerbud maggot or gallmidge *Dasineura gossypii*in 2009 in severe proportions after 95 years of its first report has been surprising. The initial minimum yield loss attributed to this past was 60 % with a localized infestation. Now this pest is widespread in Karnataka and has assumed number one position. In 2013 there was outbreak of flowerbud maggot in the state. These pests are responding satisfactorily to Profenphos 50 EC, Acephate 75 SP and Malathion 50 EC rather than to systemic molecules. Thus from square formation to boll maturity 2-4 rounds of insecticide application is required in Bt cottons apart from seed dressing and conventional sucking pest spray schedule, as they are pests infesting fruiting structures. Another important issue is resistance in neonicotinoids in sucking pests. Leaf hoppers ( Haveri population) have shown $LD_{50}$ of 0.35 ml and 0.53g per liter for spray formulations of imidacloprid 17 SL and thiamethoxam 25 WG respectively which is thousand folds higher than susceptible population.

Hence, in altered scenario IRM (Insecticide Resistance Management) of sucking pests as well as better management of new insect pests is a key issue in Bt cotton cultivation. The problem of *Spodoptera litura* and mite infestation also can not be ignored. Slowly the usage of insecticides is in upsurge trend warranting alternatives neonicotinoides or deadly organophosphates. Cultivation of Bt cottons may not remain profitable unless these issues are addressed critically.

## 45. PINK BOLLWORM SCENARIO IN DIFFERENT COTTON GROWING AREAS OF SINDH-PAKISTAN

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Cotton, a major cash crop of Pakistan, is considered backbone of the national economy. It contributes about 1.4% to GDP and 6.9% of total value addition in agriculture. Pakistan is the fourth largest producer, third largest consumer of cotton and the second largest exporter of cotton yarn in the world. Export of cotton and textile products have a share of 57% in the overall exports of the country. Cotton is grown by 1.3 million farmers on over 3.2 million hectares which is 15% of the cultivable area of Pakistan. During 2012-13, cotton production was 12.0 million bales and in 2013-14 it is around 12.5 million bales of 170 kg. This is consumed largely by 521 textile mills in the country though a significant quantity of up to 1 million bales is also exported. However, to meet the demand for extra long staple cotton, up to 2 million bales are imported annually. Cotton production in Pakistan has remained stagnant due to many reasons. Virus and pest attack on cotton has significantly hindered the cotton production. This paper highlights the infestation of Pink bollworm in different areas of Sindh, Pakistan. It has significantly damaged cotton crop in Nara belt of Sanghar District of Sindh Province. For control of pest, a number of highly toxic pesticides were used but the larvae inside seeds of boll were not controlled. The study explores the extent of toxic chemicals which are also dangerous to other natural enemies, women cotton pickers, animals and birds etc. Finally, the paper provides recommendations for, the use of eco- friendly methods that are suitable for control of the pest and will reduce the number of toxic pesticides against this pest.

# 46. NEONICOTINOID SEED TREATMENT AND ITS EFFICACY AGAINST SUCKING PESTS ON COTTON IN INDIA

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Imidacloprid and Thiamethoxam belonging to the neonicotinoid group of insecticides were introduced in India in the late nineties. Imidacloprid, as Gaucho$^R$ is widely being used for seed treatment of Bt cotton hybrids. More than ninety five percent of the cotton growing area in India currently usescotton seed treated with neonicotinoids. Despite this, insecticide use against sucking pests on cotton has increased from 2374 metric tonnes in 2006 to 7270 metric tonnes in 2010 and 6372 metric tonnes in 2011.Cotton growers also report sucking pests, particularly the leaf hoppers as causing increasing damage to Bt cotton especially in Central India. Among other factors, increase in resistance levels of leaf hoppers to neonicotinoids is one of the reasons for increased insecticide use against sucking pests in cotton. Experiments carried out in a networking mode with 6 centres under the Technology Mission on Cotton, quantified resistance levels in geographic populations of leafhoppers to neonicotinoid insecticides. This study reports a reduction in the period of protection conferred by seed treatment to leaf hoppers in cotton across 6 locations from 45-60 days after sowing (DAS) to about 15 days after sowing. Using 3 genotypes (RCH2 BGII a leaf hopper susceptible hybrid, RCH20 BGII, moderately susceptible to sucking pests and DCH32, highly susceptible variety to leaf hoppers) that were seed treated with recommended dose of imidacloprid and thiamethoxam, leaf hopper incidence and damage were recorded across 6 locations in Kharif. Leaf hoppers crossed the economic threshold level ETL, (2 nymphs per leaf) in imidacloprid (Gaucho$^R$ ) or thiamethoxam (Cruiser$^R$ ) seed treated plots at 15 DAS in Dharwad (Karnataka), 17 DAS in Guntur, (Andhra Pradesh), 25 DAS at Raichur (Karnataka) 28 DAS at Khandwa (Madhya Pradesh) and about 49 DAS in Surat (Gujarat). However the variation between genotypes in terms of leafhopper incidence above ETL was apparent only at Guntur and Surat. Geographic populations of leaf hoppers from Dharwad, Guntur, Khargaon (closest to Khandwa) reported resistance ratios of 600 fold, 3800 fold and 990 fold, respectively to imidacloprid, in lab studies. Reasons for the reduced efficacy of neonicotinoid seed treatment in cotton in the field against leaf hoppers would be elucidated. Proactive management strategies such as identifying and promoting sucking pest resistant hybrids, avoidance of neonicotinoid sprays on neonicotinoid seed treated plots, use of alternate chemistries in the early sucking pest window as part of effective sucking pest management are discussed.

## 47. ASSOCIATION OF LEAF TRICHOME DENSITY WITH SUCKING INSECT PESTS INCIDENCE IN ASIATIC COTTON

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Present investigation was carried out to investigate the relationship between leaf trichome density and incidence of sucking insect pests (jassid and whitefly) in *desi* cotton. An $F_2$ population between a trichomeless (glabrous) mutant PAUFL1 and a wild type advance line LD 902 was developed. Trichome density on the leaves of individual $F_2$ plants were counted inside a 6 mm ring. Three counts were made one on each side of the midrib just above the convergence of the two large lateral veins and third one on the midrib on the underside of the young leaf. The averages of the three counts were used in subsequent analyses. Trichome density on young leaves in the $F_2$ population was observed to vary from 17 through 218 excluding the glabrous plants. The population of jassid nymphs and whitefly adults were recorded from three leaves of upper canopy of each of the 256 $F_2$ plants. The observations were recorded during the period from end July to 3rd week of September. Okra plants were grown in and around the *desi* cotton plots for artificial infestation. During the period of observations, the population of whitefly adults ranged from 0.00 to 2.80 per three leaves, whereas, the population of jassid nymphs varied from 0.0 to 2.0 per three leaves. A positive correlation (r = 0.204) between young leaf trichome density and whitefly population was recorded indicating lower trichome density does not favour whitefly incidence and vice versa. However, no association (r = 0.074) between trichome density of young leaves and jassid population was observed suggesting that factors other than leaf trichome density might be involved in imparting resistance/tolerance to jassid.

## 48. RESPONSE OF COTTON MEALYBUG, *Phenacoccus solenopsis* TINSLEY (Sternorrhyncha: Pseudococcidae)TO DIFFERENT MANAGEMENT TACTICS UNDER SEMI-FIELD AND FIELD CONDITIONS

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Two trials were carried out under semi-field and field conditions to find out the compatibility of two native predators, *Chrysoperla carnea* larvae and adults of *Brumus suturalis* and the exotic predator *Cryptolaemus montrouzieri* with neem oil for the management of *Phenacoccus solenopsis* under semi-field and field conditions. The assessments were based on mealybug infestation (scale 0-9) and percent recovery of predators at the end of the experiment showing conservation and colonization capability of the predator to the prevailing conditions. Both native predators, *C. carnea* and *B. suturalis* showed better control of the mealybug under semi-field and field conditions over control and were also recovered at the end of the trials. In contrast to these, exotic

predator *C. montrouzieri* though proved to be the most efficient predator of *P. solenopsis* under semi-field conditions but it failed to establish under field conditions and reducing mealybug populations and no recoveries were made in either of the treatments under field conditions. Maximum reduction in the population of tested insect was noticed on the insecticide treated plants. The present study showed that application of neem oil followed by release of *C. carnea* larvae and *B. suturalis* adults can be swapped to synthetic insecticides for the safer management of mealybug on cotton.

## 49. ROLE OF ARTHROPODS BIODIVERSITY IN CONTAINING COTTON INFESTING MEALYBUGS

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Mealybugs are one of the major pests of cotton since 2007 in India. Seven species of mealybugs viz., cotton mealybug *Phenacoccus solenopsis* Tinsley, papaya mealybug *Paracoccus marginatus*Williams and Granara de Willink, Pink hibiscus mealybug *Maconellicoccus hirsutus*(Green), spherical mealybug *Nipaecoccus viridis* (Newstead),striped mealybug *Ferrisia virgata*Cockrell, mango mealybug*Rastrococcus iceryoides* (Green) and ber mealybug *Perissopneumon tamarindus* (Green) have been recorded with varying degrees of infestation ranging from low to sever. Mealybugs reduce seed cotton yield up to 50 % if proper management actions are not taken up at right time. The purpose of the study was to document bioagents associated with these mealybugs and their possible use in ecofriendly management of mealybugs infestation wherever possible. Surveys carried out during 2009 to 2014 in three cotton growing zones revealed increased arthropod bioagents diversity with increase in mealybugs diversity and spread. Bioagent arthropods biodiversity consisting of13 species of parasitoids, 4 species of hyperparasitoids and 8 species of predators have been recorded. Parasitoids recorded were *Aenasius bambawalei* Hayat, *Acerophagous papaya* Noyes & Schauff*, Metaphycus* sp., *Aprostocetus bangaloricus* Narendran, *Encyrtus aurantii* (Geoffroy), *Aprostocetus sp., Anagyrus dactylopii* (Howard), *Anagyrus mirzai* Agarwal and Alam, *Homalotylus albiclavatus* (Agarwal), *Homalotylus sp., Anagyrus kamali* Moursi, *Chartocerus kerrichi* (Agarwal), *Pachyneuron leucopiscida* Mani. Hyperparasitoids recorded were *Pachyneuron leucopiscida* Mani, *Promuscidea unfasciativentris* (Girault), *Prochiloneurus pulchellus* Silvestri and *Prochiloneurus aegypticus*(Mercet). Predators were*Cryptolaemus montrouzieri* (Mulsant), *Crysoperla carnea*(Stephens), *Cheilomenes sexmaculata* Fabricius, *Scymnus coccivora* Ayyar*, Rodolia fumida* Mulsant*, Nephus regularis* (Sicard), *Cacoxenus perspicax* (Knab), *Spalgis epius* Westwood. *Aenasius bambawalei* Hayat was found to be the predominant parasitoid of *P. solenopsis* in all the three cotton growing zones of India while *Acerophagous papaya* was on papaya mealybug *Paracoccus marginatus* in central and South zone. Lepidopteran predator *Spalgis epius* recorded on papaya mealybug in south zone. Wide diversity of bioagents has been recorded in rainfed cotton agro ecosystem of central Zone. Some of these bioagents are reported for the first time and gain importance in biological control. These bioagents need to be conserved with avoidance of indiscriminate use of pesticides, application of chemicals on accordance with the ratings of WHO/IOBC, etc..Per cent predation/ parasitization by each bioagent and their use in containing mealybug population infesting cotton are discussed.

## 50. ENTOMOPATHOGENIC FUNGI ASSOCIATED WITH COTTON MEALYBUG, *PHENOCOCCUSSOLENOPSIS*TINSLEY AND PAPAYA MEALYBUG, *Paracoccusmarginatus* WILLIAMS AND GRANARA DE WILLINK IN INDIA.

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Mealybugs (Hemiptera: Psuedococcidae) are small sap sucking insects and some species can cause severe economic damage to wide range of crops. This exotic pest introduced accidentally created havoc not only on cotton but also on other crops, thereby threatening sustainable agricultural production in India. Widespread outbreak and severe yield reduction in Cotton due to the infestation of Cotton Mealy bug, *Phenococcussolenopsis*Tinsleyand Papaya mealybug,*Paracoccusmarginatus*Williams and Granara de Willink was recorded in India. To find effective and safe biological control agents against this pest, natural occurrence of entomopathogenic fungi associated with these two mealybugs were investigated. In infested cotton fields, dead mealy bugs were collected and brought to the laboratory for the isolation of entomopathogenic fungi. The surveys resulted in recovery and isolation of 25 isolates of entomopathogenic fungi *viz.*, *Aspergillusflavus* gr.(11),*Aspergillusclavatus* gr.(3),*Aspergillusoryzae* gr.(5), *Aspergillusterreus*gr. (1).,*Fusariumverticulloides* (Sacc.) Zare& Gams.(1),*Chaetomiumglobosum*Kunze (1)., *Lecanicilliumlecanii*Zare& W. Gams 2001 (1)., *Phoma*sp.(1). and*Verticillium*sp.(1) from *Phenococcussolenopsis* whereas 32 isolates of entomopathogenic fungi viz., *Aspergillusflavus* gr.(19),*Aspergillusclavatus* gr.(2),*Fusariumverticulloides* (Sacc.) Zare& Gams.(3),*Fusarium*sp.(1), *Cladosporiumcladosporioides* (Fresen.) de Vries (1), *Lecanicilliumaphanocladii*Zare& W. Gams 2001 (1), *Lecanicilliumattenuatum*Zare& W. Gams 2001(1), *Lecanicilliumaraneicola*Sukarno &Kurihara 2009,(1),*Lecanicilliumfusisporum* (W. Gams) Zare& W. Gams 2001 (1) and *Metarhiziumanisopliae* (Metchnikoff) Sorokin (2) were recorded from *Paracoccusmarginatus*. Pathogenicity of four fungi viz., *L.lecanii, M.anisopliae, F.pallidoroseum*and*C.cladosporioides* against nymphs and adults of *P.solenopsis* and *P.marginatus* were tested.The results suggested that entomopathogenic fungi could be good biocontrol agents against mealybug and are discussed with respect to ecology of fungi. This is the first report on the natural occurrence of entomopathogenic fungi from mealybug.

# 51. COMPATIBILITY STUDIES ON SEED TREATMENTS FOR CONTROL OF PEST AND DISEASES IN COTTON UNDER HIGH DENSITY PLANTING SYSTEM (HDPS)

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Field experiment was conducted at CICR Research farm, Nagpur to evaluate the compatibility among the pesticides, fungicide, microbial consortia and bio-control agent for seed treatment to find out pest and disease controlling ability on cotton seedlings with yield enhancement using variety Suraj under HDPS. The cotton growth parameters were recorded along with the incidence of sucking pests, natural enemies and final seed cotton yield (SCY). Two insecticides – Imidacloprid and Acephate, fungicide - Thiram, microbial consortia consist of 5 bacterial isolates and a bio-agent *T. viride* (Tv) was used for seed treatment with different combinations. Significant increase in shoot length and plant biomass was observed with Imidacloprid + Thiram + Tv treatment at 46 days after sowing (DAS) compared to other treatments. Better control of jassids and aphids was recorded in Imidacloprid treatments as compared to Acephate (44 and 55 DAS) treatment. Thrips was well managed by Acephate treatment over Imidacloprid. Coccinellid population was more in control and microbial treatments than acephate and imidacloprid. Acephate + Thiram + Tv recorded highest bolls/plant (9.26) followed by Acephate alone-(8.46), Imidacloprid alone-(8.46) and *Bacillus* sp. alone-(8.43) compare to control (8.10). Imidacloprid + Thiram + Tv (25.41 q/ha) and Imidacloprid + Thiram (24.91 q/ha) recorded highest SCY followed by Thiram alone (23.61 q/ha), Acephate alone (22.50 q/ha), Imidacloprid + Thiram + MC + Tv (21.56 q/ha) and*Bacillus* alone (21.08 q/ha) compared to control (17.56 q/ha).Among microbial isolates, *Bacillus* alone recorded highest yield followed by microbial consortia and *P. fluorescens* alone. Results revealed that Imidacloprid alone or in combination with microbial consortia or *T. viride* was performing well compared to all other treatments. Though, not much variation observed over sucking pests control among Imidacloprid and Acephate except for jassids, the vigour of seedlings were very high in Imidacloprid alone or combination treatments. Imidacloprid in combination with Thiram and *T. viride* recorded highest yield.

## 52. IMPACT OF PLANTING DENSITY ON PEST AND DISEASE INCIDENCE OF COTTON

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The field experiment was conducted during 2013-14 season at CICR Research farm Nagpur, India to study impact of planting density on pest and disease incidence of cotton under HDPS in shallow and medium soils using fourteen different genotypes *viz.* KC-3, Suraj, ADB-532, NH-615, AKH-081, Vikram, Anjali, DSC-99, CINHTi-1, CINHTi-2, Supriya, C-1412, PI-8-2-BK and ADB-39 in medium soil and KC-3, Suraj, ADB-532, NH-615, AKH-081, Vikram, Anjali, DSC-99, CINHTi-1, CINHTi-2, Supriya, Arogya, SIMA CDRA SH-2-4 and ADB-39 in shallow soil. Three different spacing of 45x10, 60x10 and 75x10 cm for medium soil and 45x10, 45x15 and 60x10cm for shallow soil were adapted. The incidence of sucking pests, bollworms and pink bollworm were recorded at 40, 70 and 130 DAS respectively. The sucking pest incidence was low at initial stage of crop (33 DAS). Genotype Anjali recorded lowest jassid nymphs (1.00 jassid nymphs/3 leaves /plant) followed by NH 615 in medium soil and ADB-532 (2.33) in shallow soil at 45x10 cm spacing during 40 DAS. The boll worm incidence was negligible during entire season including peak bollworm stage in both types of soils. Pink bollworm incidence was low in DSC-99 (0.99 % locule damage) and high in SIMA CDRA SH-2-4 at 140 DAS in shallow soil. Among three spacing, 45x10 cm recorded lowest pink bollworm incidence. In medium soil, pink bollworm incidence was low in CINHTi-1 (0.28 % locules damage) and high in Vikram (4.44 % locule damage) at 140 DAS. The lowest jassid incidence was recorded in genotypes NH 615, KC 3 and Vikram in both types of soils. Bollworm incidence was below ETL in all genotypes in both soils. In general it is expected that non-Bt cotton will be affected by bollworms. But in this study the incidence of bollworm was negligible even at peak bollworm stage. In shallow soil, lowest percent disease incidence (PDI) was observed in Arogya (7.13) and CINHTi2 (8.99) for bacterial blight and Suraj (6.66), Arogya (9.44) and ADB 532 (9.44) for grey mildew. Among spacings, 45x10 cm recorded lowest average PDI for bacterial blight (32.0) and grey mildew (11.4). In medium soil, lowest PDI was observed in CINHTi2 (20.75) and ADB 532 (23.93) for bacterial blight and Supriya (3.44) and CINHTi1 (4.55) for grey mildew. 75x10 cm recorded lowest PDI for Myrothecium leaf spot (19.28) and grey mildew (12.74). Among two types of soils, bacterial blight and myrothecium leaf spot incidence were low in shallow soil compared to medium soil with respect to individual genotypes. The average PDI for bacterial blight and grey mildew were almost same for both the soils. The narrow row spacing of 45 cm performed well in shallow soil while wider row spacing of 75 cm performed well in medium soil.

## 53. IMPACT OF INSECTICIDE RESISTANCE MANAGEMENT STRATEGIES IN COTTON ECOSYSTEMS IN NORTH INDIA

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Cotton is cultivated in 11.0 to 12.0 M hectares in India. Genetically Modified cotton with cry (crystal) toxin genes from *Bacillus thuringiensis* (Bt) was introduced in India in 2002 and occupies more than 93.0% of the current area under cotton in India. Cotton is cultivated in about 1.5 M hectares in the three north Indian states, Punjab, Haryana and Rajasthan. Bt cotton occupies more than 95.0% of the area. Bt cotton has been effective in controlling bollworms but are non-toxic to sap-sucking insect pests, predators and parasitoids in the cotton ecosystem. Kranthi (2012) reported that insecticide usage on sucking pests in India increased from 2374 M tonnes in 2006 to 6372 M tonnes in 2011. The reasons ascribed were mainly, the increase in the levels of insecticide resistance in sap-sucking insect pests and the replacement of sucking-pest resistant varieties with the several hybrid cotton varieties. The recent revival CLCuD (Cotton leaf curl virus disease) is also attributed to the increased infestations of the whitefly vector populations in North India.

Insecticide resistance management (IRM) strategies were designed by Central Institute for Cotton Research (CICR) with objectives of ensuring sustainable efficacy of insecticides on sucking pests with least possible disturbance to the natural ecosystems. The strategies rely on varieties resistant to sap-sucking pests, bio-pesticides, spot application methods for systemic insecticides, sequential deployment of insecticides with different modes of action and that cause the least disturbance to the crop ecology, in consonance with the integrated pest management (IPM) practices.

The strategies were disseminated in 10,000 hectares of 9000 farmers in main cotton growing districts of Punjab and Haryana during 2010, 2011 and 2012. Data showed that there was a reduction in populations of sucking pests concomitant with an increase in the populations of generalist predators. Implementation of the IRM strategies resulted in effective pest management, yield enhancement and reduction in number of insecticide sprays. The average population of sucking pests ie leafhopper, whitefly and thrips per three leaves, in IRM villages of Haryana was 2.72, 5.90, and 5.93 in comparison 3.16, 6.72, 6.51, during the three years respectively in non IRM fields. Similarly the average population of leafhopper, whitefly and thrips in IRM villages of Punjab were 0.84, 2.17 and 0.65 in comparison to Non IRM fields i.e. 1.69, 3.39, 1.07 during the three years respectively. The Average number of sprays applied for major sucking insect pests was 2.80 and 5.09 in IRM and 4.03 and 6.55 in Non IRM villages of Haryana and Punjab, respectively. Pest management in the IRM fields was mainly based on neem preparations, entomopathogens and insecticides with a relatively safer rating of WHO classification, in place of the conventional organophosphate, synthetic pyrethroid and neonicotinoid group of pesticides or their mixtures. The overall reduction in usage of synthetic chemicals through a rational approach such as IRM resulted in significant ecological and socio-economic benefits in North India.

## G. DISEASE MANAGEMENT

### 54. GENETIC DIVERGENCE OF FIFTY ISOLATES OF *Rhizoctonia solani* ASSOCIATED WITH DAMPING OFF OF COTTON SEEDLING RECORDED IN BANGLADESH

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An experiment was conducted at the Laboratory of the Department of Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during 2008-2009 cropping season to find out variation in isolates of *R. Solani* isolated from diseased cotton seedling. Total fifty isolates were tested following CRD design with four replications. Based on pathogenicity on cotton seedling multivariate analysis was performed and fifty isolates of the pathogen were classified into five clusters. The cluster I contained ten isolates, cluster II contained five isolates, cluster III contained eight isolates, cluster IV contained maximum of sixteen isolates and eleven isolates were placed in cluster V. Isolates collected from Hilly districts of Bangladesh were more pathogenic than those collected from plain lands.

Key Words: Cotton, *Rhizoctonia Solani,* Genetic divergence.

### 55. REACTION OF COTTON LINES WITH RESISTANCE TO LEAF ROLL DISEASE IN THAILAND

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Cotton Leaf roll caused by virus is the most destructive disease. Yield reduction was up to 63 percent when infection takes place at seedling stage. Effort was made in breeding program to develop new variety with high yield and resistance to leaf roll disease by cooperating with breeder and plant pathologist. Screening cotton lines against leaf roll disease were conducted during 2006-2013at Nakhon Sawan field crops research center. One hundred thirteen lines were evaluated under greenhouse condition and 57 lines were evaluated under field condition. The cotton varieties; DPSL and Takfa 2 were used as susceptible and resistant check respectively. To prepare source of inoculum, aphids were reared and infected plants were multiply for transmission. Screening under greenhouse condition, cotton lines were sown on pot. Leaf roll disease was transmitted by transfer cotton aphids (*Aphis gossypii* Glover) to the tested plants 5 days after planting. Screening

under field condition, the susceptible variety DPSL was planted as spreader rows. Viral aphids were also transferred to seedling within spreader rows. Disease incidence was evaluated 45 days after transmission. Cotton lines were categorized into 3 groups according to disease reaction. The results revealed that 125 lines were classified as resistance, 33 lines were classified as moderately resistance, and 12 lines were classified as susceptible.

## 56. BIOCHEMICAL CHANGES AND PATHOGENESIS RELATED ENZYME ACTIVITIES DURING PATHOGENESIS OF ENTOMOPATHOGENS ON*Phenacoccus solenopsis* (Tinsley).

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Important pathogenesis related enzymes*viz*., chitinase, protease and lipaseactivities on mealybug, *Phenacoccus solenopsis* (Tinsley) during pathogenesis cycle of three entomopathogens *viz*., *Beauveria bassiana*, *Metarhizium anisopliae* and *Verticillium lecanii* was analysed quantitatively and also changes in biochemical constituents during the infection process were quantified calorimetrically during 3$^{rd}$ to 10$^{th}$ day after inoculation of entomopathogens at 24 hours interval. In all the three entomopathogens, enzyme activities increased from 3$^{rd}$ day onwards and on 6$^{th}$ to 7$^{th}$ day, attained its maximum activity and then declined afterwards. Among the three entomopathogens, *M. anisoplea* recorded with maximum enzyme activity. When entomopathogens establishes infection in insect, a sharp depletion in protein, amino acid contents of the body observed in terms of mg/g body weight in the infected larvae. The degree of depletion progressed steadily and continued with the progress of disease development. The total free sugar content of the larvae increased gradually with the advancement of the infection period. This result revealed that enzyme produced by entomopathogens during pathogenesis plays crucial role in various physiological mechanisms of the host insect. This enzyme activity and rapidity of pathogenesis mechanism decides the success of biological control of insects.

## H. FIBRE QUALITY

### 57. EFFECTS OF HARVESTING METHODS ON FIBER QUALITY IN SOME COTTON VARIETIES UNDER CONDITIONS OF CUKUROVA REGION OF TURKEY

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In this study carried out in 2012 in Cukuruva region of Turkey (in Adana province) it was aimed at to determine effects of harvesting methods on fiber quality in some cotton (*Gossypium hirsutum* L.) varieties. Four cotton varieties grown in Adana-Yuregir plain (between Seyhan and Ceyhan rivers) were used as material. Hand picking and machine harvesting methods were applied. The trial was established according to randomized block design with three replications. Ginning outturn and fiber proterties such as fiber length, fiber fineness, fiber strength, fiber maturity, uniformity index, elongation, short fiber index, spinning consistency index, reflectance degree, yellowness, trash count and trash area were investigated.

According to results, trash count, trash area, short fiber index and reflectance degree of varieties were negatively affected by harvesting machine. For fiber length and ginning outturn interaction of variety x harvesting methods was statistically significant.

### 58. CHARACTERISTICS OF COTTON FABRICS PRODUCED FROM SIROSPUN AND PLIED YARNS

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The use of Sirospun yarns eliminates two processing stages in comparison with the two-fold yarns production process and consequently, reduces the cost of production. It is claimed that, it brings many advantages for yarn and fabric quality. However, the benefit of this new concept is still to be investigated extensively.

The aim of this paper is to present and analyses the quality parameters of them (Sirospun yarns and conventional two-fold yarns and fabrics) of counts 50/2 and 80/2 In addition, the yarn properties of single yarn counts 25/1 and 40/1.

Giza 88 Egyptian cotton combed at 18% noils was used. Yarn physical properties including tensile strength, elongation, unevenness and hairiness were measured and compared. The Sirospun yarn values achieved were superb, with regard to yarn strength, elongation and hairiness. The results indicated that increasing the yarn count within the range of Ne 50/2 to Ne 80/2 decreased the hairiness of Sirospun yarn. It is also shown that the hairiness of Sirospun yarns is significantly less than that of two-fold ring spun yarns. According to results, the structural differences between Sirospun and conventional two-

fold yarns had a significant influence on weft direction fabric properties. Weft direction woven from Sirospun yarns were found to have higher tensile strength than fabrics woven from ring two-fold yarns.

The test results regarding color reflectance and color strength (K/S) indicated that there is insignificant difference in color reflectance between the fabrics of Sirospun and conventional two-fold yarns in 80/2 and 50/2 Ne. The Sirospun fabrics recorded slightly lower color strength than the conventional two-fold yarn fabrics. This result reveals that much less dye can be used for the fabrics of Sirospun fabric, so their dyeing cost might be lower for the same depth of shade in comparison to fabrics of conventional two-fold yarns.

## 59. NEW TRENDS IN COTTON GINNING & COTTON SEED PROCESSING

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The optimum utilization of all ingredients of cotton i.e. fibre, cotton seed, cotton stalk has become the necessity for survival in the competitive field of cotton growing and processing. The reduction of electrical power cost and to mechanize the operations in a way that manpower component is reduced to the minimum for complete cotton value processing chain has become necessity due to scarcity of manpower and increase in the price of electricity rates in different countries.

The continuous efforts are being made to address these issues by the manufacturers and scientific community and various new equipments / systems have been introduced in the recent year in the journey of modernization / improvement of various operations in the cotton ginning and cotton seed processing.

The goal is to achieve the optimization in the following areas:

1. The cotton fibre will be ginned in a way that it retains best natural fibre parameters i.e. maximum length, natural luster, and other natural parameters as they are available on the cotton boll when it is grown on plant in the field.
2. To fully utilize the various components of seed cotton i.e. cotton lint, cotton seed, hull, kernel, and oil.
3. To fully utilize the cotton stalk etc. to make various items such as wood pallets, particle boards, biogas, energy generation & compost making.

**Recent Advances in Cotton Processing Technologies:**

The areas in which advances have taken place in the Cotton Processing Technologies may be summarized as below:

(1) Transportation, loading-unloading and feeding of cotton
(2) Moisture control in seed cotton
(3) Efficient cleaning of different varieties of cotton and variable trash contents due to picking / harvesting practices of seed cotton such as varieties of semi-opened cotton bolls, hand stripped cotton, machine stripped cotton, machine picked cotton etc.
(4) Uniform & Proper Feeding of Seed cotton to processing machines to optimize the production quantities.

(5) Power efficient individual gin machine seed cotton feeding system.
(6) Moisture control in cotton lint.
(7) Uniform cotton bale with optimized user friendly and cost effective making of cotton bales on modernized cotton baling presses.
(8) Contamination Free Lint.
(9) Best Spinning Parameters retained after processing.

However area of contamination and trash is continuing to be bad to worse which is primarily due to commercial reasons though the technologies and systems are available to control the same to the maximum extent and the only solution appears to be that with the buyers of the lint cotton and cotton seed or the authorities if they can introduced fool proof methods for quality gradations and realistic standards for allowable trash and contamination limits and the prices of these commodities are totally related to these standards. The details would be seen at length in the full paper.

## I. NEW DEVELOPMENTS

### 60. RECENT ADVANCE IN COTTON PRODUCTION TECHNOLOGIES IN INDIA

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Cotton popularly known as White Gold being a cash crop of the country enjoys a superb status in economic and trade related activities besides sustaining substantial employment generation. Cotton in India is grown in varied soils, climates, and agricultural practices under irrigated and rainfed situations. Approximately 65% of India's cotton is produced under rainfed conditions and 35% on irrigated lands. Cotton is cultivated in three distinct agro-ecological regions (north, central and south) of the country. The northern zone is almost totally irrigated, while the percentage of irrigated area is much lower in the central (23%) and southern zones (40%). Under the rainfed growing conditions rainfall ranges from <400 to > 900 mm coupled with aberrant precipitation patterns over the years leading to large-scale fluctuations in production. Cotton in North India is grown in about 1.5 M hectares in the three states, Punjab, Haryana and Rajasthan. Cotton area in Gujarat increased from 1.54 M hectares in 2000 to 2.6 M hectares in 2010. About 36% of the area (3.9 M hectares) under cotton is in Maharashtra, primarily under rainfed conditions, with the lowest area (3-4%) under irrigation. Consequently the productivity of cotton is the lowest in this state, around 350 kg/ha.

The Government of India through GEAC, Ministry of Environment and Forests considered the proposal for the commercial release of Bt cotton in its meeting held on 26th March, 2002 after consideration, accorded approval for release. Initially it was approved only for the Central (Gujarat, Maharastra & Madhya Pradesh) and South zone states (Tamil Nadu, Andhra Pradesh & Karnataka). GEAC has approved the commercial cultivation of Bt cotton in North Zone from the year 2005-06 and the permission have been given to the four seed companies including Mahyco-Monsanto. During 2007-08 GEAC also approved the Boll Guard II ( BG II) of Bt hybrids for its commercial cultivation. Today there are more than 1000 Bt hybrids containing the different approved events in India. The overwhelming adoption of Bt transgenic cotton by farmers world over is a testimony to the power of this technology (Mayee 2011). Bt cotton was introduced into India in 2002-03 and by 2008-09; it covered around 80% of the area under cotton (Karihaloo and Kumar 2009).

Agronomic performance of transgenic cultivars may vary substantially compared with the non transgenic cultivars or germplasm lines from which they were originally developed (Jenkins et al 1997). The expression of transgene can be influenced by transgene x genetic background effects in part because of the nature of genetic transformation (Sachs et al., 1998) as the transformation technique `randomly incorporates a gene into the host genome that can influence expression of native genes as well as the transgene itself. Therefore, the resulting transgenic cultivar may exhibit different performance from linkage drag effects. Additionally, a host of factors related to the transformation process and background genotype may contribute to agronomic and transgene expression variations in the newly derived germplasm. Thus, candidate transgenic cultivars require testing to evaluate gene x background effects on agronomic performance and transgene expression. Bt transgenic cotton has shown changes in vegetative and reproductive characteristics (Chen et al., 2004). Bt cotton hybrids are compact with optimum number of functional leaves and are more efficient in converting assimilates to the economic parts, the cotton bolls. Bt cotton hybrids prove efficient in retaining higher number of bolls per plant and simultaneously with less boll and/ or locule damage even under bollworm outbreak conditions and resulting in an overall yield advantage of at least 500 kg ha-1 over non Bt cotton hybrids and the checks. Additionally, retention of early formed bolls, synchronous bursting and less labour required for harvest are the other agronomic advantages observed in Bt hybrids. To utilise the full potential of the technology, the agronomic advantages associated with Bt cotton hybrids have to be exploited by modifying or refining the existing package of practices to suit Bt hybrids in different cotton production domains. Moreover, farmers in the cotton growing region continuously need information about appropriate plant spacing to adopt newly evolved cotton genotypes to get optimum seed cotton yield. With this background the present investigation was conducted with two main objectives:

- to study the effect of varying plant population and fertility levels on the productivity of Bt hybrids
- to standardize the fertilizer application schedule for Bt cotton hybrids on Vertisols.

## 61. COTTON SCI-TECH BOOMING UP BUT ITS PRODUCTION TURNING DOWN IN CHINA

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In recent years in China, there were great progresses in scientific and technological studies on cotton but the cotton production went down sharply. Chinese scientists collaborated with ones from USA reported the first draft genome map (*Gossypium raimondii*) and they have constructed the second cotton species genome map (*G.*

*arboreum*) which will be online soon. Laboratories from both China Agricultural University (CAU) and Institute of Cotton Research, Chinese Academy of Agricultural Sciences (ICR-CAAS) have established chloroplast genome (cp-genome) maps of 22 *Gossypium* species and are sequencing cp-genomes of 16 species. The same laboratory from CAU has constructed a mitochondria genome map and got some sights from the comparative analyses on the genome maps between the organelles, and also nucleus. Laboratory from Huazhong Agricultural University applied a patent of ultra-assistant agrobacterium-mediated system of genetic transformation in cotton chloroplast, which may push the organelle into the application of genetic engineering. We have developed the molecular cytogenetic markers to identify individual chromosomes in more than 20 cotton species. Individual cotton chromosomes can be identified and further separated by hands under microscope, which may be a good way to sequence the whole polyploidy genomes like tetraploid cotton species *G. hirsutum* or *G. barbadense*. Genes related to cotton fiber have been cloned and integrated into upland cotton lines. GMO parents with better fiber quality have been released to cotton breeders widely and are considered as the second generation of transgenic cottons in China. Bt cultivars developed by Chinese breeders have been well applied with a percentage of over 98% in whole Bt cotton planting area in 2011 but the figure was about 5% in 1999. Mechanization in whole production procedure is getting higher. Picking machines and harvesting techniques are improved evidently, especially in Xinjiang cotton region. Tolerant mechanism of cotton root system to salinity has been well analyzed and cotton planting technology in salinity soil is improved. Some simplified cotton producing techniques based on substrate seedling were extended by the Chinese Ministry of Agriculture. The amount of cotton patents rose to 602 in 2011 with the average of 387 per year from 2005, more than 5.3 times of the percentage before 2004, which indicates the booming up dramatically in cotton sci-tech in China. However in these years in China, cotton production braked down apparently with a general trend of clearly falling in total planting area and total production, but stable yield with a somewhat rising without significance. In 2013 the total planting area and total production of raw cotton was 4.35 million hectares and 6.31 million tons, respectively, with reductions of 7.2% and 7.7% from 2012. The cotton planting areas both in Yangtze and Yellow river regions fell markedly. Xinjiang cotton region basically sustained or somehow reduced the cotton planting area but the total production of raw cotton increased continually with the percentage of over 50% of Chinese total from 2012. Lower and lower benefit from cotton production was the most important reason for the cotton production declines. There may be many factors leading to the declines but the most crucial ones should include: (1) continuous rising of production cost mainly due to higher and higher cost of labors and production materials, (2) price squeeze from international markets, and (3) disadvantages of the crop of cotton itself mainly because of food safety, as well as land competing with food crops. However cotton still plays non-substitutable role in Chinese national economy and people's livelihood because it is the most important strategic materials and the cotton industry provides over 120 million jobs. Maintaining a reasonable percentage of cotton self-supply is a critical event for cotton safety in China. It is predicted that China needs at least 4.5-5.0 million hectares of cotton planting area or about 6.3-7.0 million tons of raw cotton production per year in future. The changing of the cotton planting regions will continue, possibly expanding in Xinjiang region especially in north Xinjiang, shifting to salinity lands near to coast of the East China Sea, extending to dry land or the secondary salinity soil in North China mainly including the provinces (autonomous region) of Inner Mongolia, Gansu and Hebei. We called the changing as "moving to west, shifting to east and extending to north", which may lead to a new cotton production belt. So cotton sci-tech in China will meet many new demands to follow the changing, mainly including: (1)

machine picking, especially both in Yangtze and Yellow river regions and for the small size farmers in Xinjiang region, to save labors or lower production cost; (2) integrated technology of increasing tolerance to salinity or dry lands; (3) higher yield without higher input, especially in old cotton fields; (4) better fiber quality; (5) inter-specific hybrids (cultivars) between upland and sea-island cottons with lower motes; (6) persistent parent resources to breed cultivars for the above targets.

## 62. ORGANIC COTTON PRODUCTION AND SECTOR DEVELOPMENT IN KYRGYZSTAN

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There are 1.8 million farmers in 162 countries growing organically on more than 37 million hectares of agricultural land worldwide[4]. The organic agriculture helps to build balanced ecosystem, improves socio-economic condition of farmers, provides access to dynamic markets and ensures quality as well as reputation.

Organic cotton production in Kyrgyzstan has started in 2003 as a response to degraded soils, mono-cropping and lack of access to markets for smallholder farmers after the collapse of Soviet Union. The organic cotton production value chain in Kyrgyzstan has proven 27% of net profit over conventional farming[5]. Nowadays, the organic agriculture has attracted great interest at various levels in Kyrgyzstan. Government, donors, private companies, several NGOs and farmers become aware and interested in organic farming. Various actors in the country, i.e. producer groups, traders, support agencies and the government formed an association of all stakeholders, Federation on Organic Movement "Bio-KG'' in 2012. The Federation serves as a national organic umbrella organization, which has been officially launched during the First National Forum on Organic Movement in 2012.

In the same year, the Government of Kyrgyzstan and the National Organic Movement represented by the Federation decided to develop a Kyrgyz Organic National Action Plan (KONAP). The main objective of the KONAP is to set a national policy of Organic Agriculture in the country and promote Organic Agriculture. Additionally KONAP is officially integrated into the National Strategy for Sustainable Development 2013-2017, which was signed by the president in January 2013. The organic movement in Kyrgyzstan has attracted also neighboring countries to join their forces and develop joint regional organic network. The regional network established close cooperation with global IFOAM and is aimed to create regional organic standards.

With growing interest in organic agriculture it is important to create conducive environment for all stakeholders. One of the main preconditions for the Organic Agriculture is protection from genetically modified organisms. The Kyrgyz Government has developed a law to ban all import and production of GMO products in the country.

There are few local initiatives that have already started promoting their products as organic for the local market. However, it is still a long way to go from awareness at all levels to local production and local market demand. On the demand side more marketing, awareness building and the creation of strong branding is needed. On the production side support to new producers, processors and related support services is needed. And for the development of a local organic sector as a whole a supportive legal framework is a prerequisite. One project (or one local actor) is too small to develop the sector. At the same time volatile markets and political and social instability might hinder or slow down the growth of Organic Movement in Kyrgyzstan. Another challenging task for Kyrgyz producers is to ensure high quality and GMO free products when borders remain open and not controlled for GMO contamination. By focusing on consumer awareness and establishing conducive environment for organic agriculture in Kyrgyzstan the Federation can develop a good image and reputation of the country and increase competitiveness for domestic and international markets.

1. Latest Figures and Facts, 2011 www.ifoam.org
2. Centre for Development and Environment, University of Bern, Report on Socio-Economic Impact Study in BioCotton Project, Helvetas Swiss Intercooperation, 2009

## 63. OPPORTUNITIES AND STRATEGIES FOR THE REVIVAL OF *Gossypium arboreum* COTTON IN INDIA

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The *Gossypium arboreum* species (2n=26) , native to India, is commercially cultivated in India, Pakistan and Bangladesh. The arboreumcotton is highly resistant to drought, salinity, sucking pests and diseases like leaf curl virus and root rot. Being hardy, the arboreums adapt well under dryland (rainfed) conditions, marginal soils and low input management situations. Despite these virtues, the area under *G. arboreum* cotton is on a decline. In India, the proportion of arboreum cotton to the total cotton area, which was 97% in 1947, declined to 42% in 1990, further to 28% in 2003 and later plummeted to less than 3% today. Hirsutum cotton hybrids occupy around 90-95% of the cotton area at present.

In the era witnessing unforeseen climatic uncertainties and rising production costs, the current hybrid cotton production systems are not a viable option in several agro-ecological regions. Switching over to *G. arboreum* cotton would be a more sustainable option. The twin challenges for reviving *G. arboreums* today include widening the quality spectrum to enable them to spin at 30–40 counts and to develop appropriate agro-techniques to exploit non-spinnable varieties for non-textile end uses. Some recent R&D efforts have successfully converted these challenges to exciting opportunities. These include standardization of high density planting systems (HDPS) at 2.0 - 2.5 lakh plants/ha to maximize the productivity of popular varieties like RG 8, LD 327, HD 123 and AKA 7. Development of long linted arboreum varieties like PA 255, DLSA 17, MDL

2463 and Jawahar Tapti for increasing the productivity in the drylands of central India and popularizing them among organic cotton producers to avoid contamination from Bt Cotton. Deployment of high yielding *G. arboreum* varieties in those areas of North Zone, designated as hot spots for cotton leaf curl virus. Development of agro-techniques to increase the yield of short staple, coarse textured (6-8 micronaire) *G. arboreums* aimed at providing quality cotton to revamp the surgical/absorbent cotton industry. Organically produced and processed surgical/absorbent cotton is another unexplored niche area having a huge export potential. Variety Phule Dhanwantary, which is amenable to HDPS, was recently released exclusively for surgical end use. The drawbacks of small boll size and shattering in *G. arboreum* was overcome in variety (MDLA BB 1) and hybrid (Swadeshi) utilizing the cernuum race. These big bolled arboreums have rekindled the interest of farmers in the cultivation of arboreum cotton.

Today, the shortage of short staple cotton and favourable price structure offer excellent marketing opportunities for *G. arboreum* cotton. With sound planning and strategic technology placement, the *G. arboreums* can provide a low cost alternative with sovereignty to the hybrid cotton based production system.

## 64. MOBILE PHONE BASED COTTON EXTENSION – EVIDENCES FROM e-KAPAS NETWORK

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India is the first largest cultivator and second largest producer of cotton in the world. Even though it owns the laurels of being first in world acreage and second in production, it has been facing challenges with regard to increasing and sustaining its productivity for many years. Many technologies released from the cotton research system could not bring out a breakthrough in increasing the productivity.Among the various reasons cited for less productivity, lack of information about available yield enhancing cotton technologies is one among the major ones. The information and communication support for cotton crop in the country during last decades had mainly been conventional. The cotton technologies spread through extension personnel was mostly manual which could not reach majority of the cotton farmers spread across ten states of the country. The needs of cotton farmers in these states are much more diversified and knowledge required to address them is beyond the capacity of the grass root level extension functionaries. Hence, in order to speed up the diffusion of technologies from the research system to the end users, Central Institute for Cotton Research has been executing a novel extension mechanism called "e-Kapas network" foreffective knowledge transfer. Disseminating cotton technologies through regular voice SMS alerts in local language to the cotton growers registered with e-Kapas network is the major mandate of this project. Under this project, in Tamil Nadu, 7406 farmers had registered with e-Kapas network from major cotton growing districts. So far 27864 voice SMS alerts have been sent to the registered growers. In order to know the effectiveness of the new extension mechanism, an evaluation was conducted among randomly selected 370 regular attendees of e-Kapas alerts in Tamil Nadu through personal and phone interviews. Majority of them acknowledged the receipt of timely, relevant, new and actionable information about cotton cultivation. More than one third of them accredited that they had demonstrated the new technologies heard through the alerts. More than half of them agreed that there were changes in their crop management practices due to e-Kapas alerts. Majority of them believed that mobile phones significantly reduced their costs for accessing information on cotton technologies and provided them a chance to use the ICT based extension service. Cent per cent of them expressed their willingness to continue in the network and more than half of them demanded quality information on locality suited genotypes, availability of seeds, weather, price and market along with the production and protection technologies. Majority of them stressed upon the need for location and season specific information alerts. More than half of them demanded for a call back system to clarify their doubts then and there. Less than one third of them suggested reducing the duration of the call from 60 seconds to 30 seconds. For sustaining the service, majority of them suggested to charge a nominal registration fee to the e-Kapas network farmers in near future. Invalid numbers, ring timeout, DND registration and congestion were the major constraints experienced in receiving e-Kapas alerts.

## 65. IMPACT OF CLIMATE CHANGE ON COTTON PRODUCTION IN PAKISTAN AND RESEARCH PRIORITIES

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Pakistan is a major cotton producer in the World. Climate change has adversely affected Pakistan and already existing problem of drought and salinity for agricultural production has worsened due to climate change after-effects. In post-climate change scenario, there is a need to accelerate efforts to breed cotton cultivars giving stable fibre yields under adverse environmental conditions. Molecular mapping approaches are greatly facilitating traditional crop breeding approach by reducing time and cost to develop elite cultivars with desirable characteristics. By using linkage and association mapping approaches, significant markers have been identified linked to drought and salinity tolerance related traits in cotton (*Gossypiumhirsutum* L.). These identified markers are being utilized in molecular breeding for developing elite cotton cultivars resistant to drought and salinity stress. These cultivars will have potential to give sustained yield under climate change scenario.

## 66. ASIAN INTRA-REGIONAL COTTON & TEXTILE TRADE, STRATEGIC IMPERATIVES

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This paper highlights the significance of the Asia as leader in global cotton and textiles market, as, it produces more than 60 percent and consumes more than 65 percent of world cotton. The paper pinpoints imperatives that Asian cotton producing countries need to address in order to strengthen intra-region trade and tap the opportunities in cotton and textiles trade from the paradigm shift that is taking place by significant decrease in cotton production and consumption in the world other than Asia. In 2011-12, the Asian region produced 17 million metric tons,that comprises 61 percent of the world cotton production. Simultaneously, in 2012-13, the region produced 16.60 million metric tons, which comprises 62 percent and in 2013-14, the region produced 16.03 million metric tons which comprises 62.30 percent of the world cotton production (ICAC, 2014). By the same token, the average cotton consumption of the Asian region is about 15.2 million metric tons, which comprises 65 percent of the total world consumption. Statistical analysis reveals that demand for cotton and textiles from Asia, is likely to increase as cotton production and consumption by developed countries is on decline and have already lost the cost competitiveness in textiles. Cotton and textile Companies, in developed countries, are in search of location in the low cost countries of Asia for business activities. The phenomenon has resulted in increased demand for cotton and textiles from rising Asian economies, like, China, India, Pakistan, Uzbekistan and Bangladesh. This paradigm shift is about to shift global balance of economic power to Asia.