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ICAR

ANNUAL REPORT 2012-13

CENTRAL INSTITUTE FOR

COTTON

RESEARCH, NAGPUR

केन्द्रीय कपास अनुसंधान संस्थान, नागपुर

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CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

Preface

Cotton yield continues to be stable at about 500 kg lint per hectare over the past six years. The country harvested 340 lakh bales from 117.73 lakh hectares during the year 2012-13. More than 93.0% of the cotton area was under Bt hybrids. Interestingly, an outbreak of the cotton bollworm Helicoverpa armigera which caused severe damage to non-Bt cotton went unnoticed, because of the wide-spread cultivation of Bt cotton. Cotton prices fluctuated unpredictably over the season with highest at Rs 38,016 per candy (355.62 kg lint) of Sankar-6. Prices declined and fluctuated again, but reached higher levels by March.

During the year, new research initiatives were taken up at the institute. The institute pioneered a new concept of 'High density Planting Systems' (HDPS) that has potential to obtain high yields in rain-fed farming systems, especially in Maharashtra, Madhya Pradesh and Andhra Pradesh. Research conducted at CICR showed that, on marginal soils in rainfed conditions, high density planting system with early sown short duration varieties was an ideal approach for improving productivity in the rain-fed regions. Dr M. V. Venugopalan identified some early maturing compact plant types with shorter sympodia (fruiting branches) and tested them under high density planting system for 3 years during 2009-2011. Encouraged with the three year experimental farm results, the CICR took the technology to farmer fields through farmer participatory trials of HDPS in marginal soils under rain-fed conditions of one-acre (0.4 ha) fields of 155 farmers in the eight cotton growing districts of Vidarbha during the kharif season of 2012. The varieties Suraj, NH615 and PKV081 were planted at 45x10 cm or 60x10 cm spacing with early onset of monsoon. The farmer participatory trials were conducted with active participation of the State Agricultural Department and the KVKs. Despite delayed onset and erratic monsoon during 2012, the yields averaged at 11 to 18 quintals per hectare in the districts. The highest yield averages of 15 to 18 quintals per hectare in Akola and Yavatmal respectively are about double the normal average in these districts and also that of Vidarbha. However, development of compact varieties which are ideally suited for HDPS may result in higher yields in future.

The institute launched a 'weekly cotton Advisory' on the CICR web-site. The advisory was coordinated by Dr A. H. Prakash through the AICCIP net-work and was ably supported by the Heads of Divisions and Dr Isabella Agarwal. Mr M. Sabesh designed the advisories commendably. The advisory received special appreciation by the Cotton Advisory Board and many other agencies. A new program, 'E-Kapas' –a mobile voice mail based alert to cotton farmers in local languages through net-working approach all across the 10 cotton growing states, was also launched.

Some achievements by scientists of the institute were truly outstanding. Dr V. N. Waghmare co-authored a paper with Dr Andrew H Paterson, University of Georgia, on the first draft sequence of the cotton genome published in Nature on 20th December 2012. Dr Sandhya Kranthi, Dr Raghavendra and Dr K. R. Kranthi discovered some new target gene ESTs specific to the mid-gut of Helicoverpa armigera as candidates for RNAi. They also developed two new multi-gene constructs. Dr Prasun Mukherjee developed a new biopesticide formulation called TRICHOCASH using a new highly effective strain of Trichoderma harzianum. Dr P. K. Chakrabarty developed cultures with high boll weight of 8.0 grams and Dr Vinita Gotmare developed cultures with high strength of 29 g/tex. Dr S.E.S.A. Khader developed a new system of ratooning of Bt cotton hybrids, without any decline in the Cry1Ac expression in the ratoon crop. Er Gautam Majumdar discovered that a simple small-scale combine harvester could be modified into a cotton picker. Er Majumdar also developed a simple, but extremely useful 'wick applicator' that can be used in a target specific manner to kill weeds using broad spectrum weedicides. Under the Technical Assistance Programme (TAP) for Africa, two international trainings on 'Modern cotton production technologies' and 'Relevance and Techniques of Organic Cotton Production' were ably coordinated by Dr. Blaise Desouza and Dr A.H. Prakash. The trainings received 'excellent' rating by the 38 participants from seven countries.

Dr S. Ayyappan, Secretary DARE and DG ICAR, is the main source of inspiration for the progress made. Dr S. K. Datta, DDG (CS) has been the guiding force for the excellent scientific achievements made by our scientists. I gratefully acknowledge the motivation provided by Dr C. D. Mayee, Chairman QRT, Dr S.A Patil, Chairman RAC and Dr N Gopalakrishnan, ADG (CC) for all our R&D endeavors. The Heads of Divisions Dr P. K. Chakrabarty, Dr Sandhya Kranthi and Dr Blaise Desouza, and Dr D. Monga, Head, Regional Station, Sirsa, and Dr A. H. Prakash, PC and Head, Regional Station, Coimbatore deserve appreciation for their inputs and editorial assistance. I would like to personally thank Dr M. V. Venugopalan, Dr M. S. Yadav and Mrs Vandana Satish for their supreme dedication to work and outstanding efforts.

(K. R. Kranthi)

Contents

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 BNL 3371 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.

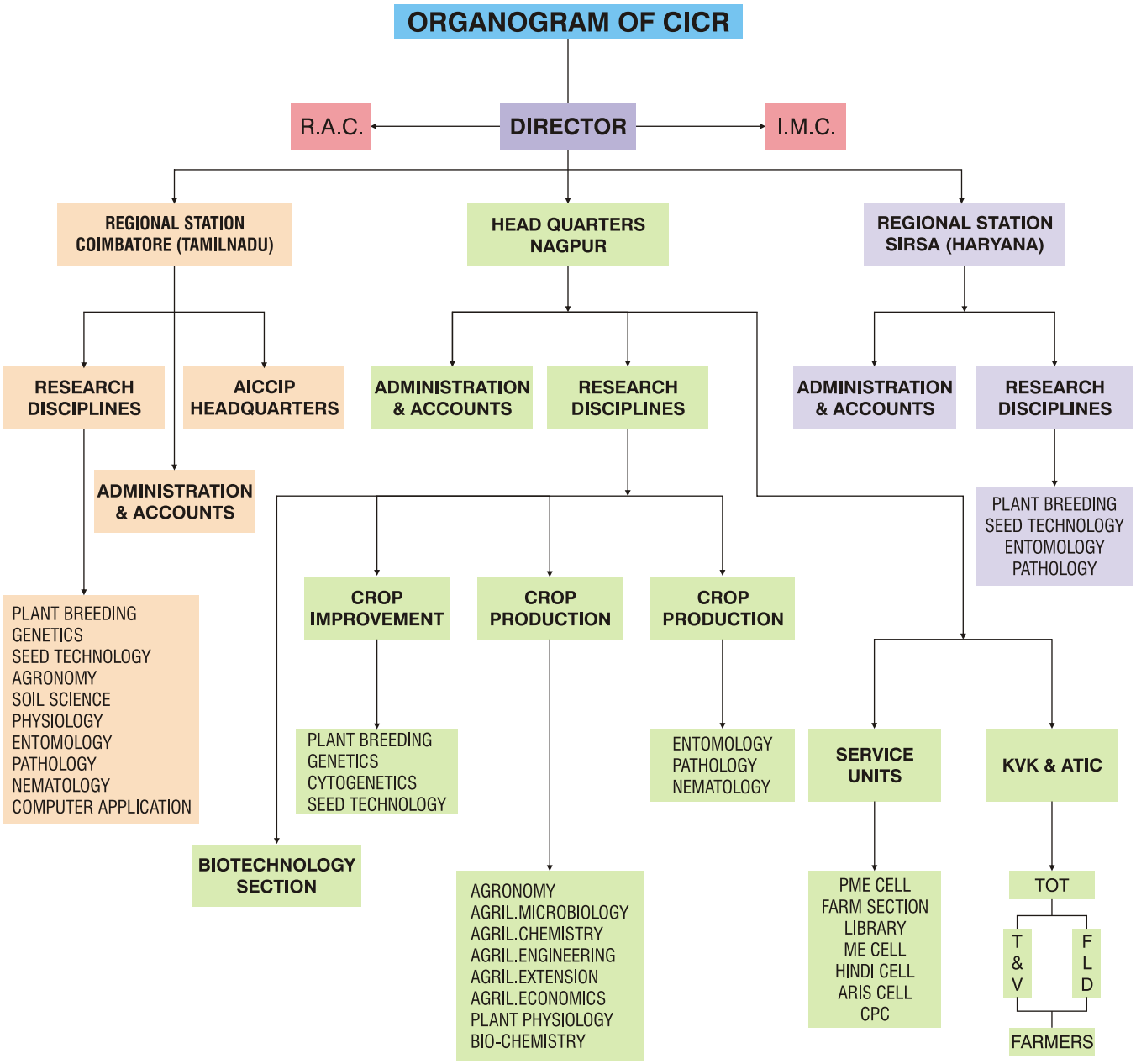
2. Introduction

2.1 : Brief History

- The Central Institute for Cotton Research was established at Nagpur by the ICAR, in 1976. The two regional stations of IARI at Sirsa (Haryana) and Coimbatore (Tamil Nadu) were transferred to CICR to cater to the needs of north and south India, respectively.

2.2 : Mandate

- To conduct basic and strategic research on cotton to improve yield, fibre quality and by-products.
- To create new genetic variability for location-specific adoption in cotton-based cropping systems.
- To assist in the transfer of modern cotton production technology to various user agencies.
- To extend consultancy and linkage with international agencies to accomplish the above mandate.



2.3: Production, Process and Technologies Developed during last five years

- Twenty-eight (28) genetic stocks (G. hirsutum – 22 and G. arboreum – 6) have been registered with NBPGR, New Delhi for their unique, novel economically/ commercially useful and distinct characteristics.
- Six high yielding cotton varieties / hybrids resistant to biotic and abiotic stresses with improved fibre qualities were released.

Sr. No.	Varieties/ Hybrids	Year of release	Spinning potential (counts)	Area of adaptability	Special qualities
	G. hirsutum				
1	CCH 510-4 (Suraj)	2008	60s	Irrigated : South & Central zone.	Superior fibre quality and tolerant to jassids
2	CNHO12 (Saraswati)	2009	20s	Central zone	Dwarf stature, early maturity, high seed oil content with synchronous boll bursting
	G. arboreum				
3	CISA 614	2010		North zone	Superior fibre quality
4	CNA 1003 (Roja)	2011	20s	Rainfed: South Zone	Medium to long staple cotton variety comparable to upland genotypes for seed cotton yield and fibre quality
	Intra-specific hybrid (Intra *hirsutum*)				
5	CSHH 243	2007	50s	Irrigated areas of north zone.	CLCuV resistant. (2420 CSP value at 50s counts, 2088 at 60s counts)
6	CSHG 1862	2011	40s	Irrigated areas of north zone.	A GMS based hybrid

- **Strategy for hybrid development :** A Thermosensitive Genetic Male sterile line (TGMS 1-1) was identified and characterized in desi cotton (G. arboreum). It produces completely male fertile flowers at minimum temperature of less than 18°C and produces completely male sterile flowers at minimum temperature more than 24°C with continuous good sunshine. Complete male sterility could be obtained only during summer flowering (i.e. month of May) for consecutive four years. This line could be successfully employed for hybrid seed production in summer with 30% boll setting efficiency.
- **Gene constructs developed and gene sequences catalogued**

  Two inverted repeat generating plasmids and five hair-pin constructs for RNAi mediated targeting of CLCuV in transgenic cotton were developed and catalogued in Gene Bank .

  Pollen tube pathway transformation was developed for direct gene transfer into cotton plants. The process is under validation.

  To silence gossypol biosynthesis in cotton seed through RNA interference, RNAi construct was generated for target gene coding for δ Cadinene synthase under seed specific promoter.
- **Site specific nutrient management (SSNM) for rainfed cotton :** This approach taking into account indigenous nutrient supply and crop demand was found to be better than the blanket recommendation of N-P-K.
- Reduced tillage system for cotton varieties was developed. The technology comprises use of pre-plant herbicide application followed by one pass of a harrow and 1-2 inter row cultivation with 1 hand weeding to control late emerging weeds. The Bt systems improved soil organic C and yielded equal to or better than the conventional till system.
- For rainfed Bt cotton hybrids grown at wider row spacing growing a green manure cover crop in the inter row space followed by surface mulching resulted in a saving of 20 kg/ha of fertilizer N and gave significantly higher yields.
- Several innovative cropping systems were evaluated and the most remunerative ones were identified. For the central zone, cotton + Cow pea, Cotton + Green Gram (1:3), Cotton + Marigold (8:2) and Cotton + Raddish (1:1) were identified.
- Nutrient use efficiency under rained conditions can be improved when cotton is grown with soil moisture conserving practices such as Broad bed furrow (BBF) and ridge furrow (RF) and application of

recommended fertilizers.

- **Strategies to control leaf reddening were developed :** (i) spraying with acephate and (ii) foliar nutrient sprays of urea (2.3%), DAP (2%), (iii) Cultivating genotypes tolerant to reddening.
- Cotton varieties most suitable for organic systems were identified. Among the G. hirsutum cultivars, NH-615 was the highest yielding followed by PKV-081 and Suraj. JLA-794 was the best yielding desi cotton genotype followed by CAN-347.
- Effective weed control can be achieved by application of a pre-emergence herbicide (Pendimethalin @1 kg a.i./ha) and early post-emergence herbicide (pyrilhiolac Na @ 70 g a.i./ha).
- 67 lines having high epicuticular wax content (93-283 μ/cm^2)were identified from 7185 germplasm lines that could be tolerant to drought and sucking pests.
- A new cultivation technique of growing cotton under polyethylene mulching and raising of zero tilled rotation maize was standardized. The new method saves 40% irrigation water compared with conventional irrigation and up to 85% when combined with drip. There is no need for separate weed control and the technique enhances yield of cotton. This technology is economically feasible in irrigated condition particularly for seed production. The polyfilm recommended has 30 micron and is classified category of recyclable plastics and hence does not cause any environmental problem.
- Bio-inoculants viz., Azospirillum, PSB and Pink Pigmented Facultative Methylotrophs (PPFM) were isolated from various cotton ecosystems and all the bio inoculants were compatible with each other and improved the vigour index of cotton. The sulphur oxidation property of PPFM was reported for the first time in India.
- A novel approach of exhausting weed seed bank before the crop emergence by stale seed bed (SSBT) approach was standardized for cotton and cotton based intercropping system. Stale seed bed technique (SSBT) using a mixture of pendimethalin 1.0 kg + glyphosate 1.0 kg one week after irrigation (one week before sowing) recorded the highest weed control efficiency of 86.6% at 35- 45 DAS with the highest net return and B:C ratio .
- Low cost drip system was developed which produced yields equivalent to 96.7% of existing drip system and could save 41.8% of irrigation water in comparison to ridge-furrow method of irrigation. Water use efficiency of 49.6 kg/ha-cm was calculated as compared to 35.6 kg/ha-cm with ridge-furrow method of irrigation. The cost of low cost (polytube) drip system are respectively of Rs. 31,252, per hectare and this was cheaper by 57.8 % in comparison to the conventional drip system (Rs 74,080/-).
- A novel solar operated knapsack sprayer was developed tested and modified which has a field capacity of 4 hrs/ha. The weight of the sprayer without pesticide is 9 kg, with a swath of 90 cm giving 20 sprays with single charge.
- A Herbicide Wick Applicator was developed to smear the weeds with herbicide solution in between the rows of cotton plants. This was developed especially for HDPS system. The wick applicator was tested in the laboratory and calibrated in field. The field capacity of wick applicator was found to be 100 lit./ha. to 550 lit./ha. which could be changed depending upon the density and age of weeds.
- Set of improved implements for small and marginal cotton farmers, e.g. Adjustable Blade Hoe, Adjustable Ridger, Bund former.
- Mealy Quit' bio originated insecticidal formulation against mealybug has been developed. Mealy Quit has been tested at 9 locations of India. The formulation has been found effective against mealybug P. solenopsis under field conditions.
- Based on the volatiles released during the signal transduction pathway in cotton, Mealy Kill 50 EC was developed and validated for its use on sucking pests of cotton and mealy bugs. It effected control of mealybugs and whiteflies by dissolving the waxy coating and making the pests vulnerable to biotic and abiotic factors. The formulation is also effective against jassid, nymphs and aphids. Mealy Kill 50Ec has been formulated using a natural emulsifier 5% soap nut extract thus making it compatible for organic systems.
- Protocol for multiplication of P. solenopsis and its biological control agents *viz.*, Aenasius bambawalei, Cryptolaemus montrouzieri has been developed. A simple protocol for studying biology of P. solenopsis under lab conditions has been developed.
- Low cost insect cage made up of PVC pipe and muslin cloth has been designed to conduct laboratory bioassay on insect on live cotton plant. The cage is light in weight (Appx. 500 gm), easy to assemble and dismantle by ordinary man, easy to pack and transport, raw material locally available, can be secure and store in little space when not in use, longevity more than 3 years with proper use, can be pop up inside cage while working with the insects on live plant with the help of 30 inch long zip.
- A new sampling technique for mirids has been

devised and optimum sample size established for field population estimates of mirid, Campylomma livida in cotton + pigeon pea cropping system in the central zone and Creontiades biseratense in cotton + pulse – maize cropping system in South zone.

- An artificial diet for sucking pests has been developed. It is ready to use, and can support nymphs and adults throughout the period of bioassay. The diet needs to be stored at 4°C and needs to be changed every alternate day. The diet has been validated across labs (Coimbatore, for jassids and Sirsa for whiteflies). This technology is for use by researchers.
- Primers have been designed for amplification of the coat protein gene of the virus causing CLCDV. PCR conditions have been standardized. The PCR protocol can be used in cotton as well as in chickpea before the manifestation of symptoms in the field.
- A monophasic diet of cotton seed flour was developed for rearing of pink bollworm in the lab. Larvae were reared from neonates till pupation on a single diet. There were no aberrations in the emergence of the adults or in their mating and fecundity.
- BT Quant, Lectin Quant are ELISA plates developed at CICR to quantify Bt toxins and lectins respectively. These plates have a shelf life of 6months when stored at 4°C.
- Ready-to-use PCR kit was developed for detection of Xanthomonas malvacearum. Pathovar-specific diagnostic PCR kit detects this pathogen in seeds and other sources. Useful for Plant quarantine stations, Plant Protection agencies, Scientists and researchers in Agril Universities and Private seed Companies.
- Protocol for the management of cotton stem weevil in Tamil Nadu was developed by integrating the cultural, botanical and chemical control strategies and demonstrated at the farmers fields. The protocol was also disseminated to farmers through State Department of Agriculture.
- Till date, seven technologies have been commercialized and patented and nine technologies are under the process of patenting and commercialization.
- The total resource generated up to March 2013 through the commercialization of the technologies was Rs. 1,96,65,254.

2.4 : Staff Position (as on 31st March, 2013)

Name of the Post	Sanctioned Cadre Strength				Post Filled Up			
	NGP	CBE	Sirsa	Total	NGP	CBE	Sirsa	Total
Director (RMP)	1	--	--	**1**	1	--	--	**1**
P.C. (Cotton) & Head	--	1	--	**1**	--	1	--	**1**
Scientific	51	20	8	**79**	33	14	6	**53**
Technical	46	16	10	**72**	39	12	8	**59**
Administrative	34	9	5	**48**	28	7	5	**40**
Supporting	43	17	10	**70**	37	11	10	**58**
Krishi Vigyan Kendra								
Training Organizer	1	--	--	**1**	1	--	--	**1**
Technical	11	--	--	**11**	10	--	--	**10**
Administrative	2	--	--	**2**	2	--	--	**2**
Supporting	2	--	--	**2**	1	--	--	**1**

NGP – Nagpur; CBE - Coimbatore

2.5 : Financial Statement

The budget grant and actual expenditure for the year 2012-13 are furnished below : **(Rs. in Lakhs)**

S. No.	Scheme	Sanctioned	Expenditure
CICR			
1	Plan	200.00	185.81
2	Non-Plan	2390.09	2439.32
Plan Schemes		1634.83	1623.05
NAIP Plan Schemes		48.78	30.65
Deposit Schemes funded by outside agencies		567.16	295.32

3.1: Cotton Genetic Resources

Nagpur

Biodiversity, characterization, conservation and utilization of cultivated and wild species

Collection and maintenance of germplasm

A germplasm collection of 10,597 accessions were maintained in the Gene Bank of the Institute. This included 44 new germplasm and 42 new land races of cultivated varieties and perennial cotton that were added during the season.

Enrichment of Cotton Gene bank

Seeds of wild species, races of cultivated species and exotic germplasms of cotton collected from different states or procured from other countries were added to the Gene bank. Two representatives of Gossypium australe, EC 735740 - variety GOS 5014 and EC 735741 - GOS 5001 were procured from CSIRO, Plant Industry Narrabri, Australia. Besides, two commercial varieties of G. hirsutum viz., IMACD 05-8221 and IMACD- 408, used for cultivation in high density planting system (HDPS) in Brazil were also procured. Later two genotypes possessed compact plant stature with short internode length and could serve as suitable sources for breeding dwarf and compact cultivars, amenable to HDPS.

Unique Gossypium hirsutum cultures registered

Four introgressed derivatives with unique traits were registered with NBPGR, New Delhi. (Table 3.1.1). The registered lines belonged to medium staple length category and possessed excellent uniformity ratio. The registered cultures were highly tolerant to jassids. Additionally, Vaidehi 95 – a dark brown introgressed genotype was also tolerant to CLCuV. Besides possessing aesthetic attribute, Vaidehi 95 also showed colour fastness on storage. The three other introgressed derivatives NISC 40, 43 and 44 being compact in nature and relatively pest tolerant are suitable for HDPS and also for breeding genotypes suitable for HDPS.

Table 3.1.1: Introgressed derivatives of cotton registered with NBPGR

S. No.	Name of the line	Unique character	Registration number
1	Vaidehi 95 (MSH- 53)	Dark brown linted introgressed derivative	National ID: IC0584260 Registration No: INGR13032
2	NISC - 40	Jassid tolerant compact introgressed derivative	ID: IC0584261 Registration No: INGR13033
3	NISC - 43	Jassid tolerant compact introgressed derivative	National ID: IC0584262 Registration No: INGR13034
4	NISC - 44	Jassid Tolerant Compact Plant Type Introgressed Derivatives	National ID: IC0584263 Registration No: INGR13035

Jassid tolerant introgressed G. hirsutum genotype NISC-40 (left) and susceptible genotype LRA5166 (right)

Evaluation of germplasm

G. hirsutum

Three thousand four hundred eighty two (3482) germplasm accessions were evaluated for fibre quality traits at CICR Nagpur and CICR Regional Station, Coimbatore. Nineteen long linted accessions (staple length 30-33mm) and 10 high fibre strength accessions (25.2 -26.7 g/tex) were identified and utilized in breeding programme and also distributed among breeders. Five thousand germplasm accessions were evaluated for tolerance against waterlogging and 150 tolerant accessions were identified.

G. arboreum

Fibre quality traits of six *G. arboreum* races including burmanicum, cernuum, indicum, bengalense, sinense and soudanense were evaluated (Table 3.1.2). Fibre quality of six arboreum races however did not show significant variation. All races possessed medium staple cotton with fibre length ranging from 22.7-24.3 mm, bundle strength 16.5-18.5 g/tex, uniformity ratio 49-54% and fineness ranging from 4.4-5.1 µ.

G. herbaceum

Base collection of *Gossypium herbaceum* consisting 565 accessions were grown at Main Cotton Research Station, Surat and ARS, Bharuch for rejuvenation and evaluation. Some of the promising germplasm lines with good agronomic traits are listed in Table (Table 3.1.2).

Table 3.1.2 : Trait-wise listing of promising G. herbaceum germplasm

Early maturing accessions (180 days)	DB- 8 (IC 371095), DB-3-12 (IC 371098), DBSB-4-7 (IC 371107), DCB 423-3-1 (IC 371448), SLG-11 (IC 371524), KAPO 1/36 (IC 371582)
Big boll and high boll weight group (2.5-3.3 g)	Digvijay (Pune) (IC 371116), E-2-12-5 (IC 371120), 27-60 (IC 371326), KAPO 1/20 (IC 371572), KAPO 1/36 (IC 371582)
Pigmented plant body with high yield potential	DB-3-12-8 (IC 371104), 6199-SS (IC 371360), 7182-1-1 (TP-1) (IC 371362)
Complete locule opening and easy to pick	E2-12-5 (IC 371120), DCB 423-3-1 (IC 371448), SLG-11 (IC 371524)

Gossypol estimation

Gossypol was estimated in 100 cotyledonary leaf samples and 670 seed samples. Though, on an average, leaf gossypol content was low, some lines showed leaf gossypol in the range of 0.7-1.4%.

Breeding for genotypes suitable for surgical cotton

A new programme was initiated on development of promising *G. arboreum* genotypes with high micronaire, suitable for surgical industry. For the purpose 20 selected germplasm lines with high micronaire and big bolls, were used in crossing programme. The seeds obtained from the cross were collected for evaluation and selection of suitable plants in next generation.

At Sirsa 48 *G. arboreum* improved lines were evaluated for yield potential and fibre properties. Ten promising cultures were found highly suitable for surgical properties with micronaire >7, absorbence 1.1 second, sinking time 1.7 second, water-holding capacity >23 g and ash content between 0.22-0.45 %.

Naturally coloured cotton

Four single plants were selected from each of the four different crosses developed, involving *G. arboreum* race cernuum (having high boll weight and GOT) and *G. arboreum* races indicum and bengalense (brown-linted). Cultures in F_4 generation were evaluated for fiber properties, seed cotton yield and yield contributing traits. Each of the 4 single plant selections possessed brown-linted, medium staple cotton. While CNA 405 was characterized by narrow leaf lobes, CNA 406 had broad lobed-leaf. CNA 407 had pigmented plant body and narrow-lobed leaf and CAN 416 –LB had long and elliptical bolls, coupled with high boll weight (5.2g) and high ginning out turn (40.7%).

Exploration for perennial trees and land races of cultivated cotton

Exploratory surveys were conducted in Andhra Pradesh, Maharashtra, Tripura, Gujarat and Tamil Nadu for collection of perennial trees and land races of cotton. Fifty cotton germplasm materials including 14 perennials, 22 landraces and 14 traditional cultivars belonging to *G. arboreum, G. herbaceum* and *G. barbadense* were collected (Table 3.1.3). Exploratories were established in the pot culture and their seeds stored in the Gene bank. Ten unique germplasms were established in a newly developed perennial species garden.

Table 3.1.3 : Perennials and landraces of cotton collected from different regions of India

S. No	Districts	State	No. of Accessions	Species	Annual/Perennial/ Landrace
1.	Vishakapatnam, Vizianagaram & Srikakulam	Andhra Pradesh	2	*G. arboreum*	Perennials
			1	*G. arboreum* race *indicum*	Landrace
			1	*G. barbadense*	Perennial
2.	Bhandara, Nagpur, Wardha	Maharashtra	2	*G. arboreum*	Perennials
			5	*G. barbadense*	
3.	Gomati, West Tripura, Kowai and Dhalai	Tripura	10	*G. arboreum*	Primitive traditional cultivar (Annuals)
			4	*G. barbadense*	Perennials
4.	Bharuch, Bhavnagar, Rajkot, Ahmedabad, Surendranagar & Banaskantha	Gujarat	7	*G. herbaceum*	Annuals
			4	*G. herbaceum* (Wagad/Kalyan)	Landraces
			5	*G. arboreum*	Annuals
			1	*G. arboreum* (Mathio cotton)	Land race
5.	Tuticorin	Tamil Nadu	6	*G. arboreum* (Karunganni cotton)	Landraces
			1	*G. arboreum*	Annual
			1	*G. herbaceum* (Uppam Cotton)	Landrace
		Total	50		

Ponduru cotton collected from Ponduru mandal, Srikakulam district, Andhra Pradesh as a individual plant, its flower and bolls in the field condition

Karuganni cotton (*G. arboreum*) with flower and bolls collected from Kovilpatti, Tamil Nadu

Uppam cotton (*G. herbaceum*) with flowers and bolls collected from Kovilpatti, Tamil Nadu

Wagad cotton (*G. arboreum*) with closed boll type and round shape collected from Patdi, Gujarat

Wagad cotton with closed boll type and round shape collected from Patdi, Gujarat

Fiber quality traits of perennial and land races of cotton

Fibre quality traits of 19 morphologically distinct *G. arboreum* and perennial *G. barbadense* germplasm materials were evaluated. Staple length of perennial *G. barbadense* cotton ranged from 32.6 – 34.9 mm while that of *G. arboreum* ranged from 17.2-19.1 mm. High micronaire *G. barbadense (*5.8 - 6.4 µ) materials can serve as source for improvement of fibre quality of ELS cotton. Development of absorbent *G. arboreum* cotton suitable for surgical industry is possible with high micronaire *G. arboreum* (> 7.0 µ).

Coimbatore

G. hirsutum

About 450 *G. hirsutum* germplasm lines maintained at the station were rejuvenated and characterized for yield and yield contributing traits. A batch of 1532 germplasm accessions received from CICR were rejuvenated and revaluated for fiber quality. The 2.5% span length of the germplasm ranged from 18.9 mm to 34.5 mm and bundle strength ranged from 9.2 to 26.4 g/tex.

G. barbadense

Twenty seven *G. barbadense* germplasm were assessed for earliness and seed cotton yield along with the check Suvin. Fourteen genotypes were found to be early maturing (153-159 days) compared to Suvin which matured in 210 days. Besides, 26 long staple genotypes, 18 high strength genotypes and 36 genotypes with high micronaire value were identified.

3.2 : Hybrid Cotton

Nagpur

Development and maintenance of male sterile cotton

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. Few promising progenies of male sterile plants in M_4 generation were maintained by sibmating

(GMS) while the CMS progenies were maintained by crossing with maintainer lines (CMS). Some mutagenized GMS progenies showed significant variation in morphological characters compared to parental lines. Progenies with big bolls, round and elliptical shape, long pedicel, broad bracts, cluster bearing and plants with two squares at each node were identified.

GMS version of a number of commercial cultivars were developed. Four single plant progenies were raised each for PKV 081, AK 32, Suman, Sharda and L 147. Progenies were tested for segregation of male sterility and fertility in 1:1 ratio followed by maintenance of GMS cotton through sibmating. These GMS lines are now ready for use in hybrid development programme after testing the fibre quality. Two genotypes possessing ms5ms6 alleles for genetic male sterility were selected. To identify molecular markers for genetic male sterility, fertile and male sterile counterparts of these two genotypes in six replicates were screened using 10 SSR markers available in public domain. None of these primers proved informative in differentiating fertile and male sterile lines. Protein profiling of three fertile lines and their sterile counterparts did not reveal any polymorphism, either.

Sirsa

The local adapted cultivars and parents of promising hybrids *viz*. CMS LRA 5166, CMS Jhorar, CMS RB 281, CMS LH 1134, CMS Pusa 31, CMS HS 6, CMS K 34007, CMS F 505, CMS F 1183, CMS CSH 25 M, and CMS SH 2379 lines possessing *G. harknesii* cytoplasm were maintained through sibmating. Ten Restorer lines were maintained through selfing. In addition, the GMS lines *viz.*, K 34, J 34, MCU 5 and GMS 13 were maintained through selfing. Crosses were also attempted between GMS lines and good combiner lines.

Maintenance of restorer lines

The new restorer lines *viz*. CIR 8, CIR 12, CIR 15, CIR 23, CIR 26, CIR 32, CIR 38, CIR 47, CIR 70, CIR 72 were mantained through selfing. Additionally, new restorers CIR97P1, CIR97P3, CIR119P1, CIR119P3, CIR126P1, CIR526P1, CIR526P3, CIR 920 P1, CIR 926 P2, CIR 926 P3, CIR 1169 P1 and CIR 1169 P2 developed through Pedigree method of breeding were maintained through sibmating.

Conventional hybrid

Some promising *desi* cottons (*Gossypium arboreum*) are susceptible to Grey mildew caused by *Ramularia areola*. Besides, they possess small sized bolls and are prone to shattering due to low boll retention. *G. arboreum* race '*cernuum*' registered earlier by the Institute possessed tolerance against some of these detriments. In order to incorporate resistance against grey mildew in susceptible *desi* cotton cultivars, crosses were effected between six *desi* cotton cultivars (AKA8401, AKA7, CNA1003, PA225, PA402 and Jawahar Tapi) and five *cernuum* cotton (30805, 30814, 30838, 30856 and G135-49). Thirty hybrids generated involving two groups of cotton in all possible combination showed good combinability with significant heterosis in yield in majority of the crosses (Table 3.2.1). Percent heterosis varied among different hybrids with some showing very high levels of heterobeltiosis. All hybrids possessed big bolls, a trait apparently dominant in *cernuum* cotton and contributed by it. Besides improvement in yield, hybrids showed tolerance against grey mildew, early maturity and improved boll retention - traits conserved in *cernuum*. Heterobeltiosis as high as 106.54% was recorded in combination AKA7 x G135-49. Hetrobeltiosis ranged from 50-106.5% in 4 crosses, 25-44.6% in 11 and 1.69-17-44 % in 5, out of 30 combinations.

Table 3.2.1: Heterosis in selected *Gossypium arboreum* hybrids

Parents and hybrids	Yield/ plant (g)	Boll wt. (g)	Hetero-beltiosis (%)	Yield/ acre (q)	Staple length (mm)	UR (%)	Mic (µ)	Strength (g/ tex)
AKA7 x G 135-49	93.1	3.3	106.5	13.8	22.8	53	6.1	19.9
AKA7	45.1	2.4		6.67	23.9	51	6.0	19.4
G 135-49	40.3	2.7		5.97	22.4	52	6.6	19.1
AKA8401 x 30838	121.0	5.5	86.15	17.9	21.6	52	6.6	17.2
AKA8401	65.0	2.6		9.66	27.7	48	5.3	19.2
30838	26.3	5.9		3.27	20.1	55	7	
J. Tapi x G135 -49	66.2	3.3	64.13	9.79	22.4	54	6.8	19.4
J. Tapi	27.8	2.4		7.62	24.9	51	5.5	20.0
G13549	40.3	2.7		5.97	22.4	52	6.6	19.1
J. Tapi x 30856	59.4	4.0	50.0	8.79	20.1	55	6.7	17.8
J. Tapi	39.6	2.4		7.62	24.9	51	5.5	20.0
30856	26.4	4		3.90	17.8	57	7	

AKA 8401 30856 AKA 8401 X 30856
Conventional *Desi* Hybrid

3.3 : Genetic Improvement

Nagpur

***G. arboreum* (Diploid Cotton)**

Identification of promising cultures

Twenty three single plant selections in F_5 generation made from crosses involving parental lines having desirable traits *viz*; boll weight, high yield, number of bolls per plant, fibre length and fibre strength were evaluated. Nine segregating progenies were evaluated for seed cotton yield and boll weight.

Two promising cultures *viz*, CNA 370 and CNA 416 with high yield potential (17-19 q/ha), medium superior staple length (27 mm) and bundle strength (19-20 g/tex) were identified and developed for further evaluation in AICCIP trials.

Similarly, 29 newly developed cultures with improved productivity were evaluated under narrow spacing of 60 x 22.5 cm. Number of cultures with agronomically superior traits like high boll number (50), high yield potential (2000-2500 kg/ha), high boll weight (3.9 g), long staple length (29 mm) and high fibre strength (23.5-23.8 g/tex) were identified. Two promising high yielding cultures *viz.* CNA 2020 and 2024 with 1700 and 1800 kg yield per ha respectively were identified. A promising *G. arboreum* cotton with staple length of 29 mm was improved for fibre strength using Dharwad Extra Long *arboreum* cotton (DLS). Advanced progeny in F_4 generation was identified with staple length of 29 mm and high fibre strength upto 23.8 g/tex.

Identified promising *G. arboreum* culture, CNA 2024

G. hirsutum (Tetraploid Cotton)

Drought tolerance

Three sets of experiment were conducted under rainfed and irrigated conditions to assess the performance and drought tolerance ability of developed cultures and genotypes. In the first set, twelve crosses in F_4 generation along with their parents were tested with drought tolerant check Rajat which recorded seed cotton yield of 1872.65 and 2396.54 kg/ha under rainfed and irrigated conditions. Eight genotypes were at par to check Rajat while three recorded more than 10 % increase in seed cotton yield under rainfed conditions. Pusa 56-6 x 29 I topped in performance under rainfed situation, while 29 I x Pusa 56-4 excelled under irrigated conditions. Based on performance under abiotic stress and irrigated conditions, drought tolerant efficiency of genotypes (DTE) was worked out. Four crosses viz. 28 I x Pusa 56-4, 30 I x Pusa 56-6, 30 I x Pusa 56-4 and Pusa 56-4 x 28I recorded more than 95%, while seven crosses recorded more than 91% DTE.

In the second set, eight cultures identified previously for drought tolerance (DTS 155, 62, 67, 39, 108, 100, 44, 104) and five lines found promising for yield, boll size and fibre quality (NHP1, NHP2, NHP3, NHP4, NHP5) to be utilized as potential candidates in crossing programme were evaluated along with LRA 5166 - moderately drought tolerant cotton. All the identified drought tolerant cultures recorded more than 15% yield over the check while among 5 promising lines, all the genotypes except NHP 5 were at par to the check with respect to seed cotton yield (1379.60 kg/ha) under rainfed condition. DTS 155 recorded ginning outturn of 41.54% with 124% higher lint yield over the check under rainfed condition followed by cultures DTS 62, DTS 44 and DTS 100. Besides, DTS 155 as a summer sown crop did not show any sign of wilting even after more than 20 days of extremely dry period during the month of May.

Out of 52 drought tolerant selections evaluated in the third set, cultures DTS 78, DTS 76, DTS 75, DTS 70, DTS 72, DTS 92, DTS 91, DTS 71 performed significantly well under rainfed condition. Among these, lines with good fibre length, strength and high GOT were identified.

Besides, an entire set of 17 intercross genotypes were found superior to the check LRA 5166, in terms of yield under rainfed situation. Among them, drought tolerant selection DTS 46-04 performed best with seed cotton yield of 1492.61 kg/ha, boll weight of 3.6 g and GOT of 39.86 per cent. It was followed by DTS 52-02, DTS 1-11 and DTS 46-01 exhibiting more than 1000 kg/ha yield. From amongst eight advanced cultures tested in bigger plots, DTS 95, DTS 147, DTS 121, DTS 123 and DTS 3 were identified for evaluation in AICCIP Br 02(a & b) and Br 06 (a & b) trials .

A new cross was generated involving Moco cotton (*G. hirsutum* race *marie galante*) - known for drought tolerance as male parent and genotypes 28 I and Suraj as female parents. Seeds obtained from the crosses will be advanced for further evaluation and selection.

Response of drought tolerant cultures under extreme summer. a. DTS100, DTS108, LRA5166 and DTS104. b. DTS39, NISC50, 30I and DTS67

Jassid tolerance

In an effort to develop quality cotton with improved yield and jassid tolerance, breeding programme was initiated. Twenty F_6 lines were evaluated for seed cotton yield and fibre properties in randomized block design at a spacing of 45 × 20 cm. CNH 8002-6 (AKH 081 × CIPT 501) recorded highest seed cotton yield of 2183 kg/ha. This was followed by CNH 8005-3 (BM COT 88 × EC 560342) with 1959 and CNH 8003-3 (SR 107 × AKH 081) with 1924 kg/ha seed cotton yield, respectively. CNH 8002-6, besides documenting highest yield recorded staple length of 29.5 mm and fibre strength of 22.5 g/tex. Culture CNH 8004-2 combined promising seed cotton yield (1891 kg/ha) with improved fibre quality traits (staple length 29.8 mm ; bundle strength 23.2 g/tex). Besides high seed cotton yield and good fibre quality

traits, a number of cultures exhibited tolerance to jassids. Atleast 25 advanced cultures in F6 generation were identified for jassid tolerance (Grade I, II) and sympodial plant types. Six cultures viz. CNH07-12, CNH 07-2, CNH 08-11, CNH 07-34, CNH 07-10 and CNH 08-55 were identified for earliness in maturity (145-150 days).

An early maturing *G. hirsutum* culture, CNH 2007-10 with Jassid tolerance and increased boll size

Breeding for yield, earliness and fiber quality

Development of *G. hirsutum* culture with big boll

A highly promising *Gossypium hirsutum* culture (Acala-B2 x Ganganagar Ageti) with big bolls ranging from 5.9-7.9 g in F_4 generation was developed. Besides possessing big bolls, it possessed staple length of 25.6 mm, strength 22 g/tex, with S /L ratio of 0.86 and appropriate fineness of micronaire 4.0. The culture has been approved by the Institute's Germplasm Identification Committee for registration as unique culture. Such big boll cultures have the potential to revolutionize productivity of Indian cotton to unprecedented levels especially if deployed under HDPS.

Promising *Gossypium hirsutum* cultures with big boll size

Early maturity

Number of cultures in F_4 generation documented promising seed cotton yields. Some of the high yielding cultures included CNH 10-10 (EC 277959 × G 67), CNH 2-4 (G. Cot. 16 × EC 277959) and CNH 9-7 (EC 277959 × NH 615) that recorded seed cotton yield of 23, 19 and 15 q/ha respectively. Some cultures generated from crosses involving jassid tolerant wild species (*G. raimondii)* like CNH 8-20 -R (289-4 × EC 277959) and CNH 9-22-R (291 × P-56-6) not only exhibited earliness (140-145 days) but also recorded good yield potential and resistance to jassids.

In addition, 252 single plant selections made in F_4 generation of crosses involving parents showing earliness in maturity and that possessed good fibre properties, showed diverse but agronomically useful and good fibre quality traits like high seed cotton yield per plant, early maturity, high boll weight, high bundle strength, long staple etc. Single plant selections CNH 09-34, CNH-09-29 and CNH 09-1 recorded high seed cotton yield of 155, 137 and 116 g / plant respectively. Similarly, boll weights of selected cultures ranged from 4.0 g (CNH 09-10) to 7.1 g (CNH 09-7). Twenty-four single plant selections documented bundle strength of 24.0 g/tex and above, while five single plant selections recorded bundle strength of 25.0 g/tex and above. Besides, 15 single plant selections generated from the cross G 67 × P 56-4, recorded staple length ranging from 30.2 to 32.8 mm, while highest ginning outturn of 43.1% was recorded in CNH 09-28 (EC 277959 × NH 615). CNH 09-67(CIPT13× P 56-4) combined high fibre strength of 25.4 g/tex with long staple length of 32 mm. CNH 09-47 (G 67 x P-56-4) combined high bundle strength of 25.1 g/tex with long staple length of 31.0 mm and CNH 09-106 (FQ9 × MDR 8) recorded bundle strength of 25.3 g/tex and long staple of 28.8 mm with S/L ratio of 0.8, 0.8 and 0.9, respectively.

Improvement of fiber strength

Breeding of high strength *hirsutum* varieties with wider adaptability

To consolidate and develop high strength cotton, fibre quality of 22 advanced cultures with good fibre properties which were sponsored in AICCIP but were not promoted based on yield competence was revisited for further use in breeding. The strength of the materials tested ranged from 23.1 to 24.7 g/tex. CNH 1114 and CNH 1435 recorded bundle strength of 23.8 and 23.6 g/tex, respectively while CNH 1107 recorded fibre strength of 24.7g/tex and staple length of 29.6 mm with a S/L ratio of 0.83. CSH 3129 recorded staple length of 28.8 mm with bundle strength of 23.1g/tex.

Breeding for compact cotton

Breeding of cotton was initiated to develop compact genotypes suitable for HDPS. A short and compact *G. hirsutum* germplasm N 170 with short height (54 cm) and

short sympodia (9.2 cm) was chosen as female parent. It was crossed individually with three trait specific donors each for fibre strength, boll weight and sucking pest resistance. F_1s have been evolved.

Besides, conscious breeding of compact genotypes amenable to HDPS (45 x 15 cms), 84 genetically enhanced lines were evaluated under HDPS. Few selected lines generated were crosses between RS-875 x MHL-557, RS-810 x MHL-557, RS-B75 x Rex and RS-810 x JBWR-JK 54 were found free from sucking pests. Progeny of H-777 x Rex was found to be high yielding with good staple length and large boll weight. Cultures SPS-HB-8-1, SPS-6-4 and SPS-6-17 recorded promising yields at 45 x 15 cm spacing. Under narrow spacing of 60 x 12 cm, a few promising backcross populations of PKV-081 x (PKV-081 x PIL-8) in BC3F5 recorded the highest plot yield of 1.9 kg/ 8.3 sq m. area.

Evaluation of genetically enhanced populations

A number of promising genotypes of cotton were subjected to enhancement of specific traits that they lacked. Some of the genotypes that were genetically enhanced drawing the specific trait from selected donor species included LRA 5166, PKV 081, LH 1134, G.Cot 10, LRK 516 etc. (Table 3.3.1).

Table 3.3.1 : Genetically enhanced varieties of cotton (*Gossypium hirsutum)*

S.No	Variety improved	Donor	Trait	Base value For the trait	Improved value
1	LRK-516	Deltapine-66	GOT (%)	36	41.6
2	PKV-081	PIL-8	Boll weight (g)	2.9	3.8
3	H 777	Rex	Boll weight (g)	2.8	3.6
4	LRA-5166	BAR-310	Fibre length (mm)	26	29
5	LRA-5166	CIHS-97-9	Sucking pest	Susceptible	Resistant
6	LH-1134	Reba vt9Lyy	Fibre Strength (g/tex)	18	23.8
7	RS-810	MHL-557	Fibre length (mm)	22	27
8	RS-810	JBWR-JK-54	Sucking pest	Moderately Susceptible	Resistant

Population Improvement

Random mating population in *G. arboreum* and *G. hirsutum*

The randomly mated population generated through conventional crossing was maintained by bulk harvesting one bursted boll from each plant in both *G. arboreum* and *G. hirsutum*.

Random mating population developed through exploitation of GMS

The sixth cycle of GMS based random mating population was completed in *G. hirsutum*. In the composite population all sterile/fertile plants in the population were tagged at flowering and allowed open pollination. The out crossed bolls from all the sterile plants were bulk harvested to be raised in the next crop season. Similarly, seventh cycle of GMS based random mating was completed in *G. arboreum*.

Single plant selection

Nine hundred and ninety eight single plant selections from randomly mated population were evaluated in plant to row progeny plots. From the composite random mating population 253 plants were selected based on manual testing for fibre quality traits. About 1200 superior single plants were reselected from the segregating single plant progenies. Several single plant selections were identified for big bolls, better fibre quality and compact plant types. Two progenies superior in fibre quality has been advanced to replicated trial.

Single plant selections for compact plant types (Zero Monopodia) and Big boll size from random mating population of *Gossypium hirsutum*

Development of heterotic pool for superior medium staple

From heterotic population developed based on geographic diversity and specific combinability, 18 breeding lines were identified. Nine lines 14-1-1, 14-6-4, 14-9-2, (PKVR X DHY 286); 7-3-3 (LRK 516 × Acala 1517); 12-2-3, 15-2-1, 15-5-3 (PKVR X Acala 1517) and 3-3-4, 3-3-2 (LRK 516 × DHY 286) were identified from the population of first heterotic group. From the second heterotic group, lines 12-2-3, 20-4-3 (Surabhi × H1252); 14-4-1 (Surabhi × ACCLD 163); 22-5-1 (LH 1948 × MCU 9); 22-4-1,17-2-2, 17-3-2 (ACCLD 163 × H 1252) and 16-3-1 (Surabhi × LH 1948) were identified with improved fibre length, strength and seed cotton yield. These lines will be utilized for testing their superiority over parents for developing hybrids amongst them.

Several advanced lines in F_7 generation developed from heterotic pool were evaluated in non-replicated yield trial. Breeding line 7-3-3 recorded seed cotton yield of 24 q/ha followed by 15-5-3 (PKV-R × Acala 1517) with 15 q/ha and 19-3-2 (ACCLD 163 × MCU 9) with 13 q/ha.

Amongst 18 breeding lines of heterotic pool evaluated in replicated trial in high density (45 × 20 cm), four lines recorded seed cotton yield of 30 q/ha (CNH7008-1), 29 (CNH 7012-13), 28 (CNH 7012-6) and 27 q/ha (CNH 7012-11). Besides recording high seed cotton yield, CNH 7012-13 also combined desirable staple length (27.9 mm.) with fibre bundle strength (23.7 g/tex).

Evaluation of GMS based hybrids in *G. hirsutum*

To develop the heterotic pools of *G. hirsutum* cotton, 52 GMS hybrids along with parents were tested in RBD with three replications. The highest seed cotton yield was recorded in GMS-20 X MC 88 (1944kg/ha) followed by GMS-26x MC 88 and GMS-20 x SA 1652 (1773 kg/ha) as against 1698 kg/ha of conventional check hybrid LH 2076. Maximum ginning outturn of 36.5 % was recorded in hybrid GMS-17 x MC 88. From this experiment it was found that the male parents SA 1017, SA 1422, MC 88, and SV 413 and female parents GMS-26, GMS-20 were found to be good general combiner for seed cotton yield. For boll weight male parents EC 138572, EC359051, SV 413 and female parents GMS 20, 26 and 27 were found to be good general combiners while parents SA 1652, EC141679, SV 413 and GMS 20 were good general combiners for ginning percentage. Out of 52 cross combinations evaluated 12 crosses *viz.* GMS 17 x SA 1422, GMS 17 x MC 127, GMS 17 x 358371, GMS 17 x 359051, GMS 20 x SA 1652, GMS 20 x MC 88, GMS 26 x EC 128334, GMS 26 x CSH 3129, GMS 27 x SA 1422, GMS 27 x EC 138572, GMS 27 x 358371 and GMS 27 x SV 413 possessed significant SCA effect for seed cotton yield. However, for boll weight only 3 cross combinations GMS 17 x SA 1422, GMS 17 x MC 127 and GMS 26 x CSH 3129 showed significant positive SCA effect. The cross combination GMS 26 x CSH 3129 besides yield and boll weight also showed significant SCA effect for ginning out turn, number of sympods, bolls per plant and lint yield.

Coimbatore

Improved *G. hirsutum* culture identified for release

A medium staple culture CCH 2623 was tested in various centers of All India Coordinated Cotton Improvement Project during the past five years in both Central and South Zones. It showed yield superiority in both the zones and recorded a mean seed cotton yield of 1739 kg/ha in Central Zone with 34% yield increase over the zonal check variety LRA 5166 and 1798 kg/ha in South Zone with 17% yield increase over the zonal check variety Surabhi. The culture has undergone trial for agronomic requirements in both the zones.

Performance of medium staple cultures

In station trial 22 medium staple cotton cultures were evaluated along with Sumangala, LRA 5166 and Suraj as check varieties. Analysis of data on seed cotton yield indicated significant difference among the entries and the highest seed cotton yield was recorded in *G. hirsutum* culture MM05-38-2-4 BK (1560 kg/ha).

Performance of long staple cultures

From F_6 population, high yielding compact genotypes were selected and evaluated at closer spacing of 75 cm x 30 cm along with Suraj and Anjali as check varieties. Analysis of data on seed cotton yield indicated significant difference among the entries and the highest seed cotton yield was recorded in PI-36-3-5-2-Bk (1433 kg/ha). Some genotypes had big bolls (as high as 5.3 g in PI-42-2-2-1-Bk) with most genotypes being erect and dwarf, possessing short internode length.

Performance of compact cultures

Data on AICCIP Plant Breeding trials were compiled and high strength cultivars tested during the past eight years (2004-05 to 2011-12) in various trials were identified. Out of 13 genotypes evaluated, genotypes with bundle strength as high as 25.0 g/tex (CCH 4474 and CCH LS 3) were identified. Analysis of data on seed cotton yield indicated significant difference among the high strength genotypes studied with highest yield in GSHV 161. Comparison of fibre quality data indicated consistency in quality of CCH 4474 (SL = 33.5 mm; BS = 25.9 g/tex as against mean value recorded in AICCIP SL = 30.1 mm and BS = 24.7 g/tex). Apart from this culture, the cultures CCH LS 2, CCH 7122 and CCH 820 also showed consistency for fibre quality.

High strength cultures

Besides the high strength varieties selected from the AICCIP trials, number of promising high strength cultures were identified from Station trials for evaluation in TMC trials. In all, 185 plants in F_6 generation were selected for high strength and some plant progenies combined both yield and quality. For instance, the progeny PI 21-1-1-1-2-6 combined promising seed cotton yield (124 g/plant) with very good bundle strength (24.4 g/tex) and 2.5% span length (26.5 mm).

Identification of lintless mutant

In the MCU 5 population, a spontaneous lintless mutant was identified and was found to breed true. The isogenic MCU 5 Lintless mutant is characterized by complete lack of lint and fuzz on the developing seed even after complete bursting of boll. The mutant is highly useful for studying the molecular basis of fibre development in cotton.

***G. barbadense* genotypes**

Eighteen advanced *G. barbadense* cultures generated under TMC MM-I and also under Institute projects were evaluated. Four cultures *viz*. CCB-5 (11 q/ha), CCB-11(11.5 q/ha), CCB-33 (9.9 q/ha) and CCB-36 (9.8 q/ha) exhibited promising yield over the check Suvin (5.65 q/ha). Besides, CCB-33 and CCB-36 possessed significantly superior boll weight of 4g and 3.9 g respectively. Cultures CCB-20 and CCB-24 were early maturing (160-165 days) compared to check Suvin (200-210 days).

In Suvin improvement programme, 7 advanced crosses involving Suvin were evaluated for seed cotton yield and earliness. Pooled data of last 3 years revealed cross Suvin x ICB 263-2 had highest yield of 1020 kg/ha with 35mm Span length and 27% g/tex strength. It also had the highest micronaire of 4.2 µ/inch, while the check Suvin under same conditions recorded seed cotton yield of 423 kg/ha, staple length 36 mm span length, strength 27g/tex and micronaire of 2.9 µ/inch.

Sirsa

Improved *G. hirsutum* culture identified for release

A high yielding *G. hirsutum* culture CSH 3129 was recommended for Agronomy trial based on its superior performance over four years in AICCIP trials. Proposal for its identification has been submitted.

Evaluation of CLCuV resistant cultures

Thirty-six *G. hirsutum* cultures were evaluated against CLCuV along with local check RS 921 and LH 2076 in replicated field trial. The highest seed cotton yield was recorded in the advance culture CSH 2931 (2986 kg/ha) followed by that in CSH 2810 (2543 kg/ha), CSH 2811 (2469 kg/ha), CSH 2934 (2393 kg/ha) and CSH 2838 (2345 kg/ha) as against check variety LH 2076 (2222 kg/ha). Highest ginning out turn of 35.1% was recorded in culture CSH 2391 followed by that in CSH 2844 (34.0%) compared to local checks RS 921 and RS 2013 with GOT of 33.5 and 32.6%, respectively. The culture CSH 2931 besides recording highest yield showed lowest incidence of CLCuV (PDI 2.5%) followed by that in cultures CSH 2836 and 2838 which suffered CLCuV incidence of 6.5 and 9.1 % PDI, respectively.

G. hirsutum

To develop improved culture of *G. hirsutum,* crosses were effected between five high strength accessions obtained from CICR Regional Station, Coimbatore and four genotypes developed at Regional Station, Sirsa. Two out of thirteen crosses in F_4 generation *viz*. CSH-3119-10-28-56 and CSH-3119-10-30-60 were early in maturity with significantly high yield compared to the superior parent CSH 3047 (2469.15 kg/ha) as well as the check variety H-1226(2175.94). Culture CSH-3114-10-14-28 in F_4 generation exhibited high fibre strength > 25 g/tex and staple fibre length >30 mm. Six cultures with promising fibre quality traits including high strength and long staple *viz*. CSH-3129, 3114, 3047, 3312, 3313 and 3314 were evaluated further under the TMC Project.

GOT of promising *G. hirsutum* cultures

One hundred and sixty five plants in F_5 generation were generated from a cross between a high (SA977) and a low (SA112) GOT culture. Analysis of progeny showed that 2 plants had GOT <30%, 38 possessed GOT between 30-35%, 111 had GOT between 35-40% while 13 plants had GOT >40 %. The promising plants can serve as mapping population for tagging genes for GOT.

G. arboreum

Forty-eight *G. arboreum* improved lines were evaluated for yield potential and fibre properties. Ten promising cultures were found highly suitable for surgical properties with micronaire >7, absorbence 1.1 second, sinking time 1.7 second, water-holding capacity >23 g and ash content between 0.22-0.45 %.

AICCIP Trials

Nagpur

Status of cultures sponsored in AICCIP trials

Fourteen promising cultures were sponsored in various AICCIP trials during 2012-13. This included four *G. hirsutum* entries CNH 15, 16, 315 and 1110 sponsored in Initial Evaluation Trial (IET) in irrigated or rainfed conditions. Two cultures CNH 14 and CCH 1111 were sponsored in preliminary varietal trial in Central zone under rainfed conditions. Among *G. arboreum*

cultures, two entries namely CCA 390 and CNA 1020 were sponsored each in national trials under rainfed and irrigated conditions. One *G. arboreum* entry *viz.*, CNA 398 was sponsored in coordinated varietal trial for evaluation under rainfed conditions in Central zone while two entries, CNA 1007 and CNA 1016 were sponsored in South zone. Besides, three compact *G. hirsutum* cultures including CNH 1105 and 1109 were sponsored in south zone while a drought tolerant genotype 28 I was promoted for second year in both central and south zones for evaluation of their suitability under AICCIP HDPS trial (Table 3.3.2).

Table 3.3.2: Status of cultures sponsored in AICCIP trials

Name of culture	Species	Promoted to
CNA 1016	*G. arboreum*	Br 24 b – Central Zone
CNA 1016	*G. arboreum*	Br 24 b – South zone
CSH 1110	*G. hirsutum*	Br 03 b – South zone
CNH 28 I	*G. hirsutum*	Br 06 b – Central zone
CNH 28 I	*G. hirsutum*	Br 06 b – South zone
CNH 1109	*G. hirsutum*	Br 06 b – South zone

Evaluation of advanced cultures

Sixteen advanced cultures of *G. arboreum* and *G. hirsutum* evaluated and found promising in the Institute trials were identified for sponsorship in AICCIP trials during 2013-14. This included six *G. hirsutum* entries *viz.* CNH 19, 1116, 2001, 7008, CSH 95 and CSH 1115 and four *G. arboreum* cultures *viz.* CNA 375, 1013, 1021 and CCA 3 that were sponsored for Initial Evaluation trial in rainfed and irrigated conditions. Besides, 6 *G. hirsutum* cultures promising for yield and / or drought tolerance were also identified for sponsorship in AICCIP compact HDPS trials in irrigated and rainfed conditions.

Coimbatore

Eight cultures from Coimbatore were tested in AICCIP multi-location testing for yield and other characters during 2012-13. In the initial evaluation trial of *G. hirsutum* varieties under irrigated condition, the culture CCH 12-2 recorded 1854 kg/ha of seed cotton yield in south zone and ranked 5th overall. The culture CCH 12-6 showed superiority in both central and south zone locations in evaluation trial of compact genotypes under irrigated condition. In the preliminary varietal trial in Central Zone, culture CCH 11-2 showed superiority in seed cotton yield (1969 kg/ha), besides documenting superior fibre quality and was promoted to coordinated varietal trail in irrigated condition.

Sirsa

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. Similarly, 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. 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.

3.4: Genetic Diversity through Introgression

Nagpur

Four hundred and twenty six introgressed derivatives were evaluated for yield and yield contributing traits coupled with biotic and abiotic stress tolerance. Fifty single plant selections were made for high yield and compact plant types under unprotected condition. The introgressed derivatives were apparently tolerant to jassids. An introgressed derivative generated from a cross between LH1134 and *G. hirsutum* race *palmeri* showed the highest fibre strength of 29.0 g/tex in F_4 generation.

G. arboreum x G. somalense (E_2) | *G. somalense (E_2) x G. arboreum* | *G. somalense (E_2)*

Promising introgressed derivatives developed

3.5: State Multi-Varietal Trial (SMVT)

Nagpur

A State Multi-location Varietal Trial consisting of 17 genotypes of *G. arboreum* and 13 of *G. hirsutum* was conducted at CICR, Nagpur. Among *G. arboreum* cultures, few cultures out-yielded even upland

genotypes. Seed cotton yield in *G. arboreum* ranged from 879-1806 Q/ha. All *G. a*

rboreum genotypes showed seed cotton yield of more than 1100 Q /ha except JLA-0807 with seed cotton yield of 879 Q/ha. The highest seed cotton yield of 1806 Q/ha was recorded in CNA1003 followed by that in PA-741 (1720 Q/ha) and PA-08 (1690 Q/ha). AKH 2006-2, besides supporting highest yield among *G. hirsutum* cultures, also combined promising fibre length (30.8 mm) and bundle strength (22.1 g/tex). CNH 1110, however, recorded highest fibre strength of 23.0 g/tex and fibre length of 29.8 mm.

3.6: Molecular Breeding

Nagpur

i. Mapping QTLs for fibre quality traits

In an effort to develop linkage map of diploid A genome cotton, an interspecific F2 mapping population (*G. arboreum* cv. KWAN-3 x *G. herbaceum* cv. Jaydhar) was developed. During 2012-13, parental polymorphism was surveyed using 1098 SSR markers based on which 77 polymorphic markers were identified (Fig.3.6.1). Genotyping of mapping population with additional 15 informative markers has been completed (Fig. 3.6.2). In *G. hirsutum*, survey for parental polymorphism (for the parental lines used for development of RIL population) was carried out using 1098 SSR markers based on which 92 informative markers were identified.

Fig. 3.6.1: Survey for parental polymorphism using SSR markers in cotton 1-EL-958, 2-UPA-5717 (*G. hirsutum*), 3-Jaydhar (*G. herbaceum*), 4-KWAN-3 (*G. arboreum*))

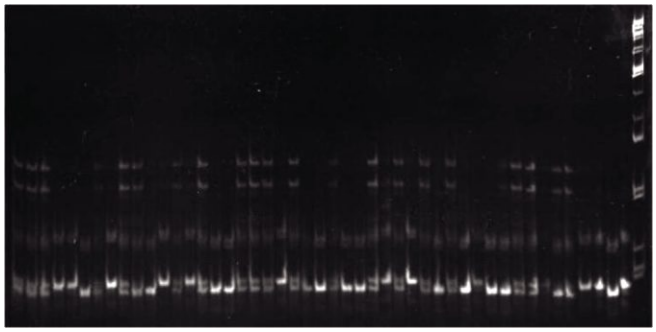


Fig. 3.6.2: Genotyping of F_2 mapping population with SSR marker NAU 905 in diploid cotton

Development of mapping populations (RIL's) for fibre quality traits in diploid and tetraploid cotton

For diploid cotton, 193 F_8 plant progenies were raised. One random plant from each progeny was selfed for maintaining RIL progenies. Few progenies yet showed segregation for morphological characters; hence selfed bolls were selected for advancing to further generation. For the progenies that showed uniformity, all plants in 5 dibble rows were bulk harvested, ginned and the lint was subjected to quality evaluation. Significant variability was observed for the quality attributes.

In *G. hirsutum,* 273 F_7 boll to row progenies were planted, selfed bolls were obtained from single random plants from each progeny and the seed cotton of remaining plants was bulk harvested to be used for evaluation in replicated trial.

ii. Molecular markers for disease resistance

CLCuV resistance

CLCuV resistant (CP 15/2) and susceptible (F 846) parental cotton were identified and crossed at CICR, Sirsa to obtain F2 mapping population. The F1 was advanced at CICR, Coimbatore for advancement of generation. An additional cross was generated between LRA 5166 (R) x HS 6 (S) to develop mapping population Besides, 5000 germplasm lines were screened against CLCuV and 30 lines were observed to be free from the virus under field conditions, for two consecutive years at Sirsa. The lines which remained free of CLCuV will be screened under epiphytotic conditions in polyhouse for further use in marker assisted breeding.

Bacterial blight resistance

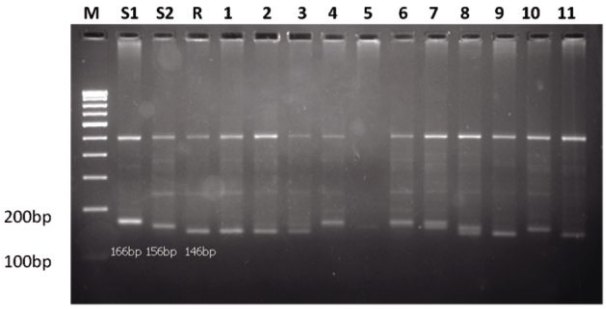
For Bacterial Leaf Blight (BLB), four parents including three BBR genotypes (101-102B, IM216, S295) and one susceptible genotype (Ganganagar Ageti) involved in developing four mapping populations were screened for parental polymorphism using 400 SSR markers. Four SSR markers were found to be polymorphic with the parental genotypes, Ganganagar Ageti and S295. F_2 mapping populations of three independent crosses involving three bacterial blight resistant and one susceptible parents were grown in the field. The entire populations of 259 (Ganganagar Ageti x 101-102B), 216 (Ganganagar Ageti x IM216) and 450 (Ganganagar Ageti x S295) individual F_2 plants were phenotyped for their reaction against bacterial blight disease under natural epiphytotic conditions. Genomic DNA was extracted from few individual plants for genotyping. The three populations have been retained as ratoon crop and the phenotyping will be completed during crop season 2013-14.

Validation of published markers for Bacterial blight resistance (BBR)

Thirty-nine genotypes were screened against race 18 of *Xanthomonas campestris* pv. *malvacearum* by artificial inoculation. Based on reaction of genotypes, 13 were found to be immune while 26 were susceptible to the bacterium.

Screening of germplasm lines for bacterial blight resistance by artificial inoculation - Host differentials and germplasm lines covered with poly bag after *Xam* inoculation

Three SSR markers linked to bacterial blight resistance (BBR) *viz*. CIR 246, BNL 3545 and BNL 3644 were used to screen resistant and susceptible lines. SSR marker CIR 246 (146 bp) was found to co-segregate with bacterial blight resistance in 9 out of 13 genotypes while in susceptible genotypes the same set of primers amplified amplicons of 156 and 166 bp (Fig 3.6.3). The marker however, remained uninformative in remaining 4 blight resistant cotton.



M- 100 bp ladder; S1- Susceptible-166bp (LRA5166); S2-Susceptible-156bp (Acala44); R-Resistant-146 bp (101-102B); 1, 2, 3, 9 and 11 – Resistant lines (146bp); 5 and 10-Susceptible lines (156 bp); 4 and 6 –Susceptible lines (166 bp); 7-Succeptible (156+166bp); 8- Heterozygote (146 +156 bp)

Fig.3.6.3: Validation of CIR 246 Market with germplasm lines for bacterial blight resistance

Nematode resistance

Parental lines for nematode (Reniform and Root-knot nematodes) resistance and susceptibility were identified. These included Bikaneri Nerma for Root Knot Nematode (RKN) resistance; G. Cot 10 and American nectariless for Reniform Nematode (RN) resistance and Suraj as susceptible parent to both RKN and RN. Survey of parental polymorphism using SSR primers has already been initiated.

Coimbatore

To develop a Nested Association Mapping population, selected promising varieties of cotton *viz.*, Suraj and Surabhi (Long staple), Sumangala (Medium staple) and Arogya (Short staple) varieties were crossed with germplasm lines like IC 359856 (Low Strength line with BS 14.5 g/tex) and IC 358438 (High Strength line with BS 26.4 g/tex) and also with Suvin.

3.7: Development of Transgenic Cotton

Bollworm resistant transgenic cotton

Molecular characterization of *cry1Ac* transgenic *G. hirsutum* cultivar Anjali (CICR-Bt-LRK-7) was done. Integration of gene was ascertained by PCR and Southern hybridization while expression of Bt protein was estimated by ELISA. Characterization of 5-new putative Bt transformants of cv Suraj showed the presence of *cry1Ac* gene. Cultivar Suraj was also transformed with *cry1F* gene through pollen-tube transformation method .Bolls set on transgenic plants were harvested and plants raised from boll to row progeny were screened for the presence of transgene. All 18 plants raised from a single boll showed the presence of *cry1F* gene (Fig. 3.7.1).

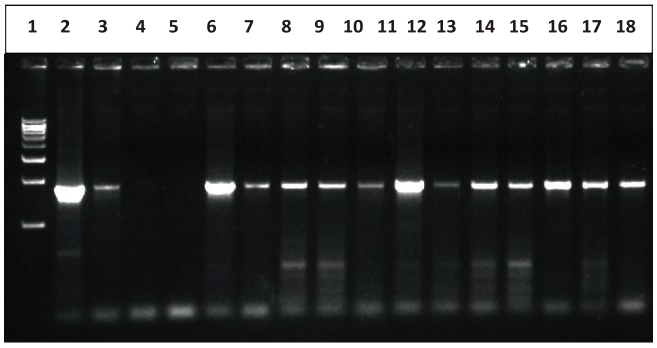


Fig. 3.7.1: PCR amplification of *cry*1F gene in putative transformants of *G. hirsutum* cv Suraj. Lane 1, 1kb ladder; 2, plasmid with cloned gene; 3, positive control; 4, negative control; 5, wild type Suraj; 6-18, *cry*1F transgenic cotton.

Development of Multi-gene Constructs and Bt Cotton Varieties for Sustainable Pest Management

A new gene cassette comprising *G. hirsutum* rubisco small subunit chloroplast transit peptide and codon optimized fusion *cry* gene was generated. Fusion *cry* gene comprising of modified *cry2* and truncated *cry1Ac* were individually cloned in pET28 expression vector (Fig. 3.7.2) and introduced in *E. coli* (BL21 codon plus). Expression of gene and efficacy of the fusion protein was confirmed through insect bioassay. Entire gene cassette was sub-cloned in plant transformation vector under double 35S promoter with NOS as terminator.

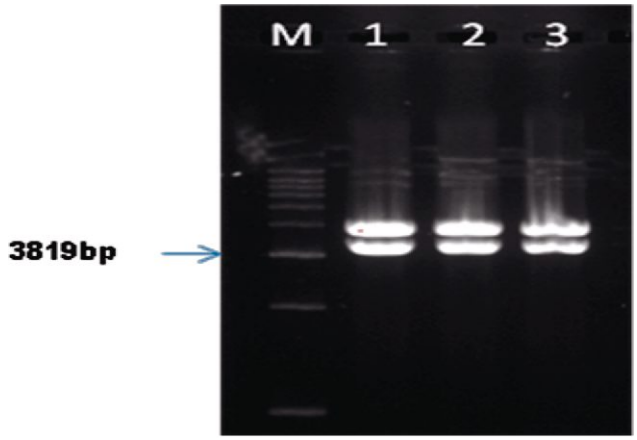


Fig. 3.7.2: F*usion cry gene (cry2+ cry1Ac) in plasmid* pET28. M, 1.0 kb ladder, lanes 1-3, fusion plasmid digested with specific restriction enzymes to release the gene.

RNAi construct

Cotton leaf curl virus isolates collected from the strategic locations of Northwestern India was obtained from the CICR Regional Station, Sirsa. The genome of a recombinant, Mohanpura (Rajasthan) isolate of the virus, was characterized for the purpose of designing dsRNAi construct for RNAi-mediated transgenic cotton. The single stranded, circular genome, comprising of Gemini viral and beta satellite DNA were subjected to rolling circle amplification using Ø29 DNA polymerase (GE, USA) following manufacturer's protocol. The amplified DNA was subjected to restriction digestion using unique restriction endonuclease *viz*., *Aat*II for geminiviral DNA and *Bcl*I for β satellite DNA (Fig. 3.7.3). The linearized DNA was cloned and sequenced (KC412251). Once a number of recombinant isolates obtained from the strategic locations of North India are characterized, their nucleotide sequences will be subjected to alignment and the conserved regions in different ORFs will be used to design RNAi constructs.

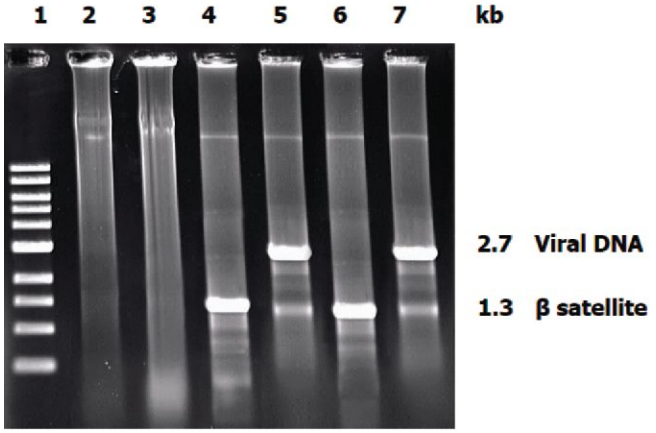


Fig. 3.7.3: Multiple displacement amplification of ss DNA genome of CLCuV. Lanes 2&3, rolling circle amplified viral DNA; 4&6, β satellite linearised using *Bcl* I and 5&7, geminiviral DNA linearised with *Aat*II

RNAi - mediated leaf curl virus resistance

Five dsRNAi constructs were used to transform two popular *G. hirsutum* cultivars, HS6 and LH 2076. Successful transformation was achieved with 4 inverted repeat constructs, pBin-AC-S-int-A and pBin-CP-S-int-A, pBin-**βC1-S-int-A and pBin-βV4-S-int-A** by agro-inoculation (Fig.). Frequency of *in planta* transformation and regeneration in HS6 ranged from 4.1 to 7.7 % (Table 3.7.1).

Table 3.7.1: Transformation of cultivar HS6 with RNAi constructs

Inverted repeat construct	No. of explants co-cultivated	No. of explants selected on kanamycin	No. of explants regenerating shoot	Transform frequency (%)
AC2	310	12	15	7.7
CP	780	22	25	5.6
ßC4	240	05	09	4.1
ßV4	448	15	13	6.6

During 2012-13, a new RNAi event of dsRNAi-CP gene construct in *G. hirsutum* cultivar LH 2076 was developed. The T0 plant was found positive for the transgene (Fig. 3.7.4).

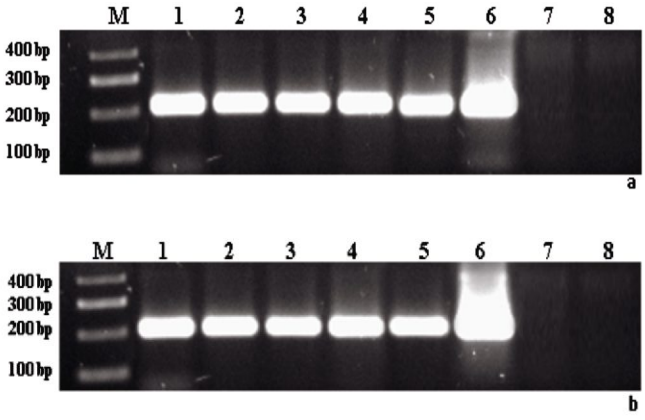


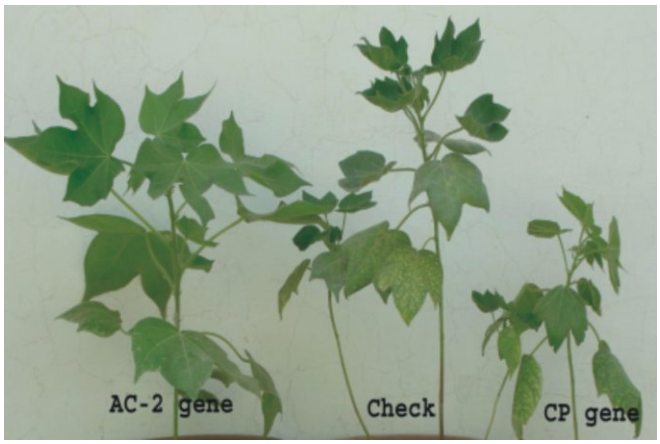
Fig. 3.7.4: Characterization of transgenic LH2076-CP transgenic cotton: amplification of sense (a) and antisense strands (b) each of 182 bp. Lanes 1-5, LH2076-CP transgenic plant; lane 6, pBSK-CP-SA plasmid (+ve control); 7, wild type HS6 (-ve control); lane 8, PCR –ve control.

Molecular characterization of transgenic events

Putative transformants with pBIn-AC2-S-int-A and pBIn-CP-S-int-A were documented by PCR for presence of viral sequence, both in sense and antisense orientations. Twelve PCR positive events of CICR-HS6-AC2 and three events of CICR-HS6-CP were established. Contained greenhouse trial with 215 transgenic cotton (T1) belonging to 5 transgenic events (T0)- comprising of 3, CICR-HS6-AC2 events and 2,

CICR-HS6-CP events, were conducted at CICR regional Station Sirsa. Entire progeny of 5 transgenic (T0) plants that were found positive for presence of inverted repeat constructs by PCR and Southern hybridization were screened against viruliferous whitefly in glass house along with the wild type cotton HS6.

Contained green house trial at Sirsa with RCGM approval



CLCuV tolerant transgenic cotton challenged with viruliferous whitefly in contained glass house at CICR Regional station, Sirsa. Transgenic plants showed delayed pathogenesis

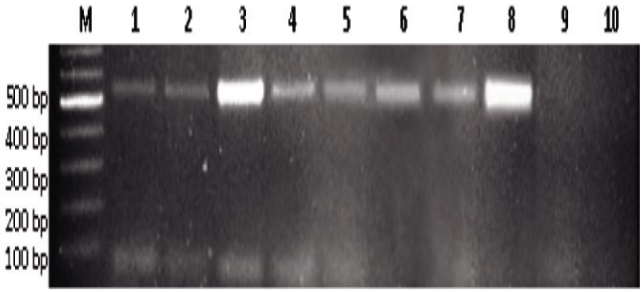


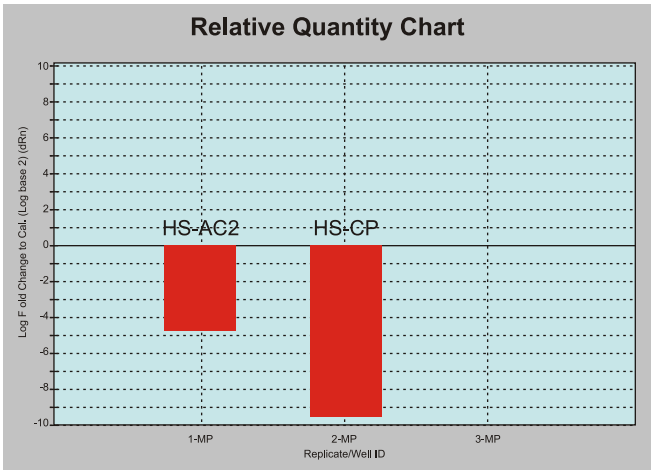
Fig. 3.7.5: Detection of inverted repeat construct in transgenic cotton with *npt*II primer. M-100 bp ladder, 1, HS6-AC2-, 2, HS6-CP-, 3, HS6-CP-, 4, HS6-CP-, 5, HS6-CP-, 6, HS6-CP-, 7, HS6-CP-, 8, pBin plasmid (positive control); 9, HS6 (wild type); negative control.

Transgenic plants appeared to vary in degree of tolerance against CLCuV, with some plants showing delayed initiation of disease symptoms. By the end of the season at least six transgenic plants possessing HS6-CP-SA construct remained free from CLCuV symptoms. Seven transgenic plants including 2 that showed delayed pathogenesis and 5 plants that remained symptomless (Table 3.7.2), were analyzed for the presence of inverted repeat sequence as well as the *npt*II reporter (Fig. 3.7.5).

Rt-PCR analysis of two transgenic plants that showed delayed pathogenesis revealed 5 (HS6-AC2-SA) and 9 fold (HS6-CP-SA) reduction in virus titre compared to wild type control plants. While analysis of 5 RNAi-mediated transgenic plants that remained symptomless till the end of the season showed more than 12 fold reduction in viral load (Fig. 3.7.6). Nevertheless, all transgenic plants showed latent infection of virus when diagnosed with PCR.

Table 3.7.2: Analysis of Transgenic plants for CLCuV infection, Inverted repeat construct, disease reaction and viral load by qualitative and Q-PCR

Sr. No.	Event	PCR result		Down regulation of virus	Disease reaction
		*npt*II Prim	CP Primer		
1	HS6-54-AC2-10-8	Positive	Positive	5 Folds	Delayed expression
2	HS6-4-CP-2-1-A	Positive	Positive	10 Folds	Delayed expression
3	HS6-11-CP-2-8-B	Positive	Positive	12 Folds	Free
4	HS6-11-CP-2-8-C	Positive	Positive	12 Folds	Free
5	HS6-6-CP-2-3-D	Positive	Positive	12 Folds	Free
6	HS6-5-CP-2-2-E	Positive	Positive	12 Folds	Free
7	HS6-9-CP-2-6-F	Positive	Positive	12 Folds	Free



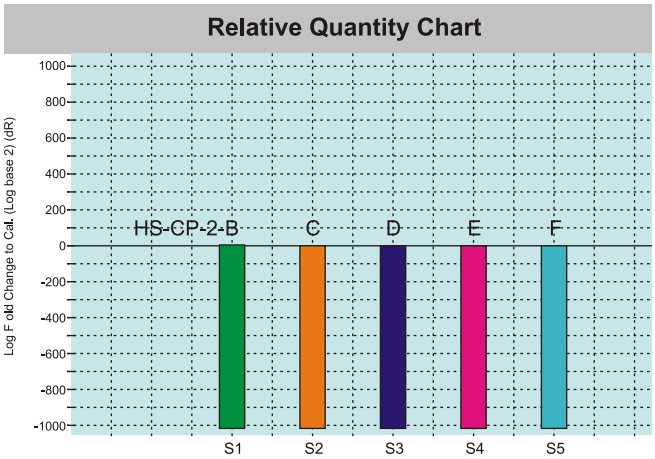
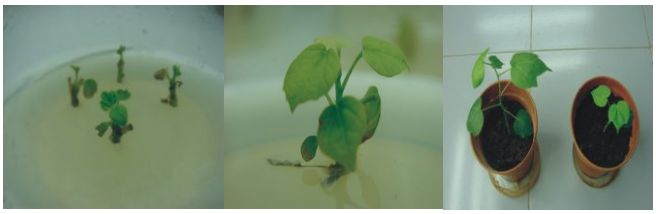


Fig. 3.7.6 : Reduction in CLCuV titer in RNAi-mediated transgenic cotton: a, plants showing delyed pathogenesis; b, symptomless plant.

Antisense resistance against CLCuV

Transgenic plants for Cotton leaf curl virus with Sense coat protein (AV1), anti-sense coat (AV1) protein and antisense replicase protein (AC2) in the elite genotypes RS 875 were developed. T_3 Transgenic events namely, HS6 (*ARep*)- 1 event, (*ACP*)- 1 event, (*SCP*)- 1 event; H777(*ACP*)-1 event, F 846 (*ARep*) -1event, (*ACP*)-1 event, (*SCP*)- 1 event were selfed and the bolls were harvested. Quantitative RTPCR of the transgenic events was carried to determine the relative quantity and copy number which revealed that HS 6 with antisense coat protein and HS 6 with sense coat protein had one copy of the gene.

New events of RS 875 (SCP)-6, RS 875 (ACP)-7, RS 875 (ARep)-5 were developed and characterized for the presence of the reporter gene *npt II* besides, specific genes (Antisense Coat protein, Sense Coat Protein and Antisense Replicase gene). The transgenic plants were screened against viruliferous whiteflies at CICR RS Sirsa. Three plants of RS 875 (SCP) and one plant of RS 875 (ARep) remained symptomless.



Transgenic plants *G. hirsutum* cultivar RS 875 with sense coat protein gene

Progenies of T_3 transgenic events namely, HS6 (*ARep*)-1 event, (*ACP*)- 1 event, (*SCP*)- 1 event; H777(*ACP*)-1 event, F 846 (*ARep*) -1 event, (*ACP*)-1 event, (*SCP*)- 1 event were selfed and the bolls were harvested. The events were subjected to qPCR analysis for quantitative expression of transgene and assessment of copy number. Rt-PCR analysis revealed single copy integration in one of the HS_6-ACP events.

Fungal resistance

Inheritance of *chi*l gene in progenies of transgenic cotton

Southern hybridization of T_1 progeny of transgenic *Gossypium arboreum* cv PA255 raised from independently transformed T0 shoot by each of three *in planta* protocols viz., meristem bisections, seed inoculations with *Agrobacterium* without injury and with injury was done. Four T_1 plants raised from 4 seeds in one boll on three independent T_0 plants generated by three methods of regeneration was subjected to Southern hybridization. All 4 plants generated by each of the methods 1 and 2 showed presence of single copy of transgene (Fig. 3.7.7). However, the plants generated by two methods possessed independent events as evident from the variation in size of the hybridization signal. In progeny of the T_0 plant generated by third method, 3 out of 4 T_1 plants showed integration of single copy of gene while one T_1 had two copies of transgene. This shows that transgene were present in majority of the populations thereby having the possibilities of the transgene segregating in 3:1 ration if adequate number of populations are analysed.

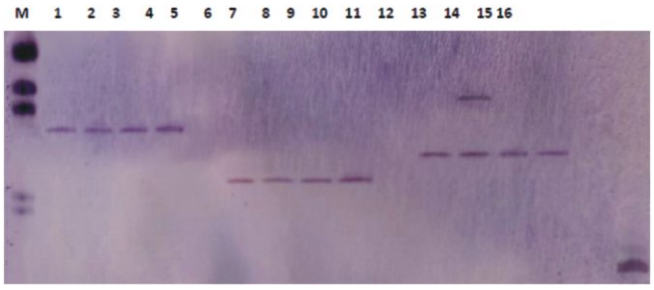


Fig. 3.7.7: Southern blot of T_1 progeny of transgenic Gossypium arboreum cv PA255 raised from independently transformed T0 shoot meristem bisections

(Lanes 1-5) and seed inoculations without (Lanes 6-10) and with (Lanes 11-15) injury. Southern blot was hybridized with DIG labelled *Gossypium hirsutum* Chitinase gene as DNA probe. Lane M, λ-Hind marker; Lane 5, 10, 15 PCR –ve plants, Lane 16, uncut probe DNA. DNA digested with EcoRI.

Each of the T_1 plants generated by 3 methods and analysed above were planted and allowed to set bolls by selfing. One T2 seed from one of the bolls on each plant were again subjected to Southern hybridization. All 4 plants generated by each method showed uniform sized signals characteristic of the original event (Fig. 3.7.8)

Fig. 3.7.8 : Southern blot of T2 progeny of transgenic *Gossypium arboreum* cv PA255 raised from T1 positive events independently sown, shoot meristem bisections (Lanes 1-5) and seed inoculations without (Lanes 6-10) and with (Lanes 11-15) injury. Southern blot was hybridized with DIG labelled Gossypium hirsutum Chitinase gene as DNA probe. Lane M, λ-Hind marker; Lane 5, 10, 15 PCR –ve plants; Lane 16, uncut probe DNA. DNA digested with *EcoRI*.

Expression of chitinase gene in Cisgenic cotton

Gene expression analysis was also carried out in selected T_1 progeny using a chitinase activity assay. The transgenic plants showed chitinase enzyme activity that was 44.48% - 90.15% higher than that in untransformed plant (Fig. 3.7.9). The chitinase activity was highest in T_1 plants-A1 (4.87 mg/ml) and A2 (4.76 mg/ml). In remaining 4 out of 6 transgenic events it remained more or less similar in range between 3.67 - 4.02 mg/ml. Although the activity of chitinase gene appeared to vary with different transformation events, it was not apparently affected with copy number of genes integrated in the plants.

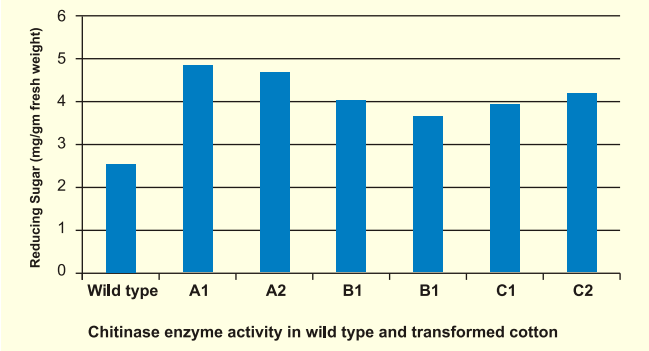
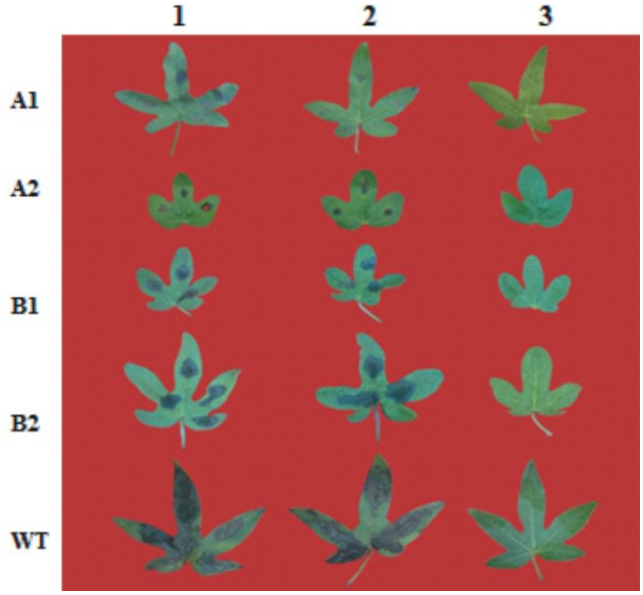


Fig. 3.7.9: Chitinase activity of T1 progeny plants of transgenic cotton (*Gossypium arboreum*) cv PA255 raised from independently transformed T0 cotton by shoot meristem bisection (A) and seed inoculation with (B) or without (C) injury

Cisgenic T_1 cottons and the wild type PA255 plant were bioassayed against *Myrothecium roridum*, a saprophytic leaf spotting disease of many plant species, and *Ramularia areola,* a semi-obligate areolate mildew of cotton. In case of *R. areola* the plants were spray inoculated with aqueous spore suspension. The spores were scraped off the leaves of freshly infected cotton and a final suspension was made in water with 0.2 % Tween 20. The concentration of spores was adjusted to 10^6 spores/ ml. The plants were maintained under glass house conditions at a temp of 30 +/- 2°C and >RH 95% for 24 h. Plants were examined for the development of disease. In case of *M. roridum* leaves of the plants were spot inoculated with aqueous spore suspension. The spores/ sporodochia formed in one week old culture growing on PDA at 27°C were used for inoculation. Inoculated plants were subjected to temp and humidity as above and observed for the development of disease. The cisgenic plants showed reduced lesion size and symptom development was delayed by at least 10 days.



Evaluation of resistance of chitinase cisgenic *G. arboreum* PA255 against *M. roridum*. T1 progeny plants raised from independently transformed T0 cotton by shoot meristem bisection (A1 & A2) and seed inoculation (B1 & B2). 1, 2 Inoculated; 3, water without spores (control); WT, wild type.

Transgenic cotton for drought tolerance

Two events of DREB1A each, in LRA 5166 (Fig. 3.7.10) and LRK 516 (Fig. 3.7.11 a & 3.7.11 b) and one event of ZF1 each in LRA 5166 and LRK 516 were selected earlier in contained field trial. T3 generations of these six

events were grown in boll to row progeny in pot house. The transgenic plants which were positive for specific genes as ascertained by gene specific and reporter *npt*II specific genes were selfed (Table 3.7.3).

Table 3.7.3: Summary of transgenic events generated with DREB1A and ZF-1 genes

Transgenic Event	No. of plants germinated	*npt*II Positive plants	Transgene positive plants	Total number of transgenic plants
LRK 516-DREB 1A-1	22	17	17	17
LRK 516-DREB 1A-2	14	12	12	12
LRA 5166 –ZF1	17	10	10	10

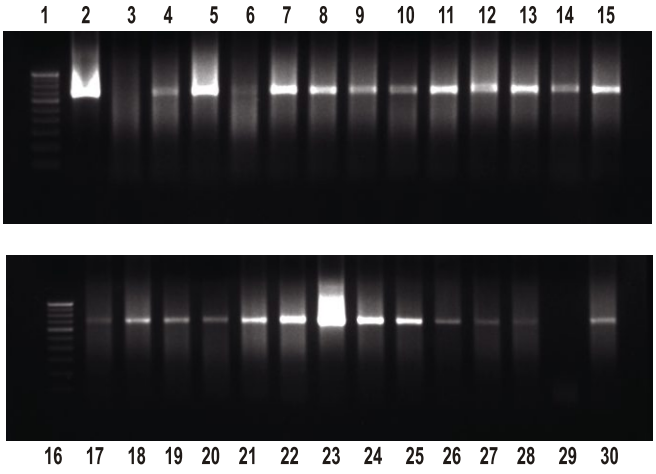


Fig. 3.7.10: Transgenic cotton expressing DREB1A and ZF1 genes. Transgenicity was ascertained by amplification of *npt*II sequence. Lanes 1 & 16, 100 bp ladder; lane 2 positive control ; Lane 3 negative control; lanes 4-7, LRK 516, DREB 1A-1 plants E19-22; lanes 8-15 and 17-20, DREB 1A-2 plants F3-F14 ; lanes 21-30, LRA 5166, ZF1- plants G1-G11.

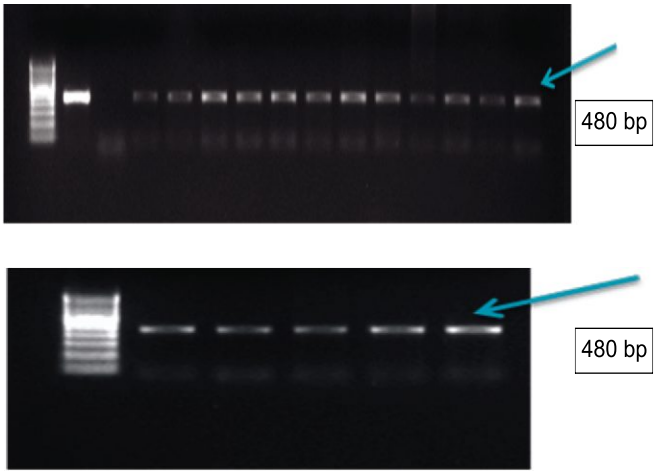


Fig. 3.7.11 a: Transgenic cotton expressing DREB 1A gene. Transgenicity was determined by amplification of DREB 1A gene. Lane 1, 100 bp ladder ; lane 2, positive control; lane 3, negative control; lanes 4-22, LRK 516-DREB1A-1 plants, E1-E22.

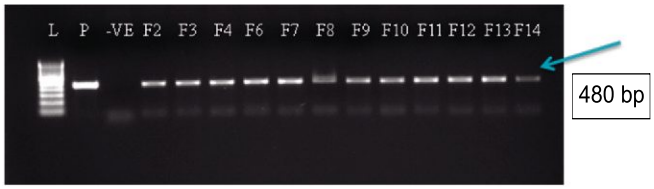


Fig. 3.7.11 b: Cotton expressing DREB1A gene. Lane 1, 100 bp ladder; lane 2, positive control; lane 3, negative control; lanes 4-15, LRK 516-DREB1A-2 plants, F2-F14.

Gene expression analysis in drought resistance related transgenic cotton

Total RNA was isolated from leaves of transgenic LRA 5166-DREB 1A and LRK 516- ZF1 plants. Reverse transcription was performed using Oligo-dT primer to get first strand cDNA. PCR was performed using DREB 1A and ZF-1 primers. Rt-PCR analysis revealed over expression of gene in transgenic cotton compared to wild type control.

Molecular characterization and validation of fiber strength genes

Genes expressed during secondary wall formation (16-35 DPA) play vital role in cotton fiber strength. Under this project efforts have been taken to identify, characterize, clone and validate genes associated with secondary cell wall formation in cotton fiber. Few genes such as *GhcesA 4, GhcesA7 and GhcesA8*, TC59194 (*GhFLA2*), TC59405 (*GhMT1*) and *AtCobl4*) have been targeted to study the transcript level during 16-35DPA. Presently the identified candidate genes would be cloned and validated with fiber specific promoter for its defined function. Experiments were carried out with selection of high and low fiber strength genotypes of G. *hirsutum* and *G. barbadense*. Total RNA was isolated at different stages of fibre development and cDNA synthesis was carried out. qRTPCR analysis was harmonized with expression profile of selected genes *viz. cesA4, cesA7* and *cesA8, GhFLA2, GhMT1, AtCobl4, AGP4* and *WDL1* at different stages of secondary wall synthesis *viz.*, 16, 18, 21, 24, 27, 33 and 36 DPA. From expression analysis, it was clear that above mentioned genes maintained relatively high expression at secondary wall synthesis phase in both cotton species. Among these genes, *Ghces*A2 and *Ghces*A7 showed relatively higher level of expression during secondary wall synthesis at 27, 33, and 36 DPA. The selected candidate genes were amplified directly from cDNA using gene specific primers (Fig. 3.7.12). Cellulose contents were analysed from 16 to 33 DPA for all the four species. *G. barbadense* genotypes showed higher deposition of cellulose during secondary wall synthesis compared to *G. hirsutum.*

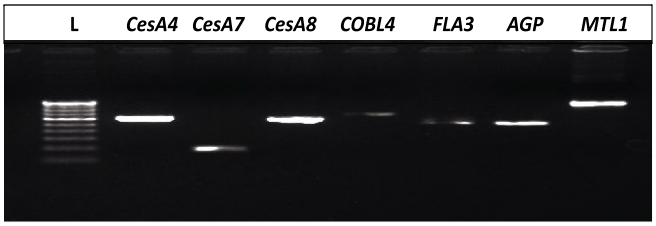
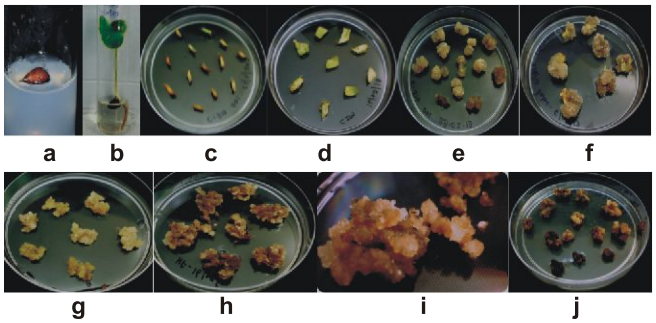


Fig. 3.7.12: PCR Amplification of candidate genes with gene specific primers

Genomics of cotton boll and fibre development

As an additional partner in NAIP Programme on "Genomics of cotton boll and fibre development", CICR has been entrusted with responsibility on transformation and validation of functional roles of genes associated with high fibre length and strength documented during the fibre extension phase. ICGEB provided three gene constructs *viz*. *Expansin, Aquaporin,* and *Arabinogalactan* in *Agrobacterium tumefaciens.* For effecting transformation by somatic embryogenesis, calli were induced using Coker 310 genotype in MS medium containing auxin (IAA 1.0 mg/l) followed with *Agrobacterium* mediated transformation with the above three genes. The transformed calli were subjected to selection in high concentration of kanamycin (100 mg/l). Agro-inoculated calli were sub-cultured to induce somatic embryos.



Callus induction and Agrobacterium-mediated transformation with Coker 310 genotype. Different stages of callus induction and transformation. (a) seed inoculated on half strength MS medium (b) seven day old seedling (c) callus induction from hypocotyls explants (d) callus induction from cotyledonary leaf explants (e-i) callus proliferation and somatic embryogenesis (j) transformed callus on selection medium

Development of inverted repeat construct to silence gossypol biosynthesis genes

To develop RNAi construct for silencing gossypol biosynthesis in cotton seed (Fig. 3.7.13, 3.7.14 & 3.7.15), the target genes coding for δ Cadinene synthase and δ Cadinene hydroxylase were isolated, sequenced and cloned in inverted repeat generating 3.1 kb plasmid pBSK-int (HQ343203). For expression of the dsRNAi construct in seed, seed-specific Beta Globulin Promoter sequence was isolated and cloned upstream of the inverted repeat sequence. Additionally, alpha globulin promoter (AGP) along with Intron A of the alpha globulin gene was also cloned to drive the inverted repeat construct, expectedly at a greater efficiency (Fig. 3.7.15).

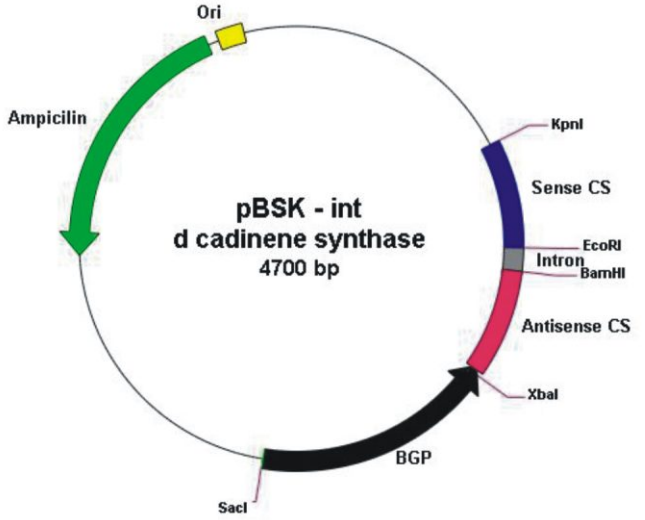


Fig. 3.7.13: Schematic representation of pBSK-int- δ *Cadinene synthase* plasmid (4.58 kb)

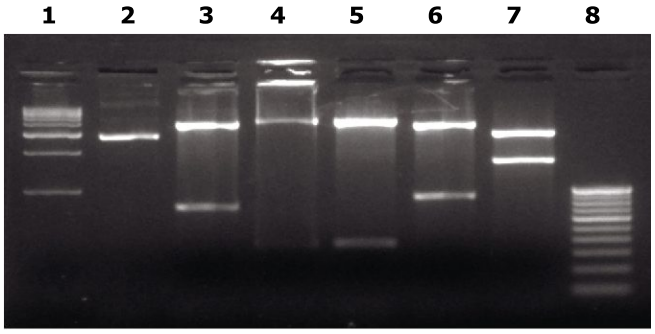


Fig. 3.7.14: Restriction digestion of inverted repeat (IR) plasmid pBSK-int- δ *Cadinene synthase* to reveal components of the constructs. Lanes 1 & 8, 1kb and 100bp ladder; 2, uncut plasmid pBSK-int (3.1 kb); 3, Beta-Globulin promoter (*Xba*I+*Sac*I= 756bp); 4, sense strand of δ *Cadinene synthase* (*Kpn*I + *Eco*RI = 375bp); 5, antisense strand of δ *Cadinene synthase* (*Xba*I +*Bam*HI=375bp); 6, IR construct (*Xba*I + *Kpn*I = 873 bp); F, IR with promoter (*Kpn*I+*Sac*I = 1629bp).

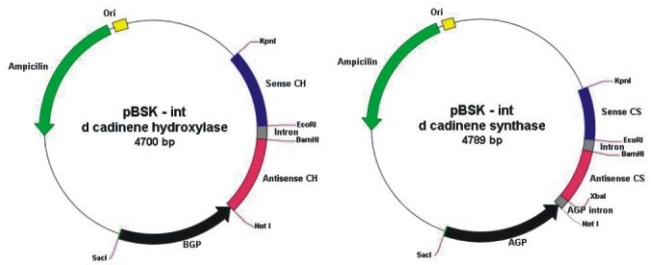


Fig. 3.7.15: Schematic representation of pBSK-int- δ-cadinene hydroxylase and δ-cadinene synthase inverted repeat construct.

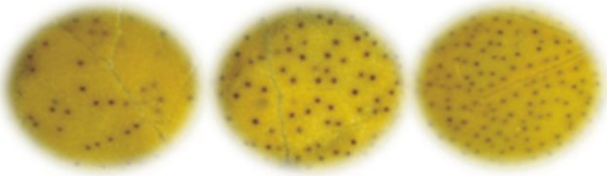
3.8: Seed Production and Seed Quality Improvement

Nagpur

DUS characterization

During 2012-13, 69 genotypes (39 candidate and 30 reference) were characterized for DUS traits. Besides, 28 diploid cotton (*G. arboreum* and *G. herbaceum*) varieties were cultivated for maintenance breeding for use as reference genotypes for characterization of DUS traits.

In order to determine feasibility of using gossypol gland density as special DUS trait, 25 *G. hirsutum* and 16 *G. arboreum* varieties were examined for variation in gossypol gland density / 2 sq.mm area under high resolution stereo-microscope. The observations were recorded on two cotyledonary leaves of three seedlings per variety. Gossypol gland density was determined in seven days old cotyledonary leaves of cotton germinated under controlled condition. Based on gland density, varieties were categorized into three groups viz. high (130 and above), medium (100-130) and low (less than 100) gossypol groups. Sixteen varieties were tested for inheritance of the trait over generation. Gossypol gland density was stably inherited in 14 out of 16 varieties tested (Table 3.7.4). The results showed that gossypol gland density could serve as an additional trait for DUS testing of cotton. Based on gossypol gland density PLC 62, a perennial cotton could be distinguished from a set of morphologically similar cotton.



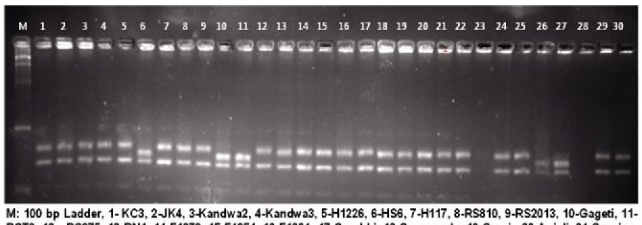
Gossypol gland density in *Gossypium hirsutum*

Table 3.7.4: Grouping of varieties of *Gossypium hirsutum* based on gossypol gland density

High (130 and above)	Medium (100-130)	Low (less than 100)
JLH 168	MCU10	NH545
AKH 8828	F1054	Abadhita
Surabhi	F1378	Sumangala
MCU 12	MCU 10	Sahana
	G Cot 16	Narasimha

DNA fingerprinting of released varieties

Fifty released (public sector) varieties of cotton were characterized using 25 SSR markers that were earlier found informative based on their ability to delineate genetic diversity among large number of genotypes fingerprinted. Four SSR markers (BNL 3371, NAU4485, DPL398 and DPL468) were found polymorphic within the tested varieties. Variety HS-6 could be distinctly identified using two markers, BNL 3371 and DPL468 (Fig. 3.7.16). Further characterization of candidate varieties with more informative markers are in progress.



M: 100 bp Ladder, 1-KC3, 2-JK4, 3-Kandwa2, 4-Kandwa3, 5-H1226, 6-HS6, 7-H117, 8-RS810, 9-RS2013, 10-Gageti, 11-RST9, 12 - RS875, 13-BN1, 14-F1378, 15-F1054, 16-F1861, 17-Surabhi, 18-Sumangala, 19-Suraj, 20-Anjali, 21-Supriya, 22-LRA5166, 23-MCU5VT, 24-Gcot20, 25-Surat dwarf, 26-G67, 27-Gcot16, 28-F846, 29-Gcot18, 30-Deviraj

Fig. 3.7.16: DNA Fingerprinting of *Gossypium hirsutum* varieties with SSR marker, BNL 3371

Seed treatment for quality improvement

The effect of seed treatment with H_2O_2 was compared with KCl, hydration with water and untreated controls at germination in 48 hours old seedlings. Preliminary observations indicated that H_2O_2 treatment supported comparatively higher germination besides, seedling fresh and dry weight. Concomitantly, improvement of cell membrane integrity as measured by reduction in release of volatile aldehydes and reduction in electrical conductivity of seed leachates was observed in H_2O_2 treated seeds compared to other treatments (Fig. 3.7.17 & 3.7.18). The activities of major antioxidant enzymes such as peroxidase and catalase were also found to be high in the H_2O_2 treated seeds.

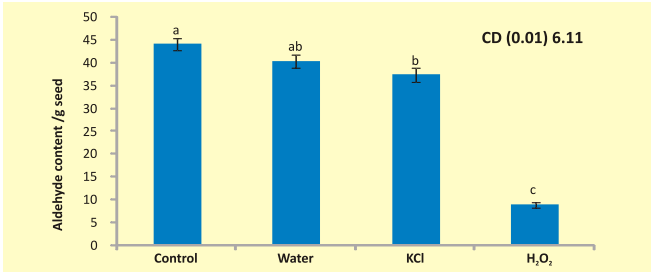


Fig. 3.7.17: Effect of seed treatment on release of volatile aldehydes

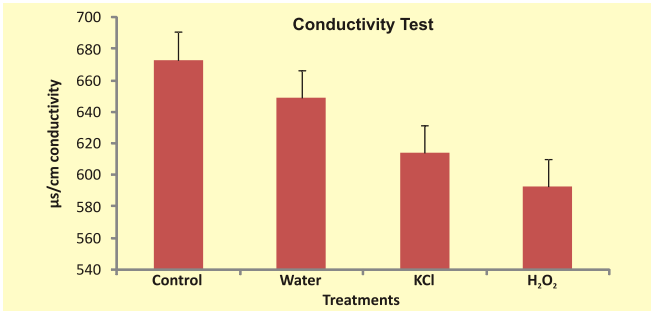


Fig. 3.7.18: Effect of seed treatment on elevated electrical conductivity of seed leacheates

Effect of Nursery substrates and transplanting on plant stand

Sixteen different combinations of nursery substrates were evaluated in commercial seedling trays for their efficacy to raise cotton seedlings for transplanting. Kelbrick was found to support good seedling stand besides being the most inexpensive substrate. Root growth observed at 20 DAS was superior in commercial (Kelbrick, Kelpeat etc.) compared to conventional substrates (Soil, FYM, Sand etc.). Vigour of the seedlings was superior in seeds sown in large slotted trays compared to trays with smaller slots.

One and 2 months old cotton seedlings were transplanted following treatments with microbial consortia, H_2O_2 and *Pseudomonas fluorescens* individually as well as in combinations compared to directly sown crop. Preliminary observations indicated that one and two months old cotton transplanted during normal season (9.7.12) yielded better than early season (5.6.12) direct sown cotton. Besides, yield advantage transplanted seedlings supported comparatively higher number of bolls, produced fewer monopodia and were comparatively short in height.

Coimbatore

Effect of Seed Coating with Synthetic Polymers and Additives

An experiment was initiated during 2009 to improve storability and sustainability of viable cotton seeds with polymer coating along with insecticides or fungicides.

After treatment, seeds were stored in cloth bag under ambient condition. Viability of seeds was evaluated at quarterly interval till August 2012. It was observed that seeds of NHH 44 Bt coated with Polymer (Polykote @ 3 ml/kg of seed), Polykote with Imidacloprid @ 6 ml / kg of seed and Polykote with Vitavax @ 2 g/kg of seeds were efficient in maintaining the viability. In case of coating seeds with polymer-polyloc alone or with carbendazim (Bavistin) @ 2 g/kg was also found effective in maintenance of viability of seeds on storage.

Effect of seed treatment on productivity of cotton

Effect of seed treatment on plant growth, promotion and enhancement and productivity was studied. Seeds were subjected to simple hydration, or treated individually with inorganic chemicals like $CaCl_2$, KNO_3, H_2O_2, KH_2PO_4, KCl; growth hormone GA_3; amino acid and succinic acid; or fungicide Thiram at specified concentration and sown. Significant enhancement in productivity in terms of increased plant height, number of sympodia, number of bolls / plant and boll weight was achieved with hydration for 10-12 h. followed by drying the seeds at room temperature and dressing with 0.25% Thiram. Seed soaking in H_2O_2 @ 40 mM for 6 hrs. or in aqueous solution of succinnic acid @ 0.2% followed by drying at room temperature before sowing were equally effective.

Effect of magnetic pulse treatment on seed cotton productivity

Seed subjected to magnetic pulse treatment showed significant enhancement in viability in all the genotypes tested especially at magnetic field intensity of 750nT followed by that in 1500nTand 500nT. Pulse field treated seeds however did not show significant enhancement in cotton productivity.

Implementation of PVP legislation, 2001

During 2012-13, 104 genotypes (56 candidate and 38 reference and 10 essentially derived varieties) were characterized for DUS under Implementation for Protection of Plant Varieties and Farmers' Rights Act, 2001. Based on filing of application for registration of extant and new cotton varieties, Plant Variety Registration Certificate for 29 extant cotton varieties have been received. The complete database on 160 *G. hirsutum,* 3 *G. barbadense,* 60 *G. arboreum,* 15 *G. herbaceum,* 50 intra-*hirsutum,* 19 interspecific, 9 intra-*arboreum* and 4 *h x a* hybrids were documented alongwith 91 varieties of common knowledge.

Under varietal maintenance, 145 *G. hirsutum,* 6 *G. barbadense,* 28 *G. arboreum* and 8 *G. herbaceum* were maintained and multiplied. Monitoring of DUS trials were conducted at Nagpur, Coimbatore, HAU Hisar, PAU Ludhiana and UAS Dharwad under the chairmanship of Dr. M.S.Kairon, Former Director, CICR Nagpur.

Sirsa

Seed Setting efficiency in *G. hirsutum* cotton

Cotton genotypes were found to vary in their seed setting efficiency. Nature of variability in seed setting efficiency was studied in two sets of cotton genotypes at CICR regional stations at Coimbatore and Sirsa. Seed setting efficiency in a set of 100 germplasm lines was analysed each at Sirsa and Coimbatore by estimation of number of ovules per ovary and corresponding number of seeds set per boll. At Sirsa, number of ovules per ovary ranged between 22-35 and corresponding conversion into seeds/boll ranged from 19-34, with seed setting efficiency of 72.2-97.1%, while at Coimbatore number of ovules per ovary ranged from 28.1-35.3 and corresponding number of seeds per boll ranged from 20.0-33.3, with a setting efficiency of 65.9-99.6%. If seed setting efficiency is an inherent trait, efforts can be made to enhance seed setting efficiency and consequentially the productivity, by seed technological interventions.

Seed Production

Nagpur

Under Mega Seed Project, TFL seed production of 24 straight varieties of cotton, *G. arboreum* race *cernuum*, Red Gram cv. BSMR-736, Bengal Gram, certified seed of Gram cv. Jaki 9218 and Digvijay was taken up. Nearly 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 were produced and resource worth Rs. 16 lakhs was generated.

Seed production of *G. arboreum* race *cernuum* was taken up. Wide genetic diversity was observed among the populations. Morphological variants within *G. arboreum* race *cernuum* such as those with different shades of lint, number of locules/ bolls and bolls/plant, erect plants with zero monopodia, etc., were documented. Morphological variants were also evaluated for stability of different traits and trait-wise purification of the material was done.

Four loculed cotton **Variation in boll size** **Coloured lint**

Variability in *Gossypium arboreum* race *cernuum* cotton

Coimbatore

Breeder seed of cotton varieties *viz*., Suraj, LRA 5166, Anjali, Surabhi, Suraj, MCU 5 VT and Suvin was produced at Coimbatore. In all, 239 kg breeder seeds of varieties were supplied to indenters including private seed producers.

Sirsa

At Sirsa, 190 kg breeder seed of *desi* cotton (*G. arboreum*) including parents of CICR-2 and varieties CISA 614 and CISA 310, was produced and distributed to stakeholders and indenters.

3.9: Nutrient Management

Nagpur

Organic nutrient sources with release rates compatible to crop demand is one of the key principles of nutrient management. Therefore, field studies were conducted with four organic components *viz.* FYM, vermicompost, bio-enriched cotton compost and mulching of green manure (sunhemp) besides a control treatment. All organic sources were applied in equal quantities (5t /ha). Two varieties, namely, Suraj (*G. hirsutum)* and JLA 794 (*G. arboreum*) were taken up under organic cotton cultivation. Three sprays of neem oil (@300 ppm) were given for controlling insect pests. Seed cotton yield of 13.6 q/ha was recorded in JLA 794 followed by Suraj (9.8 q/ha). Soil analysis data indicated that application of bio-enriched compost resulted in a buildup of available soil-N and soil organic carbon (SOC). SOC content in the organic manure amended plots ranged from 0.64 to 0.76% which was substantially greater than the SOC content in the farmers' practice plot (0.54%).

Cotton stalk compost was prepared using improved composting technique and the nutrients enriched compost was evaluated as a substitute to FYM. Field experiment was conducted in a split plot design with two main treatments [seed treatment with microbial consortia (MC) and without MC] and 6 sub treatments [recommended NPK (90:45:45 kg NPK/ha), INM Practice (60:30:30 kg NPK + 5 t FYM/ha), modified INM Practice (60:30:30 + 5 t cotton compost), FYM, cotton compost and control]. Bunny *Bt* (NCS-145*Bt*) was used as a test hybrid with a spacing of 60 x 60 cm. All the treatments were replicated 5 times. Results showed significant differences between treatments. Incorporation of cotton compost (the modified INM) was found to be as good as the INM practice comprising FYM. Seed treatment with microbial consortia improved seed cotton yield by 2-5 q/ha compared to the un-treated seeds.

Coimbatore

Recommended NPK with cotton stalk compost @ 2.5 t/ha had seed cotton yield and boll numbers similar to the

recommended INM practice (recommended NPK +FYM 12.5 t/ha).

Sirsa

Bioenriched compost evaluation

Cotton stalks compost with and without bio-enrichment was evaluated under field conditions in RBD with six replications using 1947 *Bt* hybrid. Maximum seed cotton yield was observed with the existing INM practice (70:24:24 + 5 t FYM/ha) and was at par with cotton stalk compost. The treatment NPK (70:24:24) had the lowest seed cotton yield and was significantly lesser than the existing INM practice for north zone.

3.10: HDPS for Maximizing Productivity

Nagpur

Thirteen cultivars developed under diverse agro-climate conditions viz., NH 615 and NH 545 (Nanded), ADB 39 and MDLH 1 (Ailabad), Suraj, LRK 516 (Coimbatore), KC 3 (Kovilpatti), RS 875 (Ganganagar), CSH 3178 (Sirsa), F 2383 (Faridkot), H 6 *Bt* (BG II) and H 8 *Bt* (BG II) (Surat) and PKV 081 (Akola) were evaluated at 3 spacings 45x15cm (148000 plants/ha), 60x15cm (111000 plants/ha) and 90x15cm (74000 plants/ha) on a shallow black soil (Vertic Inceptisol). The effect of spacing, cultivars and spacing x cultivar interaction were significant. Across cultivars, yield at 45x15cm and 60x15cm were at par and superior to that at 90x15cm. For both the *Bt* hybrids, H 6 and H 8, 60x15cm was the optimum spacing under HDPS. Genotypes ADB 39 (3000 kg/ha), PKV 081 (3011 kg/ha) and LRK 516 (2814 kg/ha) performed well at 45x15cm spacing whereas genotypes NH 545 (2830 kg/ha), KC 3 (3113 kg/ha) and Suraj (2976 kg/ha) gave highest yield at 60x15cm spacing.

Growth regulators *viz.* Mepiquat chloride (N, N- dimethyl piperidinium) and Stance (Mepiquat chloride + Cyclanalide) were compared at recommended (50 g a.i./ha for Mepiquat chloride and 600 ml/ha for Stance) and 150% recommended dose using different application schedules on 3 varieties *viz.* Suraj, PKV081 and NH615 at 45 x 15 cm spacing. There was a dose dependent reduction in plant height, decrease in height / node ratio an increase in boll weight and a delay in maturity with the application of growth regulators. None of the growth regulator treatments improved yields. Across growth regulator treatments, the varieties Suraj (2147 kg/ha) and PKV 081 (2143 kg/ha) gave significantly higher seed cotton yield than NH 615 (1898 kg/ha).

Under HDPS, effective control of weeds could be accomplished with pendimethalin @ 1kg a.i./ha + 2 intercultures along the row + 1 hand weeding (to remove remaining weeds) + 1 post emergence spray of tank mixed Pyrthibac Na(75 g a.i./ha) and Quizalofop ethyl (50 g a.i./ha).

Coimbatore

Under winter irrigated conditions, 10 cultivars namely, Anjali, C1412, CCH724-5, TCH 1608 ,TCH 1705, KC-3, NH615, MCU7, SVPR-3, PKV081 were evaluated at a spacing of 45 x 15 cm with and without application of growth regulator (mepiquat chloride @ 25 g a.i. at 45, 60 and 75 DAS). Two checks viz. Anjali planted at 75 x 30 cm and RCH 2 Bt planted at 90 x 60 cm were also maintained. Across cultivars, application of mepiquat chloride increased seed cotton yield from 1330 q/ha to 1530 kg/ha. Interaction effect of cultivars and application of mepiquat chloride was significant. Taller cultivars - TCH 1608 and TCH 1705 benefitted with application of mepiquat chloride compared to the other cultivars having a compact growth habit (Fig. 3.10.1).

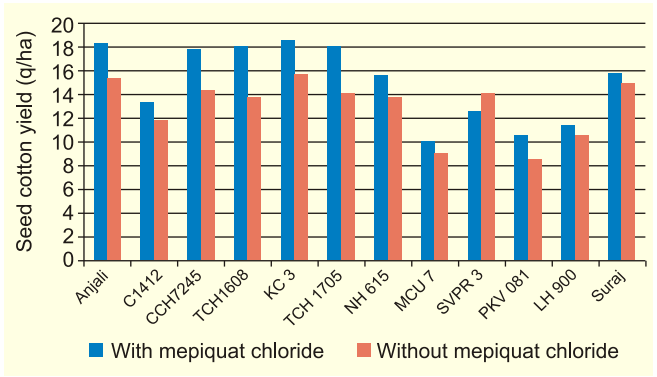


Fig. 3.10.1: Effect of mepiquat chloride application on the seed cotton yield q/ha of cotton cultivars

Weed control for high density planting system under winter irrigated conditions was standardized. Pre-emergence application of pendimethalin (1 kg a.i./ha) followed by post emergence application (tank mix of

quizalofop-ethyl (50 g/ha) and pyrithiobac sodium (75 g a.i. /ha) at 30 DAS was an effective weed management strategy. This system had an associated benefit cost ratio of 1.95.

Evaluation of inclined plate planter for sowing under HDPS in winter irrigated cotton

Sowing by tractor drawn inclined plate planter produced a variation in plant to plant spacing. However, plants adjusted and yielded similar to the manual method Although, gross return was higher with manual sowing, higher sowing cost associated with manual method lowered profit as compared to tractor sowing.

Sirsa

Twenty *G. hirsutum* genotypes were evaluated under narrow spacing of 67.5 x 10 cm with RS-875 and *Bt* 3028 as checks. Genotype CSH-3158 gave the highest yield. Six genotypes *viz* ; CSH-3178, CSH-3132, Azon-148, RS-2525, ARBH-2411 and CPT50-C gave at par seed cotton yield with *Bt* check Ankur 3028 BGII (2349 kg/ha). In large plots too, CSH-3178 and CSH-3132 gave seed cotton yield similar to the *Bt* check. CSH-3158 yielded significantly higher than the *Bt* check. CLCuD incidence ranged between 3.0 to 22.6 PDI, leaf hopper population ranged from 1.0 to 1.6, 4.9 to 8.5 for whitefly and boll damage ranged from 0.0 to 13.8%. CSH-3178, CSH-3158, CSH-3132, ARBH-2411 and CPT50-C recorded less than 10 PDI for CLCuV. CSH-3158 and ARBH-2411 had < 10% Bollworm damage.

Six *G. arboreum* genotypes HD-123, RG542, HD-432, CISA-310, CISA-614 and CISA-111 were evaluated at three spacings: 67.5 x 10, 20 and 30 cm. Higher yield, in general, were recorded for 67.5x20 cm spacing followed by 67.5 x 10 cm. However for CISA-310, 67.5 x 10 cm was ideal spacing. There was an increase in yield of 3 to 8 q/ha (10.1 to 27.8% increase) in 67.5 x 20 cm spacing over normal spacing of 67.5 x 30 cm.

Evaluation of Mepiquat chloride

There was an increase in boll weight, boll number and seed cotton yield with mepiquat chloride treatment than the control to an extent of 6- q/ha. Two to three applications of mepiquat chloride (25 g a.i./ha) resulted in (i) Reduction in plant height and number of monopods, (ii) Increase in number of squares and flowers and (iii) Increase in number of bolls, number of nodes and number of sympods.

3.11: Weed Management

Allelopathy as an alternative weed management strategy for cotton

Weed control in rainfed cotton grown on Vertisols is a major issue because soils become sticky and wet after rains and are very hard when dry conditions prevail. Thus, the time when effective weed control is possible is very narrow. Therefore, growing a cover crop that produces allelopathic effects to weeds is considered as a possible solution for integration with mechanical methods. Field studies were conducted at Nagpur and Coimbatore to evaluate the efficacy of cover crops grown in situ as well as using mulch of tree species with known allelopathic effects.

At both the locations, namely, Nagpur and Coimbatore, influence of cover crops on weed count was significant. All the cover crops recorded a significant reduction in weed count. At Coimbatore, it was comparable to sole cotton (RCH 20 *Bt*) which received two additional hand weeding. Among the treatments, the lowest weed count was recorded by sunflower as a cover crop and this may be due to strong allelochemicals of sunflower crop. At Nagpur, significant reduction in weed population and biomass accumulation was observed with cover crops

(Fig. 3.11.1). Among the cover crops evaluated, sorghum was the most effective followed by the leaf mulch of neem and eucalyptus. Weed control efficiency of using sorghum as a cover crop ranged from 76 to 84% compared to the normal weed control practice followed in sole cotton (44 to 50%). This indicates that using a cover crop further improves the efficiency of weed control.

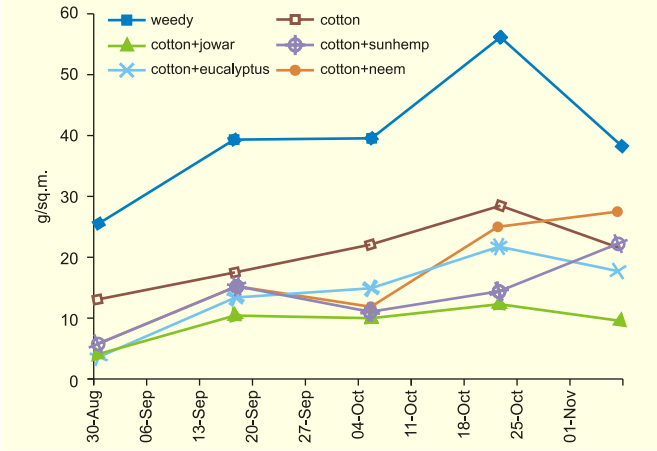


Fig. 3.11.1: Weed biomass accumulation over time with different cover crop treatments

Seed cotton yield increased significantly with cover crops. At Nagpur, cover crop treatments of sorghum, sunhemp, mulch of neem and eucalyptus produced significantly greater seed cotton yield. Yield advantages were restricted not only to effective weed control but also to other benefits accrued such as soil moisture conservation. Soil moisture in the cover treatment plots was nearly 2% greater than the sole cotton plots.

At Coimbatore, covers of wheat, barley, and sunhemp (2688 to 2719 kg/ha) had higher yield compared to sole cotton (2411 kg/ha). Among the cover crop treatments, sunflower had the least seed cotton yield (1280 kg/ha). This was probably due to its allelopathic effects to cotton as well as weeds. Hence, sunflower is not a suitable cover crop with cotton. Covers of sunflower, radish, mustard and cabbage also resulted in significantly lower seed cotton yield than the sole cotton treatment.

Results from the first year field studies indicate that weeds in cotton can be managed by integrated approach with the application of a pre-emergence herbicide such as pendimethalin (1.0 kg a.i./ha) followed by in situ cover crops around 35 - 40 DAS and one hand weeding around 70 -75 DAS to remove the later emerging weeds.

Wheat as cover crop | Barley as cover crop | Sun hemp as cover crop

Sirsa

Biosafety Research Level II trial (BGII RRF)

Biosafety Research Level trial (BGII RRF) was conducted at CICR, RS, Sirsa. The unreplicated trial was sown on 28 May 2012 comprising 8 treatments. A total 3 sprays were applied for weed management at 41, 81 and 133 days after crop sowing. Per cent yellowing data were recorded after 4 days, 7 days, 14 days and 21 days after application of roundup herbicide (MON 76366) spray. At 21 days after spray 64.4%, 86.7% and 89.8% yellowing in MRC 8017 BGIIRRF Roundup sprayed treatment and 74.2%, 95.6% and 85.8% yellowing in MRC 8031 BGIIRRF Roundup sprayed treatment was observed in broad leaves, grasses and sedges, respectively. Among broad leaved weeds, there was 100% yellowing in *Trianthema monogyna* (itsit) and *Digera arvensis* (tandla) after all sprays where as percent yellowing in case of *Convolvulus arvensis* (hiran khuri) and *Euphorbia hirta* (badi dudi) was upto 25 and 63.6%. However, the population of these weeds itself was quite low.

Total expenses of weeding and intercultural operations per ha was calculated at Rs 15075 (high weed intensity trial field).Where as in case of RRF, the total expenses (chemical cost + labour cost) for round up spraying were calculated as Rs 6774/ha. Net saving per ha for weed control by using BGIIRRF was found Rs 8301.However under normal weed intensity under farmer field conditions the net saving per ha for weed control by using BGIIRRF was estimated at Rs 2271.

3.12: Herbicide Resistance

Nagpur

Glyphosate as a pre-plant foliage application twice was less effective on - *Commelina sp., Merremia emarginata* and *Acalypha indica*.

Soybean followed by *Bt* cotton + pigeon pea crop rotation employed a rotation of herbicides. This resulted in significantly lower weed incidence from very high (420 weeds/m^2) to very low (7/m^2). Pre-plant foliage application of glyphosate followed by early post - emergence application of imzethapyr/pyrithiobac Na were ineffective in both seasons and cropping systems *on Echinocloa crussgalli*, *Celosia argentia, Acalypha*

indica, *Merremia emarginata*, *Tridax procumbence* and *Cyperus rotundus*. *Euphorbea hirta, Echinocloa* sp., *Cyperus rotundus* (partial), *Commelina communis* (less), *C. benghlensis (*total), *Cynodon dactylon,* and *Dinebra* were controlled within four days after application of pyrithiobac Na. However, *Digera arvensis* was not affected.

Chlorimuron ethyl : All grasses could be controlled effectively as early post emergence application in soybean. It did not affect G. *barbadense* cotton that succeeded soybean.

Quizalofop : was found to be very effective against a wide range of grasses, except perennials.

Fenoxoprop : It was not effective against *Cyperus rotundus, Commelina bengalensis C. communis*, where as *Echinocloa crussgalli* was effectively controlled.

Propquizafop : Pyrithiobac Na-Propquizafop was a good combination for cotton and effectively controlled *Commelina sp.* and *Cyperus rotundus.*

Coimbatore

Intensive glyphosate usage on farms for nearly 20 years at Rasipuram (Salem (Tamil Nadu) indicated that weed population was significantly reduced. It is also that over the years the weed species shifted from grasses to sedges and broad leaved weeds presumably by the continuous use of glyphosate.

Weed analysis carried out in cotton field applied with fluchloralin/pendimethalin (0.75 kg a.i./ha) for several years. It was observed that over the years, weed species shifted from grassy weeds to broad leaved & sedges by application of fluchloralin/pendimethalin.

Yield modeling

Identification of yield influencing weather parameters were attempted by correlation of weather data with the cotton yield. The correlation analysis with Virdhunagar district found that relative temperature disparity (0-45, 46-90,91-120,121-150 DAS and total), rainfall (0-45, 46-90, 91-120, 121-150 DAS and total), and evaporation (0-45, 46-90, 91-120, 121-150 DAS and total) were positively correlated with yield. The analysis of Tuticorin district found that the significant positive correlation was observed with minimum temperature of 0-45 DAS, growing degree days of 0- 45 DAS, maximum relative humidity of 46-90 DAS and 91-120 DAS,121-150 DAS ,and total ,rainfall 46-90 DAS and total quantity of evaporation .Identification of yield influencing soil parameters for cotton growth and development was studied. The survey was conducted in Kinathukadavu block of Pollachi taluk of Coimbatore district. The study covered three soil series includes Irugur, Palladam and Pilamedu of Kinathukadavu block. Among the factors, significant correlation found with soil productivity, land capability, soil depth, soil texture and cation exchange capacity.

3.13: Agronomy of *G. arboreum* race *cernuum*

Nagpur

G. arboreum race *cernuum* was evaluated at 6 crop geometries (plant populations) *viz*., 45 x 15 cm (148000 plants/ha), 45 x 30 cm (74000 plants/ha), 45 x 45 cm (49000 plants/ha), 60 x 15 cm (111000 plants/ha), 60 x 30 cm (55000 plants/ha) and 60 x 45 cm (37000 plants/ha). Significantly higher yield was o*Bt*ained at 45 x 15 cm spacing (2481 kg/ha) and 60 x 15 cm (1879 kg/ha) (Fig. 3.13.1). Yield in the other spacing were at par. Response to mepiquat chloride application (50 g a.i./ha) in two equal split applications was significant. Averaged over six spacing, mean yield advantage was 19.7%. Mepiquat chloride treated plants were dwarf, had higher leaf N, were more compact and had bigger bolls.

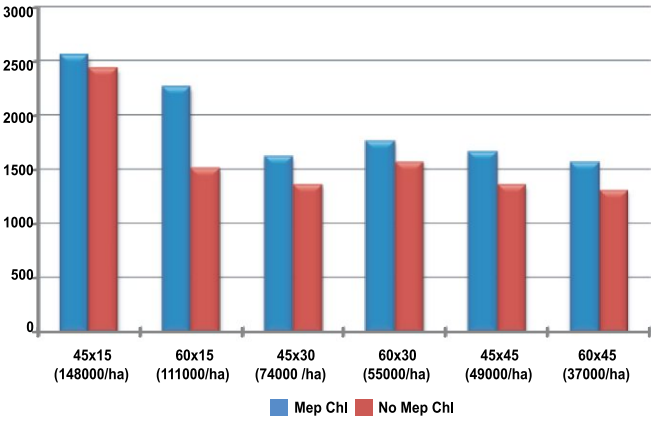


Fig. 3.13.1: Effect of spacing (cm) on yield (kg/ha) of *G. arboreum* race *cernuum* with Mepiquat chloride (Mep Chl) & without Mepiquat chloride(No Mep Chl)

3.14: Soil Biology and Biochemistry

Nagpur

Geo-referenced Soil Information System for Land Use Planning and Monitoring Soil and Land Quality for Agriculture

Survey in established benchmark soil series in Black Soil Region (BSR) of India covering 6 AERs and 17 AESRs was conducted to analyse impacts of bio-climates, cropping systems, soil sub groups, land use, and management practices on soil biological attributes for development of land quality indicators and threshold values. From each benchmark spots, soil samples were collected from individual horizon in two pedons, one each representing low management (LM) and high management (HM) regimes. Three contrasting cropping

systems were studied: the legume based, cotton based, cereal based and the sugarcane based systems. The summary of findings is as follows:

a) Soil urease activity

Cropping systems and bio-climates significantly ($p<0.01$) influenced urease activities (Fig. 3.14.1) in soil. Average urease activity in different cropping systems were in decreasing order of legume > **sugarcane > cereals > cotton based cropping systems**.

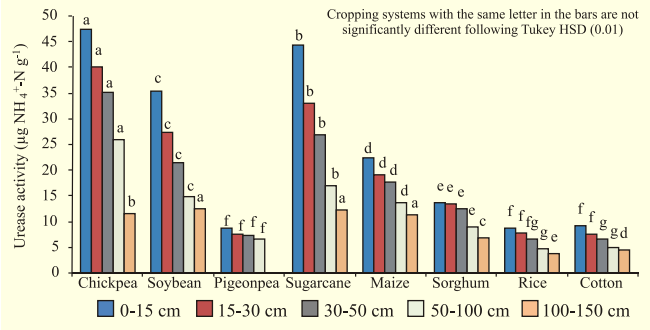


Fig. 3.14.1: Cropping systems on soil urease activity in BSR

b) Dehydrogense (DHA) activity

Cropping systems and bio-climates significantly ($p<0.01$) influenced DHA in soil (Fig. 3.14.2). Significantly (***p*<0.01)** higher DHA was recorded in sub-humid moist (SHm) bio-climate (**2.45** µg TPF g^{-1}) followed by semi-arid dry (SAd) (**2.00** µg TPF g^{-1}) and the least in arid bio-climate (1.62 µg TPF g^{-1}). Legume-based cropping system recorded higher DHA followed by cereal-based cotton and sugarcane cropping system. Comparison of DHA in different soils indicated significant differences ($p<0.01$) between soil sub groups.

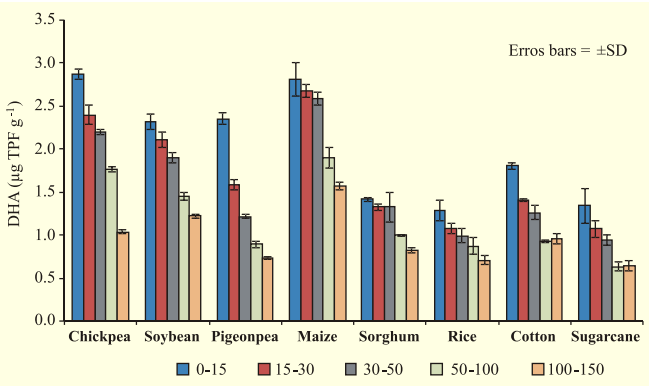


Fig. 3.14.2: Cropping systems on soil dehydrogenase activity in BSR

c) Soil microbial biomass carbon (MBC)

Among cropping systems, legume-based system had higher MBC and the lowest MBC was recorded in cotton-based system (Fig.3.14.3). within soil sub-groups, Halic Haplusterts showed higher MBC (209 µg g^{-1}) followed by Typic Haplusterts (208 µg g^{-1}), while the lowest MBC was observed in Gypsic Haplusterts (98.5 µg g^{-1}). MBC content in soil is significantly and positively correlated with SOC, total microbial population, nitrogen content, and available water content. pH correlated negatively with MBC.

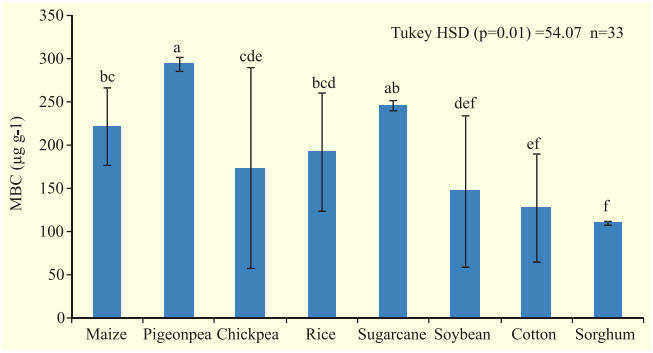


Fig. 3.14.3: Cropping systems on MBC (0-30 cm soil depth) in BSR

d) Soil microbial population

Cropping systems and bio-climates significantly ($p<0.01$) influenced the soil microbial population (Fig. 3.14.4). Significantly higher ($p<0.01$) microbial population was recorded in sub humid moist (SHm) bio-climate (6.26 $\log_{10}$ cfu g^{-1}) followed by sub humid dry (SHd) (6.21 $\log_{10}$ cfu g^{-1}) and the least microbial population was recorded in arid bio-climate (6.14 $\log_{10}$ cfu g^{-1}). Legume-based cropping system recorded significantly ($p<0.01$) higher microbial population (6.23 $\log_{10}$ cfu g^{-1}) followed by cereal based cropping system (6.23 $\log_{10}$ cfu g^{-1}). Pooled comparisons of culturable microbial population in different soil sub groups and management practices indicated a non significant ($p<0.05$) differences.

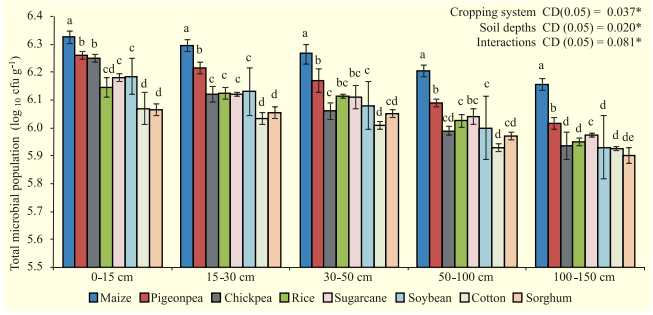


Fig. 3.14.4: Cropping systems on culturable microbial population in BSR

e) Soil culturable microbial diversity

Significantly ($p<0.01$) higher diversity indices was recorded in sub-humid-moist (SHm) bioclimates and the lowest in arid bioclimates (Fig. 3.14.5). Except Shannon

H´, other microbial diversity indices were found to be significantly ($p<0.05$) higher in cereal-based cropping system than in legume-based system. Average diversity indices in different soil subgroups were in decreasing order of Typic Haplusterts > Gypsic Haplusterts > Vertic Haplusepts/Sodic Haplusterts > Chromic Haplusterts/Halic Haplusterts > Calcic Haplusterts. Among the soil properties, sand and calcium carbonate percentage were negatively and significantly correlated with microbial diversity indices and accounted for maximum variance at all the soil depths.

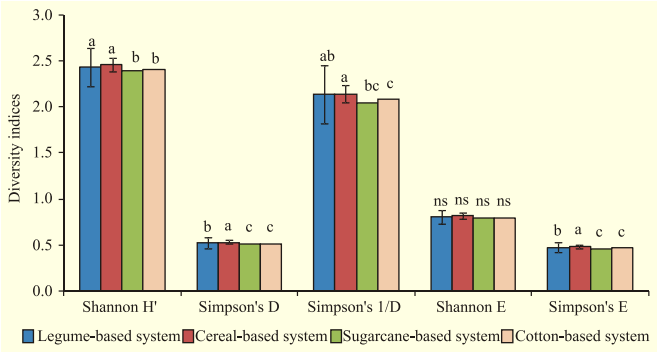


Fig. 3.14.5: Cropping systems on microbial diversity indices (0-15 cm soil depth) in BSR

3.15: Management of Abiotic Stress

Nagpur

Two Potassium silicate formulations (AgriSIL-liquid and Potassium silicate-Powder) were evaluated for their growth promotion efficiency of cotton under field conditions. With the hypothesis that nanoform of potassium silicate may improve cotton yield, potassium silicate formulations were converted to nanoform and tested at square formation stage as soil and foliar application. Field experiment was laid out in a randomized block design with 10 treatments and replicated 3 since. Three cotton genotypes [Bunny *Bt*, Suraj and AKA-5] were used as test material. No significant differences between treatments were observed in the trials conducted in the first year of study.

Amelioration of leaf reddening and parawilt in cotton

Field experiment was laid out with RCH-2 BG II *Bt* hybrid in RBD in 3 replications with 7 treatments (Potash 1%, 3% KNO_3, CCC 20 ppm, monocrotophos 3 ml/litre, lime 0. 5% and Methomyl 90 SP) including control. Early stage leaf reddening did not appear during the season. Red leaves were observed at a later growth stage which was due to senescence.

Leaf chlorophyll content, on an average, was found to be high (0.4 – 0.8 mg/gm fresh wt of leaf) in all the treatments. Since the plants did not experience stress due to leaf reddening, peroxidase activity was similar in all the treatments. Seed cotton yield ranged from 2200 to 2300 kg/ha in treated plants which was higher than the control (1800 kg/ha).

Coimbatore

Effect of Nutrient Consortia Spray on *Bt* Cotton under Elevated CO_2 Atmosphere

Irrespective of *Bt* hybrid plants grown under elevated CO_2 atmosphere was distinct with significant increase in plant height, sympodia number, boll number and yield. Significant increase in boll weight was not observed, probably due excess boll load.

Averaged over three CO_2 levels and *Bt* hybrids, there was an increase in the plant height, leaf number, boll number, boll weight and yield with nutrient spray. Apparent difference in yield could be observed with 90 g/plant in plants that received nutrient spray compared to 76 g/plant in control.

Alleviation of water logging stress under elevated CO_2 atmosphere

Plant height was significantly more in chamber with and without elevated CO_2 atmosphere compared to ambient grown plant irrespective of nutrient spray treatment. Only marginal differences could be recorded with respect to sympodia number, leaf number. However, significant differences with respect to boll number, boll weight and yield could be seen. For instance, the yield per plant was 57.6 g/plant in chamber with CO_2 while in chamber without CO_2 gave 45.6 g/plant.

Plant height and sympodia production was not altered by water logging treatment while a marginal decline in leaf number and boll number was noticed. Significant reduction in yield was observed due to water logging.

3.16: Cotton Mechanization

Nagpur

Design and development of cotton picking head

Fabrication of a Trolley mounted cotton picking head

A conceptual trolley mounted *chain type* and *peg type* pickers were fabricated with variable row to row spacing of 60, 80 and 90 cm. This conceptual design of a medium size cotton picking machine can be operated by a pair of bullocks or a person pushing from behind the machine. The machine has three components i.e. 1) picker trolley 2) crop guider & compressing mechanism and 3) picking mechanism. While the machine moves, the plants are progressively compressed and at the maximum compression, picking units pick the bolls coming in contact with them, doffed and collected at the bottom of the trolley.

Trolley mounted chain and peg picker prototype

Testing and modification of the Trolley mounted cotton picker prototype.

The prototype was tested in the field in different row spacings ranging from 60 to 90 cm row to row spacing on H6 *Bt* hybrid (90 cm), PKV 081 (60 cm) and Suraj (80 cm). It was observed that the machine was unstable and the wheels needed replacement as movement was difficult because the crop lifters were too close to ground. To facilitate multi-row testing the prototype was redesigned and fabricated with variable row to row spacing, reduced height and weight. Picking units were also modified providing more exposure of cotton bolls to chains and pegs, thus giving more response time to the picking units to pick. The throats, from each of the ten picking units were cut to allow for free flow of the picked cotton.

Testing of Prototype Picker in field and sample of machine picked cotton

It was observed that a portion of the picked cotton was falling to the ground through the opening between the lowermost guide bar and the chassis of the machine. Also the picked cotton was being brushed by subsequent branches and carried to the rear of the machine. Further modifications are in progress.

Observations on picking

It was observed that through various modifications the picking rate was increased to 8.9 kg/h compared to 4.1 kg/h with manual picking with an average picking rate of 1.6 kg/h.

Identification of a mini combine harvester for modification into a cotton stripper for small farms

A mini combine harvester was identified and tested.

The combine was run under HDPS system and whole plants were cut at the stem with the reaper portion of the combine and fed into the threshing unit. The seed cotton along with broken stems was discharged through the rice husk outlet of the combine and the finer leaf trash etc got discharged through the grain outlet. However, the stem being wet could not break down to smaller pieces and thus added to the trash load of the discharged seed cotton. The trash was about 50%. The thicker and stronger cotton stems jammed the conveyor unit, and the threshing drum as these were designed for softer plant material.

Threshing whole plants in conventional axial flow thresher

A separate experiment was done to understand the modifications needed in the threshing drum of the existing combine harvester. Whole plants were cut and fed into a conventional axial flow thresher in order to see if these could handle the tougher cotton plant material. Again the seed cotton was threshed from the plant and discharged through the outlet meant for husk and the stem part collected in the concave of the thresher. It was observed that some seeds were crushed because of the vigorous handling by the thresher.

Feeding only cotton bolls harvested manually into the combine harvester

Cotton plants were hand stripped and the whole bolls collected and fed into the mini combine. The seed cotton this time was discharged with considerably less trash as the plant stems were eliminated. The trash came down to 27% and consisted mainly of bracts and smaller stems. Therefore, it was decided to convert the combine harvester into a stripper harvester of cotton.

3.17: Socio Economic Dimensions of Cotton Farming

Technological Needs for Sustainability and Stability of Cotton Production

Concerns of cotton challenges/issues before farmers, extension workers, especially in the context of wide scale adoption of *Bt* technology and priority ranking of technological need was worked out using a detailed questionnaire. The challenges were categorized into five main categories: technological options, socio-economic aspect, transfer of technology, marketing and institutional/operational/structural barriers. Technological need requirement was assessed based on criteria and priority on farmers' income (economic

profitability) and social acceptability. Data was collected and analyzed for eighty six respondents (47 farmers and 39 extension officials) from Vidharbha rainfed region from Nagpur, Amravati, Wardha, Chandrapur, Washim and Yeotmal districts. Under technological challenges, majority (77%) of the respondents completely or to a certain degree felt that poor soil and rainfed situation is not ideal for the performance of *Bt* cotton hybrids and ranked first followed by non-availability of exact nutrient requirement strategy for different *Bt* cotton hybrids for shallow soil. Other socio-economic, transfer of technology, marketing and structural/operational impediment statements prioritized by the respondents were climate variation and change are impacting negatively on cotton production. With the entry of *Bt* cotton, the practice of use of 'farm saved seeds' come to permanent halt, scientific knowledge and spurious seed/fertilizers, average farmers is not knowledgeable about market trends or price level. The technological need assessment has come up with the results that the priority technology needed for sustainable cotton production was climate rebelient varieties followed by innovative package of practices for maximizing yield of *Bt* cotton hybrids, insect resistant varieties/hybrid for sucking pests.

E-Kapas Network to Connect 100,000 Farmers for Technology Dissemination and Backstopping

Nagpur

E-Kapas network centres are being developed by creating infrastructure facilities at lead centre CICR; Nagpur. Telecom software i.e. phone recorder software suitable for mobile technology was developed and is being finalized after testing with a few clients. This has to be provided and installed at all cooperating centres. The software created is capable of storing the registered farmer's queries in the database, sending SMS/MMS in the regional language to the farmers. The registered famers may store their query at any time in the call server situated at participating centres and on real time basis the query gets replied to with automated stored message. All centres use the best cotton management practices and make it available on mobile phone of farmers using short message service (SMS) technology in their regional language, also alerts regarding insect pest and diseases management be sent as SMS.

Coimbatore

During the year, a total of 1340 potential and interested farmers in e-Kapas network in major cotton growing districts of Tamil Nadu were identified. From the scoping study it was identified that information with regard to suitable cotton cultivars, price, weed management, farm machineries and tools, Government schemes, weather forecasting, market information, nutrient management, bank credit information and new technologies were the major information need expressed by the interested farmers with regard to cotton.

Impact evaluation of *Bt* cotton in Maharashtra

This project was taken up to evaluate impact of *Bt* cotton in Maharashtra. During the reporting year, data was collected and analyzed from 1200 cotton farmers belonging to 8 cotton growing districts of Maharashtra namely, Yavatmal, Amravati, Akola, Wardha, Nagpur, Chandrapur, Nanded and Parbhani.

Though *Bt* cotton was introduced in 2002, its adoption in the selected districts was very slow up to 2004. Afterwards *Bt* cotton adoption gained momentum and by the end of 2009 almost 90 percent of respondents adopted it. Currently almost all the respondents are growing *Bt* cotton.

Significant changes took place after the introduction of *Bt* and the important ones are listed in the Table 3.17.1 below.

Table 3.17.1: Use of inputs before and after introduction of *Bt* cotton

S. No.	Particular	Before *Bt*	After *Bt*
1.	Seed Quantity (kg/acre) Cost (Rs/acre)	 1.52 926.00	 0.79 1922.00
2.	No of insecticidal sprays	7.4	4.3
3.	Fertilizers Quantity (kg/acre) Cost (Rs/acre)	 106 636	 230 3418
4.	Respondents used weedicides (%)	0.00	21.50
5.	Respondents used growth regulators (%)	0.25	35.08
6.	Yield (q/acre)	4.15	6.32

As per the respondents no new pests were observed after the adoption of *Bt* cotton. Nearly 82 per cent respondents felt that sucking pest problem is increasing year after year. Majority of the respondents (69%) felt that availability of pesticides is not a problem.

As per the respondents there are more than 30 *Bt* hybrids in the market. They mainly depend on the advice of seed dealers/private companies for the selection of hybrid. Alternatively, they observe the performance on the neighbor's field before selecting hybrid suitable to their field. Most of the respondents (62%) felt that selected hybrids are not giving expected yield which indicates that they are unable to make good decision

regarding the selection of hybrids. Fifty four percent of the respondents felt that they are unable to get their preferred hybrid at maximum retail price (MRP) and they need to pay more than MRP to get it. High yield, big boll size and quality fibre are the three major traits preferred by the respondents. Mallika, Ajeet and Ankur are the top three preferred brands by the respondents. Most of the respondents (61%) are not using non *Bt* seed as refugia and they are simply throwing them away. Only 39%use non *Bt* seed on borders and those who got redgram seed as refugia are using it as intercrop.

Opinion survey revealed that *Bt* cotton was not responsible for suicides of cotton farmers. Ninety seven percent respondents felt that crop failures are not the reason for suicides and 98 percent felt that *Bt* cotton is not responsible for suicides. Almost all the respondents perceived that there were no incidence of death of animals due to *Bt* cotton and there were no health hazards due to *Bt* cotton cultivation.

3.18: Seasonal Dynamics of Insect Pests and Diseases

Nagpur

Seasonal dynamics of cotton sucking pests and bollworms

Mealybugs *Phenacoccus solenopsis* and *Nipaecoccus* viridis were recorded in some fields with negligible population during late season of crop. Two peaks of aphids were recorded during 34 and 42 SW with highest population of 19.06 and 19.86 aphids per plant coinciding with coccinelid population of 0.54 and 0.64 per plant, respectively. The maximum whitefly population of 3.7 and 3.2 per plant was recorded during 38 and 39 SW respectively when maximum and minimum temperature ranged between 32-35 ^{0}C and 23-25 ^{0}C with corresponding RH (%) range of max 81-90 and min 50-61. Leafhopper activity and damage coinciding with heavy rainfall, when population ranged from 8 to 18.44 leafhoppers/ 3 leaves/ plant peaked at 33-36 SW. Cohabitant thrips were also recorded in greater numbers during this period. Mirid C. livida incidence was low even after recession of rainfall from 40 SW and remained fluctuating till the end of season. The population of *H. armigera, E. vitella, P. gossypiella* and *S. litura* was found negligible on Bt-cotton during the season.

Correlation of insect pest with weather parameters

The population of mirid was negatively correlated with minimum temperature, RH maximum and minimum and rainfall. Similarly, population of leafhoppers and thrips was positively correlated with temperature minimum, RH maximum and minimum, rainfall and rainy days. However aphid, whiteflies and spider population was positively correlated with all the weather parameters under study.

Cropping system based population dynamics for (a) mirid *C. livida*

Highest nymphal population was recorded in cotton surrounded by cotton and soybean (1.32 mirids/ plant) which was at par with cotton surrounded by cotton and canal (1.17 mirids/plant). Comparatively lowest population was recorded in unprotected fields (0.86 mirids/plant) and cotton surrounded by soybean and road (0.87 mirids/plant) and both were statistically non significant. The population dynamics of nymph and adult was similar. The total mirid population was statistically similar in cotton surrounded by cotton and soybean (1.97 mirids/plant), cotton and canal (1.77 mirids/plant), unprotected field (1.18 mirids/plant) and soybean and road (1.21 mirids/plant).

(b) leafhopper Amrasca bigutulla bigutulla

Highest nymphal and adult leafhopper population was recorded in unprotected fields compared to protected fields. The population under protected fields was similar. Maximum population was recorded in research station (2.77 leafhoppers /3 leaves /plant) followed by cotton surrounded by soybean and road (1.69 leafhoppers /3 leaves /plant), cotton and soybean (1.61 leafhoppers /3 leaves /plant) and cotton and canal (1.45 leafhoppers /3 leaves /plant). Leafhopper activity was more in unprotected fields than protected field as expected.

(c) spiders

Overall spider population was high in unprotected condition compared to protected fields. Least population was recorded in cotton surrounded by cotton and canal (0.59 spiders/ plant) which was statistically similar with cotton surrounded by cotton & soybean (0.81 spiders/ plant) and soybean and road (0.69 spiders/ plant). The spider population in unprotected field was always high till 41 SW but thereafter fluctuated.

Investigations on role of plant parasitic nematodes in emerging cotton maladies

Population of plant parasitic nematodes associated with cotton maladies reported from Buldhana, Khargone, Saoner and Wardha were estimated qualitatively as well as quantitatively. The population of Reniform nematode *Rotylenchulus reniformis*, associated with cotton stunting was 300-356 preadult nematodes/250 cc of soil which was well above threshold level. Other nematodes like *Hoplolaimus sp.* (80 nematodes/250 cc soil) and *Pratylenchus sp.* (13 nematodes/250 cc soil) were also recorded from soil samples. Advisory was issued to

manage reniform nematode with Carbofuran 1 kg a.i./ ha.

Stunting of cotton due to reniform nematode in Buldhana

In soil samples collected from Khargone where stunting was reported, the following nematode populations were recorded: Reniform preadult- 113 nematodes/250 cc soil, *Ditylenchus* sp.-180 nematodes/250 cc soil and Pratylenchus sp. -23/ 250 cc soil. More soil sampling is necessary for conclusive results. Sampling was also done to estimate nematode populations in ELS cotton at CICR, Nagpur grown under drip irrigation. At the time of sowing, nematode populations were 20-36 nematodes per 250 cc soil The population of *R. reniformis* was highest (110-300 nematodes/250 cc soil) on March 20, 2013 i.e. five months after sowing in October, 2012 sown crop and lowest in November, 2012 sown crop (90 nematodes/250 cc soil). The population of plant parasitic nematode in samples from Saoner and Wardha were less ranging between 25-70 nematodes/250 cc soil.

Coimbatore

Dynamics of mealybug species *Paracoccus marginatus* and *Phenacoccus solenopsis* under cotton + cowpea intercropping system were studied from the month of October (in experimental fields) which indicated there was no incidence of both the species. Under farmers fields from the month of July till the end of the season there was no incidence except first fortnight of November, incidence of *P. marginatus* observed with a severity index of below one and per cent incidence ranging from 3-5%. Minimum per cent incidence (5-6%) was observed in alternate hosts namely *Parthenium hysterophorus, Hibiscus rosa-sinensis* and *Abutilon indicum.*

3.19: Biological Diversity of Insect Pests and Pathogens

Nagpur

Biological diversity of insect pests in central India

Reduced diversity of mealybugs was recorded during the crop season. Only two mealy bugs, *Phenacoccus solenopsis* and *Nipaecoccus viridis* were recorded in some fields in cotton+ pigeon pea-fallow cropping system of Central India. Papaya mealybug *Paracoccus marginatus* was recorded from Aurangabad infesting cotton and from Nagpur on hibiscus. Mealybug species *Coccidohystrix insolita* Green have been recorded on pigeon pea. Regular sucking pests like aphids, leafhoppers, thrips, mirids, whiteflies were recorded as usual.

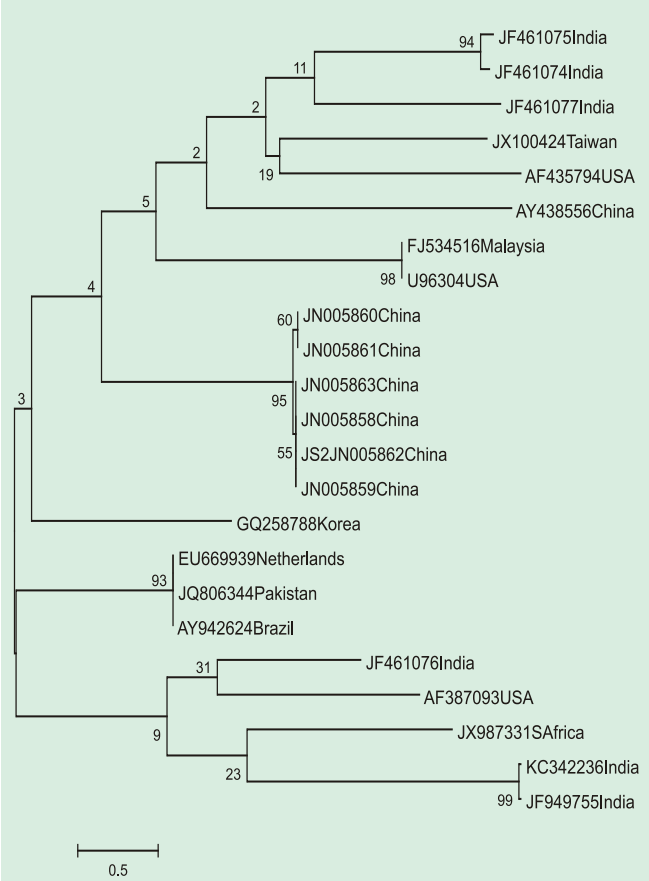
Biological diversity of nematodes – molecular and morphological characterization

Race profiling and phylogenetic analysis of root knot nematode, *Meloidogyne incognita* population from Nagpur was done. Root knot nematode was found associated with vegetables as well as cotton in CICR, farm. The morphological and molecular characterizations were also done for the population. The morphological features like perineal pattern, body length, body width, body length/body width, stylet length, dorsal gland orifice (DGO), vulva length and vulva-anus distance were considered for characterization of adult females. Juvenile's characters like juvenile body length, stylet length, tail length and hyaline tail terminus were considered for juveniles and male characters like body length, stylet length, distance to DGO, spicule length and gubernaculum length were considered for males and measured. Based on morphology it was identified and recorded as *Meloidogyne incognita*. The population was tested on host differentials like tomato, cotton, tobacco and pepper for confirmation of racial profiling. The population reproduced on tomato and cotton but not on tobacco confirming it as Race 3.

The 18sRNA was amplified and sequenced for molecular characterization. Based on results, it was confirmed as *Meloidogyne incognita* and sequence submitted to NCBI (Acc. No. KC342236). Restriction enzymes *SwaI, Bsa1, EcoR1* and *BsmA1* are known to differentiate races of *M.incognita.* The sequence in our studies had sites for EcoR1 at 209 and 687 positions but not for *SwaI, Bsa1* and *BsmA1* thus confirming Nagpur Root knot population as Race 3.

Phylogenetic Tree was made in MEGA 3.1 software using Neighbor Joining method and this population was in same clade as root knot population (JF949755) recorded from Andhra Pradesh. Other root knot

nematodes (JF461074/75/77) fall in different clades and these accessions do not carry the species name, and call them "Meloidogyne"



Phylogenetic Tree made in MEGA 3.1 software using Neighbor Joining method

Pheromone trap catches

The population of *H. armigera* in pheromone trap catch was minimum (0.1 - 0.8/ trap) till the mid of October, and records were the highest (11.4 moths/ trap) on 23 October 2012. The *Spodoptera* catches were high during initial growth stage of crop (219.9 moths/ trap) on 18 August followed by highest (239.4 moths/ trap) one month later and then decreased. Maximum activity of pink bollworm was recorded during November and December which coincided with boll developmental stage coupled with low temperature. The Earias population was negligible throughout the season and recorded maximum 3.3 moths / trap on 23 Nov 2012. The pheromone trap catches of pink bollworm was recorded from first week of October to last week of February during the crop season. The initial moth activity of pink bollworm was 3.00 moths /trap /week and recorded highest of 68.27 moths /trap /week during the second week of December (Fig 3.19.1).

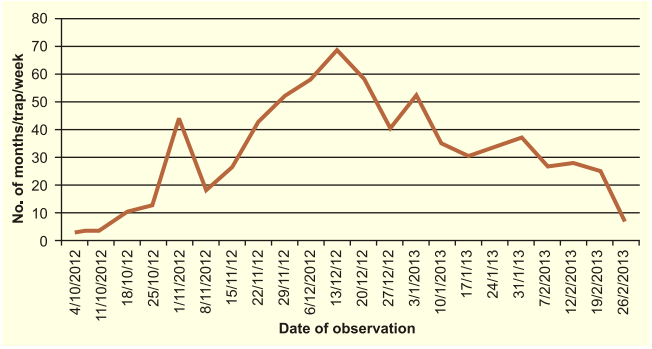


Fig. 3.19.1: Pheromone trap catches of pink bollworm at Nagpur

Survival of pink bollworm, *Pectinophora gossypiella* (Saunders) on Bt cotton

The incidence of Pink bollworm population was examined on three popular hybrids namely MRC-6301 Bt, RCH2 BG-II and RCH2 non Bt starting from 100 days after sowing at 15 days interval during *Kharif* 2012-2013 under rain fed conditions at CICR, Nagpur. The larval population, number of exit holes and per cent locule damage observed were zero on MRC-6301 Bt and RCH2 BG-II hybrids throughout the crop growth period compared to non-Bt hybrid. However, the mines on epicarp were noticed on Bt hybrids from 115 DAS with 2.00/25 green bolls on MRC- 6301 and 6.00 /25 green bolls on MRC-7301 BG II. The minimum and maximum larval population on RCH2- non Bt hybrid were 8.00 larvae/25 green bolls at 115 DAS and 15.00 larvae/25green bolls at 175 DAS respectively. Locule damage was noticed on non Bt cotton hybrids from 115 DAS to 175 DAS. The mean no. of exit holes ranged from 3/25 green bolls at 130 DAS to 6/25 bolls at 175 DAS.

Monitoring of pink bollworm in India

Field monitoring of pink bollworm larvae in India was carried out. Green bolls of BG, BG-II and NBt were received from different centers of AICCIP of India *viz*. Coimbatore, Srivilliputhur, Dharwad, Guntur, and Nandyal of South India (South Zone); Akola, Nanded, Junagarh, Rahuri, Khandwa of Central India (Central Zone); Faridkot, Hisar, Banswara and Sirsa of North India (Northern Zone). Green boll samples were dissected and observed for per cent larval recovery on Bt hybrids at different intervals throughout the cropping season and the intensity of pink bollworm incidence was recorded on BG, BG-II and non Bt. The larval recovery on BG was 18.67% in Junagarh and 8.00 % in Khandwa from Central India. However, no larval recovery was observed on BG-II across locations.The boll samples were tested for trait purity and found positive and larval recovery on non-Bt was more in Rahuri (83.00 %) followed by Junagarh (48.00%) and Dharwad (43.75%) (Fig. 3.19.2).

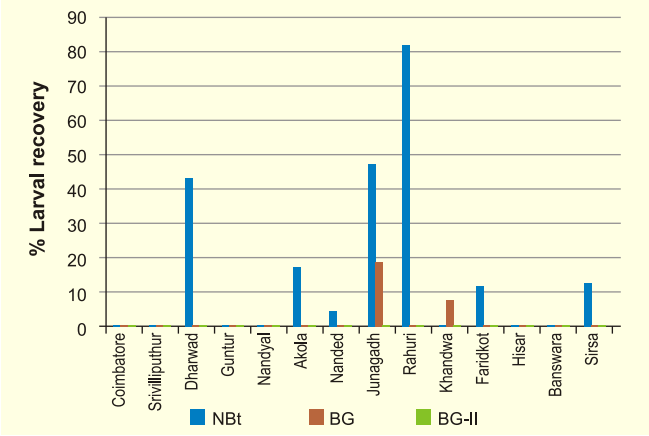


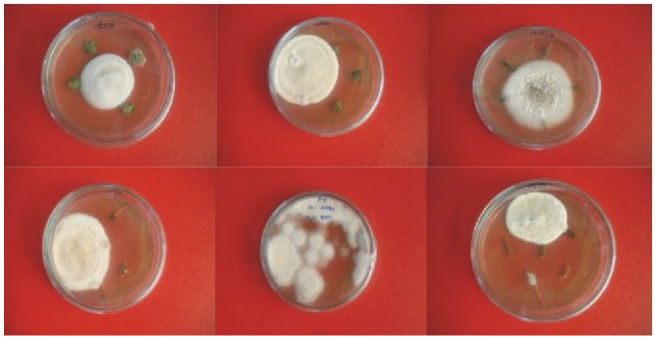
Fig. 3.19.2: Intensity of pink bollworm larvae

Coimbatore

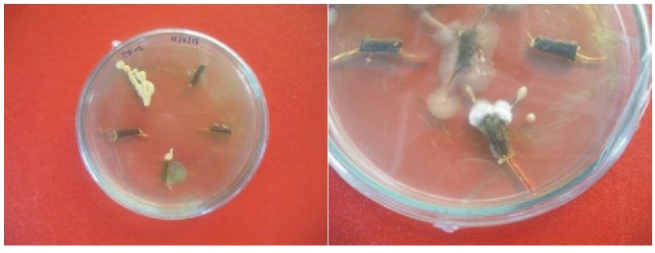
i. Isolation of endophytes

From each plant, two leaves, two pieces of stem were surface sterilized in a 0.5% sodium hypochlorite suspension for 2 min, 70% ethanol for 2 min, and rinsed in sterile autoclaved water.

Seven fungal cultures and three bacterial cultures were isolated as endophytes from leaves and stem portion of cotton plant.



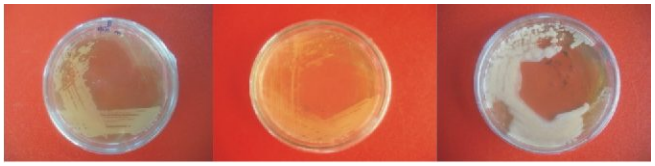
Fungal endophytes



Bacterial endophytes

ii. Isolation of micro flora from the gut system of the insects

Third-instar larvae were selected for culturing studies following a 24 h starvation period. Three bacterial endosymbionts were isolated from *H. armigera* larvae.



Bacterial endosymbionts from *H. armigera* gut system

Record of entomopathogenic fungus from aphids

Occurrence of a new entomopathogenic fungus from CICR, Regional station, Coimbatore was recorded during November, 2012. The fungus was identified as *Cladosporium cladosporioides* (Fresen.) de Vries (NFCCI-2958). Occurrence of *C. cladosporioides* to the tune of 55-90% in different fields was recorded. Preliminary pathogenicity study revealed that it was pathogenic to all life stages of aphids.

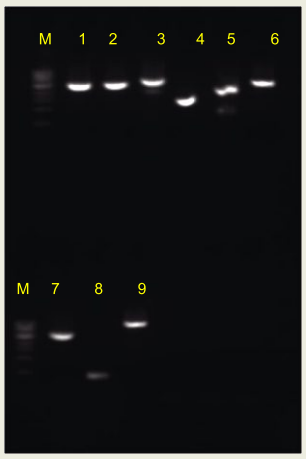
3.20 : New Genes and Gene Sources for Pest Management

Nagpur

Cloning and characterization of potent toxin gene from heat tolerant isolate Heterorhabditis indica, an entomopathogenic nematode

Bacterial symbiont associated with heat tolerant entomopathogenic nematode *Heterorhabditis indica* was characterized. 16sRNA gene of *Photorhabdus luminescens* subsp. *akhurstii* strain CICR-BBSc was submitted to NCBI (Acc. No. JX276776). 18s RNA gene of *Heterorhabditis indica* isolate NG was also submitted to NCBI (Acc no. JQ083661).

Primers were designed for full length amplification of toxins genes and amplification of TcaA 3.2 kb, TcaB 3.8 kb, TcaC 4.4 kb, TcaZ 1.5 kb, TccA 2.8 kb, TccB 4.6 kb, TccC 3.1 kb, TccZ 399 bp, TcdA 7.5 kb with long range Taq polymerase was achieved. The previous amplicons were not full length. Amplicons amplified from long range enzyme up to 3 kb were cloned using Promega pGEMT vector.

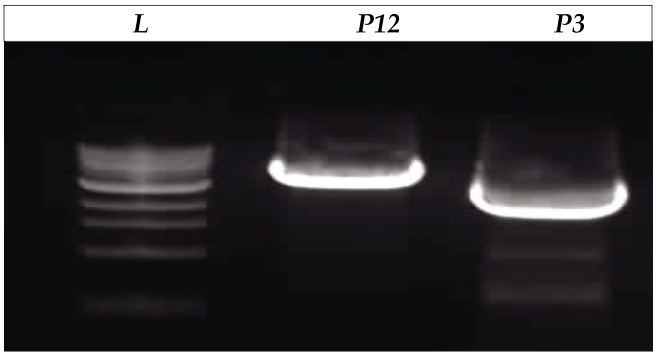


M: MARKER	MOL wt in kb
1.TOXINS TcaA	3.2
2: TOXINS TcaB	3.8
3: TOXINS TcaC	4.4
4: TOXINS TcaZ	1.5
5:TOXINS TccA	2.8
6:TOXINS TccB	4.6
7: TOXINS TccC	3.1
8:TOXINS TccZ	0.4
9:TOXINS TcdA	7.5

Tca and Tcd have oral toxicity.

About 20 amplicons were sequenced and aligned with sequences available on the NCBI site of BBSc TccC sequence was found to have 99% identity with Photorhabdus luminescens strain W14 toxin complex tccC locus. BNTcc1 found to have 99% identity with Xenorhabdus nematophilus xptA1 gene and 98% identity with Xenorhabdus nematophilus TccC1 gene. BBSc Photorhabdus luminescens amplicons (P12, P3) showed similarity with Photorhabdus tcc C and tcac locus with 96-97% identity.

The protein yield using New England Biolabs PURExpress® In Vitro Protein Synthesis Kit was 10 – 200 µg/ml in Photorhabdus BBSC TccC. The protein caused cessation in H. armigera larval feeding and reduced weight in bioassays. Growth reduction (81%) was observed at 7.3 µg/g (w/w) toxin protein.



Evaluation of novel CICR Bt toxins against *Helicoverpa armigera*

Cry1Ac CICR and Fusion CICR were evaluated against neonate *H. armigera* larvae using diet incorporation method. *Cry1Ac* CICR crude toxin at 2 µg/ml of diet caused 50% mortality with growth regulation of 84% while at 1 µg/ml of diet it caused 20% mortality with 73% growth regulation. MVPII caused 100% mortality at 9.21 µg/ml of diet. Fusion CICR crude protein at 2 µg/ml and 1 µg/ml of diet caused mortality of 20% and 10%, respectively with growth regulation of 86% and 76%, respectively. *Cry1Ac* CICR and Fusion CICR crude proteins were both effective against the cotton bollworm *H. armigera.*

Generation, evaluation and quantification of effects of novel dsRNA against *H. armigera.*

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 the chitin synthase B isolated in the present study is reported for first time in *Helicoverpa armigera*.

Suppression subtractive hybridization (SSH) library has been successfully 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 provides hints towards the discovery of novel genes that may have potential to affect the insect physiology or metabolism using RNAi technology.

Eighteen gene sequences of these were validated for their differential expression at transcript level using qPCR.

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.

The dsRNA of P1 (unidentified), P2 (unidentified), and P3 (serine protease), chitin synthase B (CSB) and JHEH genes were superior over the rest in silencing the corresponding gene thereby inducing mortality (CSB and JHEH) and growth regulation (in the rest). qPCR indicated that the expression of P1 was down regulated by 9.58 fold on day 1 of bioassay while P3 exercised constant down regulation of up to 3 fold, both day 1 and day 4 after bioassay.

A novel plant expression vector designated as pEV-CICR has been constructed with multiple cloning sites introduced for flexibility in cloning of 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) harbouring both endotoxin and lectin domain has been cloned in *E. coli* expression vector.

Trichoderma spp. have proved in the past to be sources of useful transgenes. Hydrophobins are small cysteine-rich secreted proteins unique to filamentous fungi that envelop the hyphae at the water-air interface and provide strength to the hyphae emerging out of water to conidiate in air. In the past, fungal hydrophobin-fusion has been used to enhance protein expression in plants. A hydrophobin gene from the filamentous fungus *Trichoderma virens* has been cloned for use in transgenic programme for improving expression of

insecticidal proteins. In addition, using bioinformatics, a unique protein in *T. virens* genome was identified, that harbours two potentially insecticidal domains - the N-terminal endotoxin domain and the C-terminal mannose specific lectin domain. This gene has been cloned in *E. coli* expression vector and the bioassay for insecticidal properties is underway.

ChiA, a gene for chitinase that works in alkaline environment has been identified, codon-optimised, and got synthesized with required restriction enzymes. This gene, along with cotton (*Gossypium hirsutum*) rubisco small subunit chloroplast transit peptide, fused in frame, has been cloned in a plant expression vector with double 35S promoter, AMV enhancer and NOS terminator and also in *E. coli* expression vector.

3.21: Development of New Methods, Tools and Protocols

Nagpur

Weather based population prediction model for Mirid Campylomma livida

Weather based population prediction model for Mirid Campylomma livida was developed with prediction accuracy of 88.24%. The model was revalidated in the current season with prediction accuracy of 89.47%. The criteria was satisfying with ≥ 5, four and ≤ 3 of the six weather based parameters viz., temperature maximum (>31 ^{0}C) & minimum (21-24^{0}C), relative humidity maximum (>85%) and minimum (30-70%), rainfall (< 25 mm) and rainy days (between 2 and 4 days on weekly basis) to predict the severity of C. livida on Bt cotton to high (>4 nos/plant), moderate (>2-4 nos/plant) and low (0-2 nos/plant) levels.

To verify label claim at random in seed samples purchased from the open market of north, south and central India

Seventy six Bt seed packets were procured from the open market of North (48) Central (20) and South India (8). Ten percent of the samples procured were tested at random. Event testing using event specific PCR was carried out for MON531, MON15985 and Nath event in a total of 10 randomly selected samples. In addition GUS Detect and dipstick were used to confirm gene expression in all 76 samples. No discrepancies were observed between the trait claimed on the label and the trait found in the seeds.

Field evaluation of Built-in Refugia concept

Evaluation of Built in Refuge at six centres (CICR-Nagpur, Coimbatore, Sirsa, NAU-Surat, Lam farm-Guntur and UAS-Raichur) was carried out using a common hybrid (except at Sirsa) The avoidable loss due to the spotted bollworm on BGII was 41%, late in the season at Sirsa. In Raichur the avoidable loss due to all bollworms and armyworm was 72% on Rasi 134 BGII while in Nagpur and Guntur, the avoidable loss was 42% due to the Amercian bollworm and *Spodoptera*, respectively. The yields of 5% built in refuge were on par with 100% BGII across all locations. In some locations 10% Built in Refuge was also on par with 100% BGII. The yields ranged from 18Q/Ha (Nagpur) to 23.35Q/Ha (Guntur) with 100% BGII. Yields from 100%non Bt ranged from 5.95Q/Ha (Raichur) to 13.96Q/Ha (Guntur).

Thus 5% BIR (Built in Refuge) with RCH 2 BGII may be considered for validation without compromising on yield and bollworm control.

Coimbatore

Sucking pest populations *viz.*, aphids, jassids, thrips, white flies and mealy bugs were quantified under three different strata such as top, middle and bottom in different sample sizes namely 5, 10, 15, 20 and 25 plants of Bt hybrids (Bunny) and non-Bt (Suraj). Among the five sampling sizes evaluated, in non-Bt 10 plants/plot recorded significantly maximum populations of jassids and thrips. For aphids 10 and 15 plants recorded significantly higher population. In Bunny Bt, aphid population did not show significant difference among the sampling sizes, however numerically higher population was recorded in sample size of 10 plants/ plot. Jassids and thrips recorded significantly maximum population in 10 plants/ plot. White flies did not differ significantly among the sample sizes.

Studies on the distribution pattern of sucking pests within the plant strata namely top, middle and bottom indicated that top leaves recorded maximum population of aphids, jassids, thrips and white flies in all the 3 cultivars evaluated BG (Bunny Bt), BG II (RCH 708) and NBt (Suraj) (Fig. 3.21.1).

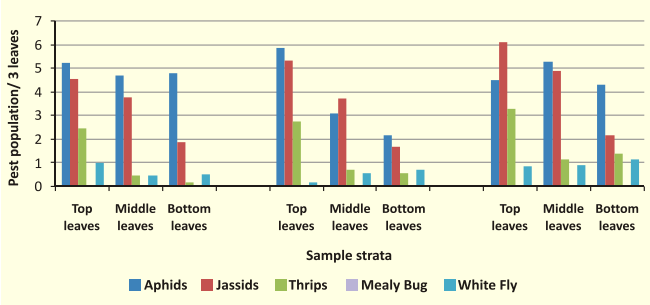


Fig. 3.21.1: Estimation of population of sucking pests from plant strata Bunny, RCH 708 and non Bt

Weather based prediction model for mirid bug

Mirid bug *Creontiades biseratense* prediction model was developed in cotton with pulse as inter crop. By using the

mirid population data for last 3 years (2008-09, 2009-10and 2010-11), a weather parameter based prediction model was developed. The prediction accuracy of 80.56% was recorded.

3.22: Host-Plant Resistance to Insect Pests and Diseases

Coimbatore

To study the impact of extended cotton crop through pruning technique, periodical observations on pest population, feeding bioassay for boll worms and Bt toxin quantification were conducted. Among the two types of pruning normal (at the base of the plant) and top pruning (1.5 feet height from top), all the sucking pests were maximum in top pruning when compared to normal pruning except thrips, jassids (Bunny and RCH 708) and white fly (RCH 708). Mealy bug and boll worms infestations were not found (Fig. 3.22.1).

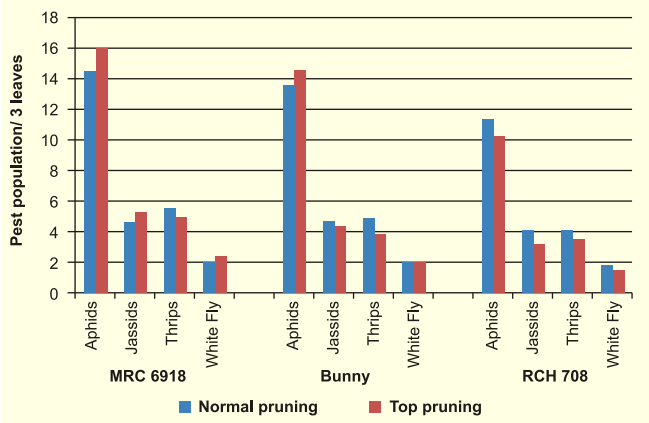


Fig. 3.22.1: Influence of different Bt cotton hybrids on sucking pests

Under laboratory conditions, leaves of Bt hybrids (Bunny, RCH 708 and MRC 6918) were evaluated for the survival of *Helicoverpa armigera.* In top pruning early larval mortality was observed around 72 hrs when compared to 96 hrs in normal pruning, except in MRC 6918. Maximum mortality ranging from 75-100 % was observed in both the types of pruning in all the hybrids (Fig. 3.22.2).

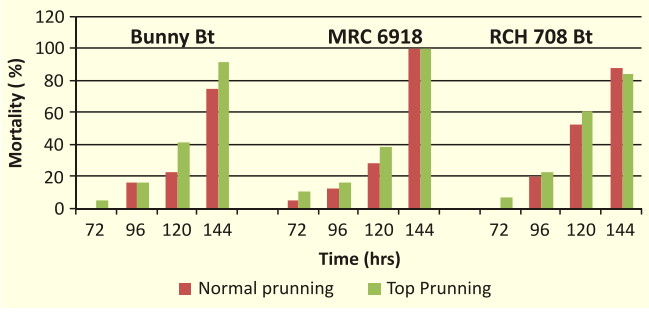


Fig. 3.22.2: Influence of extended crop (Bunny Bt, RCH 708 Bt and MRC 6918 Bt) through pruning on mortality of *Helicoverpa armigera*

Estimation of *cry1Ac* in leaves and squares of Bt hybrids in top pruning (136 days after pruning) indicated that, in leaf tissues of RCH 708 and MRC 6918 maximum quantity of 5.59 µg/g dry weight and minimum of 2.57 µg/g dry weight was recorded. In squares of Bunny maximum quantity of 5.36, RCH 708 -4.09 and MRC 6918 - 5.07 µg/g dry weight was recorded (Fig. 3.22.3).

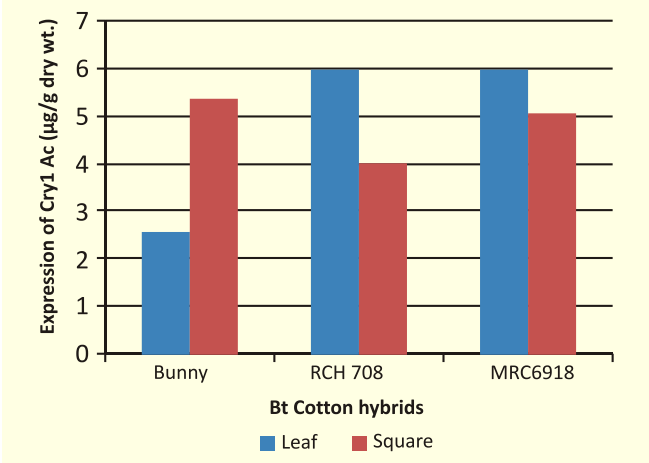


Fig. 3.22.3: Estimation of *cry1Ac* in extended cotton crop through pruning technique

Sirsa

Total of 1920 CLCuD tolerant germplasm lines were evaluated for their reaction to insect pests. Six hundred and fifty entries were recorded tolerant to leafhopper, 231 entries were found tolerant to whitefly population and 896 entries recorded no bollworm infestation.

Out of 1970 lines of germplasm which were free from cotton leaf curl virus disease during 2011-12 season and were again screened against disease under field conditions with susceptible check in 2012-13, 142 lines remained free from disease. Three hundred and thirteen new lines were also screened during 2012-13 season and sixty five lines were observed free from cotton leaf curl virus disease.

3.23: Biological Control

Nagpur

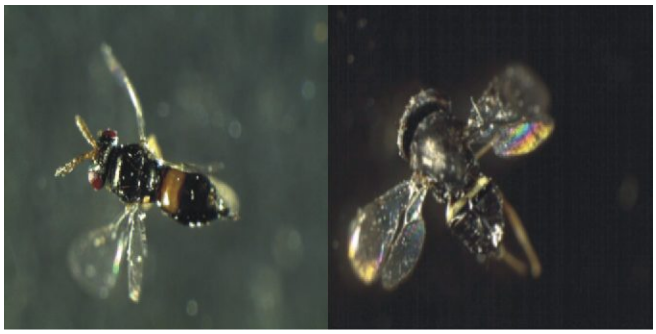
Development of nanoparticles based biocontrol formulation for the management of major cotton pests and diseases

Chitosan, Mesoporous Silica and Cellulose Nanoparticles have been synthesized by wet chemical method and Kaolin has been synthesized by ball milling and they are characterized using Particle size analyser. Chitosan nanoparticles 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 nanoparticles size ranged from 300- 380 nm with Zeta potential of 31.33 mV and cellulose nanoparticles from 200-250 nm with -16 mV.

Parasitoid diversity

Central India : Survey was conducted at 43 locations on parasitization of *P. solenopsis* by *A. bambawalei.* The percent parasitization recorded as follows: Nagpur 31% (15 locations), Wardha 2.36% (10 locations), Akola 18% (6 locations), Jalna 14% (2 locations), Yeotmal 12 % (4 locations) and Chhindwada MP 34% (6 locations). *Aprostocetus* sp. parasitization was 8.5% at Akola (2 locations) and 60% at Jalna (1location). Population of hyperparasitoid Promuscidea unfasciativentris Girault was also recorded along with *A. bambawalei.*



Aprostocetus sp. **Promuscidea unfasciativentris - Girault**

Isolation, identification and evaluation of *Trichoderma* spp. and formulation of TrichoCASH (*Trichoderma harzianum*-CICR-G)

Three novel isolates of Trichoderma have been evaluated in green house and one, named *T. harzianum* CICR-G was selected and formulated (TrichoCASH). The formulation product applied as seed treatment protected cotton seeds and seedlings in non-sterile soil infested with the test pathogen *Sclerotium delphinii*. This formulation was entered into multi-location trials under AICCIP.

Three novel strains of *Trichoderma* have been identified as *Trichoderma harzianum* CICR-G, *T. harzianum* CICR-E and *T. atroviride* CICR-A using sequence analysis of tef1 gene. The strains are deposited with MTCC, Chandigarh and sequences are deposited with GenBank (NCBI).

Trichoderma spp. is widely used as commercial biofungicides all over the world. Continued commercial success of *Trichoderma* would depend on identification of novel strains adapted to local conditions. Since the diversity of *Trichoderma* is profound on the above-ground, the success of novel strains to be developed as biocontrol products would be greater if the newer isolates are obtained that are naturally mycoparasites, as against collecting a large number of typical saprophytes (from soil) and mass screening. We have isolated three novel strains of *Trichoderma* (two *T. harzianum* and one T. atroviride) from wild mushroom and tree bark, and evaluated their biocontrol potential against *Sclerotium delphinii* infecting cultivated cotton seedlings. *T. harzianum* strain CICR-G, isolated as a natural mycoparasite on a tree-pathogenic *Ganoderma* sp. exhibited the highest disease suppression ability. This isolate was formulated into a talcum-based product (TrichoCASH 1% WP) and evaluated against the pathogen in non-sterile soil. This isolate conidiated profusely under conditions that are non-conducive for conidiation by three other *Trichoderma* species tested, thus having an added advantage from commercial perspective. All the three new isolates, *T. harzianum* CICR-G (MTCC 11511), *T. harzianum* CICR-E (MTCC 11500) and *T. atroviride* CICR-A (MTCC 11512) have been deposited with MTCC, Chandigarh and the Tef1 large (fourth) intron sequence data has been deposited with GenBank. Accession nos. are KC679853 (*T. harzianum* CICR-G), KC679855 (*T. harzianum* CICR-E) and KC679854 (*T. atroviride* CICR-A). TrichoCASH 1% WP has entered the AICCIP for multilocation trials.

Coimbatore

Compatibility of entomopathogenic fungi with insecticides

Compatibility of three native entomopathogenic fungi isolated from mealy bug *viz., Lecanicillium lecanii* (NFCCI-2579), *Metarhizium anisopliae* (ARSEF- 9613) and *Fusarium pallidoroseum* (7587.09) with insecticides commonly used in cotton ecosystem at field recommended dose was studied by dual culture assay. Radial growth and spore production was recorded. The results revealed that thiodicarb was found to be harmless to *F.pallidoroseum* whereas dimethoate was found to be slightly harmful. In case of *M.anisopliae*, indoxacarb, imidocloprid and thiomethoxam were graded as harmless. Dimethoate alone was found to be harmless to *L. lecanii*. Observations on both radial growth and spore production are essential for compatibility studies.

New Protocol

Lipase production by entomopathogenic fungi and bacteria

An easy method for screening of large number of fungi and bacteria for lipase production was developed. Lipase production was observed by the production of orange flourescens upon irradiation with UV light at 350 nm.Agar plates containing trioleoglycerol and

rhodamine B appear opaque and are pink coloured. Lipase production by *Xenorhabdus stockiae* (bacterial symbiont of a native entomopathogenic nematode, *Steinernema siamkayai*) led to formation of orange fluorescence. Lipase production was observed at 16 hours after inoculation in *X. stockiae*, and at 20 hours after inoculation in *M. anisopliae*, *L. lecanii* and *F. pallidoroseum*. Maximum lipase activity recorded for *X. stockiae , M. anisopliae, L. lecanii* and *F. pallidoroseum* was 81.68 , 69.84 , 78.21 and 80.00 U/ ml respectively.

Compatibility studies among biocontrol agents

Compatibility studies among entomopathogens (*X. stockiae , M. anisopliae, L. lecanii* and *F.pallidoroseum*) revealed that none of them were compatible and inhibited the growth and sporulation.

Antogonism between *X. stockiae* and fungi

Studies on the antagonistic activity of *X. stockiae* with three native entomopathogenic fungi (*M. anisopliae, L. lecanii* and *F. pallidoroseum*) and six plant pathogenic fungi was carried out by dual culture assay method in SDAY and NBTA medium. All tested fungi grow well in NBTA medium and this is the first report on the growth of fungi in NBTA medium. *X. stockiae* inhibited the radial growth and spore production of all three entomopathogenic fungi. Among plant pathogenic fungi, *X. stockiae* inhibited the radial growth of *Pythium* sp. and *Sclerotium sp.*

Wide spectrum activity of *L. lecanii*

Wide spectrum activity (insecticidal, fungicidal and nematicidal) of a native entomopathogenic fungus, *L. lecanii* isolated from mealy bug was reported. *L. lecanii* was found to be pathogenic to sucking pests and inhibited the growth of plant pathogenic fungi (*Pythium* sp. and *Sclerotium* sp.). Culture filtrate of *L. lecanii* significantly reduced the hatching of *Meloidogyne incognita* and *Rotylenchulus reniformis* eggs. Immature eggs were found to be more susceptible. Presence of nematicidal toxins in culture filtrate resulted in mortality of juveniles. Soil drenching with culture filtrate significantly reduced the nematode entry into the roots.

Evaluation of entomopathogenic fungal formulations against aphids

Talc based formulation of three entomopathogenic fungi were tested against aphids. Spraying talc based formulation of *L. lecanii* caused significantly higher mortality followed by e*F. pallidoroseum* and *M. anisoplia* at 5 and 7 days after spraying.

Sirsa

Among various insecticides and biopesticides applied for CLCuD and vector (whitefly) management in different modules, module- 4 (Nimbecidene at 30 DAS; Clothianidin at 45 DAS; Nimbecidene+YST at 60 DAS; *V. lecanii* at 75 DAS and Acephate 95 SG at 90 DAS) resulted in maximum (15.77%) reduction of whitefly population. Minimum reduction (1.78%) in whitefly population was observed in module-7 (Nimbecidene at 30 DAS; Nimbecidene at 45 DAS; Nimbecidene+YST at 60 DAS; *V. lecanii* at 75 DAS and Triazophos 40% EC at 90 DAS).

3.24: Integrated Pest Management

Nagpur

Compatibility of insecticides, weedicides, growth regulators and fungicides

Compatibility of insecticides, weedicides, growth regulators and fungicides were evaluated with thirteen treatments in order to reduce the number of sprays in HDPS. The treatments were T1-Neem oil 1 l/acre, T2- NSKE 5%, T3- Hitweed (Pyrithiobac sodium 72 g a.i./acre), T4- Chamtkar (Mepiquat chloride 20 g a.i./ha), T5- T1+T2+T3+T4 combination, T6 -T1+T2+T3 combination, T7 -T1+T2 combination, T8- No spray, T9- Water spray,T10 -T1+T2+T4+Acephate 75SP (300-400 g/acre), T11 -T1+T2+T4+Acephate 75SP (300-400 g/acre) + Bavistin (1 g/l) , T12- Acephate 75SP (300-400 g/acre), T13-Bavistin (1 g/l). In all the treatment combinations, individual chemicals were miscible and pH was in the range 6-8. Except Hitweed, treatments did not demonstrate phytotoxicity.

Sirsa

Innovative interventions for leaf curl management

The following treatments i.e. T1- Whey protein @ 5%, T2- Cow urine @ 6.6%, T3- Neem oil @1%, T4- Mustard oil @ 3%, T5- Kaolin @ 2%, T6- Calcium nitrate @ 0.5%, T7- Potassium nitrate @ 0.5% T8- Paraffin liquid @ 2% T9- Strobilurin @ 0.1%, T10- Acephate @ 0.4% and T11- Control were sown with three replications under RBD to study their effect on the cotton leaf curl virus disease control. Six sprays starting from appearance of disease were given at fortnightly interval. Pre and post spray data (weekly) on CLCuD incidence were recorded. Data on white fly incidence was recorded at weekly interval.

Among different treatments, Cow Urine @ 6.6% was found most effective in managing disease (% incidence-54.4, PDI-15.3) followed by Kresoxim methyl @ 0.1% (% incidence-54.9, PDI-17.7) and Calcium nitrate @ 0.5% (% incidence-64.7,PDI-21.4) as compared to control (% incidence-73.9,PDI-26.6). Based on pooled result of two years, Cow urine, kresoxim methyl, calcium nitrate, whey protein and neem oil were promising in reducing CLCuD incidence.

Insecticide Resistance Monitoring and Management

Nagpur

1. **Monitoring of American bollworm with *Cry1Ac* toxins**

   H. armigera populations collected from chickpea and pigeon pea (2012-13) were subjected to log dose probit assays with *cry1Ac* (MVPII) in the F_1 generation. With populations from 14 districts the LC_{50} was found to vary from 0.105 µg/ml of diet (Amravati) to 1.453 µg/ml of diet (Jalna). F_2 screen study for populations collected from Maharashtra and Gujarat (9 districts: Surat, Baruch, Vadodara, Anand, Ahmedabad, Bhavnagar, Amreli, Junagadh, Rajkot) are in progress. As part of the F_2 screen, single pair mating progeny from Rajkot, Surat, Jalna survived (9.17ug/ml of diet) concentration of MVPII in a 7 day bioassay period. Bioassay survivors entered pupation and adults emerged and laid fertile eggs, but F_3 larvae from Jalna and Rajkot did not survive.

2. *H. armigera* populations from 8 districts viz. Coimbatore, Nagpur, Salem, Amravati, Khammam, Wardha, Parbhani and Washim were subjected to log dose probit bioassays with *cry2Ab.* LC_{50} was calculated from the log dose probit bioassays with populations from 3 districts (Coimbatore, Salem and Nagpur) where LC_{50} ranged from 1.25, 0.45 and 0.57 µg/ml of diet, respectively. Populations from other 5 districts did not record dose dependant larval mortality in a 7 day bioassay. However, growth regulating effects were recorded with populations of Coimbatore, Salem and Nagpur in addition to mortality with EC_{50} values of 0.14 µg/ml, 0.06 µg/ml and 0.02 µg/ml of diet respectively. Populations from Aurangabad, Khammam and Parbhani recorded EC_{50} values of 0.011 µg/ml, 0.023 µg/ml and 0.12 µg/ml of diet respectively.

3. **Monitoring of Pink bollworm with Cry1Ac toxins**

   Bioassays with *cry1Ac* were conducted for pink bollworm populations collected from non-Bt cotton fields of different locations of India using diagnostic doses *viz.* 10 ppm, 1 ppm and 0.1 ppm. Cent per cent larval mortality was recorded over the control at 10 ppm except in populations from Jalgaon, Aurangabad and Raichur. The highest LC_{50} (0.41 µg *cry1Ac*/ml of diet) was recorded in Bharuch of Gujarat and the lowest (0.01 µg.ml of diet) was from Jalgaon of central India (Fig. 3.24.1).

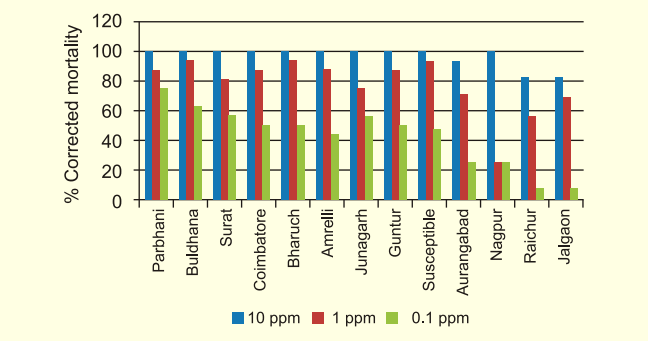


Fig. 3.24.1: *Cry1Ac* diagnostic dose bioassay of pink bollworm

3. IRM Project was implemented successfully in 10 major cotton-growing states of the country covering 250 villages in 18 districts. Till date a total of 10,512 farmers were enrolled as direct beneficiaries to implement IRM strategies in total 28,962 hectares area. Novel approaches such as 'Hello IRM' (live phone in programme on radio), Street Play, farmer group meetings (1417), field day (74), field visits (2260) , training and demonstration etc. were major extension activities adopted as tools for dissemination of the IRM strategies to create awareness about the program among the farming community.

4. **Effect of different insecticides on insect pests of cotton under high density planting.** The efficacy of different insecticides on insect pests of cotton was evaluated under high density planting system at CICR farm. Buprofezin, Fipronil, NSKE, *V. lecani,* Mealy Kill, Mealy Quit, Bacterial formulation, Imidacloprid, Neem oil, Diafenthiuron, Spiromesfin, Flonicamid and Acephate along with control were tested.

Flonicamid (50% WG @ 50 g a.i./ha) and Acephate (75% SP@ 562.5 g a.i./ha) recorded 2.19 nymphs/3 leaves/plant and 2.59 nymphs/3 leaves/plant respectively and both were highly effective and significantly superior to all other treatments in reducing the leafhopper populations. The next best treatment was Buprofezin (25 % SC @100 g a.i./ha) followed by Fipronil 5% SC@ 40 g a.i./ha with populations of 3.31 and 3.20 nymphs /3 leaves /plant respectively and on par with each other as compared to control (4.72 nymphs /3 leaves /plant).

Nagpur

High Density Planting System in Vidarbha

The Central Institute for Cotton Research, Nagpur developed and demonstrated a new concept of 'High density Planting Systems' (HDPS) that has potential to improve yields of rainfed cotton, especially in Maharashtra, Madhya Pradesh and Andhra Pradesh. Under HDPS, the plant population per hectare (ha) is increased 3-4 fold, from the normally recommended plant population of 55,000 plants/ha to 150000 to 200,000 plants/ha. The concept of high planting density is widely adopted in several countries such as China, Brazil, Uzbekistan, Australia and Argentina wherein plant population of 100,000 to 200,000 per hectare is maintained and high seed cotton yields of 40-50 quintal/ha is realized, using dwarf compact varieties. The plant population with hybrid cotton in India, ranges from 6000 to 15000/ha. The HDPS system requires dwarf varieties with compact stature bearing 6-8 bolls per plant, so that they do not compete with one another for light and other inputs such as nutrients and water.

Cotton is cultivated primarily under rain-fed conditions in Maharashtra and majority of the regions in Madhya Pradesh and Andhra Pradesh. The yields are low in these regions. About 35% of the soils are marginal and not ideally suited for hybrid cotton. Water and nutrient requirement during peak boll formation phase are most critical for realizing high yields. Protective and supplemental irrigations are not available for majority of the farmers, especially in Vidarbha wherein 97% of the area is under rainfed cultivation. Rainfall commences in June and recedes by mid September. Boll formation in long duration varieties and hybrids starts in October and reaches a peak by the end of November. Boll formation and retention get negatively affected due to inadequate soil moisture, especially in shallow soils resulting in low yields. Soils with very low moisture retention capacity have been found to produce low yields in long duration cotton hybrids and varieties.

Research conducted at CICR showed that, cultivating short duration varieties with a high plant density is an ideal approach for improving productivity in the rain-fed regions. Early maturing compact plant types with short sympodia were identified and evaluated under high density planting system for 3 years during 2009-2011. Non Bt varieties-AKH 081, NH 615 and Suraj, though not specially developed for high density planting, were identified as amenable to planting at 150,000 to 200,000 plants/ha at spacing of 60 x 10 cm or 45X10 cm. Variety Suraj was released by CICR in 2008 is known for its excellent fiber qualities, especially with a high fiber strength of 25 g/tex. AKH 081 was released in 1987 by Dr PDKV Akola, and NH 615 is a compact variety released recently by MAU Parbhani and all tolerant to sucking pest. By increasing plant population it was possible to obtain yields of 18-20 q/ha with these varieties on marginal soils. Further, production costs were low and the crop matured a fortnight earlier than the crop sown at normal density. The yields could be improved further by dry sowing (just after the receipt of first monsoon rains), using 25% higher rate of fertilizer over the recommended rate of 60:30:30 NPK and also by using established moisture conservation agro-techniques.

Encouraged with the three year experimental farm results, CICR initiated a farmer participatory trials of HDPS in marginal soils under rain-fed conditions of one-acre (0.4 ha) fields of 155 farmers in the eight cotton growing districts of Vidarbha during the *kharif* season of 2012. The varieties Suraj, NH 615 and AKH 081 were planted at 45 x 10 cm or 60 x 10 cm spacing with early onset of monsoon. The seed rate was 12 kg/ha. The farmer participatory trials were conducted with assistance from the State Agricultural Department and the Krishi Vigyan Kendra.

Despite delayed onset and erratic monsoon during 2012, high yields of 25 to 30 q/ha of seed-cotton were obtained by several farmers. A severe bollworm outbreak was noticed in the initial fruiting phase and 2 insecticide applications had to be given to control the pest. Across the trials, the yields averaged at 15 to 18 quintals, which is double the average of Vidarbha.

Highest yields were obtained in Chandrapur, Amaravati, Nagpur, Yavatmal and Akola districts (Table 4.1). Severe drought in Buldhana, Washim and some parts of Wardha resulted in relatively lower yields of 8-10 quintals per hectare. The increase in yields was estimated to be at least 35-40% above the yields that were normally obtained by the farmers in the previous years. The cost of cultivation was Rs 20,000 to 25,000 per hectare. Net profit ranged from Rs 12,000 to 90,000 per hectare.

Table 4.1: Seed cotton yield (q/ha) in HDPS demonstrations

District	No. of Trials	Minimum	Maximum	Average
Akola	20	10.2	18.8	15
Amaravati	37	6.3	20.7	11.2
Buldhana	28	5	11.3	9.7
Chandrapur	20	4.5	31.2	12.8
Nagpur	13	8.8	20.9	12.2
Washim	8	7.9	13.4	10.3
Wardha	13	5	21	9.5
Yavatmal	16	12.5	30	18.1

The farmer participatory trials generated excitement and renewed interest in the cultivation of varieties in the region and many farmers are enthusiastic to try the HDPS system. A few farmers also tested HDPS under organic conditions and obtained yields of about 25 to 28 q/ha. Buoyed by the success CICR is proposing to upscale these demonstrations in Vidarbha and extending it to the Marathwada region of Maharashtra and also to the neighboring states of Madhya Pradesh, Karnataka and Andhra Pradesh in 2013-14.

Integrated Resistance Management

During crop season 2012-13, the IRM strategies were disseminated by 16,276 farmers in 31720.49 hectares in a total of 263 villages of 18 districts from 10 different states across India. In IRM fields, farmers sprayed average 2.75 sprays/ha as compared to 5.04 sprays/ha by non-IRM fields. Average yield of IRM and non-IRM fields was 18.88 and 16.56 q/ha. Implementation of the programme resulted in 14.01% yield increases and 45.49% reduction in insecticide use, thus adding up to a total additional benefit of Rs 40.29 crores due to the project. A total of 2260 field visits, 1417 group meetings, 74 field day and 100 training programme were adopted as tools for dissemination of the IRM strategies among the farming community to create awareness about the program. Novel approaches such as 'Hello IRM' (live phone in programme on radio), Street Play, farmer group meetings, field day, field visits, training and demonstration etc. were major extension activities adopted as tools for dissemination of the IRM strategies to create awareness about the program among the farming community. A summary of physical activities carried out during the year is given below.

Field Visit – The state coordinator developed direct contact with farmers by addressing farmer gathering representing clusters of villages twice a week thereby covering the entire project area during the crop season. A total of 2260 field visits were carried out during the year.

Farmer meeting - Regular meetings at fortnightly intervals were conducted in different villages so as to cover all the adopted area twice a month. A total of 1417 farmers meeting were carried out during the year.

Field day - To disseminate the IRM technology to the cotton growers, 74 field day were conducted in the adopted villages.

Training programme of field workers - Field workers training programme and feedback from them about the progress of dissemination of the IRM strategies was conducted at the research station at weekly intervals. A total of 100 field workers training were carried out during the year.

Training programme of farmers - Total 303 farmers training camp was organized to trained farmers for identifying the harmful and beneficial insect pests, their nature of damage and to use insecticides for insect pest management.

Technology Chart – Boards (7' x 4' size) depicting IRM window based strategies along with life cycles and pictures of pests and beneficials were prepared and erected in each villages. Pictorial key boards depicting the whole management strategies of newly emerging pest i.e mealy bug were prepared and erected, one board in each village. A total number of 14 technology charts were published in Punjab, 10 each in Haryana, Maharashtra and Madhya Pradesh and 5 in Tamil Nadu.

A total of 66 wall paintings of size 6 x 2.5 on different IRM technologies were painted on different places in Wardha and Yavatmal district of Maharashtra.

Manuals/popular articles - A total number of 10 (each) popular articles were published in Punjab and Parbhani (Maharashtra), and 6 in Madhya Pradesh.

Pamphlets - Pamphlets of IRM strategies month wise, spray methodologies and mealy bug management were distributed in each village. A total number of 19 pamphlets were published in Punjab, 8 in Haryana, and 7 each in Wardha and Madhya Pradesh.

Press releases - A total number of 26 press articles were published in local newspapers of Punjab, 8 in Haryana, 2 in Wardha, 5 in Madhya Pradesh and 1 in Tamil Nadu.

Radio talk – A total of 7 radio talks on IRM technology was aired each in Local radio channel of Punjab and Madhya Pradesh.

TV shows – A total of 8 TV shows on IRM was broadcasted in local channel of Punjab, 2 in Madhya Pradesh and 17 in Wardha, respectively.

Field Schools – A total of 6 field schools were carried out in Punjab, 4 in Haryana, 6 in Madhya Pradesh, 2 in Parbhani and 15 in Wardha.

Farmers were unanimously found to be highly motivated for the reduction in number of insecticidal sprays and so to cost of cultivation without any compromise with the seed cotton yield. A large number of farmers of Non-IRM villages were found to be ready to participate voluntarily in the extension programme of IRM as they were highly convinced with the results of villages adopted under IRM.

Crop pest surveillance and advisory project (CROPSAP) for cotton in Maharashtra

Crop pest surveillance and advisory was carried out in 28 districts of Maharashtra comprising 75 subdivisions. Under the project probable pest situation based IPM strategies were formulated for targeted insect pests of cotton along with modified ETL and observation sheet. These were circulated among concerned stakeholders (Agril Deptt, SAUs, involved ICAR institutes) for further dissemination. On-line pest situation have been regularly monitored through information uploaded on website and personal visits. ICT tools (Computer, internet) for continuous monitoring and dissemination of advisory for pest management through mobile was adopted.

Coimbatore

Polymulch technology

Variety Suraj was evaluated under the polymulch technology in two farmers fields. The polymulch technology recorded additional seed cotton yield of 15.6 q/ha over conventional method.

Stale seed bed technique of weed control

Stale seed bed method of weed control using pendimethalin 1.0 kg + glyphosate 1.0 kg/ha was demonstrated on farmer fields for Suraj. This technique controlled the weeds efficiently and recorded 22.5 q/ha of seed cotton yield.

Cotton value chain

The impact of adoption integrated cotton production technologies , significantly increased the area of ELS cotton which has now become major crop in the villages of Mampalli and Kinathukadavu in Coimbatore district. During the year, soil moisture conservation by ridge and furrow method, mulch by application of crop residues, pendimethalin (stomp) @ 700 ml per acre for pre emergence weeds, combination of hit weed (250 ml /acre)+targa super (250 ml/acre) for control of late emerged weeds and use of Tricho compost were demonstrated. Effective utilization of natural resources, multi-tier cropping system was demonstrated. The demonstration involved fifty farmers who facilitate the dissemination of NAIP-CVC technologies to non project farmers of surrounding villages.

5. Education And Training

5.1: Training Received

5.1.1: International Training

Name of the Scientist	Name of the course/training	Place	Period
Dr. Surender Kumar Verma	DNA sequence-assisted breeding using single nucleotide polymorphisms (SNPs) in Cotton using genotyping by sequencing (GBS) approach. (DBT-CREST Award 2010)	College Station & Texas A&M University, USA	27-10-2011 to 14-10-2012
Dr. Rishi Kumar	Environmental impact of insect resistant genetically modified cotton on non target beneficial (predators) arthropods. (Fulbright Nehru Environment Leadership Program)	New York Agriculture Experiment Station, Cornell University Geneva, USA	09-10-2012 to 31-01-2013
Dr. K.R. Kranthi	Leadership Decision Making: Optimizing Organizational Performance	Harvard Kennedy School, Executive Education, Cambridge, USA	28-10-2012 to 02-11-2012

5.1.2: National Training

Name of the Official	Name of the course/training	Place	Period
Shri. A. Sampath Kumar	Microbial Agents of Major Insect Pests and Diseases of Crops	DOR, Hyderabad	11-03-2013 to 20-03-2013
Dr. P.K. Chakrabarty , Dr.M.V. Venugopalan, Dr S.M. Palve	Special training course for Cotton Breeders	CIRCOT, Mumbai	9-05-2012 to 11-05-2012
Dr.S.Manickam	Computational Genome Analysis Techniques in discovery of agronomically important crop genes	NBPGR, New Delhi	24-09-2012 to 29-09-2012
Dr. D. Monga	Management Development Program on Leadership Development	NAARM Hyderabad	8-10-2012 t o 19-10-2012
Dr. A. R. Raju	Advances in weed management	DWSR, Jabalpur	30-10-2012 to 19-10-2012
Mrs. Vandana Satish	Training on Agropedia	ICRISAT, Hyderabad	24-01-2013 to 25-01-2013
Dr. A. R. Raju	SAS for data reduction and multi-variate analysis	CIFE, Mumbai	11-02-2013 to 10-02-2013

5.2: Training Imparted

International training

Nagpur

Modern cotton production technologies

A two week long (22 Oct. to 3 Nov. 2012) training programme on 'Modern cotton production technologies' under the Technical Assistance Programme (TAP) for Africa. IL&FS as the Project Implementing Agency and the programme is under the aegis of the 2nd India Africa Forum Summit. The training was conducted with the specific objective of capacity building of the Master Trainers from C-4 countries (Benin, Burkina Faso, Mali and Chad) and Malawi, Nigeria and Uganda. Dr. Blaise Desouza was the course coordinator. Thirty two Master

Trainers from six countries of Africa participated in the training programme.

The programme was funded by the Ministry of External Affairs, Govt of India.

Coimbatore

Relevance and techniques of Organic Cotton Production under TAP for Africa (Uganda)

Six cotton Researchers from Uganda underwent a training program on Relevance and techniques of Organic Cotton Production at Central Institute for Cotton Research (CICR), Coimbatore from 21 January 2013 to 25 January 2013 under Cotton Technical Assistance Programme (TAP) for Africa.

National Training

Training on production technology for high density planting system

Three training programmes for one day duration each on 'High density plant population system', 'Integrated nutrient management and Weed management in cotton' were conducted at Taluka Agril office, Karajna Lad, dist. Washim and at villages Dhanora tathod, Ganeshpur and Khanapur in Karajna Lad, dist Washim in Vidharbha region of Maharashtra. The programme was coordinated by Dr. S. M. Wasnik, Principal Scientist (Extension) and Dr. Chinna Babu Naik, Scientist Entomology.

Training –cum-Awareness Programme

Nagpur

DUS testing in cotton for extension workers

CICR, Nagpur conducted one day Training–cum-Awareness Programme on DUS testing in cotton for extension functionaries of the district. The programme was held on 23.01.2013 at KVK training hall and was attended by 50 participants. Dr. V. Santhy conducted the training programme.

Training programme on Surgical Cotton for tribal farmers

CICR, Nagpur Imparted training on Surgical Cotton (*G. arboreum*) for High Density Planting System for 30 Tribal farmers of Hingna, Nagpur. Dr. Vinita Gotmare conducted the programme.

Coimbatore

Training Progarmme on IRM for farmers

Under the project TMC MM - II - Insecticide Resistance management a farmers meeting was organized at Vadakkipalyam village of Pollachi North Block, Coimbatore District on 25th August, 2012. Dr. Dharajothi, Senior Scientist (Entomology) and District Co-ordinator of the Project explained about the insecticide resistance management (IRM) project activities that were implemented in the village and requested the farmers to utilize the opportunity for sustainable cotton cultivation.

During the occasion a training-cum-group meeting for the farmers was also organized. An exhibition with photographs, display boards and live specimens of

cotton pests, natural enemies and diseases of cotton was inaugurated Dr. Laksmi Raj, Joint Director of Agriculture, Department of Agriculture Coimbatore. In the inaugural address he briefed about the present scenario of cotton cultivation.

National level awareness workshop cum training on ELS cotton cultivation and value addition

A three day national level awareness workshop cum training on "ELS cotton cultivation and value addition" sponsored by NAIP –Cotton value chain project was held at Central Institute for Cotton Research, Regional Station, Coimbatore from 26 to 28 Dec.2012. Twenty one extension officers /workers from Dept of Agriculture, Tamil Nadu & Karnataka, MYRDA KVK, Gopichetipalayam, Hans Rover KVK, Perambalur and SIMA- CDRA, Coimbatore participated.

Clean cotton production practices

A one days awareness workshop for non project farmers of NAIP -Cotton value chain project was held at Mampalli, Kinathukadavu, Coimbatore on 29 Dec. 2012. Interactive session with NAIP project farmers those who made success stories was held followed by impact of adopting integrated cotton production techniques and different value addition in cotton were explained.

Training–cum-Awareness Programme for farmers on PVP & FR

One day awareness cum training programme on protection of plant varieties and farmers rights was conducted. There were 90 participants including 36 progressive farmers of Kanjappalli and Allapalayam villages of Annur Taluk.

6. Awards And Recognitions

Awards

Keith Runcorn Award

Dr. Blaise Desouza received the Keith Runcorn Award for convening a session in the European Geoscience Union (EGU) General Assembly 2012.

Best Paper Award -2012

Dr K. Sankaranarayanan, Principal Scientist (Agronomy) received the Best Paper Award -2012 for his paper entitled "Low cost drip as a precision irrigation tool in Bt cotton (*Gossypium hirsutum*) cultivation" published in Indian Journal of Agronomy Volume 55(4): 312-318 (December 2010) during the inaugural function of Third International Agronomy Congress held at IARI, New Delhi.

Best Oral paper presentation award

Dr. M.V. Venugopalan, Principal Scientist (Agronomy) received the Best Oral paper presentation award for the paper entitled "H.D.P.S-The Brazil experience and Indian perspective" during the National Convention on India Cotton: Gearing Up For Global Leadership held during 18 -20 December, 2012 at Main Cotton Research Station, NAU, Surat, organized by GAU, ISCI & CICR.

Best poster presentation award

Dr. Chinna Babu Naik, Scientist (Entomology) received the best poster presentation award for his poster entitled "Changing Scenario of Pink Bollworm, *Pectinophora gossypiella* (Saunders) Incidence on Cotton in India" during the International Symposium on Global Cotton Production Technologies vis- a- vis climate change held at CCSHAU, Hisar during Oct. 10-12, 2012.

Dr. V. S. Nagrare, Senior Scientist (Entomology) received the best poster presentation award for his poster entitled "Description, damage, scenario, weather based prediction and management of mirid bugs (*Campylomma livida* Reuter; Miridae: Hemiptera) on Rainfed Cotton of Central India" during the International Conference on Plant Health Management for Food Security held at Hyderabad during 28-30 Nov 2012.

Dr. K. Velmourougane received Best poster award for his poster entitled "Microbial diversity indices of agro-ecological sub regions of black soil regions in India" during the National Seminar on Managing land resources for sustainable agriculture organized by NBSS & LUP, Nagpur during Oct 12-13 2012.

Recognitions

Dr. M. V. Venugopalan, Principal Scientist (Agronomy) and Head, PME Cell has been nominated as a member of the Executive Committee of the International Cotton Research Association (ICRA) for the period 2012-2016, by the International Cotton Advisory Committee (ICAC), Washington.

Dr. P. K. Chakrabarty has been recognized as of Courtesy Professor, in the Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Fl, USA in recognition of his effective research and collaboration as post-doctoral researcher and visiting Scientist.

Dr. P. K. Mukherjee, Principal Scientist, Crop Protection Division was elected as Fellow of her National Academy of Sciences, India (Allahabad).

Dr. Nandini Gokte-Narkhedkar, Principal Scientist, Crop Protection Division Nominated as Member, Board of Studies, Entomology/ Nematology at Dr. PDKV, Akola.

Dr. Vinita Gotmare was felicitated by the Raisoni Group of Institutions in recognition of her achievements in cotton research on the International Womens Day i.e. March 8, 2013.

7. Linkages And Collaborations

Areas of Linkages	Institution
NATIONAL	
Fibre testing, fiber quality evaluation and nanotechnology	CIRCOT, Mumbai
Multi-location testing of promising cultures, Bt Cotton evaluation	AICCIP (21 centers)
Germplasm collection maintenance and plant quarantine clearance	NBPGR, New Delhi
Seed technological research and breeder seed production	NSP, New Delhi
Development of *cry1A* (a) gene construct	NBRI, Lucknow
Supply of gene construct and molecular evaluation of transgenic plant.	NRC Plant Biotechnology, New Delhi
DNA finger printing of cotton	NRC DNA Finger Printing, New Delhi
Efficacy of lectins on sucking pests- New Millineum Initiatives of Technologies Leading India (NMITLI)	NBRI, Lucknow Bose Institute, Kolkata, NII, New Delhi, Delhi University, New Delhi, UAS, Dharwad, JK seeds.
Technology for pink bollworm resistance monitoring and management	State department of Agriculture, Haryana, KVKs, CCS HAU, Hisar, NCIPM etc
Crop pest surveillance and advisory for cotton pests in Maharashtra.	Agriculture Department, Government of Maharashtra
Mechanization	CIAE, Bhopal

Research Collaboration with Universities

The Central Institute for Cotton Research, Nagpur has signed MoU with the SGB Amaravti University, Amaravti on 04/06/2012, Dr PDKV, Akola on 15/03/2013 and RTM, Nagpur University, Nagpur on 26/03/2013 and recognized CICR as a centre of post graduate education and research.

RTM, Nagpur University

Dr. PDKV, Akola

8. All India Coordinated Cotton Improvement Project

Research Highlights

Crop Improvement

National Trials

- In the initial evaluation trial (IET) of *G. hirsutum*, the entries Su-Flum, P 5430 and BGDS 1063 were the best under irrigated condition in terms of seed cotton yield in north, central and south zones, respectively. Under rainfed situations, ADB 542 was the best in Central Zone, whereas, GBHV 180 was the best in South Zone.
- In the preliminary intra *hirsutum* hybrids trial under irrigated conditions, LHH 1411 was the best for seed cotton yield in North Zone, while TSHH 0629 was the best in both central and south zones. Under rainfed situation, DHH 1251 was the best hybrid in Central Zone, while RAHH 806 was the best in South Zone.
- In the IET of compact genotypes under closer spacing, CSH 3075 was the best in North zone, whereas LH 2298 was the best in South Zone under irrigated conditions. In rainfed situation, ARBC 64 was the best in Central zone.
- The *barbadense* culture DB 16 was the best in central zone, whereas, GSB 40 was the best in south zone. Quality wise, Suvin was the best in both the zones.
- Interspecific hybrid DHB 12017 was the best hybrid in Central Zone and RHB-0812 was the best in South Zone.
- Among the *G. arboreum* cultures tested Zonal check was the top yielder in North Zone, while in Central Zone and South Zones, the cultures JLA-0614 and CAN 1016 recorded the highest yield, respectively. Several entries were found to have superior fibre quality attributes.
- Among the desi hybrids tested FMDH 40 was the top performer in Central Zone.
- Among the *herbaceum* cultures tested under rainfed condition Central Zone and South Zone locations, the Local Check was the best in Central Zone and RAHS 852 was the top performer in South Zone.

Zonal Trials – North Zone

- In the *G. hirsutum* Preliminary Varietal Trial, the highest seed cotton yield was recorded in LH 2256 (2450 kg/ha). In Coordinated Varietal trial, F 2228 was the best recording 2246 kg/ha of seed cotton yield.
- In the Coordinated Hybrids trial, five hybrids performed better than both the check hybrids. FHH 200 (2470 kg/ha) was the best hybrid.
- In the Coordinated *G. arboreum* varietal trial, out of five cultures tested, LD 949 was found to be the best culture recording 2706 kg/ha of seed cotton yield.
- In the Coordinated *desi* hybrid trial, FMDH 23 (2545 kg/ha) outperformed the checks and other test entries.

Zonal Trials – Central Zone

Irrigated Trial

- In the Preliminary Varietal Trial of *G. hirsutum* genotypes, the culture GISV-272 topped the rank with 2170 kg/ha of yield. In the Coordinated varietal trial, GISV 159 (2301 kg/ha) recorded the highest seed cotton yield.
- In the Coordinated intra hirsutum hybrid trial, the test hybrid GSHH 2729 ranked 1st with 2513 kg/ha. The best check, local hybrids recorded an yield of 2371 kg/ha.
- In the preliminary varietal trial of *G. barbadense* under irrigated condition, DB 16 recorded the highest seed cotton yield of 1370 kg/ha. In the Coordinated varietal trial, GSB 40 (1110 kg/ha) recorded the highest seed cotton yield.
- In the Coordinated interspecific (*G. hirsutum* x *G. barbadense*) hybrid trial, ten test hybrids showed yield superiority over both the check hybrids. RHB-0713 recorded the highest yield of 1323 kg/ha.

Rainfed Trial

- In the Preliminary Varietal Trial of *G. hirsutum* genotypes, two cultures were better than both the check varieties. The highest seed cotton yield of 1131 kg/ha was recorded in GBHV 170.
- In the Coordinated varietal trial of *G. hirsutum*, four cultures were better than the check varieties and the highest yield of 1304 kg/ha was recorded in the variety NH 635.
- In the Coordinated intra *hirsutum* hybrid trial, two test entries were better than both the check hybrids and the hybrid NHH 250 was the best with 1593 kg/ha of mean seed cotton yield.

- In the Coordinated varietal trial of *G. arboreum*, two test cultures were better than the check varieties and the highest seed cotton yield of 1533 kg/ha was recorded in JLA 505. In the Coordinated *Desi* hybrid trial, two test hybrids were superior to both the checks and the highest yield of 1839 kg/ha was recorded in NACH 18.

Zonal Trials – South Zone

Irrigated Trial

- In the Preliminary Varietal Trial of *G. hirsutum* genotypes, the culture GISV 272 with 2128 kg/ha was the best. In the Coordinated Varietal Trial, SCS 793 was the best entry with 2022 kg/ha of seed cotton yield.
- In the preliminary varietal trial of *G. barbadense* under irrigated condition, four test entries showed yield superiority over the check variety Suvin. In the Coordinated Varietal Trial, RAB 8 was the best entry with 1292 kg/ha of seed cotton yield.
- In the interspecific hybrids trial, six test hybrids were superior to the check hybrid and the highest seed cotton yield of 1930 kg/ha was recorded in the test hybrid RHB-0707.

Rainfed Trial

- In the Preliminary *G. hirsutum* varietal trial, two test entries showed yield superiority over the check varieties and the highest yield was recorded in P 2151 with 1490 kg/ha.
- In the coordinated hybrid trial, ten test hybrids showed yield superiority over the Zonal Check hybrid Bunny. However, the highest seed cotton yield of 1557 kg/ha was recorded in the local check hybrid.
- In the Coordinated *G. arboreum* varietal trial, two cultures outperformed both the check varieties and the highest seed cotton yield of 1430 kg/ha was recorded in AKA 2005-3.
- In the Coordinated *desi* hybrid trial, three hybrids were better than both the check hybrids and the highest mean seed cotton yield of 2092 kg/ha was recorded in NACH 18.

Agronomy

- The weed free situation recorded the highest seed cotton yield at all the locations and pendimethalin @ 1.0 kg a.i./ha + quizalofopethyl @ 50 g a.i./ha + one hoeing was promising in North zone conditions. Similar observations was noted in central zone locations also. Whereas, in south zone locations, pyrithiobac sodium @ 62.5 g a.i./ha + quizalofopethyl @ 50 g a.i./ha at 20-30 DAS or 2-4 weed leaf stage + one hoeing was promising.
- Drip irrigation schedules at 0.6 ET was optimum at all the locations of central and south zone.
- For organic cotton production, Vermicompost @ 5 t/ha + Seed treatment with Azotobactor + PSB @ 25 g each /kg seed gave significantly higher seed cotton yield in north zone centres.
- In most of the central and south zone centres, recommended dose of nutrient through organics based on P equivalent basis + green manuring with sunnhemp @ 50 kg seed/ha and incorporated at 30-45 DAS was found promising.
- Delayed sowing resulted in delay in days for 50 % squaring and 50 % flowering, whereas, days to 50 % boll bursting and days to maturity were reduced.
- Significant differences in per cent defoliation were noticed due to the foliar application of Drop Ultra on different genotypes. Foliar application of Dropp Ultra @ 200 ml at 140 DAS in Lam and Faridkot, 200 ml/ha Thidiazuron + Diuron at 150 DAS in Dharwad, Ethrel 2000 ppm at 140-145 DAS in Ludhiana was the best for defoliation.
- Nitrate reductase, peroxidase and proline content was more in drought tolerant genotypes *viz.*, BS-279, SCS-793, BGDS-802 and QJHV-500.

Entomology

- In Faridkot, F 2276 and Bihani 251 was found to be resistant against leaf hopper under confirmative test.
- In Khandwa, minimum number of Leaf hoppers at 20 DAS and 27 DAS were found in KH- 157.
- At Junagadh, the incidence of Pink bollworm larva was recorded in 20 green bolls and the minimum number of larva found in GJHV-500 (2.33), BS-37 (2.40) and GJHV-460 (2.40).
- Epizootic screening showed that five genotypes *viz.*, GISV-272, GSHV-162, GTHH-197, GTHH-194 and TSHH- 0629 were consistently resistant to leaf hopper at Rahuri.
- At Nanded, IS-376-4-1 (6.24/3 leaves) and IS-181-1-4-1 (6.35 / 3 leaves) recorded lower leaf hopper incidence than other lines.
- At Guntur, lowest leafhopper incidence per three leaves was recorded in NDLH 1938.
- Based on leaf anatomy studies, SCS 793 and TCH 1728 showed moderate resistance (2 grade) to leaf hopper.

- The factors which play a role in resistance of cotton to leaf hopper include higher number of leaf trichomes, higher leaf thickness, higher distance of phloem elements from lower epidermis, compact arrangement of palisade cells and palisade cell height.
- New insecticides *viz.*, Sulfoxaflor 24% SC and Flupyradifurone 20 SL were evaluated for their efficacy in controlling the sucking pests.

Plant Pathology

- The cotton leaf curl virus disease (CLCuD) appeared on 22nd June at Hisar in Haryana and first week of July at Faridkot and Sriganganagar. During this year, incidence and severity of disease was higher as compared to last year, particularly at Faridkot, Muktsar and Fazilka in Punjab, Sriganganagar in Rajasthan and Jind in Haryana.
- Among other diseases, *Alternaria*, Bacterial blight and Grey mildew were the major diseases in Central and South zone. In addition, Leaf rust in Karnataka and Andhra Pardesh and Tobacco streak virus in Andhra Pardesh and Tamil Nadu are gaining ground.
- MR 786 and Bihani 251 showed resistant reaction against CLCuD at Faridkot, P 2151, BGDS-801, BGDS-802 and BS-47 showed resistance against Bacterial blight at Akola during 2011-13, NDLH 1938 and TCH 1707 were found resistant continuously for three years (2010-12) against *Alternaria* blight at Rahuri.
- Treatment of seed with carboxin and thiram combination with highest concentration of 4.5 g/kg showed lowest seedling mortality.
- Location specific IDM modules for the management of cotton diseases were developed at Rahuri, Guntur and Coimbatore.
- Economics of crop loss estimation from bacterial blight was estimated at Dharwad, Guntur and Akola. Based on pooled means, maximum B:C ratio (2.24) was observed when three sprays of COC (0.3%) + SS 500 ppm were given at 65, 80 and 95 DAS followed by four sprays of COC (0.3%) + SS 500 ppm at 50, 65, 80 & 95 DAS. Similarly, B:C ratio for rust at Dharwad (2.68) and Guntur (1.82) was highest when four sprays of Propiconazole were given at 75, 90, 105 & 120 DAS.
- Crop loss estimation due to CLCuD showed reduction in boll number ranging from 46.4 to 55.7 and seed cotton yield from 49.4 to 59.8% in different Bt cotton hybrids due to cotton leaf curl virus disease at Hisar and Faridkot.
- Study on distribution pattern of cotton leaf curl virus disease on local popular Bt hybrid at farmers' field in north zone showed that Cotton Leaf Curl Disease PDI ranged from 8.3 to 57.6 in different districts of Punjab, 29.8 at Sriganganagar in Rajasthan and 0.0 to 15.8 in different districts of Haryana in various Bt cotton hybrids grown by farmers.

9. Krishi Vigyan Kendra

Training Achievements

Ninety short duration (1 to 3 days) on-campus and off-campus training courses were conducted in different disciplines by SMS and Program Assistants for practicing farmers, rural youth and extension functionaries. In all 2648 participants including 770 SC/ST participants were benefited.

In addition to the above trainings twelve sponsored training courses were organized in Crop Production, Horticulture, Plant Protection, Veterinary Science and Home Science for farmers and extension functionaries, deputed by State Agriculture Department of Maharashtra, ATMA, CIPMC, Nagpur, RCF, MAFSU Nagpur, MCED & ICDS Nagpur, NGOs. In all 622 participants attended these courses.

Front Line Demonstrations

Seven front line demonstrations on crops and seven FLDs on other than crops were demonstrated in the discipline of crop production, plant protection, horticulture, livestock production and home science on farmer's field of adopted villages of Nagpur district viz., Manori, Pipra, Thana, Navegaon (Sadhu), Ranmangli, Datala, Sukli, Boruzwada, Angewada, Patkakhedi, Tirkhura, Karhandla and Patansawangi. Several extension activities like field day, field visit of farmers to FLD, group discussions, and scientists-farmers meet etc. were conducted for effective implementation of FLDs. Data on important production parameters as well as feedback from farmers and visitors were recorded (Table 9.1).

Table: 9.1: Details of Assessment of technologies under Front Line Demonstrations

Sr. No	Crop	Technology Demonstrated	No. of farmers	Area (ha)	Yield (q/ha)		Increase over FP (%)
					FLD	FP	
1	Cotton	HDPS	20	8.0	12.75	10.50	17.65
2	Linseed	NL 260	12	2.4	8.0	6.5	18.75
3	Nagpur Mandarin	Rejuvenation of moderate decline of trees	10	4.0	66.00	47.00	47.00
4	Nagpur Mandarin	Management of pre-harvest fruit drop	10	4.0	63.01	52.00	21.34
5	Chillies (Dry)	Nursery management and production technology	10	04	13.50	11.65	15.85
6	Okra	Varietal demonstration of Akola bahar	10	04	48.56	41.30	17.57
7	Onion	Varietal demonstration of Akola safed	10	04	86.18	72.00	19.69
8	Bt-cotton (FLD)	Sucking pest management	20	8.0	22.00	18.00	22.22
9	Redgram (FLD)	Production technology	30	12.0	17.11	13.40	27.69
10	Chickpea (FLD)	Production technology	30	12.0	16.33	12.42	31.48
11	Nagpur Mandarin (FLD)	Gummosis management	08	3.2	56.50	42.15	30.04
12	Soybean (OFT-Assessment)	Biocontrol of semiloopers	06	2.4	17.50	15.92	9.92
13	Nagpur Mandarin (OFT-Assessment)	Thrips & mites management	06	2.4	58.50	51.00	14.71

Onion (Akola safed)

Chilli (Tejas)

Rejuvenated tree of Nagpur Mandarin

Okra (Akola bahar)

FLD on drudgery reduction of farm women by use of Gujarat Serrated sickle

Production technology FLD on Redgram in Village Sukdi, Taluka- Hingna

OFT on 'Swarnadhara breed' under BYP

Food cooked through Bio-Briquettes under OFT

Table 9.2 : FLD's on Livestock Enterprises

Enterprise	No. of animals, poultry birds etc.	Performance parameters / indicators	Data on parameter in relation to technology demonstrated		% change in the parameter
			Demon	Local check	
Dairy (Vitamin-mineral @30g/day feed supplementation and Deworming-repeated after 2 weeks in Jersey Crossbred cows	20	a) Avg. Milk yield (lit/cow/day) b) No. of heifers in anoestrus at the end of trial c) Conception rate d) Avg. No of days required for onset of oestrus in treated heifers e) BC Ratio	9.80 1 90% 17 2.70	8.20 4 60% -- 2.20	19.51 75.00 30.00 -- --
Dairy (Detection of mastitis in Jersey cross bred cows	40	Avg. milk yield lit/cow/day	8.60	5.00	41.86
Dairy (Chelated mineral feeding in CB Jersey Cow	20	a) Avg. milk yield (lit/cow/day) b) Milk fat (%) c) BC Ratio	12.7 4.0 2.80	11.0 3.85 2.10	15.45 3.90

Table 9.3: Performance of FLD during (2012-13) Home Science

No of farmers selected for demonstration of each technology: 16

Name of Technology	Crop	Performance of technology on different parameters.								Result increase in Out put (%)	Percent reduction in drudgery
		ΔHR beats min^{-1}		Strokesmin^{-1}		Area covered m^2/h		Output m^2/h			
		Demo	Local check	Demo	Local check	Demo	Local check	Local check	Local check		
Gujarat sickle	Soybean	17	15	38	34	Nil	Nil	34	35	34	13
Gujarat sickle	Rice	11	13.9	43	39	Nil	Nil	39	28	08	16
Improved cotton picking bag	Cotton	11	16.1	Nil	Nil	42.9	35.2	5.2	4.0	30	30
Bhendi plucker	Bhendi	17	15	Nil	Nil	Nil	Nil	21	18	17	15

Establishment of Fruit Cafeteria

Krishi Vigyan Kendra, CICR, Nagpur has established a Fruit Cafeteria on about 6 acre of land at KVK farm with the objectives to disseminate and assess the performance of varieties of fruit crops such as Pomegranate (Bhagva), Guava (L-49), Orange (Nagpur mandarin) and Sweet Orange (Katol Gold) so that the performances of these crops can be conveyed to the farmers .The fruit crops were planted in the month of July 2012 and all fruit crops are well established. Fruit cafeteria is also developed under the able guidance of Director CICR.

Construction of goat shed

A model goat shed of size 16m x 6 m having capacity to rear 50 goats is constructed at Technology Park to strengthen Osmanabadi goat unit which was established 15 years at KVK. This goat unit is being utilized to conduct demonstrations and trainings for clientele farmers, rural youth, farmwomen and members of Mahila Bachat Guts of Nagpur district.

Kisan Mobile Advisory Services (KMAS)

KVK, Nagpur has launched Kisan Mobile Advisory Services (KMAS) for the benefit of the farmers of Nagpur district. Advisory messages on agriculture and allied technologies on the mobiles of the farmers who are registered with KVK, are regularly being sent. Fifty one advisory messages were sent to 431 registered farmers during 2012-13.

Exposure visits

Dr. Vinita Gotmare and Sh. Harish Kumbhalkar arranged a Exposure Visit of 14 Extension Officers of Chandrapur district to wild species garden of CICR on 15.12.2012.

Soil Testing Activities

Two hundred thirty six soil samples were collected from Umrer, Bhivapur, Katol, Kalmeshwar, Saoner, Ramtek and Parshivani blocks of the Nagpur district. These samples were analyzed for different soil testing parameters and 210 soil health cards depicting soil test based fertilizer recommendation for different crops were distributed to the beneficiaries. Under Human Development Programme one mobile soil testing van was received from SAO, Nagpur to carry out test on physico-chemical properties of soils from different blocks of Nagpur district.

Delivering Soil Health Card to beneficiaries

KVK monitored CROP-SAP Programme in Nagpur District

Dr. R.R. Gupta SMS (Plant Protection) monitored Crop Pests Surveillance and Advisory Programme on soybean, cotton and paddy during *kharif* and on chickpea during *rabi* season in six tehsils of Nagpur District of Maharashtra.

Chief minister Shri Prithviraj Chauhan visited KVK ,Nagpur stall

Shri Prithviraj Chauhan, Chief Minister of Maharashtra visited KVK, Nagpur stall on 31, May, 2012, which was organized by Dr. P.D.K.V. Akola at Akola in which Tulsi Mahila Bachat Gat, Kamptee explained training and in-depth knowledge received from KVK, CICR on soybean processing unit. This training has helped them generate monthly net income at Rs. 12000 - 20,000/month thus making them self reliant. Shri Prithviraj Chauhan, Chief Minister appreciated this effort. On Cotton production technology aspects Shri Tajaswi Zade, Saoner, who was motivated by KVK and provided technical inputs, harvested seed cotton yield of 36.8 q/ acre under drip with fertigation. His efforts were also appreciated by dignitaries. More than 350 farmers, dignitaries visited the stall.

Sh. Prithviraj Chauhan, Chief Minister, Maharashtra visited KVK's stall during Innovative farmers meet

Participation in exhibitions

KVK, CICR Nagpur participated in the following events to display various research findings of CICR for the benefit of farmers, farm women, students, entrepreneurs, bureaucrats, line department officials during the report period. During exhibition large number of visitors interacted with KVK and CICR officials on various issues related to cotton.

1) On event of “Dharmmachakra Pravartan Din” at Deekshabhoomi, Nagpur 23-25 October, 2012.
2) 'Agro One Expo – 2012' a National exhibition

organized by SAKAL Group at Pune 1- 5 December 2012.

3) Agro-Tech-2012' a State Level Exhibition organized by Dr. PDKV at Akola 27-29 Dec., 2012.

4) Agro-Vision Exhibition" held at Reshimbagh, Nagpur 24 to 27 January, 2013.

5) 12th Rashtriya Kisan Mela on citrus held at NRCC, Nagpur 22-23rd February 2013.

Success story of an Innovative Cotton Farmer

Name of the farmer : Shri Tejaswi Shivram Zade; Village: Boruzwada; Taluka: Saoner, Distt. Nagpur

Total land holding = 1.62 ha; Soil type : light calcareous

Bt. Hybrids grown: Mallika-207Bt., Ajit-155Bt.

Yield of seed cotton Kharif	= 92 q/ha.
Gross Income	= Rs. 3,68,000/- per ha.
Expenditure	= Rs. 1,08,000/- per ha.
Net Income	= Rs. 2,60,000/- per ha.

The raised bed system of 15 inch height and 24 inch width was followed by him and drip lateral was placed on raised bed . Plant spacing : 150 cm x 30 cm; no. of plants : 22,222 / ha.

Seed Treatment: Wonder ST (germinator) @ 5 ml/2.5 kg seed and liquid PSB + Azotobactor + potassium mobilizing bacteria @ 100 ml each /5 kg seed.

Weed Management : Soil application of Pendimethalin before sowing + hand weeding - twice.

Nutrient Management

a. Soil application of fertilizers/ha: City- compost before bed formation - 463 kg; 10:26:26 – 154.32 kg (equivalent to N:P:K 15.43 : 40.12 : 40.12 kg/ha, respectively); $ZnSO_4$ – 9.26 kg; Humic Acid Gr. – 9.26 kg + $MgSO_4$. 15.43 kg; Vizard (Sulphur) - 463g; Mycorrhiza (VAM)– 3.09 kg/ha each.

b. Fertigation : Since 1st week of Oct. to Nov. 2012- Urea 20.73 kg; 19:19:19 – 15.43 kg; 12:61:0 - 21.6 kg; 13:0:45 – 24.69 kg; White Potash – 30.86 kg, Sulphate of Potash – 12.35 kg, liquid Sulphur (20%) – 12.35 lit., 0:52:34-24.6 kg, urea-14.2 kg (equivalent to N:P:K 36.21 : 29.41 :44.52 kg/ha); humic acid – 9.88 lit./ha each

Use of growth Regulators & nutrients: Warranty–Tech(80% humic acid) 5 g + 19:19:19 N P K foliar spray at 20 DAS. At 50 DAS , Biozyme – 100 ml. At 100 DAS-Nitrobenzene @ 40 ml/15 Lit. + Lihocin @ 3 ml/15 lit + foliar application of micronutrients @ 50 ml/15 lit. At 125 DAS foliar spray of KNO_3 (13:0:45) + $Ca(NO_3)_2$ (20:12) @ 100 g/15 lit; foliar spray of GA-3.

Plant Protection : Foliar application of Thiomathoxam @ 10 g /15 lit at 50 DAS. At 80 DAS Healine(Parachlotrobin (20%) @ 30 g /15 lit. + Acetamiprid @ 5 g/15 lit; Propaconzol @ 1 ml/lit + Wonder (nitrobenzene)@ 10 g/15 lit; Diafenthuron (Polo) @ 20 g/15 lit.

List of publications

1. Behera, M.S., Mahapatra P K, Singandhupe R B, Verma O. P. and Kumar A. (2013). Effect of irrigation and fertility levels on yield, quality and economics of Japanese mint (Mentha arvensis) under drip irrigation system. Indian Journal of Agronomy 58 (1): 17-21 (March 2013). (NAAS score 5.0).
2. Behera, M.S., Mahapatra P.K., Singandhupe R B, Verma O.P. and Kumar A. (2012). Drip fertigation impact on yield and alkaloid content of Ashwagandha (Withania somnifera (L.). Medicinal Plant-International Journal of Phytomedicines & Related Industries. 4(3): 133-137. (NAAS score 3.6).
3. Behera, M.S Mahapatra P K, Singandhupe R B, Verma O. P. and Kumar A. (2013). Effect of fertigation on Stevia (Stevia rebaudiana) under drip irrigation. Indian Journal of Agronomy 58 (1): 72-79 (March 2013).(NAAS score 5.0).
4. Behera, M.S.. Mahapatra P.K., Verma O.P,.Singandhupe R.B and .Kumar A. (2012). Productivity,quality and economics of Aswagandha (Withania somifera) as influenced by irrigation and fertility levels under drip irrigation system. Indian J. Agronomy . 57(2):195-199.(NAAS score 5.0).
5. Brahmanand, P.S., Kumar, A., Ghosh, S., Roy Chowdhury, S., Singandhupe, R.B., Singh, R., Nanda, P., Chakraborthy, H.C., Srivastava, S.K. and Behera, M.S.(2013). Challenges to Food Security in India. Current Science, 107 (4): 841-845.(NAAS score 7.3)
6. Panda, D.K.,.Kumar A,.Singandhupe R.B,. Sahoo N. (2012). Hydroclimatic changes in climate sensitive tropical region. International Journal of Climatology. (Royal Meteorological Society, UK) DOI:1.1002/JOC.3538.(NAAS score 7.7)

Popular Articles

1. Chauhan, Sunita; Rokde, S.N. and Kranthi, K.R., (2012). Biomass Charcoal Briquetting(Marathi)
2. Galkate Ulhas (2012), 'Garmiyon me murgi palan mein prabandhan' (Management of poultry in summer), MARU KRISHI CHAYANIKA(special issue on livestock production)-2012, published by CAZRI (ICAR), Jodhpur

3. Galkate Ulhas (2012), 'Kami kara janavaratil tan' (Stress management in livestock), Agrowon daily published by Sakal on 19.05.2012 : P.P. 12.
4. Galkate Ulhas (2012), 'Navjat Vasranche Sangopan' (Care and management of newly born calf), Lokmangal Shetipratik Masik, Issue- May 2012, p. 44-45
5. Galkate Ulhas (2012), 'Parasbagetil kombdi palnasathi kontya jati nivdavya?' (Selection of breeds for Back Yard Poultry), Agrowon daily published by Sakal on 03.05.2012 and 22.07.2012
6. Galkate Ulhas (2012), 'Shastriy vyavsthapanatun wadhava dudh utpadan' (Scientific dairy farming), Agrowon daily published by Sakal on 25.07.2012 : P.P. 12.
7. Gupta, R.R. (2012). Harbhara lagwadiche sudharit tantra in Marathi (Improved technology for chickpea cultivation), published in Baliraja,Oct., 88-91 pp.
8. Gupta, R.R., Nagrare, Vishlesh., Tayade, A. S and Kranthi, K. R. (2012). Kapas mein mealy bug ka prakop aur iska prabandhan (in hindi) published by CICR, Nagpur
9. Kumbhalkar H.B. (2012). Seed classification and precaution while purchasing seed from market (Marathi). Daily Newspaper Lokshahi Warta.
10. Singh Gulbir and Kumbhalkar H.B (2013). Importance of micronutrients in fruit crops (Marathi) Daily Newspaper Lokshahi Warta
11. Singh Gulbir and Kumbhalkar H.B (2013). Improved vegetable varieties for higher production (Marathi) Daily Newspaper Lokshahi Warta.
12. Sunil Rokde, Deulkar Pundlik and Galkate Ulhas (2012), 'Welich olkha Janavaramadhil Vishbadha, Bhag - 1' (Common poisoning in livestock, Part-1), Adhunik Kisan Vol.6 , 15-21 March 2012, pp.36
13. Sunil Rokde, Deulkar Pundlik and Galkate Ulhas (2012), 'Welich olkha Janavaramadhil Vishbadha, Bhag - 2' (Common poisoning in livestock, Part-2), Adhunik Kisan Vol.7 , 22-28 March 2012,pp.40
14. Sunil Rokde, Deulkar Pundlik and Galkate Ulhas (2012), 'Welich olkha gaimadhil vanzpanachi samasya' (Tips to avoid infertility in cattle), Adhunik Kisan Vol. 9, 5-11 April 2012, pp. 28

Radio Talks

1. Delivered a radio talk on “Dugdhotpadan: Mahatwapurna tips” (Important tips for higher milk production) in Marathi programme “Maza ghar maza wavar” broadcasted by AIR, Nagpur on 13th April 2012 at 7.30 pm.
2. Answered queries of farmers in a live phone in programme 'Hallo Annadata – Pashuvishayak shanka samadhan' in a series 'Maza ghar maza wavar' on 06.11.2012, 13.11.2012 and 27.11.2012
3. Delivered a radio talk on “Aangdhun Mori Pani”, which was broadcasted by AIR, Nagpur on 20.06.2012 at 6.20 pm in Marathi programme Otivar.
4. Delivered a radio talk on “Selection of good dairy breeds for milk production” on 13.08.2012 and broadcasted on 21.08.2012 at 7.30 pm on “Pashujagat programme” by AIR, Nagpur
5. Delivered a radio talk on “Milk fever in high yielding animals” on 01.12.2012 and broadcasted on 07.12.2012 at 7.30 pm on “Pashujagat programme” by AIR Nagpur.
6. Delivered a radio talk on “Integrated nutrient management for Kharif crops” on 04.07.2012 and broadcasted on 13.07.2012 at 7.30 pm on “Maza Ghar Maza Vavar” by AIR Nagpur.
7. Delivered a radio talk on “Processing Technology of Soybean Product”, which was broadcasted by AIR, Nagpur on 17.08.2012 at 7.30-8.05 pm at 7.30-8.05 pm.in Marathi programme Maza Ghar Maza Vavar.

10. General

10.1 List of Publications

Papers Published in Research Journals

1. Amudha J , Balasubramani G. and Monga D. (2012). Inheritence and identification of molecular markers linked to leafcurl virus resistance gene in cotton. Cotton Research Journal 3(1):33-39. **(NAAS Rating : 2.6)**
2. Amutha , M. and Banu, J.G. (2012).Compatibility of Metarhizium anisopliae and Verticillium lecanii with insecticides. Annals of Plant Protection Sciences 20(2): 354-357. **(NAAS Rating : 3.7)**
3. Amutha , M. and Banu, J.G. (2011). Susceptibility of cotton mealy bugs , Phenococcus solenopsis and Paracoccus marginatus at different developmental stages to entomopathogenic Fungi. Indian J. Plant Protection 39(3): 242- 246. **(NAAS Rating : 4.3)**
4. Andrew H. Paterson, Vijay N. Waghmare et.al. (2012). Repeated polyploidization of Gossypium genomes and the evolution of spinnable cotton fibres. Nature, 492 (7429): 423 DOI: 10.1038/nature11798. **(NAAS Rating : 10.0)**
5. Banu, J.G. (2012).Effect of nutrition on the growth and sporulation of Lecanicillium lecanii. Insect Environment 17(3): 117-119. **(NAAS Rating : 2.9)**
6. Banu, J.G. (2011). Life table for reniform nematode , Rotylenchulus reniformis on cotton. Current Nematology 22(1, 2):5-10. **(NAAS Rating : 3.0)**
7. Behere, G.T., Wee Tek Tay, Russell, D.A., Kranthi,K.R. and Batterham , P (2013). Population Genetic Structure of the Cotton Bollworm Helicoverpa armigera (Hu¨ bner) (Lepidoptera: Noctuidae) in India as inferred from EPIC-PCR DNA Markers. PLOS Volume 8 (1) e53448. **(NAAS Rating : 8.1)**
8. Chakrabarty P. K., Kalbande B. B., Chavhan R. L., Sable, Narwade, A., Sable, Suchitra, Warade, J. W. , Nandeshwar, S.B., Monga, D. 2012. Engineering Cotton Leaf Curl Virus Resistance Cotton through RNA Interference Approach. *Cotton Research Journal* 3(2): 174-192. **(NAAS Rating : 2.6)**
9. Chavhan, R.L., Hinge, V.R., Chakrabarty, P.K. and Patil, H.B. 2012. Molecular Characterization of six Fungal Pathogens Associated with Leaf Spot and Blight Diseases of Sunflower. *J Mycol Plant Pathol.* 42: 207-212. **(NAAS Rating : 3.8)**
10. Dongre, A. B., Raur, M.P., Meshram, K. J., Punit Mohan and Munne, K. K.(2012). Genetic diversity of tetraploid and diploid cotton cultivars revealed by rapid markers. *Annals of Plant Physiology*, 25 (1): 56-62. **(NAAS Rating : 2.9)**
11. Kumar, R., Kranthi, S., Nitharwal, M., Jat, S L and Monga, D (2012). Influence of pesticides and application methods on pest and predatory arthropods associated with cotton. *Phytoparasitica*, 40:417-424. **(NAAS Rating : 7.0)**
12. Kumar, R., Monga, D., Jat, S L., Indoria,A K., Chauhan, R and Kranthi, K R (2012). Impact evaluation of insecticide resistance management startegies in Cotton under Technology Mission on Cotton (*Gossypium hirsutum*). *Indian J. Agril. Sci.*, 82:852-857. **(NAAS Rating : 6.6)**
13. Mukherjee, A.K., Chahande, P.R., Meshram, M.K., and Kranthi, K.R. (2012). First report of *Polerovirus* of the family *Luteoviridae* infecting cotton in India. *New Disease Reports,* 25:2. (Published by The British Society of Plant Pathologists, UK).
14. Nagrare V.S., Rishi Kumar, Amutha M., Dharajothi B., Kranthi S., Vennila S.,Deshmukh A.J., Bisane K.D., Manjula, Kranthi K.R. *(2012).* A record of host plants of mealybug, *Phenacoccus solenopsis* Tinsley for devising eco-friendly management strategies. *J. ent. Res., 36 (4): 327-344* **(NAAS Rating : 3.9)**
15. Nalayini, P, Shankarnarayanan, K and Velmourougane, K. (2013). Herbigation in cotton: Effects on weed control, soil microflora and succeeding green gram. *Indian Journal of Agricultural Sciences*.– in press **(NAAS Rating : 6.6)**
16. Nalayini,P., S.Paul raj and K.Sankaranarayanan. 2012. Drip fertigation of major, secondary and micronutrients for enhancing the productivity of extra long staple Bt Cotton. *J.Cotton Research.Dev.26*(2)186-189. **(NAAS Rating : 4.3)**
17. Nalayini,P., S.Paul raj and K.Sankaranarayanan.

2012. Water use efficiency, nutrient uptake and production potential of extra long staple Bt cotton – maize system with moisture conservation techniques and ET based irrigation. *J.Cotton Research.* Dev.27 (1): 45 – 49. **(NAAS Rating : 4.3)**

18. Padmalatha KV, Patil DP, Kumar K, Dhandapani G, Kanakachari M, Phanindra ML, Kumar S, Mohan TC, Jain N, Prakash AH, Vamadevaiah H, Katageri IS, Leelavathi S, Reddy MK, Kumar PA, Reddy VS. (2012). Functional genomics of fuzzless-lintless mutant of Gossypium hirsutum L. cv. MCU5 reveal key genes and pathways involved in cotton fibre initiation and elongation.*BMC Genomics*. 2012 Nov 14;13:624. DOI: 10.1186/1471-2164-13-624. **(NAAS Rating : 8.1)**
19. Raju, A.R., Thakare, Soniya Majumdar, G. and Bharambe,P.R. (2013).Risk aversion in shallow soils with innovative intercropping systems. *Journal of Cotton Research and Development 27 (1) 37-44.* **(NAAS rating: 4.5)**
20. Rathinavel K., Deshmukh R.K. and Vijaya Kumari P.R. (2012) Control of Planting Seed Deterioration Through post Harvest Management" *Cotton Research Journal* (3) 213-227.**(NAAS Rating : 2.6)**
21. Reddy AR, Alexander S,Yelekar SM, Narala A (2012). Analysis of growth and instability of cotton production in Maharashtra. *Journal Cotton Research and Development*, 26(2): 261-266. **(NAAS Rating : 4.3)**
22. Rokde, S.N. (2012). Performance of Osmanabadi goats under feeding of Bt and Non-Bt cotton leaves. *Cotton Research Journal 3(2): 135-141.* **(NAAS Rating : 2.6)**
23. Sankaranarayanan, K., Nalayini P, Praharaj, C.S. (2012). Multi-tier cropping system to enhance resource utilization, profitablity and sustainablity of Bt cotton (*Gossypium hirsutum)* production system. *Indian Journal of Agricultural Sciences* 82(12):1044-50. **(NAAS Rating : 6.6)**
24. Singh J, Babar S , Abraham S, Venugopalan MV, Majumdar G (2012). Fertilization of high density rainfed cotton, grown on Vertisols of India. *Better Crops*, 96(2): 26-30.
25. Singh Suman Bala, Prakash AH, Kranthi KR (2012). CNH 301 (IC0587405; INGR11061), a Cotton (*Gossypium hirsutum*) Germplasm with Drought Tolerant Nature and Yield Stability. *Indian Journal of Plant Genetic Resources*, 26(1): 99. **(NAAS Rating : 3.0)**
26. Srinivasa, Rao, Ch., Blaise, D., Venugopalan, M.V., Patel, K.P., Biradar, D.P., Aladakatti,V.R., Marimuthu, S., Buttar, G.S., Brar, M.S., Ratnakumari, S. and Reddy, V.C.(2012). Soil fertility management strategies for maximizing cotton production of India. Indian Journal of Fertilisers 8(12): 80-95. **(NAAS Rating : 3.8)**
27. Surulivelu, T., Banu, J.G**.,** Sonai Rajan, T., Dharajothi, B. and Amutha , M. (2012).Evaluation of fungal pathogens for the management of mealybugs in Bt cotton. *J. Biol. Control.* 26(1):91-96.
28. Velmourougane, K and Apeksha Sahu. (2013). Impact of transgenic cottons expressing c*ry1Ac* on soil biological attributes. *Plant, Soil and Environment*. 59 (3), 108-114. **(NAAS rating: 7.5)**
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30. Velmourougane, K, Venugopalan M.V, Bhattacharyya, T Sarkar, Dipak, Lal,D.K.,Sahu, Apeksha, Ray, S.K, Nair,K.M, Prasad Jagdish, Singh, R.S. (2013). activity in agro-ecological sub regions of black soil regions in India. *Geoderma, (197-198): 186-192.* **(NAAS rating: 7.7)**
31. Venugopalan MV, Blaise D, Yadav MS and Vandana Satish (2012). Advances and milestones in agronomic research in cotton in India. *Ind J Agron* (special issue), 57:71-78 **(NAAS Rating : 5.0)**
32. Venugopalan MV, Rachana Deshmukh, Hebbar KB, Tandulkar NR (2012). Productivity and nitrogen-use efficiency yardsticks in conventional and Bt cotton hybrids on rainfed Vertisols. *Ind Journal Agric Sci.*, 82 (7) 641-644. **(NAAS Rating : 6.6)**
33. Wasnik S. M, Raju AR, Palve S.M, Mujumdar G& Parwate P.P (2013).Technology Interventions Performance under front-line demonstrations in Bt hybrid cotton (*G. hirsutum* L). *Journal Cotton Research and Development*, 27(1) 126-133. **(NAAS Rating : 4.3)**

10.2 List of On-going Projects (2012-13)

No.	Name of project
1.	Collection, conservation, evaluation, documentation and maintenance of germplasm of cultivated species of *Gossypium* (Dr.Punit Mohan (PL), Dr.S.Manickam, Dr.RA.Meena , Mrs.M.Chakrabarti, Dr. (Mrs.) KPM.Damayanthi)
2.	Improvement of tetraploid and diploid cottons for fibre properties through population improvement approaches (Dr.VN Waghmare (PL), Dr. (Mrs.) Vinita Gotmare , Dr.OP.Tuteja)
3.	Fine mapping and advance backcross QTL analysis of fiber quality and economic traits in diploid cotton (Dr.VN Waghmare (PL))
4.	Fine mapping of fiber quality and economic traits using RILs in diploid cotton (DBT) (Dr.VN Waghmare (PL), Dr. TR. Loknathan)
5.	Development of saturated genetic linkage map for *Gossypium hirsutum* L. using SSR and SNP markers (DBT) (Dr. VN. Waghmare (PI), Dr.Punit Mohan)
6.	Conservation, characterization and utilization of wild species, races of cultivated species and synthetic polyploids of *Gossypium* (Dr.(Mrs) Vinita Gotmare (PL), Dr. G. Balasubramani)
7.	MAS/MAB for Water-logging in Cotton (Dr. (Mrs) Vinita Gotmare (PL), Dr. SESA.Khader, Dr.M.Saravanan)
8.	Breeding of upland cotton for improved fibre quality and resistance to biotic stress (bollworms and jassid) (Dr.S.M. Palve (PL), Dr. (Mrs) Vinita Gotmare)
9.	Development of heterotic pool for superior medium staple in tetraploid cotton (*G. hirsutum*) (Dr.S.M. Palve (PL))
10.	Development of drought tolerant genotypes with good fibre quality in *G. hirsutum* (Dr. (Mrs) Suman Bala Singh (PL), Dr. A.H. Prakash)
11.	Exploration, collection and conservation of perennials and land races of *desi* cotton from different regions of India (Dr. M. Saravanan (PL))
12.	Development of long staple *G. hirsutum* variety with improved fibre strength (Dr. S.Manickam (PL), Dr. V N.Waghmare, Dr. SL.Ahuja)
13.	Development of high yielding, early maturing extra long staple *G. barbadense* genotypes with high GOT (Dr. (Mrs) KPM. Dhamayanthi (PL))
14.	Development of early maturing, medium staple varieties and hybrids Resistant to CLCuV (Dr. O.P.Tuteja (PL), Dr. D. Monga, Dr. Rishi Kumar, Dr. S.M.Palve)
15.	Identification of male sterile plants in genetic male sterility (GMS) using molecular markers (Dr.O.P. Tuteja (PL), Dr. (Mrs) S.B. Singh, Dr. M. Sarvanan)
16.	Development of *G. hirsutum* genotypes with high yield and high GOT Dr. S.L. Ahuja (PL), Dr. RA.Meena, Dr. D.Monga Dr. Rishi Kumar
17.	Seed Production in Agricultural Crops and Fisheries (MSP) (Dr. (Mrs) P.R.Vijayakumari (Nodal Officer), Dr. (Mrs) V. Santhy, Dr. K. Rathinavel, Dr. R.A. Meen a)
18.	Characterization of public sector released genotypes of cotton (*Gossypium* spp) based on molecular markers to serve as Special test for Varietal Protection (Dr. (Mrs) V.Santhy (PL))

19.	National Seed Project (Crops) (NSP) (Dr. K.Rathinavel (PI))
20.	Testing & Documentation of Extant Varieties, hybrids and their Parents for Distinctness, Uniformity & Stability (PVP & FR ACT, 2001) (DUS) (Dr. K Rathinavel (Nodal Officer))
21.	Studies to improve the seed setting efficiency in cotton (Dr. R.A. Meena (PL), Dr. Rishi Kumar, Dr. K. Rathinavel)
22.	Transgenics in Crops – Cotton (NPTC) (Dr. G. Balasubramani (PI), Dr. K.P. Raghvendra, Dr. (Mrs) J. Amudha, Dr. (Mrs) S.B. Singh, Dr. S.B. Nandeshwar)
23.	Genomics of cotton boll and fibre development (NAIP) (Dr. G. Balasubramani (PI), Dr. K.P. Raghvendra, Dr. (Mrs) J. Amudha, Dr. S.B. Nandeshwar)
24.	Molecular characterization and validation of fiber strength genes with fiber specific promoter for improvement in cotton (NFBSFARA) (Dr. G. Balasubramani (PI), Dr. K.P. Raghvendr a, Dr. (Mrs) J. Amudha, Dr. S.B. Nandeshwar)
25.	Development of drought resistant transgenic cotton and identification of new genes for high water use efficiency (Dr. (Mrs) J. Amudha (PI), Dr. A.H. Prakash, Dr. G. Balasubramani, Dr. R.B. Singandhupe)
26.	Isolation and identification of seed specific promoter and gossypol synthesis genes for silencing through RNA interference (DBT) (Dr. K.P. Raghavendra (PI), Dr. (Mrs) J. Amudha)
27.	Allelopathy as an alternative weed management strategy in cotton (Dr. Blaise Desouza (PI), Dr. (Mrs) P. Nalayini, Mrs. M. Chakrabarty)
28.	Identification of 'crop-cycle' for Extra Long Staple (ELS) Cotton in non-conventional regions (Dr.R.B.Singandhupe (PI), Dr. Blaise Desouza)
29.	Herbicide resistance weeds and their management strategies (Dr. A.R. Raju (PI), Dr. K. Sankarnarayanan)
30.	Screening of Cotton Varieties for Organic Cultivation under Rainfed Condition (Dr. Jagvir Singh (PI), Mr. K. Velmourougane, Dr. (Mrs) P.R. Vijayakumari)
31.	Georeferenced soil information system for land use planning and monitoring soil and land quality for agriculture (NAIP) (Dr. M.V. Venugopalan (CCPI), Mr. K.Velmourougane)
32.	Synthesis and characterisation of nano-formulated micronutrient foliar spray for yield maximisation in different cotton genotypes (Dr. (Mrs) D.Kanjana (PL))
33.	An accelerated process for preparation of bio enriched compost from cotton plant residues (CIRCOT project) (Dr.P.Nalayini (PA), Dr.D.Monga (PA), Mr. K.Velmourougane (PA))
34.	A Value Chain for Cotton Fibre, Seed and Stalks: An innovation for higher economic returns to farmers and allied stakeholders (NAIP) (Dr. K. Sankarnarayanan (CoPI))
35.	Studies on mechanism and enhancement of cuticular absorption of nutrients and hormones in Bt cotton (Dr.S.E.S.A Khader (PI))
36.	Role of Leaf Phytochemicals in cotton leaf reddening and plant responses to management through growth chemicals, nutrients and insecticides (Mrs. M. Chakrabarty (PI))

37.	Performance of white leghorn layers under feeding of Bt and non-Bt cotton seed (Dr.S.N.Rokde (PI))
38.	Assessment of cotton based intercropping system and its popularization through farmer to farmer's participatory learning approach (Dr. S.M. Wasnik (PI), Dr. (Mrs) S. Usha Rani, Dr. A.R. Raju)
39.	Technological Need Assessment for Sustainability and Stability of Cotton Production (Dr.S.M. Wasnik (PI), Dr. (Mrs) Anuradha Narala)
40.	Gender and Labour Issues in Hybrid Cotton Seed Production Sector in India (Dr. (Mrs) Usha Rani (PI))
41.	Impact evaluation of Bt cotton in Maharashtra (Govt. of Maharashtra) (Dr. A.R. Reddy (PI), Dr. R.B. Singandhupe, Dr. S.N. Rokde)
42.	Design & Development of a cotton picking head (DST) (Er.Gautam Majumdhar (PI))
43.	Identification of species specific dsRNA or siRNA or miRNA in cotton insect pest to explore their use in pest management through RNAi based technologies (DBT) (Dr. K.R. Kranthi (PL), Dr. S. Kranthi, Dr. K.P. Raghavendra)
44.	Dissemination of IRM strategies in India (TMC MM II) (Dr. K.R. Kranthi (PI), Dr. (Mrs) S. Kranthi , Dr. D. Monga, Dr. (Mrs) B. Dharajothi, Dr. Rishi Kumar)
45.	Novel approaches for production of hybrid seeds with characteristics of improved insect resistance and higher yield (CSIR-NIMITLI) (Dr. K.R. Kranthi (CCPI), Dr. (Mrs) S. Kranthi)
46.	Evaluation of built in refuge for insect resistance management requirements for Bollgard II cotton (Contract) (Dr. S. Kranthi (PI), Dr. (Mrs) B. Dharajothi, Dr. Rishi Kumar)
47.	Event based approval mechanism (GEAC) (Dr. S. Kranthi (PI), Dr. K.R. Kranthi)
48.	Monitoring changes in baseline susceptibility to Cry toxins in the cotton bollworm, *H. Armigera.* (Contract) (Dr. (Mrs) S. Kranthi (PI), Dr. K.R. Kranthi, Dr. Chinna Babu Naik)
49.	Research into development of decision support systems for management of insect pests of major rice and cotton based cropping systems (NAIP) (Dr.VS Nagrare (CCPI), Er. G. Majumdar, Dr.Rishi Kumar, Dr. (Mrs) B. Dharajothi, Mr.M. Sabesh, Dr. (Mrs) M. Amutha)
50.	Crop pest surveillance and advisory project (CROPSAP) in Maharashtra (Govt. of Maharashtra) (Dr. V.S. Nagrare (PI))
51.	Establishment of *Beauveria bassiana* as symbiotic insecticide against major insect pests and diseases of cotton (Dr. (Mrs) M. Amutha (PI), Dr. M. Gunasekaran)
52.	Isolation and characterisation of endophytes in cotton and endosymbionts in boll worms (Dr. (Mrs) M. Amutha (PI))
53.	Bt resistance in pink bollworm, *Pectinophora gossypiella* (Saunders) - Monitoring mechanism and Management (Dr. Chinna Babu Naik (PL), Dr. (Mrs) S. Kranthi)
54.	Isolation, characterization and formulation of a novel *Trichoderma* strain (Dr.P.K. Mukherjee (PI), Dr. A.K. Mukherjee, Mr. A.Sampath Kumar, Dr. (Mrs) S. Kranthi)
55.	Use of innovative methods for management of cotton leaf curls virus disease (Dr.D. Monga (PL), Dr. Rishi Kumar)

56.	Development of nanoparticles based bio-control formulation for the management of major cotton pests and diseases (Mr. A. Sampath Kumar (PL), Mr. K. Velmourougane)
57.	Compatibility studies of various plant protection inputs for HDPS Cotton (Mr. A. Sampath Kumar (PI), Mr. K. Velmourougane, Dr. V. Chinna Babu Naik, Dr. P.K. Mukherjee)
58.	Disease monitoring of Tobacco Streak Virus (TSV) on cotton for South zone consisting of Andhra Pradesh, Karnataka and Tamil Nadu (Dr. M. Gunasekaran (PI))
59.	Cloning and characterization of potent toxin gene from heat tolerant isolate of *Heterrorhabdus indica,* an Entomopathogenic nematode (DBT) (Dr.(Mrs) Nandini G. Narkhedkar (PI), Dr. P.K. Charkrabarty)
60.	Isolation of novel insecticidal proteins from bacterial symbionts of native entomopathogenic nematodes (Dr. (Mrs) Gulsar Banu (PI))
61.	Production, stabilisation, formulation and validation of microbial agents and their natural products against insects and nematode pests of cotton (Dr. (Mrs) Gulsar Banu (PI), Dr. (Mrs) M. Amutha)
62.	Development of multi-gene constructs and Bt cotton varieties for sustainable pest management. (TMC MM 1.1) (Dr. K. R. Kranthi (PI), Dr. P. K. Chakrabarty,Dr. K. P. Raghavendra, Dr. S. B. Nandeshwar, Dr. G. Balasubramani, Mr. K. Velumourougane, Dr. (Mrs) S. Kranthi, Dr. (Mrs) S. B. Singh, Mrs Mukta Chakrabarty)
63.	Development of cotton varieties resistant to cotton leaf curl disease (CICuD), bacterial leaf blight (BLB) and Nematodes through marker assisted breeding. (TMC MM 1.2) (Dr. V. N. Waghmare (PI), Dr. P. K. Chakrabarty, Mr. Sampath Kumar, Mr. (Mrs) Nandini Nar khedkar , Dr. S. Manickam, Dr. (Mrs) Gulsar Banu, Dr. Dilip Monga, Dr. S.K.Verma)
64.	Consolidation of repository of high strength cotton genotypes and evaluation for quality traits and yield in specific agro-eco zones. (TMC MM 1.3) (Dr. S. Manickam (PI), Dr. (Mrs) P. Nalayini, Dr. S. M. Palve, Dr. T.R. Lokanathan, Dr. (Mrs) Vinita Gotmare)
65.	Agrotechniques for high density planting system and surgical cotton varieties. (TMC MM 1.4) (Dr. M.V.Venugopalan (PI), Dr. Blaise Desouza, Dr. V. Chinna Babu Naik, Dr. A. R. Reddy, Dr. Punit Mohan, Dr. T.R. Lokanathan, Dr. A.R. Raju, Dr. K. Sankaranarayanan, Dr. S. L. Ahuja, Dr. R. A. Meena)
66.	Simulation models/electronic gadgets to predict insect infestation, bollworm resistance to Bt cotton, area, production and price of cotton. (TMC MM 1.5) (Dr. (Mrs) S. Kranthi (PI), Dr. V. S. Nagrare, Dr. K.R. Kranthi, Dr. V Chinna Babu Naik, Dr. A. R. Reddy, Dr. (Mrs) N. Anuradha, Mrs. Mukta Chakrabarty, Dr. A.H. Prakash, Dr. (Mrs) M. Amutha, Dr. K. Sankaranarayanan, Dr. (Mrs) Isabella Agarwal, Dr. (Mrs) B. Dharajothi, Dr. Rishi Kumar)
67.	E- kapas network and technology documentation. (TMC MM 1.6) (Dr. S. M.Wasnik (PI), Mrs Mukta Chakrabarty, Dr. (Mrs) Usharani, Dr. A. H. Prakash, Dr. O. P. Tuteja)
68.	Development of cotton picking machinery for small scale cotton production systems. (TMC MM 1.7) (Er. G. Majumdar (PI))

10.3: Consultancy, Patents, Commercialization of Technology

Revenue Generation

The Bt Referral lab generated revenue Rs. 7.22307 lakhs through sale of Bt express, Bt Quant, GUS detection kits in 2012-13.

Patented Technology published in IPINDIA website

Bacterial biopesticidal formulation derived from Entopathogenic nematodes for management of sucking pests of crops: Application No. 1854/MUM/2010 was published in www.ipindia.gov.in on 27-07-2012. A formulation developed from an isolate of bacteria *Paenibacillus* found associated with heat tolerant isolate developed of Entomopathogenic nematodes *Heterorhabditis indica* along with other additives for use as insecticides against sucking pests of Agricultural crops. This formulation when sprayed was found to cause mortality of nymphs of sucking pests as aphid *Aphis gossypii*, leaf hopper *Amrasca devastans*, White fly *Bemisia tabaci,* thrips *Thrips tabaci* etc. This formulation can also be used for controlling pests as Bracon sp, in biocontrol laboratories where bioagents as Trichogramma are cultured on Corcyra larvae. The formulation developed has no tangible adverse effect on natural biocontrol agents as *Trichogramma* etc.

ITMU Meeting

ITMU Meeting was held on 16-06-2012. The committee approved the reconstitution of terms and condition for commercialization of Bt-strips with Innovative Biosciences, Nagpur. Patent applications submitted for filing was reviewed. Ergonomically designed cotton picking bag submitted for design patent was suggested to publish the design for the benefit of public. Mealy Quit (Bio-formulated Insecticide) and Mealy Kill applications has to be submitted to ZTM&BPD Unit CIRCOT to seek interested entrepreneur for commercialization.

10.4: Significant Decisions of RAC, IRC, IMC and Other Important Meetings

Research Advisory Committee Meeting

The RAC Meeting was held at CICR, Nagpur on 21-22nd Feb 2013 and the following RAC members were present

Dr. S.A. Patil, Chairman, RAC

Dr. Srinivasan. Ex Director, CIRCOT, Mumbai

Prof. K.R. Koundal, ICAR-Emeritus Scientist, NRCPB, Delhi

Dr.V.Kumar, Ex-Head, Cotton Research Station, Surat

Dr. Jadhav, Ex-Director of Extension, MAU, Parbhani

Shri. Sharad Tasare, Ex.MLA and Member, IMC, CICR, Nagpur

The proceeding started with the presentation of Action Taken Report of the RAC 2012 by Dr. K.R. Kranthi, Director, CICR and followed by presentations by Heads of Divisions of CICR, Nagpur and Regional Stations.

Specific recommendations of the RAC

1. The future research programmes attempted in the Institute should be oriented to specific agro-ecological conditions.
2. A team of Economists from CICR should prepare and publish a consolidated statistical report (40-50 pages) of Indian cotton production and productivity in changing global scenario to help the farmers and policy makers.
3. Production of ELS cotton should be enhanced in the country considering the low production in ELS cotton producing countries such as Egypt, USA, and Sudan. Opportunities for the ELS cotton in unconventional areas may be attempted.
4. CICR should intensify research programmes on management of jassids in cotton.
5. CICR should make video films depicting the cotton cultivation practices adopted by the champion farmers in different regions (success stories) to demonstrate their technologies to other cotton farmers in different parts of the country.
6. Instead of single gene, cassette of genes (bollworm, leaf curl virus, biotic and abiotic stress) should be explored for future gene constructs. Construction of fusion gene with cry + lectin for durable resistance in transgenic cotton may be explored.
7. Concern was raised about the exclusion of cotton entries in AICCIP trials which showed poor yield but exhibited good fibre quality properties. It was informed that many entries have been knocked out during the initial evaluation owing to their low yield

performance. The RAC felt that there should be separate window in the AICCIP trials to test the entries only of fibre quality attributes. The promising accessions in the germplasm and also 20-25 elite cultivars can be tested for its quality attributes in three locations for three years to study the impact of weather parameters on fibre quality to use in future conventional breeding programs.

8. The RAC suggested using PA 255 instead of RG-8 in *arboreum* and Suraj in *hirsutum* for transgenic cotton development. It was also suggested to try *cry1Ac* and *cry2Ab* in combination and as separate constructs to test the transformation efficiency in Suraj cotton.
9. The RAC suggested testing Pusa 'Hydrogel' a water conservation technique developed by IARI, New Delhi in cotton production to improve water use efficiency in rainfed systems.
10. The RAC strongly felt that CICR should be supported with sufficient manpower to take up intensive research to tackle the emerging pest problems.
11. Research on Plant Type for HDPS and for Machine picking must be intensified.
12. Development of varieties with Bt gene may be attempted in all the cultivated species.

The Chairman and members of RAC also had discussion with the Coordinators of the HDPS programme in cotton of various districts. The meeting ended with the vote of thanks by Dr.P.K.Chakrabarty, Head, Division of Crop Improvement, CICR, Nagpur.

Institute Research committee (IRC) meeting

The Annual Institute Research committee (IRC) meeting of CICR was conducted in two sessions. A special IRC for CICR, Nagpur Scientists on 16th March 2013 and a combined IRC for all the centres from 21-23rd March 2013 at CICR, Nagpur.

Dr M.V. Venugopalan, Member Secretary, RAC presented the specific recommendations of Research Advisory Committee meeting held on 21-22 Feb 2013. K. Velmourougane, Secretary IRC presented the Action Taken Report of the previous IRC (2012). The IRC confirmed the minutes of the last IRC meeting.

The results of research projects at CICR, Nagpur, RS, Coimbatore and RS, Sirsa were presented by individual Project leaders and discussed in IRC. Technical programme for 2013-14 was also finalized for each project. The meeting was chaired by the Dr. K.R. Kranthi, Director, CICR and scientists of Nagpur, Coimbatore and Sirsa participated in the deliberations.

The Chairman in his concluding remarks appreciated the work of all the Scientists and assured every possible help for good research in terms of research facility and manpower. The Chairman also urged to bring out Annual book of recommendations and package of practices each year for the benefit of cotton researchers and farmers. There was also discussion on testing and release of technologies through AICCIP as an alternative to AGRESCO. The IRC meeting ended with vote of thanks by the Dr. J. H. Meshram, Joint Secretary.

Institute Management Committee (IMC) Meeting

The 50th Meeting of Institute Management Committee of CICR, Nagpur was held on 16th June, 2012 at CICR, Nagpur under the Chairmanship of Dr. K. R. Kranthi, Director, CICR, Nagpur. The following Committee Members were present during the meeting:

1.	Dr. K.R.Kranthi, Director, CICR, Nagpur	Chairman
2.	Shri J.C.Bhutada, Joint Director of Agriculture, Govt. of Maharashtra, Nagpur	Member
3.	Shri Sharad Tasare, Ex M.L.A., Amravati	Member
4.	Dr Dilip Monga, Head CICR Regional Station, Sirsa.	Member
5.	Dr P.K.Chakrabarty, Head Division of Crop Improvement, CICR, Nagpur	Member
6.	Dr G.Balasubramani, Sr.Scientist, CICR Nagpur	Member
7.	Dr (Mrs.) Sandhya Kranthi, Head Division of Crop Protection CICR Nagpur.	Spl. Invitee
8.	Dr Blaise Desouza, Head Division of Crop Production, CICR, Nagpur	Spl. Invitee
9.	Shri Deepak Maheshwari, F. & A.O., CICR Nagpur	Spl. Invitee
10.	Dr R.B.Singandhupe, Pri. Scientist & I/c KVK CICR , Nagpur	Spl. Invitee
11.	Shri Sachin Agnihotri, Sr. Admn. Officer CICR Nagpur	Member Secretary

The Committee members noted the progress on Financial Management / Progress of works/ Farm Development / KVK activities and Research Achievements of the Institute and expressed their satisfaction. The meeting ended with thanks to Chair and the Members by the Member Secretary.

Results -Framework Document (RFD) Committee

A RFD Committee has been re-constituted in 2011 as per the guidelines of the ICAR with the following officials of this institute.

Name	Designation
Dr. K.R. Kranthi	Director
Dr. M.V. Venugopalan	Nodal Officer (Principal Scientist and Head, PME Cell)
Shri. Sachin Agnihotri	Administrative Officer
Shri. Deepak Maheshwari	Finance & Accounts Officer
Dr. (Mrs.) S.B. Singh	Co –opted Member
Dr. P.K. Mukherjee	Co –opted Member
Dr. (Mrs.) Mukta Chakrabarty	Co- Nodal Officer & Co –opted Member

The committee meets periodically to discuss the success indicators of the monthly RFD report before sending to ICAR. This committee also finalizes the mid-term and annual RFD performance achievement reports.

RFD Cell has been constituted as per the guidelines of the ICAR with the following officials to manage the activities of the RFD.

S. No	Category	Name & Designation
1	RFD Nodal Officer	Dr. M. V. Venugopalan, Principal Scientist (Agronomy) and Head, PME Cell
2	One Scientist	Dr. K. P. Raghavendra, Scientist (Biotechnology)
3	One Technical Officer	Dr. M.S.Yadav, Technical Officer (T-9)
4	One Administrative Staff	Mr. Ghanshyam D. Sakhare Lower Division Clerk & Typist

The Institute set a high performance standard and achieved a total composite score of 93% in the Annual (April 1,2012 to March 31, 2013) Performance Evaluation Report.

QRT Meeting

The Indian Council of Agricultural Research constituted the Quinquennial Review Team (QRT) vide letter F.No.5(2)/2006-IA.IIII dated 03rd July 2012, to review the functioning and progress of the Central Institute for Cotton Research (CICR), Nagpur and the All India Coordinated Cotton Improvement Project (AICCIP) for the period from 2007 to 2012. Subsequently, in October, 2012, the QRT was asked to extend the review period till Feb, 2013.

The Team consisted of Dr. C.D. Mayee, Former Chairman, ASRB as QRT Chairman; Dr. S.S. Mehetre, Former Director Research,Mahatma Phule Krishi Vidyapeeth Rahuri; Dr. (Mrs.) Usha Barwale, Director, Mahyco Life Sciences Research Centre, Jalna; Dr. H.C. Sharma, Principal Scientist (Entomology), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru; Dr. D.P. Biradar, Registrar, UAS Raichur and Dr. D.K. Marothia, President, National Institute of Ecology as QRT members. Dr.M. V. Venugopalan, Principal Scientist, Agronomy and Head PME Cell, CICR acted as the Secretary of the QRT.

The QRT visited CICR, Nagpur, its Regional Stations at Coimbatore and Sirsa and reviewed the research work carried out at these places. The members visited most of the centres of AICCIP and interacted with the Scientists and assessed the progress made at the centres.

The details of the visits to various centres are given below:

Date	Place	Station Reviewed
20.10.12	Sirsa	CICR (RS, Sirsa), PAU Ludhiana, CCSHAU Hisar, RAU Sriganganagar, MPUA&T Banswada
21.10.12	Hisar	Field demonstration of CCSHAU (Hisar)
17.12.12	Nagpur	CICR(Nagpur)
18.12.12	Akola	Dr.PDKV (Akola), RVSKVV (Khandwa and Indore)
19.12.12	Jalna	MKV (Parbhani), MPKV (Rahuri & Pune)
09.01.13	Surat	NAU (Surat), JAU (Junagarh)
10.01.13	Mumbai	CIRCOT (Fibre quality issues)
21.02.13-23.02.13	Coimbatore	CICR(RS, Coimbatore) + TNAU (Coimbatore), UAS(Dharwad), UAS (Raichur), ANGRAU (Guntur), OUAT(Bhubaneswar), CSAUT &T (Kanpur).

QRT members visit - CICR, Nagpur

QRT members visit at Surat and CICR, Regional Station, Sirsa

The QRT had detailed discussions on 17 December 2012 at Nagpur with Director, HODs and Scientists of CICR, Nagpur. The members visited major experimental fields, important laboratories and other facilities. Views of the representatives of public and private sector stakeholders on cotton related issues and the opinions from them were elicited for shaping or fine tuning of the cotton research agenda. The recommendations are being finalized.

Project Monitoring and Evaluation Committee (PMC)

The Project Monitoring and Evaluation Committee of the Central Institute for Cotton Research (CICR) re-constituted as per the ICAR guidelines to review and evaluate the progress of ongoing research projects of the institute consisted of the following members from CICR, Nagpur.

1.	**Chairman**	Dr. K. R. Kranthi, Director
2.	**Members**	Dr. P.K. Chakrabarty, Head, Crop Improvement
		Dr. Sandhya Kranthi, Head, Crop Protection
		Dr. Blaise Desouza, Head, Crop Production
3.	**Member Secretary**	Dr. M. V. Venugopalan, I /c, PME Cell

The committee evaluated the projects as given below:

Division	Date
Crop Production	26 Nov. 2012
Crop Improvement	27 Nov. 2012
Crop Protection	01Dec. 2012
Biotechnology Section & Laboratories	03 Dec. 2012

The Chairman and the members visited experimental fields and verified the implementation of the IRC approved technical programme. Modification of the approved technical program was suggested to derive additional information.

22nd meeting of ICAR Regional Committee No.VII

The 22nd meeting of ICAR Regional Committee No.VII was held during November 9-10, 2012 at the International Centre, Goa hosted by ICAR Research Complex, Goa under the Chairmanship of Dr S. Ayyappan, Secretary, DARE & Director-General, ICAR.

The meeting was inaugurated on November 9, 2012 by His Excellency, the Governor of Goa, Shri Bharat Vir Wanchoo in the presence of Dr. Ramkrishna Kusmaria, Hon'ble Minister of Farmer welfare and Agriculture Development, Government of Madhya Pradesh. Nine Vice Chancellors of State Agricultural and Veterinary Universities located in the region VII, five DDGs and five ADGs of ICAR, Secretaries, Agricultural Commissioner and Senior Government Officers from the State Departments, members representing ICAR Society & NGOs, Directors of ICAR Institutes, PCs of AICRPs , Heads of Regional Stations, special guests and invitees were present on this occasion .

The inaugural function was presided over by Secretary, DARE & Director-General, ICAR Dr S. Ayyappan. Dr. N. P. Singh, Director ICAR Research Complex for Goa and Chairman Local Organizing Committee, welcomed the participants. Dr. M. M. Pandey, DDG (Engineering) & Nodal Officer, Regional Committee VII, in his opening remarks stated that the meeting assumes significance because of the on-the-spot recommendations on all the

key issues of the region covering all aspects of agriculture, livestock and fisheries. The meeting is unique because it brings together all stake holders and provides a platform to discuss issues confronting the region and provide immediate recommendations.

Speaking on the occasion Dr. S. Ayyappan, Secretary, DARE & DG, ICAR, and Chairman of the Regional Committee, expressed a sense of pride and satisfaction that the agriculture sector of the country performed well and contributed enormously to enhancement of production and productivity of agricultural commodities, whereby food grain production assumed a new height of 257 million tonnes during last year. While lauding the contribution of the region-VII in National prosperity, Dr. Ayyappan informed the participants that the region contributed 15.5% of food grain produced in the country. Besides contributing nearly 12% each of rice and wheat to food grain bowl of the country, 58% sorghum production of the country came from this region. Similarly the region-VII contributed 25% each of cotton and sugarcane and 27% of fruit production of the country along with the sizeable production of oilseeds, pulses, vegetables, poultry and fish. He minced no words in acknowledging the roles and efforts of Indian farmers, agricultural scientists and state governments of the region, backed by strong technical support from 15 ICAR institutes, 10 agricultural and veterinary universities and 100 KVKs. While expressing his happiness in agricultural development and contribution of the region in national agricultural prosperity including production of efficient breeds of poultry, pigs, cows and fish, Dr. Ayyappan expressed concern regarding the potential challenges of the region that could hinder the speed of agricultural development and improvement of productivity. These challenges arose due to major areas in the region being tilled under rainfed conditions, vulnerability to climatic aberrations, fractured land holdings, expensive and scarce availability of labour on account of rural migration, etc. Large portions of livestock produce in the region are non-descript and low productive and lack of availability of good quality fish seed. To overcome these challenges, the efforts need to be intensified to make agriculture more lucrative and more remunerative. In addition to re-revolutionizing green revolution, we should aim at strengthening blue revolution ushering an era of blue-green revolution, exploiting the marine and fresh water resources that this region is richly endowed with. To make agricultural sector more viable, vibrant and farmer-accepted profession, Dr. Ayyappan announced efforts of ICAR in initiating three specific programmes that include i) Farmer-First programme, ii) Student-Ready programme and iii) Retain-youth-in- agriculture programme.

While appreciating the overall agricultural development in the region, Dr. Ramkrishna Kusmaria, Hon'ble Minister of Farmer welfare and Agriculture Development, Government of Madhya Pradesh and Guest of Honor of the inaugural function expressed concerns about the deteriorating soil conditions and depletion of traditional agricultural practices and breeds of animals from most of the states of the region. He expressed pride in telling that sizable areas in his state still enjoy the privilege of being organic in agricultural practices, probably by chance and may not be by choice. He stressed the need to strengthen research on organic cultivation practices to preserve soil health which often suffers damage due to excess use of inorganic fertilizers. Based on his own experience, he spoke with strong conviction that higher productivity with good soil health could be maintained by following traditional agricultural practices and cropping patterns. He urged upon the scientific community in the region to protect and preserve natural breeds of animals which by its enormous potential cater to the needs of farming community from time immemorial. He expressed concerns that agricultural development can never be one sided exclusively with inorganic inputs. Stressing the need for an alternate practices, he urged upon ICAR to initiate first of its kind University for Organic Agriculture in the State of Madhya Pradesh, most regions of which practice organic agriculture with great promise.

While expressing happiness on the overall development of Agriculture in the region, His excellency, the Governor of Goa, Shri Bharat Vir Wanchoo, Chief Guest of the inaugural function, expressed concerns that the people in the region in particular and country in general still face the challenge of poverty, malnutrition and insecurity. He stressed that the living conditions of the farming community need improvement. While inaugurating the meeting, he remarked that Agricultural development plays a predominant role in socio-economic development and forms the backbone of economy of the country. Recalling the words of the past Prime Minister of the country Smt Indira Gandhi that "no country can prosper if It can't feed its people", he stressed upon the stake holders to rededicate their cause for improving the quality of lives of the farmers and people in general. If farmers prosper, the country would prosper. He urged upon the functionaries to work sincerely and concertedly to make agriculture more vibrant and dynamic so that it can become a way of life rather than a source of income. He also stressed that all those who matter in development of agriculture of the region and the country should play roles sincerely, to become agents of change and the angels to growth. He further stressed that small land holdings and low farm productivity prevents agriculture in Goa and makes it as a difficult proposition

to serve as a sole source of income for the farmers. He urged upon the Government agencies and ICAR to rededicate their cause for reinvigoration of agriculture in the state and motivate young generation to adopt it as a viable source of livelihood with renewed vigor.

A number of useful publications in the form of bulletins, CDs, books from ICAR institutes and SAUs were released.

Dr. K.R. Kranthi, Director, Central Institute for Cotton Research, Nagpur and Member Secretary of the ICAR Regional Committee No.VII, proposed the vote of thanks.

Dr S Ayyappan, Secretary, DARE & DG, ICAR chaired all the Interactive sessions. The action points along with the proceedings have been finalized and submitted to the ICAR for approval.

National Seminar on "New Initiatives for Cotton Research"

The Central Institute for Cotton Research, Nagpur in collaboration with the Indian Society for Cotton Improvement, Nagpur organized a National Seminar on "New Initiatives for Cotton Research" at Nagpur on 17th September, 2012. The inaugural session was Chaired by Dr. C.D. Mayee, Former Chairman ASRB, New Delhi and President ISCI. Dr. Atanu Purkayastha, IAS, Joint Secretary, TMC, Govt. of India, Dr. N.K. Krishna Kumar, Deputy Director General (Horticulture), ICAR, New Delhi and Dr. N. Gopalakrishnan, Assistant Director General (CC), ICAR, New Delhi were the Guests of Honour. The special guests who graced the occasion included Dr. S. K. Chattopadhyay, Director, CIRCOT, Mumbai, Dr. Dipak Sarkar, Director, NBSS&LUP, Nagpur, Dr. V.J. Shivankar, Director, NRCC for Citrus, Nagpur, Dr. Anupam Barik, Additional Commissioner Agriculture, Govt. of India and Dr. J.C. Bhutada, Joint Director Agriculture, Nagpur Division. In his introductory remarks Dr KR Kranthi, Director CICR and Chairman, Nagpur Chapter of ISCI, emphasized that the aim of the seminar was to identify critical research gaps which need to be tackled during the 12th Plan period. Dr. N. Gopalakrishnan, in his address informed that the R&D programmes during the 12th plan period will focus on knowledge based technologies, a shift from the traditional input based techniques and hoped that the next phase of the Technology Mission on Cotton will further consolidate the research outputs. Dr. N.K. Krishna Kumar, DDG (Horticulture) hoped that the new research initiatives on cotton will have spillovers and ramifications beyond the cotton crop and other crops would also benefit. He stressed on the need for intensifying research on vector dynamics of viruses. Dr.

Atanu Purkayastha, IAS, expressed his concern that new technologies are being debated in public even before they are evaluated properly. He felt that the future of GM technology depends upon how strategically we place and evaluate our Bt cottons. In his inaugural address, Dr. C.D. Mayee, expressed concern over the stagnation in cotton yield despite widespread adoption of Bt hybrids and urged the scientists to develop better management techniques to reverse this trend. He opined that breeding short, compact varieties and transferring Bt genes into varieties should top the agenda for new research initiatives from the public sector.

Dr. Atanu Purkayastha, and other dignitaries visited the experimental fields and research laboratories and had a quick interaction with the scientists.

The next session was a technical session held from 11:30 hrs. to 13:30 hrs. This was chaired by Dr. C.D. Mayee and there were four lead presentations in this session.

1. Dr. S.K. Chattopadhyay : Quality requirements of textile sector and breeding of cultivars.
2. Dr. V.N. Waghmare : New initiatives in Marker Assisted Breeding.
3. Dr. O.M. Bambawale : Technology dissemination in the new ICT era.
4. Er. Gautam Majumdar : Mechanization needs and indigenous cotton-picker designs.

During the post-lunch session, held under the Chairmanship of Dr. N. Gopalakrishnan, Assistant Director General (CC), ICAR, Dr. K.R. Kranthi, Director, CICR, outlined the research programmes proposed to be taken up during the 12th plan period under Technology Mission on Cotton, focusing on their specific objectives and deliverables. The 12 individual projects which were formulated were discussed in detail and the strategic partners within NARS (AICCIP Centres, ICAR Institutes) and outside NARS were tentatively identified. The Chairman in his remarks expressed satisfaction over the manner in which the projects were reformulated based on the outcome of previous deliberations. He wanted a comprehensive socio-economic feasibility study of the products and technologies developed. He also wanted a more stringent monitoring of the targets assigned keeping the timelines fixed for each target.

In all 73 delegates comprising of scientists, administrators, officials from seed, pesticide and textile industry attended the seminar. The seminar ended with a vote of thanks proposed by Dr. A.R. Reddy, Member Secretary, TMC Cell, Nagpur.

10.5 : Participation of Scientists in Seminars/ Symposia/ Workshops

Sr. No.	Seminars/Conferences/Symposia / Workshops/Trainings	Place and Date	Participants
Seminars			
1.	AICCIP Workshop	Hyderabad 9 to 11 April 2012	Dr. K. R. Karnthi, Dr. Blaise Desouza, Dr. M. V. Venugopalan, Dr. S. M. Wasnik, Dr.A.H.Prakash, r.S.Manickam, Dr.B.Dhara Jothi, Dr. Dhamayanthi, Dr. S.Usha Rani
2.	Brain storming session on Entomopathogenic nematodes	NBAII, Bangalore in April 2012.	Dr. Nandini Gokte-Narkhedkar
3.	IAFS Workshop, IL&FS	New Delhi, 13 April 12	Dr. Blaise Desouza
4.	European Geosciences Union General Assembly 2012	Vienna, 23 to 27 April 2012	Dr. Blaise Desouza
5.	Inception Workshop of UNEF/GEF Supported Phase II capacity Building Project on Biosafety	NASC Complex, Delhi 18-19 June, 2012	Mrs.Mukta Chakrabarty
6.	IAFS Launch workshop in Uganda	CDO, Kampala, 28 June 2012	Dr. Blaise Desouza
7.	IAFS Launch workshop in Malawi	Blantyre, 3 July 2012	Dr. Blaise Desouza
8.	National Seminar on New Initiatives for Cotton Research organized by Indian Society for Cotton Improvement on Nagpur Chapter	Central Institute for Cotton Research, Nagpur. 17 September 2012	Dr. Blaise Desouza, Dr. M. V. Venugopalan, Dr. R. B. Singandhupe, Dr. J. Singh, Dr. S. M. Wasnik, Dr. A. R. Raju, Mrs. M. Chakrabarty, Er. G. Majumdar, Dr. A.R. Reddy, Dr. K. Velmourougane
9.	International Cotton Genome Initiative Research Conference12	Raleigh, North Carolina, USA on 9-12 October12.	Dr. S.K.Verma
10.	International Symposium on "Global cotton Production Technologies vis-à-vis climate change	CCS Haryana Agricultural University, Hissar 10 - 12 October, 2012	Dr. R. B. Singandhupe, Dr. J. Singh, Dr. S. M. Wasnik, Dr. A. R. Raju, Er. G. Majumdar, Dr. A.R. Reddy, Dr. Nandini Gokte-Narkhedkar,

			Dr. O. P. Tuteja, D Monga, Dr. S. L. Ahuja, Dr. S. Manickam, Dr. V.N. Waghmare, Dr.P.Nalayini, Dr.K.Sankaranarayanan, Dr.S.UshaRani, Dr. Nandini Gokte-Narkhedkar, Dr. V. Chinna Babu Naik, Dr. Vinita Gotmare and Dr. M. Saravanan
11.	Nat Sem "Managing land resources for sustainable agriculture"	NBSS&LUP, Nagpur 12-13 Oct 2012,	Dr.K.Velmourougane
12.	Molecular Plant Pathology Research with Special reference to Cotton and its pathogens.	PKV Akola, Oct. 30-31, 2012.	Dr. P.K. Chakrabarty
13.	World Neem Conference	Nagpur from 21st to 24thNovember, 2012	Dr. (Mrs.) S Kranthi, Shri. A. Sampath Kumar
14.	3rd International Agronomy Congress	New Delhi 26 to 30 November 12	Dr. Blaise Desouza, Dr.P.Nalayini, Dr.K.Sankaranarayanan, Dr.S.UshaRani
15.	National Workshop on "Taxonomy, Ex-situ Conservation and Bioprospecting of Fungi"	Agharkar Research Institute, Pune Nov. 30, 2012.	Dr. P.K. Chakrabarty
16.	Blending Conventional and Modern Plant Pathology for Sustainable Agriculture	4-6 Dec, 2012 at IIHR, Bangalore	Dr. P.K. Mukherjee
17.	International Symposium on Food Security Dilemma: Plant Health and climate change issues.	BCKVV,Kalyani, Dec.7 9, 2012.	Dr. P.K. Chakrabarty
18.	Review Workshop of PME cells of ICAR Institutes	NDRI, Karnal Dec. 8, 2012	Dr. M.V.Venugopalan
19.	Regional Workshop on Agrarian Crisis and Climate Change	CSA, Hyderabad Dec. 30, 2012	Dr. M.V.Venugopalan
20.	100th Indian Science Congress	Kolkata,3-7 Jan.,2013	Dr.J.H. Meshram
21.	National convention on India Cotton: Gearing up for Global Leadership	Navsari Agri. University, at Main Cotton Research Station, Surat from 6-8 January, 2013	Dr. K.R. Kranthi, Dr. M.V. Venugopalan, Dr. S. L. Ahuja, D. Monga, Dr A.H. Prakash, Dr. T. R. Loknathan, Dr. P.K. C hakrabarty Dr. S. B. Nandeshwar
22.	Beltwide Cotton Conference 2013	January 7-10,13 at San Antonio, Texas, USA.	Dr. S. K. Verma
23.	Plant and Animal Genome XXI	January 12-16, 2013 at San Diego, CA, USA.	Dr. S. K. Verma
24.	MDP workshop on PME of Agricultural Research Projects	NAARM, Hyderabad Jan 21-25, 2013	Dr. M.V.Venugopalan
25.	10th Nat symp "Biotechnological approaches for plant protection: Constraints and opportunities	27.01.13 to 29.01.13. ICAR Research Complex, Goa	Dr.J.Gulsar Banu
26.	National Seminar on Biosafety Environment of India and Challenges Ahead	Feb.7, 2013. Gujarat State Biotechnology Mission, Gandhi Nagar	Dr. P.K. Chakrabarty
27.	International Conference on Insect Science	14.02.13 to 17.02.13 UAS, Bangalore.	Dr.B.Dhara Jothi, Dr.J.Gulsar Banu, Dr.M.Amutha, Dr. V. Chinna Babu Naik

10.6: Distinguished Visitors

Name & Designation	Organisation	Date
Nagpur		
Dr. S.B. Agnihotri, Additional Secretary,	DAC, MoA, Krishi Bhawan, New Delhi	13.07.2012
Shri Atanu Purkayastha, Joint Secretary (TMC)	Department of Agriculture & Cooperation, New Delhi	17.09.2012
Dr. N.K. Krishna Kumar, Deputy Director General (Horticulture)	Indian Council of Agricultural Research, KAB, New Delhi	17.09.2012
Dr. N. Gopalakrishnan, ADG (CC)	Indian Council of Agricultural Research, New Delhi	17.09.2012
Dr. S. Ayyappan, Secretary, DARE and Director General,	Indian Council of Agricultural Research, KB, New Delhi	24.11.2012
Dr. S.K. Datta, DDG (CS)	Indian Council of Agricultural Research, KB, New Delhi	24.11.2012
Dr. R.G. Dani, Vice Chancellor	Dr. PDKV, Akola	24.11.2012
Dr. C.D. Mayee, Ex-Chairman & Chairman, QRT for CICR and AICCIP	ASRB, New Delhi	17.12.2012
Dr. (Mrs.) Usha Barwale, Director	Mahyco Research Centre, Dawalwadi, Jalna, MS	17.12.2012
Dr. D.P. Biradar, Registrar	UAS Raichur, Karnataka	17.12.2012
Dr. D.K. Marothia, President	National Institute of Ecology, Raipur	17.12.2012
Dr. S.A. Patil, Ex- Director, IARI & Chairman, RAC	Chairman, Farmers Commission of Karnataka, Bengaluru	21.02.2013
Coimbatore		
Dr. C.D. Mayee, Ex-Chairman & Chairman, QRT for CICR and AICCIP	ASRB, New Delhi	22.02.13
Dr. S.S. Mehetre, Retd. Director Research	MPKV, Rahuri (M.S.)	22.02.13
Dr. D.P. Biradar, Registrar	UAS Raichur, Karnataka	22.02.13
Dr. H.C. Sharma, Principal Scientist, Entomology,	ICRISAT, Hyderabad, AP	22.02.13
Sirsa		
Dr. C.D. Mayee, Ex-Chairman & Chairman, QRT for CICR and AICCIP	ASRB, New Delhi	20.10.12
Dr. (Mrs.) Usha Barwale, Director	Mahyco Research Centre, Dawalwadi, Jalna, MS	20.10.12
Dr. D.P. Biradar, Registrar	UAS Raichur, Karnataka	20.10.12
Dr. H.C. Sharma, Principal Scientist, Entomology,	ICRISAT, Hyderabad, AP	20.10.12




10.7: Personnel

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N V R N Murty, Finance & Accounts Officer (Trfd. & relived on 21.04.2012)
Deepak Maheshwari, finance.cicr@rediffmail.com (Joined on 12.06.2012)

10.8: Other Information

Director General, ICAR Visit

The Honorable DG Dr. S. Ayyappan visited the Central Institute for Cotton Research ,Nagpur on 24.11.2012. He was accompanied by Dr. Swapan Datta, Deputy Director General (Crop Science), Dr. C.D.Mayee QRT Chairman, Dr S.K. Chattopadhyay, Director, CIRCOT, Mumbai and Dr.Dipak Sarkar, Director NBSS &LUP, Nagpur.

They visited the High Density Planting Field of Suraj in the institute and the DG expressed satisfaction at the effort made by CICR in popularizing an alternative technology to Hybrid cotton for resource poor farmers cultivating cotton on shallow and marginal soils of Vidarbha under rainfed conditions. An innovative experiment on the cultivation of ELS cotton during the off season was also highlighted. This was followed by a visit to the experiment on screening of released varieties for HDPS in which 11 new straight varieties and 2 Bt Hybrids were demonstrated under the HDPS system. Subsequently they visited the Bt 6 fields where growth regulators were being evaluated to modify the architecture to maximize yields. The DDG expressed the need to breed for compact varieties rather than attempting to physically modify their architecture with the use of growth regulators. The trial on the standardization of agronomy of *G. arboreum* race *cernuum* (Comilla cotton) drew applause. The cotton picking machine prototype developed by Er. G. Majumdar was exhibited in the field. The visit to the breeding fields showcasing breeding material available with the Crop Improvement elicited a good response and the DG complimented the breeders for their efforts. However he desired that breeding material be stabilized into cultures. He stressed on the need to initiate talks with the private sector for enhanced public private partnership in the area of generation of Bt transgenic varieties for the benefit of cotton farmers.

The team visited the Wild species garden, the insectary and expressed satisfaction at the progress. Later the officials also interacted with the media. The DG also gave a patient hearing to the problems of temporary status labourers.

The Hon. DG inaugurated the Training Hall and the Tissue culture laboratory that were recently developed. Dr. Nandehswar Head I/C Biotechnology described the progress made in the area of cotton tissue culture. This was followed by an appraisal of work being carried out in Biotechnology. The team also visited the newly developed Marker Assisted Breeding Lab. They were shown the pest tolerant cultures with elite fibre properties developed by the Crop Protection Division for use under HDPS. He suggested that the concerned official be given an opportunity to present his work at the Director's conference. Dr D Blaise, Head Crop Production Division, CICR and Dr S.K Chattapadhyay made brief presentations on the activities being undertaken under Technical Assistance Programme for Africa.

Finally, the DG and DDG addressed the scientists in an interaction meet where inputs were sought from scientists for strengthening the research program under the 12th Five Year Plan.

Visits Abroad

- Dr. K.R. Kranthi, Director, CICR, Nagpur as a member of Indian delegation visited Brazil from 11-20 April, 2012. The objective of the visit was to study the system of cotton cultivation in Brazil and identify the practices, which can be of relevance for cultivation of cotton in India and can be incorporated to increase the productivity of cotton in India to at least the world average of 752 kg lint/ha. The delegation visited cotton growing farms in the main cotton growing States of Mato Grosso and Goias, in Brasilia and also interacted with the stake holders/ officials/ groups engaged in cotton cultivation and its promotion in Brazil.

- Dr. Blaise Desouza, Principal Scientist (Agronomy) & Head, Division of Crop Production, CICR, Nagpur visited Vienna, Austria from 22-27 April. 2012 and convened session on cotton production practices impacts soil quality during European Geosciences Union General Assembly 2012". He presented paper on "Cotton production practices change soil properties" and also presented a poster paper on "Organic cotton systems improves soil properties".

- Dr. D. Monga, Head, CICR, Regional Station, Sirsa attended the launch program of Cotton Technical Assistance Program (Cotton TAP) for C-4 countries in Ouagadougou, Burkina Faso, Africa on May 28, 2012.
- Dr. Blaise Desouza, Principal Scientist (Agronomy) & Head, Division of Crop Production, CICR, Nagpur visited Uganda and Malawi to participate in the Cotton TAP launch workshop in Africa and assess training needs from 27 June to 04 July, 2012.

Library

Additions

In the period from 2012-13, the Library purchased 42 new books and subscribed to the Life membership of the Indian journal, *Current Science*.

Documentation Services

- Library has developed computerized bibliographic database on Cotton to provide comprehensive and updated information on cotton. About 4276 bibliographic references along with abstracts have been stored in it. Based on this bibliographic database the Library publishes a current awareness bulletin namely "*COTTON RESEARCH ABSTRACTS*". The Bulletin is circulated to all the scientists of the Institute and to all AICCIP Centers in India. In the reported period, four issues of *COTTON RESEARCH ABSTRACTS (V26, (No. 1-4), January – December 2012)* were published and circulated.
- The Library is actively participating in the E-Journal Consortium by responding regularly through E-mails and thus also receiving updates. More than 2000 on-line journals on agriculture and crop science are made available over the network through this consortium.
- Four user terminals installed in the Library have facilitated the users to access the databases uploaded in the Library Server. Users can also access the Internet on these terminals. Similarly the entire catalog of the library has been downloaded on these terminals for ease of use.
- The WebOPAC version of the Library software SLIM21 was updated and by using this Library Application Software, the entire catalogue of holdings of the Library (books and bound volumes) is available on all terminals within the Institute. By its virtue, the entire holdings and the catalogue of the Library are visible on the LAN terminals within the Institute by clicking on the following link. Library Catalogue Web-OPAC Link http://dbserver/w27/

Progressive Use of Hindi

Nagpur

Hindi Week

Hindi awareness fortnight was celebrated at CICR, Nagpur from 30.09.2012 to 16.10.2012 with great

enthusiasm. Various competitions were organized to encourage the staff members to show their potential in Hindi language. Dr. R.G. Dani, Vice Chancellor, Dr. PDKV, Akola graced the occasion as the Chief Guest and commended the level and spirit of participation in various events. The entire programme was organized under the leadership of Dr. K.R. Kranthi, Director, CICR and was ably coordinated by Dr. G. Balasubramani, Mrs. Mukta Chakrabarty, Dr. R.R. Gupta and Mr. Sachin Agnihotri.

Coimbatore

Hindi Activities

- In the month of September 2012, Hindi Week celebrations were held at CICR, Coimbatore. In view of this, various competitions like memory contest, Administrative usage of Hindi, Comprehension based Questions and General knowledge in Hindi were held for Scientists and Staff members. The Winners of these competitions were awarded on the Hindi Day celebration held on 14.9.2012 chaired by Sh. Hariganesh, Hindi Pradhyapak, Hindi Teaching Scheme, Coimbatore.
- In the month of October' 12 committee members of Hindi Committee participated in various Hindi Competitions held by TOLIC in view of Hindi Month Celebrations at different Central Government Offices, Coimbatore.
- The Quarterly Reports and Half yearly Progress Reports were regularly prepared and dispatched to Head Quarters and TOLIC, Coimbatore for review of Progress on Hindi activities.
- The Scientist nominated for Hindi Prabodh Classes organized by Hindi Teaching Scheme, Coimbatore for the July-Nov' 2012 session has passed the same and nominated for next level exam *viz.*, Praveen for Jan-May'13 session.

- On 30.10.2012, CICR, Coimbatore has been conferred the Third Prize by the Town Official Language Implementation Committee, Coimbatore for effective Hindi Implementation work among Govt. Offices Category for the year 2011-12 and the award was received by the Hindi cell convener during the Half yearly Meeting of TOLIC held at BSNL Community Hall, Coimbatore.
- The Technical Hindi-English Terminology has been prepared by the Committee and submitted for approval by the PC & Head for usage of Hindi by Staff members.

Exhibiting CICR technologies

All technologies developed at CICR, Coimbatore were displayed in a stall in the Exhibition conducted at 21st National Conference on Scientific Tamil held at Perur Tamil College, Coimbatore on 9th and 10thFebruary 2013. The programme was coordinated by Dr (Mrs) S. Usha Rani, Senior Scientist (Agricultural Extension).

10.9: Weather

Nagpur

Month	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
June, 2012	38.8	28.0	62.5	37.3	62.0	6
July, 2012	30.5	24.2	89.4	74.1	356.0	17
August, 2012	29.4	24.0	90.2	78.7	184.0	13
September, 2012	32.3	24.0	88.5	63.0	184.0	9
October, 2012	33.0	18.5	77.0	44.3	15.0	1
November, 2012	30.5	14.6	74.2	37.3	10.0	1
December, 2012	30.2	12.2	76.2	27.1	0.0	0
January, 2013	28.2	11.7	70.4	38.1	0.0	0
February, 2013	32.1	15.8	68.3	31.0	15.0	1
Total					**826**	**48**

Coimbatore

Month	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	Normal Rainfall (mm)
	Max	Min	Max RH	Min RH		
Aug.2012	31.1	22.9	85.3	56.7	19.9	35
Sept. 2012	32.5	22.5	83.7	49.1	4.3	68.0
Oct. 2012	29.6	22.3	89.8	63.1	126.6	146.0
Nov. 2012	31.2	20.2	90.2	45.6	7.4	118.0
Dec. 2012	30.5	20.5	84.7	43.8	6.9	41.4
Jan.2013	31.3	18.6	85.0	35.0	0.0	14.0
				Total	**165.1**	**387.4**

Sirsa

Month	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
April 2012	37.4°	16.2°	83	18	13.2	2
May 2012	45.8°	18.8°	64	8	12.0	2
June 2012	45.4°	22.8°	71	8	11.0	3
July 2012	45.0°	28.4°	95	21	48.6	5
August 2012	38.6°	23.4°	95	41	119.4	7
September 2012	37.0°	21.0°	95	30	70.4	5
October 2012	36.4°	12.6°	90	23	11.2	2
November 2012	31.4°	7.2°	90	10	0.0	0
Total					**285.8**	**26**

10.10: Cotton Scenario

Details of state-wise cotton area, production and productivity are given below:-

State-Wise Cotton Area, Production and Productivity

Zone/State	2011-2012 *			2012-2013 *		
	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)
Punjab	5.60	18.50	561.61	5.06	20.00	671.94
Haryana	6.41	26.00	689.55	6.14	24.00	664.50
Rajasthan	4.70	17.50	632.98	4.50	16.00	604.44
North Zone	**16.71**	**62.00**	**630.76**	**15.70**	**60.00**	**649.68**
Gujarat	29.62	120.00	688.72	24.00	87.00	616.25
Maharashtra	41.25	74.00	304.97	41.46	74.00	303.42
Madhya Pradesh	7.06	18.00	433.43	6.08	18.00	503.29
Central Zone	**77.93**	**212.00**	**462.47**	**71.54**	**179.00**	**425.36**
Andhra Pradesh	18.79	56.00	506.65	22.69	76.00	569.41
Karnataka	5.54	14.00	429.60	4.85	13.00	455.67
Tamil Nadu	1.33	6.50	830.83	1.26	6.00	809.52
South Zone	**25.66**	**76.50**	**506.82**	**28.80**	**95.00**	**560.76**
Orissa	1.02	2.50	416.67	1.19	4.00	571.43
Others	0.46	2.00	739.13	0.50	2.00	680.00
Grand Total	**121.78**	**355.00**	**495.57**	**117.73**	**340.00**	**490.95**

1 bale= 170 kg.

Source : Office of the Textile Commissioner, Mumbai. * - As estimated by CAB in its meeting held on 17.04.2013

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