



वार्षिक प्रतिवेदन  
ANNUAL REPORT



2016-17

भा.कृ.अनु.प.—केन्द्रीय कपास अनुसंधान संस्थान, नागपुर  
ICAR-CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR



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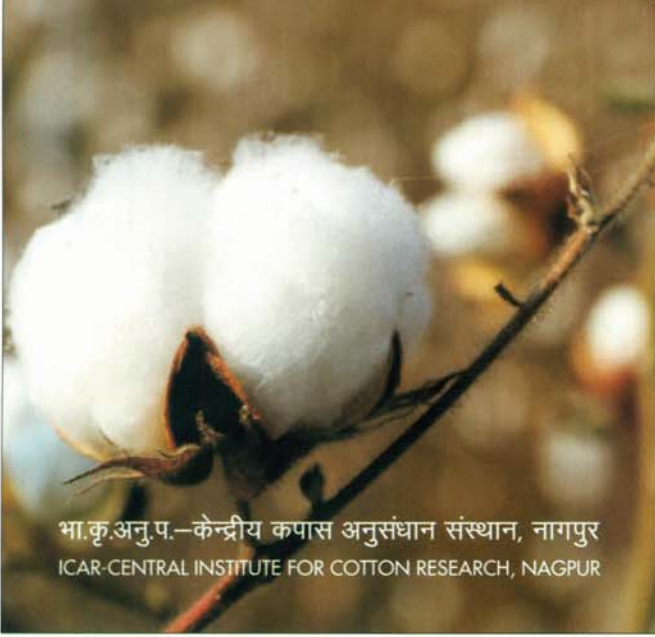
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**Dr. M.S. Ladaniya**

Director (Additional Charge)

**Editorial Committee**

Dr. M.S. Ladaniya

Dr. M.V. Venugopalan

Dr. V.N. Waghmare

Dr. D. Blaise

Dr. S.B. Nandeshwar

Dr. (Mrs) Nandini G. Narkhedkar

**Compilation, Collation and Production**

Dr. Mahendra Singh Yadav

Mrs. Vandana Satish

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## PREFACE



The year 2016-17 has been an eventful year on many counts from cotton R&D perspective. It marked the Golden Jubilee year for the AICRP on Cotton. The celebrations were concluded with the approval of a new road map to increase the productivity of cotton to 1000 kg lint/ha in a socially, economically and environmentally responsible manner. The area under cotton declined from 11.88 m ha in 2015-16 to 10.5 m ha in 2016-17. But the cotton production was 351 lakh bales in 2016-17 as compared to 338 lakh bales in 2015-16. This happened only because of increase in productivity from 484 kg/ha to 568 kg/ha. For the first time in the period of this decade the desi, *G. arboreum* cotton was planted on 80,000 ha area replacing hybrids. For the first time, 21 Bt varieties developed by public sector institutes were evaluated across different AICRP centres and ICAR-CICR stations at Coimbatore and Sirsa and promising ones for each state were short listed for approval. The first ever *G. hirsutum* variety, CSH 3075, developed exclusively for planting under High Density Planting System was notified. Additionally, 2 more *G. hirsutum* varieties, CSH 3129 for irrigated north zone and high strength CCH 4474 (Subiksha) variety for irrigated conditions of south zone were released.

The ICAR-CICR has also collected, characterized and preserved for posterity the fast eroding land races and perennials from across the country. A novel protocol for in-vitro culture of cotton ovules of inter-specific (*G. arboreum* x *G. hirsutum*) crosses, embryo rescue techniques and Agro-bacterium tumefaciens mediated in-planta transformation protocol were standardized. A protocol has also been standardized to enable DNA extraction from harvested matured cotton fibre.

The institute provided leadership and coordinated the implementation of strategies to manage whiteflies in the north zone. The proactive strategies devised helped to minimize losses due to pink bollworms in Gujarat, Maharashtra, Telangana and Andhra Pradesh. A protocol using LAMP for diagnosis of cotton leaf curl virus was developed. Technologies for managing multiple nutrient deficiencies on calcareous soils through seed treatment of chelated micronutrients and humic-acid were developed. A brush type harvester with pre-cleaner was developed and evaluated in collaboration with Mahendra & Mahendra and ICAR-CIRCOT. Through the e-kapas, voice mail service, the institute issued regular advisories and reached out to 1.59 lakh cotton farmers. 'Cotton Doctor' a decision support system for pest management was developed. Our efforts to reach out to the farmers were further intensified through the 'Mera Gaon Mera Gaurav' (MGMG) programme and Tribal Sub Plan (TSP). Weekly articles on various production and protection technologies for the benefit of cotton farmers were disseminated through the most popular agricultural daily news paper in Marathi language in Maharashtra.

I am grateful to Dr Trilochan Mohapatra, Secretary DARE & DG ICAR; Dr J. S. Sandhu, DDG (CS) and Dr R. K. Singh, ADG (CC) for their constant encouragement, guidance and support. The dynamic leadership



provided to the Institute by Dr. K. R. Kranthi, Former Director, who joined the International Cotton Advisory Committee as the Head, Technical Information Section is fondly acknowledged. The Heads of Divisions Dr Sandhya Kranthi, Dr Blaise Desouza, Dr V. N. Waghmare and Dr Suman Bala Singh and Dr D. Monga, Head, Regional Stations, Sirsa, and Dr A. H. Prakash, PC and Head, Regional Station, Coimbatore have contributed immensely to the execution of research programmes and their documentation in this report. I thank them all for the excellent camaraderie and support. Dr M. V. Venugopalan, Dr M. S. Yadav and Mrs Vandana Satish deserve to be commended for their outstanding inputs and commitment to all aspects related to this annual report.

Cotton farming is on a threshold of a new revolution. With a vision and the roadmap for the future of cotton industry in India, innovative and appropriate technologies can be developed.

**(M. S. Ladaniya)**  
Director (Additional Charge)  
ICAR-CICR, Nagpur

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# 1. EXECUTIVE SUMMARY

## Crop Improvement & Biotechnology

### Genetic Resources

- Exploratory survey of NEH region Nagaland and Karbi Anlong (Assam) was conducted and 17 morphological variants consisting 5 of *G. arboreum*, 11 of *G. barbadense* perennials and one *G. hirsutum* perennial were collected. Sundarban areas South and North 24-Parganas districts of West Bengal, was surveyed and 41 waterlogging and salinity tolerant cotton accessions were collected of which 32 were of *G. hirsutum* and 9 of *G. barbadense*. Of the nine, eight *G. barbadense* accessions belonged to var. *brasiliensis* and had fused seeds (Kidney cotton).
- Five hundred seventy five accessions were added to cotton gene bank consisting 567 of *G. hirsutum* of which 340 for high boll weight and high ginning outturn, 26 - restorer, 84 CMS, 72 maintainer B lines, 8 GMS, 37 elite lines of heterotic pool, and 8 of *G. arboreum* possessing high boll weight and high GOT.
- A set of 36 exotic accessions, including 34 Coker variants and 2 of CLCuD resistant, were acquired from U.S.A and evaluated for economic and fibre quality traits. Promising lines for specific traits have been identified.
- Eight thousand twenty accessions, i.e. *G. hirsutum* 7113, *G. arboreum* 330, *G. herbaceum* 565 and wild species seeds and cuttings 12, were distributed to Breeders of the Institute and SAUs for their cotton improvement programme.
- Germplasm field days were organized twice on 06<sup>th</sup> & 27<sup>th</sup> December, 2016 at ICAR - CICR, Nagpur. Breeders of the Institute and SAUs of North, Central and South Zone participated and selected 943 elite germplasm lines which have already been supplied to them.
- A set of 1900 accessions of *G. hirsutum* were grown for rejuvenation and seed multiplication. Seeds of 1602 *G. hirsutum* accessions were supplied to ICAR-NBPGR, New Delhi for long term storage and also conserved in MTS at ICAR-CICR, Nagpur.
- Morphological and DUS characterization of 235 landraces of *desi* cotton and perennials have been completed.
- *G. hirsutum* (730) and *G. arboreum* (760) accessions were evaluated for yield traits at CICR, Regional Station, Sirsa.
- 1059 *G. arboreum* accessions were evaluated in augmented block design-1 for lint yield, boll weight, seed index, ginning percentage, days to flowering and days to boll opening. A set of 14 accessions, namely AC 3265, AKH 496, PBS 1127 - SP1, AC 3522 B, AC 3216, H 503, H 509, AC 3097, AKA 13 - SP1, N 11-54-31-32, H 173, PBN 565, 3930 A and AC 3244 were identified for seed cotton yield.
- A set of 582 *G. herbaceum* germplasm was evaluated for various morphological and economic traits. Accessions identified for specific and unique traits include - 6 genotypes for seed cotton yield/plant *viz.*, IC 371582, IC 371575, IC 371587, IC 371560, IC 371602 and IC 371437; erect type (IC 371260), absence of nectaries on leaves (IC 371582), dwarf type (IC 371254, IC 371150, IC 371490), high boll weight (IC 371413) and boll number (IC 371156). Based on type of boll opening germplasm lines were classified as open, semi-open and closed boll types.
- Twenty four wild species, 15 races of cultivated species and more than 45 synthetic polyploids are conserved and maintained in the wild species garden and green house.
- Four hundred and sixty one introgressed derivatives were evaluated for fibre & economic traits and three high fibre strength lines i.e. CICR-16004, CICR-16022 and CICR-16280 were identified. Three light brown linted lines, i.e. CNH LB-1, CNH LB-2 and CNA LB-3, were identified for registration as unique germplasm.



- 310 *G. barbadense* germplasm lines were maintained and evaluated. Accessions with superior plant types in terms of yield, quality, earliness, hairiness and short branching were identified. Evaluation of 11 hairy germplasm accessions for resistance to sucking pests revealed that CCB-124 was superior than check Suvin followed by ICB-284 and ICB-85. The highest span length was observed in ICB-105 (36.1 mm) followed by HAG-02 (35.4 mm) and ICB-124 (35.1 mm).

### Genetic Improvement

- Of the sixteen genotypes evaluated in RBD, two genotypes CISA-6-165 (3026 kg/ha) and CISA-8 (3193 kg/ha) recorded significantly higher seed cotton yield than checks CISA 614 (2665 kg/ha) and CISA 310 (2535 kg/ha).
- Twelve long linted high strength cultures developed at ICAR-CICR, Nagpur were evaluated in replicated trial at Sirsa. Two cultures produced seed cotton yield of more than 18 q/ha and four cultures CNA-1054 (27.3 mm, 28.0 g/tex), CNA-1056 (28.1 mm, 28.6 g/tex), CNA-1057 (27.0 mm, 26.8 g/tex) and CNA-1063 (27.2 mm, 27.1 g/tex) recorded UHML >27.0 mm and better fibre strength.
- In station trial, CISA 33-5 (2512 kg/ha), CISA 7 (2464 kg/ha), CISA 6-165 (2401 kg/ha) and CISA 8 (2362 kg/ha) were higher yielder than checks, CISA 310 (2059 kg/ha) and CISA 614 (2319 kg/ha). The cultures CISA 33-5 and CISA 7 were recommended for evaluation in AICRP National Trial.
- Of the 25 entries evaluated in replicated trial, CNH 09-73 recorded highest seed cotton yield of 3074 kg/ha followed by CNH 09-79 (2608 kg/ha) and CNH 09-70 (2508 kg/ha). CNH 09-45 recorded highest bundle strength of 35.8 g/tex followed by CNH 09-77 (34.7 g/tex). In another trial, CNH 09-11 recorded highest seed cotton yield of 3085 kg/ha followed by CNH IS 5 (2997 kg/ha) and CNH 8 (2746 kg/ha).
- In two backcross populations *viz.*, LRK-516 x (LRK-516 x Deltapine-66) and PKV-081 x (PKV-081 x PIL-8), enhancement of trait values for GOT from a base value of 36% to 40% in LRK-516 and for boll wt. from 3 g to 5.3 g in PKV-081 was recorded at the end of BC<sub>3</sub>F<sub>8</sub> generation. Selections with fibre length upto 33.5 mm and fibre strength of 33 g/tex have been identified.
- Thirteen long staple cultures were evaluated and identified YLS 21-4 with highest seed cotton yield of 1566 kg/ha in comparison to Surabhi and Suraj. The test culture YLS 19-2 gave seed cotton yield of 1315 kg/ha with fibre length 34.5 mm and tenacity 33.3 g/tex.
- Eight identified drought tolerant lines showed significant seed cotton yield ranging from 2378.14 to 3328.06 kg/ha, 15% more than the check LRA 5166 (2378 kg/ha). DTS 104 recorded highest yield of 3326 kg/ha with 40 per cent increase over the check, boll weight upto 4.8 g, GOT 37.6 per cent, fibre length 28.3 mm, fibre strength 25.6 g/tex and micronaire of 3.5 ug/in.
- Twenty-three *G. hirsutum* cultures were evaluated in RBD with three replications. Highest seed cotton yield of 3111 kg/ha was recorded in culture CSH 1602 followed by CSH 2916 (2675 kg/ha) as against the check variety LH 2076 (2505 kg/ha). Maximum ginning outturn of 40.3 per cent was recorded in culture CSH 2931.
- Six high yielding early maturing, ELS genotypes *viz.*, CCB-51, CCB-64, CCB-129, CCB-143, CCB-143B and CCB-93 have been identified.
- A stable cleistogamous plant has been identified in the segregating populations of intra-*barbadense* cross Suvin x Giza-45. The progeny of cleistogamous plant was stable and it may be registered as unique line with NBPGR, New Delhi.

### Population Improvement

- The random mating population developed through conventional crossing was maintained by bulk harvesting one open boll from each plant in both *G. arboreum* and *G. hirsutum*.
- From among 296 of *G. arboreum* and 504 of *G. hirsutum* male sterile single plant progenies evaluated, 5-7% superior plant progenies were identified and trait specific groups for boll

weight, seed cotton yield, GOT, fibre strength and fibre length were constituted. Trait based population of selected progenies were grown, allowed open cross pollination and all sterile and fertile plants were tagged at flowering. All sterile plants from each group harvested separately for plant progeny evaluation for second cycle of recurrent selection.

- Single plant selections from random mating population and reselection from segregating progenies, about 2634, were evaluated in plant to row progeny plots. Forty superior progenies (16 of *G. hirsutum* and 24 of *G. arboreum*) were identified for advancement and 1650 single superior plants were reselected from the segregating plant progenies for further evaluation.
- 145 *G. arboreum* and 150 cultures of *G. hirsutum* were evaluated in 12 replicated trials. The seed cotton yield among the *G. arboreum* cultures ranged from 1277 to 4996 kg/ha while in *G. hirsutum* it ranged from 1488 to 3081 kg/ha.

#### Interspecific Hybridization

- Interspecific crosses were attempted to introgress genes for whitefly and CLCuD resistance from *G. arboreum* to *G. hirsutum* tetraploid cotton. A total of 15369 crosses have been made and 1200 more crossed seeds were obtained.
- A protocol for *in-vitro* culture of cotton ovules of interspecific wide crosses, embryo rescue technique, has been standardized and more than 100 F<sub>1</sub> seedlings from crosses between *G. hirsutum* and *G. arboreum* and reciprocals were established.
- Introgression breeding in *G. arboreum* × *G. herbaceum* genotypes was initiated to improve the fibre length of *G. herbaceum*. Three crosses, namely GVHV 655 × PA 740, GVHV 655 × PA 785 and GVHV 655 × PA 812 including reciprocals were attempted and F<sub>1</sub> crossed seed for each combination was obtained.
- Induction of autopolyploidy: Pre-soaked seeds of diploid were subjected to Colchicine treatment of 0.1, 0.2, 0.5 and 1.0% for 18 hrs and

also the growing axial buds were treated with 0.1, 0.2, and 0.5% Colchicine. Plants showing abnormality for leaf and boll characters, putative plants, have been identified and harvested separately for further advancement and cytological studies.

#### Bt Cotton Varieties

- Early maturing 66 Bt (*cry1Ac* gene; Mon 531 event) F<sub>4</sub> plant progenies were evaluated and most promising progenies were identified.
- Sixty-one genotypes were converted into Bt background which are under various stages of backcross breeding. Fifteen of these converted lines were tested in replicated trial which gave higher seed cotton yield than their non-Bt counterparts. Four of these genotypes were sponsored for testing in AICRP multi-location trial under HDPS.

#### Varietal Development

- Notification of *G. hirsutum* variety CSH 3075: Variety CSH 3075 developed at CICR, RS, Sirsa was evaluated in closer spacing of 67.5 × 10 cm (HDPS) in the North Zone for three years during 2012 to 2014. It ranked first with Zone average yield of 2467 kg/ha against 2037 and 2034 kg/ha of the local checks, an increase of 21.14 and 21.26 percent, respectively over checks.
- Notification of *G. hirsutum* variety CSH 3129: *G. hirsutum* culture CSH 3129 developed at CICR, Regional Station, Sirsa was identified for irrigated north zone. It recorded an overall mean seed cotton yield of 2293 kg/ha as against 1935 kg/ha (>18.5%) and 2068 kg/ha (>10.9%) of zonal and local checks, respectively. It has 29.5 mm fibre length, fibre strength of 23.6 g/tex and was spinnable at 40s count.
- Central Cotton CCH 4474 (Subiksha) has been recommended by Central Variety Identification Committee for release in South Zone States under irrigated conditions. The variety has long staple (30.6 mm), high strength culture (24.0 g/tex) and capable of spinning upto 60s count yarn. It combines high yield potential as high as 4201 kg/ha under closer spacing, better ginning outturn and tolerance to pests and diseases.

- A proposal for identification of CCH 12-2 was submitted to CVIC for Central Zone under irrigated conditions. Central Cotton CCH 12-2 recorded a mean seed cotton yield of 1767 kg/ha as against 1644 kg/ha of the Zonal. The variety recorded UHML (28.0 mm), micronaire (4.2), tenacity (29.0 g/tex) and capable of spinning at 40s count.
- Central Cotton CCH 12-3 recorded a mean seed cotton yield of 1060 kg/ha as against 1053 kg/ha of the Zonal check under rainfed condition of Central Zone. The variety recorded an UHML of 27.0 mm, micronaire of 4.3 and tenacity of 28.7 g/tex and spinnable at 30s count. Proposals for identification of this variety submitted to CVIC.
- Central Cotton CCH 13-2 recorded mean seed cotton yield of 2178 kg/ha as against 2049 kg/ha of the Zonal check under irrigated condition in South Zone. The variety recorded UHML of 26.9 mm, micronaire of 4.2 and tenacity of 27.7 g/tex and spinnable at 30s count yarn. Proposals of CCH 13-2 submitted for identification to CVIC for South Zone under irrigated conditions.
- The long staple culture MM03-39-4-2-3 (CCH 14-1) tested in coordinated varietal trial under irrigated conditions of both central and south zones also exhibited superior fibre quality combining good length and strength and has been recommended for agronomic evaluation.

#### Multilocation Testing in AICRP on Cotton

- In IET of *G. hirsutum*, entries CSH 3269, CCH 16-1, CCH 16-2, CNH 39 and CNH 108 were tested in Br 02 (a) trial. CNH 1125, CNH 09-77, CNH 7012, and CCH 16-3 were tested in Br 02 (b) trial. CSH 5640 and CSH 31292 tested in Br 06 (a) trial. In Br 06 (b) IET of compact genotypes, 8 entries CNH 15, CNH 75, CNH 09-4, CNH 09-62, CNH 1122, CNH 1123, CCH 16-7 and CCH 16-8 were tested. In IET of *G. arboreum*, five entries CNA 2030, CNA 1031, CNA 1032, CISA 333 and CISA 1793 were tested in Br 22 (a/b). *G. barbadense* genotypes CCB 51 and CCB 143 were tested IET Br 12a trial.
- Entries promoted under AICRP trials: *G. arboreum* entry, CSA 1028 stood first in Br. 24b

zonal trial in Central Zone, was retained for second year trial. Two entries CNA 1031 promoted in central and South zone while CNA 1032 promoted for South Zone. CNH 1123 ranked fourth in Br. 06(b) trial promoted in Central Zone.

#### Genetic Diversity

- Diversity analysis of fourteen *desi* cotton (*G. arboreum*) accessions collected from Arunachal Pradesh was carried out using 19 SSR polymorphic markers that produced a total of 43 alleles across all the accessions. Number of alleles per locus ranged from 2 to 3 with a mean of 2.263, PIC values ranged from 0.071-0.529 with average value of 0.295 and three major clusters were formed with fourteen accessions.
- Forty eight released varieties (46 of *G. hirsutum* and 2 of *G. barbadense*) were characterized using 68 SSR markers. A set of 14 SSR markers distinguishing each variety were identified. Twenty four released varieties of *G. arboreum* were characterised using 32 polymorphic markers. A set of 10 robust markers could distinguish each variety. A unique marker BNL 3971 was identified that distinguish *G. barbadense* varieties from *G. hirsutum* varieties.
- Twenty-two popular private sector Bt cotton (BGII) hybrids and 26 popular non-Bt cotton varieties were evaluated for 35 DUS characters and genetic diversity using 62 polymorphic SSR markers. Markers data clearly distinguished the *G. hirsutum* Bt cotton hybrids, *G. hirsutum* cotton varieties and *G. barbadense* cotton varieties. Higher genetic similarity with narrow range was observed among the popular Bt cotton hybrids.

#### Marker Assisted Breeding

- In *G. arboreum*, a set of 193 progenies were selfed and maintained by single seed decent method. The population is intended to be used for genetic mapping studies and for construction of consensus genetic linkage map in a DBT funded project.
- BLB: In three BC<sub>2</sub> populations with Suraj as recurrent parent, 371 plants were screened with marker CIR 246 and phenotyped by artificial



inoculation with BLB culture. One hundred thirty six phenotypically resistant and marker positive plants were subsequently backcrossed with Suraj to obtain BC<sub>3</sub> seeds.

- Nematode resistance: BC<sub>2</sub> populations from Suraj (Suraj x G. cot 10) cross were grown as boll to row progeny while F<sub>3</sub> population was sown in pots for phenotyping. Nematode reproduction was taken as criterion to evaluate reaction in F<sub>3</sub> population to reniform nematode. Marker NAU 2152 located on chromosome 11 was validated for reniform nematode resistance. Plants selected with NAU-2152 marker also showed reduction in nematode reproduction to the extent of 90-93%. F<sub>3</sub> marker positive 10 plants were identified for further advancement.

#### Development of Transgenic Cotton

- Putative transgenic plants 121 of LRK-516, 310 of LRA-5166 and 220 of Suraj were screened. PCR analysis showed positive amplification with 3 of LRA 5166, one of LRK 516 and 4 plants of Suraj. However, ELISA results recorded very low Cry protein expression of transgene.
- Around 1440 putative transformed seeds of *G. hirsutum* var. Suraj were tested for Bt gene expression by ELISA and 142 Bt gene positive plants using leaf were identified while 108 plants were tested positive using seeds.
- Transgenic plants were developed using sense coat protein (*SCP*), anti-sense coat protein (*ACP*) and antisense - replicase protein (*AREP*) genes in three genotypes viz., HS-6, H 777 and F846. T<sub>3</sub> generation 15 plants showed amplification of *ACP* in H777, 2 plants of *ACP* in HS 6, 3 plants of *ACP* in F 846 and 9 plants of *AREP* in F 846 showed amplification.

#### Somatic Embryogenesis of Cotton

- Cotton genotypes AKA 07, PKV 081, Suraj and Coker 310 were screened for response to somatic embryogenesis of which only Coker 310 showed positive response. Tissue culture media was standardized for callus initiation, proliferation, somatic embryo initiation and maturation. High frequency of somatic embryogenesis could be obtained in Coker 310.

- *Agrobacterium tumefaciens* mediated *in planta* transformation protocol was standardized. It involves sonication followed by vacuum infiltration of *Agrobacterium* strain harbouring the transgene deep into meristematic cell mass. Parameters for sonication and vacuum infiltration were optimized for higher transformation efficiency.

#### Seed Quality Improvement

- Effect of plant growth hormones and other chemicals was assessed on seed yield and quality of *G. hirsutum* viz. Suraj. Results indicated glycine betaine (4 mM) followed by putrescine (4 mM) and KNO<sub>3</sub> (4 mM) significantly influenced number of bolls/plant, boll weight, seed cotton yield and GOT. 12.5% increase in seed cotton yield was recorded with glycine betaine (4 mM) (40.4 qt) over control (35.9 qt). Application of spermine (0.5 mM), spermidine (0.1 mM) and putrescine (1.0 mM) had positive effect on fibre strength as compared to control.
- The effect of growth hormones, pollinator attractant and pollinator population was estimated on boll setting and seed setting percentage. Significantly higher boll setting (72%), seed setting efficiency (83.8%) and seed cotton yield (11.3 qtl. SCY/acre) was observed in hand pollination treatment. No significant contribution of pollinators was observed in boll and seed setting in sterile population. However, in fertile population, boll and seed setting were higher.
- Enhancement of primed seeds quality through pulsed magnetic seed treatments was studied. The mean data revealed that seed priming significantly enhanced seed germination to the extent of 12% due to KH<sub>2</sub>PO<sub>4</sub> priming (450 ppm) and MnSO<sub>4</sub> (0.1%) in Surabhi and 10% due to neem leaf extract (1%) and 8% due to KH<sub>2</sub>PO<sub>4</sub> priming (450 ppm) in cv. Suraj. Pulsed magnetic field treatment further enhanced the seed germination to the tune of 13% due to CaCl<sub>2</sub> hydration (2%) and 8% due to MnSO<sub>4</sub> in Surabhi and 7 and 5% respectively due to prosopis leaf extract and CaCl<sub>2</sub> hydration (2%) in Suraj.
- Seed coating significantly enhanced seed



germination to the tune of 13% due to polykote (@ 5 ml/kg) and 12% due to arappu leaf powder (@ 100 g/kg) in Surabhi; whereas 10% due to polykote (@ 5 ml/kg) and 8% due to micronutrient mixture (@ 10 g/kg) in Suraj. Pulsed magnetic field treatment further enhanced the seed germination to the tune of 10% due to micronutrient mixture (@ 10 g/kg) and 9% due to turmeric rhizome powder (@ 20 g/kg) in Surabhi and 5 and 4% respectively due to micronutrient mixture (@ 10 g/kg) and arappu leaf powder (@ 100 g/kg) in Suraj.

### DUS Testing

- Seventy three genotypes, that include 4 candidate varieties, 4 VCK varieties, 12 EDV, their respective initial varieties and 30 reference varieties, were characterized for DUS traits at Nagpur. Twenty nine diploid lines were maintained and multiplied.
- A total of 49 new candidate varieties were tested in the second year trial at Coimbatore. For the first year trial, 5 new candidate varieties, 3 VCK, and 3 EDV along with 3 initial varieties were taken up and 60 reference varieties were grown for comparison. The EDVs and their corresponding initial varieties were compared in protected and unprotected conditions.

### Seed Production

- Breeder seed production of Suvin, Suraj and Surabhi was undertaken at Coimbatore and a total of 126 kg seed produced and distributed to various seed producers.
- Breeder seed of cotton 500 kg, TFL cotton seed 1188 kg and 863 kg seed of cv. Phule Dhanvantri on the Farmers' field was produced. Besides cotton, certified seed of Wheat cv. HD 2967, Red Gram cv. BSMR-736 and Gram cv. Vijay were produced for State Seed Corporations at Haryana and Maharashtra. Resource of around Rs 10.5 lakhs was generated through the sale of seeds / lint.

### Crop Production

#### • Long-linted *Desi* Cottons

Seventeen cultivars of *desi* cotton (*G. arboreum*)

were evaluated for earliness and fibre quality under high density of planting system *vis-à-vis* the popular BGII hybrid Ajeet-155. Three cultivars, G Cot 15, DLSa 17 and Roja were early with respect to days to the time taken for 'first boll opening'. Cultivars TKA-9102/3, DLSa 17, PA 740, PA 812 and PA 785 had longer fibres and greater seedcotton yield than that of Ajeet 155 BG II Bt. Several compact cultures of both *desi* and American cotton developed at the Institute were also evaluated for high yield and fibre quality.

#### • Nutrient Management on Calcareous Soils

Multiple nutrient deficiencies constrain cotton production on calcareous soils. Results of on-farm trials indicate that seed treatment application of chelated form of micronutrient is a better option than foliar spray of the micronutrients along with application of recommended dose of fertilizers. Further seed treatment with humic acid was found to improve germination and root proliferation when sown on ridges and furrows.

#### • Weed Management

Weeding is one of the major operations that add to high cost of cultivation since it is labour intensive. Field trials conducted for the fourth consecutive year indicated that cover crops such as jowar, bajra, sunnhemp, forage cowpea and sesbania were effective in reducing weed density on the rainfed Vertisols at Nagpur and Coimbatore. Compared to polythene mulch that is costly, newspaper mulch was found to be a cheaper alternative and was as effective as the polythene mulch.

#### • Cropping Systems

To sustain production and reduce dependency on legumes, a field trial was conducted with 17 different grain and fodder legumes. *Kharif* legumes were better than the *rabi* legumes. Of the 17 legumes, clusterbean, lablab, groundnut and greengram improved seedcotton yield of the American cotton. However, the productivity of the *desi* cotton 'cv. Phule Dhanwantari' was less with an intercrop than the sole crop. At Coimbatore, cotton - groundnut + pigeon pea, cotton - maize (for green cobs) + pigeon pea,

cotton – black gram – maize (for grain purpose) were significantly superior than the conventional cotton – fallow system.

#### • Brush type Cotton Harvester

Finger type harvester developed in the previous year was found to harvest significant quantity of trash along with the harvested cotton. Therefore, a brush type cotton harvester was developed in a PPP mode with Mahindra and Mahindra. The brush type harvester was field tested. It was found to harvest less trash that is within acceptable limits.

#### • Decision Support Systems

Android mobile based interactive decision support systems (DSS) for cotton pest management with pre-recorded voice modules was developed. DSS aids farmers to identify the pest based on damage symptoms and helps to choose an appropriate pest control measure including selection of pesticide brand of their choice.

Android based mobile app 'Cotton Doctor', a user friendly software tool was developed to support the cotton stakeholders in cotton insect management.

#### • e-Kapas and Advisories

More than 1.59 lakh farmers were registered from the 11 cotton growing states in the country during 2016-17. Voice messages and weekly advisories were provided to the farmers registered. These messages were useful in alerting the farmers on the market prices, weather and control measures for pests and diseases of cotton.

### Crop Protection

- Population of aphids, whitefly and thrips were below ETL in 2016-17 during Nagpur. Jassids were above ETL starting from first week of September to second week of October.
- All the surveyed districts in North India showed whitefly population above Economic Threshold Level (ETL) from September onwards.
- Hanumangarh, Sriganaganagar and Faridkot

districts were identified as the hotspot areas for CLCuD. Disease incidence and severity was not correlated with the number of whiteflies in the surveyed locations.

- Talc based soil application at 30 DAS and 60 DAS of PGPR formulation *B. amyloliquefaciens* ( $2 \times 10^9$  cfu/ml) on cv. Suraj (*G. hirsutum*) and Phule Dhanwantari (*G. arboreum*) significantly reduced population of leafhoppers.
- *Oxycetonia versicolor* was recorded as a pest on cotton during a survey conducted during September, 2016 in Saurashtra region of Gujarat. Incidence was noticed on cotton in 11 districts of Gujarat.
- Six surveys for monitoring mealybug incidence were conducted in 5 districts of Maharashtra during 2016-17. Only two mealybug species viz., *Phenacoccus solenopsis* and *Nipaeococcus viridis* were recorded in surveyed area.
- All the three species of bollworms viz., *Helicoverpa armigera*, *Erias insulana*, *Pectinophora gossypiella* were seen to damage non-Bt cotton. Significant square damage (20%), flower damage (6.67%) by *H. armigera* was seen during reproductive stage of crop. Rosette flowers caused by pink bollworm infestation from mid August with negligible damage at the initial phase, increased up to 20% by mid October.
- In order to identify the prevalent cotton leaf curl viral strain(s) in north India a genetic variability study was carried out. Rajasthan Cotton leaf curl virus (CLCuRV) and Multan virus (CLCuMuV) were the prevalent strains observed in partial sequence study.
- Molecular diversity analysis of whitefly was done for the north Indian population and presence of Asia I and Asia III1 genetic group of whitefly was confirmed. Forty eight gene sequences have been submitted to the NCBI and the accession numbers are KY503195, KY503217, KY547806, KY547830 and KY348784.
- Natural epizootics of an unknown entomopathogenic fungus to the tune of 15 per cent was recorded from Mite, *Tetranychus* sp. during the month of November.

- Fifteen fungal endophytes genera *Cladosporium* sp., *Cochliobolus* sp., *Curvularia lunata* (3 isolates), *Curvularia aerea*, *Curvularia hawaiiensis* and *Aspergillus* sp. were isolated from cotton leaves.
- Out of 42 strains of *Beauveria bassiana* tested 4 strains; F-391, MTCC-4516, MTCC-4497, MTCC-4562 were most effective against aphids. Against jassids 5 strains; (MTCC-4575, MTCC-4605, MTCC-4556, MTCC-4122, MTCC-6099) out of 107 *Beauveria bassiana* strains tested were most effective.
- One step single tube and rapid nucleic acid amplification protocol for the detection of whitefly transmitting devastating cotton leaf curl virus has been developed. This is the first report of use of LAMP for diagnosis of Cotton Leaf Curl Virus (CLCuV) on cotton.
- Natural essential oils in combination with yellow sticky traps were evaluated for possible enhanced efficacy against sucking pests of cotton. The traps treated with Sandalwood oil and Basil oil attracted whiteflies and leaf hoppers significantly.
- Different pheromone traps and lures were evaluated against pink bollworm in cotton. All the lures and traps were at par except in some observations where PCI-Funnel trap along with season long lure (120 Days) was best.
- Seventeen bacteria isolated as endophytes from stem and leaf parts of cotton plant were evaluated against major insect pests of cotton. *Bacillus subtilis* inoculated plant recorded low population of sucking pests and *B. cereus* strain inoculated plant recorded low pink bollworm damage.
- Five *Beauveria bassiana* entomopathogenic fungal endophytes used as foliar spray were recorded effective against sucking pests.
- Parasitoids *Apanteles angaleti* Muesebeck, *Apanteles glomeratus* (L.), *Palexorista laxa* Curran were recorded on cotton semilooper, *Aphelinus mali* on aphids.
- General predators of cotton pests viz., lady bird beetle *Cheilomenes sexmaculata* (Fab.), lace wings *Chrysoperla carnea* (Stephans), lady bird beetle *Scymnus coccivora* Ayyar, predatory stink bug, *Eocanthocona furcellata* (Wolff), big eyed bug *Geocoris ochropterus* (Fieber), etc were recorded.
- Egg parasitoid *Trichogramma bactrae* and *Trichogramma brasiliensis* were evaluated against Pink bollworm through inundative release. The lowest larval infestation was noticed again in insecticides treated plot @ 1.17 larvae/10 green bolls followed by *Trichogramma bactrae* 1.61 larvae/10 GB and *Trichogramma brasiliensis* 1.51 larvae/10 GB as compared control.
- Eight Wax degrading bacteria of genera *Bacillus*, *Enterobacter*, *Pseudoxanthomonas*, *Pseudomonas* and *Serratia* were isolated from carcass of adult female mealybug samples. Two isolates PSAD 2 and PSAD 7 showed maximum biosurfactant potential of 142.14 mm<sup>2</sup> and 115.93 mm<sup>2</sup>, respectively.
- A larval parasitoid, *Rogas* sp. (Hymenoptera: Braconidae) was recorded on the pink bollworm in cotton variety LRA 5166 at Coimbatore. The natural parasitism of *Rogas* sp. was found to be 1.7% on pink bollworm larvae.
- Oil based formulation of *Lecanicillium lecanii* and *Metarhizium anisopliae* was standardized for use against sucking pests. Spraying of formulation at the rate of 10 g/l significantly reduced the population of sucking pests under field condition. Both formulations had shelf life of six months and were safer to the natural enemies (Spiders and Coccinellids) under field condition.
- Addition of corn oil and skimmed milk powder to the *L. lecanii* formulation could increase the spore viability upto 66 per cent as against 22 per cent in spore suspension alone at 4DAS (Days After Spraying).
- Resistance monitoring against cotton whitefly was undertaken by taking 21 insecticides, resistance ratio was < 20 fold.
- Out of the four locations studied (Sirsa, Sriganagar, Hisar, Mansa), among the neonicotinoid, the maximum resistance ratio for white flies was obtained in Thiamethoxam (13.07 folds) and comparatively less in Imidacloprid, Acetamiprid and Dinotefuran.

- Abohar location had maximum resistance Ratio of white flies to Acetamiprid (11.63 folds), Thiamethoxam (58.96 folds) whereas Dinotefuran (17.8 folds) at Sirsa and Imidacloprid (3.14 folds) at Ganganagar recorded highest RR. Among IGRs Sipromesifen (238.6 folds) at Abohar, Diafenthiuron (81.6 folds) at Sirsa were recorded highest RR whereas Pyriproxyfen and Flonicamid were recorded least RR at all the locations studied. Among organophosphate Triazophos (23.42-43.15 folds) was recorded maximum RR.
- The resistance development of pink bollworm on BG-II and non Bt cotton fields was monitored in 37 districts across India. Resistance to Cry1AC and Cry2Ab was recorded in Pink bollworm populations from Telangana, Andhra Pradesh, Gujarat and Maharashtra. Resistance of pink bollworm population ranged between 148 to 1500 fold against Bt toxins.
- Green bolls from Coimbatore (Co 14), Raichur (DCH 32 and RCH2 Bt) and Srivilliputtur (RCH2 BG II, SVPR 2, SVPR 4 and DCH 32) were monitored for the infestation of pink bollworm. Survival of pink bollworm on Bt hybrids was observed on RCH2 Bt from Raichur.
- The two day old larvae of *Earias insulana* were released on BG-II and Bt and Non-Bt plants leaves (at 95-100 DAS) and squares (at 80 DAS) of the genotypes under laboratory conditions. The larval mortality ranged 97.3-100% in BG II and 1.3-2.7 % in Non Bt leaves
- Newer chemistry molecules were evaluated for management of Pink bollworm under High density Planting system (HDPS). The lowest per cent of locule damage was observed in Deck (Cypermethrin+Profenophos) (2.44%) followed by Spark (Deltamethrin+Triazophos) (4.42%) as compared to control (31.17%). The lowest larval incidence was observed in Deck (Cypermethrin+Profenophos) (0.78 larvae/ 10 GB) as compared to control.
- Among eight dispensers evaluated against the pink boll worm on variety LRA 5166, Polypropylene (10.13 adult/trap/week) and the silicone (9.31 adult/trap/week) dispensers were

significantly superior to the standard rubber dispenser (8.44 adult/trap/week). The neoprene dispenser had highest catch (14.67 adult/trap/week) in first three weeks but has short persistence (7 weeks) compared to that of standard dispenser (13 weeks).

- Among the ecological interventions applied for the management of whitefly, guar gum and wax recorded a reduction of 19.53-30.72% in whitefly adults population and found safer to natural enemies.
- Castor oil + liquid soap (55.36%), Pongamia oil (58.36%), Sesame oil + liquid soap (45.48%) and Neem oil were found effective in whitefly adults reduction under laboratory evaluations after diafenthiuron (76.15% reduction). Under field conditions also same trend was observed with comparatively less reduction.
- The efficacy of various insecticides was studied under laboratory conditions at ICAR-CICR Sirsa against all the label claim insecticides for whitefly. Bifenthrin, Diafenthiuron, Flonicamid, and Dinotefuran were found effective against whitefly adults whereas Spiromesifen, Pyriproxyfen and Buprofezin were found effective against whitefly nymphs. Flonicamid and Ethion gave good results against both the adult and nymphal stages of whitefly.
- Disseminated cotton pest management strategies in 28 districts of Maharashtra.
- Among the top 10 entomopathogenic fungi tested against whitefly, the highest nymphal mortality was recorded in MTCC-4511 (*B. bassiana*) (95.1%) followed by MTCC-4565 (*B. bassiana*) (89.9%) and NAIMCC-1299 (86.7%).





## 2. INTRODUCTION

### 2.1: Brief History

The ICAR-Central Institute for Cotton Research was established at Nagpur, 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.

#### Location of the of ICAR-CICR Institute

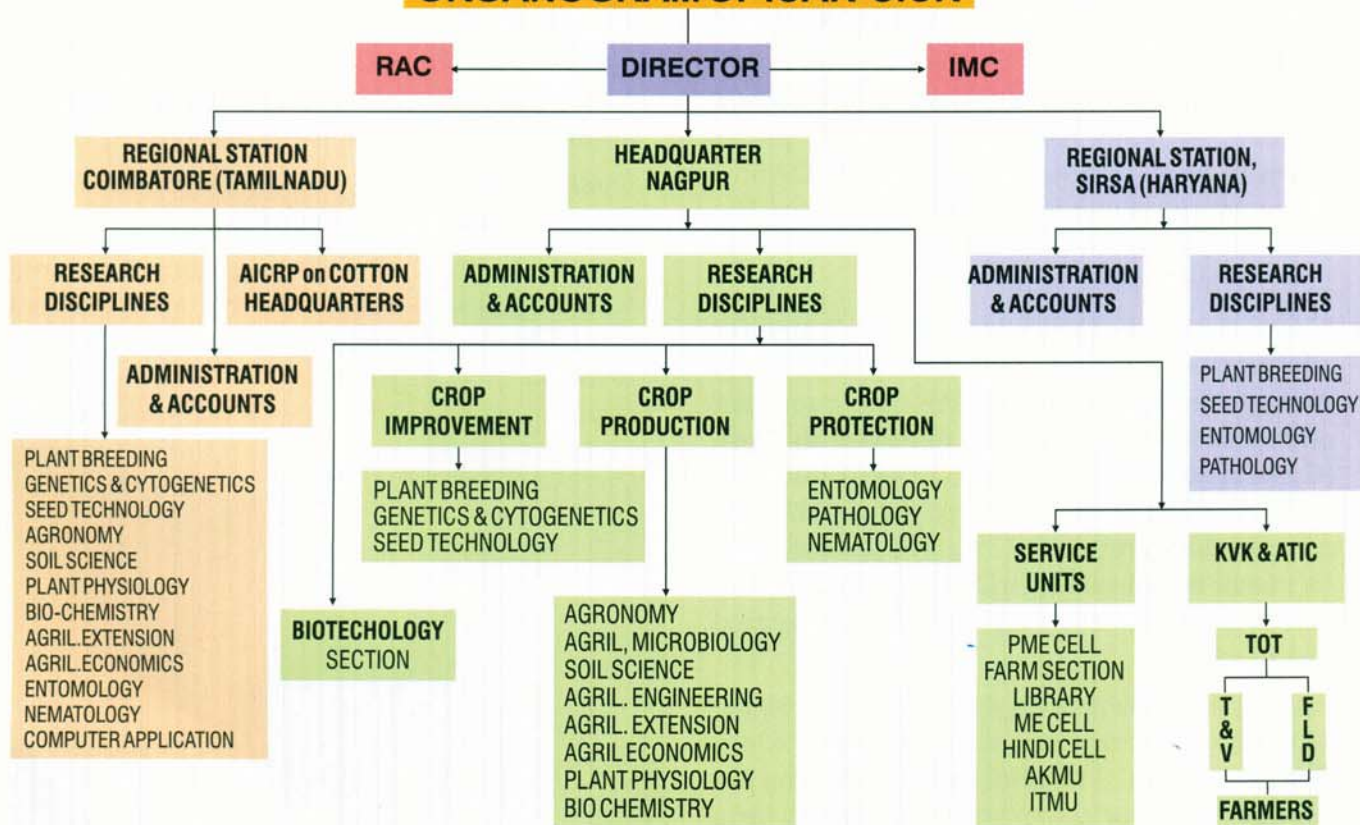
Center	Latitude	Longitude
ICAR-CICR, Head Quarters, Nagpur, Maharashtra	21.037043	79.056023
ICAR-CICR, Regional Station, Coimbatore, Tamil Nadu	11.014327	76.929456
ICAR-CICR, Regional Station, Sirsa, Haryana	29.543302	75.038545

### 2.2: Mandate

- Basic, strategic and adaptive research on production, protection, fibre quality and by-products of cotton
- Creation of new genetic variability for location-specific adoption in cotton-based cropping systems

- Coordination and monitoring of applied research on national and regional issues to develop improved varieties and technologies
- Dissemination of technologies and capacity building

### ORGANOGRAM OF ICAR-CICR



INTRODUCTION

### 2.3 : Staff Position (as on 31<sup>st</sup> March, 2017)

Name of the Post	Sanctioned Cadre Strength				Post Filled Up			
	NGP	CBE	Sirsa	Total	NGP	CBE	Sirsa	Total
Director (RMP)	1	--	--	1	--	--	--	--
Scientific	51	21	8	80	43	20	7	70
Technical	46	16	10	72	22	11	6	39
Administrative	34	9	5	48	21	6	5	32
Supporting	43	17	10	70	31	14	11	56
<b>Krishi Vigyan Kendra</b>								
Training Organizer	1	--	--	1	1	--	--	1
Technical	11	--	--	11	9	--	--	9
Administrative	2	--	--	2	1	--	--	1
Supporting	2	--	--	2	--	--	--	--

NGP - Nagpur; CBE - Coimbatore

### 2.4 : Financial Statement

The budget grant and actual expenditure for the year 2016-17 are furnished below:

(Rs. in Lakhs)

S. No.	Scheme	Sanctioned	Expenditure
<b>ICAR- CICR</b>			
1	Plan	352.00	351.59
2	Non- Plan	3124.36	3136.60
<b>Plan Schemes</b>		2058.56	1967.76
<b>Deposit Schemes funded by outside agencies</b>		320.30	295.09



### 3. RESEARCH ACHIEVEMENTS

#### 3.1: Cotton Genetic Resources

##### Nagpur

##### Exploration and collection of germplasm

ICAR-CICR has conducted National Exploration Programme in collaboration with ICAR-National Bureau of Plant Genetic Resources (NBPGR), New Delhi, Punjab Agricultural University (PAU), Ludhiana and Main Cotton Research Station, Navsari Agricultural University, Surat to collect land races of *desi* cotton and perennial cotton from Assam and Nagaland. Karbi anglong district of Assam and Dimapur, Kohima, Phek, Kiphire and Tuensang districts of Nagaland were surveyed during the exploration programme. Seventeen cotton variants including five *G. arboreum*, eleven *G. barbadense* and one *G. hirsutum* were collected. Among five *G. arboreum* accessions, two represent

*G. arboreum* race *cernuum* which were collected from Karbi anglong district of Assam.

ICAR-CICR in collaboration with ICAR-NBPGR, Regional Station, Cuttack, collected 41 water logging and salinity tolerant accessions of cotton germplasm from Sundarbans regions of West Bengal. Two districts namely, South 24-Parganas and North 24-Parganas, were surveyed during the exploration programme. Among forty-one, thirty-two represents *G. hirsutum* and nine represents *G. barbadense* accessions (Table 3.1.1). Out of nine, eight *G. barbadense* accessions belonged to *G. barbadense* var. *brasiliensis* and they had unique character of fused seeds (Kidney cotton). The collected seeds were conserved in the medium term storage in the Cotton Gene Bank at ICAR-CICR, Nagpur.

**Table 3.1.1: List of perennials/landraces of cotton collected from different regions of India**

Sl. No.	Districts	State	No. of Accessions	Species	Perennial/Landrace
1.	Karbi anglong	Assam	2	<i>G. arboreum</i> race <i>cernuum</i>	Landrace
			6	<i>G. barbadense</i>	Perennial
			1	<i>G. hirsutum</i>	Perennial
2.	Phek	Nagaland	3	<i>G. arboreum</i>	Primitive cultivar
			5	<i>G. barbadense</i>	Perennial
3.	South 24 Paraganas and North 24 parangas (Sundarbans Region)	West Bengal	8	<i>G. barbadense</i> var. <i>brasiliensis</i>	Perennial
			1	<i>G. barbadense</i>	Perennial
			32	<i>G. hirsutum</i>	Perennial

Fibre quality traits of 9 morphologically distinct *G. arboreum* and perennial of *G. barbadense* were

evaluated (Table 3.1.2).

**Table 3.1.2: Fibre quality traits of collected cotton accessions from Assam and Nagaland**

Name of the Species	2.5 % Span Length (mm)	Fineness Micronaire $10^{-6}$ g/in	Bundle Strength Tenacity (g/tex)
<i>G. arboreum</i>	20.7-25.3	3.5->7	23.7-28.5
<i>G. barbadense</i>	30.8-32.5	4.0-5.5	25.5-32.2

### Characterization of perennials and land races

Morphological including DUS characterization was completed for the collected 235 landraces of *desi* cotton and perennials.

### Enrichment of cotton Gene Bank

Five hundred seventy five accessions were added to cotton gene bank consisting 340 of *G. hirsutum* - (high boll weight and high ginning outturn), 26 restorer lines, 84 CMS lines, 72 maintainer B lines, 8 GMS lines, 37 elite lines of heterotic pool, and 8 *G. arboreum* accessions with high boll weight and high GOT.

### Evaluation of germplasm

A set of 36 exotic accessions including 34 Coker variants and 2 accessions of CLCuD resistant were grown in pots, characterized and evaluated for economic and fibre quality traits. The superior accessions were identified for ginning outturn (%), staple length and fibre bundle strength. The



promising accessions are listed trait wise as under-

**Ginning outturn** : EC 882401 (34.0), EC 882398 (33.4), EC 882429 (33.4), EC 882418 (33.2), EC 881780 (33.1), EC 882406 (33.1), EC 882411 (33.1), EC 882415 (33.1), EC 882420 (32.9), EC 882399 (32.8), EC 882428 (32.8), EC 882409 (32.4).

**Fibre length (>30 mm UHML)** : EC 882398 (36.7), EC 882424 (33.1), EC 882408 (32.9), EC 882425 (32.9), EC 807817 (32.8), EC 882420 (31.9), EC 882422 (31.6), EC 882429 (31.5), EC 796545 (31.3), EC 882405 (31.3), EC 882417 (31.1), EC 882415 (30.9), EC 882418 (30.9), EC 882423 (30.9), EC 882431 (30.9), EC 882403 (30.6), EC 882413 (30.6), EC 882426 (30.3).

**Fibre strength (>28 g/tex)** : EC 882398 (32.8), EC 882424 (31.5), EC 882425 (31.3), EC 807817 (30.4), EC 882408 (30.2), EC 882423 (29.8), EC 796545 (29.7), EC 882428 (29.6), EC 882430 (29.3), EC 882431 (29.2), EC 881781 (29.1), EC 882421 (29.1), EC 882419 (29.1), EC 882406 (28.7), EC 882416 (28.5), EC 882400 (28.3), EC 882420 (28.2), EC 882399 (28.0).



### Characterization & Evaluation of Exotic accessions of *G. hirsutum*

#### Colour linted *G. arboreum*

Full spinning test of three brown coloured linted *desi* cotton genotypes was conducted and CSPs were recorded for CNA - 405 (1987), CNA - 407 (1750) and CNA - 407 SPL (1691) while strength (lb) recorded was 141.9, 125.0 and 119.1 respectively.

#### *G. herbaceum*

A set of 582 germplasm of *G. herbaceum* were evaluated for various morpho-economic traits. Six genotypes *viz.*, IC 371582, IC 371575, IC 371587, IC

371560, IC 371602 and IC 371437 had yield level from 160 to 190 g / plant. Grouping of germplasm in open, semi-open and closed boll types, boll shape, fibre length helped to distinguish several genotypes in higher order variation than other traits. Accessions with unique traits like erect type (IC 371260), absence of extra floral nectaries on leaves (IC 371582), dwarf type (IC 371254, IC 371150, IC 371490), high boll weight (IC 371413) and more bolls (IC 371156) were identified.

### Distribution of germplasm

Eight thousand twenty germplasm lines of *G. hirsutum* (7113), *G. arboreum* (330), *G. herbaceum* (565) and wild species seeds and cuttings (12) were distributed to Breeders/Scientists of ICAR-Central Institute for Cotton research and State Agricultural Universities for Cotton Improvement programme.

### Germplasm Field Day

Two germplasm field days on 06 & 27 December, 2016 were organized at Main Cotton Research Farm of ICAR - Central Institute for Cotton Research, Nagpur. Breeders/Scientists of State Agricultural Universities of North Zone, Central Zone and South Zone participated in the event and identified / selected germplasm accessions in the field for their breeding programme. Nine hundred forty three elite germplasm lines of *G. hirsutum* including exotic accessions were selected by the Breeders/Scientist of ICAR and SAUs from the field and the same were later supplied to them.

### Rejuvenation and seed multiplication

A set of one thousand nine hundred accessions of *G. hirsutum* were grown for rejuvenation and seed multiplication.

### Coimbatore

### Maintenance and evaluation of *G. barbadense* germplasm

Three hundred and ten *G. barbadense* germplasm lines were being maintained at CICR, Regional Station, Coimbatore during 2016-17 crop seasons. Accessions with superior plant types in terms of yield, quality,

earliness, hairiness and short branching were identified. Hairy germplasm accessions (11 Nos.) were evaluated for resistance to sucking pests.

### Evaluation of 11 hairy germplasm accessions

Eleven hairy germplasm lines were identified as sucking pests tolerant lines. In order to understand the nature and the density of hairs present in the identified lines, pubescence studies was carried out using Scanning Electron Microscope (SEM). The density of hair was more in HAG-02 and falls under the type pilose. Among the hairy lines, CCB-85, CCB-124, CCB-264 has exhibited dense hairs but when it was subjected to SEM, it was observed that they were moderately hairy and designated as hirsute. Hairy lines were compared with the non hairy type Suvin. Yield performance trial was conducted with the 11 genotypes. However, yield was very low during 2016-17. The pooled yield data of the last 2 years indicated that CCB-124 was superior than the control Suvin.

The ginning outturn of ICB-264 and EC-13 was 35% while the check variety Suvin recorded 29%. With regards to fibre quality parameters, the span length ranged from 33-36 mm. The highest span length was observed in ICB-105 (36.1 mm) followed by HAG-02 (35.4 mm) and ICB-124 (35.1 mm).

### Sirsa

*G. hirsutum* (730) and *G. arboreum* (760) accessions were evaluated for yield traits at ICAR-CICR, Regional Station, Sirsa. Range for trait values and promising entries for each trait were evaluated and given in Table 3.1.3.

Table 3.1.3: Trait wise promising lines

Yield traits	<i>G. hirsutum</i>		<i>G. arboreum</i>	
	Range	Promising lines	Range	Promising lines
Days to flowering	62 - 97	G4-B5 (62), Million Doller (62)	-	-
Plant height (cm)	84-130	355-E6 (84), 78/1A(84), EC 794232 (130), EC 144055 (130)	-	-
Number of monopodia	0 -11	EC 700415 (11), EC 155382 (8)	0 -11	688 (11), 89 (7)
Number of sympodia	1-17	EC 700075 (17) , EC 700073 (17)	2-13	3 (13), 562 (12)
Boll number per plant	3-50	EC692158 (50), EC 700025 (50)	3-44	253 (44),657(41)
Boll weight (g)	1-3.3	EC700472 (3.3), EC700507(3.3)	0.8- 2.95	107 (2.95), 20 (2.95)
Seed cotton yield/plant (g)	10-160	EC137595 (160), EC700247(160)	5-105	74 (105), 41 (105)

### 3.2: Hybrid Cotton

#### Sirsa

##### Evaluation of GMS based *G. arboreum* hybrids

Eight GMS based *G. arboreum* hybrids were evaluated for seed cotton yield with two check hybrids AAH 1 and CICR 2. GMS based hybrids CISAA 16-42 (2815 kg/ha) recorded significantly higher seed cotton yield than the highest yielder check hybrid CICR 2 (2413 kg/ha). Two hybrids CISAA 16-40 (2640 kg/ha) and CISAA 16-42 (2815 kg/ha) recorded significantly higher seed cotton yield than check hybrid AAH1 (2361 kg/ha).

**Maintenance of GMS lines:** Twenty-one GMS lines namely DS5, CISA 2, GAK 413A, CISG-1, CISG-2, CISG-4, CISG-8, CISG-9, CISG-10, CISG-11, CISG-13, CISG-14, CISG-15, CISG-16, CISG-17, CISG-18 (narrow leaf), CISG (broad leaf), CISG-19, CISG-21, CISG-22 (narrow leaf) and CISG-22 (broad leaf) were maintained through sibmating. Pigmented GMS line CISG 20 possess red flower colour with petal spot, robust plant type, thermo-insensitive and no pollen shedders. CISG-20 is proposed for registration as genetic stock at NBPGR, New Delhi.

**Fresh crosses:** Six new crosses were attempted for evaluation of performance for seed cotton yield while crossed seed of 2 hybrids CISAA 16-1 and CISAA 16-2 were produced in bulk (2 kg each) to sponsor in AICCIP trial Br 25a/b.

### 3.3: Genetic Improvement

#### *G. arboreum*

##### Nagpur

CNA-2030 has been promoted to Br 4 a/b advanced trial with an yield of >1500 kg/ha and fibre length of 28.0 mm in Central Zone. CNA-2031 is being sponsored for IET Br 22 a/b for the year 2017-18. It ranked third in Institute trial recording >3000 kg/ha. Fibre quality parameters ranged from (fibre length 22.7 mm, fibre strength-28.1 g/tex, mic value 4.6) to (fibre length 28.9 mm, fibre strength-27.6 g/tex, mic value - 4.4). A maximum of 33.3 g/tex was recorded for one culture. Quite a few lines recorded fibre strength > 30 g/tex indicating the potential for improving fibre quality traits in *G. arboreum*. Five long staple cultures upto

28 mm were multiplied. CNA-2010 recorded yield of 3259 kg/ha, with boll no. of 102 and boll wt. 2.7 g.

##### Coimbatore

*G. arboreum* accessions (1059) were evaluated in augmented block design (ABD 1) for lint yield, boll weight, seed index, ginning percentage, days to flowering, and days to boll opening. A set of 14 accessions out yielded the check varieties while 95 accessions had higher boll weight (3.5 g/boll), 41 genotypes recorded higher seed index (>7.1) and 5 genotypes had higher ginning out turn (>37%). Fourteen genotypes namely AC 3265, AKH 496, PBS 1127 - SP1, AC 3522 B, AC 3216, H 503, H 509, AC 3097, AKA 13 - SP1, N 11-54-31-32, H 173, PBN 565, 3930 A and AC 3244 were identified with single plant yield more than 37 g/pl. Five genotypes viz., AC 727, AC 515, H 502 - SP3, *arboreum* (Surat) - SP1 and O-S-217 - SP1 recorded more than 37 % ginning outturn. Six accessions namely AC 3265, AKH 496, AC 3216, AC 3097, N 11-54-31-32 and AC 3244 were identified with high seed cotton yield (>37g/pl) and early maturity (< 104 days).

##### Sirsa

##### Evaluation of Spinnable *G. arboreum* cultures

Fourteen cultures were tested in RBD along with two checks CISA 310 and CISA 614. None of the genotypes gave higher yield than the checks (Table 3.3.1). However, six genotypes CISA-6-295, CISA 33-8, CISA 33-9, CISA 64, CISA 33-2 and CISA 33-2 possess better fibre properties and yielded more than 22 q/ha. Four cultures (CISA 6-350, CISA 6-295, CISA 33-6 and CISA 33-8) recorded UHML~25 mm or more and fibre strength >24 g/tex.

##### Evaluation of high yielding *G. arboreum* genotypes

Sixteen genotypes were evaluated in RBD with two checks CISA 310 and CISA 614. Two genotypes CISA-6-165 (3026 kg/ha) and CISA-8 (3193 kg/ha) recorded significantly higher seed cotton yield than local check CISA 614 (2664 kg/ha). Two more genotypes namely CISA 6-2 (2963 kg/ha), and CISA 6-187 (2895 kg/ha) gave significantly higher seed cotton yield than local check CISA 310 (2535 kg/ha).

Table 3.3.1: Performance of spinnable *G. arboreum* genotypes in replicated trial

S. No.	Genotype	Seed cotton yield (kg/ha)	GOT (%)	Boll wt (g)	UHML (mm)	UI	Strength	Mic
1	CISA 6-350	2037	39.0	1.9	23.40	80	23.3	6.8
2	CISA 6-295	2320	38.2	2.0	25.2	81	23.8	6.6
3	CISA 33-6	1571	36.3	1.8	24.7	81	24.0	5.7
4	CISA 33-7	1816	39.1	1.8	23.1	80	23.3	6.6
5	CISA 33-8	2264	39.1	1.8	24.2	80	23.7	6.0
6	CISA 54-1	1482	39.7	1.9	23.2	80	23.7	6.3
7	CISA 41-1	1904	38.3	1.7	23.5	80	23.3	6.9
8	CISA 33-9	2677	40.9	1.9	20.3	77	22.2	7.3
9	CISA 6-256	1535	39.2	1.8	24.5	81	23.9	6.5
10	CISA 6-209	1915	38.2	1.8	23.8	80	23.7	6.7
11	CISA 64	2243	36.0	1.5	22.1	79	22.7	6.6
12	CISA 33-1	1952	38.0	1.8	24.6	81	24.4	6.2
13	CISA 33-2	2282	38.6	1.8	24.3	80	24.3	6.7
14	CISA 33-3	2671	38.1	1.9	24.0	80	24.3	6.7
15	CISA 614	2886	39.3	1.8	21.2	78	22.4	7.1
16	CISA 310	3609	40.2	2.0	19.7	77	22.0	7.2
	CD	325						
	CV	8.8						

### Evaluation of high strength lines

Twelve cultures from ICAR-CICR, Nagpur were evaluated in replicated trial at Sirsa (Table 3.3.2). Only two cultures gave seed cotton yield >18 q/ha. Four cultures CNA-1054 (27.3 mm, 28.0 g/tex), CNA-1056 (28.1 mm, 28.6 g/tex), CNA-1057 (27.0 mm, 26.8 g/tex) and CNA-1063 (27.2 mm, 27.1 g/tex) recorded UHML >27.0 mm and better fibre strength.

### Evaluation of long linted cultures

Four long linted cultures were evaluated along with quality check PA 255. All the cultures recorded higher seed cotton yield and UHML than quality check; however the yield levels were comparatively very low (577 to 1006 kg/ha).

### Station Variety Trial

Under station trial, eight cultures along with two checks CISA 310 and CISA 614 were evaluated for

their yield performance (Table 3.3.3). Cultures CISA 33-5, CISA 7, CISA 6-165 and CISA 8 gave higher seed cotton yield than both the checks, CISA 310 and CISA 614. The cultures CISA 33-5 and CISA 7 recommended to be sponsored for evaluation in AICRP Br 22a/b National Trial during 2017-18.

### American cotton *G. hirsutum*

#### Nagpur

#### Improvement for earliness and fibre quality

Twenty-five entries were evaluated in replicated trial for seed cotton yield and fibre properties. CNH 09-73 recorded highest seed cotton yield of 3074 kg/ha followed by CNH 09-79 (2608 kg/ha) and CNH 09-70 (2508 kg/ha). Entry CNH 09-45 recorded highest bundle strength of 35.8 g/tex followed by CNH 09-77 (34.7 g/tex) and CNH 09-72 (34.6 g/tex) with long staple of 30.4 mm, 30.0

Table 3.3.2: Evaluation of high strength lines

S.No.	Entry Name	Seed Cotton Yield (kg/ha)	GOT %	Boll Wt (g)	UHML (mm)	UI	Strength (g/tex)	Mic
1	CNA-1052	447.74	38.67	1.23	25.6	81	25.6	4.9
2	CNA -1053	1661.59	39.30	1.33	26.4	82	27.2	5.4
3	CNA -1054	1910.35	30.47	1.57	27.3	82	28.0	5.7
4	CNA -1055	1266.53	29.13	1.43	26.8	82	27.6	5.3
5	CNA -1056	1350.75	43.47	1.37	28.1	83	28.6	5.4
6	CNA -1057	1024.90	33.20	1.57	27.0	82	26.8	5.7
7	CNA -1058	1129.56	36.63	1.55	26.6	82	27.3	5.7
8	CNA -1059	1601.03	40.63	1.47	26.7	82	26.6	5.7
9	CNA -1060	1822.91	35.63	1.54	26.3	82	26.6	5.7
10	CNA -1061	1505.42	38.57	1.50	26.4	82	26.4	5.5
11	CNA -1062	1426.75	36.77	1.41	26.2	82	26.3	5.8
12	CNA -1063	1103.70	37.83	1.76	27.2	82	27.1	5.7
	CD	216.09						
	CV	7.16						

Table 3.3.3: Variety Station Trial

S.No.	Entry Name	Seed Cotton Yield (kg/ha)	GOT %	Boll wt (g)	UHML (mm)	UI	Strength (g/tex)	Mic
1	CISA 6-165	2401	41	2.0	21.6	78	22.5	6.8
2	CISA 33-6	1530	38	1.9	24.5	81	24.0	5.3
3	CISA 41-1	1956	38	1.8	24.6	81	25.0	6.2
4	CISA 33-5	2512	45	2.0	21.4	78	22.3	6.4
5	CISA 33-2	1924	40	1.7	23.7	80	23.6	6.4
6	CISA 7	2463	45	2.0	21.5	78	23.0	6.5
7	CISA 8	2362	45	1.9	22.3	79	22.8	6.6
8	CISA 405	1993	46	2.0	20.9	78	22.0	6.3
9	CISA 310	2058	45	1.9	20.9	78	22.5	6.7
10	CISA 614	2318	44	2.2	21.7	79	22.4	6.5
	CD	245						
	CV	6.60						

mm and 29.3 mm, respectively.

In another trial, CNH 09-11 recorded highest seed cotton yield of 3085 kg/ha followed by CNHIS 5 (2997 kg/ha) and CNH 8 (2746 kg/ha). Entry CNH

8 had boll weight of 5.8 g with seed cotton yield of 2746 kg/ha and fibre bundle strength of 30.2 g/tex. Entries CNH 09-11, CNH 09-32 and CNHIS-3 had recorded fibre bundle strength 31.3 g/tex, 30.9

g.tex and 30.3 g/tex, respectively. CNH 09-4, CNH 09-5 and CNH 09-62 were sponsored in Br 06 (b) -Initial Evaluation of Compact genotypes under rained condition for the year 2017-18.

Three-way and multiple crosses were attempted in order to increase genetic variability in the populations. In segregating populations of these crosses, single plant selections were made. Around 3200 single plants were selected from populations of three-way and multiple crosses for better quality, tolerance to sucking pests and early maturity of 145-165 days.

In three-way crosses, cross (NH615 × Suvin) × IC 356751 had staple length of 33.0 mm with fibre strength of 31.0 g/tex. Cross (Suraj × G-21-19-619) × NH 615 had staple length of 30.2 mm and fibre strength of 31.3 g/tex. Amongst complex crosses, cross (Suraj × G-21-19-615) × (NH615 × CCH 4474) had staple length of 32.8 mm and fibre strength of 30.7 g/tex followed by cross (NH615 × CCH 4474) × (Suraj × CCH 4474) with staple of 29.1 mm and fibre strength of 29.8 g/tex in comparison to parents NH 615 (27.5 mm, 25.2 g/tex) and Suraj (29.7 mm, 30.4).

Single plant selections (1400) were made for recombinants and transgressive segregants in F<sub>2</sub> population of *G. hirsutum* × *G. barbadense* crosses. Single plant selections of segregating F<sub>2</sub> generation of three-way and multiple crosses were affected with Suraj, NH 615 and CCH 18-5.

Entries CNH 7012-13 and CNH 09-4, CNH 09-62 sponsored in AICCIP trials Br 02 (b) and Br 06 (b), respectively during 2016-17. CNH 09-4 recorded fibre bundle strength of 29.0 g/tex and ranked first

in Central zone. Entry CNH 09-62 recorded upper half mean length of 30.1 mm (rank 4 - Central zone) and fibre bundle strength of 33.0 g/tex (rank 5 - South zone).

Seven promising advanced breeding lines CNH 12-4-2, CNH 2-2, CNH 09-7, CNH 10-6-1, CNH 09-77, CNH 18-8-3 and CNH 12-12-4 were entered in Institute Common Trial 2016-17. Of the seven, two entries CNH 12-4-2 and CNH 09-77 were promoted to multilocation Initial evaluation trial Br 02 (b) under AICRP for 2017-18.

### Compact type and jassid tolerance

A total of 91 F<sub>1</sub> populations were evaluated for different traits including earliness, jassid tolerance and compact plant architecture. The promising F<sub>1</sub> populations having higher seed cotton yield and boll weight were selected for generation advancement. Six F<sub>2</sub> populations from these crosses developed in 2014-15, were evaluated and promising plants were selected based on earliness, jassid tolerance, compact plant architecture, boll weight and seed cotton yield. Twenty-six non-Bt and 66 Bt (*cry1Ac* gene; Mon 531 event) F<sub>1</sub> plants to progeny rows and individual plant selections were evaluated (Photo a & b) and most promising progeny selections were selected for further advancement. These selected progenies (Photo c) possess earliness (120 days), jassid tolerance (grade I- II), compact plant architecture (height 100 cm and horizontal width 40 cm with 0-1 monopodia), boll weight (3.5-5 gm), fibre length (23-27 mm) and fibre strength (24-27 g/tex). These promising progenies have the potential to provide higher cotton yields under HDPS.





Promising early maturing selections [a: Field View; b. progeny view, c: Individual plant selections]

**Coimbatore**

**Long staple *G. hirsutum* with improved fibre strength**

Thirteen long staple cultures were evaluated in the station trial along with long staple check varieties viz., Surabhi and Suraj. Yield data analysis indicated significant differences among the entries and six test cultures recorded significantly higher seed cotton yield over the best check variety. The highest seed cotton yield of 1566 kg/ha was recorded by the test culture YLS 21-4. The test culture YLS 19-2 combined superior yield (1315

kg/ha), upper half mean length (34.5 mm) and tenacity (33.3 g/tex).

From the segregating population, 45 single plants with big boll were identified. Thirty single plants were selected with the mean ginning outturn of 45.1%. The maximum ginning outturn recorded was 48.5%. In addition, 89 single plants with brown lint were selected for further screening.

Two big boll progenies viz., Surabhi x MM02 19-1-10-3-3-3 and CCH 526612 X VN WH-1-26-1-3-2 showed promise in yield and fibre quality parameters.



Surabhi x MM02 19-1-10-3-3-3



CCH 526612 X VN WH-1-26-1-3-2

**Sirsa**

**Breeding for high strength in *G. hirsutum***

Thirteen crosses were attempted between 5 long linted Coimbatore types with 3 high fibre strength Sirsa cultures. F<sub>8</sub> progenies of the two crosses viz; CSH-3119-10-30-60 (1842.6 kg/ha and MMO.3 (39-2-5)-3114-10-64 (1831.26kg/ha) were early in maturity and higher yielding than the Check H-1226 (1770.9 kg/ha). These progenies performed

better for yield and fibre quality for last three years.

**Breeding for high GOT and seed cotton yield**

Evaluation of 13 F<sub>7</sub> recombinant inbred progenies of the cross SA-977 (HG) x SA-112 (LG) in an un-replicated trial revealed that the progeny P-69 (2414 kg/ha) and P-164 (2220 kg/ha) had significantly higher seed cotton yield than Check H-1226 (1718 kg/ha). As many as seven recombinant inbred line progenies viz; P-68, P- 69,

P-70, P-84, P-139, P-164 and P-184 possessed GOT equal to or more than 40%.

F<sub>5</sub> individual plant progenies of three selected crosses were evaluated in a replicated trial. Progenies P-17 (2304 kg/ha), P-4 (2198 kg/ha) of the cross RS-875 x SA524 and F-1861 x SA668; P-15 (2202 kg/ha), P57 (1931 kg/ha) and P6 (1849 kg/ha) of the cross F-1861 x SA-668 recorded more than 40% GOT in comparison to check F-1861(1951 kg/ha) with GOT of 34%.

#### **Breeding for CLCuV tolerance**

**Evaluation of *G. hirsutum* cultures :** Twenty-three *G. hirsutum* cultures were evaluated against the check varieties RS 2013, LH 2076, F 1861 and susceptible check HS-6 in RBD with three replications. The highest seed cotton yield was recorded in the advance culture CSH 1602 (3111 kg/ha) followed by CSH 2916 (2675 kg/ha) as against the check variety LH 2076 (2505 kg/ha). Maximum ginning out turn of 40.3 per cent was recorded in the culture CSH 2931. The culture CSH 1602 also recorded the highest upper half mean length of 28.2 mm and CSH 2836 recorded the bundle strength of 26.1 g/tex.

**Selection of single plants progenies :** To develop the segregating populations of *G. hirsutum* cotton, 16 crosses were attempted among CLCuV tolerant germplasm lines in Line x Tester fashion. Out of 91 single plants progenies six progenies with high yield potential and tolerance to CLCuV were selected in F<sub>5</sub> generation. The culture CSH 1705 recorded the highest yield of 2140 kg/ha followed by CSH 1702 (1783 kg/ha) as compared to check variety LH 2076 (1708 kg/ha). The culture 1701 recorded the highest ginning out turn of 40.0 % followed by CSH 1707 (39.7%).

**Screening of exotic germplasm against CLCuV:** Two germplasm lines GVS 8 and GVS 9 were screened against CLCuV in poly house and screening nursery and were found to be free from cotton leaf curl virus disease.

#### ***G. barbadense***

##### **Coimbatore**

#### **Identification of extra long staple (ELS) genotypes**

In all, 21 high yielding early maturing ELS

genotypes were identified. Among them, CCB-29 exhibited highest seed cotton yield of 16 q/ha with 38.4 mm staple length, 32 g/tex bundle strength and micronaire value of 3.4  $\mu$ /inch. The culture CCB-29 was sponsored in AICRP trial-2015-16 and subsequently promoted to zonal trial and ranked third in yield and second in fibre length and bundle strength. Six high yielding early maturing, ELS genotypes *viz.*, CCB-51, CCB-64, CCB-129, CCB-143, CCB-143B and CCB-93 were identified during 2016-17 crop season. The promising genotypes *viz.*, CCB-51 and CCB-11 were promoted from IET to PVT in 2017-18. Four promising advanced genotypes were entered in IET National Trial during 2017-18. Two promising ELS genotypes (CCB-143 and CCB-129) and one inter-specific hybrid CCHB-32 was entered in an initial evaluation trial during 2017-18. A stable complete cleistogamous plant progeny was identified in the segregating populations of *intra-barbadense* cross (Suvin x Giza-45).

#### ***G. herbaceum***

##### **Nagpur**

Thirty one genotypes identified for early maturity in the last year and it was confirmed further during 2016-17 crop seasons in replicated trial. Early maturity traits *viz.*, days to germination, days to first squaring, days to first flowering, days to first boll opening, percentage of yield at first picking and days to harvest were recorded. Seasonal effects were highly significant with respect to seed cotton yield. IC - 371437 recorded highest seed cotton yield (3078 kg/ha) followed by G. Cot - 25 (3049 kg/ha). Out of 32 genotypes, 12 recorded seed cotton yield ranging from 20 to 30 q/ha. In the accessions Baluchistan-1, IC 371100, IC 371112, IC 371118, IC 371130, IC 371148, IC 371158, IC 371166, IC 371437, IC 371561, G. Cot - 25 and Jayadhar, 60 to 70% seed cotton was harvested in the first picking at 180 days. Significant negative association was found between percent first picking and days to germination (- 0.758), plant height (-0.579), days to first squaring (-0.472), days to first flowering (- 0.496) and days to first boll opening (-0.391).

## Genetic enhancement

### Nagpur

Eleven *G. hirsutum* cultures were evaluated with two checks *viz.*, Suraj and NH-615 in a multi-location trial at Sirsa, Nagpur and Coimbatore. It revealed superior performance of CNH-2046 with regard to seed cotton yield (3148 kg/ha), lint yield (1023 kg lint/ha) and GOT (39.3%) over check varieties Suraj (2963 kg/ha) and NH-615 (2861 kg/ha) at Nagpur Centre. CNH-2049 recorded better fibre quality (fibre length 30.3 mm, fibre strength of 23.3 g/tex) and CNH-2039 showed a synchronous flowering and high GOT (39.6%) at Coimbatore. CNH-2048 (lint yield 795 kg/ha) was superior to check Suraj (706 kg lint/ha) and NH-615 (477 kg lint/ha) at Sirsa. Nineteen jassid tolerant lines tested revealed superiority of CNH-2053 (3148 kg seed cotton /ha) and CNH-2067 (3056 kg/ha) over checks Suraj (2222 kg/ha), NH-615 (2222 kg/ha), and LRA-5166 (2500 kg/ha). CNH-2052 recorded fibre length 32.1 mm, fibre strength 25.4g/tex; CNH-2064 recorded fibre length 32.8 mm and fibre strength 24.6 g/tex. Of the 17 high fibre strength lines tested, CNH-2068 recorded fibre length (31.3 mm) and fibre strength of 33.5 g/tex (HVI mode). In two backcross populations *viz.*, LRK-516 x (LRK-516 x Deltapine-66) and PKV-081 x (PKV-081 x PIL-8), there was a visible genetic gain with GOT 40.0% and boll weight 5.3 g in the respective backcrosses from a base value of 36% in case of LRK-516 and 3.0 g in case of PKV-081. In the entire spectra of fibre quality, fibre length upto 33.5 mm and fibre strength of 33 g/tex were identified. CNH-2050 ranked fourth in Institute trial and was sponsored for IET AICRP trial for 2017-18.

### Sirsa

#### GMS based random mating population

At flowering, the individual plant in the population was monitored for sterility/fertility at anthesis repeatedly at an interval of a week and tagged all the 440 sterile plants. All the out-crossed bolls from the sterile plants in the population were bulk harvested and ginned to constitute the next cycle of GMS based random mating population. After the fifth cycle of random mating 105 fertile plants having high yield potential and tolerance against CLCuV were selected for evaluation in progeny to row trial.

#### Interspecific hybridization

##### Nagpur

In order to develop synthetic polyploids which can help in introgression of genes from diploid *Gossypium* species for Upland cotton improvement with specific reference to CLCuV and whitefly resistance, pollen from *G. raimondii* ( $D_5 D_5$  genome) plants were used for crossing with *G. herbaceum* ( $A_2 A_2$  genome) cv. Jayadhar, G.cot. 25 and DDhC11 and  $F_1$  seeds were harvested. *G. hirsutum* (AADD genome) cv. CNH 409-9, Arogya, CNH 1102, CCH 15-1, Ganganagar Ageti, Sahana and CCH 2623 were crossed with *G. arboreum* ( $A_1 A_1$  genome) cv. Roja and PA 255. Very limited seeds were harvested. Colchiploidy was attempted on  $F_1$  seeds of *G. arboreum* x *G. raimondii* developed in 2015-16 to obtain *G. arboreum* based synthetic polyploids. Plants treated with colchicine exhibited some strange phenotypes like Y forking of stem, smaller leaf size, thicker leaves, shorter internode, delayed growth and flowering (upto 1 month), etc. Very few bolls were set on the treated plants and very few seeds were harvested. Plants were pruned for regrowth and for confirmation of results including ploidy status through cytology.



Colchicine treatment of  $F_1$  seeds of *G. arboreum* x *G. raimondii*

### Breeding for earliness

Fifty-five  $F_1$ s and 12 parents were evaluated in RBD for earliness and better fibre properties. Crosses IC 356847 × Suraj, Peedee-4548 A × IC 358438, Pee dee 4548 A × IC 358149, FTA 266 × IC 358438, Pee dee 875B × IC 358149, Sengul-2 × IC 358438, C1412 × IC 358438, C1412 × IC 358149, IC 358149 × Suraj and IC 358438 × Suraj were identified for better fibre properties and earliness. Cross Pee dee 4548 A × FTA 266 had recorded fibre strength of 32.6 g/tex, followed by IC 358149 × Suraj (32.1 g/tex) and FTA 266 × IC 358438 (31.5 g/tex). For earliness crosses Pee dee - 4548 A × IC 358438, FTA 266 × IC 358438 and FTA 266 × C 1412 recorded earliness index of 0.9 indicating early maturity. Parental lines *viz.* C 1412, PRS 72 and Pee dee 4548, Pee dee 875 B also recorded early maturity index of 0.9 and 0.8, respectively. Parents IC 358438 and C 1412 were good general combiners for earliness index.

### Big boll character

Twenty-three advance progenies ( $F_8$  generation) of a cross Ganganagar Ageti × Acala 44  $B_2$  which was reported to possess boll weight of 7.89g were evaluated for boll weight for the fourth consecutive year. The progenies are showing stability for boll weight (3.49 to 5.32 g). Some lines *viz.* 137/1, 137/2, 138/2, 140/1, 140/2, 148, 149 recorded high yield, boll weight upto 5 g and good fibre quality.

### Drought tolerance

#### Nagpur

Three experiments were conducted under rainfed and irrigated condition to evaluate breeding materials for drought tolerance. During the crop season, intermittent to heavy rain was received until the month of October, hence, no moisture stress was observed obviating requirement of irrigation for the crop. Hence, all the experiments were treated as rainfed. Twelve crosses in  $F_4$  generation were evaluated alongwith their parents and two checks *viz.* LRA 5166 and Rajat. Seed cotton yield (SCY) ranged from 1404 to 2877 kg/ha. Highly significant differences for SCY were observed. Six genotypes were at par to the check

LRA 5166 (2648 kg/ha SCY) and seven to Rajat (2386 kg/ha SCY). PKV 081 × CCH 510-4 recorded highest seed cotton yield of 2877 kg/ha with 7% increase over the check LRA 5166, boll weight of 4.1 g, GOT 35%, UHML 40 mm, fibre strength 29.9 g/tex, micronaire 3.9 ug/in, uniformity ratio of 83% and elongation 5.1%. This cross was followed by NH 615 × Rex, PKV 081 × P3 and PH 93 × Rajat.

Eight identified drought tolerant lines were evaluated alongwith five good performing genotypes and check LRA 5166. The treatments showed significant differences for seed cotton yield which ranged from 2378 to 3326 kg/ha. All the genotypes exhibited of 15% more SCY than the check LRA 5166 (2378 kg/ha). DTS 104 was the highest yielder recording 3326 kg/ha seed cotton yield, boll weight of 4.8 g, GOT 37.6%, fibre length 28.3 mm, fibre strength 25.6 g/tex and micronaire 3.5 ug/in.

Another experiment comprised of testing of 31  $F_2$  generation crosses of single, double, six, eight parental and three-way cross. The crosses showed significant differences for seed cotton yield and ranged from 1733 to 3395 kg/ha. Multi-parental crosses were attempted to obtain good combination of desirable characters which is otherwise very difficult to obtain in single cross. Boll weight in this material ranged from 3.1 to 5.2 g and GOT from 33 to 38%. Some of these crosses *viz.* PH 93 × Suraj, (CCH 510-4 × MOCO) × (NH 615 × Rex) × (PH 93 × Rajat), (28I × HSD) × (NH 615 × Rex) recorded very good fibre properties indicating scope to get good lines from these crosses.

Fifteen new crosses (single, eight and ten parental crosses) were evaluated alongwith parents. Single crosses involved parents with cluster boll bearing habit and good fibre quality to develop drought tolerant genotypes for high density planting system. All  $F_1$ s showed cluster bearing indicating it to be a dominant trait. The seed cotton yield ranged from 1712 to 4373 kg/ha. Cross CB 228 × G 21-19-615 recorded boll weight of 6.76 g with GOT upto 37% and SCY of 3104 kg/ha.

To improve the fibre quality of identified drought tolerant culture, 28I, backcross progenies (5 nos.) were raised alongwith parents. Seed cotton yield

ranged from 1699 to 3191 kg/ha, lowest being for the cross where Suvin as donor parents was involved. The crosses showing good yield during this crop season had also recorded good yield in the previous year and recorded 50% increase in yield over the drought tolerant culture 28I (1981 kg/ha SCY).

Nineteen advance cultures were tested along with check at Regional Station, Coimbatore for the effect of stress on plant growth, changes in the biochemical and photosynthetic activities besides seed cotton yield. Based on the effect of stress on these parameters, DTS 402, DTS 404, DTS 406, DTS 407, DTS 408, DTS 419 and LRA 5166 were identified as drought tolerant and DTS 410 and DTS 413 as moderately tolerant genotypes.

#### Water logging tolerance

Ten tolerant (4314, 4409, 4393, 4458, 4460, 3694, 3844, 4282, 2283, 2289) and 4 susceptible lines (3742, 2085, 3207, 4231) were shortlisted for Marker Assisted Breeding (MAB).

Crosses between waterlogging tolerant and susceptible accessions were attempted. Based on information about submergence gene tolerance in rice, three primer sets were designed targeting submergence gene and ethylene - responsive element binding gene respectively to identify the submergence tolerance in cotton. Both tolerant and

susceptible genotypes under study showed amplification for the designed primers and no polymorphism was detected.

Two hundred and ten germplasm accessions were screened at Coimbatore based on morphological characters/reflecting growth, soil plant analysis device (SPAD) values, time of lenticels and adventitious roots formation, iron deficiency, nitrate reductase activity and yield and yield components to confirm the identified tolerant and susceptible accessions (Table 3.3.4).

**Table 3.3.4 : Range of different parameters observed in 210 germplasm lines**

S. No.	Parameter	Range
1	Plant height (cm)	25.0 to 72.7
2	Number of sympodia per plant	7.0 to 27.0
3	Height to node ratio	0.1 to 2.3
4	Number of leaves	14.0 to 115
5	SPAD value	3.3 to 22.7
6	% reduction of SPAD value over control	26.7 to 89.2
7	Nitrate reductase activity (NO <sub>2</sub> g/h)	11-170 ug



Iron deficiency symptoms started at 5 days after initiation of waterlogging. However few lines did not show Fe deficiency symptoms upto 10 to 15 days after initiation of waterlogging.



Lenticels and Adventitious roots formation, Lenticels formed as early as 5 Days after initiation of waterlogging.



**Submergence study in cotton based on information available in rice** (Fukao et al. 2009 Annals of Botany 103: 143-150)

Primers	Sequence	Amplicons
Primer Sub1 F& R	Sub1-forward (5' <u>GAVGAMTGGGAGGCCGCTTCCRS</u> GAGTTC-3') Sub1-reverse (5'-GTCGWAGSCGGCGAGGAGGCT <u>GTCCATC</u> -3'), Where M=A or C, R=A or G, S= C or G, V=A or C or G, and W=A or t.	
Primer 3 & 4	Forward <u>AGCCCTGTT</u> CAGCCAAAT Reverse <u>TTGACCGATGGCTTCTCTTC</u> ( <i>Gossypium hirsutum</i> ethylene-responsive element binding protein ERF2 )	104
Primer 5 & 6	Forward <u>CAA</u> ACTTGAGCAGGGCTACTA Reverse <u>ATTCTCAGGGTCAGCAA</u> AGG ( <i>Gossypium hirsutum</i> putative ethylene responsive element binding protein mRNA, complete cds)	133



T-Tolerant S-Susceptible Accessions

### Population Improvement

#### Nagpur

**Conventional random mating population :** The random mating population developed through conventional crossing was maintained by bulk harvesting one open boll from each plant in both *G. arboreum* and *G. hirsutum*.

**GMS based simple recurrent selection:** From among 296 single plant progenies of *G. arboreum* and 504 of *G. hirsutum* evaluated, about 5-7% superior plant progenies were identified separately for boll weight, seed cotton yield, GOT,

fibre strength and fibre length. The selected plant progenies seed from the previous year was bulked to form trait specific groups. Trait based bulk seeds of selected progenies were grown on large plots comprising population of about 1000 plants, and the populations were allowed open cross pollination. At flowering, all sterile and fertile plants were tagged. For enhanced out crossing, flowers from fertile plants were randomly collected and used for crossing flowers of sterile plants in the same trait specific population during the entire flowering period. All sterile plants from each group harvested separately for plant progeny

evaluation for second cycle of recurrent selection. About 50-60 single superior fertile plants from each group were selected for evaluations as plant to row progeny.

**Evaluation of single plant selection :** Large number of single plant selections from random mating population and reselected plants from the segregating progenies, about 2634, were evaluated in plant to row progeny plots. Based on the performance and uniformity of plant progenies about 40 progenies (16 of *G. hirsutum* and 24 of *G. arboreum*) were identified for evaluation in replicated trial. Based on manual evaluation for fibre quality traits, about 1650 superior single plants were reselected from the segregating plant progenies.

**Evaluation of advance cultures :** One hundred and

forty five *G. arboreum* cultures and 150 cultures of *G. hirsutum* were evaluated in 12 different trials (4 rows plots in 2 replications) during the crop season 2016-17. In all, 7 trials of *G. arboreum* and 5 of *G. hirsutum* were conducted following spacing of 60 x 45 cm and 60 x 60 cm, respectively. Seed cotton yield among the *G. arboreum* cultures ranged from 1277 to 4996 kg/ha while in *G. hirsutum* it ranged from 1488 to 3081 kg/ha. Based on the seed cotton yield performance about 60 cultures of *G. arboreum* and 55 of *G. hirsutum* were retained for second year replicated trial. From the evaluated selections, four *G. hirsutum* and six *G. arboreum* cultures entered in AICRP National trial. The cultures entered in AICRP trials were grown on large plots for seed multiplication which included CNA 1028 of *G. arboreum*, CNH 11-11, CNH 1123, CNH 1125, and CNH 1126 of *G. hirsutum*.

**Plants with high boll number, big boll size and compact plant type selected from random mating population**



*G. hirsutum*



*G. arboreum*

### 3.4: Genetic diversity through introgression

Twenty four (24) wild species, 15 races of cultivated species and more than 45 synthetic polyploids were conserved in the wild species garden and green house. During 2016-17, fresh crosses were attempted using wild species *G. capitata virides*, *G. anomalum*, *G. stocksii* and *G. longicalyx* for diversification of genetic base. Single plant selections were made from F<sub>4</sub> population of

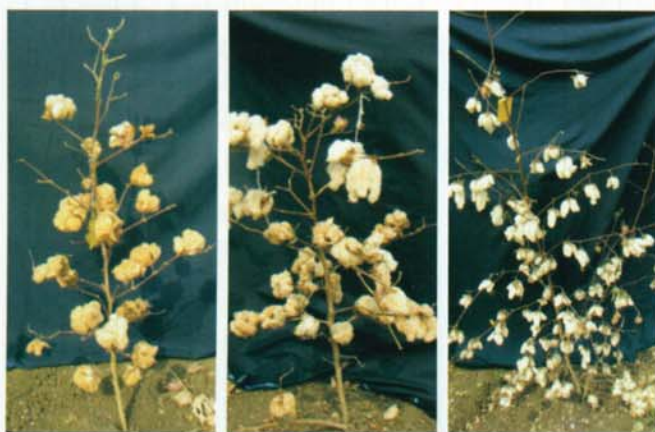
crosses namely *G. herbaceum* x *G. longicalyx*, *G. arboreum* x *G. thurberi*, *G. arboreum* race indicum x *G. davidsonii* and *G. arboreum* (var. AK 8401) x *G. davidsonii*. Four hundred and sixty one (461) introgressed derivatives were evaluated for fibre and economic traits and three high fibre strength lines were identified (Table 3.4.1) which will be re-evaluated during the next cropping season. Among the introgressed derivatives, three light brown linted lines were also identified for registration as unique germplasm (Table 3.4.2).

**Table 3.4.1: High fibre strength introgressed lines identified during 2016-17**

S.No.	Genotype	Fibre length (mm)	Fibre strength (g/tex)	Micronaire
1	CICR-16004	29.6	36.2	4.14
2	CICR-16022	30.9	37.3	2.75
3	CICR-16280	30.5	34.5	3.04

**Table 3.4.2: Light brown linted lines identified for registration as genetic stocks**

S.No.	Genotype	Fibre length (mm)	Fibre strength (g/tex) HVI	Micronaire
1	CNH LB-1	26.7	28.7	3.42
2	CNH LB-2	26.2	28.2	3.17
3	CNA LB-3	21.2	19.4	3.45



**CNH LB 16-1**  
 FL: 26.73 mm  
 FS: 28.73 g/tex  
 Mic: 3.42

**CNH LB 16-2**  
 FL: 26.20 mm  
 FS: 28.26 g/tex  
 Mic: 3.17

**CNA LB 16-3**  
 FL: 21.20 mm  
 FS: 19.46 g/tex  
 Mic: 3.45

**Cloth from coloured lint :** Dark brown lint of Vaidehi-95 (MSH-53) was spun in thread, woven into cloth in Handlooms and stitched into jackets in collaboration with Gram Seva Mandal, Gopuri, Wardha.

#### *G. herbaceum*

Introgression breeding was initiated to improve the fibre length of *G. herbaceum*. Three crosses namely GVHV - 655 x PA - 740, GVHV - 655 x PA - 785 and GVHV - 655 x PA - 812 and their reciprocals were attempted. A total of 960 F<sub>1</sub> seeds and 1145 selfed parental seeds were obtained during the crop season.

**Inter specific hybridization between *G. herbaceum* and *G. arboreum***



**Jacket stitched from Dark Brown lint at Gram Seva Mandal, Gopuri, Wardha**

The plants in F<sub>4</sub> generation from *G. herbaceum* and *G. anomalum* cross were advanced to F<sub>5</sub>.

#### **Intra - specific hybridization in *G. herbaceum***

In order to improve early maturity and genetical traits of *G. herbaceum*, fourteen intra - specific crosses and their reciprocals were attempted. The crosses including Baluchistan - 1 x IC-371437, Jayadhar x IC - 371437, Jayadhar x IC - 371336, IC-371336 x IC-371366, IC-371177 x IC-371366, IC-371177 x IC-371437, Jayadhar x IC-371177,

Baluchistan - 1 x Jayadhar, G. Cot - 25 x Jayadhar, G. Cot - 25 x Baluchistan - 1, IC - 371527 x ayadhar, IC-371362 x Jayadhar, IC - 371527 x IC-371437 and IC-371362 x IC-371 437. A total of 2415 F1 seeds were collected. Among seven intra-*herbaceum* crosses; IC - 371437 x Baluchistan-1 and IC-371437 x Jayadhar showed better yield performance, boll numbers and boll size over the mid parent.

### 3.5 : Development of variety and Multi-location testing

#### Sirsa

**Notification of *G. hirsutum* variety CSH-3075 :** Variety CSH-3075 developed at CICR RS Sirsa was evaluated in closer spacing of 67.5 x 10 cm (HDPS) in the North Zone locations for three year during 2012 to 2014. It ranked 1<sup>st</sup>, 3<sup>rd</sup> and 1<sup>st</sup> during these years recording seed cotton yield 3050, 2061 and 2291 kg/ha respectively against 2036 and 2033 kg/ha of the local checks planted at 67.5 x 10 and 67.5 x 30cm spacing respectively. Zonal average lint yield recorded over three years for this culture was 873 kg/ha as against the local check 720 kg/ha.



#### Notification of *G. hirsutum* variety CSH-3129

*G. hirsutum* culture CSH-3129 developed at the CICR, Regional Station, Sirsa was identified for irrigated north zone. It recorded mean seed cotton yield of 2293 kg/ha as against 1935 kg/ha and 2068 kg/ha of zonal and local checks, respectively; The increase in SCY was 18.5 and 10.9 percent over the Zonal and local check, respectively.. The culture has 29.5 mm span fibre length and fibre strength of 23 g/tex. Full spinning fibre quality parameters

indicated that CSH-3129 was spinnable at 40's count.



Field view of CSH-3129 (Single Plant as well as Field)

#### Coimbatore

#### *G. hirsutum* variety CCH 4474

Long staple (30.6 mm) and high strength (24.0 g/tex) culture Central Cotton CCH 4474 (Subiksha) has been recommended by Central Variety Identification Committee for release in South Zone States under irrigated conditions. The variety is capable of spinning upto 60s count yarn. It combines high yield potential under closer spacing (as high as 3325 kg/ha in Coimbatore and 4201 kg/ha in Guntur), better ginning outturn and tolerance to pests and diseases.



#### Central Cotton CCH 4474 (Subiksha)

Proposals of three varieties viz., Central Cotton CCH 12-2 (Central Zone - irrigated conditions), Central Cotton CCH 12-3 (Central Zone - rainfed conditions) and Central Cotton CCH 13-2 (South Zone - irrigated conditions) were submitted for identification by Central Variety Identification Committee during AICRP Workshop 2017 at TNAU, Coimbatore.

**G. hirsutum variety CCH 12-2**

Central Cotton CCH 12-2 recorded mean seed cotton yield of 1767 kg/ha as against 1644 kg/ha of the Zonal check in Central Zone under irrigated conditions. The variety recorded an Upper Half Mean length (UHML) of 28.0 mm, micronaire of 4.2 and tenacity of 29.0 g/tex matching the CIRCOT norm for 40s count yarn.

**G. hirsutum variety CCH 12-3**

Central Cotton CCH 12-3 recorded mean seed cotton yield of 1060 kg/ha as against 1053 kg/ha of the Zonal check variety under rainfed condition in Central Zone States. The variety recorded an UHML of 27.0 mm, micronaire of 4.3 and tenacity of 28.7 g/tex matching the CIRCOT norm for 30s count yarn.

**G. hirsutum variety CCH 13-2**

Central Cotton CCH 13-2 recorded mean seed cotton yield of 2178 kg/ha as against 2049 kg/ha of the Zonal check variety under irrigated condition in South Zone States. The variety recorded an UHML of 26.9 mm, micronaire of 4.2 and tenacity of 27.7 g/tex matching the CIRCOT norm for 30s count yarn.



Central Cotton CCH 12-2



Central Cotton CCH 12-3



Central Cotton CCH 13-2

**Testing of cultures in AICRP on Cotton**

In IET of *G. hirsutum*, entries CSH 3269, CCH 16-1, CCH 16-2, CNH 39 and CNH 108 were tested in Br 02 (a) trial. CNH 1125, CNH 09-77, CNH 7012, and CCH 16-3 were tested in Br 02 (b) trial. CSH 5640 and CSH 31292 tested in Br 06 (a) trial. In Br 06 (b) IET of compact genotypes, six entries CNH 15, CNH 75, CNH 09-4, CNH 09-62, CNH 1122, CNH 1123, CCH 16-7 and CCH 16-8 were tested. In IET of *G. arboreum*, four entries CNA 2030, CNA 1031, CNA 1032, CISA 333 and CISA 1793 were tested in Br 22 (a/b). *G. barbadense* genotypes CCB 51 and CCB 143 were tested IET Br 12a trial.

Besides, culture CSH 5640 promoted to HDPS Zonal trial and CSH 1613 sponsored in HDPS national trial of AICRP.

The culture Surabhi x M5Z2 18-5 (CCH 15-1) was tested in preliminary evaluation trial of *G. hirsutum* varieties under irrigated condition in both Central and South Zone locations. The culture recorded an upper half mean length of 31.6 mm in Central Zone and 32.7 mm in South Zone locations. Further, the culture also exhibited the highest bundle strength of 34.4 g/tex and 37.0 g/tex in HVI mode in Central and South Zone, respectively.

The long staple culture MM 03-39-4-2-3 (CCH 14-1) tested in coordinated varietal trial under irrigated conditions of both central and south zones also exhibited superior fibre quality combining good length and strength and has been recommended for Agronomic evaluation.

**Entries promoted under AICRP trials:**

*G. arboreum* entry, CSA 1028 promoted in Central Zone during 2016-17 that stood first in Br. 24b zonal trial in Central Zone and was retained for second

year trial. Two entries CNA 1031 promoted in central and south zone while CNA 1032 promoted for South Zone. *G. hirsutum* entry CNH 1123 ranked fourth in Br. 06(b) trial promoted in Central Zone.

### 3.6: State Multi-location Varietal Trial

#### Nagpur

A State Multi-location Varietal Trial (SMVT) of *G. arboreum* consisting of 20 + 3 (control varieties) genotypes and of *G. hirsutum* consisting of 13 + 4 (control varieties) genotypes with three replications following recommended package of practices was conducted at CICR, Nagpur.

In *G. arboreums*, the range for seed cotton yield was from 1183 to 2305 kg/ha. The maximum seed cotton yield of 2305 kg/ha was obtained with CNA 2016 followed by JLA-505 (2043 kg/ha) and CNA 1003 & CNA 1028 (2034 kg/ha). The control variety JLA 794 recorded highest seed cotton yield of 1995 kg/ha which was quite higher than other control varieties and genotypes under testing.

In *G. hirsutum*, seed cotton yield ranged from 1339 to 3428 kg/ha. CNH 09-5 recorded significantly high seed cotton yield of 3428 kg/ha followed by culture RCH 1217 (3078 kg/ha) and AKH-09-5 (3062 kg/ha). The seed cotton yield of control variety NH 545 was 2892 kg/ha.

### 3.7: Genetic diversity

**Molecular characterization of the *desi* cotton (*G. arboreum*) from Arunachal Pradesh :** Nineteen SSR polymorphic markers were used for diversity analysis of 14 *desi* cotton (*G. arboreum*) accessions collected from Arunachal Pradesh. Nineteen

primers produced 43 alleles across all the accessions. The number of alleles per locus ranged from 2 to 3 with a mean of 2.263. The polymorphism information content (PIC) values ranged from 0.071-0.529 with average value of 0.295. Neighbour joining tree showed three major clusters with the 14 accessions.



Perennial cotton *G. barbadense* of Phek, Nagaland



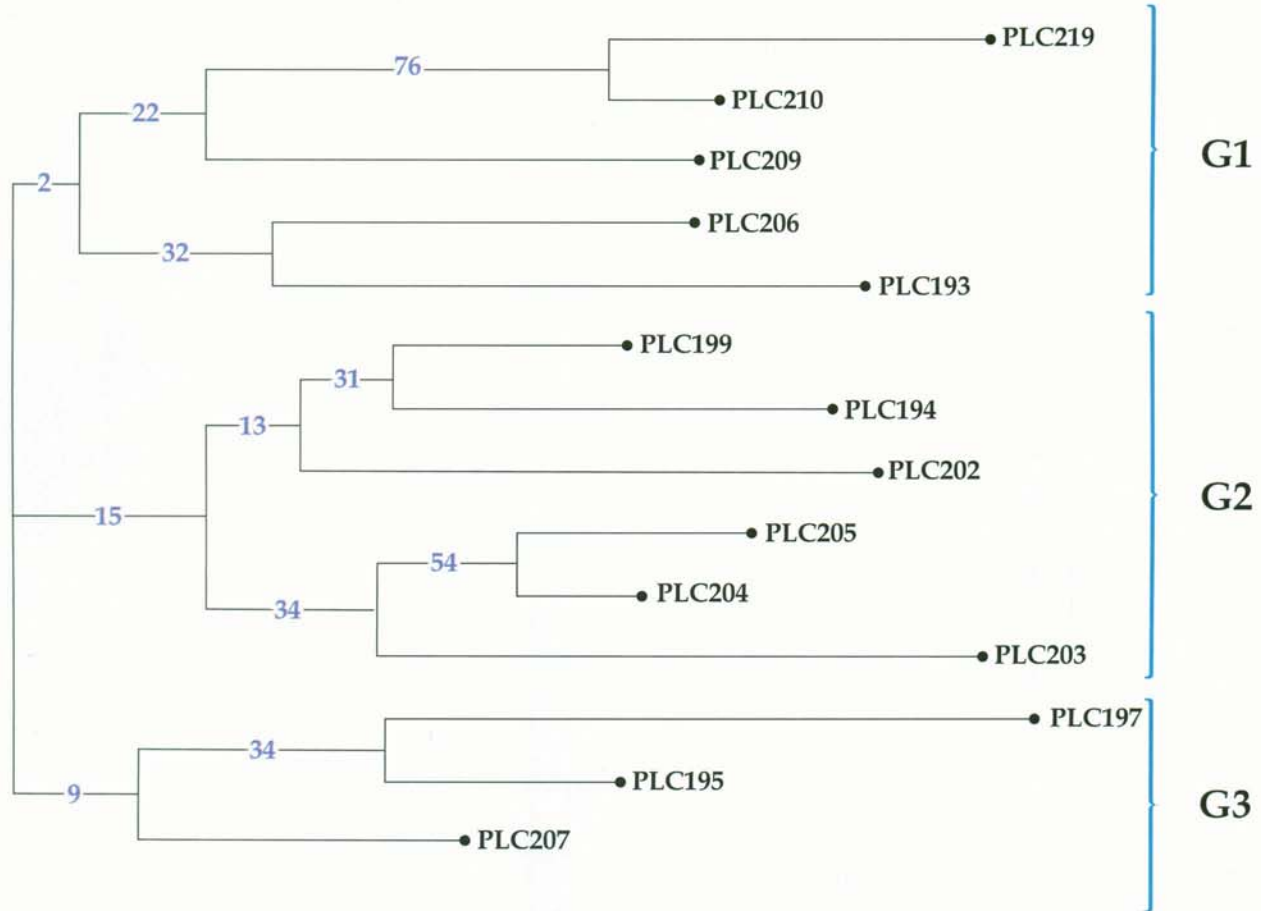
Landrace of *desi* cotton *G. arboreum* race *cernuum* of Karbi along, Assam



Perennial *G. barbadense* var. *brasiliense* of South 24-Parganas (Sundarbans of West Bengal)



Fig. 3.7.1: Banding pattern of 14 landraces of *G. arboreum* accessions generated using BNL 2965



Neighbour joining tree showing relationship of 14 landraces of *G. arboreum* collected from Arunachal Pradesh

**Molecular Breeding**

**Maintenance of RILs in diploid cotton:**

In *G. arboreum*, a set of 193 progenies were selfed and maintained by single seed decent method. The populations are intended to be used for genetic mapping.

**Development of Bt cotton genotypes through backcross breeding**

Sixty-one (61) genotypes from different cotton agro-ecological zones of the country are being converted into Bt background which are under various stages of backcross breeding. Fifteen of these converted lines were tested in replicated trial alongwith their non-Bt counterpart and two checks Ajeet 155 BG II and JKCH 8836. Though none of these Bt genotypes surpassed the check but they gave much higher yield than their non-Bt counterparts. Four of these genotypes were also sponsored for testing in AICRP multi-location trial

under HDPS. Sufficient quantity of seeds has been produced for other promising genotypes for evaluation in AICRP trial.

**CLCuD:** Twenty one  $F_1$  crosses obtained by crossing resistant/tolerant parents were evaluated for CLCuD reaction. Most of the  $F_1$  crosses were grouped in Grade 1.  $F_2$  population from a cross MR 786 x HS-6 was screened for CLCuV.

**BLB:** Three  $BC_2$  populations with Suraj as recurrent parent were grown at Nagpur. The  $BC_1$  populations include-Suraj (Suraj x CSH 3047), Suraj (Suraj x GTHH 032) and Suraj (Suraj x CSH 3313).  $BC_2$  plants (371) were screened with marker CIR 246 and phenotyped by artificial inoculation with BLB culture. Of the 371  $BC_2$  plants, 136 were phenotypically resistant and marker positive which were subsequently backcrossed with Suraj to obtain  $BC_3$  seeds.

**Nematode resistance:** In previous years, nematode

resistant American Nectariless, G.cot 10 and Bikaneri Narma were crossed with elite parents Suraj, Surabhi and NH615. In 2016-17 BC2 populations were sown as boll to row. Sowing of F<sub>3</sub> seeds were also taken up for phenotyping with respect to reniform nematode resistance. For phenotyping F<sub>3</sub> (Suraj x G.cot10) were sown in pots and inoculated with reniform nematode *Rotylenchulus reniformis*. Observations on nematode reproduction were recorded 60 days after inoculation. Marker NAU 2152 located on chromosome 11 was validated for reniform nematode resistance. Nematode reproduction was taken as criterion to evaluate reaction of F<sub>3</sub> population to reniform nematode. Plants selected with NAU-2152 marker also showed reduction in nematode reproduction to the extent of 90-93%. F<sub>3</sub> marker positive 10 plants each were selfed to get F<sub>4</sub> seeds.

#### Introgression of genes for whitefly and CLCuD resistance in upland cotton

Pre-soaked seeds of identified *G. arboreum* varieties (i.e. CNA 1003, AKA 8401, AKA 5, AKA 7, AKA 8 PA 255, PA 402) were subjected to colchicine treatment of 0.1, 0.2, 0.5 and 1.0% for 18 hrs. Treated seeds were washed for two hrs. and then planted in pots. The growing axial buds were also subjected to colchicine treatment by applying colchicines to growing axial buds. Treatment of axial buds repeated 3-4 times on every alternate day. Plants showing some abnormality for leaf and boll characters were harvested separately for further advancement and cytological studies. Treatment of different concentrations of colchicine to seeds and growing axial buds for induction of autotetraploid in *G. arboreum* yielded positive results and putative plants were identified.



Bolls of untreated and treated plant



Established interspecific F<sub>1</sub> hybrid seedlings through embryo rescue technique

Interspecific crosses were attempted between the *G. arboreum* and *G. hirsutum* including reciprocals, modest number of crosses in *G. arboreum* (5862) and *G. hirsutum* (9507) background, a total of 15369, have been made and sizable amount of crossed seeds was obtained. A protocol for *in-vitro* culture of cotton ovules of interspecific wide crosses, embryo rescue technique, was standardized and more than 100 F<sub>1</sub> seedlings from a cross between *G. hirsutum* and *G. arboreum* and reciprocal crosses were established. The embryo rescue protocol would help introgression of desired traits/genes from other wild species of cotton into cultivated one. It would also help to advance the generations in short period.

#### Genetic diversity

Forty-eight released varieties (46 of *G. hirsutum* and 2 of *G. barbadense*) were characterized using 68 SSR markers. A dendrogram constructed using DARwin software grouped varieties from North zone into a separate cluster. A set of 14 SSR markers obtained, capable of distinguishing each variety which, could be complimented with DUS data. Twenty four released varieties of *G. arboreum* were



(a) Interspecific Crossed bolls between *G. hirsutum* and *G. arboreum*; (b) matured busted crossed boll

surveyed for polymorphism using 350 SSR markers having wide genome coverage. Among these, 32 markers were found to be polymorphic (Fig. 3.7.2). A set of 10 robust markers could distinguish each variety. A unique marker BNL

3971 could distinguish *G. barbadense* varieties specifically from *G. hirsutum* varieties (Fig. 3.7.3). This was repeatedly confirmed using 60 *G. barbadense* germplasm lines and 46 *G. hirsutum* varieties.



Fig. 3.7.2: SSR polymorphism in *G. arboreum* varieties M: 100bp Ladder; 1-24: Released varieties of *G. arboreum*



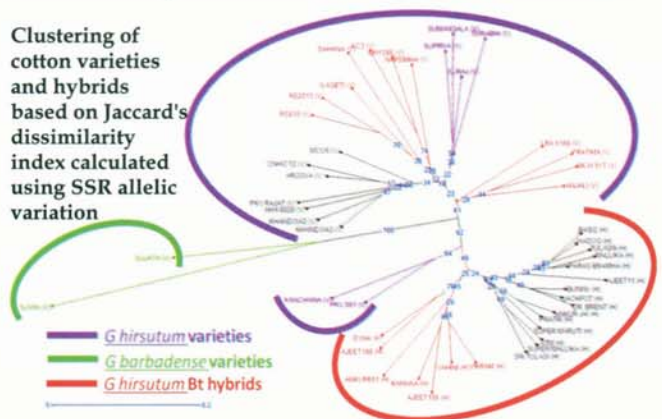
Fig. 3.7.3 : Molecular differentiation of *G. hirsutum* from *G. barbadense* M-100bp ladder; 1-20 : *G. hirsutum* varieties; 21-32 : Germplasm lines of *G. barbadense*

### Genetic diversity in Bt hybrids

Twenty-two most popular private sector Bt cotton (BGII) hybrids and 26 popular non-Bt cotton varieties released from different research institutes and SAU's were evaluated for 35 DUS characters under replicated RBD trial as per National DUS Testing Guidelines for tetraploid cotton. The genomic DNA of these cultivars was also profiled for 62 distinctly polymorphic SSR markers identified after extensive screening. Both morphological and molecular data was statistically analysed. Microsatellite markers in comparison to morphological characters clearly distinguished the *G. hirsutum* Bt cotton hybrids, *G. hirsutum* cotton varieties and *G. barbadense* cotton varieties. Significant variation for all most all the parameters of genetic diversity was observed between Bt cotton hybrids *vis-a-vis* cotton varieties (Table

3.7.1). Higher genetic similarity within narrow range was observed among the popular Bt cotton hybrids of India revealing their inherent genetic vulnerability to various biotic and abiotic stresses.

Clustering of cotton varieties and hybrids based on Jaccard's dissimilarity index calculated using SSR allelic variation



Molecular profiling of private sector Bt cotton hybrids *vis-a-vis* public sector cotton varieties



**Table 3.7.1: Basic parameters of genetic diversity among cotton varieties vis-a-vis Bt cotton hybrids**

Genetic Parameter	Cultivar	Mean ± SD	Minimum	Maximum
Genetic Similarity	Varieties	0.60±0.14	0.29	0.84
	Bt hybrids	0.75±0.07	0.54	0.93
Allele Number	Varieties	2.50±0.65	2	4
	Bt hybrids	1.97±0.75	1	4
Gene Diversity	Varieties	0.37±0.21	0.04	0.75
	Bt hybrids	0.29±0.23	0.00	0.71
Heterozygosity	Varieties	0.29±0.37	0.00	1.00
	Bt hybrids	0.35±0.41	0.00	1.00
PIC	Varieties	0.31±0.18	0.04	0.70
	Bt hybrids	0.23±0.19	0.00	0.66

A total of 74 varieties (Table 3.7.2) of *Gossypium spp.* (*G. hirsutum*-52, *G. barbadense*-2, *G. arboreum*-17 and

*G. herbaceum*-3) were established and conserved in perennial form as 'Cotton Varietal Garden' in the ICAR - CICR, Nagpur.



**Cotton Varietal Garden established at ICAR - CICR, Nagpur**

G hirsutum Varieties								G barbadense Varieties		G arboreum Varieties			
S. No.	Variety	S. No.	Variety	S. No.	Variety	S. No.	Variety	S. No.	Variety	S. No.	Variety		
1	Anjali	12	MCU5VT	23	F1054	34	JK4	45	NH615	1	Suvin		
2	Arogya	13	MCU5	24	DHY286	35	KC3	46	Phule688	2	Sujata		
3	CHNO12	14	GCot18	25	Deviraj	36	Khandwa2	47	PKV Rajat	TOTAL: 02	3	AKA8	
4	Khanchana	15	GCot16	26	Bikaneri Narma	37	Khandwa3	48	PKV081		4	AKA8401	
5	LRA5166	16	GCot12	27	AKH8828	38	LH900	49	RS2013	G herbaceum Varieties	5	GCOT15	
6	Pratima	17	GCot10	28	Abaditha	39	MCU10	50	RS875		S. No.	Variety	6
7	Sumangala	18	G Ageti	29	GCot20	40	MCU12	51	RST9	1	GCOT23	7	HD107
8	Supriya	19	F846	30	H1117	41	MCU8	52	Sahana	2	JAYADHAR	8	HD324
9	Surabhi	20	F1861	31	H1226	42	MCU9			3	RAGHAVENDRA	9	JAWAHAR TAPTI
10	Suraj	21	F1378	32	HS6	43	Narasimha			TOTAL : 03	10	LD694	
11	CISH3178	22	CCH2623	33	CCH4474	44	NH545				11	PA183	
TOTAL = 52											12	RG18	
Total cotton varieties conserved and maintained: 74											13	RG8	
											Varietal Garden, ICAR - CICR, Nagpur		
											15	Roja	
											16	PA255	
											17	Phule Dhanwantry	
											TOTAL: 14		

**Table 3.7.2: Species-wise list of cotton varieties established in "Cotton Varietal Garden" at ICAR - CICR, Nagpur**

### 3.8: Development of Transgenic Cotton

#### Screening of putative transgenic plants

##### Insect Resistance

Putative transgenic cotton varieties ( $T_3$ ) LRK-516 (121 plants), LRA-5166 (310 plants) and Suraj (220 plants) were screened under contained facility after approval of CICR-IBSC. The plants were raised in green house condition and screened by PCR and Bt Quant ELISA test. PCR analysis showed positive amplification with 3 plants LRA 5166, one plant of LRK 516 and 4 plants of Suraj. However, ELISA results recorded very low *Cry* protein expression of transgene.

Around 1440 putative transformed seeds of *G. hirsutum* (var. Suraj) varieties were obtained by *in-planta* method using *Agrobacterium*. Younger leaves as well as seeds of these plants were tested for Bt gene expression by ELISA.

Among 1440 plants, 142 plants of *G. hirsutum* were tested positive for Bt gene using leaf, while 108 plants of *G. hirsutum* were tested positive using seeds. Plants no 982-14 and 982-20 were PCR positive.

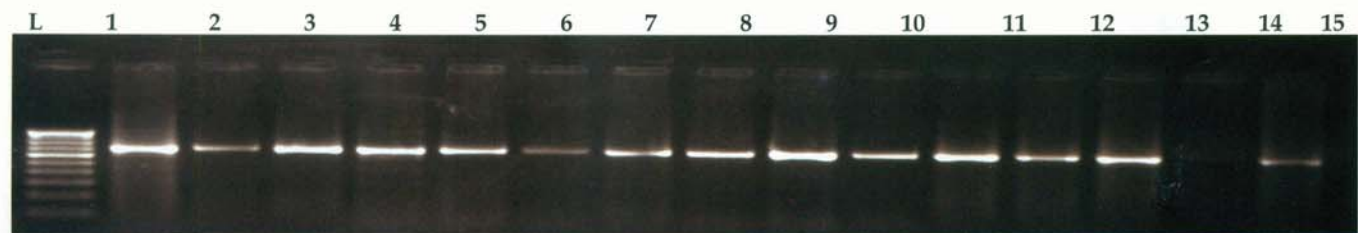
Plants with high OD 450 (app. >1 in both leaf and seeds) are shown in the Table 3.8.1.

Table 3.8.1: Plants with high OD 450

Sr. No.	Plant No.	leaf OD 450	Seeds OD 450
1	437	0.993	1.007
2	982	1.473	1.095
3	983	1.197	0.939
4	986	0.726	1.256
5	996	0.873	1.002

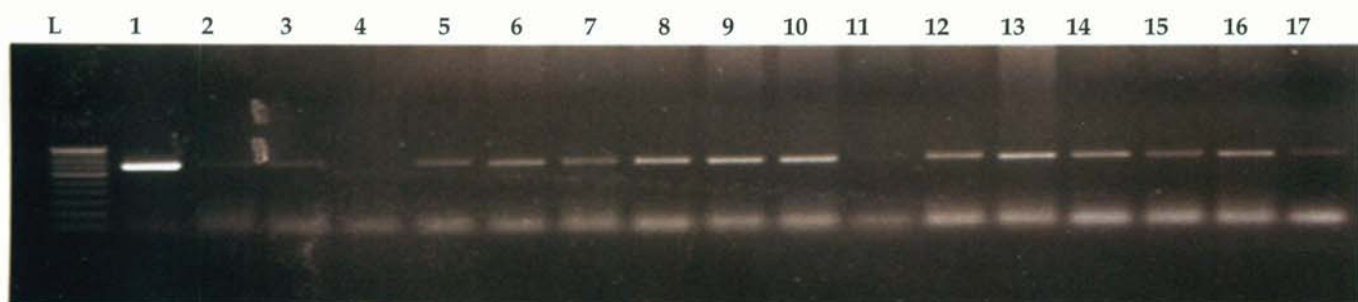
##### Leaf curl virus resistance

Cotton leaf curl virus resistance transgenics plants were developed using three genes, Sense coat protein (*SCP*), anti-sense coat (*ACP*) protein and antisense replicase protein (*AREP*) in three genotypes *viz.*, HS-6, H 777 and F 846. Transgenic seedlings of  $T_3$  generation were raised in the polyhouse. Genomic DNA was isolated from the individual seedlings and screened for the presence of the specific gene. Fifteen plants showed amplification of *ACP* gene in H 777, 2 plants in HS6 and 3 plants in F 846 while 9 plants of F 846 showed amplification for *AREP* gene primer.



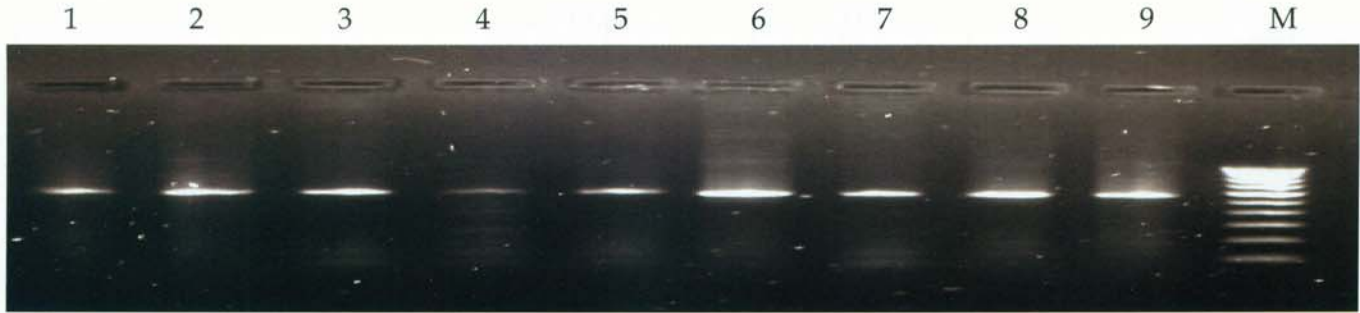
PCR analysis of the transgenic plants with Antisense Coat Protein (ACP) primer (5'-3') F-CATGAATTCATGTCGAAGCGAGC and R-TTAAAGCTTTAATCCAACAAA

Lane 1-15: H 777 positive plants (ACP)



Lane 1-9: HS6 positive plants (ACP); Lane 10-17: F 846 positive plants (ACP)

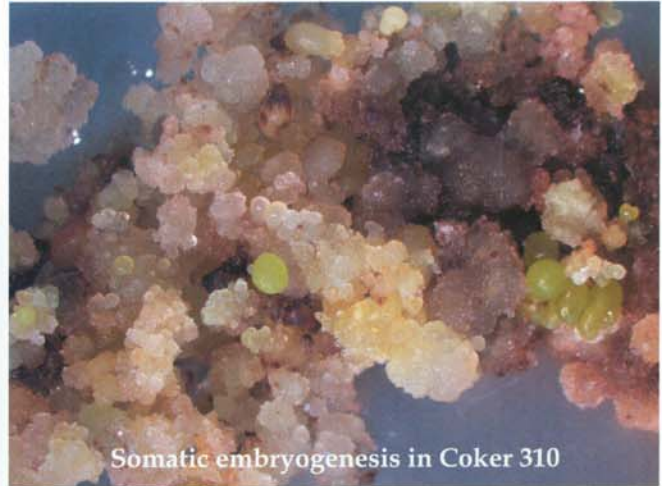
PCR analysis of the transgenic plants with *AREP* primer; F(5'-3') ATG CCA CGT GAT TTA AAA ACA and R- GTG GGG AGA GTT TCA GAT CG



Lane 1-9: F 846 positive plants (Arep)

**Somatic embryogenesis of cotton**

Cotton genotypes viz. AKA 07, PKV 081, Suraj and Coker 310 were screened for their response towards somatic embryogenesis under varied *in vitro* media regimes. Among the four genotypes, only Coker 310 showed positive response towards somatic embryogenesis. Tissue culture media was standardized for callus initiation and proliferation followed by somatic embryo initiation and maturation of Coker 310 under *in vitro* culture. High frequency somatic embryogenesis was achieved in Coker 310.

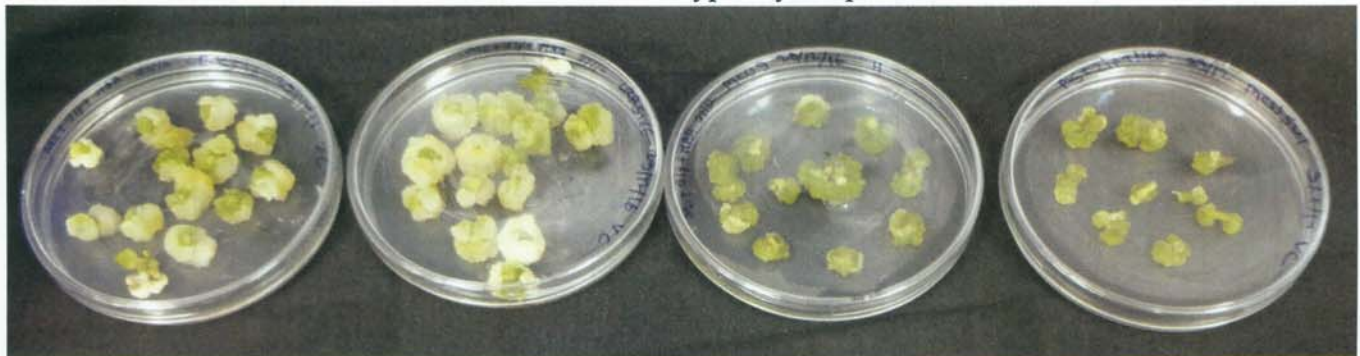


Somatic embryogenesis in Coker 310

Explants of hypocotyl and cotyledons of *Gossypium hirsutum* cvs LRA 5166, LRK 516, MCU 5VT and MCU9 were used to study their response to somatic embryogenesis. MS media was supplemented with 2iP 5 mg/L and NAA 0.1 mg/L for callus initiation and proliferation. Subsequent subculture was done on medium supplemented with the NAA 5 mg/L and 2iP 0.1 mg/L for embryogenic callus induction (Firoozabady and deBoer 1993). Hypocotyl

explants of LRK 516 and LRA 5166 produced creamy soft callus within 3 to 4 weeks of inoculation while MCU 5VT and MCU 9 produced green hard callus. But cotyledonary explants of all the genotypes produced only green callus. Subsequent subculture on embryogenic callus induction media produced responsive callus only in LRK 516.

**Callus initiation on hypocotyls explants :**



LRK 516

LRA 5166

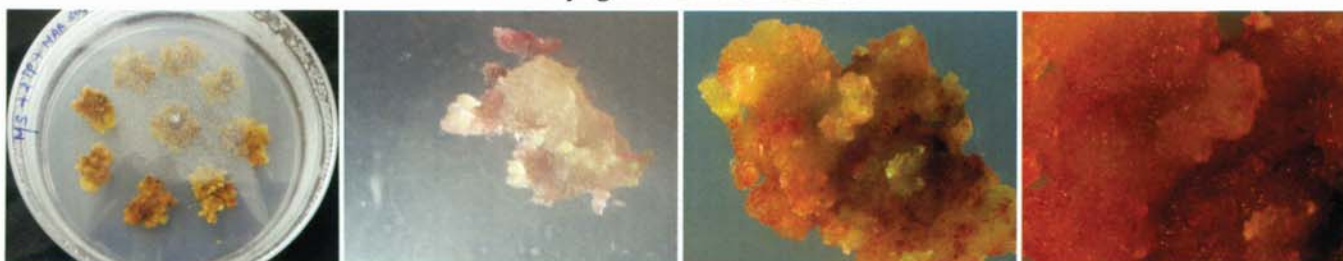
MCU 9

MCU 5VT

LRK 516 and LRA 5166 showed callus initiation in 3 to 4 weeks

Callus type : Creamy friable in LRK 516 and LRA 5166  
Green hard callus in MCU 9 and MCU 5VT

### Embryogenic Callus induction



LRK 516 showed good response on embryogenic callus induction medium

### *In planta* transformation method

A novel *Agrobacterium tumefaciens* mediated *in planta* transformation protocol was standardized. In this system, sonication followed by vacuum pressure was applied to infiltrate *Agrobacterium*

strain harbouring the transgene deep into meristematic cell mass. Mature intact embryos with intact apex were used as explants and parameters for sonication and vacuum infiltration were optimized for higher transformation efficiency.



A- Explant-Excised embryo with apex; B-Transformed embryos showing *gus* gene expression; C-Expression of *gus* gene near target tissues (Apex and cotyledonary nodes)

## 3.9 Seed Production and Technology

### Seed Quality Improvement

#### Nagpur

An experiment was conducted to assess the effect of exogenous application of plant growth hormones and other chemicals on seed yield and quality of *G. hirsutum* viz. Suraj. Based on positive response of hormone treatments in 2015-16, 14 treatments (putrescine (1.0 mM and 4.0 mM); spermidine (0.1 mM and 1.0 mM); spermine (0.1 mM, 0.5 mM and 1.0 mM); 5-sulphosalicylic Acid (0.5 mM and 1.0 mM); glycine betaine (4.0 mM); (KNO<sub>3</sub>) (4.0 mM); NAA (0.5 mM); control water and absolute control) were used as foliar spray at 65 and 85 days after sowing.

The crop yield parameters were recorded during crop growth stages and post harvest data was statistically analysed. Results of the experiment indicated that the total number of bolls/plant

(25.5), boll weight (4.19 g), lint/plant (39.0 g), seed yield/plant (66.6 g), SCY/plant (105.6 g), GOT (36.98%), and SCY/ha (40.4 qt) were significantly higher with foliar application of glycine betaine (4 mM) followed by putrescine (4 mM) and KNO<sub>3</sub> (4 mM) as compared to the control and other treatments.

Post harvest seed quality studies indicated that the seedling vigor was significantly higher with glycine betaine (4 mM), and 5-sulphosalicylic acid (1.0 mM) treated seeds than control while the seed germination and 100 seed weight and other quality parameters were found to be non-significant.

#### Sirsa

The effect of growth hormones, pollinator attractant and pollinator population was estimated on boll setting and seed setting percentage. In nine (9) treatments, significantly higher boll setting (72%) was observed in hand pollination treatment

against control. In rest of growth hormone treatments, no significant enhancement for boll setting was observed over control (67.2%). Seed setting efficiency (83.8%) and yield (11.8 qtl. SCY/acre) in hand pollination treatment was significantly higher than in control (75.1% and 10.9 qtl. SCY/acre).

With augmented pollinators, the boll and seed setting in GMSDS 5 was not significant than without augmented pollinator.

### Coimbatore

#### Enhancement of primed seeds quality through pulsed magnetic seed treatments

A laboratory experiment was conducted to enhance quality of primed seeds through pulsed magnetic seed treatments. Delinted seed of cotton cultivar Surabhi and Suraj were used with initial germination of 72% and 76% respectively. Seeds were primed with  $\text{KH}_2\text{PO}_4$  priming (450 ppm),  $\text{CaCl}_2$  hydration (2%), KCL priming (1.0%),  $\text{MnSO}_4$  (seed soaking 0.1%), succinic acid priming (0.2%), prosopis leaf extract (seed soaking 1.5%), neem leaf extract (seed soaking 1%) and compared with untreated seeds. The primed seeds were subjected to pulsed magnetic field strength 750 nT (7.5 mA 10 Hz) for 15 days at the rate of 5 hours per day. The pulsed magnetic waves treated seeds were evaluated for seed germination, seedling vigour and biochemical parameters. The replicated mean data of treated seeds when compared with primed seeds and control seeds revealed that seed priming significantly enhanced seed germination in both the varieties. The enhancement was 12% due to  $\text{KH}_2\text{PO}_4$  priming and  $\text{MnSO}_4$  (0.1%) in Surabhi against the control. However, in Suraj, enhancement was 10% due to neem leaf extract (1%) and 8% due to  $\text{KH}_2\text{PO}_4$  priming. Pulsed magnetic field treatment further enhanced the seed germination to the tune of 13% due to  $\text{CaCl}_2$  hydration (2%) and 8% due to  $\text{MnSO}_4$  in Surabhi and 7 and 5% respectively due to prosopis leaf extract and  $\text{CaCl}_2$  hydration (2%) in Suraj.

#### Enhancement of coated seeds

In another laboratory experiment, delinted seeds of cotton cultivar Surabhi and Suraj were coated with Trichoderma (10 g/kg), Arappu leaf powder (@ 100 g/kg), turmeric rhizome powder (@ 20 g/kg),

polykote (@ 5 ml/kg), DAP (@ 20 g/kg), micro nutrient mixture (@ 10 g/kg), Pseudomonas (15 g/kg), phosphobacterium (50 g/kg), and compared with untreated seeds for germination and seedling vigour. The coated seeds were subjected to pulsed magnetic field strength 750 nT (7.5 mA 10 Hz) for 15 days at the rate of 5 hours per day. Seed coating significantly enhanced seed germination in both the varieties than the control seeds. The enhancement in seed germination was 13% due to Polykote (@ 5 ml/kg) and 12% due to Arappu leaf powder in Surabhi while in control it was 72%. In variety Suraj, enhancement in seed germination was 10% due to Polykote and 8% due to micronutrient mixture. Pulsed magnetic field treatment enhanced the seed germination to the tune of 10% due to micronutrient mixture and 9% due to Turmeric rhizome powder in Surabhi and 5 and 4% due to micronutrient mixture and Arappu leaf powder respectively in Suraj.

### DUS testing

#### Nagpur

Seventy-three genotypes that includes (4 candidate varieties, 4 VCK varieties, 12 Essentially Derived Varieties and their initial variety and 30 reference varieties, were characterized for DUS traits under Protection of Plant Varieties and Farmers' Rights Act, 2001. Under varietal maintenance, 29 diploid lines were maintained and multiplied.

In trait behavior studies, varieties with diverse expressions for various traits were crossed and  $F_1$ s were planted to study the phenotypic expression in a population of 50 plants/ trait.

#### Coimbatore

#### Implementation of PVP legislation, 2001 and DUS testing of cotton under ICAR-SAU system

This programme is implemented with ICAR-CICR, Regional Station, Coimbatore as the nodal center and ICAR-CICR, Nagpur, National Seeds project Unit, UAS, Dharwad, Department of Cotton CCSHAU, Hisar; Regional Research Station Bhatinda, PAU; Department of Cotton, MPKV, Rahuri as participating centres.

Field trials for the establishment of Distinctiveness, Uniformity and Stability (DUS) of new cotton genotypes, varieties of common knowledge, and

essentially derived varieties was conducted in tetraploid and diploid cotton. A total of 49 new candidate varieties were tested in the second year trial, of which 48 were of *G. hirsutum* and one *G. arboreum*. For the first year trial, 5 new candidate varieties, 3 varieties of common knowledge, and 3 essentially derived varieties along with 3 initial varieties were taken up. In both trials, for comparison, 60 reference varieties were grown. The essentially derived varieties and their corresponding initial varieties were grown in unprotected and protected environment. The

characteristic measurement and visual assessment was done on randomly selected ten plants in each plot. The claimed characters of the applicant were compared with characters of reference varieties for establishment of DUS of candidate genotypes.

### Seed Production

#### Nagpur

Seed production of cotton varieties, parents of hybrids and other crop varieties was taken up under ICAR-Mega Seed Project 'Seed Production in Agricultural Crops and Fisheries' (Table 3.9.1).

**Table 3.9.1: Seed Production achieved during 2016-17 at ICAR- CICR, Nagpur, Coimbatore and Sirsa**

Crop	Variety	Stage	Seed (quintal)
Cotton	Breeder Seed		
	CNA 1003 (Roja)	BS	0.5
	CICR-2 Female parent	BS	0.3
	CICR-2 Male parent	BS	0.2
	CISA 614	BS	3
	CISA-310	BS	1
		<b>Total (BS)</b>	<b>5</b>
	Stock Seed		
	48 varieties		2.2001
	CICR-2		2.805
	TFL (Institute)		
	9 varieties		3.146
	Suraj	TFL	2
		<b>Total (TFL)</b>	<b>11.88</b>
Phule Dhanvantari (under farmer's participatory mode)	<b>Total (TFL)</b>	<b>8.63</b>	
Wheat	HD 2967	CS	180
Red gram	BSMR-736	CS	14.5
Gram	Vijay	CS	25.2
		<b>Total (CS)</b>	<b>219.7</b>
		<b>Grand Total</b>	<b>245.51</b>

Besides cotton, certified seed of wheat cv. HD 2967, red gram cv. BSMR-736 and gram cv. Vijay were produced for State Seed Corporation at Haryana and Maharashtra. The total seed production was 245.51q of cotton, Red Gram, Wheat and Gram at 3 stations. Details are given in Table above. Resource of around Rs. 10.5 lakhs was generated through the

sale of these seeds or its by-products.

#### Coimbatore

##### Breeder Seed Production

Breeder Seed Production was undertaken in respect of Suvin, Suraj and Surabhi. During the year 2016-17, 126 kg of breeder seed was distributed to various seed producers.

### 3.10 : Integrated Crop Nutrition Management

Nagpur

#### Practical Approaches to Maximize the Cotton Production in Calcareous Soils

Cotton production on calcareous soils is constrained by severe multiple nutrient deficiencies. Station field experiments were conducted with 10 different nutrient treatments to improve seed cotton yield of *G. hirsutum* cultivars PKV081 (60 x 30 cm spacing) and Ankur 3028 BGII (90 x 60 cm). Seed treatment with humic acid (0.02%), Azotobacter and phosphorus solubilizing bacteria increased percent germination and rate of nutrient absorption. Humic acid (0.02%) treated seed along with 125% recommended dose of fertilizers and micronutrient application (15 kg ha<sup>-1</sup> for hybrid and 12 kg ha<sup>-1</sup> for variety) produced more seed cotton yield than the foliar spray of chelated micro nutrients (0.5%) at 45 to 60 DAS.



Cotton production on calcareous soil

#### Participatory technology & e-tools development for calcareous soils

Participatory trials were conducted on calcareous soils in Budhala, Ladai-Linga, Khairi-Deshmukh, Lohagarh-Budhala of Kalmeshwar Tehsil in Nagpur district. Plots receiving the biofertilizer (*Azotobacter* + *Azospirillum* + PSB and *Trichoderma viride* treated seed) treatment along with 125% recommended dose of NPK + Mg, S, Fe, Mn, Zn and B produced 2.0 q ha<sup>-1</sup> more seed cotton yield over the 100% NPK. Seed treatment with humic acid and soil application of chelated micronutrients along with 125% NPK resulted in 2.8 q ha<sup>-1</sup> more seed cotton yield with favourable

cost benefit ratio over the 100% RDF (N:P:K ::80:40:40 kg/ha). Results indicate that micro-nutrients need to be supplied in a chelated form in highly calcareous soils. Possible phytotonic effect provided by humic acid improved root proliferation in calcareous soils under ridges and furrows type of rain water conservation.

Among the BGII hybrids evaluated on calcareous soils in an on-farm trial, RCH-659 produced the highest seed cotton yield under rainfed condition with two supplemental irrigations (18.5 and 32 q ha<sup>-1</sup>) followed by Ankur 3028 and Denim.

#### Bio-efficacy trials of plant growth promoter based on waste human hair developed by MGIRI

Commercially available plant growth promoters that are recommended for cotton are usually costly. Human hair is a waste product and is rich in amino acids. Waste hair was extracted and a mixture was developed by Mahatma Gandhi Institute for Rural Industrialization (MGIRI), Wardha. Field trials were conducted in collaboration with MGIRI to test the efficacy of the formulation from waste human hair and cow urine. The product was applied as a foliar spray at three different concentrations (6, 9 and 12 ml/l). The product was sprayed either two or three times fortnightly from 60 days after sowing (DAS). Compared to the NPK treatment and NPK + water spray, the human hair extract sprayed two times resulted in significantly higher seed cotton yield (Fig 3.10.1). There was no benefit when the number of spray was more than two. The plots that were sprayed three times had few bolls (35.3 bolls per plant with two sprays vs. 31.3 bolls per plant with three sprays). Preliminary results indicate that there is a scope of using the waste human hair as a plant growth promoter.

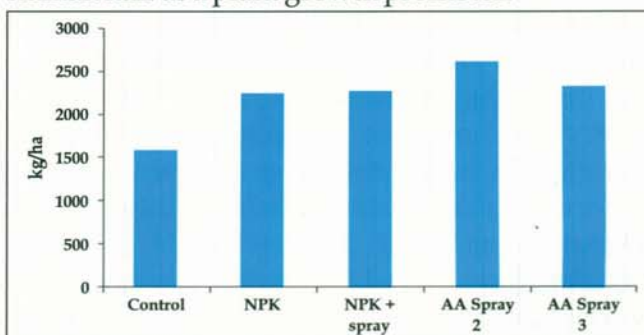


Fig 3.10.1: Effect of spray of waste human hair on seed cotton yield

## Coimbatore

### Evaluation of commercially available nanofertilizers on cotton growth and yield

Field experiment was conducted to evaluate the effectiveness of foliar application of nanofertilizers like Nualgi and Nanomol with or without surfactant at different dosages. Results indicated that an application of higher dose of nanofertilizer (200%) like Nualgi increased physiological parameters of the plant like number of leaves, leaf area index, reducing sugar and total chlorophyll content. Even though, the physiological attributes were improved by high dose of nualgi nanofertilizer with surfactant, yield related parameters (number of opened bolls and seed cotton yield) did not increase by higher dosage of nanofertilizers like Nualgi and Nanomol. Normal recommended dose of both nanofertilizers i.e., 100% only increased the seed cotton yield without surfactant. But there was no significant difference among the treatments. This may be due to severe infestation of alternaria blight during the rainy period i.e., 110 DAS resulting in drop of foliage.

Another field experiment was conducted to study the interacting effect of the best performed four different types of metal oxide nanoparticles like zinc, iron, copper and magnesium with organic fertilizer i.e., seaweed liquid fertilizers. Experimental results indicated that an application of single and combined form of metal oxide nanoparticles increased the physiological parameters. However, these parameters were not improved by combined application of metal oxide nanoparticles along with seaweed liquid fertilizers. The possible reason that nutrient entry, uptake and translocation may be reduced due to complexation of smaller size nanoparticle with macro sized particles of seaweed liquid fertilizer and forms the bigger size particle or otherwise. Also, there may be a competition between nutrients in metal oxides and seaweed liquid fertilizers. Among those treatments studied, single micronutrient 100 ppm of ZnO (50 nm) nanoparticle increased the number of opened bolls as well as seed cotton yield which was followed by ZnO + CuO + MgO + FeO nanoparticle and then the same yield was recorded in combined form of

ZnO + MgO + CuO treatment. These results need to be validated further.

### 3.11 : High Density Planting Systems (HDPS) for Maximizing Productivity

#### Nagpur

#### Evaluation of short, medium and long linted *G. arboreum* cotton under HDPS

Of the 17 *G. arboreum* genotypes evaluated, eight were long linted with fibre length >27.5 mm. Seed cotton from all the genotypes was picked twice at 140 days and 165 days after sowing and the combined yield at 165 DAS is shown in Fig. 3.11.1.

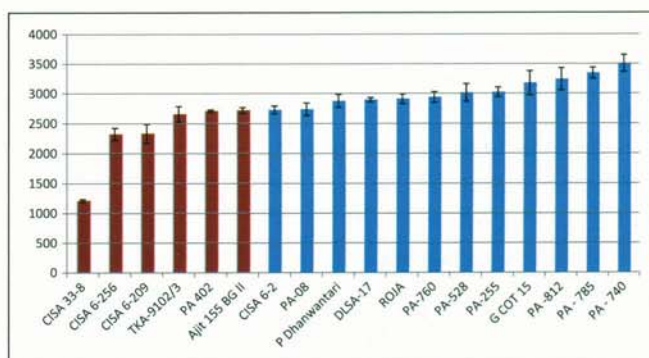


Fig. 3.11.1: Mean seed cotton yield (kg/ha) at 165 days after sowing

Differences among genotypes were statistically significant for the seed cotton yield. The genotypes that produced significantly higher seed cotton than Aji 155 BGII Bt were PA 255, G. Cot 15, PA 812, PA 785 and PA 740. Thirteen genotypes viz. PA 255, PA 08, PA 528, PA 760, PA 402, Roja, CISA 6-2, Phule Dhanwantari, G. Cot 15, DLSa 17, PA 740, PA 812 and PA 785 gave significantly higher lint yield than Ajeet 155 BGII Bt. Based on proportionate yield at first pick, G Cot 15, DLSa 17 and Roja were relatively early. Genotypes G Cot 15, DLSa 17 and Roja were early with respect to days to the time taken for "first boll opening". Genotypes TKA-9102/3, DLSa 17, PA 740, PA 812 and PA 785 had fibres longer than that of Ajeet 155 BG II Bt.

#### Evaluation of breeding material

Two *G. hirsutum* entries viz. SPS 1-5-1 (3583 kg/ha) and SPSS 1-5-2 (3272kg/ha) were found significantly superior to check NH 615 in seed cotton yield.

These entries were compact and ideal for HDPS.

For surgical cotton production, three cultures of *G. arboreum* viz. CNA 2014- 4, CNA 2014 - 8 and CNA 2014 - 9 were selected on the basis of sulphate ash content, moisture absorbency, sinking time, water holding capacity and water soluble matter.

### Sirsa

Replicated evaluation of 16 compact selections made from various genotypes with <1 monopodia indicated that compact selections of CSH 3088 (2428 kg/ha), AZON 148 (2486 kg/ha), CSH 3132 (2242 kg/ha) and SA 164 (2364 kg/ha) could out yield Bt check 6588 (1897 kg/ha) whereas other two checks used were F 2383 (1801 kg/ha) and F 1861(1897 kg/ha).

During 2016-17, in a station trial five improved cultures along with three checks were evaluated at recommended spacing. Culture CSH 1613 gave 2160 kg/ha against Bt check Bioseed 6588 BG-II (1950 kg/ha). Other cultures with higher yield were CSH 3622 and CSH 3047. From this trial cultures CSH 1613 and CSH 3047 were sponsored in AICCIP trials.

Fifteen *G. arboreum* compact cultures were evaluated in a replicated trial along with promising checks CICR 3, Phule Dhanwantari and HD 432. The culture G 166 (2400 kg/ha), AC 621 (2370 kg/ha) and 6040 (2380 kg/ha) were observed to be superior for yield. Another set of 15 *G. hirsutum* compact cultures were evaluated along with promising Bt check Bioseed 6588 and non-Bt check F 1861 and F 2383. The culture SA 1719 was observed to be significantly superior to varietal check F1861.

## 3.12: Weed management

### Nagpur

#### Allelopathy - an alternative weed management strategy for cotton

Weeding is a labour intensive operation and is one of the main factors for increasing cost of cultivation. Furthermore, the land is frequently tilled and hoed to obtain timely weed control which may not be possible under heavy rainfall situations. Herbicide usage has increased to obtain an effective weed control. Allelopathic cover crops are an alternative option to reduce the reliance of

herbicides and further improve soil health because organic residue is recycled back into the soil. Twelve cover crops were evaluated at Nagpur. Among them, pearl millet and sorghum cover plots had significantly lower seed cotton yield than the weed free plot without a cover crop. All the remaining cover crops were similar with a higher yield in the sunnhemp cover crop plots. However, these differences were not significant. Total weed control was provided by polythene mulch and the plots also resulted in early harvest.

### Coimbatore

At Coimbatore, forage cowpea, sesbania and sunnhemp had very low weed count and dry weight followed by thornless mimosa and *Desmanthes*. All the cover crop treatments provided effective weed control compared to the stale seed bed method without a cover crop. Seed cotton yield increased significantly with the sunnhemp and forage cover crop compared to the other cover crops and the control. Thornless mimosa, sesbania and *Desmanthes* had lower yield probably due to competition for space and resources with cotton.

#### Studies to identify the low cost weed management solutions for HDPS cotton

Major weed flora identified were grassy weeds *Echinochloa* sp. and *Cyperus rotundus*. Early post-emergence application of Glyphosate 4 and 6 ml L<sup>-1</sup> also controlled *Echinochloa* sp. and *Cyperus rotundus* effectively within 7-10 days after foliar application. Although glyphosate was very effective in controlling all weeds, it also suppressed the apical dominance of cotton with irrecoverable effect on crop growth. Hence, it can be used only as a late directed-application as confirmed in the previous years. *Echinochloa* sp. and *Cyperus rotundus* weeds were easily controlled by propaquizafop 1.8 ml L<sup>-1</sup> or chlorimuron 0.075 g L<sup>-1</sup>, cyhalofop butyl 0.5 ml, pyriithiobac sodium 1.8 ml L<sup>-1</sup>, fenoxoprop methyl 1.8 ml L<sup>-1</sup>, quizalofop ethyl 4-5ml L<sup>-1</sup> or pyrazosulphuron ethyl 0.7 g L<sup>-1</sup>.

## 3.13: Soil Biology and Biochemistry

### Nagpur

Soil with available nitrogen from 17 legume

intercrops in cotton of 1:1 ratio with 45 x 10 cm and 90 x 10 cm spacing rhizosphere samples were compared with legume monocrops (45 x 10 cm). Sunnhemp and sesbania were mulched on 45 DAS which recorded higher soil available N (0.045 g kg<sup>-1</sup>) on 120 DAS than other grain legume (Fig. 3.13.1). Overall contribution of different legume varied with time during cropping season.

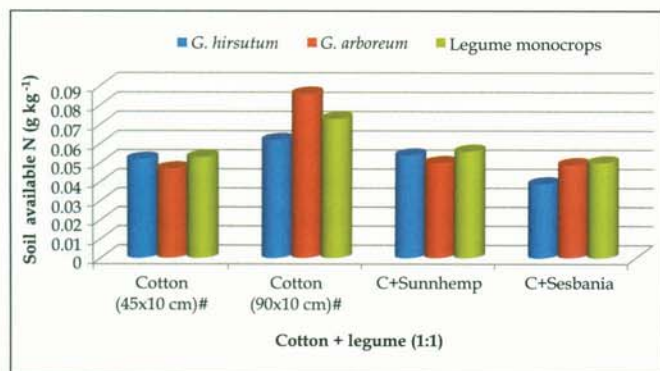


Fig. 3.13.1: Effect of N fixing legumes intercrops on availability of Nitrogen in soil (g kg<sup>-1</sup>) of cotton

### 3.14: Abiotic Stress Management

Consortia Research Project (CRP) : Agro Biodiversity

Nagpur

Phenotyping of selected 2000 germplasm accessions of *G. hirsutum* was done for the last two consecutive years for drought tolerance. Among these accessions; IC-325280 was better performing whereas IC-357406 was moderate and 3944 had a poor performance with regard to drought tolerant traits.



Field view of *G. hirsutum* germplasm accessions in response to heat and moisture deficit conditions

### MAS/MAB for Waterlogging in Cotton Nagpur

Screening of 242 *G. hirsutum* germplasm lines was carried out under water logging conditions. Forty five days old cotton plants were subjected to continuous water logging by maintaining a water level of 15 cm for 25 days. Among the short-listed germplasm lines from the previous year; 25 were screened for water logging tolerance. Lines identified for water logging tolerance and susceptibility were grouped based on presence and absence of lenticels and adventitious roots. These lines were also evaluated for leaf senescence characters and yield attributing characters. Sixteen lines were shortlisted for water logging tolerance and 62 for moderate tolerance.



Response of germplasm lines of *G. hirsutum* to waterlogging

Exploiting the epigenetic transgenerational inheritance of stress responsive traits for imparting abiotic stress tolerance in cotton

### Coimbatore

Suraj and LRA 5166 seeds were treated with different concentrations of five Epigenetic Regulating Chemicals (ERC) 5-Azacytidine - 10µM, 5- Azacytidine - 40 µM, Sulfamethazine- 10 µM, epigallocatechin gallate- 100 µM, Nicotinamide - 35 µM and sown in germination trays along with control to study the germination compatibility. Germination percentage was similar to the non-treated control in both the varieties and no malformations in seedlings were observed. Hence the chemicals used were compatible for seed germination. These plants treated with ERC will be screened for drought tolerance in the subsequent generation. Pot culture experiment was conducted with cotton varieties Suraj, LRA 5166, 891 and Nagpur 9 and drought stress was imposed at flowering stage for 5 days and re-watered. Generation is advanced and F<sub>1</sub> plants are being screened in the field for drought tolerance and stress memory.

### Correlation of leaf colour transmittance with soil/plant nutrient status

Field experiment was conducted with 6 levels of N (0% RDN, 25% RDN, 50% RDN, 75% RDN, 100% RDN and 150% RDN) with variety Suraj with three replications. SPAD values of 4<sup>th</sup> leaf from the top 5 plants/replication were recorded and correlated with N content estimated from the same leaves. Correlation coefficient (R) of 0.715 was obtained between SPAD values and N content of cotton leaves which is slightly lower than the correlation coefficient (R) of 0.795 between N content and greenness values obtained by the gadget "Nitrogen Guru" during 2015-16.

### 3.15: Cropping Systems

#### Nagpur

#### Efficient nitrogen fixing legumes for cotton based cropping systems

Nitrogen fixing legumes can restore soil fertility and reduce dependency on fertilizer-N. Seventeen N fixing legumes were evaluated as an intercrop in rainfed cotton at 1:1 row ratio with a spacing of 90 x 10 cm. Intercropping with *kharif* legumes improved soil nitrogen content at 120 DAS. *Rabi* legumes

germinated well; however, their growth was poor in 150 DAS of cotton due to insufficient soil moisture. Overall growth and yield was higher with *kharif* than with *rabi* legumes. Higher seed cotton yield was recorded in *kharif* legumes cluster bean (2446 kg ha<sup>-1</sup>) followed by sesbania, lablab, groundnut and green gram intercropped in American cotton (Fig. 3.15.1). In *desi* cotton, seed cotton yield was lower with intercropping than sole cotton 90 x 10 cm (2276 kg ha<sup>-1</sup>) yield.



Desi cotton+ legume intercropping in 1:1 ratio

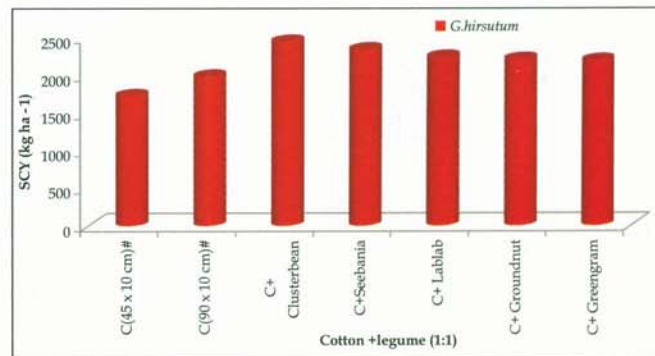


Fig. 3.15.1: Effect of N fixing legume intercrops on seed cotton yield (SCY) of Suraj variety

#### Coimbatore

#### Alley cropping of perennial legumes with cotton for sustainability

Three perennial legumes *viz.*, *Desmanthus virgatus* (hedge lucerne), *Medicago sativa* (lucerne) and *Mimosa invisa* (thornless mimosa) were grown as alley cropping with cotton. The recommended spacing of 90 x 60 cm was followed for sole cotton. In perennial legume plot, spacing followed was 90 x 45 cm. Every fifth row was sown with two rows of perennial legume without sacrificing the cotton plant population as compared to sole cotton. The yield attributes and seed cotton yield were not significantly altered in the first year of the study

due to perennial legumes. Among the perennial legumes, the growth of *Desmanthus* was very fast and it produced 15.44 t/ha of fresh biomass followed by thornless mimosa (4.21 t/ha). The

growth of Alfalfa was very slow and produced only 0.48 t/ha of fresh biomass during first and second pruning.



Alley cropping of *Desmanthus* with cotton

### 3.16: Conservation Agriculture

#### Development of remunerative cotton based cropping systems using conservation agriculture principles under irrigated condition

Field experiment was conducted with cotton-based cropping system using strip plot design. The main plots involved conventional system ( $M_1$ : Farmer's practice), conservation agriculture (CA) system with minimal land reshaping and partial (50% of residue from above ground biomass) residue recycling ( $M_2$ ) and CA system with 100% residue recycling ( $M_3$ ). For CA treatments, beds and furrow system was used while for the conventional system, ridges and furrow system for cotton and flat beds for other crops was used. The

CA plots were maintained on a permanent basis. The sub-plots consisted of four cropping systems *viz.*,  $S_1$ : cotton - black gram - maize (for grain purpose);  $S_2$ : cotton - maize (for green cobs) + pigeon pea (strip cropping in 4:2 ratio);  $S_3$ : cotton - groundnut (for table purpose) + pigeon pea (strip cropping in 8:2 ratio) and  $S_4$ : cotton - fallow (Control).

Analysis of Cotton Equivalent Yield (CEY) of different cropping systems (2015-16 sequence) indicated that land shaping treatments *viz.*, Ridges and furrows ( $M_1$ : 4623 kg CEY ha<sup>-1</sup>), Beds and furrows (4261 kg CEY ha<sup>-1</sup> in  $M_2$  & 4513 kg CEY ha<sup>-1</sup> in  $M_3$ ) had no significant effect on CEY. However, in terms of cropping systems, cotton - groundnut



(for table purpose) +pigeon pea recorded CEY of 5007 kg ha<sup>-1</sup>; cotton - maize (for green cobs) + pigeon pea recorded CEY of 4934 kg ha<sup>-1</sup>; cotton - Black gram - Maize (for grain purpose) registered CEY of 4521 kg ha<sup>-1</sup> (Fig. 3.16.1) which were significantly higher than the conventional Cotton - Fallow system (CEY of 3400 kg ha<sup>-1</sup>). On an average 3.91, 0.98, 5.87, 3.81 and 1.75 t ha<sup>-1</sup> residue of cotton,

black gram, maize, groundnut and pigeon pea, respectively, was produced under M<sub>3</sub> and 1.72, 0.47, 2.72, 1.71 and 0.95 t ha<sup>-1</sup> residue of cotton, black gram, maize, groundnut and pigeon pea, respectively, was produced under M<sub>2</sub> and recycled as surface mulch according to treatments in addition to the roots which were retained in the soil.

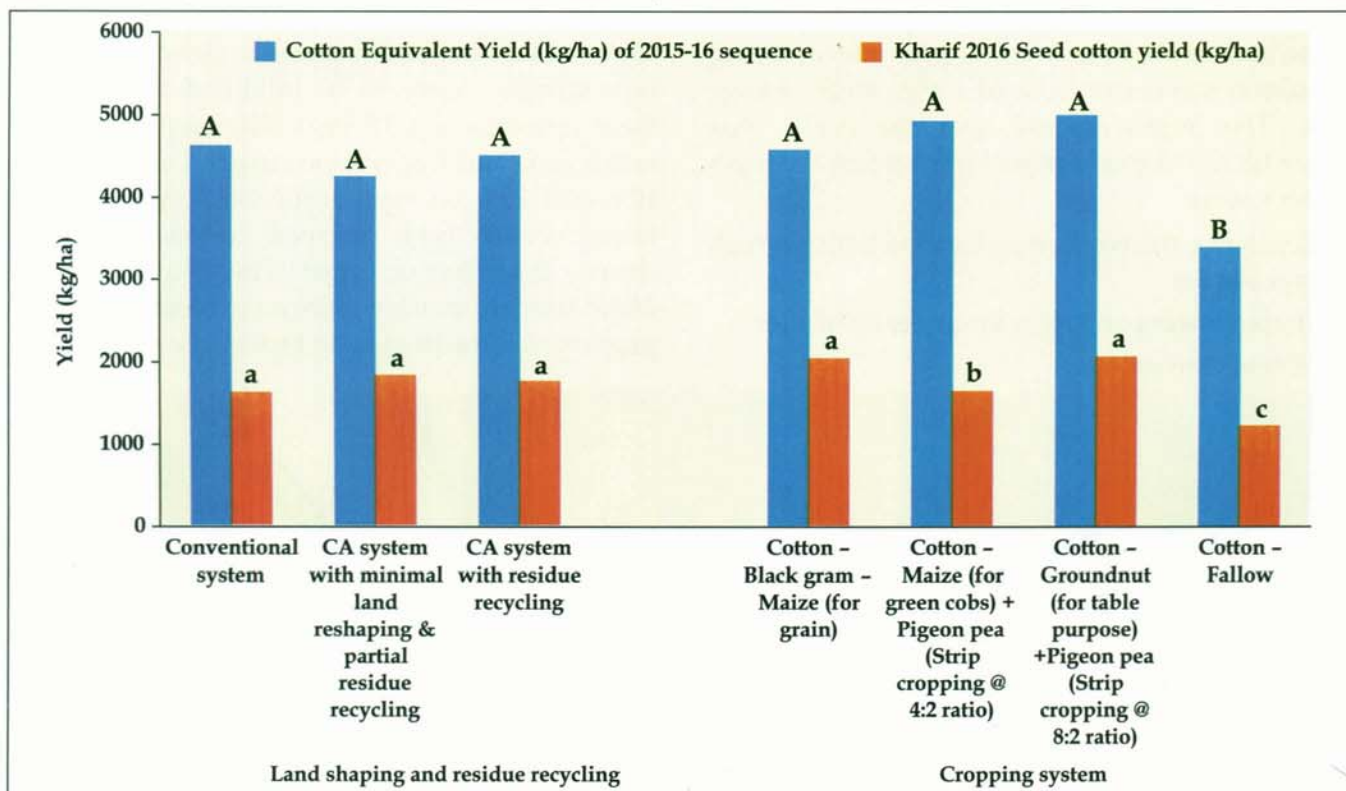


Fig. 3.16.1: Cotton Equivalent Yield (kg CEY ha<sup>-1</sup>) of 2015-16 cropping sequence and Kharif 2016 seed cotton yield (kg ha<sup>-1</sup>)

(Different lower case and upper case letter indicate significant difference among treatments within the group)

### 3.17: Water Management

#### Coimbatore

#### Evaluation of structured water for cotton production

Field study was conducted in a split plot design with structured water and bore-well water in the main plot and seven cotton cultivars viz., Suvin, Suraj, Surabhi, MCU 5 VT, Anjali, Mallika Bt and Bunny Bt in the sub-plot. Cotton cultivars responded to structured water irrigation as evidenced from an additional seed cotton yield of 3.87 q/ha across cultivars due to structured water irrigation. Irrigation using structured water also

resulted in higher dry matter, nutrient uptake, root cation exchange capacity and boll numbers as compared to bore-well irrigated cotton. The available moisture holding capacity on fourth day of irrigation was 27.1 % with structured water as compared to 25.6 % with bore-well water indicating better hydration due to structured water.

### 3.18: Mechanization of Cotton Production

#### Nagpur

The finger type concept of header was found to harvest trash beyond acceptable limits. Therefore, a brush type stripper was developed. The brush

type stripper header consists of two rotary brushes for stripping of cotton from the plants and two auger conveyors for collection of the stripped cotton. Brush type header was mounted on the tractor mounted cotton stripper harvester, developed earlier under the project, as a replacement for the comb type header. From the header, the stripped cotton was conveyed through a perforated conveyor to the field cleaner mounted at the back of the tractor and finally after cleaning the cotton was conveyed into a wire mesh storage tank. The improvements over the comb type harvester developed earlier for lowering the trash content, were

1. Replacing the comb type header with a brush type header
2. Slotted lower pan below the auger on header
3. Slotted conveyor

Field evaluation of the brush type stripper was done at ICAR-CICR, Nagpur during January 2017. During the trials, it was found that the brush type stripper was able to harvest cotton from a height of 300 mm and above and the cotton bolls situated below 300 mm height were left unharvested on the plants, mainly because of positioning of brushes at 300 mm height from ground surface. Moreover, the doffers were throwing significant amount of harvested cotton on the ground. Hence, the brush type stripper needs to be modified to overcome these operational problems. The trash content of brush type and finger type stripped cottons were 10.8 and 29% on raw cotton basis, respectively. Hence, brush type stripped cotton was much cleaner than that of finger type stripped cotton. There was not much significant difference in fibre properties of the finger and brush type headers.



Brush type stripper harvester



Brush type header



Slotted under cover for conveyor

### 3.19 : Socio Economic Dimensions of Cotton Farming

#### e-Kapas network to connect cotton farmers nationally for technology dissemination

Information and Communication Technology initiatives play a vital role and can help an average Indian farmer to get relevant information regarding crop cultivation, fertilizer application, pest management, processing, marketing, agro-finance and management of farm agric - business etc. The novel extension mechanisms 'e-Kapas Network' was initiated in April, 2012. The project implemented to provide opportunities to the cotton growers to get relevant, location specific, timely agro-advisory services and deliver appropriate cotton technologies to farmers to improve the efficiency of current manual system

by saving time, money and making technologies available 'anywhere and anytime' to users. The components of e- Kapas includes farmers' database, FAQs on cotton, content development and recording of voice messages, information delivery as voice calls on mobile numbers, kapas panchang and cotton apps.

#### e-Kapas farmers' database

Farmers were motivated to register themselves as 'e- Kapas' beneficiaries through publicity in newspapers, State Agricultural Departments, Agriculture Expos, cooperative banks, NGOs, etc. During the year, from the districts of eleven cotton growing states, 1, 59,948 new farmers were registered. State wise cotton growers registered were as follows: Maharashtra: 1,04,806, Gujarat: 60,247, Madhya Pradesh: 12,269, Orissa:

10,187, Rajasthan: 38,901, Haryana: 51,532, Punjab: 12,973, Andhra Pradesh: 15,367, Tamil Nadu: 24,682, Karnataka: 18,839 and Telengana: 25,659.

#### Information delivery through mobile based voice messages

Advisories and bulk messages in local languages on a regular basis to the registered cotton farmers through Mobile-based voice message service was introduced by CICR. The service was provided to all farmers irrespective of the telecom network. During the crop season 2016-17; 1,18,81,231 noise free and clear recorded voice messages were uploaded to the registered farmers in the form of automatic phone calls across the county, out of which 75,97,296 were attempted successfully and the delivery percentage was 64%. Advisories on production, protection, harvest and post-harvest technologies apart from weather alerts and market information were disseminated to the registered cotton farmers. The effect of these advisories evaluated with 400 'e- Kapas' beneficiary farmers indicated that the messages were useful in alerting the farmers on the market prices, weather and control measures for pests and diseases of cotton.

#### Impact of Institutional Credit on Cotton Farming in Vidarbha Region of Maharashtra

A sample of 300 cotton farmers covering both credit users (borrowers) and non-users of credit (non-borrowers) were interviewed from Vidharbha districts through well-structured comprehensive questionnaire. The study pointed out that more than 90% respondents received short-term credit or crop loan. Only 9 and 2% of respondents received medium-term and long-term credit, respectively. Results of stochastic frontier analysis showed that the credit using cotton farmers are more efficient than non-credit using ones. Range of technical efficiency was 0.46 to 0.98 with a mean 0.52 for the credit using farmers and values for the non-credit using farmers were 0.34 to 0.94 with a mean of 0.49. Maximum likelihood estimation results of the stochastic frontier production function showed positive and significant coefficients of irrigation, bullock labour and credit dummy variables indicating that the overall cotton production can be enhanced by exploiting irrigation, bullock labour and expansion

of credit (Table 3.19.1).

Agriculture credit indirectly helps in enhancing the output through buying various modern inputs. Hence, enhanced agriculture credit should be available to large proportion of rural population. Financial institutions provided credit to the marginal and small farmers in limited quantity based on the size of holding. This study recommends that subsidized credit to be given to small size holdings. Cotton being rainfed crop the increase in irrigation facilities such as drip, sprinkler, tube well and tractor, plays an important role in enhancing the productivity. Therefore, special loans should be given directly to farmers on easy installments for irrigation facility.

**Table 3.19.1 : Distribution of Technical Efficiency of Borrowers and Non-Borrowers (Stochastic Frontier Analysis)**

Efficiency class	Borrowers (%)	Non-Borrowers (%)
<0.60	3.49	2.47
0.61-0.80	21.32	33.00
0.80-1.00	75.19	64.53
Total	140	140
Minimum	0.46	0.34
Maximum	0.98	0.93

#### Cotton Price Forecasting

An appropriate price forecasting model in cotton was validated to forecast its price markets of nine States, three in each of North, Central and South Zones of India.

The study included major cotton markets *viz.*, in the North Zone, constituting about 81 per cent of the major cotton markets' share at Punjab, 90 per cent share at Haryana and Rajasthan. In case of Central Zone, it was 42 per cent coverage of the major cotton market share in Gujarat, 39 per cent in Maharashtra and 67 per cent share in Madhya Pradesh. Likewise in the South Zone, it constituted about 66 per cent share of total cotton markets in Andhra Pradesh, 39 per cent in Karnataka and 52 per cent share of the total cotton in Tamil Nadu. Based on  $R^2$  value, 15 variables *viz.*, Indian cotton

production, Mill Use, Exports, Imports, Beginning stock, Ending stock, World cotton production, Mill Use, Exports, Imports, Beginning stock, Import of cotton by China, MSP of cotton, Production of crude oil in India, Production of crude oil at world level were selected and data collected from 2002 to 2016 sourced from National Cotton Council of America, Statistics OECD Factbook, Min. of Agri. GOI and www.agmark.nic.in, respectively. Price

Forecasting was tried using Artificial Neural Network (ANN) with EXCEL (Alyuda Excel Forecaster) and SPSS 16 Software. The results revealed that the forecast accuracy with ANN through Excel was to the tune of 95 to 97 per cent in all the cotton growing states (Table 3.19.2). Alternative model ANN through SPSS was used to forecast the cotton prices with the same set of 15 variables.

**Table 3.19.2: Comparative Forecast Accuracy**

States	Forecast Accuracy (%)		
	ARIMA	ANN (EXCEL)	ANN (SPSS)
Punjab	92.53	97.26	96.08
Haryana	92.96	96.36	92.72
Rajasthan	93.58	96.14	94.22
Gujarat	96.13	97.89	94.78
Maharashtra	93.50	95.88	92.93
Madhya Pradesh	95.23	96.72	94.65
Andhra Pradesh	95.82	96.82	95.04
Karnataka	96.95	96.01	96.18
Tamil Nadu	96.53	96.75	96.78

The forecast accuracy was to the tune of 92 to 96 per cent. All the three models including ARIMA showed forecast accuracy above 90 per cent. The forecasted cotton price during 2017 hovers around Rs.5000/- to Rs.5800/- predicted through ANN with Excel. It was around Rs.5262/q in case of Punjab, Rs. 5790/q in case of Haryana and Rajasthan. It was almost Rs. 5030/- to Rs. Rs. 5300/q in the Central and South Zone cotton markets. Based on the trend of world cotton economic and trade situations, the variables considered for the price forecast may vary. Accordingly those variables are to be included with caution in forecasting the cotton price.

**Mobile based interactive DSS for cotton pest management**

Android mobile based interactive decision support systems (DSS) for cotton pest management with pre-recorded voice modules was developed. The system has detailed information of major cotton pests, including life cycle, ETL, symptoms of damage on leaf, stem, square, flower, boll, open boll etc. Also management options of chemical

control, bio-control, natural or cultural control for each of the pests has been incorporated. For the chemical control, the list of chemicals recommended with dosage information, along with available brands in the market with approximate price. The interactive DSS was embedded with a voice module for clear understanding of the information for the users. The DSS aids the farmers to identify the pest based on damage symptoms and helps to choose an appropriate pest control measures including selection of pesticide brand of their choice.

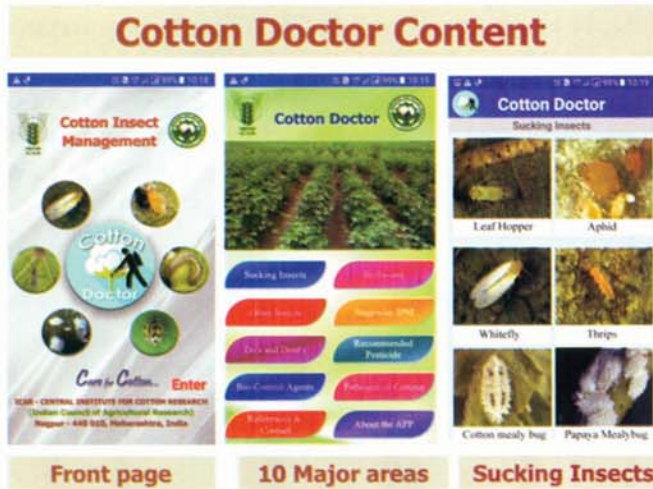


**Mobile Phone App – Cotton Doctor**

## Cotton Doctor

Android based mobile app “Cotton Doctor” was developed under the project “Development of Interactive Decision Support Systems for Cotton

Pest Management with Pre Recorded Voice Modules”. It is a user friendly software tool developed to support the cotton stakeholders in cotton insect management.



## ICAR- Flagship Project - Gender Knowledge System in Agriculture

In order to provide better information on gendered data and to sensitize cotton researchers, development/extension workers and policy makers on gender in cotton sector the project on “Gender Knowledge System in Cotton” was carried out. During the year 2016-17, data on women friendliness of cotton TOT programs *viz.*, e-Kapas network and Front Line Demonstration in cotton was collected among 170 women beneficiaries of e-Kapas (120) and FLD (50) through personal interview and focus group discussions using well constructed semi structured interview schedule. Results pointed out that both the cotton TOT program had medium level of women friendliness. Regarding the constraints faced by the women as regards to cotton extension program, majority of them (81.5%) expressed lack of awareness about cotton extension programs. Lack of inclusiveness in extension programs *i.e.*, not included in the programs unless separate requirement (quota) and less chance to participate in the training programs especially on campus training programs, not owning mobile phones/lands and lack of time to participate in TOT activities due to severe labor scarcity at farm

level were the other constraints expressed by the respondents.

Similarly, a study was undertaken in Yavatmal and Wardha districts of Vidarbha region of Maharashtra. Fifty three farm women from four villages of two districts were identified as respondents were interviewed personally using well structured pre-tested interview schedule to study the gender issues faced by the women. The study revealed that on an average, a woman spent 15 hours in household, crop and livestock activities. While they spent 7.23 hours in household activities, the time spent for crop activities and livestock activities were 6.47, 2.02 hrs respectively. Participation index in cotton picking was worked out as 147. Weeding, sowing and gap filling, application of fertilizer, manuring and uprooting occupied continuing position with the work participation index 143, 139, 115, 84 and 75 respectively which formed predominant activities dominated by women. The participation of women in decision making in cotton cultivation was minimal. In most of the activities a woman earns half of what a man gets for the same time spent. A major challenge confronted by majority (73.6%) of the farm women in cotton farming was limited labor availability during peak time.

### 3.20 : Seasonal Dynamics of Insect Pest and Diseases

Nagpur

#### Economic Threshold Level (ETL)

Data on seasonal pest population were recorded under pesticide free conditions by taking weekly sucking insect number counts on DCH 32 hybrid. Throughout the season, population of aphids, whiteflies and thrips were below ETL. Jassids were above ETL from first week of September to second week of October (Fig. 3.20.1). Negligible population of American bollworm, spotted bollworm, mirid and spider populations were recorded during the crop season.

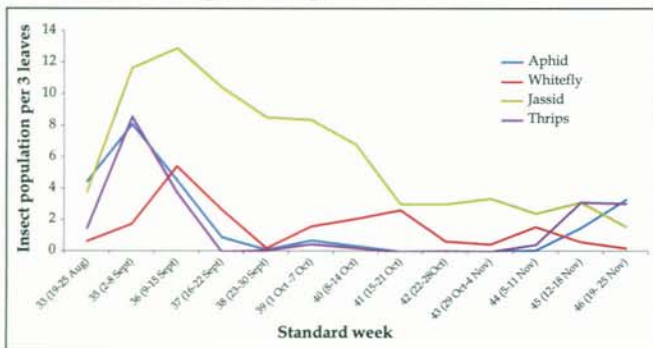


Fig. 3.20.1 : Population dynamics of sucking pests over the season 2016-17

#### Pheromone trap catches

During 2016-17, highest moth catches of American bollworm (27.44 moths/trap/week), spotted bollworm (9 moths/trap/week), pink bollworm (42.89 moths/ trap/week) and tobacco caterpillar (77.8 moths/ trap/week) was recorded at 48 (2-8 Dec), 38 (23-30 Sept), 50 (16-22 Dec) and 44 (5-11 Nov) Standard week (SW), respectively (Fig. 3.20.2).

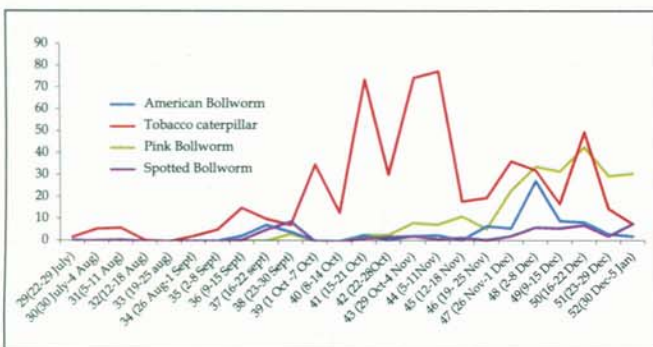


Fig. 3.20.2: Pheromone trap catches at Nagpur

#### Yellow sticky trap catches

Highest jassid population 1185 (jassid/trap/week) was recorded in the unprotected pesticide free (PF) compared to 483 (jassid/trap/week) pesticide intervention (P), during 39 SW (1 Oct-7 Oct.) (Fig. 3.20.3). Whitefly population 55 and 154 (whitefly/ trap/week) was trapped highest in PF and P respectively in 43 SW (29 Oct-4 Nov.) (Fig.3.20.4). Highest tachinid fly population 66 was recorded in SW 42 (22-28 Oct.) where as LBB population 10 Adult/trap/week in SW 43 (29 Oct.-4 Nov.).

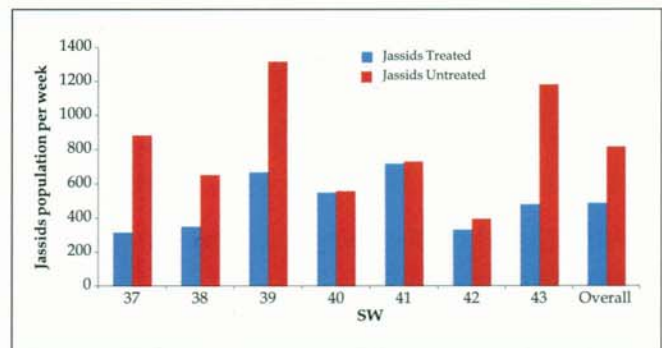


Fig. 3.20.3: Jassid population trapped in yellow sticky traps

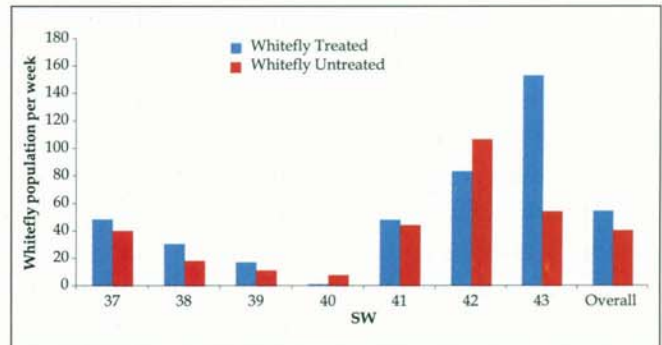


Fig. 3.20.4 : Whitefly population trapped in yellow sticky traps

Seasonal dynamics of leafhoppers and foliar diseases data was recorded in HDPS with talc based soil application at 30 DAS and 60 DAS of PGPR formulation ( $2 \times 10^9$  cfu/ml) on cv. Suraj (*G. hirsutum*) and Phule Dhanwantari (*G. arboreum*). In both cv. Suraj and Phule Dhanwantari, average reduction in population of leafhoppers was observed in *B. amyloliquefaciens* (T11) treated plots (Fig. 3.20.5 and Fig. 3.20.6).

Similarly, in cv. Suraj lowest PDI was observed for *Myrothecium* blight (2.78) and *Alternaria* blight (2.78) in *B. megaterium* (T16) treated plots followed by *B. amyloliquefaciens* (T11) treated plots with *Myrothecium* blight PDI (8.33) and *Alternaria* blight PDI (2.78). However, in cv. Phule Dhanwantari,

lowest PDI was observed for *Myrothecium* blight (2.78) and *Alternaria* blight (2.78) in *B. amyloliquefaciens* (T11) treated plots as well as in *B. megaterium* treated plots with *Myrothecium* blight PDI (2.78) and *Alternaria* blight PDI (2.78).

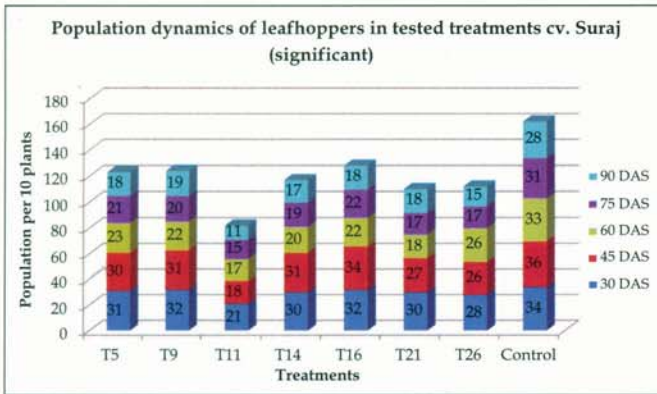


Fig. 3.20.5: Seasonal dynamics of leafhoppers during 2016-17 at Nagpur in PGPR treated plots (cv. Suraj)

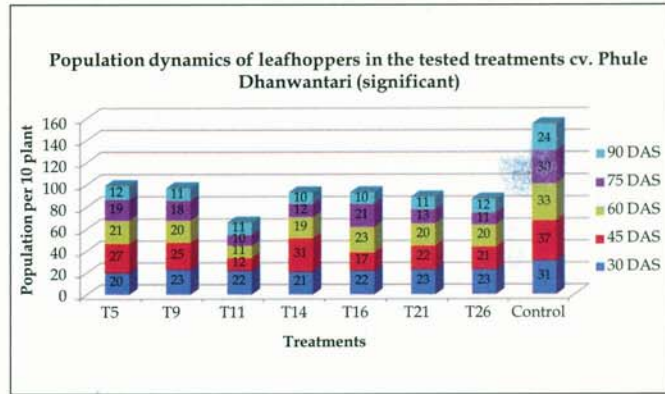


Fig. 3.20.6: Seasonal dynamics of leafhoppers during 2016-17 at Nagpur in PGPR treated plots (cv. Phule Dhanwantari)

**New report of *Oxyctonia versicolor* Fabricius, (chatter beetle) as a pest on cotton from central India:**

*Oxyctonia versicolor* was recorded as a pest on cotton during a survey conducted during September, 2016 in Saurashtra region of Gujarat.

Incidence was also noticed on cotton in districts of Surat, Bharuch, Ahmadabad, Anand, Botad, Bhavanagar, Amreli, Junagadh, Vadodara, Surendranagar, and Rajkot (Table 3.20.1). The highest number of beetle was found in Rajkot (5.27), Bhavnagar (4.83) and Junagadh (4.17) as

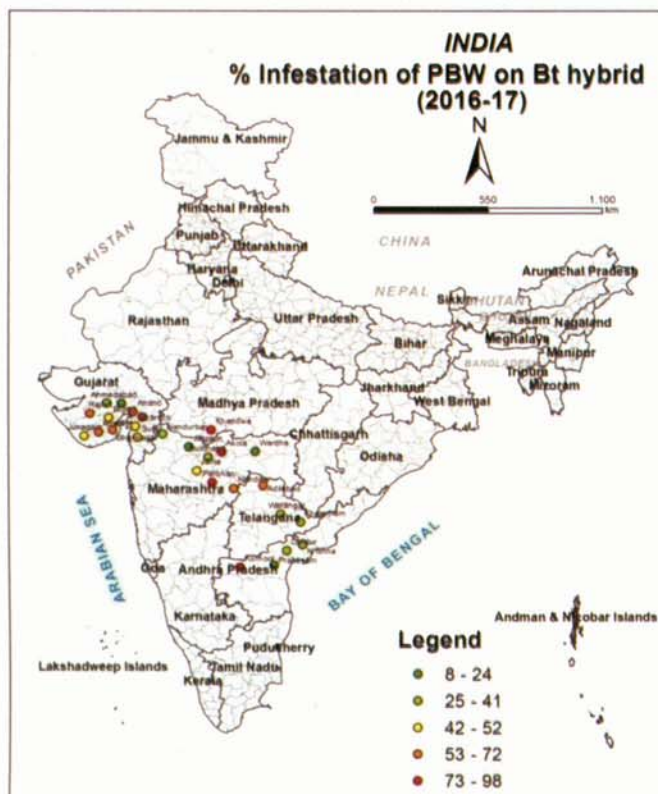
Table 3.20.1: Incidence levels of *O. versicolor* F. across Saurashtra (Gujarat) and Maharashtra

State	Locations	Number of samples /location	Number of flowers/ 30 plants	Number of Chaffer beetle/ 30 plants	% Infestation of
Gujarat	Surat	4.00	50(6.8)	3.0(0.4)	6.1(0.7)
	Bharuch	8.00	45.9 (17.7)	1.4(0.4)	4.4(1.6)
	Vadodara	6.00	135.8 (23.7)	1.8(0.7)	2.1 (1.3)
	Anand	3.00	39.3 (12.1)	2.0(0.6)	5.2(0.2)
	Ahmedabad	4.00	81.2 (9.0)	2.5(1.2)	5.4(3.7)
	Botad	5.00	73.2 (30.2)	1.4(1.2)	4.6(3.1)
	Bhavnagar	6.00	87.8(19.5)	4.83(1.6)	5.1(1.2)
	Amreli	6.00	86.0(14.3)	3.00(0.9)	3.7(0.7)
	Junagadh	6.00	56.2(8.8)	4.17(0.6)	7.6(0.7)
	Rajkot	11.00	63.6(16.3)	5.27(1.1)	12.9(2.7)
Maharashtra	Surendranagar	6.00	57.2(6.0)	3.83(0.7)	7.2(1.7)
	Wardha	6.00	72.8(3.2)	0.33(0.3)	0.4(40.0)
	Nagpur	4.00	80.3(9.9)	0.50(0.5)	0.6(0.6)

Numbers in parentheses are standard error

compared to other locations. Similarly, the incidence was also observed on cotton in Nagpur and Wardha regions of Maharashtra. In Maharashtra incidence of *O. versicolor* was very low. Adults feed on petals, anthers and pollen of the flowers, resulting in reduced boll formation followed by low yield of cotton. Early detection of *Oxyctonia versicolor* in central India (Gujarat and Maharashtra) should be taken as a forewarning that this insect may emerge as major pest in future. Monitoring surveys need to be carried out in all major cotton growing states of the country for awareness.

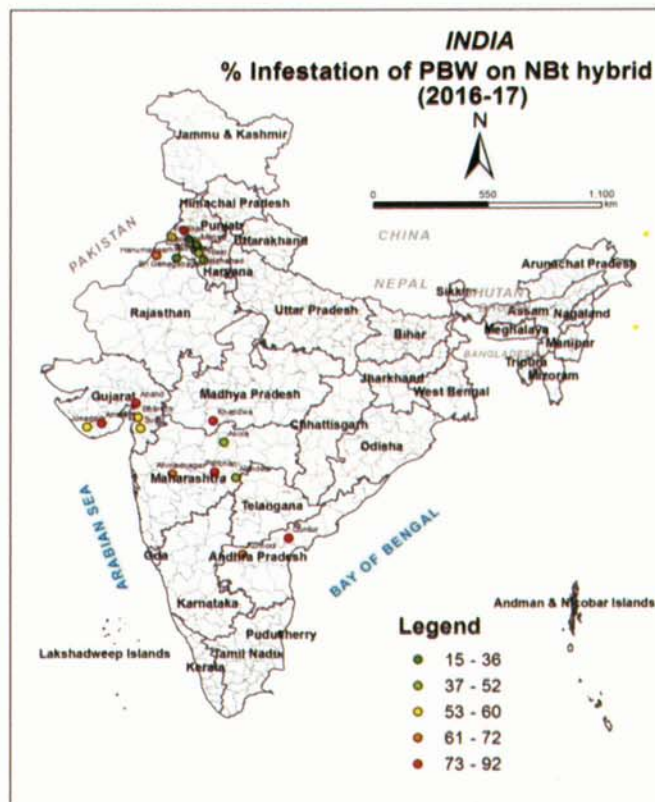
The infestation of pink bollworm on BG-II was observed in all cotton growing states of Maharashtra at 100-180 days after sowing crop. The infestation of green bolls in different districts of Maharashtra on different BG-II hybrids recorded was : Wardha 8.00 %, Akola 88 %, Nanded 66%, Jalna 48%, Jalgaon 21.3%, Buldhana 40% Nandurbar 34.6% and Parbhani 98%.



**Infection of PBW on BG-II hybrids on cotton in India**

The cotton fields of Bharuch, Vadodara, Anand, Bhavnagar, Amreli, Junagadh, Rajkot, Surendra-

nagar and Ahmedabad districts in Gujarat were monitored for Pink bollworm infestation on Cotton. The infestation of green bolls on BGII hybrids in Gujarat was higher in Amreli 72%, Anand 64% and Bhavnagar 64%. Over five locations, the infestation in NBt cotton was 84% at Anand closely followed by Amreli at 80%.



**Infection of PBW on NBt cotton hybrids in India**

The pink bollworm infestation in districts of Andhra Pradesh on green bolls was 35 % in Guntur, 55.7% in Prakasam, Kurnool 96% and 34.6 % in Krishna. The per cent infestation of Non Bt cotton on higher side observed in Guntur (86.00%) and Kurnool (72.00%) respectively. In Telangana, the incidence of pink bollworm was monitored in Adilabad, Khammam, Warangal and Karimnagar districts. The pink bollworm incidence was observed in extended irrigated cotton fields on Bt cotton. The per cent infestation of Pink bollworm on different Bollgard-II hybrids was recorded in Adilabad 58.8%, Khammam 41% and Warangal 38% respectively. In north India, the incidence of pink bollworm on Bt was nil in all the three states of North India.



**Coimbatore**

Pest population was compared in five genotypes over the season. Though significant variation was observed in aphid and whitefly population but it was negligible across the genotypes. Jassid population was significantly highest on Suvin and DCH32 (6.1-7.0 jassid/3 leaves). Thrips population was highest on RCH 2 and Suraj and it ranged between 3.6-3.9 thrips/3 leaves. American and spotted bollworm, mirid and spider populations were negligible during the season.

**Sirsa**

After the whitefly havoc in north India during 2015, survey and surveillance on severity of the Cotton Leaf Curl Disease (CLCuD) and whitefly was conducted from 48 locations across 8 important cotton growing districts of north India namely- Sirsa, Fatehabad and Hisar districts of

Haryana, Hanumangarh, Sriganganagar of Rajasthan and Fazilka, Bhatinda and Mansa districts of Punjab. To record the per cent disease incidence (CLCuD) grading (0-6 scale) technique developed by AICCIP on cotton was adopted (Proceeding AICCIP, 2015). Various kinds of symptoms *viz.*, vein thickening, upward and downward curling (cupping), mottling/crinkling and cup shape outgrowths or enations on the lower side of the infected leaves was recorded. Disease progression was very slow except along the Indo-Pak border of Hindumalkot of Sriganganagar district of Rajasthan and some locations of Sirsa district of Haryana. (Fig. 3.20.7). In August, none of the districts and in September all most all the surveyed districts showed whitefly population above Economic Threshold Level (ETL).

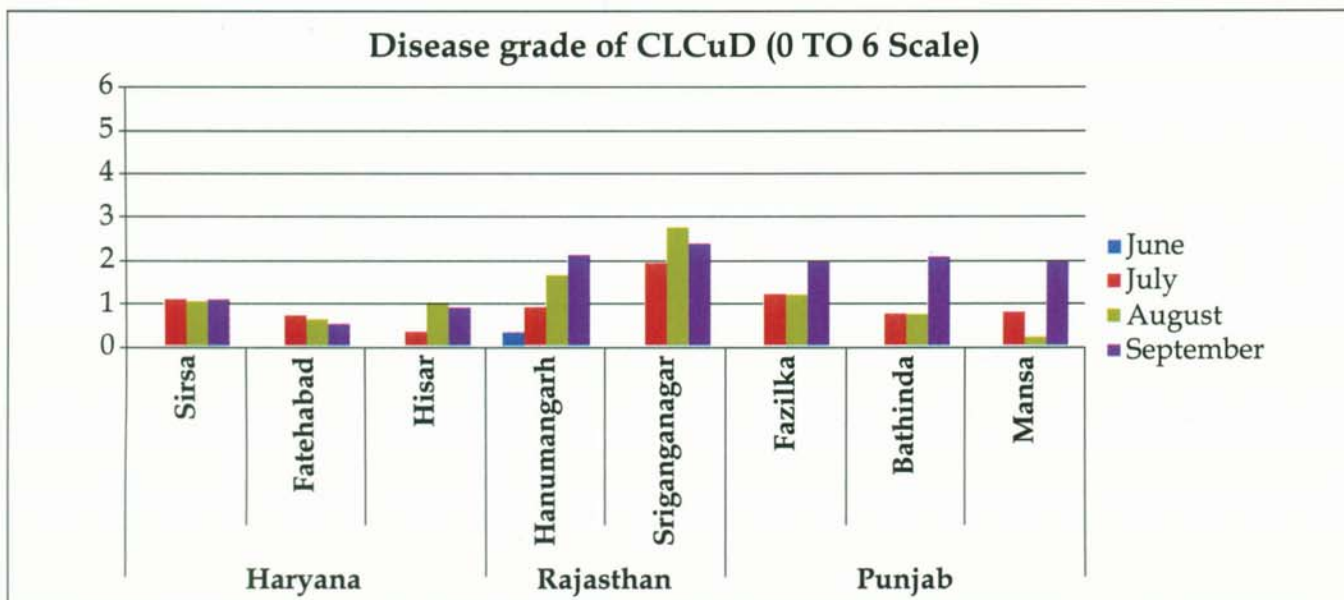


Fig. 3.20.7: Survey and surveillance of Cotton leaf curl infected field in North India

Hanumangarh, Sriganganagar and Faridkot districts were identified as the hotspot area for CLCuD. Disease incidence and severity was not correlated with the number of whiteflies in the surveyed locations.

- Population of whitefly was initially observed in 21 Standard metrological week (SMW) on RCH 650 BG-II (4.80 whitefly/3 leaves), HS-6 (6.50 whitefly/3 leaves), Ganganagar Ageti (3.10 whitefly/3 leaves) and RS-2013 (4.60 whitefly/3 leaves) and peak activity occurred in 31 SMW (17.30 whitefly/3 leaves), (26.90 whitefly/3 leaves), (23.60 whitefly/3 leaves), (21.90 whitefly/3 leaves) respectively.
- Leafhopper population observed in RCH-650 BGII (0.10-8.50 leafhoppers/ 3 leaves), RS-2013 (0.00 to 6.60/3 leaves), HS-6 (0.00 to 7.20 leafhoppers/ 3 leaves) and Ganganagar Ageti (0.00 to 6.20 leafhoppers/ 3 leaves). Leafhopper was first noticed during 23 SMW and peak activity was observed in 29-30 SMW
- Thrips population ranged from 0.00 to 32.10 thrips/3 leaves (RCH-650 BGII), 0.00 to 24.20 thrips/3 leaves (RS-2013), 0.00 to 26.90 thrips/3 leaves (HS-6) respectively which were first noted in 23 SMW. In Ganganagar Ageti, thrips population ranged from 0.00 to 25.90 thrips/3 leaves which were first noticed in 29 SMW. Peak activity of thrips was observed in 29 SMW in all genotypes.
- Bollworm infestation was not observed in RCH-650 BG II. In non- Bt varieties i.e. HS-6, GA and RS 2013 first population of bollworm was observed in the 30 and 33 SMW which ranged from 0.00 to 10.90, 0.00 to 13.43 and 0.00 to 11.01 percent fruiting bodies damage respectively.

### 3.21 : Biological Diversity of Insect Pests and Pathogens

Nagpur

#### Diversity of Mealybugs

Six surveys were conducted in 5 districts of Maharashtra (Nagpur, Wardha, Amravati, Yeotmal, and Akola) and Chindwara of Madhya Pradesh during 2016-17. Reduced diversity of mealybug was recorded during the crop season.

Only two mealybug species viz., *Phenacoccus solenopsis* and *Nipaecoccus viridis* were recorded in surveyed area. Overall mealybug population was negligible in the areas surveyed.

#### Bollworms

All the three species of bollworms viz., *Helicoverpa armigera*, *Earias insulana*, *Pectinophora gossypiella* were seen to damage non-Bt cotton. Significant square damage (20%), flower damage (6.67%) by *H. armigera* was seen during reproductive stage of crop. Rosette flowers caused by pink bollworm infestation from mid August with negligible damage at the initial phase, increased up to 20% by mid October.

#### Genetic diversity among CLCuV in north India

In order to identify the prevalence cotton leaf curl viral strain(s) in north India a genetic variability study has been carried out. Field isolates from different geographic locations of 8 cotton growing districts of north India were collected and subjected to partial DNA sequencing (904 bp Rajgopalan *et. al.*, 2012) and sequences were compared to those available on NCBI. Based on partial genome sequences and using Rajasthan and Burewala promoter regions primer, it can be concluded that Rajasthan Cotton leaf curl virus (CLCuRV) and Multan virus (CLCuMuV) are the prevalent strains observed in partial sequence study. RCA- PCR proved to be effective for the amplification of DNA template having low virus titer. By using promoter regions primer, most of the samples were recorded to have mixed infection of both Rajasthan and Burewala viral strains and co-infection is needed for recombination and evaluation of new viral strains.

#### Diversity of natural enemies and whitefly

To record the abundance and diversity of natural enemies in cotton ecosystem in central, south and north India, a study was conducted. Where yellow pan trap was used for recording parasitoids and visual count method was used to record predators. In central India, the study was conducted in cultivars Phule Dhanwantari, Suraj, Suvin, RCH-2 and DCH-32. More than 35 different kinds of natural enemies were recorded. Diversity indices such as Shannon Index (H), Shannon evenness

Index (E), Simpson Index (D), Sorenson's Coefficient (CC) and Species richness (S) were calculated for above varieties of cotton. Species richness and abundance was more in Phule Dhanwantari and Suraj compared to the Suvin, RCH-2 and DCH-32. Unprotected conditions carry more species richness than protected ones.

Molecular diversity analysis of whitefly was done for the north Indian population and presence of Asia I and Asia II1 genetic group of whitefly was confirmed. Forty eight gene sequences have been submitted to the NCBI and the accession numbers are KY503195, KY503217, KY547806, KY547830 and KY348784.



*Scymnus nubilus*

*Cheilomenus sexmaculata*

*Brunaides suturalis*

*Encarsia sp*

*Brachymeria sp*

## Coimbatore

### Natural occurrence of entomopathogenic fungus

Natural epizootics of an unknown entomopathogenic fungus to the tune of 15 per cent was recorded from Mite, *Tetranychus* sp. during the month of November.

### 3.22: Isolation and Identification of New Genes and Gene Sources

#### Nagpur

#### Gene associated with somatic embryogenesis

*Wnt* gene is well characterized in animal system and is known to be associated with myriad of functions including regulation of cell fate determination and patterning during metazoan embryogenesis. A novel *wnt-3a* like gene homologue has been identified in *G. hirsutum* and recorded its expression in *in vitro* cultured callus. However, further characterization is under process.

#### LIM gene family analysis in *G. arboreum* L

A number of actin-binding proteins participate in the regulation of actin cytoskeleton dynamics of cotton fibre and known to play a pivotal role through active changes in the organization of microtubules. The LIM family proteins are also known actin binding protein. Protein containing

LIM domains are well documented for their role in regulation of gene expression at transcription level and cytoskeleton organization. Its role in regulation of fibre strength and fineness, seed and organ size is reported in *Gossypium hirsutum* and *Arabidopsis thaliana* respectively. Taking the clue from the above studies and published genome sequence information, genome wide analysis of *G. arboreum* LIM (GaLIM) gene family was carried out to identify and characterize the LIM gene family members of diploid *G. arboreum*. It resulted in identification 20 members of GaLIM family representing two groups. The phylogenetic analysis of retrieved protein sequences LIM family proteins of cotton with that of LIM gene family sequences from published plant species revealed the occurrence of WLIM1, WLIM2, PLIM1 and PLIM2 subgroups in cotton. RT-PCR analysis of LIM gene family showed differential organ specific gene expression.

#### Isolation of microbes for gossypol detoxification

To isolate gossypol detoxifying microorganism's, different cotton rhizosphere soil samples and pink boll worm larvae (mid gut) were collected. Bacterial, fungal and actinomycetes isolates were isolated by using gossypol (100ppm) as sole source of carbon on minimal media. The microbes identified through 16s and ITS region sequencing

as Actinomycetes *Streptomyces* spp, and fungus *Aspergillus versicolor*, *Penicillium griseofulvum*, *Aspergillus terreus*, *Aspergillus quadrilineatus* /*Emericella* Spp. Some isolates were able to utilise and survive on 250 ppm and 500 ppm gossypol containing media.

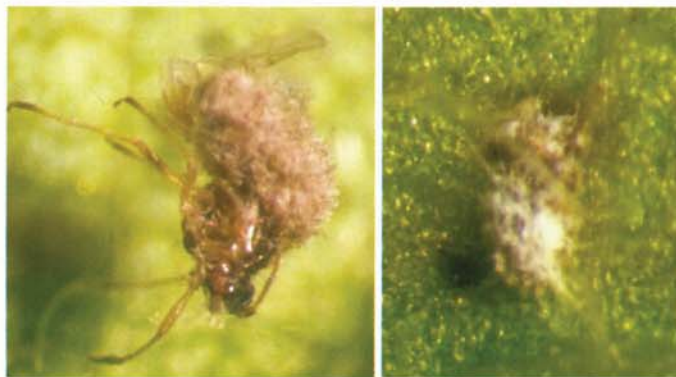


Screening fungal isolates at 250 ppm

Screening actinomycete isolates at 500 ppm

### Isolation and identification of endophytes from cotton

Fifteen fungal endophytes were isolated from cotton leaves following standard tissue isolation methods and were morphologically characterised.



Different stages of infected aphids

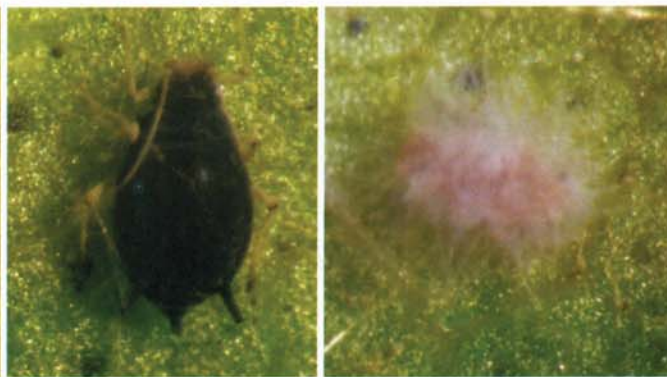
Eight fungal endophytes were identified based on their ITS sequences. The endophytes belonged to the genera *Cladosporium* sp., *Cochliobolus* sp., *Curvularia lunata* (3 isolates), *Curvularia aerea*, *Curvularia hawaiiensis* and *Aspergillus* sp.



Different fungal endophytes isolated from cotton leaves on PDA

### Bioassay of sucking insect pests of cotton against *Beauveria bassiana*

Bioassay study on sucking pests of cotton revealed that out of 42 strains of *Beauveria bassiana* tested 4 strains; F-391, MTCC-4516, MTCC-4497, MTCC-4562 were most effective against aphids. Against jassids in pot cage method out of 107 *Beauveria bassiana* strains, 5 strains; (MTCC-4575, MTCC-4605, MTCC-4556, MTCC-4122, MTCC-6099) were most effective.



### 3.23 : Development of New Methods, Tools and Protocols

Nagpur

#### PCR amplifiable DNA isolation from mature cotton fibre

A protocol has been standardized to enable DNA extraction from harvested matured cotton fibre. Using this protocol, it was possible to isolate PCR amplifiable DNA representing both chloroplast and nuclear genome. Subsequently, both chloroplast and nuclear genome segment were

amplified using genome specific primers respectively. In addition, using specific primers, *cry1Ac* gene (787 bp) was detected from matured fibre DNA harvested from transgenic cotton plant.

#### Embryo culture

A new embryo culture protocol has been developed for *in vitro* rescue of inter-specific F1 hybrids and to also aid generation advancement in cotton. Immature cotton ovules of more than 15-20 DPA were successfully raised aseptically under *in vitro* condition and healthy seedling were established.



Embryo culture of inter-specific F<sub>1</sub> hybrids of *G. hirsutum* and *G. arboreum* and vice versa

#### Standardized medium for *in-vitro* cotton fibre initiation:

An attempt was made to generate fibre from *in vitro* cultured ovular epidermal cells (which can be considered as the stem cell for *in vivo* cotton fibre synthesis) with a long term objective of in-depth understanding of molecular genetic network underlying fibre initiation and mass production of cotton fibre under *in vitro* condition. -1 Days Post Anthesis (DPA) ovules were crushed and cultured on medium with following composition: MSB2K + Kinetin + 3% Sucrose, pH 5.8 at 30°C in dark. This induced callus proliferation of ovular tissue clumps (which includes ovular epidermal fibre inducing cells). Later, these proliferated callus mass was subcultured in medium with same composition except kinetin was replaced with gibberellin (used @ 1µM) and indole acetic acid (used @ 5µM). These treatments induced fibre in the cultured cell mass. Control was devoid of hormone treatment and hence, did not showed any fibre initiation.



#### Rapid detection of Cotton leaf curl virus infection by using Single tube Loop Mediated Isothermal Amplification technique (LAMP)

One step single tube and rapid nucleic acid amplification protocol for the detection of whitefly transmitting devastating cotton leaf curl virus has been developed. This is the first report of use of LAMP for diagnosis of Cotton Leaf Curl Virus (CLCuV) on cotton. Primer set by using conserved region selected by multiple sequence alignment for standardisation of LAMP protocol were designed using Primer Explorer V4 software (<http://primerexplorer.jp/e/>). CLCuV infection

of samples were confirmed with the PCR amplicon size of 199 bp using F3 and B3 primers of LAMP. The temperature and time essential for LAMP assay was standardized at isothermal conditions of 61 °C for 60 min for set of four primers (F3, B3 and FIP, BIP) targeting six regions of sequence of CLCuV. Detection of target sequence amplification in PCR was accomplished by 1.5% agarose gel electrophoresis. Formation of ladder like amplifications confirms positivity of samples for CLCuV infection of LAMP assay. No products were detected in the blank and no template control in LAMP or the PCR. Currently, for the diagnosis of the CLCuV affected samples of cotton crops, serological and nucleic acid based methods such as PCR and ELISA have been extensively employed by the researchers. Development of LAMP as diagnostic tool having rapidity, specificity and sensitivity will have immense role to play in detection and management of economically important CLCuV.

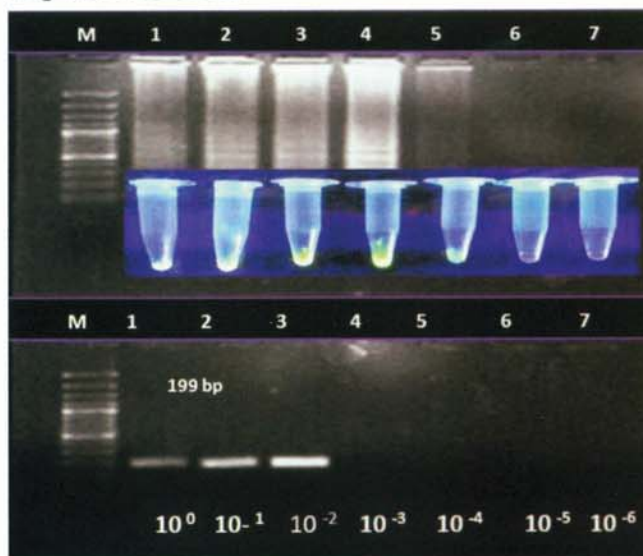


Fig 3.23.1: Optimization of LAMP condition for CLCuV of Cotton and study on sensitivity of LAMP

#### Standardization of protocols for the evaluation of microencapsulated Bt toxin against *H. armigera*

Cry1Ac toxin was isolated and purified from *Bacillus thuringiensis* Kurstaki (HD 73 strain). Toxin isolated from HD 73 strain was quantified and loaded in the microcapsules. Different concentrations of the toxin were prepared as 1000, 2000, 3000, 4000 ppm and used for bio-assay. Direct toxin and

encapsulated toxins were exposed to pH (3 and 10.5), UV (12 and 24 hrs.), sunlight (24 and 48 hrs) and compared with unexposed direct and encapsulated toxin for its stability of efficacy. Evaluation of encapsulated Bt toxin at 1000, 2000, 3000 & 4000 ppm resulted in maximum weight reduction (45.88 to 60.03%) as compared to 40.25 to

58.66% over control in direct toxin isolated from Bt HD 73 strain. Same trend was recorded in the encapsulated Bt toxin and direct toxin (1000, 2000, 3000 & 4000 ppm) when exposed to pH (3 & 10.5), UV (12 & 24 hrs) and Sunlight (24 & 48 hrs) (Fig 3.23.2).

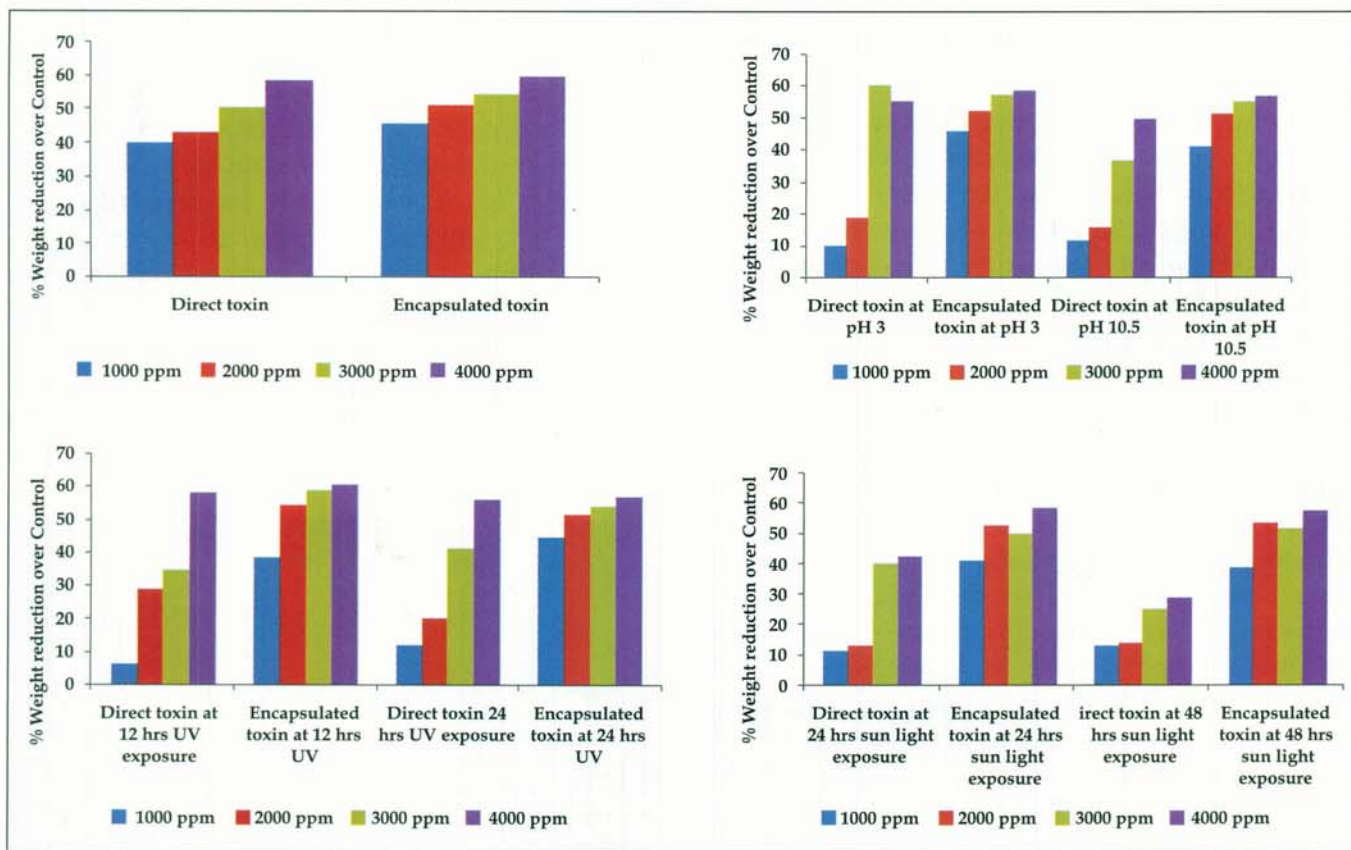


Fig 3.23.2: Effect of Cry1 Ac direct toxin and encapsulated Cry1Ac toxin against *H. armigera*

### Enhancing the efficacy of yellow sticky traps using natural essential oils against sucking pests in cotton

The evaluation of natural essential oils in combination with yellow sticky traps was carried out against sucking pests of cotton (Whitefly, jassids and aphids) to enhance the efficacy of yellow sticky traps at CICR, Nagpur. The 6 different natural essential oils viz., Sandal wood, Basil, Clove, Grape fruit, Rose and Mint oils were evaluated in three replication. The traps were placed at equal distance in unsprayed homogenous fields and observation was taken at every 10 days interval. The traps treated with Sandalwood oil and Basil oil attracted whiteflies

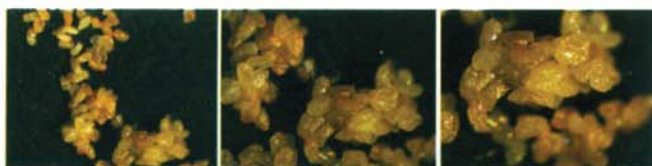
and leaf hoppers significantly. However, these combinations will be further evaluated for confirmation.



Yellow sticky traps in combination with essential oils were placed in the cotton fields

### Push-Pull strategy for management of pink bollworm in cotton

The field population of pink bollworms from Nagpur (CICR farm) was established in the laboratory. The eggs and faecal pellets of pink bollworm were collected in three solvents namely hexane, acetone and methanol with difference in polarity. The samples were analysed in GC-MS for identification of volatiles. Two compounds each in acetone and methanol fraction were identified.



Egg masses of pink bollworm collected from cotton twigs in the laboratory rearing

### Evaluation of Pheromone Traps and Lures against Cotton Pink Bollworm

Different pheromone traps and lures *viz.*, PCI-Funnel Trap, AGC-Funnel trap, Phero-Sensor TM-SP, Phero-sensor TM-BP and CICR trap were evaluated against pink bollworm in cotton. All the lures and traps were at par except in some observations as third week of November, second week of January and February where PCI-Funnel trap along with season long lure (120 Days) was best.

#### Coimbatore

### Evaluation of bacterial endophytes inoculated cotton plants against major insect pests of cotton

Seventeen bacteria were isolated as endophytes from stem and leaf parts of cotton plant. Based on its virulence, nine isolates were selected for field experiment during 2015-16 and based on the results, finally five isolates were used in field experiment during 2016-17. Three methods *viz.*, seed coating, soil drenching and foliar spray were followed to inoculate the bacterial endophytes into cotton plants in field condition. Under unprotected condition, all the treatments recorded significantly low population of sucking pests *viz.*, Aphid, Jassid, Whitefly and Thrips compared to control. Method of treatment did not show any significant

difference among them. However, *B. subtilis* inoculated plant recorded low population of sucking pests and *B. cereus* strain inoculated plant recorded low pink bollworm damage.

### Evaluation of entomopathogenic fungi *Beauveria bassiana* inoculated cotton plants against insect pests of cotton

Five *Beauveria bassiana* entomopathogenic fungal endophytes recorded effective against insect pests in 2015-16 were reevaluated by three methods of application *viz.*, seed coating, soil drenching and foliar spray on cv. Suraj. Sucking pests *viz.*, Jassids, Aphids, whitefly and pink bollworm population were recorded under unprotected condition. Among the three methods of inoculation, foliar spray method recorded low population of sucking pests and pink bollworm followed by soil drenching and seed coating method. Thirty five MTCC *B. bassiana* cultures were also evaluated against whitefly, aphids and *Spodoptera litura*. For whitefly and aphid, 100% mortality was recorded. For *S. litura*, 15 isolates shows more than 50% mortality.

## 3.24: Biological Control

### Nagpur

#### Bioagent diversity

Due to negligible population of mealybugs, occurrence of natural control agents was minimal. Only parasitoid *Aenasius arizonensis* was recorded on *P. solenopsis*. Parasitoids *Apanteles angaleti* Muesebeck, *Apanteles glomeratus* (L.), *Palexorista laxa* Curran were recorded on cotton semilooper, *Aphelinus mali* on aphids. General predators of cotton pests *viz.*, lady bird beetle *Cheilomenes sexmaculata* (Fab.), lace wings *Chrysoperla carnea* (Stephans), lady bird beetle *Scymnus coccivora* Ayyar, predatory stink bug, *Eocanthocona furcellata* (Wolff), big eyed bug *Geocoris ochropterus* (Fieber), etc were recorded.

#### Parasitoid and predators diversity on cotton infesting mealybugs during 2009-2016 in central India

Parasitoid and predators diversity on cotton mealybugs was studied during 2009-2016 in central India. In all 468 colonies were collected

from 22 districts of three states viz. Maharashtra-17, Gujrat-4 and Madhya Pradesh-1 district respectively. Per cent parasitization by each parasitoid on mealybug species was recorded by rearing colonies on sprouted potatoes in the lab. Predators feeding on mealybugs immature stages also recorded.

In central India 6 species of mealybugs viz., *Phenacoccus solenopsis*, *Nipaeococcus viridis*, *Paracoccus marginatus*, *Rastrococcus iceryodes*, *Maconellicoccus hirsutus* and *Ferrisia virgata* were observed infesting cotton. Parasitization by at least one or more parasitoids was recorded in all mealybugs except *Ferrisia virgata*. In all 16 parasitoid species were recorded on 5 species of mealybug (Table 3.24.1). Among them *Aenasius arizonensis* was dominant and recorded throughout the years in most the locations surveyed with

average parasitization recorded at 14% over the years 2009-16. In addition, 8 predators were observed preying these mealybugs (Table 3.24.2). Highest number of parasitoids were recorded during 2009 and least during 2016. Three hyperparasitoids viz, *Promuscidea unifasciatiiventris* Girault, *Prochiloneurus albifuniculus* (Hayat et al.), *Prochiloneurus pulchellus* Silvestri was also observed. *P. unifasciatiiventris* Girault was most common. All these parasitoids were mostly dominant during August to January. Maximum parasitization of *P. solenopsis* by *A. arizonensis* was recorded during September (37%). Maximum diversity of parasitoids was recorded during December followed by August. In all the locations maximum diversity of parasitoids (16 species) was recorded at Nagpur as frequent surveys were conducted at this location.

**Table 3.24.1: Parasitoid diversity on cotton infesting mealybugs during 2009-2016 in central India**

Mealybug species	Parasitoid	Mealybug species	Parasitoid
<i>Phenacoccus solenopsis</i>	<i>Aenasius arizonensis</i>	<i>Nipaeococcus viridis</i>	<i>Aprostocetus</i> spp.
	<i>Anagyrus kamali</i> Moursi		<i>Anagyrus kamali</i> Moursi
	<i>Anagyrus dactylopii</i> (Howard)		* <i>Prochiloneurus albifuniculus</i> (Hayat et al.)
	<i>Anagyrus mirzai</i> Agarwal and Alam		<i>Pseudleptomastix mexicana</i> Noyes and Schauff
	<i>Aprostocetus bangaloricus</i> Narendran	<i>Paracoccus marginatus</i>	* <i>Promuscidea unifasciatiiventris</i> Girault
	<i>Aprostocetus</i> sp.		<i>Acerophagus papayae</i> Noyes & Schauff
	<i>Chartocerus kerrichi</i> (Agarwal)		<i>Aprostocetus</i> sp.
	<i>Encyrtus aurantii</i> (Geoffroy)		<i>Pseudleptomastix mexicana</i> Noyes and Schauff
	<i>Homalotylus albiclavatus</i> (Agarwal)		* <i>Promuscidea unifasciatiiventris</i> Girault
	<i>Metaphycus</i> sp.	<i>Rastrococcus iceryodes</i>	<i>Anagyrus kamali</i> Moursi
	* <i>Prochiloneurus albifuniculus</i> (Hayat et al.)		<i>Pseudleptomastix mexicana</i> Noyes and Schauff
	* <i>Promuscidea unifasciatiiventris</i> Girault		* <i>Promuscidea unifasciatiiventris</i> Girault
	<i>Pachyneuron leucopiscida</i> Mani.	<i>Maconellicoccus hirsutus</i>	<i>Anagyrus kamali</i> Moursi
* <i>Prochiloneurus pulchellus</i> Silvestri			

\*Hyperparasitoids

Table 3.24.2: Predator diversity on cotton infesting mealybugs during 2009-2016 in central India

Mealybug species	Predator	Mealybug species	Predator
<i>Phenacoccus solenopsis</i>	<i>Brumus</i> sp.	<i>Nipaecoccus viridis</i>	<i>Cacoxenus perspicax</i> (Knab)
	<i>Cheilomenes sexmaculata</i> (Fabricius)		
	<i>Cryptolaemus montrouzieri</i> (Mulsant)		
	<i>Chrysoperla carnea</i> (Stephans)		
	<i>Nephus regularis</i> (Sicard)		
	<i>Rodolia fumida</i> Mulsant		
	<i>Scymnus coccivora</i> Ayyar		

#### Evaluation of egg parasitoid *Trichogramma bactrae* and *Trichogramma brasiliensis* through inundative release

A field trial was conducted for evaluation of egg parasitoid *Trichogramma bactrae* and *Trichogramma brasiliensis* through inundative release in cotton. Two releases at flowering (40-45 DAS) and two releases at Boll maturation (60-75 DAS) stage at weekly interval along with three insecticides at 40 DAS, 60 DAS and 90 DAS.

There was no difference in exit hole and number of mines on the epicarp in *Trichogramma bactrae* and *Trichogramma brasiliensis*. The lowest percent of locule damage was observed in (Profenophos 50EC + Thiodicarb 75WP + Cypermethrin 25EC) @ 2.88 % as compared to *Trichogramma bactrae* and *Trichogramma brasiliensis* and control. However the per cent locule damage was reduced due to *Trichogramma bactrae* and *Trichogramma brasiliensis* @ 3.37 % and 4.88 % respectively as compared to control 11.60 % locule damage. The lowest larval infestation was noticed again in insecticides treated plot @ 1.17 larvae/10 green bolls followed by *Trichogramma bactrae* 1.61 larvae/10 GB and *Trichogramma brasiliensis* 1.51 larvae /10GB as compared control

#### Coimbatore

#### Wax degrading bacteria for the control of cotton mealybugs

Biopesticides based on microbes as whole, microbial toxins, biochemicals derived from microorganisms are emerging faster but the potential of

certain group of microbes like wax degrading bacteria (WDB) still remains unexplored. Wax degrading microorganisms hydrolyze complex waxy substances through pseudosolubilization, adherence, biosurfactant production and enzyme secretion. Work was initiated at ICAR-CICR, RS, Coimbatore under National Post Doctoral Fellowship (N-PDF) scheme of DST-SERB with the objective to isolate and characterize novel WDB associated with mealybugs infesting cotton for their possible application as a biocontrol agent.

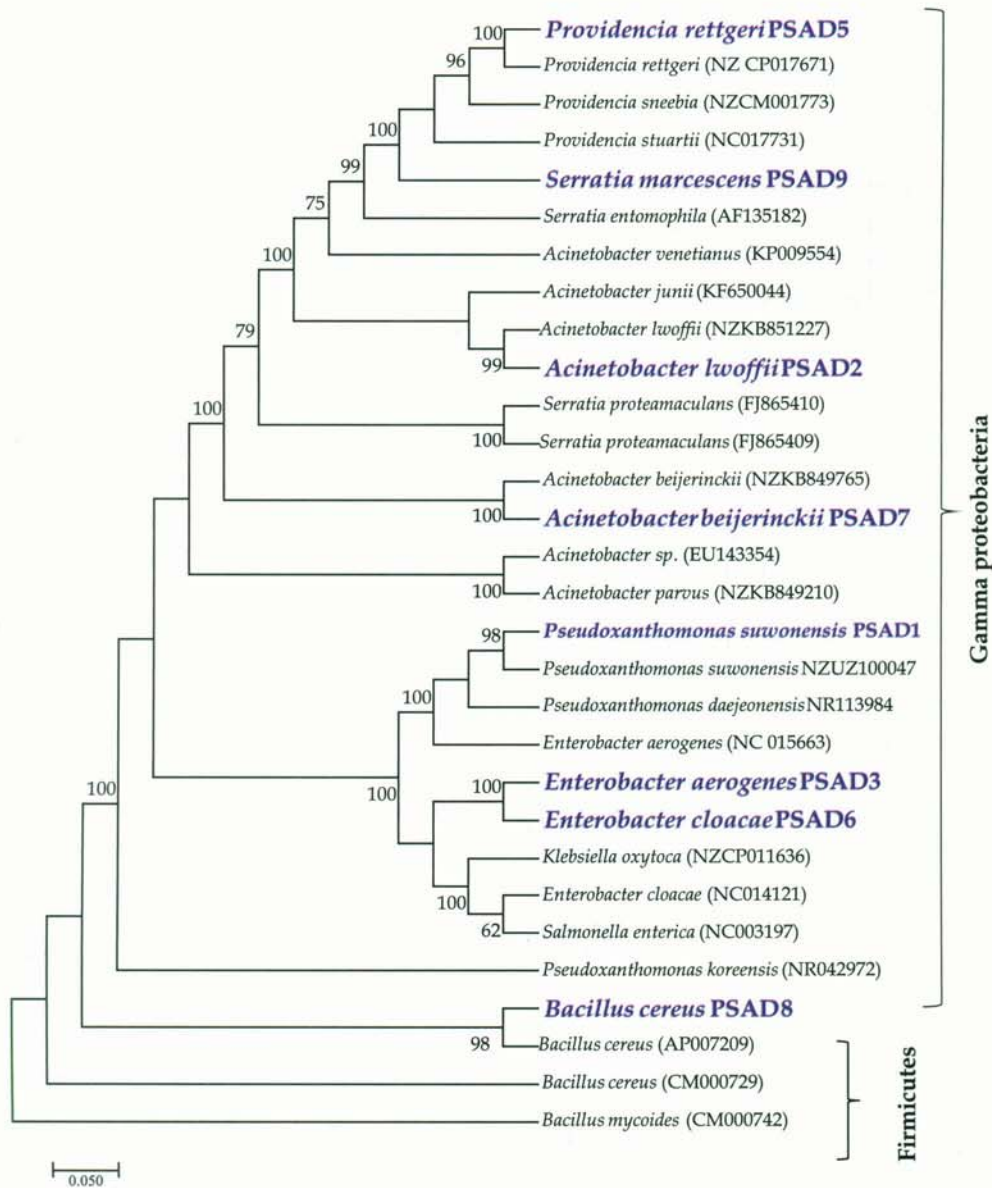
In all wax degrading bacterial isolates (PSAD 1 to 17) were obtained from the carcass of adult female mealybug samples. Upon screening of the isolates for lipase production and biosurfactant efficacy revealed that only eight isolates (PSAD 1,2,3,5,6,7,8 and 9) out of the seventeen were very efficient in wax degradation. Based on morphological and biochemical profiles, the isolates were tentatively identified belonging to the genera *Bacillus*, *Enterobacter*, *Pseudoxanthomonas*, *Pseudomonas* and *Serratia*. The results obtained during screening clearly confirmed the ability of the WDB isolates to utilize wax substrates and among all the isolates PSAD 2 and PSAD 7 showed maximum biosurfactant potential of 142.14 mm<sup>2</sup> and 115.93 mm<sup>2</sup>, respectively.

The genomic DNA of the wax degrading bacterial isolates were amplified and phylogenetic tree was constructed with 16S rRNA amplified gene sequence (Figure 2). The phylogenetic tree inferred from 16S rRNA gene sequences confirmed that the

bacterial isolates were *Pseudoxanthomonas suwonensis* PSAD1 (KY780940), *Acinetobacter lwoffii* PSAD2 (KY780940), *Enterobacter aerogenes* PSAD3 (KY780940), *Providencia rettgeri* PSAD5 (KY780940), *Enterobacter cloacae* PSAD6 (KY780940), *Acinetobacter beijerinckii* PSAD7 (KY780940), *Bacillus cereus* PSAD8 (under submission), *Serratia marcescens* PSAD9 (under submission).



Purified wax degrading bacterial isolates on Nutrient Agar (NA) medium



Neighbour-joining phylogenetic tree based on complete 16S rRNA sequences. Bar, 0.05 nucleotide changes per positions. Wax degrading bacteria strains obtained in this study are shown in bold. Bootstrap value  $\geq 50$  are shown.



Parasitised larvae of pink bollworm

*Rogas sp.*, adult parasitoid*Rogas sp.*, a larval parasitoid of pink bollworm

A larval parasitoid, *Rogas sp.* (Hymenoptera: Braconidae) was recorded on the pink bollworm in cotton variety LRA 5166 at Coimbatore. To know the level of natural parasitism, a study was undertaken during 2<sup>nd</sup> week of January 2017. Cotton bolls with the symptoms of pink bollworm infestation were collected and observed under 10x hand lens for parasitization. Parasitized larvae were separated and individually placed in glass vial for the emergence of adult parasitoids. The natural parasitism of *Rogas sp.* was found to be 1.7 % on pink bollworm larvae.

**Development of oil based formulation of entomopathogenic fungi**

Oil based formulation of *Lecanicillium lecanii* and *Metarhizium anisopliae* was standardized. The formulation developed with different solvents and additives recorded maximum spore load of  $12 \times 10^8$  without sedimentation, flocculation and recorded maximum spore load and spreadability on plant system. The formulation was safer to natural enemies (Spiders and Coccinellid beetles).

**Safety of entomopathogenic fungi to Coccinellid beetle**

Spraying of Coccinellid beetle, *Chilomenes sexmaculata* with spore suspension of *M. anisopliae* was carried out. Spraying of *M. anisopliae* spores at

maximum concentration of  $1 \times 10^8$  recorded maximum survival rate in indirect (residual) method than direct spray method.

**Safety of entomopathogenic fungi to earthworm**

Field recommended dose ( $2 \times 10^6$ ) of talc based formulation of *M. anisopliae* at 5 and 10 per cent and crude culture filtrate of *M. anisopliae* was incorporated into the substrate to test their effect on the survival of earth worm *Eisenia fetida* (Savigny). At the end of experiment, no reduction in weight of worms was noticed. Spores of *M. anisopliae* could survive in the substrate and none of the dissected worms showed the presence of fungus.

**Persistence of bio-pesticide formulation under field condition**

Addition of corn oil and skimmed milk powder to the *L. lecanii* formulation could increase the spore viability upto 66 per cent as against 22 per cent in spore suspension alone at 4DAS (Days After Spraying). Maximum spore germination of 96 per cent was recorded in formulation with corn oil and skimmed milk powder.

**Field evaluation of biopesticides**

Field evaluation of two talc based formulation of *L. lecanii* and *M. anisopliae* was tested in comparison with oil formulation of *M. anisopliae* @ 5 ml/l

(ICAR-IIHR), a commercial formulation and an insecticide treatment. Among different treatments, insecticides ranked first followed by biopesticides in reducing the sucking pests under field condition. Spraying of talc based formulation of *L. lecanii* and *M. anisopliae* at the rate of 10 g/l significantly reduced the population of sucking pests under field condition. Both formulations were safer to the natural enemies (Spiders and Coccinellids) under field condition.

#### Shelf life studies on biopesticide formulation

Shelf life studies of oil based formulation of two entomopathogenic fungi *viz.*, *L. lecanii* and *M. anisopliae* was carried out at monthly interval and spore viability was assessed. These two formulations can be stored for six months under room temperature without much loss in spore viability.

### 3.25: Integrated Pest Management

#### Nagpur

#### Insecticide induced resurgence of whitefly and other pests of cotton

Experiment on insecticide induced resurgence of whitefly and other pests of cotton were undertaken by taking 25 insecticides belonging to 9 groups (Botanicals, Pyridinecarboxamide, Neonocotinides, IGR, spinosyns, Organophosphate, Phenylpyrazole, Pyrethroid, Ketoenols). The experiment was conducted under rainfed conditions in randomised block design with three replications. Untreated seeds of genotype 'Suraj' was used. Repeated insecticidal sprays were given starting from 67 days after sowing with interval of 10 days between two sprays. Post-treatment counts of whitefly and other pests of cotton were recorded at 7 DAT after each spray. Results indicated that in all the sprays there was no significant difference in whitefly number except at first sprays where population was at lowest level. Though mean number of whitefly over the season was observed significantly higher in insecticidal treatments *viz.* Clothianidin 50% WDG, Dinotefuran 20% SG, Imidacloprid 17.8% EC, Thiamethoxam 25% WG, Acephate 75% SP, Triazophos 40% EC, Fosmite 50% EC, Fipronil 5% SC, Cypermethrin 25% EC

and Spiromesifen 22.9% SC, however, ETL was not crossed (6 whitefly/leaf) during entire season. Hence it is inferred that even after repeated application of 8 sprays of insecticide no whitefly resurgence was seen. Insecticides used for bollworm control *viz.* Spinosad 45% SC, Triazophos 40% EC, Fipronil 5% SC, Bifenthrin 10% EC significantly produced yield higher yield as compared with other insecticides, while insecticides recommended especially for whitefly control *viz.* Pyriproxifen 10% EC and spiromesifen 22.9% SC also yielded at par (3244-3539 kg/ha). Insecticides exclusively recommended for sucking pest control *viz.* Dinotefuran 20% SG, Imidacloprid 17.8% EC, Thiamethoxam 25% WG produced lowest yield (1846-2202 kg/ha).

#### Resistance monitoring against cotton whitefly (*Bemisia tabaci*) for Nagpur population

Resistance monitoring against cotton whitefly (*Bemisia tabaci*) was initiated from 2015-16 for Nagpur population. Twenty one insecticides from 10 groups (Biorationals, Neonicotinoid, Phenylpyrazole, Carbamates, Pyridinecarboxamide, Insect Growth Regulators, Organophosphate, Pyridine, Tetrionic acids, Synthetic pyrethroid) were taken for resistance monitoring during 2015-16 and 2016-17. Over the two years it was observed that resistance ratio could not exceed > 20 fold. For some of the insecticides the resistance recorded as Imidacloprid- 10 fold, Acetamiprid-7 fold, Fipronil-6 fold, Fosmite-2 fold, Acephate-2 fold, Neemraj- 15 fold, Pyriproxifen-18 fold. Whereas, susceptibility of whitefly was unchanged in insecticides Diafenthiuron, Dinotefuran, Bifenthrin, Triazophos, Thiomethaxon, Flonicamid, Monocrotophos, Fenpropathrin, Spiromesifen, Piryproxifen + Fenpropathrin, Clothianidin, Chloropyriphos, Neemban and Buprofezin respectively.

#### Resistance development in cotton mealybug *Phenacoccus solenopsis* Tinsley (Homoptera: Pseudococcidae) to five insecticides in Vidarbha region of central India

Results indicated that all the populations showed very low resistance to all the tested insecticides except Amravati and Wardha population for

buprofezin, and the corresponding RFs were very high (378.29) and low (16.63), respectively.

**Insecticide resistance monitoring of 6 insecticides against leaf hoppers**

Leaf hopper samples from four locations were subjected to resistance monitoring studies. LC<sub>50</sub> to Flonicamide ranged from 0.001 mg/L (Amravati) to 0.007 mg/L (Nagpur). LC<sub>50</sub> of Monocrotophos ranged from 0.005 mg/L (Yavatmal) to 0.01 mg/L (Amravati). LC<sub>50</sub> of Acephate ranged from 0.003 mg/L (Amravati) to 0.05 mg/L (Yavatmal). LC<sub>50</sub> of Imidacloprid ranged from 0.0005 mg/L (Yavatmal) to 0.021 mg/L (Nagpur). LC<sub>50</sub> of Acetamiprid ranged from 0.008 mg/L (Amravati) to 0.08 mg/L (Yavatmal). LC<sub>50</sub> of Thiamethoxam ranged from 0.0005 mg/L (Amravati) to 0.113 mg/L (Yavatmal). Yavatmal populations were more susceptible to Flonicamid, Monocrotophos and Imidacloprid than the other populations. Populations from Amravati were more susceptible to Acetamiprid, Thiamethoxam and Acephate.

**Monitoring of Pink bollworm Resistance in India**

The resistance development of pink bollworm on BG-II and non Bt cotton fields was monitored in 37 districts across India. In North India, 9 districts from three states (Hisar, Fatehabad and Sirsa of Haryana, Mansa, Abohar, Bathinda and Faridkot of Punjab, Sriganganagar and Hanumangarh of Rajasthan), in Central India 24 districts (Wardha, Yavatmal, Washim, Hingoli, Nanded, Parbhani, Aurangabad, Buldana, Akola, Amravati, Rahuri, Jalgaon districts of Maharashtra; Khandwa and Pandhurna districts of Madhya Pradesh, Surat,

Bharuch, Vadodara, Anand, Ahmedabad, Bhavnagar, Amreli Junagadh, Rajkot and Surendranagar districts of Gujarat), in South India 13 districts (namely Guntur, Kaddapa, Anantpur, Kurnool and Krishna in Andhra Pradesh; Karimnagar, Adilabad, Warangal and Khammam in Telangana, Srivilliputtur and Coimbatore in Tamil Nadu and Dharwad and Raichur in Karnataka) were monitored for pink bollworm damage at 100-180 days after sowing.

Resistance to Cry1Ac and Cry2Ab toxin genes was recorded in Pink bollworm populations from Telangana, Andhra Pradesh, Gujarat and Maharashtra. Pink bollworm populations from Guntur, Warangal, Vadodara, Amreli, Rahuri, Rajkot, Jalna and Khammam recorded 148, 166, 166, 242, 350, 440, 570 and 640 fold resistances to Cry1Ac over susceptible check. Populations from Junagadh, Rahuri, Nanded, Warangal, Guntur, Amreli, Buldhana, Prakasam, Parbhani and Adilabad recorded 100, 134, 135, 183, 200, 216, 340, 350, 365, 1130 and 1500 fold resistance over the susceptible check to Cry2Ab.

Green bolls from Coimbatore (Co 14), Raichur (DCH 32 and RCH2 Bt) and Srivilliputtur (RCH2 BG II, SVPR 2, SVPR 4 and DCH 32) were monitored for the infestation of pink bollworm. Survival of pink bollworm on Bt hybrids was observed on RCH 2 Bt from Raichur. Number of larvae for 50 bolls, percentage of boll damage and locule damage were recorded as 12.08 Nos., 25.27% and 8.79%, respectively (Table 3.25.1).

**Table 3.25.1: Survival of *P. gossypiella* on NBt/ Bt hybrids from different locations**

Name of the Centre	Variety	Bolls observed on	No.of mines/ 50 bolls	Total surviving larvae/ 50 bolls	Bolls damage %	Locule damage %
Coimbatore	Co-14 (NBt)	135 DAS	136.8	56.00	53.55	63.39
Raichur	DCH-32 (NBt)	120 DAS	48.13	8.84	16.82	7.01
	RCH2 Bt	120 DAS	48.90	12.08	25.27	8.79
Srivilliputtur	RCH2 BGII	130 DAS	26.47	0.00	0.00	0.00
	SVPR2 (NBt)	130 DAS	74.00	13.00	22.00	7.00
	SVPR4 (NBt)	130 DAS	23.28	1.72	3.45	0.86
	DCH-32 (NBt)	130 DAS	27.88	0.96	25.27	0.96

### Insecticides for pink bollworm

The field experiment was conducted at CICR, Nagpur to study the effects of newer chemistry like Quinolphos 25 EC, Profenophos 50 EC, Thiodicarb 75 SP, Cloranthraniliprole 18.5 SC, Spinosad 45 SC, Neem Oil, Cypermethrin 25 EC, Deck (Cypermethrin + Profenophos), Spark (Deltamethrin + Triazophos), Traizophos 40 EC, Deltamethrin 2.8 EC for management of Pink bollworm under High Density Planting System (HDPS). The lowest per cent of locule damage was observed in Deck (Cypermethrin + Profenophos) (2.44%) followed by Spark (Deltamethrin + Triazophos) (4.42%) as compared to control (31.17%). The lowest larval incidence was observed in Deck (Cypermethrin + Profenophos) (0.78 larvae/10 GB) as compared to control.

### Evaluation of plant material for induction of Systemic Acquired Resistance against phyto nematode

Bio formulations (Curcumin water soluble and alcohol soluble extracts, neem oil and cow urine in different combinations) were evaluated for induction of systemic acquired resistance against reniform nematode under field conditions. Effect of bio formulations on nematode population in field and effect on cotton yield was evaluated. In 2016-17 best formulation was Neem oil with cow urine. The spray treatments were better than the corresponding treatments applied to soil in reducing nematode population and increasing seed cotton yield.

### Coimbatore

#### Exploring novel dispensers to enhance the trapping efficacy of gossypure in managing pink bollworm in cotton

Eight dispensers *viz.*, neoprene, polypropylene, polyvinylpyrrolidone, cellulose acetate, zeolite, silicone, paraffin wax and rubber were prepared for the pheromone compound gossypure and evaluated against the cotton pink bollworm in field experiment in RBD with 3 replications on variety LRA 5166. The Polypropylene (10.13 adult/trap/week) and the silicone (9.31 adult/trap/week) dispensers were significantly superior to the standard rubber dispenser (8.44

adult/trap/week). The neoprene dispenser had highest catch (14.67 adult/trap/week) in first three weeks but has short persistence (7 weeks) compared to that of standard dispenser (13 weeks) (Fig. 3.25.1)

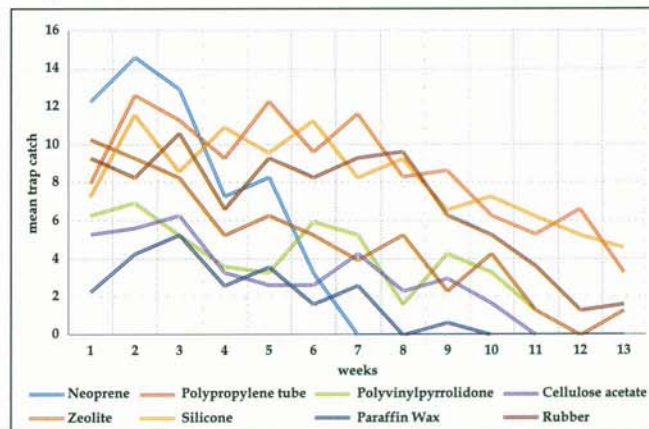


Fig. 3.25.1: Efficacy of different dispensers in mass trapping PBW males on cotton

Eight different traps *viz.*, wing trap, LED light trap, funnel trap, delta sticky trap, bottle trap, PET trap, water trap and cone trap were fabricated and evaluated against the pink bollworm in field on variety LRA 5166. The weekly mean catches of PBW adult males were in the order of wing trap(10.64) > LED light trap (10.23) > funnel trap (8.67) > delta sticky trap (7.21) > bottle trap (4.26) > pet trap (3.97) > water trap(3.72) > cone trap (2.87). The trap catches of pink bollworm male moth had significant negative correlation with the per cent boll infestation ( $r = -0.79$ ) larval population ( $r = -0.86$ ) while it had significant positive correlation with the seed cotton yield ( $r = 0.89$ )





## Sirsa

- Out of 160 shortlisted germplasm entries screened, one entry recorded whitefly 0-5/3 leaves, 49 between 5-10, 106 between 11-15/3 leaves and 5 between 16-20/3 leaves.
- Quantity of wax extracted from tolerant /susceptible entries twice during the season and role of epicuticular wax on whitefly and CLCuD incidence couldn't be correlated.
- Among the ecological interventions applied for the management of whitefly, guar gum and wax recorded a reduction of 19.53-30.72% in whitefly adults population and were found safer to natural enemies.
- Castor oil + liquid soap (55.36%), Pongamia oil (58.36%), Sesame oil + liquid soap (45.48%) and Neem oil were found effective in whitefly adults reduction under laboratory evaluations after diafenthiuron (76.15% reduction). Under field conditions also same trend was observed with comparatively less reduction.
- Whitefly distribution within plant was studied where maximum population of the adults was recorded in bottom canopy /lower side leaves (13.27/3 leaves) followed by middle canopy leaves (9.62/3 leaves) and upper canopy (5.35/3 leaves). However the nymphal counts were at par in the middle and lower canopy and significantly higher than the upper canopy of the plant. Field biology of whitefly was conducted and among the natural mortality factors the maximum was due to dislodgement followed by the parasitization

## Laboratory and field monitoring of Resistance in bollworms against Cry toxins and against insecticides in sucking pests

- The susceptibility of *H. armigera* to cry toxins was studied through leaf, square, flower and bolls bioassays against Cry1Ac at various stages of crop growth. The mortality (%) at 80,100,120 and 140 DAS ranged between 60-86.7, 52-68, 42.7-52 and 25.3-56.0 in various Bt-cotton varieties tested under AICCIP. Similarly in square (80 DAS), flower (80 DAS) and boll (100 DAS) bioassay the reduction percentage

obtained was 45-72, 44-72 and 28-42.7%, respectively. However, the weight of surviving larvae on Bt varieties ranged between 1.2-19.7 mg in comparison to 88.8-125.4 mg in control indicating severe growth regulation of the surviving larvae.

- The two day old larvae of *Earias insulana* were released on BG-II and Bt and Non-Bt plants leaves (at 95-100 DAS) and squares (at 80 DAS) of the genotypes under laboratory conditions. The leaves were replaced every day and mortality was recorded. The larval mortality ranged 97.3-100% in BG II and 1.3-2.7 % in Non Bt leaves.
- The efficacy of various insecticides was studied under laboratory conditions at ICAR-CICR Sirsa in Common trials on evaluations of Agrochemicals against all the label claim insecticides for whitefly including IGR's, Organophosphate, Organochlorine, Neonicotinoid, Biopesticides etc. Bifenthrin, Diafenthiuron, Flonicamid, and Dinotefuran were found effective against whitefly adults whereas Spiromesifen, Pyriproxyfen and Buprofezin were found effective against whitefly nymphs. Some of the chemistries (Flonicamid, Ethion) gave good results against both the adult and nymphal stages of whitefly.
- The most commonly used and label claimed insecticides for whitefly were studied for their resistance status in whitefly adults population from the four different locations of North cotton growing zone of India. Out of the four locations studied (Sirsa, Sriganaganar, Hisar, Mansa), among the neonicotinoid, the maximum resistance ratio was obtained in Thiamethoxam (13.07 folds) and comparatively less in Imidacloprid, Acetamiprid and Dinotefuran as affected due to the pesticide use pattern. Among all the locations, Abohar location was having maximum resistance Ratio to Acetamiprid (11.63 folds), Thiamethoxam (58.96 folds) where as Dinotefuran (17.8 folds) at Sirsa and Imidacloprid (3.14 folds) at Ganganagar recorded highest RR. Among IGRs Sipromesifen (238.6 folds) at Abohar, Diafenthiuron

(81.6 folds) at Sirsa were recorded highest RR whereas Pyriproxyfen and Flonicamid were recorded least RR at all the locations studied. Among organophosphate Triazophos (23.42-43.15 folds) was recorded maximum RR.

- Monitoring of Pink Bollworm (PBW) was done in North Zone where 5 districts (Faridkot and Bhatinda in Punjab; Sriganganagar in Rajasthan; Hisar and Sirsa in Haryana) were monitored for recovery of PBW larvae through dissection of green bolls collected at various stage of crop growth. 60-150 green bolls each from different varieties (RCH 650 BGII, RS-2013, GA and HS6) were collected at 120, 140, 160 and 175 DAS as per the availability of bolls. PBW larvae were not recovered in RCH 650 BGII from any of the location. In Non-Bt genotypes at different intervals in North Zone during 2016-17 revealed 0-11.34% larval recovery from green. The maximum larval recovery was recorded at 160 DAS.

**Studies to identify most virulent strains of entomopathogenic fungi for whitefly control**

**Survey and collection of entomopathogenic fungi**

Field surveys were conducted and more than 500 samples were collected of whitefly adults and nymphs infesting cotton, vegetables and weeds from 19 locations of 11 districts of Punjab, Haryana and Rajasthan. The collected samples were subjected to isolation and purification of entomopathogenic fungi. In all 105 entomopathogenic fungal strains were isolated and purified.

**Evaluation of entomopathogenic fungi against whitefly nymphs**

The poly house bioassay was conducted against whitefly nymphs using fungal suspension @ 107 spore /ml. The observations on percent nymphal mortality was recorded at 3, 5 and 7 days after inoculation using Abbotts corrected formula. Among the top 10 entomopathogenic fungi, the highest nymphal mortality was recorded in MTCC-4511 (95.1%) followed by MTCC-4565 (89.9%) and NAIMCC-1299 (86.7%) at 33.7-26.7 OC Max. Min. Temp. & 80.3-68.4 %RH (Fig.3.25.2). However, local isolate showed faster and more mycelial growth compared to the others.

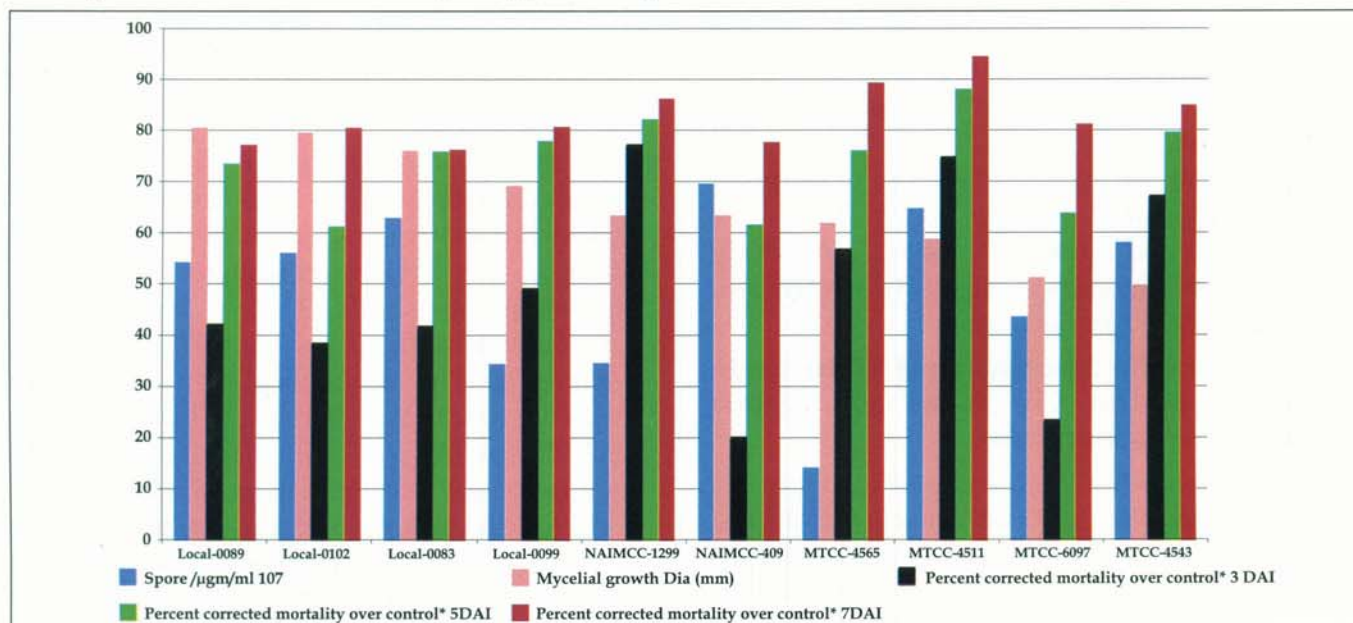


Fig. 3.25.2: Top 10 entomopathogenic fungi recorded highest nymphal mortality under poly house conditions

**Comparative evaluation of entomopathogenic fungi and chemicals against whitefly nymphs**

The comparative study to evaluate the best selected entomopathogenic fungi and chemical pesticides

recommended for whitefly management were evaluated against whitefly nymphs under poly house. The highest nymphal mortality was recorded by MTCC-6096 culture (*Beauveria*

*bassiana*) (75.5%) followed by spiromecifen (69.6%), MTCC-4565 (*B. bassiana*) (67.8%) and MTCC-

4511 (*B. bassiana*) (64.4%) at 28- 21 °C Max. Min. Temp. and 65-45 % RH (Fig.3.25.3).

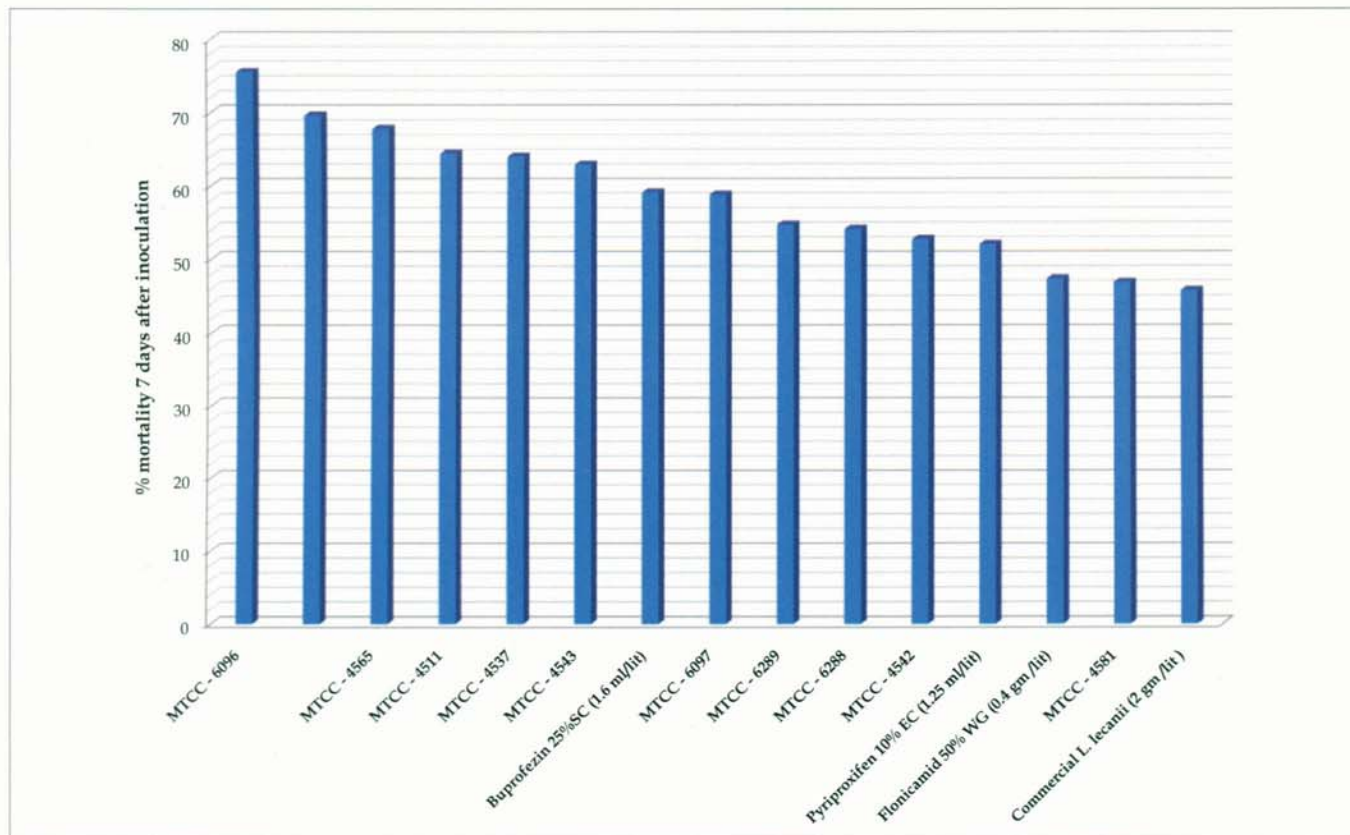


Fig.3.25.3: Comparative bioassay of selected entomopathogenic fungi and recommended chemical pesticides against whifly nymphs under poly house condition

### Mass multiplication of entomopathogenic fungi

The comparative study to evaluate the liquid media (PDB and SDB) for mass multiplication of best selected entomopathogenic fungi were done at 28±2 °C temperature. Seven isolates including Local- 089, Local--0102, MTCC-4543, MTCC-4511, MTCC-4537, MTCC-6097 and NAIMCC-409 were evaluated. Mycelia fresh and dry weight per 200 ml and spore per gram was recorded. The highest dry mycelia growth was harvested in Local- 089, Local-0102, and MTCC-4573 isolates in SDB media. Moreover, the highest spores per gram was also recorded in SDB media in Local- 089 ( $93 \times 10^9$ ) and , Local--0102 ( $88 \times 10^9$ ) MTCC-4511 ( $88 \times 10^9$ ).

### 3.26 Event Based Approval Mechanism

#### Confirmatory test for Bollgard-II & RRF (Round up Ready Flex)

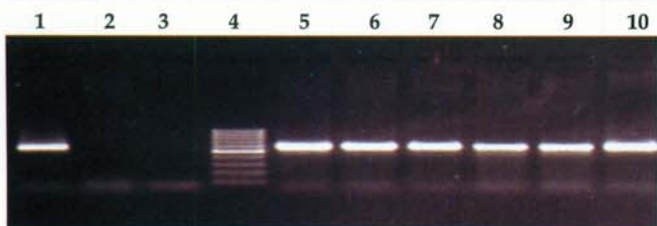
ELISA (Enzyme linked immunosorbent assay) and

PCR (Polymerase chain reaction) tests confirmed the presence of *Cry1Ac + Cry2Ab + epsps* genes in six field samples of seed-cotton collected from nine fields of seven villages in Nagpur district. The results confirm that bolls collected from six fields were positive for Bollgard-II and EPSPS, ROUND-UP-READY-FLEX.

Seeds that were positive for both *Cry1Ac + Cry2Ab* were subjected to PCR (polymerase chain reaction) test for tested for the presence of 5-enolpyruvyl-shikimate-3-phosphate synthase (*epsps*) gene expressed in Roundup Ready Flex.

All the nine samples tested positive for Bollgard-II (BG-II). Six out of the nine samples that were positive for BG-II were also found to contain the EPSPS gene. The results confirm that bolls collected from six fields were positive for Bollgard-II and EPSPS, ROUND-UP-READY-FLEX.

S.No.	Hybrid	Code no	Cry2Ab test	Cry1Ac test	RRF test
1	Jadoo (Karmbadh)	1 <sub>14</sub>	Positive	Positive	Positive
		1 <sub>22</sub>	Positive	Positive	Positive
		1 <sub>24</sub>	Positive	Positive	Positive
2	ATM (Karmbadh)	2 <sub>3</sub>	Positive	Positive	Positive
		2 <sub>4</sub>	Positive	Positive	Positive
		2 <sub>13</sub>	Positive	Positive	Positive
3	Balbhadra (Saoner)	3 <sub>5</sub>	Positive	Positive	Positive
		3 <sub>7</sub>	Positive	Positive	Positive
		3 <sub>18</sub>	Positive	Positive	Positive
4	Krishna Gold (Esapur)	4 <sub>5</sub>	Positive	Positive	Negative
		4 <sub>18</sub>	Positive	Positive	Negative
		4 <sub>24</sub>	Positive	Positive	Negative
5	Arjun (Nimba)	5 <sub>11</sub>	Positive	Positive	Positive
		5 <sub>19</sub>	Positive	Positive	Positive
		5 <sub>26</sub>	Positive	Positive	Positive
6	Jambo (Saoner)	6 <sub>7</sub>	Positive	Positive	Negative
		6 <sub>19</sub>	Positive	Positive	Negative
		6 <sub>26</sub>	Positive	Positive	Negative
7	Krishna Gold (Malapur)	7 <sub>15</sub>	Positive	Positive	Positive
		7 <sub>24</sub>	Positive	Positive	Positive
		7 <sub>26</sub>	Positive	Positive	Negative
8	Supershakti (Yerla)	8 <sub>13</sub>	Positive	Positive	Negative
		8 <sub>19</sub>	Positive	Positive	Negative
		8 <sub>34</sub>	Positive	Positive	Negative
9	Balbhadra (Saoner)	9 <sub>18</sub>	Positive	Positive	Positive
		9 <sub>25</sub>	Positive	Positive	Positive
		9 <sub>32</sub>	Positive	Positive	Positive



Well no            sample code  
 1,2,3            - ATM, NBt, NTC

Rest are test samples

Fig 3.26.1: Detection of ESPS, Round Up ready Flex from DNA of seeds obtained from open bolls in farmers fields in and around Nagpur



## 4. TECHNOLOGY ASSESSED AND TRANSFERRED

### Demonstrations on farmers' field

#### Nagpur

Seventy five FLDs on interventions ICM (41), *desi* cotton under HDPS (15) and intercropping (9) were conducted in Nagpur and Wardha districts. ICM technologies included integrated nutrient management, foliar application of DAP & MgSO<sub>4</sub>, plant protection and weed management packages. In *desi* variety Phule Dhanwantary and Roja were undertaken while in cotton intercropping G cot Hy 8 was intercropped with cluster bean Navbharat. Critical inputs along with package of practices were provided to farmers. In the ICM FLD's, average productivity was 1462 kg/ha in ICM FLD as compared to farmers practice of 1119 kg/ha.

#### Coimbatore

HDPS technology was demonstrated to 15 farmers' (one acre each) in Andhiyur Taluk of Erode district. The season was characterized by unprecedented drought and even irrigated farmers harvested very low yield. Despite this adversity, the HDPS demonstration recorded an average seed cotton yield of 1250 kg/ha while control plots (with Bt hybrid) registered only 750 kg/ha. The B:C ratio under HDPS was 1.68 as against 1.31 in control (BG II hybrid).

Front line demonstrations on Integrated Crop Management were conducted in forty hectares in one hundred farmers' fields. The technologies *viz.*, improved variety Suraj, Integrated Weed Management, Integrated Nutrient Management and Integrated Pest Management, application of growth regulators and soil test based fertilizer recommendation were demonstrated in forty hectares. Due to severe drought the average seed cotton yield obtained in FLD on ICM was only 1235 kg/ha as against the farmers' practice yield of 1094 kg/ha. Ten demonstrations on ELS cotton variety Surabhi are being conducted during summer irrigated season in Tirupattur Taluk, Vellore District of Tamil Nadu.

#### Sirsa

One hundred demonstrations were conducted

using *G. arboreum* variety, CICR 3, planted under HDPS in 53 villages spread across 12 tehsils in 4 districts *viz.* Sirsa, Fatehabad, Hisar and Hanu-mangarh. Seed cotton yield ranged from 500 - 3250 kg/ha. Twelve demonstrations of CSH-3075, identified for HDPS (planted at 67.5 x 10 cm) were conducted in 7 villages of Haryana and Rajasthan. Average seed cotton yield was 2850 kg/ha under HDPS as against 2447 kg/ha with Bt hybrids thus giving an average increase of 17%. The B:C ratio of CSH-3075 was 2.43 against 1.93 with Bt hybrid.

Front line demonstrations in 95 hectares of land allotted by Ministry of agriculture, cooperation and farmers welfare under NFSM (CC) were planned, implemented and monitored during the season in 40 ha ICM technology with Bt hybrids, 40 ha HDPS with *Desi* cotton variety CICR-3 and 15 ha ICM with *G. hirsutum*. The other varieties demonstrated under HDPS was CSH 3129 (5 ha) and CSH 3129 (10 ha) under normal sowing.

- FLDs of CSH-3129 on 10 ha with 25 farmers of 17 villages in Haryana & Rajasthan States were conducted during 2016-17 crop season through AICRP. Highest seed cotton yield of variety CSH-3129 obtained was 30.17 q/ha whereas seed cotton yield of Bt hybrid grown by corresponding farmers was 27.50 q/ha. The variety gave 9.70 % increase over the Bt hybrid RCH 773. Average seed cotton yield of 25 FLDs conducted with variety CSH-3129 was 25.51 q/ha whereas average seed cotton yield of Bt hybrids at farmers field was 23.22 q/ha. An average increase of 10.37 % was obtained by the farmers for the variety CSH-3129 over the Bt hybrids. Average fibre quality parameters (length, strength & micronaire) of this variety for FLDs conducted in Haryana & Rajasthan was better than Bt hybrid.
- FLDs of CSH-3075 on 5 ha with 12 farmers of 7 villages in Haryana & Rajasthan states was conducted during 2016-17 crop season through AICRP. Highest seed cotton yield of the variety CSH-3075 (HDPS in spacing of 67.5 x 10 cm) was obtained as 32.5 q/ha whereas seed cotton yield

of Bt hybrid (67.5 × 60 cm) grown by corresponding farmer was 26.3 q/ha. The variety gave 23.80 % increase over the Bt hybrid RCH 773. Average seed cotton yield of 12 FLDs conducted with variety CSH-3075 (HDPS) was 28.5 q/ha whereas average seed cotton yield of Bt hybrids at farmers field was 24.5 q/ha. An average increase of 17.12 % was obtained by the farmers for the variety CSH-3075(HDPS) over the Bt hybrids. The cost benefit ratio of CSH-3075 was 2.43 against Farmer's (1.93) and farmer was benefited by Rs 27022/ha by growing CSH-3075 (HDPS) as compared to Bt hybrid.

- Front line Demonstrations (FLDs) on ICM in Bt cotton hybrids were conducted in 40 ha with 100 farmers belonging to 30 villages of Haryana & Rajasthan. Highest seed cotton yield of the Bt hybrid Ankur 3028 was obtained (40 q/ha). Whereas other Bt hybrids namely RCH 773, Sriram 6588, RCH 650 yielded up to 35 q/ha under FLD on ICM. The average seed cotton yield of Bt cotton hybrids in Haryana and Rajasthan was 25.2 q/ha, respectively compared to the 22.4 q/ha under farmers practice. The ICM practice gave 12.5% more yield than Bt cotton hybrids, grown under the normal farmers practice. The cost benefit ratio was 2.25 and 2.2 in Haryana and Rajasthan, respectively compared to 1.79 and 1.7 in farmers practice. Farmers were benefited by Rs 22760 and Rs.17,570 /ha in Haryana and Rajasthan by adopting the ICM practices in Bt hybrid compared to adoption of normal farmers practices.

### CROPSAP

Disseminated cotton pest management strategies through ICT tools as one of the stakeholders in Crop Pest Surveillance and Advisory Project (CROPSAP) 2016-17 in 28 districts of Maharashtra.

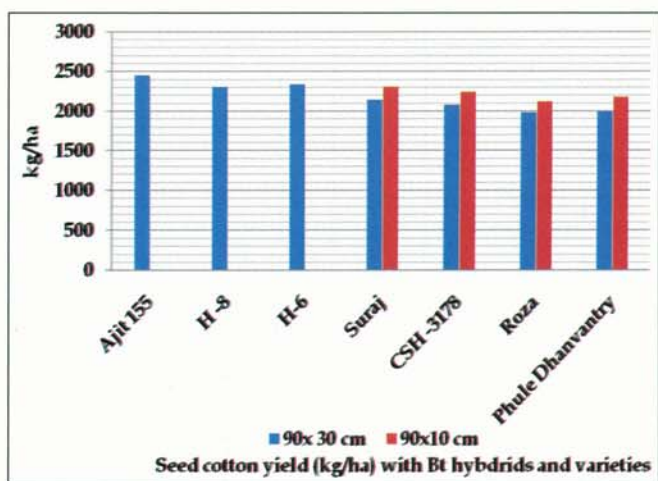
### On Farm Demonstrations

#### Nagpur

The on farm demonstration was conducted during kharif 2016-17 to assess the performance of cotton varieties (*G. arboreum* - P. Dhanwantary and Roja and *G. hirsutum* - Suraj and CSH 3178) and BGII Bt hybrids viz Ajit 155, H8 and H6 (*G. hirsutum*) under

two crop geometries. The sowing of the cotton seed was done on 30.6.2016 and 1.7.2016. The recommended fertilizer dose for variety was 80:40:40 kg N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O/ha and for Bt hybrids was 120:60:60 kg N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O/ha and it was applied as splits application in case of nitrogen and as basal dose in case of phosphorus and potassium. Intercropping with green gram and dhaincha was also followed.

The results revealed that the seed cotton yield in case of Bt hybrids ranged from 2306 to 2455 kg/ha with the highest yield in case of Ajit 155 and lowest in H-8 when these Bt hybrids were planted in crop geometry of 90 x 30 cm. In case of straight varieties the seed cotton yield under the same crop geometry ranged from 2081 to 2144 kg/ha in case of *G. hirsutum* and 1984 to 2003 kg/ha in *G. arboreum*. As these straight varieties are not responsive to exploit available natural resources as well as the inputs added to the plants during the crop growing period the yields declined. However, when these varieties were planted at 60 x 10 cm spacing seed cotton yield increased to 2308 to 2245 kg/ha in case of *G. hirsutum* and 2118 to 2178 kg/ha in *G. arboreum* even though the total plant population was about 81 to 83 % of the designed plant population. Thus it is inferred that the straight varieties should be taken up under narrow row spacing (60 cm x 10 cm).



#### Coimbatore

#### HDPS demonstration

Large plot demonstration under HDPS was carried out at CICR, RS, Coimbatore. The results revealed

that manual sowing had a huge impact on Seed Cotton Yield (16.8 q/ha), which were higher by 48% and 97.64% as compared conventional plating (75 x 45 cm) of RCH BG II and of Suraj. The net return (Rs. 29,800/ha) was also higher by 113.6% and 635.8%. Benefit cost ratio (1.70) was maximum with HDPS planted by machine.

#### Varieties demonstration

A total of ten varieties (CCH 4474, CCH 2623, Suraj, Sumangala, Surabhi, Anjali, MCU 5 VT, Supriya, LRA 5166 and Suvin) were demonstrated in the institute farm for the benefit of visitors. The programme was coordinated by Dr (Mrs) S. Usha Rani, Principal Scientist (Agricultural Extension)

and Dr (Mrs) Isabella Agarwal, Principal Scientist (Agricultural Economics).

#### Sirsa

##### HDPS demonstration

*G.hirsutum*: CSH-3075 (67.5×10 cm) vs Bt RCH-773 (67.5×60 cm). CSH-3075 in HDPS gave 2708 kg/ha while Bt check gave 2106 kg/ha. Yield increase under HDPS was 28.6%

*G arboreum*: CICR-1 & CICR-3, were demonstrated at normal spacing of 67.5 x 30 cm and HDPS spacing of 67.5x20 cm. CICR-1 and CICR-3 gave 6.1 and 9.3% higher yield under HDPS than under normal spacing.



## 5. TRAINING AND CAPACITY BUILDING

### 5.1: Training

#### 5.1.1: Training Received

##### i) Participation in training (category-wise)

Sr. No.	Name of the Officials	Name of the course/training	Place	Period
<b>Scientists</b>				
1.	Dr. S. B. Nandeshwar	Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR	NAARM, Hyderabad	20-22 Feb-17
2.	Dr. S. M. Wasnik	Skill development in Agriculture - Kaushal vikas se krishi vikas	NAARM, Hyderabad	19-21 Feb-17
3.	Dr. D. V. Patil	Training on refresher course on Agriculture research management	MANAGE, Hyderabad	15-26 Nov-16
4.	Dr. J. A. Sheeba	Phenotyping for drought adaptive trait and their introgression for crop improvement, Crop phys.	UAS, JKVK, Bengaluru	17-24 Oct-16
5.	Mr. Madhu TN	DST-SERB Workshop on Chemical Ecology	NCBS, Bangalore	3-16 July-16
6.	Dr. M. Amutha	Techniques in Insect Molecular Biology and Toxicology	ICAR- Sugarcane Breeding Institute	7-16 Sep-16
7.				
<b>Technical</b>				
8.	Mrs. Sunita Chauhan	Promotion of agro Enterprise and food processing	ni-msme, Hyderabad	21-23 Feb-17
9.	Dr. U.V. Galkate	Commercial Dairy production	SRS ICAR - NDRI, Bengaluru	27 Feb to 4 Mar-17
10.	Mr. G.V. Deogirkar	Use of molecular techniques in crop improvement program	NRCPB, New Delhi	17-31, Jan-17
11.	Mrs. R. Deshmukh	Advances weed management	Directorate of WR, Jabalpur	3 Nov to 9, Dec-16
12.	Mrs. Swati Dixit	Digital Library Management.	CMFRI, Kochi	25-26 Nov-16
13.	Mr. R.V. Salame, Mr. Prashant Gavhale, Mr. Bhausahab Naikwadi, Mr. Mayur Meshram	Statistical techniques for agriculture data analysis.	IASRI, New Delhi	2-11 Nov-16
14.	Dr. Pundalik B Deulkar	Competence enhancement programme for technical officers of ICAR.	NAARM, Hyd.	17-26 Aug-16



15.	Mr. Bhausahab Naikwadi	Agrometeorological data collection, analysis and management	CRIDA, Hyd.	25 Jul to 6 Aug-16
16.	Mrs. Subashree K.	Competence enhancement programme for technical officers of ICAR.	NAARM, Hyd.	1-10 June-16

#### Administration

17.	Mr. N.V. Dhande	Enhancing efficiency and behaviour skill of PA/PS/PRS	NAARM, Hyderabad	24-30 Nov-16
18.	Mrs. Shubhangi Kharche, Mr. N. Ramesh	Pension and other retirements benefits	ISTM, New Delhi	5-8 Sep-16

### ii) Training organized for various categories of employees (category-wise)

#### Skilled Supporting Staff

Sr. No.	Name of the Officials	Name of the course/training	Place	Period
1.	Bathran Palaniappan, Rajamani Sakthivel, Kalyani Sampathkumar, Rajathi Kumarasamy, Chitra Mani, Dhara Essakki, Savithri Panneerselvam, Jegadambal Krishnasamy, Karuppusamy Kaliappan, Subbammal Brahman, Ramamurthy Krishnan, Manimekalai Karuppusamy, Laxmi Rangasamy, Kannaiyan Marudhan, Murgan Ammasalp, Thangavel Palani, Velingiri Kittan, Sarojini Najappan	Multi-skilled training programme to supporting staff	ICAR-CICR, Regional Station Coimbatore	22-24 Feb-17

### iii) HRD fund allocation and utilization

Sr. No.	BE 2016-17 for HRD			Actual Expenditure up to March. 2017 for HRD		
	Plan	Non-plan	Total	Plan	Non-plan	Total
	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)
1	4.00	2.00	6.00	4.03	1.99	6.02

#### 5.1.2: Training Imparted

##### International training

**2-Day training programme on Farm Implements for African Delegates at CICR, Nagpur, under Cotton-TAP for Africa Programme, 8-9<sup>th</sup> Sept., 2016**

Two-day training was organized at CICR, Nagpur

for participants from Africa under Cotton TAP. Four participants from Benin, Chad, Nigeria and Uganda attended the training programme. Dr. Blaise Desouza, Head, Crop Production and Training Co-ordinator gave an overview to the participants and hoped that the agri-implements to be shared would benefit the cotton growers in their

respective countries. Er. Majumdar, Course Leader of the programme gave detailed presentation of the agri-implements and also demonstrated these implements in the field and conducted an out-door activity to visit the farmers fields. Dr. Sandhya Kranthi, I/c Director briefed the participants about the Institutional activities and hoped that it would

be useful to the participants. All the participants appreciated the training programme and thanked the organizers, the Government of India, New Delhi and their respective Governments for sponsoring their nomination for this training programme.



**National Training  
Nagpur  
Tribal Sub-Plan**

Under Tribal Sub-Plan (TSP) of NSP, 6 trainings were organized for tribal farmers in 6 villages

adopted under Mera Gaon Mera Gaurav programme. They are Ladai ( Lingala), Wathoda, Nimboli, Budhla of Kalmeshwar tehsil; Murdapur of Bela tehsil and Narhar of Parseoni tehsil. Nearly 2000 tribal farmers and women got benefited by these trainings.



Ladai (Lingala)



Wathoda



Narhar

**Cultivation of Desi Cotton**

A training program on “Desi Kapus Lagwad Prashikshan Shibir” (Training Program on Cultivation of Desi Cotton) for farmers of four districts was organized by ICAR-Central Institute for Cotton Research, Nagpur with the special help of Yuva Rural Association (Y.R.A.) on 28.04.2016.

Around 65 farmers from different villages of Nagpur, Wardha, Amravati and Bhandara districts of Maharashtra attended the program. The function was chaired by Dr. K. R. Kranthi, Director, CICR, Nagpur while it was graced by Shri. Datta Patil (Y.R.A.). Other participants Shri Padole (Neem Foundation), Dr. Blaise Desouza, Head,



Crop Production, CICR, Nagpur, Dr. R. B. Singandhupe, In-charge, KVK, CICR, Nagpur, Dr. Punit Mohan, Principal Scientist, Dr. V. Santhy, Senior Scientist, Dr. Sunil Mahajan, Senior Scientist, Dr. Saravanan M, Scientist also attended the meet. Director, CICR elaborated the importance of desi cotton in comparison with Bt cotton. He also emphasized the future demand and dependency of market for surgical cotton. Shri. Datta Patil (Y.R.A.) shared his experience regarding how his organization has organized and monitored the seed production of *desi* cotton, Phule Dhanwantari on farmer's field, ginned and processed at CICR, Nagpur. Different farmers have also exchanged their experiences based on the cultivation of *desi* surgical cotton var. Phule Dhanwantari in previous year. They showed their willingness to grow the *desi* cotton in next season also. The farmers experienced that the cost of cultivation of *desi* cotton is much less due to less use of inputs like pesticides and fertilizers as compared to the Bt cotton. 'Package of Practices' (PoP) of *desi* surgical cotton var. Phule Dhanwantari was presented by Dr. Sunil Mahajan through power point presentations and its ready reckoner cards have also been distributed to the farmers. The 4 kg bag of quality seed of *desi* surgical cotton var. Phule Dhanwantari for one acre to each farmer was also distributed on payment basis by the Yuva Rural Association.

#### Implementation of Cotton FLDs

A training programme was held in Shivanphal in Girad cluster of Samudrapur tahsil of Wardha district on June 18, 2016 for undertaking cotton

FLD interventions on *Desi* cotton, cotton intercropping and integrated cotton management under the aegis of AICRP on cotton. 40 Farmers were motivated for cotton intercropping system. The benefits and role played by intercrops in improving soil fertility status of soil especially cotton- cluster bean intercropping system was discussed with the farmers. FLDs trials on cotton (H-8) BG II and cluster bean were conducted in one acre plot. Dr. S. M. Wasnik, Principal Scientist Extension, coordinated the FLD activities.

#### Protection of cotton plant varieties and farmers Right

Sixty farmers of KVK, Nagpur were trained on Protection of cotton plant varieties and farmers Rights on 22-25 March, 2017.

#### Soil Testing and Fertilizer Recommendations

Twenty persons belonging to private laboratories and soil testing staff on micro, and secondary nutrient deficiencies in cotton, soil testing and interpretation were trained on 23 March 2017.

#### Coimbatore

##### Tribal Sub-Plan

Scientists - Extension Officials - Farmers Interface Meeting cum Off - Campus Training Program on "Integrated Crop Management Practices in Cotton" for Tribal Cotton growers was conducted at State Horticultural Farm, Karumanthurai village, Pethanayakkanpalayam block, Attur Taluk, Salem district on 29.07.2016 under All India Coordinated Research Project on Cotton - Tribal Sub Plan (TSP). Scientists from ICAR - CICR, Coimbatore, extension officers from the State Horticulture farm and Department of Agriculture





and 59 tribal cotton growers from Pethanayakkanpalayam block, Attur Taluk, Salem district of Tamil Nadu have participated in the interface meeting cum training program.

Two on-campus training programs on Integrated Cotton Management techniques were conducted in CICR, Regional Station, Coimbatore during 3.11.16 & 4.11.16 and 9.2.17 & 10.2.17 for 37 tribal cotton growers from Jolarpet Taluk and Attur Taluk under ICAR- AICRP on Cotton (TSP).

### Sirsa

#### IPM/IRM under NFSM

A one day Farmers training programme on IPM/IRM under NFSM was organized at ICAR-Central Institute for Cotton Research Regional Station, Sirsa under the Chairmanship of Dr. D. Monga, Head CICR-Regional Station on 02.09.2016. Dr. D. Monga, Head. Dr. R.A. Meena delivered talks on crop production aspect, while Dr. Rishi Kumar and Dr. SK Sain delivered the lecture topics on IRM concept & cotton insect-pest management and cotton disease management, respectively. A total of 125 farmers who were enlisted for conducting Front Line Demonstrations on Integrated Pest management-Integrated Pesticides Resistance Management in Bt cotton varieties were trained.

#### Low-cost on-farm production technique of Trichoderma

Two 1-day farmers training programmes on "Low-cost on-farm production technique of Trichoderma" under NFSM were organized at ICAR- Central Institute for Cotton Research Regional Station, Sirsa.

On 25.01.2017, Dr. D Monga and Dr. SK Sain

delivered talk on Trichoderma: Introduction, its uses and technique for low-cost on-farm production. The technology was also demonstrated. A total of 30 progressive farmers from eight villages, and technical persons from Art of Living Foundation were trained in this training.

On 07.02.2017, Dr. Rishi Kumar gave the information on identification of cotton insect-pests and their Integrated Pest management. Dr. S.K. Sain delivered the lecture on identification and management of Cotton Diseases. The participants were also given hands-on practices on Low-cost on-farm production technique for Trichoderma. A total of 30 progressive farmers and extension personals from different districts of Haryana participated in this training.

### Mera Gaon Mera Gaurav Programme

'Mera Gaon Mera Gaurav (My Village My Pride)' programme was implemented through a team of scientists; each team comprising of four scientists with five clusters of villages as per guidelines. MGMG programme presently covered following 70 adopted villages with 14 clusters i.e. nine, four and one respectively from Nagpur (Maharashtra), Coimbatore (Tamil Nadu) and Sirsa (Haryana):

#### Maharashtra

Ganeshpur cluster, Wardha: Ganeshpur, Digras, Zadgaon, Belgaon, Borgaon (Sawli)

Parseoni cluster, Nagpur: Narhar, Kolutmara, Nehra, Banera, Dhawalapur

Girad cluster, Wardha: Jogingumpha, Shivanphal, Arvi, Faridpur, Mohgaon

Nandura cluster, Wardha: Nandura, Nagapur, Karanji (Bhoge), Karanji (Kaji), Pujai

Hingna cluster, Nagpur: Mangali, Mandavghorad, Junewani, Nanda Khurd, Ukhali

Godhani cluster, Umred, Nagpur: Godhani, Mhasala, Mohpa, Sukali, Telkavads

Kaslmeshwar cluster, Nagpur: Sonegaon, Pahi, Ladai, Linga, Uparwahi

Navegaon cluster, Umred, Nagpur: Navegaon Sadhu, Tirkhura, Karhandla, Thana, Sev

Tumdi, Sukali, Navarmari, Lodhi panjri, Mangrul

## Tamil Nadu

Vadapudur Panchayat, Kinathukadavu block, Coimbatore District: Vadapudur, Singaiyanpudur, Sikkalampalayam, Yelur, Kallapuram

Sokkanur panchayat, Kinathukadavu block, Coimbatore district: Sokkanur, Muthugoundanpudur, Palapathy, Veerappagoundanur, Venkaiyagoundanpudur

Kanjapalli Panchayat, Annur Block, Coimbatore District: Kanjapalli, Dhasarpalayam, Oothupalayam, Kumaragounderpudur, Neelagoundarpudur

Allapalayam Panchayat, Annur Block, Coimbatore District: Allapalayam, Konarpalayam, Uthirampalayam, Mathireddypalayam, Akravachengapalli

## Haryana

Jhonpra, Alleekan, Nejadela Kalan, Rangari, Begu

During the *kharif* season 2016-17, the HDPS technology was demonstrated to 40 tribal farmers in adopted village of Umred Taluk under MGMG under TSP.

### Training to Tribal Farmers on “Enhancing Cotton Productivity”

On the occasion of National Productivity week (12 to 18 February, 2017), a training programme on “Enhancing cotton productivity” was organized by the ICAR-Central Institute for Cotton Research (ICAR-CICR), Nagpur in collaboration with Ginning Training Centre, Nagpur and Department of Agriculture, Nagpur, Government of Maharashtra under the theme “From waste to profit through reduce, recycle and reuse”. Nearly hundred tribal farmers of Muradpur, Nissanghat, Surabardi, Kawadapur and Khursapar of Umred Block, Nagpur district participated in the day long training at Muradpur, Bela. Dr. Blaise, Head, Division of Crop Production, ICAR-CICR, Nagpur delivered the inaugural address on improving cotton productivity by recycling farm waste Dr. Mageshwaran explained about post harvest practices to prepare value added products from cotton stalks like mushroom production, pellet, briquette, card board etc. Mr. Chandrikapure (Taluka Agricultural Officer, Umred) explained



about various government schemes for benefit of cotton farmers. Dr. Manikandan and Dr. Santosh demonstrated rapid method of composting cotton stalks in the field.

### CICR scientists trained tribal farmers of Bela under MGMG programme

One day training programme was organized at Muradpur, Bela cluster in Umred Tahsil of Nagpur District on 13 Feb 2017 and imparted training to more than 60 farmers on cotton production and protection. Five villages namely Suraburdi, Murdapur, Nissanghat, Kawadapur and Khursapur were selected under Mera Gaon Mera Gaurav program. The cluster leader Dr. Nandeshwar (Head, Biotechnology Section) explained about Bt-cotton cultivation in irrigated areas. Dr. Gotmare highlighted the benefits of desi cotton in rainfed areas and also covered cotton seed production and storage aspects. Dr. Manikandan and Mr. Prabhulinga described innovative technologies of cotton cultivation. Mr. Chandrikapure (Taluka Agricultural Officer, Umred) spoke about organic farming benefits in horticultural crops. Dr. Wasnik explained about the program for the benefits of farmers and technological perspective.



### Scientists-Farmers Interface

The various teams organize an interactive meet with farmers at MGMG villages to have Scientists – farmers interface on the issues farmers are facing on regular basis. The farmers and scientists interacted on various issues related to insect pest management of agricultural, horticultural crops and animal husbandry issues. A training and demonstration was given to the farmers for the collection of soil samples from the field with due precautions. The farmers also been advised to protect the crops from wild animals by fencing with iron wires and old sarees.

### Soil Health Awareness Training

- ICAR-CICR organized soil health awareness training and card distribution programme at Magan Sangrahalaya, Girad of Wardha District on 30 April and 17 Dec., 2016. More than 100 farmers participated in the programme where soil health cards were distributed to 74 farmers from five villages viz., Arvi, Faridpur, Shivanphal, Mohgaon and Jogingumpha in Girad Cluster in Samadrapur Tahsil of Wardha district under MGMG Programme
- Dr. S.M. Wasnik, Principal Scientist, Extension & Nodal Officer MGMG Programme urged the farmers to apply the fertilizers judiciously according to recommendations given in soil health card. Earlier, Dr. Nandini Gokte Narkhedkar, Principal Scientist, Nematology emphasized on importance of soil analysis for actual nutrient requirement and scientific cultivation of cotton. Dr. Shailesh Gawande, Scientist, Plant Pathology conducted programmes and highlighted about the MGMG scheme. Dr. J. Das and Dr. Sarvanan talked about *desi* cotton and tree cotton and its role in organic cotton cultivation. They also explained about “Praddhan Mantri Fasal Bima Yojna” and provided printed pamphlets for further dissemination of information.

### Tribal Farmers Meet - cum- Trainings organizes at Villages

ICAR-CICR, Nagpur scientists organizes five training programmes - cum- tribal farmers meet at Nimboli, Lohagad and Budhla in villages of

Kalmeshwar cluster and Narhar village for 5 adopted villages of Parseoni block under Mera Gaon Mera Gaurav programme on 17<sup>th</sup>, 21<sup>st</sup> December, 2016 and 16.02.17 under TSP of National Seed Project (NSP). The farmers were trained on different aspects of agriculture, poultry, goat rearing and exclusively on cotton seed production technology. Key issues related to choose right cotton hybrids having sucking pests tolerance, disease tolerance; cotton bollworm management, control measures to be taken to ensure better yield levels. The training programme was attended by around 1120 tribal farmers which include more than 400 farm women. Scientists from ICAR-CICR and KVK Nagpur; Dr. Sujit Shukla of GTC, CIRCOT, Nagpur; Dr. Gajbhiye and Yellorkar of Dr. PDKV Agriculture College and Shri Tambekar, Bhise and Smt Atram of State of Agricultural Departments provided the information and demonstrations on various aspects of agricultural, horticultural, animal husbandry and apiculture enterprises. Four Krishi Mitras were also felicitated for their active involvement in MGMG programme.

### Swachhta Pakhawara and Farmers Meeting at Sirsa Villages

CICR, RS, Sirsa implemented the activities under Swachh Bharat Mission and organizes farmers awareness towards clean and green agriculture in Mera Gaon Mera Gaurav villages, promotion of clean and green technologies, weed management for cotton pest management, promoting compost making, plantation of new trees etc. under the leadership of Dr. D Monga, Head, CICR RS, Sirsa. Also around 25 farmers participated in the meeting organized at Neza dela Kalan village under MGMG programme by Dr. S. K. Verma along with Sh. Sarfraj Ahmad and Sh. Anuj Kumar on 29/07/2016 and 31/08/2016. Farmers were trained on how to observe the whitefly population per three leaves for following the whitefly management schedule. Farmers have followed the CICR strategy for whitefly management- the first spray of Neem based followed by flonicamid and IGRs. And they observed that the whitefly population was under check. The pamphlets distributed on whitefly management were appreciated by the farmers.

## 6. AWARDS AND RECOGNITIONS

### Awards

#### Fellowship of the Maharashtra Academy of Sciences

Dr D. Blaise, Head, Division of Crop Production, ICAR-CICR, Nagpur received the Fellowship of the Maharashtra Academy of Sciences which was conferred on 9 November 2016 at National Chemical Laboratory, Pune by Padma Shri Prof. G. D. Yadav, Vice-Chancellor, Institute of Chemical Technology, Mumbai.

#### Fellow of Indian Society of Agronomy

Dr D. Blaise, Head, Division of Crop Production, ICAR-CICR, Nagpur was conferred Fellow, Indian Society of Agronomy on 22 November 2016 at the Fourth International Agronomy Congress, New Delhi.



#### Fellowship of Indian Society of Soil Survey and land Use Planning (ISSLUP)

Dr. M V. Venugopalan, Principal Scientist (Agronomy), Division of Crop Production, ICAR-CICR, Nagpur was conferred the Fellowship of the Indian Society of Soil Survey and land Use Planning (ISSLUP), Nagpur for his outstanding research contribution in the fields of participatory and perspective land use planning, carbon sequestration in rainfed land use systems and application of crop simulation models in land use planning and soil quality analysis. He received this award on 10 November, 2016.



#### Fellow of the Society for Bio-control Advancement

Dr. M. Amutha, Scientist (Entomology), ICAR-CICR, Regional Station, Coimbatore received the Award of Fellow of the Society for Bio-control Advancement, Bengaluru on 9.2.2017.

#### Young Scientist Award

Dr. Savitha Santosh received 'Young Scientist Award' from the Society of Scientific Development in Agriculture & Technology (SSDAT) for "Screening of native isolates of Pink Pigmented Facultative Methylobacteria for Zeatin production" in National Conference on Innovative and current advances in Agriculture and Allied Sciences (ICAAAS-2016) held at Prof. Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during December 10-11, 2016.

Dr. Shankaraganesh, Scientist (Entomology), ICAR-CICR, Regional Station, Coimbatore received Young Scientist Award 2017 from the Gochar Educational and Welfare Society, Saharanpur, Uttar Pradesh, India.

#### Distinguished Scientist Award

Dr. K. Sankaranarayanan received "Distinguished Scientist Award 2016" from Society for Scientific Development and Agriculture Technologies (SSDAT), Meerut.

#### Best paper award

Dr. V. Santhy , Mrs. Mithila Meshram, and Dr. S.

Mahajan were awarded best paper award for the scientific achievement of research work on “Trait repository to strengthen DUS test in cotton” presented at XIV National Seed Seminar held at ICAR-IARI, New Delhi from 28-30 January 2017.

#### Best oral presentation award

Dr N. Arunkumar, undergoing NPDF (DST-SERB) under the mentorship of Dr. N. Gopalakrishnan and Dr. J. Gulsar Banu participated and presented a paper entitled “Screening and Quantification of Microbial Surfactants Produced by Wax Degrading Bacteria Isolated from Cotton Mealybugs” in the National Symposium on Advances in Agriculture through Sustainable Technologies and Holistic Approaches (AASTHA) organized by Society for Advancement of Human and Nature

(SADHNA), Solan, HP and ICAR-Central Coastal Agricultural Research Institute, Ela, Old Goa from 15 – 17, February, 2017. The research paper was adjudged as Best oral presentation.



## 7. LINKAGES AND COLLABORATIONS

Areas of Linkages	Institution
<b>NATIONAL</b>	
Fibre testing, fibre quality evaluation and nanotechnology	CIRCOT, Mumbai
Multi-location testing of promising cultures, Bt cotton evaluation	AICCIP (21 centres)
Germplasm collection, maintenance and plant quarantine clearance	NBPGR, New Delhi
Seed technological research and breeder seed production	NSP, New Delhi
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	Precision tools, Nagpur
Vision-based expert system for picking of cotton	IIIT&M, Gwalior; Jamia Milia Islamia Univ., Delhi; CMERI-CoEFM, Ludhiana
HDPS and sustainable pest management strategies	Better Cotton Initiative
Desi cotton production	Yuva Rural Association

## 8. AICRP ON COTTON

During the year 2016-17, the Golden Jubilee Celebration of the All India Coordinated Research Project on Cotton (AICRP on Cotton), formerly known as All India Coordinated Cotton Improvement Project (AICCP), was a historic moment. This Coordinated project has been one of the pioneers in the field of agricultural research in the country, especially for cotton. It is a matter of great satisfaction in Indian Council of Agricultural Research (ICAR) that during the last 50 years, the project has developed a number of cotton varieties and hybrids that have contributed to the economic well-being of not only cotton farmers but also the associated industries in India, thus justifying its establishment and also the continued need for its relevance. The success achieved by the AICRP on Cotton is due to the dedication and hard work of scientists and other technical personnel since 1967.

Over the years, AICRP on Cotton has made significant achievements and contribution in the discipline of Plant Breeding, Agronomical practices and production physiology, Plant Protection and dedicated fibre quality evaluation. AICRP on Cotton has developed more than 350 improved cotton varieties/hybrids since its inception. AICRP on Cotton has focused on formulating innovative methodologies and technical programmes to develop improved cotton varieties and economically viable agronomical practices along with eco-friendly and cost effective plant protection strategies for increasing cotton productivity of the country.

In commemoration of the Golden Jubilee Year of AICRP on Cotton, Brain storming sessions were organized at ICAR-CICR, Regional station, Coimbatore on 9<sup>th</sup> and 10<sup>th</sup> November, 2016. The sessions covered wide range of topics including past achievements and present status and road map for future of Cotton and in particular to AICRP on Cotton; Cotton Biotechnology: Issues & Tasks Ahead; New Molecules and Chemistries – an array for plant protection and production; and

finalization of the road map for cotton R & D. The Plenary session was addressed by Dr. Trilochan Mohapatra, Hon'ble DG, ICAR and other eminent cotton scientists and representatives from private R&D.

It is worth mentioning that, India is the leading country in terms of area under cotton cultivation and raw cotton production in the world. As per CAB estimate, cotton production in India during 2016-17 is estimated at 351 lakh bales of 170 kg from 105 lakh hectare with a productivity of 568 kg lint/ha (CAB as on 24:10:2016). According to USDA estimate, during the last ten years from 2007-08 to 2016-17, the average total domestic raw cotton consumption was 275 lakh bales of 170 kg and the average export during the period was 80 lakh bales of 170 kg. During the current year, Gujarat, Maharashtra and Telangana were the major cotton growing states covering around 70% (74.5 lakh hectare) in area and 67% (232 lakh bales) of cotton production in India.

During the year 2016-17, Nineteen cotton cultivars / hybrids evaluated through ICAR-AICRP on Cotton system have been notified for various agro-climatic zones *viz.*, RHC 0717 (Phule Yamuna), SVHH 139, F 2164, RHCb 011 (Phule Rukmai), RHB 0711 (Phule Dhara), RHH 0707 (Phule Tarang), NDLH 1938 (Sri Rama), MR 786, CO 14, F 2383, G Cot 20 (GSHV 97/59), DHB 915, SVPR 5 (TSH 0250), F 2228, Cotton Hybrid SVPR 1 (TSHH 0629), RAHH 455 (Raichur Shakthi 455), JLA 505, GN COT 25, and GN COT 22.

As quality seed availability is a key component in enhancing productivity of any crop, an effective maintenance of Nucleus and Breeder seed programme was undertaken by the concerned participating centres of AICRP on Cotton. The Breeder seed production, as per the Department of Agriculture, Cooperation and Farmers Welfare indent for the year 2016-17, was taken up at different centres of AICRP on Cotton and at ICAR-CICR, Regional Station, Coimbatore. The



production was 102 quintals as against allocation of BSP-I of 24 quintals.

With active participation from scientists of AICRP on Cotton and ICAR-CICR, 26 weekly advisories were issued to cotton farmers in nine regional languages. The advisory included sowing recommendation, agronomical interventions, nutrient management and irrigation scheduling, pest and disease management. The advisories were uploaded at ICAR-CICR website ([www.cicr.org.in/weekly\\_advisory.htm](http://www.cicr.org.in/weekly_advisory.htm)). Periodical monitoring of pest and disease was carried out by AICRP scientists across centres and timely advisories have been issued especially for whitefly and CLCuD management. Pink bollworm damage and surviving larvae on Bollgard-II hybrids have been recorded from different regions in Gujarat, Andhra Pradesh, Telangana, Maharashtra and Karnataka. Immediate monitoring and management measures were recommended in the ICAR-CICR advisory to prevent any further damage.

Under the activity of Implementation of PVP legislation, 2001 and DUS testing of cotton under ICAR-SAU system, the data base on extant cotton varieties have been updated from time to time. Seed multiplication, characterization and maintenance breeding of 109 extant cotton varieties were carried out. Reference varieties for conduct of DUS test in tetraploid and diploid cotton are maintained in respect of 66 in *G. hirsutum*, 38 in *G. arboreum* and 5 in *G. herbaceum*.

During the year, Front Line Demonstrations under NFSM - Commercial Crops, 275 FLDs on Integrated Crop Management (ICM) on cotton, 225 FLDs on *Desi*/ELS cotton/ELS cotton seed production and 95 FLDs on intercropping with cotton were conducted by fifteen centers of All India Coordinated Research Project on Cotton with a budgetary outlay of 43.90 lakh rupees. Under the program of Tribal Sub Plan (TSP), a sum of 14.00 lakh rupees was utilised to conduct training programmes, demonstrations and other extension programs to disseminate the cotton production technologies exclusively to the tribal cotton farmers for improving their livelihood status.

As regards *G. hirsutum* genotypes tested under irrigated condition, HS 298, CPD 1602 and RHC 1217 gave the higher seed cotton yields in both central and south zones. Compact genotypes RS 2818, BS 30 and GISV 298 were found promising in irrigated trials. Interspecific ELS hybrids, ARBHB 1601 and ARBHB 1602 were promising in Central and South zones. In North zone, the average yield potential of *G. arboreum* genotypes was 3187 kg/ha in irrigated situation. Under long linted *arboreum* trial, the entries indicated the maximum UHML of 31.2 mm (PAIG 373) and strength of 32.3 g/tex (PA 781).

In Zonal trials, RS 2815, GSHV 172 and BGDS 1033 were the top ranking genotypes under irrigated condition in all the three zones. The compact cultures, RS 2814, DSC 1501 and LHDP 1 were the best in zonal trials under irrigated conditions, whereas GSHV 180 and GTHV 13/32 were the best in rainfed trials. Nutritional and geometrical requirements for normal as well as High Density Planting System (HDPS) were worked out. Nineteen genotypes were identified as drought tolerant and thirteen genotypes were identified as salt tolerant. Oil, protein and gossypol contents of different genotypes were estimated for deploying the genotypes in breeding programmes.

Genotypes tolerant to sucking pests were identified from national and zonal breeding trials. Pest dynamics was recorded in all the three zones under experimental field conditions for sucking pest and bollworms. Evaluation of organic cotton production indicated that the population of sucking pests, square, open boll and locule damages were significantly lower in seed treatment and soil application of recommended bio-fertilizer and foliar application of PPFM + neem cake + intercropping with green gram/black gram/ ground nut/ soya bean. Cotton leaf curl virus in north zone, *Alternaria* leaf blight, bacterial blight and tobacco streak virus in central zone and *Alternaria* leaf blight, bacterial blight, grey mildew and rust in south zone were the major diseases reported during 2016-17 crop season.

## 9. KRISHI VIGYAN KENDRA

### Training Achievements

Ninety four short duration (1 to 3 days) on-campus and off-campus training courses were conducted in different disciplines for practicing farmers, rural youth and extension functionaries. In all 3885

participants including 1137 SC/ST participants benefited from the training programs conducted by SMS and Program Assistants of KVK are summarized below.

Sr.No.	Disciplines	No. of courses	No. of Total Participants	SC/ST Participants
1	Crop Production	12	468	122
2	Horticulture	07	228	68
3	Plant Protection	20	957	253
4	Veterinary Science	21	1102	347
5	Home Science	16	395	134
6	Extension	18	735	213
	<b>Total</b>	<b>94</b>	<b>3885</b>	<b>1137</b>

In addition to the above trainings eight 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 459 participants attended these courses.



### Cluster Front Line Demonstrations on Oilseed and Pulses

Three CFLD on oilseed & Pulses crops were demonstrated on farmers field of adopted villages of Nagpur district viz. Salaimendha, Ghatpendhri and Boruzwada. Several extension activities like field day, field visit of farmers and extension functionaries, group discussion and scientist farmers meet etc. were conducted for effective implementation of technologies under Cluster Front Line Demonstration. Data on important



production parameters as well as feedback from farmers and visitors were recorded.



**Details of Assessment of technologies under Cluster Front Line Demonstrations (2016-17)**

Sr. No	Crop	Technology Demonstrated	No. of farmers	Area (ha)	Yield (q/ha)		Increase over FP (%)
					FLD	FP	
1	Soybean (Oilseed)	INM/IPM	43	16.8	21.4	16.23	31.85
2	Pigeonpea (Pulses)	IPM/INM	50	20	13.37	10.9	22.66
3	Chickpea (Pulses)	IPM/INM	50	20	20.69	15.6	32.62

**FLD's on Livestock Enterprises**

Enterprise	Breed	No. of farmers	No. of animals	Performance parameters / indicators	Data on parameter in relation to technology demonstrated		% change in the parameter
					Demo	Local check	
Feeding of bag Silage to milking cows	Jersey Cross breed cows	10	20	a) Avg. Milk yield (lit/cow/day)	7.88	7.00	8
				b) fat %	4.27	3.96	7.83
				c) BC Ratio	1.53	1.43	
Feeding by - pass fat @ 200 gm/cow/day	Jersey Cross breed cows	10	20	a) Avg. Milk yield (lit/cow/day)	9.9	8.4	17.85
				d) fat %	4.5	3.95	13.92
				c) BC Ratio	1:1.85	1:1.65	--
Goat (Oral administration of single dose of liquid closantel 15% @ 10 kg b. wt for Ecto-endo parasite control)	Local goat	10	40	Body weight gain in kg/2 months	4.2	3.12	34.62
				C:B ratio	1:1.86	1:1.40	--

### Performance of FLD during (2016-17) Home Science

Sr. no	Name of Technology	No of farmers	Crop	Performance Evaluation of different parameter								
				$\Delta$ HR beats $\text{min}^{-1}$			Area covered $\text{m}^2/\text{h}$			Yield $\text{kg m}^2/\text{h}$		
				Demo	Local check	Percent Reduction in drudgery over local	Demo	Local check	% increase in area	Demo	Local check	Increase in yield (%)
1	Bhindi plucker	20	Bhindi	15	18	20	33	26	27	5.06	4.2	21
2	Improved Cotton Picking bag	20	Cotton	12	16	25	42.9	35.2	22	5.4	4.2	25
3	Maize Sheller	20	Maize	11	14	21	--	---	--	400 g/m	310 g/m	29

### Details of assessment of livestock production technologies under OFT on farmer's field

S. No	Animal	Technology Demonstrated	No. of farmers	No. of animals	Parameters studied	Yield		% Increase over Farmers Practice
						Demo.	Farmers Practice	
1	Cows	Feeding of area specific mineral mixture @ 50 gm/cow/day	15	30	a) Milk yield (l/cow/day)	9.25	8.75	5.71
					b) Fat content	4.5	4.0	12.5
					c) No of cows conceived	29	23	26.09
					d) BC Ratio	1.69	1.54	-

### OFT: Assessment of Cotton Pellets: An alternative cooking fuel

Sr. No.	Description N=10	Traditional Method	Cooking with Bio-briquette	% saving over farmers practice
1	Rice & Dal (g)	250	250	
2	Quantity of coal required (g)	310	260	19
3	Cost of coal (Rs)	8.7	3.9	56
4	Time required for cooking (minute)	29	23	21
5	Ash recovered (%)	06	2.5	58

Result : Food cooked through cotton pellets is cost effective and eco-friendly by 56% & 58% respectively

**OFT: Assessment of Protein rich diet provided under sable for reducing protein calorie malnutrition adolescent girls 11-14 yr.**

Client	Technology demonstrated	No	Av. Age (yr.)	Av. Weight			Av. Hb		
				Before	After	Chang in weight %	Before	After	Chang in Hb %
Adolescent Girls	T-1: Local Diet : Cereals 553 g, pulses 30 g, GLV 14 g, Other vegetables 51 g. Fruits 35 g, Milk and Its products 70 ml, Fish and Flesh foods 10, Fats & Oils 9 ml, Sugar and Jaggary 19 g	20	15	30	32	60	11.2	11.9	5
	T-2 : Local diet + 50/day Sattu + 50 green leafy veg.			30	33	10	11.2	12.2	9.8

**Diagnostics Surveys Conducted**

Sr. No.	Discipline	Date	Crop	Title	Area Covered (ha)	No. of farmers benefited
1	Plant Protection	21.07.16	Bt-cotton	Sucking pests under ETL	22.0	58
2	Horticulture	04.08.16	Chilli	Dying of seedlings in nursery	10 nursery	32
3	Plant Protection	22.08.16	Bt-cotton	Sucking pests incidence	24.0	97
4	Agronomy	26.08.16	Cotton	INM in cotton	12.0	22
5	Vet. Science	27.08.16	Cows	Infertility in cows	45 cows	22
6	Vet. Science	17.09.16	Cows	Low milk yield in cross breed cows	48 cows	28
7	Agronomy	29.09.16	Cotton	Parawilt in cotton	15.0	28
8	Agronomy	06.10.16	Cotton	Leaf reddening in cotton	12.0	25
9	Horticulture	12.10.16	Nagpur mandarin	Pre harvest fruit drop in Nagpur mandarin orchards	11	22
10	Plant Protection	18.10.16	Redgram	Incidence of wilting	12.0	35
11	Plant Protection	21.10.16	Bt-cotton	Sucking pests incidence	16.0	45
12	Plant Protection	10.11.16	Redgram	<i>Helicoverpa</i> incidence	12.0	25
13	Plant Protection	14.12.16	Chickpea	<i>Helicoverpa</i> incidence	11.0	22
14	Plant Protection	04.01.17	Chickpea	<i>Helicoverpa</i> incidence	20.0	57
15	Plant Protection	11.01.17	Nagpur Mandarin	Sucking pests incidence, fruit drop	10.0	15
16	Home Science	17.01.17	Soybean processing	Curdling of Soymilk	-	15
17	Home Science	21.01.17	Soybean processing	Hardening of Tofu	-	20
18	Home Science	10.02.17	Fruit processing	Colour maintenance of lemon squash	-	35
19	Vet. Science	16.02.17	Goats	Low weight gain in kids	40 kids	22

### Fruits crops at KVK farm

Krishi Vigyan Kendra, CICR, Nagpur has established fruit crops such as Guava (L-49), Pomogranate (Bhagva), Orange (Nagpur mandarin) and Sweet Orange (Katol Gold), Mango and Sapota (Kali Patti) at its farm, for the benefit of farmers and other visitors.

### Scientific Advisory Committee (SAC) Meetings

Krishi Vigyan Kendra, ICAR-CICR, Nagpur organized 21<sup>st</sup> and 22<sup>nd</sup> SAC meetings on 07/09/2016 and 15/03/2017 respectively. Director, ICAR\_CICR was the Chairman and Dr. Chari Appaji, Pri. Scientist, ICAR-ATARI, Hyderabad was the chief guest of both the meetings. Members from agriculture and allied departments participated in these meetings.



### World Soil Day

Krishi Vigyan Kendra, ICAR-CICR, Nagpur organized "World Soil Day" at Village Bhugaon, Taluka Kampthee as well as in Salai and Sillari villages of Ramtek tahsil on December 5, 2016. On this occasion Dr. Blaise Head, Crop Production Division, ICAR-CICR, Nagpur was the Chief Guest. Five hundred soil health cards were distributed to the farmers.



### Cluster FLD workshop of all KVK's of Maharashtra

Krishi Vigyan Kendra, ICAR-CICR, Nagpur organized a 'Review Workshop on Cluster Front Line Demonstrations on Oilseed and Pulses' at KVK, ICAR-CICR, Nagpur on 24 and 25 September 2016. Programme coordinators/SMSs of all KVK's of Maharashtra attended this workshop.

### Kisan Goshti

Krishi Vigyan Kendra, ICAR-CICR, Nagpur organized "Kisan Ghoshti" on the occasion of "Jai Kisan Jai Vigyan Diwas" at Panchgaon, Umred on December 29, 2016.

KVK also participated in 'Kisan Sangoshthi' organized at Borgaon, tah. Sousar, district. Chindwara organized by Borgaon Industries Association on 01/10/2016.

### Soil Testing Activities

Three thousand nine hundred seventy eight soil samples were collected from Ramtek taluka of the Nagpur district through Mobile Soil Testing Van provided under Human Development Programme by Govt. of Maharashtra. These samples were analyzed for different soil testing parameters and soil health cards depicting soil test based fertilizer recommendation for different crops were distributed to the beneficiaries. KVK has received Mobile Soil Testing Van under Human Development Program of Nagpur district which is being used effectively for the said purpose.

Now KVK's soil testing lab has been upgraded for analyzing 9800 soil samples per year by a committee headed by Divisional Joint Director of Agriculture by assessing the facilities and expertise available in KVK's STL.

### Participation in Exhibitions

KVK, ICAR-CICR Nagpur participated in the following events to display various research findings of ICAR-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 ICAR-CICR officials on various issues related to all research activities performed at ICAR-CICR Nagpur.



- 1) On event of "Dharmmachakra Pravartan Din" at Deekshabhoomi, Nagpur during 10-12 October, 2016, KVK, ICAR-CICR, Nagpur participated and exhibited the achievement on various activities of cotton production technologies.
- 2) Participated in "Agro-Vision" exhibition held at Reshimbagh, Nagpur from 11 to 14 November, 2016.
- 3) Participated in "Agro-Tech" Exhibition held at Dr. PDKV, Akola on the occasion of "Birth Anniversary of Dr. Panjabrao Deshmukh" from 27-29 December, 2016.
- 4) Participated in "Unnati Krishi Mela" exhibition held at IARI New Delhi from 15 to 17 March, 2017.

#### Meetings attended

1. Dr. R. B. Singandhupe attended the IMC meeting at ATARI, Hyderabad on 30.08.2016.
2. Dr. R. B. Singandhupe attended the Carrier Advancement meeting of ARS Scientist in the discipline of Soil Science, Agronomy & Soil Water Conservation, Engineering at NBSS&LUP, Nagpur on 26-27.09.2016.
3. Dr. R. B. Singandhupe attended meeting to review Dryland Farming Activities & Soil Analysis Status and Distribution of Soil Health Card with District Collector and State Agriculture Department on 07.10.2016.
4. Dr. R. B. Singandhupe attended the ARYA Project meeting at ATARI, Hyderabad on 05.11.2016.
5. Dr. R. B. Singandhupe attended meeting on "Soil Analysis Status and Soil Health Card Distribution" in District Collector Office, Nagpur on 14.12.2016.
6. Dr. R. B. Singandhupe attended meeting on "Skill Training Of Rural Youth" at Vanamati, Nagpur on 29.12.2016.
7. Dr. R. B. Singandhupe attended meeting with SAO and Taluka Agriculture Officers to review the Agriculture activities at Nagpur on 30.01.2017.
8. Dr. R. B. Singandhupe attended the ATMA Governing Body meeting on 27.02.2017.

#### Workshop/Conference/Trainings Attended

1. Programme Coordinatoor, all SMSs and all Programme Assistant of Krishi Vigyan Kendra, Nagpur participated in 'Action Plan Workshop 2016-17 of all KVKs of Vidharbha which was held at Dr. PDKV, Akola. The workshop was organized by Zonal Project Directorate, Zone-V, Hyderabad on 19<sup>th</sup> May 2016
2. Programme Coordinator Dr. R. B. Singandhupe attended Annual Zonal Workshop Zone-V which was held at YSR Horticulture University, Tadepalligudem, West Godavari (AP) during June 2-4, 2016
3. Dr. U. V. Galkate, SMS (Veterinary Science), KVK attended workshop on, 'Livestock insurance and marketing management' held at Nagpur Veterinary College, Nagpur on 01/07/2016
4. Programme Coordinator Dr. R. B. Singandhupe attended ZREAC Kharif Workshop which was held at Yeotmal on July 19, 2016
5. Programme Coordinator Dr. R. B. Singandhupe attended the Workshop on CFLD Oilseed & Pulses which was held at KVK, CICR, Nagpur on September 9, 2016
6. Programme Coordinator Dr. R. B. Singandhupe attended workshop on "Climate Resilient Agriculture in Maharashtra at Pune (MS) during October 3-4, 2016
7. Programme Coordinator Dr. R. B. Singandhupe attended ZREAC Rabi Workshop which was held at Yeotmal on October 14, 2016
8. Programme Coordinator Dr. R. B. Singandhupe attended "ARYA" Workshop which was held at New Delhi on January 17-18, 2017
9. Dr. S. S. Patil, SMS, Extension attended workshop on "Review and Planning of Soil Analysis and Soil Health Card Distribution" which was held at KVK, Kosbad Hills Dist. Palghar on February 10, 2017
10. Smt. Sunita Chauhan, SMS, Home Science attended workshop on "Promotion of Agro-Enterprises and Processing" which was held at MSME & ATARI, Hyderabad on February 21-23, 2017

11. Dr. S. S. Patil, SMS, Extension attended workshop on "CFLD Oilseed & Pulses" which was held at ATARI, Hyderabad on February 27-28, 2017.

#### KVK staff participated as a Guest Speaker

1. Dr. R. B. Singandhupe participated and delivered talk on "Climate Resilient Agriculture in Maharashtra at Pune (MS) during October 3-4, 2016
2. Dr. S. S. Patil delivered lecture on "Integrated pest management in pigeonpea" in a monthly workshop of State Agril. Dept. at Agriculture College, Nagpur on 09/11/2016.
3. Dr. U. V. Galkate delivered lecture on 'Role of livestock in organic farming' in a programme 'World Soil Day, celebrated at Bhugaon, Salai & Sillari in Nagpur district on 05/12/2016
4. Smt. Sunita Chauhan delivered talk on Value addition of fruits and vegetables at to the SHG's of Kalmeshwar on dated 17/12/16. about 150 SHG members were present.
5. Smt. Sunita Chauhan delivered talk on Enterprises for rural youths at Chikana village dist. Nagpur on dated 04/01/2017. Around 80

rural youths were present.

6. Smt. Sunita Chauhan delivered talk on Squash and sauce preparation- An enterprise for SHG and rural youths at KVK, CICR Nagpur on dated 05/01/2017.

#### Radio Talks:

- ❖ Smt. Sunita Chauhan delivered a radio talk on "Rural Handicraft" in Marathi and telecasted by AIR, Nagpur on 21-23 Feb. 2017

#### T.V. Talk

- ❖ Dr. U.V. Galkate delivered T.V. Talk on 'Goat farming for self employment generation' in Marathi in a programme Krishi Darshan programme broadcasted on 18/01/2017 by Doordarshan channel Sahyadri

#### Advisory Services Provided

KVK has provided advisory services to the farmers, rural youth and extension functionaries, through personnel guidance, telephonic calls and mobile services on Agricultural production and protection technology and allied fields. Through there advisory services 21942 clients in Nagpur district were benefitted.



## 10. GENERAL

### 10.1 List of Publications

Research papers published by the Institute's scientists NAAS rating > 6

1. Chaudhury S., Bhattacharyya T., Wani S.P., Pal D.K., Sahrawat K.L., Nimje A., Chandran P., Venugopalan M.V. and Telpande B. (2016). Land use and cropping effects on carbon in black soils of semi-arid tropical India. *Current Science*, 110 (9), 1692-1698. (NAAS rating: 6.93)
2. El-Moghny M. Abd, Santosh H. B., Raghavendra K. P., Sheeba J. A., Singh S. B. and Kranthi K. R. (2017). Microsatellite marker based genetic diversity analysis among cotton (*Gossypium hirsutum*) accessions differing for their response to drought stress. *J. Plant Biochem. Biotechnol.* doi:10.1007/s13562-016-0395-1 (NAAS Rating: 7.35).
3. Jandrajupalli; Naik V.Chinna Babu, Ghodke Amol, Kranthi Sandhya, Kranthi K. R., Singh Bir Pal, Choudhary Jaipal Singh and Krishna MSR. (2016). Population genetic structure of cotton pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) using mitochondrial cytochrome oxidase I (COI) gene sequences from India: *Mitochondrial DNA Part A*, 2470-1408. (NAAS Rating: 7.21).
4. Kranthi S., Ghodke A. B., Raghavendra K.P., Mandle M., Nandanwar R., Satija U., Kumar R., Desai H., Udikeri S. S, Dhara Jothi B., Bheemanna M, Monga D. and Kranthi K. R. (2016). Mitochondria CO-I based genetic diversity of the cotton leafhopper *Amrasca bigutulla bigutulla* (Ishida) populations from India. *Mitochondrial DNA*, p.No-1-56. (NAAS Rating: 7.21)
5. Meena R.A., Monga D., Venugopalan M.V., Ahuja S.L. and Sahay Ratna. (2016). Screening of *Desi* cotton (*G. arboreum*) suitable for surgical properties. *Journal of Scientific and Industrial Research*, 75: (9) 570-573. (NAAS Rating: 6.50)
6. Prasanna R., Ramakrishnan B., Ranjan K., Venkatachalam S., Kanchan A., Solanki P., Monga D., Shivay Y.S. and Kranthi S. (2016). Microbial inoculants with multifaceted traits suppress *Rhizoctonia* populations and promote plant growth in cotton *J. Phytopathol*, 164: 1030-1042. (NAAS-6.82).
7. Reddy D. D., Blaise D., Kumrawat B. and Singh A.K. (2016). Evaluation of Integrated Nutrient Management Interventions for Cotton (*Gossypium hirsutum*) on a Vertisol in Central India. *Communications in Soil Science and Plant Analysis*, 48:4,469-4,475. (NAAS Rating: 6.39).
8. Sethi K., Siwach P. and Verma S. K. (2015). Assessing genetic diversity among six populations of *Gossypium arboreum* L. using microsatellites markers. *Physiology and Molecular Biology of Plants*, 21 (4): 531-539. (NAAS rating 7.25).
9. Vennila S., Yadav S. K., Wahi P., Kranthi S., Amutha A. and Dharajothi B. (2016). Seasonal Dynamics, Influence of Weather Factors and Forecasting of Cotton Sap Feeders in North India (2016). Proceedings of the National Academy of Sciences, India Section B: Biological Sciences. DOI: 10.1007/s40011-016-0776-1. (NAAS Rating: 6.00)
10. Waghmare V. N., Rong J., Rogers C.J., Bowers J.E., Chee P.W., Gannaway J.R., Katageri I. and Paterson A.H. (2016). Comparative transmission genetics of introgressed chromatin in *Gossypium* polyploids. *American Journal of Botany*, 103: 719-730. (NAAS Rating: 8.81).

Research papers published by the Institute's scientists NAAS rating < 6

1. Aga T. M., Tambe V. J., Nagrare V. S. and Naikwadi Bhausahab. (2016). Parasitoid, *Aenasius arizonensis* (Girault) (Hymenoptera: Encyrtidae): Its biology, morphometrics, host stage preference and use in biological control. *Journal of Biological Control*, 30(2): 91-98. (NAAS Rating: 3.96).
2. Arunkumar, N., Gulsar Banu J., Gopala-

- krishnan N. and Prakash A.H. (2017). Isolation, screening and characterization of microbial surfactants producing wax degrading bacteria from cotton mealybugs, *Phenacoccus solenopsis* Tinsley and *Ferrisiavirgata* Cockerell (Homoptera: Pseudococcidae). *Journal of Entomology and Zoology Studies*; 5(2): 1191-1195. (NAAS Rating: 5.6).
3. Arunkumar, N., Gulsar Banu J., Gopalakrishnan N. and Prakash, A.H. (2017). Wax Degrading Bacteria: Scope and Applications in Agriculture. *International Journal of Current Microbiology and Applied Sciences*. 6(2): 649-664. (NAAS Rating: 5.3).
  4. Banu J.G., Meena K. S., Selvi C. and Manickam S. (2017). Molecular marker-assisted selection for nematode resistance in crop plants. *Journal of Entomology and Zoology Studies* 5(2): 1307-1311. (NAASrating - 5.53).
  5. Blaise D., Bonde A.N., Reddy D.D., Patil V.D., Dhawan A.S., Aladakatti Y.R., Vadivel A. and Ratnakumari S. (2016). Nutrient management options for rainfed cotton grown on vertisols. *Indian Journal of Fertilisers*, 12(10): 46-52. (NAAS Rating: 3.78).
  6. Dhara Jothi B., Kranthi Sandhya and Naik Chinna Babu. (2016). Efficacy of transgenic Bt cotton hybrids on pink bollworm, *Pectinophora gossypiella* (Saunders) under irrigated and rainfed conditions of south and central India. *Journal of Applied Zoological Research*, 27 (2): 143-148. (NAAS Rating: 2.63).
  7. Meena RA, Monga D, and Sahay Ratna. (2016). Effect of defoliation on maturity behavior and seed cotton yield in cotton *J. Cotton Res. & Dev.* 30 (1) 63-65. (NAASrating 3.41)
  8. Nagrare V. S., Sheeba J.A., Bhoyar P., Naikwadi B. and Satija U. (2017). Biochemical changes in cotton plants due to infestation by cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae). *Journal of Applied and Natural Science*, 9 (1): 382 - 388. (NAAS Rating: 5.08).
  9. Nagrare V. S., Deshmukh A. J., Dharajothi B., Amutha M., Kumar Rishi, Kranthi S. and Kranthi K.R. (2016). Sampling methodology for assessing field population of mirid, *Campylomma livida* infesting cotton. *Indian Journal of Plant Protection*, 44 (2): 250-250. (NAAS Rating: 4.90).
  10. Nagrare V.S. and Naikwadi B. (2016). An outbreak of gall inducing thrips *Gynaikothrips uzeli* Zimmermann (Thysanoptera : Phlaeothripidae) on *Ficus benjamina* Linn. in central India. *Journal of Entomology and Zoology Studies*; 4(5): 294-296. (NAAS Rating: 5.53)
  11. Nagrare V.S., Kranthi S., Kranthi K.R., Naik V. Chinna Babu, Deshmukh V., Naikwadi B. and Dahekar A. (2016). Relative toxicity of insecticides against cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) and its fortuous parasitoid *Aenasius bambawalei* Hayat (Hymenoptera: Encyrtidae). *Journal of Applied and Natural Science*, 8 (2): 987 - 994. (NAAS Rating: 5.08).
  12. Pable D., Chatterji S. and Venugopalan M.V. (2016). Soil quality assessment of two cotton growing agroecological subregions of Vidarbha, Maharashtra. *Indian Journal of Soil Conservation*, 44(3): 343-349. (NAAS Rating: 5.20).
  13. Pable D., Chatterji S. and Venugopalan M.V. (2016). Soil quality assessment in rainfed cotton growing environs of Vidarbha, Maharashtra *International Journal of Agricultural Science and Research*, 6 (4): 243-250. (NAAS Rating: 4.13).
  14. Raju, AR. (2017). Leaf Reddening in Bt Hybrid Cotton. *Agri Res & Tech*, 3(4): 1-4.
  15. Rathinavel, K. (2017). Effect of seed treatments on viability and vigour of cotton seeds (*Gossypium hirsutum* L.) under ambient storage. *Journal of Cotton Research and Development*. 31(1):1-6. (NAASrating - 3.41).
  16. Sankaranarayanan K., Venugopalan M.V. and Rajendran K. (2016). Pulses are companion crop for soil fertility improvement and pest

- control in cotton – A review, *Indian Journal of Agronomy*, vol 61, Special issue, 230-237. (NAAS Rating: 5.46)
17. Waghmare V.N. and Salame R.V. (2016). CNA 1051 (IC0613964; INGR15016) - An induced virescent mutant of diploid cotton (*Gossypium arboreum* L.). *Indian Journal Plant Genetic Resources*, 29(2): 203-205. (NAAS Rating: 5.12).
18. Waghmare V.N. and Salame R.V. (2016). CNH 1102 (IC0611336; INGR15015) - A high ginning outturn germplasm of Upland cotton (*Gossypium hirsutum* L.). *Indian Journal Plant Genetic Resources*, 29(2): 202-203. (NAAS Rating: 5.12).

## 10.2 : List of on-going Projects

S. N.	Project title & Investigators	Duration
<b>Crop Improvement</b>		
1.	Cotton Breeding Program (CBP)	
	CBP 1: Improvement of tetraploid and diploid cottons for fibre properties through population improvement approaches. V.N. Waghmare (PI), Vinita Gotmare (PA), O.P. Tuteja (PA), S. K Verma	2000-20
	CBP 2: Studies on genetic enhancement of <i>G. hirsutum</i> . T. R. Loknathan (PI)	2002-17
	CBP 3: Development of drought tolerant genotypes with good fibre quality in <i>G. hirsutum</i> . Suman Bala Singh (PL), A. H. Prakash (PA)	2008-17
	CBP 4: Breeding of Upland cotton for improved fibre quality and resistance to biotic stress (Jassid). S. M. Palve (PI)	2005-21
	CBP 5: Development of long staple <i>G. hirsutum</i> variety with improved fibre strength. S. Manickam (PL), V. N. Waghmare (PA), S. L. Ahuja (PA)	2008-17
	CBP 6: Development of early maturing, medium staple varieties and hybrids Resistant to CLCuV. O. P. Tuteja (PL), D. Monga (PA), S. K. Verma (PA), Rishi Kumar (PA), S. M. Palve (PA)	2008-17
	CBP 7: Development of <i>G. hirsutum</i> genotypes with high yield and high GOT. S. L. Ahuja (PL), R. A. Meena (PA), D. Monga (PA), Rishi Kumar (PA)	2012-18
	CBP 8: Development of high yielding, early maturing extra long staple <i>G. barbadense</i> genotypes with high GOT. K. P. M. Dhamayanthi (PL), R. B. Singandhupe (PA), M. Saravanan (PA)	2012-17
	CBP 9: MAS/MAB for water-logging in cotton. V. Gotmare (PL), S.E.S.A. Khader (PA), M. Saravanan (PA), J. H. Meshram (PA), J. Annie Sheeba (PA)	2012-20
	CBP 10: Breeding for early maturity compact plant type and jassid tolerance in cotton. H. B. Santosh (PI), S. Manickam (PA)	2014-19
	CBP 11: Identification of male sterile plants in genetic male sterility (GMS) using molecular markers. O. P. Tuteja (PL), S. B. Singh (PA), M. Saravanan (PA)	2012-17
	CBP 12: Development of cotton leaf curl virus resistant genotypes using <i>G. arboreum</i> / <i>G. herbaceum</i> through introgression. S. K. Verma (PI), O. P. Tuteja (PA), D. Monga (PA), Rishi Kumar (PA), V. Gotmare (PA), H. B. Santosh (PA)	2015-21
	CBP 13: Breeding to improve performance of <i>Gossypium herbaceum</i> for adaptation to climate change in central India. D. V. Patil (PI), Punit Mohan (PA)	2015-20
	CBP 14: Development of high yielding, early maturing Asiatic cotton ( <i>Gossypium arboreum</i> ) genotypes suitable to south zone. A. Manivannan (PI), Punit Mohan (PA), M. Saravanan (PA), V. N. Waghmare (PA), N. Gopalakrishnan (PA)	2015-20



S. N.	Project title & Investigators	Duration
2.	Cotton Germplasm Management Program (CGMP) CGMP 1: Collection, conservation, evaluation, documentation and maintenance of germplasm of cultivated species of <i>Gossypium</i> . Punit Mohan (PL), S. Manickam (PA), R. A. Meena (PA), K. P. M. Damayanthi (PA), S. S. Mahajan (PA), M. Saravanan (PA)	2006-17
	CGMP 2: Conservation, characterization and utilization of wild species, races of cultivated species and synthetic polyploids of <i>Gossypium</i> . V. Gotmare (PL), G. Balasubramani (PA).	2008-18
	CGMP 3: Exploration, collection and conservation of land races of desi cotton and perennials and from different regions of India. M. Saravanan (PL)	2011-17
3.	DUS characterization and DNA finger printing of public sector cotton varieties. V. Santhy (PL), H. B. Santosh (PA)	2012-17
4.	Studies to improve the seed and boll setting efficiency in cotton. R. A. Meena (PL), R. Kumar (PA), K. Rathinavel (PA)	2012-18
5.	Evaluation of exogenous application of plant growth hormones and other chemicals on seed yield and quality of cotton. S. Mahajan (PI)	2015-17
<b>Biotechnology</b>		
6.	Deployment of biotechnological tools for enhancing cotton seed by -product utilization: Reduction of gossypol content using CYP6AE14 gene. K. P. Raghavendra (PI), S. Kranthi (PA), G. Balasubramani (PA), K. Velmourougane (PA), Savita Santosh (PA)	2014-17
7.	Basic Studies on Somatic embryogenesis of Cotton. Joy Das (PI), Rakesh Kumar, S.B. Nandeshwar (PA)	2015-17
8.	Development of novel methods for gene delivery into cotton. Rakesh Kumar (PI), Joy Das (PA)	2015-17
<b>Crop Production</b>		
9.	Allelopathy as an alternative weed management strategy in cotton. B. Desouza (PI), P. Nalayini (PA), A. Manikandan (PA)	2012-18
10.	Evaluation of nano-formulated micronutrients foliar spray for yield maximization in different cotton genotypes. D. Kanjana (PI)	2012-17
11.	Correlation of leaf colour transmittance with relation to soil/plant nutrient status. J.A. Sheeba (PI)	2014-17
12.	Evaluation of structured water for cotton production. P. Nalayini (PI)	2014-19
13.	Efficient nitrogen fixing legumes for cotton based cropping systems. A. Manikandan (PI), P. Nalayini (PA)	2015-20
14.	Development of remunerative cotton based cropping systems based on conservation agriculture principles. R. Raja (PI), D. Kanjana (PA)	2015-19
15.	Survey, surveillance and identification of weeds of Economic Value in Cotton Based Cropping System. S. N. Rokde (PI)	2015-17
16.	Participatory evaluation of technology for improving profitability in calcareous soils. A.R. Raju (PI), S. N. Rokde (PA), R. B. Singandhupe (PA), Anuradha Narala (PA) A. Manikandan (PA)	2016-20
17.	Exploiting the epigenetic transgenerational inheritance of stress responsive traits for imparting abiotic stress tolerance to cotton. J A. Sheeba (PI)	2016 -21
18.	Impact of Institutional Credit on Cotton Farming in Vidarbha Region of Maharashtra. A. Narala (PI), S. M. Wasnik (PA), N. Gokte (PA), V. Gotmare (PA)	2016-17

S. N.	Project title & Investigators	Duration
19.	Development of interactive decision support systems for cotton pest management with prerecorded voice modules. M. Sabesh(PI), K. R. Kranthi (PA), C. Karpagam (PA)	2016-19
20.	Bio-efficacy trials of plant growth promoter based on cow urine and waste human hair to improve the cotton crop productivity. B. Desouza (PI), G. I. Ramkrushna (PA)	2016-17
21.	Influence of nitrogen (urea) and organophosphate (Monocrotophos) on crop duration, flowing, fruiting and insect pests in cotton. G. I. Ramkrushna G.I. (PI), R. Pande (PA)	2016-17
<b>Crop protection</b>		
22.	Gene discovery for useful traits. K. R. Kranthi (PI), S. Kranthi (PA), K. P. Raghavendra (PA), K. Velmourougane (PA), J. A. Sheeba (PA), A. Sampath Kumar (PA)	2014-19
23.	Role of epicuticular wax in reaction of cotton genotypes to whitefly/CLCuD. Rishi Kumar (PI), D. Monga (PA), S. Kranthi (PA), J. A. Sheeba (PA)	2014-17
24.	Isolation and characterization of endophytes in cotton and endo-symbionts in bollworms. M. Amutha (PI)	2012-17
25.	Production, stabilisation, formulation and validation of microbial agents and their natural products against insects and nematode pests of cotton. J. Gulsar Banu (PL), M. Amutha (PA)	2012-17
26.	Development of reverse transcription loop mediated isothermal amplification (RT- LAMP) for early detection of cotton leaf curl and tobacco streak viruses of cotton ( <i>G. hirsutum</i> ). S. P. Gawande (PI), D. Monga (PA)	2015-18
27.	Studies to identify the most virulent strains of entomophthogenic fungi for whitefly control. S. K. Sain (PI), D. Monga (PA), S. Kranthi (PA), Rishi Kumar (PA), T. Prabhulinga (PA), D. Nagrale (PA)	2016-19
28.	Diversity analysis of Whitefly ( <i>Bemisia tabaci</i> ), predators and parasitoids. T. Prabhulinga (PI), S. Kranthi (PA), Rishi Kumar (PA), M. Amutha (PA), V. Chinna Babu Naik (PA)	2016-18
29.	Evaluation of cotton PGPR for broad spectrum resistance against insect pests and diseases. Dipak T Nagrale (PI), T. Prabhulinga (PA)	2016-19
30.	Whitefly: Studies on ecology and host plant resistance. Rishi Kumar (PI), S. K. Sain (PA), T. Prabhulinga (PA), S. Kranthi (PA), D. Monga (PA)	2016-20
31.	Exploring novel dispensers to enhance the trapping efficacy of gossyplure in managing pink bollworm in cotton. K. Rameash (PI), B. Dharajothi (PA)	2016-17
32.	Push-pull strategy for management of pink bollworm in cotton. Vivek Shah (PI), Pooja Verma (PA)	2016-19
33.	Studies on chemical cues mediating sucking pests and natural enemy interactions in cotton eco-system. T. N. Madhu (PI), Rishi Kumar (PA), Shankarganesh (PA)	2016-18
34.	Enhancing the efficacy of yellow sticky traps using essential oils against sucking pests in cotton. T. N. Madhu (PI), Rishi Kumar (PA), Shankarganesh (PA)	2016-17
35.	Technology Mission on Cotton MM I TMC MM 1.1: Development of multi -gene constructs and Bt cotton varieties for sustainable pest management. K. R. Kranthi (PI), S. B. Singh (PA), K. P. Raghavendra (PA), S. B. Nandeshwar (PA), G. Balasubramani (PA), K. Velmourougane (PA), S. Kranthi (PA), H. B. Santosh (PA) TMC MM 1.2: Marker Assisted Breeding for cotton leaf curl disease (CLCuD), bacterial leaf blight (BLB) and nematodes resistance in cotton. V. N. Waghmare (PI), A. Sampath Kumar (PA), N. Narkhedkar (PA), S. Manickam (PA), J. Gulsar Banu (PA),	2012-17



S. N.	Project title & Investigators	Duration
	H. B. Santosh (PA), S.K. Verma, D. Monga (PA) TMC MM 1.4: Evaluation of genotypes and a grotechniques for high density planting system and surgical cotton varieties. M. V. Venugopalan (PI), B. Desouza (PA), V. Chinna Babu Naik (PA), Punit Mohan (PA), T. R. Lokanathan (PA), A. R. Raju (PA), A. Sampath Kumar (PA), K. Shankarnarayanan (PA), S. L. Ahuja (PA), R. A. Meena (PA) TMC MM 1.5 : Simulation models/electronic gadgets to predict insect infestation, bollworm resistance to Bt cotton, area, production and price of cotton. S. Kranthi (PI), K. R. Kranthi (PA), V. S. Nagrare (PA), V. Chinna Babu Naik (PA), Anuradha Narala (PA), A. H. Prakash (PA), M. Amutha (PA), K. Shankarnarayanan (PA), Isabella Agarwal (PA), B. Dharajothi (PA), Rishi Kumar (PA), M. Sabesh (PA), J. A. Sheeba (PA) TMC MM 1.6 : e-Kapas network and technology documentation. S. M. Wasnik (PI), A. H. Prakash (PA), S. Usha Rani (PA), O. P. Tuteja (PA), M. Sabesh (PA), Anuradha Narala (PA), N. Gopalakrishnan (PA) TMC MM I 1.7: Development of cotton picking machinery for small scale cotton production systems. G. Majumdar (PI)	
	<b>Externally funded projects</b>	
36.	Consortia Research platform- Natural Fiber Development of tissue culture technology for cotton fibre initiation. S. B. Nandeshwar (PI), Rakesh Kumar (PA), Joy Das (PA)	2015-17
37.	Consortia Research Platform on biodiversity. Punit Mohan (PI), V. Gotmare (PA), J. H. Meshram (PA), S. Manickam (PA), R. A. Meena (PA)	2014-17
38.	DST : Design & Development of a cotton picking head. G. Majumdar (PI)	2012-17
39.	DST : Development of vision based expert system for vacuum picking of cotton. G. Majumdar (PI)	2013-17
40.	NSP: National Seed Project (Crops). K. Rathinavel (PI)	1999-17
41.	DUS: Implementation of PVP legislation 2001 and DUS testing of cotton under ICAR-SAU system. K. Rathinavel (PI)	2003-17
42.	MSP: ICAR project on seed production in agricultural crops and fisheries. P. R. Vijayakumari (Nd Offi), V. Santhy (PA), K. Rathinavel (PA), R. A. Meena (PA)	2007-17
43.	NASF: Molecular characterization and validation of fiber strength genes with fiber specific promoter for improvement in cotton. G. Balasubramani (PI), K. P. Raghvendra (PA), J. Amudha (PA), S. B. Nandeshwar (PA)	2012-17
44.	NPTC: Transgenics in crops. Insect and disease resistant transgenic cotton. G. Balasubramani (PI), J. Amudha (PA), S. B. Nandeshwar (PA), K. P. Raghvendra (PA), Suman Bala Singh (PA)	2012-17
45.	NICRA: National Innovations in climate resilient agriculture NICRA: Climate change- adaptation and mitigation strategies in cotton. S.E.S.A Khader (PI), A. H. Prakash (CoPI), B. Desouza (CoPI), M.V. Venugopalan (CoPI) NICRA: Development of IPM strategies to combat whitefly and other emerging pests of cotton. S. Kranthi (PI), V. S. Nagrare (PA), T. Prabhulinga (PA), D. Monga (PA), Rishi Kumar (PA), M. Sabesh (PA)	2013-17 2016-19
46.	Mahyco: Monitoring changes in baseline susceptibility to Cry toxins in the cotton bollworm, <i>H. armigera</i> , pink bollworm and <i>Spodoptera litura</i> . Sandhya Kranthi (PI), K. R. Kranthi (CoPI), V. Chinna Babu Naik (CoPI)	2012-17

S. N.	Project title & Investigators	Duration
47.	GEAC: Event based approval mechanism. S. Kranthi (PI), K. R. Kranthi (CCPI)	2010-17
48.	Consortia Research Platform IIHR (Lead centre): ORP on Management of sucking pests in horticultural crops. S. Kranthi (PI), M. Amutha (PA)	2014-17
49.	DST: Entomopathogenic -endophytes mediated plant defense as a novel approach for the management of bollworms in cotton. M. Amutha (PI)	2013-17
50.	Maha. Govt: Crop pest surveillance and advisory project (CROPSAP) in Maharashtra. V. S. Nagrare (PI)	2010-17
51.	ICAR Extramural: Introgression of genes for whitefly and CLCuD resistance in upland cotton ( <i>G. hirsutum</i> ). V.N. Waghmare (PI), S. M. Palve (CoPI), (S. B Nandeshwar (CoPI), Rakesh Kumar (CoPI), D. Monga (CoPI), S. K. Verma (CoPI), Rishi Kumar (CoPI)	2016-17
52.	Gender Knowledge System in Agriculture (ICAR Flagship Project). S. Usha Rani (CCPI) A. Narala (Co PI)	2015-17
53.	DST-SERB : Evaluation of selectivity of insecticides against different mealy bug species and their major natural enemies associated with cotton, tomato, brinjal and papaya. K. Shankarganesh (PI)	2016-18
54.	DST-SEED: Exploration and development of thermal tolerant strain of biocontrol agent, <i>Acerophagus papayae</i> for sustainable management of papaya mealybug, <i>Paracoccus marginatus</i> in crops. K. Shankarganesh (PI), C. Karpagam	2016-19
55.	DST-SERB-Effect of thermal stress on fitness traits of two mealybug pests, <i>Phenacoccus solenopsis</i> , and <i>Paracoccus marginatus</i> and their parasitoids <i>Aenasius bambawalei</i> and <i>Acerophagus papaya</i> . K. Shankarganesh (PI), S. Kranthi (CoPI), K. Rameash (CoPI)	2016-19

### 10.3 : Consultancy, Patents, Commercialization of Technology

#### Patent submitted and published in IPINDIA website:

A complete patent application was submitted by Er. A. Majumdar *et al* (2016) for the invention of "A Simple Device to Detect Specific Hues" (Filing is under process).

#### Revenue Generation

Particular	Amount (Rs.)
Sale of Farms Produce	35,27,868.40
Licence Fee	2,70,815.00
Application fee from candidates	4,600.00
Income generated from internal resource generation	60,000.00
Miscellaneous Receipts	14,31,302.50
Sale of Bt detection kits	1,600.00
<b>Total</b>	<b>52,96,185.90</b>

#### MoU signed by ICAR-CICR

1. MoU was signed between ICAR-CICR, Nagpur

and M/s. Innovative Bioscience, Samartha Nagar, Ajni Sq., Nagpur for Yellow sticking Trap on 28 April 2016.

2. MoU was signed between ICAR-CICR, Nagpur and Better Cotton Initiative, Jasola, and New Delhi on development of an 'APP' for sustainable Cotton Production in India on 2<sup>nd</sup> Jun 2016.

3. MoU was signed between ICAR-CICR, Nagpur and M/s. Ankur Seeds Pvt Ltd. Nagpur for "Registered varieties seeds for potential commercialization" on 26<sup>th</sup> Dec 2016.

### 10.4 : Significant Decisions of RAC and IRC

#### Research Advisory Committee Review Meeting

Research Advisory Committee (RAC) meeting was held at ICAR-Central Institute for Cotton Research (CICR), Nagpur from 1-2 December 2016. The meeting was held under the Chairmanship of Dr. B.V. Patil, Director of Education, University of

Agricultural Sciences, Raichur, Karnataka.

Dr. K. R. Kranthi, Director, ICAR - CICR, Nagpur welcomed the Chairman and members of RAC. In his introductory remarks, the Chairman RAC expressed his happiness over the crop condition in the country during 2016-17. He reiterated that timely sowing, well distributed rainfall and above all the relentless training and information campaign coordinated by ICAR-CICR, SAUs and State governments that kept the key pests (pink bollworm and whitefly) under control were the reasons for high yields expected this year. He stressed on strengthening research on control of pink bollworm, mechanical picker for small farms and compact early varieties with Bt suitable for High Density Planting. Action Taken Report (ATR) was placed before the RAC for deliberation. Dr. B. V. Patil, Chairman, RAC expressed satisfaction on ATR and appreciated the research efforts of the institute.

Dr. K.R. Kranthi, Director ICAR-CICR, in his presentation "Global and National Cotton Perspectives" emphasized that sustainable cotton production depends upon prudent use of water and agrochemicals. He presented the National and Global cotton scenario and narrated the reasons for enhanced yields (>1500 kg lint/ha) achieved by Australia, China, Brazil, Turkey, Mexico and Israel. The reasons for low yields and approach to improve cotton yields in India were also elaborated. The Chairman and the members of RAC widely appreciated the presentation.

Research Advisory Committee members along with the Director, ICAR-CICR and Heads of divisions/sections/regional stations visited different experimental fields and laboratories and interacted with the scientists regarding the research programmes being implemented. They also visited the polyhouse where backcrossing of F<sub>1</sub> (Tg2E-13 event) with their corresponding recipients and crossing of donor (CH12 event) with recipients is being carried out. The research achievements during 2016 were presented by Heads of the Division of Crop Improvement, Crop Production, Crop Protection, I/c Biotechnology Section, Head CICR Regional Station Coimbatore



and Dr. O.P. Tuteja from Regional Station Sirsa. The work done was reviewed thoroughly. The committee appreciated the efforts and made specific recommendations:

1. CICR has developed excellent cultures with specific economically important trait values (earliness, compact plants, zero monopodia, fibre quality, drought tolerance, sucking pest tolerance etc). Desired traits can be combined by adopting appropriate breeding strategies like multiple crossing (involving more than four parents), diallele selective mating system, early generation intercrossing or by subjecting the segregating populations to different mating systems to obtain good recombinants.
2. Based on the results of the multilocation trials involving 21 Bt varieties, the commercial release and subsequent seed production of the most adaptable and high yielding varieties may be expedited.
3. ICAR-CICR should sponsor varieties, irrespective of their performance in AICRP on cotton trials, to State Varietal Evaluation Trials and promising ones must also be released through State Varietal Release Committees.
4. Research on the contribution of microbiome including PGPR towards lint yield, fibre quality and stress tolerance needs to be explored.
5. Rearing system for whitefly and protocol for screening for whitefly tolerance needs to be standardized and a dedicated rearing facility may be developed through proper funding support.

6. Resistance to CLCuD in the reported germplasm lines may be confirmed using Agro-infectious clones of virus biotypes.
7. There is a need to prioritize the projects and improve focus on immediate issues confronting cotton production (Whitefly, Pink bollworm, HDPS, Bt varieties, Picker, Long linted *desi* cotton etc.). Projects of lesser importance can be shelved. Young scientists must concentrate on basic research with latest methodology (state of art protocols).
8. The road map discussed and finalized during the golden jubilee celebrations of AICRP on Cotton during 9-10 November 2016 to achieve 1000 kg lint per hectare can form the basis for future cotton research and development.
9. Large scale validation and performance evaluation of newly identified varieties of long linted *G. arboreum* under different soil and climatic environments of HDPS needs to be undertaken for which funding may be sourced from Council.
10. There is a strong genotype x environment interaction in *G. hirsutum* and *G. arboreum*. The segregating populations ( $F_2$  to  $F_6$ ) are subjected to different seasonal climatic variation and the characters identified during  $F_2$  stage may not be reproduced in later generations. Seasonal climate data need to be correlated to yield to unravel this. A different planting window or other environmental modification may work better.

The Chairman and members of RAC also released CICR Technical Bulletin on "Whitefly and CLCuD management strategies for cotton in North India". RAC meeting concluded with the vote of thanks proposed by Dr. V.N. Waghmare, Head, Division of Crop Improvement, ICAR-CICR, Nagpur.

#### Institute Research Committee (IRC) meeting

The first Mid-term Institute Research Committee (IRC 2016) meeting was conducted on 23 June 2016 at CICR, Nagpur. Dr K. R. Kranthi, Director CICR Nagpur Chaired the meeting. Chairman in his introductory remarks, directed the scientists to bring their projects into logical conclusion without



waiting for long period. He asked the researchers to identify the best legume as intercrop in cotton that can fix up nitrogen and thus reduce the chemical fertilizer load into the soil. Dr Kranthi stressed to evaluate large no. of germplasm lines to shortlist amongst them for various traits. He expressed satisfaction over increase in *desi* cotton area in North India where outbreak of whitefly was experienced last year.

The second mid- term IRC 2016 meeting was conducted on 5 October 2016 at CICR, Nagpur. Dr K. R. Kranthi Director CICR Nagpur Chaired the meeting. Chairman in his introductory remarks desired that scientists who are working on basic aspects of research should also have an applied aspect and must make a difference now or later. He mentioned that in electronics tremendous progress has been made and that advancement in electronics can be utilized as special vehicle to translate ideas into products. Areas like remote sensing, laser sensing etc. can also be explored. He further emphasized to look at possibility for robust publication in reputed journals. He also made an appeal to scientists to think for newer ideas, even out of box.

Dr V.S. Nagrare, Secretary IRC and Dr J.H. Meshram, Joint Secretary, IRC coordinated both the meetings.

#### 10.5 : Other Important Workshop/Symposia/Meetings

##### National Workshop on Indigenous (*Desi*) Cotton in India

A national workshop on "Indigenous (*Desi*) Cotton in India" was jointly organized by Yuva Rural Association (Y.R.A.), ICAR-CICR and SAHAJA

SAMRUDHA at ICAR-Central Institute for Cotton Research, Nagpur from 28 to 30 November, 2016. The purpose of the workshop was to chalk strategies to tap the forgotten potential of indigenous cotton, to revive Khadi in real sense as envisaged by Gandhi and Kumarappa and to provide more sustainable alternatives to the cotton farmers of the country.

The workshop was inaugurated Dr. Sharad Nimbalkar, Former Vice Chancellor of Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola. The inaugural programme began with a welcome speech from Shri Datta Patil, Director General, Yuva Rural Association. Shri Daniel Anand Raj, Senior Programme Officer, SWISSAID in his address stressed upon the need to bring together all the stakeholders of indigenous cotton and removing the bottlenecks in cotton value chain. Dr K. R. Kranthi, Director, CICR, Nagpur exhorted the need for a blueprint to promote indigenous cotton. He further stated that water, cost of cultivation and chemical pesticides are the three factors that decide the cultivation of cotton. Shri Rajeev Baruah, India Country Manger, Better Cotton Initiative stated the need for mainstreaming the technology available for indigenous cotton using the good quality varieties developed by public sector institutions. Dr. Nimbalkar suggested to develop varieties with big boll size in indigenous cotton and to suggest a more rational in price fixation of inputs and output of cotton cultivation. The inaugural session was followed by technical sessions.

**Some of the major issues discussed were:**

- Indigenous cotton seed quality and availability of seeds in order to attain seed sovereignty
- Issues in cropping systems management and sustainability of *desi* cotton
- Processing of indigenous cotton
- Problems in marketing of indigenous cotton and price received by farmers
- Crop improvement of indigenous cotton
- Niche areas of indigenous cotton production.
- Analyzing its bottlenecks in indigenous cotton production and preparing a roadmap to increase availability and ensuring sustainable

cotton value chain

The workshop brought together different stakeholders involved in the indigenous cotton value 'chains to address the challenges related to scaling up of indigenous cotton. Around 70 personals representing researchers, farmers, spinners, weavers, NGOs, and entrepreneurs and private sector players and social entrepreneurs have participated in the workshop.

**SAARC Regional Consultation Meeting**

A three day SAARC Regional Consultation Meeting was jointly organized by ICAR-Central Institute for Cotton Research, Nagpur and SAARC Agriculture Centre (SAC), Bangladesh at CICR. The meeting was held from 29-31 August 2016. Twelve participants from the SAARC countries namely, Afghanistan, Bangladesh, Bhutan, Pakistan, India and SAC attended the meeting. Dr. K. R. Kranthi, Director, CICR introduced the Chief Guest Dr. C. D. Mayee and welcomed the participants. Director, CICR in his introductory remarks briefed the importance of the meeting in different aspects covering cotton crop, textile industry and foreign exchange earnings. He also stressed the dynamic cotton cultivation patterns across countries which affects the global trade through imports and exports. He explained the need of synchrony between crop management practices and critical stages of cotton crop. He strongly opined that there is tremendous scope to improve the yield levels of the cotton in SAARC region which can be achieved through narrowing the window period of flowering and fruiting and high density planting. Dr. Tayan Raj Gurung, Senior Program Specialist, SAARC Agriculture Centre, Dhaka, Bangladesh explained the initiatives of SAARC Agriculture Centre and about Cotton program. He expressed his gratitude to Director General (ICAR), Director (CICR), Asian Cotton Research and Development Network (ACRDN) for Regional Consultation Meeting and ministries of the respective SAARC countries for nominating the participants. He opined that outcomes of the meeting in terms of policy and technology guidelines will have far reaching consequences.



Dr. C. D. Mayee, Former Chairman, ASRB, New Delhi and Chief Guest of the meeting in his inaugural address called for production and productivity technologies for the SAARC countries and suggested three strategies for lint productivity enhancement in SAARC countries *viz.*, a target cotton yield of 1000 kg per hectare, strong extension network for efficient technology transfer and better resource utilization. He also suggested SAARC countries to take advantage of network of ICAR institutes including CICR and All India Cotton Improvement Programme (AICCIP). The inaugural session was concluded with the vote of thanks proposed by Dr. Blaise Desouza, Head, Division of Crop Production, CICR, Nagpur. Country presentations on status of cotton, challenges and opportunities were made by Mr. Abdulrahimzai, Head of Industrial and Oil crops, Afghanistan; Dr. Farid Uddin, Executive Director, Cotton Development Board, Bangladesh; Mr. Chorten, Extension Officer of Bhutan; Dr. Venugopalan, CICR, India; Mr. Ghimire, Department of Agriculture, Nepal and Dr. Dil Baugh Mohammad, Principal Scientific Officer, Central Cotton Research Institute, Pakistan. Following the country presentations, four lead presentations on various aspects were made by Dr. Waghmare on cotton improvement, cotton production by Dr. Desouza, cotton protection by Dr. S. Kranthi and Ginning and post-harvest by Dr. Shukla of GTC. "Cotton Production in SAARC, Problems analysis & Way forward" was the major theme area for discussions followed by a Brainstorming session which was initiated by Dr. Gurung, SAARC. He stressed on the importance of this meeting to benefit the small cotton growing countries that do not have adequate resources to

conduct research. The session was facilitated by Dr. Desouza, Head, Crop Production and Fatema Nasrin of SAC, Dhaka during which the major challenges were prioritized. The common problems were considered as tackling the problem of bollworms, drought and salinity tolerance and the production constraints of high input use and cost of cultivation. An Action Plan was prepared by mutual consultation for the various issues. The major solution to enhancing production at a low cost of cultivation was taking up cultivation of early maturing varieties with high density planting systems. Also one of the suggestions made by Dr. Mayee, Former Chairman, ASRB was initiating a common SAARC cotton adaptive research trials. Dr. Gurung emphasized that the most suitable variety could then be released through SAARC and identified as of regional importance. India and Pakistan jointly agreed to share their production technologies with the cotton growing countries of SAARC. Furthermore, they also expressed to conduct in-country trainings. The participants also visited Ginning Training Centre, Nagpur, Bhagirath Mills and MGIRI, Wardha which was co-ordinated by Dr. Lokanathan, CICR. The programme concluded with the Valedictory session Chaired by Dr. P.B. Kale, Director, MGIRI, Wardha. Certificates were distributed to the participants by the Chief Guest, Dr. Kale. The programme was co-ordinated by Dr. Desouza, Head, Crop Production, CICR, Nagpur.

#### **24<sup>th</sup> Meeting of ICAR Regional Committee No.VII**

The 24<sup>th</sup> meeting of ICAR Regional Committee No.VII was held during September, 8-9 2016 at International Centre Goa, Goa under the Chairmanship of Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR, New Delhi.

Hon'ble Minister for Agriculture, Sports & Youth Affairs, Tribal Welfare and Animal Husbandry & Veterinary Services, Govt. of Goa, Shri Ramesh Tawadkar, inaugurated the 24<sup>th</sup> meeting of ICAR Regional Committee No.VII at International Centre Goa on 8<sup>th</sup> September 2016 in the presence of Shri Pandurang Pundalik Fundkar, Hon'ble Minister for Agriculture and Horticulture,



Government of Maharashtra and Shri Mahadev Jankar, Hon'ble Minister for Animal Husbandry & Dairy Development and Fisheries Development, Govt. of Maharashtra. The Inaugural session was Chaired by Dr. Trilochan Mohapatra, Secretary, DARE, GOI & Director-General, ICAR New Delhi. Dr. N.P. Singh, Director ICAR-CCARI, Goa welcomed the dignitaries on the dais and participants.

In his opening remarks, Dr. K. Alagusundaram, Dy Director General (Agril. Engg.) & Nodal Officer, ICAR Regional Committee VII briefed about the importance of the meeting and provided glimpse of landscape of the region No. VII and challenges faced by farmers.

Shri Chhabilendra Roul, Additional Secretary (DARE) & Secretary ICAR in his special address stressed the need to increase the productivity in agriculture and also to sustain the productivity. He called for increasing income of the farmers by reducing cost of production and increasing productivity to make agriculture profitable.

Chairman of the Regional Committee Dr. T. Mohapatra, Secretary, DARE, GOI and DG, ICAR, New Delhi in his address, briefed about the genesis of the regional committees. He explained that the regional committee meeting is an occasion where senior officials from central government and state government meet and arrive at solutions to the problems in agriculture and allied sectors. He also added that such meetings help scientists to reorient their research programmes to address immediate and futuristic problems expressed in the meeting.

He also briefed about the various schemes and programmes initiated by the central government during the last two years. He stressed on the target to double the income of the farmer in next five years. He added that even in consecutive two years of drought, India could feed its population and there was an export of surplus food grains. He lauded the states of the region for their achievements in agriculture and allied sector. He appreciated the leadership role of Maharashtra in sugarcane, cotton, grapes, onion and garlic, Chhattisgarh in rice production and Goa in fish production and horticulture and Madhya Pradesh in pulse production. This year being an *International Year of Pulses*, he urged that we should bring the imports to zero by increasing yield and production of pulses in the region. Extrapolation of the achievements of one state to other state of the region with similar agro climatic features is very much needed. He also suggested for diversification in agriculture, by integrating with animal husbandry, fisheries, horticulture to increase the farm income. Farmers in agriculture should get into gainful employment so that agriculture becomes a profitable venture. He also insisted for quality agriculture education and urged that agriculture universities to get accreditation and improve the standard of education.

Shri Pandurang Pundalik Fundkar, Hon'ble Minister for Agriculture and Horticulture, Government of Maharashtra complimented the DG, ICAR for conducting the regional committee in this region. He briefed about the climate, agro ecological and diversities of cropping pattern of Maharashtra and suggested for a discussion on effect of climate change on crop yield. He informed that, the Jalyukta Shivar Yojana has yielded good results and it is getting overwhelming response from farmers of Maharashtra. He also praised the central government schemes in agriculture and explained the strides made in the field of agriculture and horticulture sector by Maharashtra.

Shri Mahadev Jankar, Hon'ble Minister for Animal Husbandry & Dairy Development and Fisheries Development, Govt. of Maharashtra highlighted various schemes being promoted by Government

of Maharashtra for development of animal husbandry and fisheries.

In his presidential address, Shri Ramesh Tawadkar, Hon'ble Minister for Agriculture, Sports & Youth Affairs, Tribal Welfare and Animal Husbandry & Veterinary Services, Govt. of Goa stressed the need to double crop yields and increase the farm income. He suggested for the adoption of high-tech and protected agriculture by providing subsidy to the extent of 100%. Further he emphasized the various programs initiated by state government of Goa to attract youth to agriculture and animal husbandry. He also advised deliberations on technology transfer to farmers, agriculture education, dairy development and horticulture production of state Goa and the region in the technical sessions. He expressed his happiness for organizing this meeting in Goa as it

would facilitate agricultural officers in the state to discuss pressing issues faced by the state.

The programme was compered by Dr. M. V. Venugopalan, Principal Scientist, ICAR-CICR, Nagpur. Dr. K.R. Kranthi, Director, ICAR-Central Institute for Cotton Research, Nagpur and Member Secretary of the CAIR Regional Committee - VII proposed the vote of thanks.

The inaugural session was followed by technical session under the gracious presence of Shri Pandurang Pundalik Fundkar, Hon'ble Minister for Agriculture and Horticulture, Government of Maharashtra and Shri Mahadev Jankar, Hon'ble Minister for Animal Husbandry & Dairy Development and Fisheries Development, Govt. of Maharashtra and chaired by Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR



## 10.6: Participation of Scientists in Seminars/Symposia/Workshops/Meetings

Sr. No.	Seminars/Conferences/Symposia / Workshops/ Meetings	Place and Date	Participants
1.	AICRP Annual meeting	Surat 7-9 April 2016	K. R. Kranthi, S. Kranthi, D. Blaise, G. Balaubramani, M.V. Venugopalan, V.S. Nagrare, D. Monga, O.P. Tuteja, R.A. Meena, Rishi Kumar, S. K. Verma, A.H. Prakash, N. Gopalakrishnan, K. Rathinavel, S. Manickam, B. Dharajothi, K.P.M. Damayanthi, K. Sankaranarayanan, J. Gulsar Banu, S. Usha Rani, M. Sabesh, A. Manivannan, M. S. Yadav
2.	Launch of ICAR Biosafety Portal and Third Training Workshop for Institute Biosafety Officers (IBOs)	New Delhi, 13 April 2016	V. S. Nagrare
3.	Annual Group Meeting of AICRP - National Seed Project (crops)	Thrissur 19-21 April, 2016	K. Rathinavel
4.	World Cotton Research Conference-6	Goiânia, Brazil 2-6 May 2016	K.R. Kranthi, S. M. Palve, J.H. Meshram, P. Nalayini, S. Usha Rani
5.	State level steering committee meeting of CROPSAP	Pune 14-15 June 2016	V.S. Nagrare
6.	11 <sup>th</sup> Meeting of Expert Committee-National Innovations In Climate Resilient Agriculture	New Delhi 14-16 June 2016	M. V. Venugopalan
7.	Fourth training workshop on 'Confined Field Trial'	New Delhi, 5 July 2016	V. S. Nagrare
8.	Conference on Innovations in Agricultural Mechanization- Development of Linkage among R&D Institutes-Industry-Farmers	New Delhi, 7-8 July, 2016	G. Majumdar
9.	XI Annual Review Meeting of ICAR Seed Project	Pantnagar. 17-18 August, 2016	P. R. Vijayakumari
10.	Regional Consultation Meeting on "SAARC Regional Coordinated Cotton Technology Exchange Program	ICAR-CICR, Nagpur 29 August, 2016	K.R. Kranthi, S. Kranthi, D. Blaise, V. N. Waghmare, M.V. Venugopalan, S.B. Nandeshwar
11.	International training workshop on Comparative Studies in Regenerative Food Systems in India	Dharamitra, Wardha 31 August, 2016	M.V. Venugopalan
12.	Regional Committee Members Meeting of BCI, India	New Delhi 2 September, 2016	M.V. Venugopalan



Sr. No.	Seminars/Conferences/Symposia / Workshops/ Meetings	Place and Date	Participants
13.	24 <sup>th</sup> Meeting of ICAR Regional Committee No. VII	Goa, 8-9 September 2016	K.R. Kranthi, V.N. Waghmare, M.V. Venugopalan, G. Balasubramani, K. P. Raghavendra
14.	National Symposium on Agrarian Crisis in Vidarbha - Challenges and Options	Nagpur. 18 September, 2016	V.N. Waghmare, S.S. Mahajan, S.M. Wasnik, V.S. Nagrare, D.T. Nagrale
15.	4 <sup>th</sup> Annual South Asia Biosafety Conference	Hyderabad, 19-21 September, 2016	V.S. Nagrare
16.	Fifth Training Workshop for IBOs	Hyderabad 22 September, 2016	V.S. Nagrare
17.	Seminar on Development in Soil Science: Climate change and its influence on NRM	Dapoli 22-23 September, 2016	M.V. Venugopalan
18.	POCRA Workshop	Pune 3-4 Oct. 2016	D. Blaise, R.B. Singandhupe
19.	Global Cotton & Textiles Teams Meeting	New Delhi 19 October, 2016	M. V. Venugopalan
20.	International Agro - Biodiversity Conference 2016	New Delhi 6-7 November, 2016	V.N. Waghmare, Punit Mohan, J. H. Meshram, R.A. Meena, D. Monga S. Manickam
21.	International Conference - Integrated Land Use Planning for Smart Agriculture. -An Agenda for Sustainable Land Management	NBSS&LUP, Nagpur 10 -13 November, 2016	M. V. Venugopalan
22.	'Agro - Vision' - National Agricultural Exhibition for farmers of Central India	Nagpur, 12-13 November, 2016	D. V. Patil
23.	4 <sup>th</sup> International Agronomy Congress- Agronomy for Sustainable Management of Natural Resources, Environment, Energy and Livelihood Security to Achieve Zero Hunger Challenge	New Delhi, 22-26 November, 2016	D. Blaise, K. Sankaranarayanan, G. I. Ramkrushna
24.	Development of Roadmap for Organic Farming Sector in Madhya Pradesh	Bhopal, 25 November, 2016	D. Blaise

Sr. No.	Seminars/Conferences/Symposia / Workshops/ Meetings	Place and Date	Participants
25.	National workshop on indigenous cotton	Nagpur, 28 November 2016	K. R. Kranthi, V.N. Waghmare, S. Kranthi, D. Blaise, M.V. Venugopalan, V.S. Nagrare, D. T. Nagrale
26.	Innovative and current advances in agriculture and allied sciences (ICAAAS-2016)	Hyderabad 10-11 December, 2016	H. B. Santosh, Savitha Santosh
27.	National Symposium on 'Climate smart agriculture for nematode management'	Goa, 11-13 January, 2017	Nandini Gokte Narkhedkar
28.	Meeting of the Hindi Parliamentary Committee	Coimbatore, 12 January, 2017	V .N. Waghmare
29.	Revival of Desi cotton	Nanded, 16 January, 2017	D. Blaise
30.	Workshop on KRISHI( Knowledge based Resources Information System Hubs for Innovations in Agriculture)	New Delhi 24-25 January, 2017	Rishi Kumar
31.	XIV National Seed Seminar Food Security through augmented seed supply under climate uncertainties	IARI, New Delhi 28-30 January, 2017	V. Santhy
32.	Meeting to discuss Draft Note on "Best Global Practices for a Sustainable Cotton Roadmap in India"	Mumbai 02 February, 2017	K.R. Kranthi, D. Blaise M.V. Venugopalan
33.	Meeting on finalization of report on Best Practices for sustainable cotton roadmap in India-Min of Textiles, GOI	Mumbai, 09 February, 2017	K.R. Kranthi, D. Blaise, M.V. Venugopalan
34.	Brainstorming Session as a part of Platinum Jubilee Celebrations of ISG&PB	New Delhi 11 February, 2017	V.N. Waghmare
35.	International conference on Emerging areas of Environmental Science and Engineering"	Hisar 16-18 February, 2017	S. K. Verma
36.	Regional Workshop on "Skill Development in Agriculture-Kaushal Vikas se Krishi Vikas"	Hyderabad 20 February, 2017	S.M. Wasnik
37.	Inter Drought-V	Hyderabad, 21- 25Feb, 2017	J.H. Meshram

Sr. No.	Seminars/Conferences/Symposia / Workshops/ Meetings	Place and Date	Participants
38.	XIII Indian Agricultural Science Congress	Bengaluru, 21-24 February, 2017	T.R. Loknathan, S.M. Palve, H.B. Santosh
39.	BCI - Maharashtra and MP stakeholder	Amravati, 23 February, 2017	M.V. Venugopalan
40.	Meeting to discuss guidelines for approval of Bt cotton varieties containing deregulated events	New Delhi 20 March, 2017	M.V. Venugopalan
41.	Meeting to discuss Phase II of TMC	New Delhi, 22 March, 2017	D. Blaise

### 10.7: Distinguished Visitors

Name & Designation	Organisation	Date
<b>Nagpur</b>		
Shri Nitin Gadkari, Union Minister for Road Transport, Highways & Shipping	Ministry for Road Transport, Highways & Shipping, GOI, New Delhi	16.04.2016
Shri Krupal Balaji Tumane, Member of Parliament	Ramtek constituency	16.04.2016
Dr. Trilochan Mohapatra, Secretary DARE & Director General (ICAR)	ICAR, New Delhi	27.10.2016 09.03.2017
<b>Coimbatore</b>		
Dr. R.K. Singh, ADG (CC)	ICAR, New Delhi	07.09.2016
Dr. J. S. Chauhan, ADG (Seeds)	ICAR, New Delhi	20.10.2016
Dr. Trilochan Mohapatra, Secretary, DARE & Director General (ICAR)	ICAR, New Delhi	10.11.2016
<b>Sirsa</b>		
Dr. R. K. Singh, ADG (CC)	ICAR, New Delhi	17.08.2016
Dr J. S. Sandhu , DDG(CS)	ICAR, New Delhi	23.10.2016



## 10.8 : Personnel

### Director

**K R Kranthi**, Director, krkranthi@gmail.com (VRS on 15.03.2017)

**MS Ladaniya**, Director (Additional Charge) (from 16.03.2017)

### Project Coordinator (Cotton)

#### Coimbatore

**A.H. Prakash**, I/c P.C. (Cotton) & Head, prakashcicr@gmail.com

#### Biotechnology

##### Nagpur

**G Balasubramani**, Principal Scientist, bala77bio@gmail.com

**Smt. J Amudha**, Principal Scientist, jamudhacicr@gmail.com

**K P Raghavendra**, Scientist, kpraghavendra@gmail.com

**Joy Das**, Scientist, uasjoy@gmail.com

**Rakesh Kumar**, Scientist, rakesh.goswami12@gmail.com

#### Genetics & Plant Breeding

##### Nagpur

**V N Waghmare**, Head & Principal Scientist, vijayvnm@yahoo.com

**Smt. S. B. Singh**, Principal Scientist, sumanbalasingh2009@gmail.com

**T R Loknathan**, Principal Scientist, loknathantr14@gmail.com

**S B Nandeshwar**, Principal Scientist, sbn3@rediffmail.com, sbn5855@gmail.com

**Smt. Vinita Gotmare**, Principal Scientist, vinitag22@gmail.com

**S M Palve**, Principal Scientist, smpalve2kl@yahoo.com

**D V Patil**, Senior Scientist, dvpatil1962@gmail.com

**M Saravanan**, Scientist, msaraniari@gmail.com

**H B Santosh**, Scientist, santoshgpb@gmail.com

#### Coimbatore

**S Manickam**, Principal Scientist, manickam.cicr@gmail.com

**Smt. K.P.M Damayanthi**, Principal Scientist, dhamayanthikpm@yahoo.com

**Manivannan A**, Scientist, manivannan461@gmail.com

#### Sirsa

**S L Ahuja**, Principal Scientist, slahuja2002@yahoo.com

**O P Tuteja**, Principal Scientist, optuteja2001@yahoo.co.in

**S K Verma**, Principal Scientist, surenderkumar64@yahoo.co.in

#### Seed Technology

##### Nagpur

**Smt. P R Vijayakumari**, Principal Scientist, rachelvk123@gmail.com

**Smt. V Santhy**, Principal Scientist, santhy100@gmail.com

**S S Mahajan**, Senior Scientist, mahsunil@gmail.com

#### Coimbatore

**K Rathniveel**, Principal Scientist, krathniveel@gmail.com

#### Sirsa

**R A Meena**, Principal Scientist, rameenacotton@rediffmail.com

#### Economic Botany

##### Nagpur

**Punit Mohan**, Principal Scientist, punitmohan@gmail.com

#### Agronomy

##### Nagpur

**Blaise Desouza**, Acting Head, Crop Production, blaise\_123@rediffmail.com

**M V Venugopalan**, Principal Scientist, mvvenugopalan@gmail.com

**A R Raju**, Principal Scientist, bumaraju@gmail.com

**Ramkrushna G I**, Scientist (joined on 30.06.2016), rgidu@yahoo.co.in

#### Coimbatore

**K Sankaranarayanan**, Principal Scientist, sankaragro@gmail.com

**Smt. P Nalayani**, Principal Scientist, nalayiniganesh@gmail.com

**R Raja**, Senior Scientist, rajatnau@gmail.com

#### Soil Science

##### Nagpur

**A Manikandan**, Scientist, poonamani223@gmail.com

#### Coimbatore

**Smt. D Kanjana**, Scientist, kanjana16@rediffmail.com

#### Farm Machinery & Power

**G Majumdar**, Scientist, gama62@rediffmail.com

#### Plant Pathology

##### Nagpur

**A Sampath Kumar**, Scientist, sampath\_a@rediffmail.com (on study leave)

**S P Gawande**, Scientist, spgawande1@gmail.com

**D T Nagarale**, Scientist, dip29unique@gmail.com

**Neelakanth Hiremani**, Scientist (joined on 11.04.2016), nhneelmani@gmail.com

#### Sirsa

**Dilip Monga**, Head of Station, dmonga2009@gmail.com

**Satish Kumar Sain**, Senior Scientist, sain.skumar@gmail.com

#### Entomology

##### Nagpur

**Smt. Sandhya Kranthi**, Acting Head, Crop Protection, sandhya.kranthi@gmail.com

**V S Nagrare**, Principal Scientist, vs.nagrare@gmail.com

**Chinna Babu Naik V**, Scientist, chinnaenton@gmail.com

**Prabhulinga Tenguri**, Scientist, prabhut07@gmail.com

**Madhu TN**, Scientist (joined on 11.04.2016), madhuentomology@gmail.com

**Shah Vivek Hanskumar**, Scientist (joined on 11.04.2016), vivek4256@gmail.com

**Smt. Rachna Pande**, Scientist (joined on 30.06.2016), rachna.ento@gmail.com

#### Coimbatore

**Smt. B Dhara Jothi**, Principal Scientist, dhara56@yahoo.co.in

**Smt. M Amutha**, Sr. Scientist, amuento@yahoo.co.in

**K Shankarganesh**, Scientist (joined on 02.05.2016), shankarento@gmail.com

**K Rameash**, Senior Scientist (joined on 09.06.2016), krameash@gmail.com

#### Sirsa

**Rishi Kumar**, Principal Scientist, rishipareek70@yahoo.co.in

#### Nematology

##### Nagpur

**Smt. Nandini Narkhedkar**, Principal Scientist, nnarkhedkar@rediffmail.com

#### Coimbatore

**Smt. J Gulsar Banu**, Principal Scientist, gulsarsci@gmail.com

#### Plant Physiology

##### Nagpur

**J H Meshram**, Senior Scientist, j.h.meshram@gmail.com

#### Coimbatore

**S E S A Khader**, Principal Scientist (Retired on 31.05.2016)

**J Annie Sheeba**, Scientist, anniephysiology@gmail.com

#### Biochemistry (PS)

##### Nagpur

**Ms Pooja Verma**, Scientist, poojaverma1906@gmail.com

#### Coimbatore

**N Gopalakrishnan**, Principal Scientist, gopal55@rediffmail.com

#### Microbiology (PS)

##### Nagpur

**K Velmourougane**, Scientist, velicar@gmail.com (on study leave)

**Smt. Savitha Santosh**, Scientist, abdhi2050@gmail.com

#### Live Stock Management

**S N Rokde**, Principal Scientist, sunilrokde\_2007@rediffmail.com (LMP) (Relieved on 31.03.2017)

#### Agriculture Extension

##### Nagpur

**S M Wasnik**, Principal Scientist, wasniksm2012@gmail.com

#### Coimbatore

**Usha Rani**, Principal Scientist, ushajoshua@rediffmail.com

**C Karpagam**, Senior Scientist, karpiscar@gmail.com

#### Agricultural Economics

##### Nagpur

**Smt. Anuradha Narala**, Scientist, anuradhanarala@gmail.com

#### Coimbatore

**Smt. Isabella Agarwal**, Principal Scientist, is\_agarwal@rediffmail.com

#### Computer Applications

##### Coimbatore

**M Sabesh**, Scientist, sabesh23@gmail.com

#### KVK

##### Nagpur

**R B Singhandhupe**, Principal Scientist, rbsingandhupe@gmail.com

#### PME Cell

**M S Yadav**, Nodal Officer, cicrcmunit@yahoo.co.in (retired on 30.11.2016)

#### Administration

**Sachin Agnihotri**, SAO, sach\_agni123@rediffmail.com

**G C Prasad**, SFAO, finance.cicr@gmail.com

## 10.9 : Other Information

### Library

In the period from 2016-17, the Library purchased 122 new books and 46 Hindi books. The Library subscribed to 11 Foreign Journals and 17 Indian Journals.

### Documentation Services

- Library has developed computerized bibliographic database on Cotton to provide comprehensive and updated information on cotton. About 4775 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 (V30, (No. 1-4), January - December 2016) 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 library 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-OPACLink <http://10.0.0.52/w20/>

### Progressive Use of Hindi

**हिन्दी प्रशिक्षण योजना** : मई-2016 के प्रबोध, प्रवीण, प्राज्ञ तथा पारंगत परीक्षा के लिए संस्थान में ही हिन्दी प्रशिक्षण योजना के अंतर्गत पाठ्यक्रम की कार्यशाला आयोजित की गई। इसके अंतर्गत प्रवीण में 1, प्रबोध में 1, प्राज्ञ में 6 तथा पारंगत में 34 कर्मचारियों ने सफलता प्राप्त की।

**नगर राजभाषा कार्यान्वयन समिति की ओर से प्राप्त पुरस्कार** : केन्द्रीय कपास अनुसंधान संस्थान को नगर राजभाषा कार्यान्वयन समिति, नागपुर कार्यालय-2 के अंतर्गत 22 जून, 2016 को उत्कृष्ट कार्यालय कार्यान्वयन प्रथम पुरस्कार तथा संस्थान द्वारा प्रकाशित गृह पत्रिका 'श्वेत स्वर्णिमा' को विशेष प्रोत्साहन पुरस्कार दिया गया।

**हिन्दी पखवाड़ा** : साल 2016-17 में 14 सितंबर, 2016 में संस्थान में हिन्दी दिवस तथा हिन्दी पखवाड़ा का आयोजन किया गया। 14 सितंबर से 1 अक्टूबर के अंतर्गत विभिन्न प्रतियोगिताएं आयोजित की गईं। 1 अक्टूबर, 2016 को पखवाड़े का समापन समारोह किया गया। इस समारोह में आर.के.दास, सचिव, नगर राजभाषा कार्यान्वयन समिति-2, मुख्य अतिथि रूप में तथा डा. केशव राज क्रांति, प्रमुख अतिथि के रूप में उपस्थित थे। विजेताओं को अतिथियों द्वारा संस्थान की ओर से निर्धारित धनराशी एवं स्मृतिचिन्ह प्रदान किए गए।

**राजभाषा कार्यान्वयन समिति की बैठकों का आयोजन** : राजभाषा के प्रगामी प्रयोग तथा प्रसार के लिए इस बैठक का आयोजन हर तिमाही के समापन के पूर्व किया जाता है। इस के अंतर्गत कार्यवृत्त सूचना अनुपालन तथा आवश्यक कार्रवाई हेतु विभाग प्रमुख तथा सभी विभागों को दिया जाता है।

**ई-साप्ताहिक परामर्शी किसानों के लिए** : इस ई-साप्ताहिक परामर्शी में हर सप्ताह किसान भाइयों को सलाह तथा मार्गदर्शन किया जाता है। यह परामर्शी ऑन लाईन प्रणाली द्वारा प्रकाशित की जाती है।

### ICAR - CICR - KVK, Nagpur Organizes Pradhan Mantri 'Fasal Bima Yojana': Farmers Awareness Programme

ICAR- Central Institute for Cotton Research (CICR), Krishi Vigyan Kendra, Nagpur launched 'Pradhan Mantri Fasal Bima Yojana' (PMFBY) farmers awareness programme during a farmers' meet organized on 16.04.2016 at CICR, Nagpur. Hon'ble Union Minister for Road Transport, Highways & Shipping Shri Nitin Gadkari ji inaugurated the programme while Sh. Krupal

Balaji Tumane, Member of Parliament, Ramtek constituency was the guests of honour. Shri Nitin Gadkari ji also inaugurated an AgriExhibition on technologies and varieties developed by various agricultural institutions and ICAR-CICR, Nagpur. ICAR Institutes, i.e. ICAR-CCRI, ICAR-NBSS & LUP, GTC (ICAR-CIRCOT), Animal and Fisheries Science University (MAFSU) & Agriculture Department participated in the Agri-exhibition.



Chief Guest Shri Nitin Gadkari ji informed the audience about the various schemes of Govt of India for the benefits of the farmers and added that there is a budgetary provision of Rs. 9 lakh crore for crop loans. He specially mentioned the benefits of soil health analysis in crop productivity. He also advocated the need of making check dams at village level which will give quantum jump to crop

productivity. Sh. Krupalji Tumane spoke about benefits of new crop insurance scheme and asked the farmers to take advantage of this new crop insurance scheme. Earlier, Dr. K.R. Kranthi, Director, ICARCICR in his welcome address apprised about various technologies developed by CICR. Inaugural session was followed by technical session in which farmers - scientist's interaction was held. Sh. Ramesh Rajurkar, Branch Manager,



Universal Sampko General Insurance Com. Ltd. explained in detail about PMFBY. Dr. Y.S. Jumde, TAO, Dept. of Agriculture, Nagpur gave information about different agriculture related schemes being operated in Nagpur division. More than 500 farmers participated in day long programme.

**Swachh Bharat Abhiyan**

**Nagpur**

ICAR-CICR Nagpur joins hands for 'SWACHH BHARAT ABHIYAN'. The employees took pledge on 'Swachhta Shapath' on 2<sup>nd</sup> October 2016 on the



auspicious day 'Mahatma Gandhi's Jayanti'. Thereafter voluntary cleaning was done by all employees outside of office building. The Director urged to every employee to make this Abhiyan a great success.



## Coimbatore

As per the directives of Hon'ble Union Minister for Agriculture & Farmer's Welfare Special 'Swachhta Pakwara' was celebrated during May 16-31, 2016 at Central Institute for Cotton Research, Regional Station, Coimbatore. As a part of this celebration and to create awareness among the staff members the implementation committee under the chairmanship of Dr. K. Rathinavel, Principal Scientist, an easy writing competition in vernacular language was organized on 23/05/2016 on the title "Clean India 2025-contribution of Individual citizens". Three scientists and eight technical staff participated. Under the chairmanship of Dr. N. Gopalakrishnan, I/C Project Coordinator Elocution competition was conducted on 24/05/2016. Six staff members enthusiastically spoke on "Environmental pollution-causes and remedies". Dr. S. Manickam and Dr. K. Rathinavel Principal Scientists acted as jury

## Sirsa

Under "Swachh Bharat Mission" was initiated on 2 October 2016, Mahatma Gandhi's 147<sup>th</sup> birth anniversary. On this occasion the "Cleanliness Oath" (Swachhta Shapath) was administered by Dr. Dilip Monga, Head CICR Regional Station to all the staff members. The activities were discussed and planned for the "Swachhta Abhiyan" including cleaning within and around the CICR campus, farmers awareness towards clean and green agriculture in MGMG, promotion of clean and green technologies, weed management for

cotton pest management, promoting compost making, whitewashing of the gate and boundary walls, plantation of new tree etc.

The "Swachhta Pakhawara" beginning on 16 to 31 October 2016 was celebrated by CICR Regional Station, Sirsa. All officials and staff member came forward and joined this mass movement of Swachhta Pakhawara activities at CICR-RS campus, surrounding areas and in MGMG villages under the leadership of Dr. D. Monga, Head.

## "Maha Agro 2016" Exhibition

ICAR-CICR coordinated ICAR stall during 4-day long State-level Agriculture Exhibition "Maha Agro 2016" held from 24-27 December, 2016 at Ayodhya Nagari Ground, Station Road, Aurangabad, Maharashtra. The event was organized by Marathwada Sheti Sahayya Mandal (MSSM) in Association with Maharashtra Chamber of Commerce, Industry and Agriculture (MACCIA), Agriculture Department of Central and State Governments. CICR Nagpur displayed the cotton technologies like color cotton, Bt express kit, e-Kapas, management of cotton reddening and the farm implements developed by the institute. More than 20,000 farmers and other stake holders visited the ICAR - CICR stalls from Marathwada region and other parts. During the event, more than 1,000 farmers registered for CICR 'e-Kapas' dissemination. Hon'ble Minister Shri Radha Mohan Singhji, Union Minister for Agriculture and Farmers Welfare, GoI attended the exhibition on the concluding ceremony on 27 December along with other leaders. Dr S. M. Wasnik, Principal Scientist; Extension, CICR, Nagpur coordinated the activities. Other team members included Dr Vivek Shah, Sh. Bhuneshwar Fande & Sh Ratnadeep Ramteke.

## International Yoga Day

### Nagpur

ICAR-Central Institute for Cotton Research (CICR), Nagpur celebrated 'International Yoga Day' on 21 June, 2016 at Community Hall, ICAR residential complex (Krishi Kunj), Bajaj Nagar, Nagpur. Dr. K. R. Kranthi, Director, ICAR-CICR chaired the session. Dr. S. Kranthi, Head of





Department (Crop Protection) welcomed yoga experts, all the staff of CICR and family members of the staff. Dr. K.R. Kranthi mentioned the importance of yoga and asked all staff to continue to practice every day. Dr. Vithalrao Jibhakate, Yogacharya and Mrs. Meenatai Deshmukh demonstrated and conducted various yoga asanas. Mr. Sachin Agnihotri, Senior Administrative Officer proposed vote of thanks. Mr. M. V. Dhande and Mr. Rajnikant Chaturvedi coordinated the programme.

#### Sirsa

International yoga day celebrations were also organised at the regional station, Sirsa on 21 June 2016. Shri Suresh Tayal, Yoga expert carried out a yoga session of two hours and demonstrated Pranayam, Yog Asanas and Accupressure techniques to the participants. All the staff members including TSL and contractual staff participated in the event. On this occasion he also talked about the importance of yoga in uniting the body, mind and soul and also elaborated on the cure of various diseases.



#### Visit of Secretary, DARE & Director General, ICAR

Dr Trilochan Mohapatra, Secretary, DARE & Director General, ICAR visited ICAR-CICR, Nagpur on 27<sup>th</sup> October 2016 and inaugurated Farmers Training Hostel of KVK, CICR, Nagpur. Director CICR felicitated Hon'ble Director General on the occasion.



On the occasion CICR research activities were showcased and explained to Hon DG. He was taken to polyhouses, wild germplasm conservatory, experimental fields, and laboratories. He discussed various research activities with individual scientists. Addressing to all the staff members Hon DG urged for proper maintenance of the campus, generation of 20% revenue, implementation of Govt. schemes like MGMG in right spirit, development of mobile app in local languages. He urged everybody to cultivate and promote science. He emphasized capitalizing strength and helping farmers to minimize the sorrow. He advocated the feeling of working for the country. Earlier,



### Dr T Mohapatra Secretary, DARE and DG, ICAR visit to ICAR-CICR, Nagpur:

Dr Trilochan Mohapatra, Secretary, DARE and Director General, ICAR visited ICAR- Central Institute for Cotton Research, Nagpur on 9<sup>th</sup> March 2017. All the scientists of the ICAR institutes (CICR, CCRI, NBSS & LUP and GTC of CIRCOT) located in Nagpur attended the interactive meeting with Director General. Prior to the meeting the Cotton harvester with pre cleaner developed recently was demonstrated. The DG complimented the Director Dr K R Kranthi and the engineer Er. Majumdar for developing the cotton picker.



During his interaction with the scientists he appreciated the research achievements of the ICAR institutes. He however urged all Directors of Nagpur based ICAR institutes to have focused research program to bring novel technologies to solve the problems faced by the farmers of Vidarbha. He opined that good work and research publications need to be concentrated to assess the output of any research based institution.



Further, he congratulated Dr Kranthi for his

outstanding contributions notably the Bt cotton testing kits, insecticide resistance management techniques and HDPS technology. He honored Dr Kranthi for his selection as Head, Technical Information Section, ICAC, and Washington DC, USA.



### Farewell to Dr. K. R. Kranthi, Director ICAR-CICR, Nagpur:

Dr. K.R. Kranthi, Director, ICAR-CICR, was given warm farewell by all the staff members of ICAR-CICR, former directors of CICR, Dr A.K. Basu, Dr. M.S. Kairon, Dr. N.D. Mannikar, Dr. K.D. Koranne, Dr. P. Singh, Dr Sheo Raj and various cotton stackholders on 15<sup>th</sup> March 2017. Initially Dr. Kranthi presented his life time research achievements and his contribution to cotton science. He joined ICAR-CICR, Nagpur in 1991 and served the institute in different capabilities including as Head, Division of Crop Protection and entries Director from May 2008 to March 2017. He has been honored with many awards for his hard work and dedication. He created research facilities and inspired many young scientists with his vision and incredible job on research. Dr. Kranthi was congratulated by all the former directors on his selection as Head, Technical Information Section, ICAC, and Washington DC, USA and they blessed him to achieve more heights and revolutionize cotton world.



## 10.10: Weather

### Nagpur

Month	Temperature (°C)		Relative Humidity (%)		Rain fall (mm)	No. of Rainy Days
	Max	Min	Max	Min		
June, 2016	37.96	27.58	67.78	49.90	126	7
July, 2016	30.39	24.34	86.89	78.63	424	23
August, 2016	31.03	24.41	85.86	71.38	92	7
September, 2016	31.95	24.14	84.51	63.17	92	10
October, 2016	32.22	22.57	81.29	48.77	47	4
November, 2016	30.60	12.01	78.14	35.62	0	0
December, 2016	29.07	9.76	63.40	31.82	0	0
January, 2017	29.09	10.32	79.35	39.94	0	0
February, 2017	33.21	13.91	60.81	32.67	0	0
<b>Total</b>					<b>781</b>	<b>51</b>

### Coimbatore

Month	Temperature (°C)		Relative Humidity (%)	Rain fall (mm)
	Max	Min		
July, 2016	31.1	23.7	67.0	21.5
Aug. 2016	32.3	23.0	66.9	5.0
Sept. 2016	32.4	22.9	68.0	4.5
Oct. 2016	32.5	22.2	69.5	22.0
Nov. 2016	31.4	22.1	67.0	71.5
Dec. 2016	30.0	21.2	67.8	28.0
Jan. 2017	31.3	20.1	55.7	7.0
Feb. 2017	32.5	19.8	51.6	20.5
<b>Total</b>				<b>180</b>

### Sirsa

Month	Temperature (°C)		Rain Fall (mm)	Rainy days
	Maximum	Minimum		
April 2016	38.8	20.7	0.0	0
May 2016	41.7	25.8	0.0	0
June 2016	40.9	28.5	13.6	2
July 2016	36.7	27.5	133.4	4
August 2016	34.9	27.5	85.2	1
September 2016	36.5	24.0	0.0	0
October 2016	35.8	12.0	0.0	0
November 2016	32.8	7.2	0.0	0
<b>Total Rainfall</b>			<b>232.2</b>	<b>7</b>

### 10.11 : Cotton Scenario

#### State-Wise Cotton Area, Production and Productivity

Zone/State	2015-2016		
	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)
Punjab	3.39	7.50	376
Haryana	6.03	15.00	423
Rajasthan	4.48	15.00	569
<b>North Zone</b>	<b>13.90</b>	<b>37.50</b>	<b>459</b>
Gujarat	27.19	94.00	588
Maharashtra	38.27	75.00	333
Madhya Pradesh	5.47	18.00	559
<b>Central Zone</b>	<b>70.93</b>	<b>187.00</b>	<b>448</b>
Telangana	17.78	59.50	569
Andhra Pradesh	6.66	24.00	613
Karnataka	6.33	20.00	537
Tamil Nadu	1.42	5.00	599
<b>South Zone</b>	<b>32.19</b>	<b>108.50</b>	<b>573</b>
Others	1.75	5.00	486
<b>Grand Total</b>	<b>118.77</b>	<b>338.00</b>	<b>484</b>

1 bale= 170 kg.

Source : Cotton Advisory Board, Ministry of Textile, Govt. of India by CAB in its meeting held on 24.10.2016





भा.कृ.अनु.प.-केन्द्रीय कपास अनुसंधान संस्थान, नागपुर  
ICAR-CENTRAL INSTITUTE FOR COTTON RESEARCH

Post Bag No. 2, Shankar Nagar PO, Nagpur - 440 010 (M.S.)

Tel: 07103-275536 Fax: 07103-275529 Email: [cicrnagpur@gmail.com](mailto:cicrnagpur@gmail.com) website: [www.cicr.org.in](http://www.cicr.org.in)

