1. Executive Summary

1.1 Crop Improvement

Nagpur

- Germplasm collection of 10,597 accessions of cotton were maintained in the Gene Bank of the Institute. In all, 2650 germplasm lines including 1300 *G. hirsutum*, 800 *G. arboreum* and 550 *G. herbaceum* were rejuvenated. Genbank was enriched with 44 new germplasm comprising races of cultivated species and exotic germplasm of cotton.
- Four introgressed derivatives *viz.* Vaidehi 95 (MSH-53), NISC - 40, NISC - 43, and NISC - 44 with tolerance against bollworms, jassids and CLCuV were registered with NBPGR.
- An introgressed derivative generated from a cross between LH1134 and *G. hirsutum* race *palmeri* showed the highest fibre strength (29.0 g/tex) in F_4 generation.
- Nineteen long linted (staple length 30-33 mm), 10 high fibre strength (25.2 -26.7 g/tex) and 150 waterlogging tolerant accessions were identified based on evaluation of 5000 *G. hirstum* germplasm.
- Preliminary evaluation of 565 *G. herbaceum* accessions led to identification of 6 early maturing, 5 big boll and 6 high yielding promising accessions.
- Twenty germplasm lines of *G. arboreum* with traits desirable for surgical cotton (micronaire >7 and boll weight >4 g) were identified from germplasm.
- Four promising brown-linted *G. arboreum* accessions with boll weight upto 5.2 g and GOT upto 40.7% were developed by crossing race *cernuum* with *G. arboreum* races *indicum* and *bengalense.*
- Fifty germplasm lines including 14 perennials, 22 landraces and 14 traditional cultivars belonging to *G. arboreum*, *G. herbaceum* and *G. barbadense* were collected from Andhra Pradesh, Maharashtra, Tripura, Gujarat and Tamil Nadu. Some perennial *G. barbadense* cotton possessed coarse fiber with high micronaire (5.8-6.4).
- One hundred and thirty seven CMS (*harknessii* based), 15 CMS (*G. aridum* based), 19 GMS lines, 57 restorer and one GMS line developed through induced mutation were maintained. GMS version of PKV 081, AK 32, Suman, Sharda and L 147 were developed.
- *Desi* hybrids (Intra-*arboreum*) with high degree of heterobeltiosis (106.5%) for yield coupled with tolerance against grey mildew, big bolls and high boll retentivity were developed by crossing promising *desi* cottons varieties and *G. arboreum* race '*cernuum*'.
- Drought tolerant selection DTS 155 recorded 124% higher yield over the check with a high GOT of 41.54% under rainfed condition.
- *G. hirsutum* cultures CNH 8-20-R and CNH 9-22-R developed from crosses involving jassid tolerant wild species (*G. raimondii)* exhibited not only earliness (140-145 days) but also high yield potential and jassid resistance.
- A jassid tolerant culture CNH 8002-6 recorded promising seed cotton yield (2183 kg/ha) with staple length of 29.5 mm and fibre strength of 22.5 g/tex. Besides, 6 advance cultures *viz.* CNH07-12, CNH 07-2, CNH 08-11, of CNH 07-34, CNH 07-10 and CNH 08-55 were found jassid tolerant and early maturing (145-150 days).
- A promising *G. hirsutum* culture with big bolls ranging from 5.9-7.9 g in F_4 generation was identified. The culture possessed staple length of 25.6 mm, strength of 22 g/tex with ideal S /L ratio (0.86) and desired fineness (mic. 4).
- Four out of 14 *G. hirsutum* and *G. arboreum* cultures sponsored in AICCIP trials during 2012-13, *viz.*, CSH1110, CNH 28 I, CNH 1109 and CNA 1016, were promoted further based on superior performance in initial evaluation trials.
- Sixteen advanced cultures of *G. arboreum* and *G. hirsutum* evaluated and found promising in the Institute trials were sponsored for AICCIP trials for 2013-14.
- Amongst 18 breeding lines of heterotic pool evaluated in high density (45 × 20 cm), four lines recorded seed cotton yield of 3000 kg/ha (CNH7008-1), 29 (CNH 7012-13), 28 (CNH 7012-6) and 27 q/ha (CNH 7012-11). Besides recording high yield, CNH 7012-13 also combined desirable staple length (27.9 mm.) with bundle strength (23.7 g/tex).
- CNA1003 documented highest seed cotton yield (1806 kg/ha) out of 17 *G. arboreum* genotypes evaluated under State Multi-Varietal Trial.

- Parental polymorphism for fiber quality traits (*G. arboreum* cv. KWAN-3 and *G. herbaceum* cv. Jaydhar) was surveyed using 1098 SSR markers based on which 77 polymorphic markers were identified. Genotyping of F2 mapping population with 15 informative markers was completed.
- In *G. hirsutum*, parental polymorphism (for the parental lines having contrasting fiber quality traits, used for development of RIL population) was surveyed using 1098 SSR markers based on which 92 informative markers were identified.
- Bacterial blight resistant (S295) and susceptible genotype (Ganganagar Ageti) were screened for polymorphism using 400 SSR markers, based on which 4 SSR markers were found informative.
- RNAi-mediated transgenic cotton showing delayed pathogenesis documented 4-9 fold reduction in virus titre, while plants that remained symptomless showed >12-fold reduction in viral load.
- Five new RNAi events of dsRNAi-CP were generated in *G. hirsutum* cultivar LH 2076. The T_0 plants were found positive for the viral inverted repeat sequence.
- Transgenic PA 255-*chi*1 cotton showed 44.48% - 90.15% higher chitinase activity compared to wild type untransformed cotton. Plants also showed reduced lesion size and delayed pathogenesis of Myrothecium leafspot had grey mildew of cotton.
- The full-length genome of one of the resistant breaking, recombinant isolates of leaf curl virus of cotton was characterized for the purpose of designing dsRNAi sequence for development of multigene construct.
- Heritability of gossypol gland density based on analysis of *G. hirsutum* and *G. arboreum* varieties revealed that it could serve as an additional trait for DUS testing of cotton.
- Based on DNA fingerprinting using 25 SSR markers, *G. hirsutum* cv. HS-6 could be distinctly identified from among 50 candidate cultivars using BNL3371 and DPL468.
- Seed treatment with H_2O_2, improved germinability and seedling weight through reduction in release of volatile aldehydes and electrical conductivity and improvement in peroxidase and catalase activities under laboratory conditions.
- About 170 q quality seeds of cotton (including breeder seed of Suraj and DS-5, female parent of CICR 2; TFL seeds of *G. arboreum* race *cernuum* and 20 varieties of cotton), pigeon pea and chick pea worth Rs. 16.0 lakhs was produced.

Coimbatore

- Fibre quality evaluation of 1532 *Gossypium hirsutum* germplasm revealed accessions with 2.5% span length ranging from 18.9 – 34.5 mm and bundle strength ranging from 9.2-26.4 g/tex.
- Medium staple culture CCH 2623 showed promising yields both in Central and South zones with seed cotton yield of 1739 and 1798 kg/ha respectively, in Central and South zone.
- In the Initial Evaluation Trial (IET) of *G. hirsutum* varieties under irrigated condition, culture CCH 12-2 ranked 5th overall documenting seed cotton yield of 1854 kg/ha and in South zone while, culture CCH 12-6 – a compact *G. hirsutum* genotype excelled both in central and south zone locations in IET for compact genotypes under irrigated conditions.
- In the preliminary varietal trial of AICCIP in central zone locations, the culture CCH 11-2 recorded seed cotton yield of 1969 kg/ha with superior fibre quality.
- In the station trial, the highest seed cotton yield was recorded in MM 05-38-2-4 (1560 kg/ha).
- The highest seed cotton yield was recorded in a compact genotype PI-36-3-5-2-Bk (1433 kg/ha) grown at close spacing (75 x 30 cm) while a compact genotype PI-42-2-2-1-Bk possessed big bolls >5.3 g.
- *G.hirsutum* genotype CCH 4474 evaluated previously in AICCIP trials showed consistency in high bundle strength (25.9 g/tex) and long staple length (33.5 mm) when re-evaluated in station trial.
- A spontaneous lintless mutant of MCU 5 was identified. The mutant could serve as ideal candidate for characterization of genes involved in fibre development.
- Fourteen early maturing *G. barbadense* genotypes that matured in 153-159 days as compared to cultivated Suvin that matures in 210 days were identified.
- Twenty six *G. barbadense* accessions with long staple length, 18 accessions with high strength and 36 accessions with high micronaire values were identified from *G. barbadense* germplasm.
- Two promising *G. barbadense* cultures CCB-11 (1150 kg/ha) and CCB-5 (1100 kg/ha) were significantly better than Suvin in terms of seed cotton yield.
- DUS testing of 54 *G. hirsutum* varieties and 2 *G. arboreum* candidate varieties were completed. Besides, Plant Variety Registration Certificate for eight extant cotton varieties have been received

during 2012-13.

- Polymer coating of seeds with Polykote alone @ 3 ml/kg seed, polykote with Imidacloprid @ 6 ml / kg seed, Polykote with Vitavax @ 2 g/kg seed or Polyloc with Bavistin @ 2 g/kg were found effective in maintaining viability of seeds and ensuring higher productivity.
- Seed hydration followed by dressing with Thiram @ 0.25% or seed soaking in H_2O_2 @ 40 mM or seed soaking in succinic acid @ 0.2% before sowing enhanced productivity of cotton.
- Seeds exposed to magnetic pulse at an intensity of 750nT significantly enhanced their viability irrespective of cotton genotypes studied.

Sirsa

- A high yielding *G. hirsutum* culture CSH 3129 was recommended for Agronomy trial based on its superior performance over four years in AICCIP. Proposal for its identification has been submitted.
- Two promising cultures each of *G. hirsutum* (CSH 3114 and 2982) and *G. arboreum* (CISA 8 and 111) were sponsored in IET of AICCIP in irrigated and rainfed zones.
- Based on their superior performance in National trials, genotype CSH 3088 was promoted to zonal trial (north & south zone) in irrigated condition, while GMS based hybrid CISAA 20 was promoted to coordinated hybrid trial (central zone) under irrigated and rainfed conditions.
- GMS based hybrid one each for *G. hirsutum* (CSHG 2118) and *G. arboreum* (CISAA 22) were also sponsored in AICCIP preliminary hybrid trials under irrigated and rainfed conditions.
- The genotype CSH 2931 gave highest seed cotton yield of 2986 kg/ha with minimum CLCuV incidence of 2.5 PDI.
- Thirteen F_5 progenies with >40% GOT were identified from a cross between high GOT line SA-977 and low GOT line SA-112.

1.2 Crop Production

Nagpur

- Under high density planting system (HDPS), on Vertic Inceptisol, yield at 45 x 15 cm and 60 x 15 cm were at par and superior to 90 x 15 cm. ADB 39 (3000 kg/ha), PKV 081 (3011 kg/ha) and LRK 516 (2814 kg/ha) performed well at 45 x 15 cm spacing whereas NH 545 (2830 kg/ha), KC 3 (3113 kg/ha) and Suraj (2976 kg/ha) performed best at 60 x 15 cm spacing. Growth regulators *viz.* Mepiquat chloride and Stance (Mepiquat chloride + cyclanilide) reduced height, decreased height/node ratio, increased boll weight and delayed maturity but did not increase yield. Weeds in HDPS system could be managed with pendimethalin @ 1 kg/ha + 2 intercultures $_+$ 1 HW + 1 post-emergence spray of Pyrthibac Na @ 75 g a.i. /ha + Quizalofop ethyl @ 50 g/ha.
- Yield of *G. arboreum* race *cernuum* cotton was higher at 45 x 15 cm (2481 kg/ha) and 60 x 15 cm (1879 kg/ha) spacing. Response to Mepiquat chloride application @ 50 g a.i./ha was significant and the mean yield advantage was 19.7%. Mepiquat chloride treated plants were dwarf, had higher leaf N, were compact and had bigger bolls.
- Among field cover crops evaluated, *Sorghum* was found to be the most effective in weed suppression. Mulch of tree species such as neem, eucalyptus showing allelopathic effects also suppressed weed emergence.
- A conceptual trolley mounted Chain type and Peg type picker was fabricated with fixed row to row spacing of 80 cm and was tested in the field on H 6 hybrid, PKV 081 and Suraj.
- Suraj was demonstrated on more than 5 ha with an average production of 3.4 bales/ha (1400 kg seed cotton/ha). Truthfully labeled seed to an extent of 3.5 t was also produced.

Coimbatore

- Wheat, barley and sun hemp suppressed the weeds efficiently and significantly enhanced the seed cotton yield. Allelopathic effect of sunflower not only suppressed weeds but also the cotton crop and lowered seed cotton yield and hence is not suitable to grow as cover crop with cotton.
- Weeds in cotton could be managed by integrated approach with application of pre emergence pendimethalin @ 1.0 kg on third day of cotton sowing followed by growing of *in-situ* cover crops and application as mulch around 35 - 40 DAS combined with one hand weeding around 70 -75 DAS.
- Recommended NPK along with cotton stalk compost (2.5 t/ha) prepared by improved composting procedure (with or without microbes) were on par with recommended NPK + 12.5 t/ha of FYM (recommended INM) for yield attributes and seed cotton yield.
- Biodegradable polyethylene mulching controlled weeds throughout the growing season under organic cotton production system.

1.3 Crop Protection

Nagpur

- Diversity reduction of mealy bugs over previous year was recorded in cotton + pigeonpea - fallow cropping system of Central India. *P. solenopsis* and *Nippaecoccus viridis* were recorded in traces at few locations of farmers' field. *Paracoccus marginatus* was recorded on cotton from Aurangabad and on Hibiscus from Nagpur. The parasitization of *P. solenopsis* by *A. bambawalei* ranged from 2.36 to 34% in the survey conducted from 43 locations of central India.
- The maximum whitefly population of 3.7 and 3.2 /plant was recorded during 38 and 39 SW respectively when the maximum and minimum temperature ranged 32-35 ^{0}C and 23-25 ^{0}C with corresponding RH (%) at 81-90 (max) to 50-61 (min). Leaf hopper activity and damage were at its peak with population ranging between 8 to 18.44 leafhoppers/ 3 leaves/ plant during 33-36 SW coinciding with heavy rainfall.
- Mirid population was negatively correlated with temperature minimum and maximum, RH minimum and maximum and rainfall but not with rainy days. Weather based population prediction model for mirid *C. livida* was developed with accuracy of 88.24% and revalidated in the current season with prediction accuracy of 89.47%.
- Insecticides - neem oil, NSKE, Acephate; fungicide - Bavistin; growth regulator- Mepiquat chloride were found to be compatible at recommended doses with no phytotoxicty and may be used as tank mixes to reduce the number of sprays in HDPS cotton.
- Out of 39 genotypes screened through artificial spray inoculation by pinprick method against bacterial blight *Xanthomonas campestris* pv. *malvacearum*, 13 were found to be immune. Out of these 13 immune lines, 9 were found to be positive for the marker CIR 246 (146 bp) and 4 were found to be negative. All the 26 susceptible lines were found to be marker positive (156 &166 bp) for susceptibility. CIR 246 marker is best for screening as it segregates for single locus (146 bp for resistance and 156 &166 bp for susceptible) when compared to the markers BNL 3545 and BNL 3644 as they segregate over more than two loci.
- Imidacloprid + Thiram + *Trichoderma viride* seed treatment were found to be statistically significant in improving shoot length and biomass production under field conditions in var. Suraj sown under HDPS. Imidacloprid was better for sucking pest control (jassids and thrips) compared to Acephate (44 and 55 DAS).
- Four nanoparticles were synthesized and characterized using particle size analyser. Chitosan nanoparticle size ranged from 60-80 nm with Zeta potential of – 7.24 mV and mesoporous silica from 250-330 nm with 38.32 mV. Kaolin nanoparticle size ranged from 300- 380 nm with Zeta potential of 31.33 mV and cellulose nanoparticles from 200-250 nm with -16 mV.
- Among different treatments for sucking pest control, lowest incidence of aphids, jassids, whiteflies and thrips was recorded in Flonicamid treatment which was statistically superior over other treatments.
- At Nagpur, the incidence of pink bollworm larvae and per cent locules damage was nil on *Bt* cotton on RCH2 BG-II and MRC6301. The incidence of pink bollworm larvae on non-*Bt* hybrid was high at 175 DAS. The pink bollworm larval recovery from bolls collected on Bollgard cotton on farmer's fields in Junagarh and Khandwa was 18.67% and 8% respectively.
- Bioassays with *cry1Ac* on pink bollworm populations using discriminatory doses recorded cent per cent mortality at 10 ppm except for populations from Jalgaon, Aurangabad and Raichur.
- A novel plant expression vector designated as pEV-CICR has been constructed with multiple cloning sites introduced for flexibility in cloning gene of interest under double 35S promoter and NOS terminator.
- A hydrophobin gene, known to improve protein expression, has been cloned from *Trichoderma virens*. A novel *Trichoderma* gene (*tel1*) harboring both endotoxin and lectin domain has been cloned in *E. coli* expression vector.
- Three novel isolates of *Trichoderma* have been evaluated in green house and one, *T. harzianum* CICR-G has been selected and formulated as TrichoCASH and introduced into the All India Coordinated Cotton Improvement Project for field trials as biocontrol agents against soil borne diseases of cotton.
- *Root rot pathogen Sclerotium delphinii* is reported as a new record on cotton which was so far considered as a non-host crop.
- Compost based formulations fortified with *Calothrix* sp, *Anabaena* sp. or *Providencia* increased germination by 10-15%, fresh weight, plant height

and microbiological activity along with 20-50% increased available nitrogen in soil and significant improvement in plant growth compared to other treatments.

- The concept of "refugia-in-bag" for Bollgard II was evaluated at 6 centres using RCH134, 5% refugia was found to yield on par with 100% Bollgard II in completely randomized block design with no compromise in bollworm control.
- Lectins from *Colocasia esculentum* and *Amorphophallus paenifolius* were evaluated for their direct toxicity to *Chrysoperla carnea.* The lectins in abdomens (quantified using ELISA) of live and dead treated *Chrysoperla* grubs and adults indicated that these lectins affect the predator adversely.
- Using gene sequence primers for the same and related species, chitin synthase B (CSB), Juvenile hormone acid methyltransferase (JHAMT) and Juvenile hormone epoxide hydrolase (JHEH) were amplified from *Helicoverpa armigera*. Partial coding sequence of chitin synthase B was reported for first time in *Helicoverpa armigera.*
- Suppression subtractive hybridization (SSH) library was generated using Pooled midgut tissue from 3rd, 4th and 5th instar larvae of *Helicoverpa armigera* that was used as tester and rest of the tissue was pooled from the same instars and used as driver.
- From the first batch of SSH library sequencing, 27 differentially expressed genes of *Helicoverpa armigera* midgut tissue were identified. Among them, 15 sequences showed no similarity with available sequences in NCBI database, that provided hints towards the discovery of novel genes that may have potential to affect the insect physiology or metabolism using RNAi technology. Nine genes (three sequences from no similarity group – B06, D03, E09 and C06, one each from serine proteases and α-amylase sequence) along with sequences of chitin synthase B, Juvenile hormone acid methyl transferase (JHAMT) and Juvenile hormone epoxide hydrolase (JHEH) were subjected to insect bioassay using diet incorporation method.
- Bioassay results indicated that dsRNA generated against Chitin synthase B and two unreported genes were very effective in growth regulation of *H. armigera.*
- CICR truncated *cry1Ac* and CICR fusion gene were very effective against early instar *H. armigera* in preliminary log dose probit assays.
- *H. armigera* populations collected from chickpea and pigeon pea from 14 districts (2012-13) were subjected to log dose probit assays with *cry1Ac* (MVPII) in the F_1 generation. The LC_{50} was found to vary from 0.105 µg/ml of diet (Amravati) to 1.453 µg/ml of diet (Jalna).
- LC_{50} was calculated from the log dose probit bioassays with populations from 3 districts *viz.* Coimbatore, Salem and Nagpur with *cry2Ab* and the LC_{50} value was found to be 1.25, 0.45 and 0.57 µg/ml of diet, respectively. In 10 other populations *cry2Ab* did not exhibit larval mortality but exhibited growth regulation instead.

Coimbatore

- Seven fungal cultures and three bacterial cultures were isolated as endophytes from leaves and stem portion of cotton plant.
- Three bacterial endosymbionts were isolated from *H. armigera* larval gut.
- Experiment on effect of antibiotic (streptomycin) at different concentrations by addition in diet on biological parameters *H. amrigera*, revealed that there was prolongation of growth period, larva-adult intermediaries, gynandropmorph adult was observed at high concentration (1.5 g/l) of antibiotic treatment.
- Wide spectrum activity (insecticidal, fungicidal and nematicidal) of a native entomopathogenic fungus, *L. lecanii* was reported.
- Antagonism of *X. stockiae* to plant pathogenic and entomopathogenic fungi was recorded.
- Occurrence of a new entomopathogenic fungus, *Cladosporium cladosporioides* (Fresen.) deVries from aphid was recorded. Pathogenicity was proved under laboratory condition.

Sirsa

- Peak catch of pink bollworm moths was recorded during 40th SMW (1st Oct. to 7th Oct. 2012), America bollworm during 13th SMW (26th March to 1st April 2012), Tobacco caterpillar moths during 19th SMW (7th to 13th May 2012) and Spotted bollworm moths was observed during 40th SMW (1st Oct. to 7th Oct. 2012).
- Based on pooled result of two years, Cow urine, kresoxim methyl, calcium nitrate, whey protein and neem oil were promising in reducing CLCuD incidence.