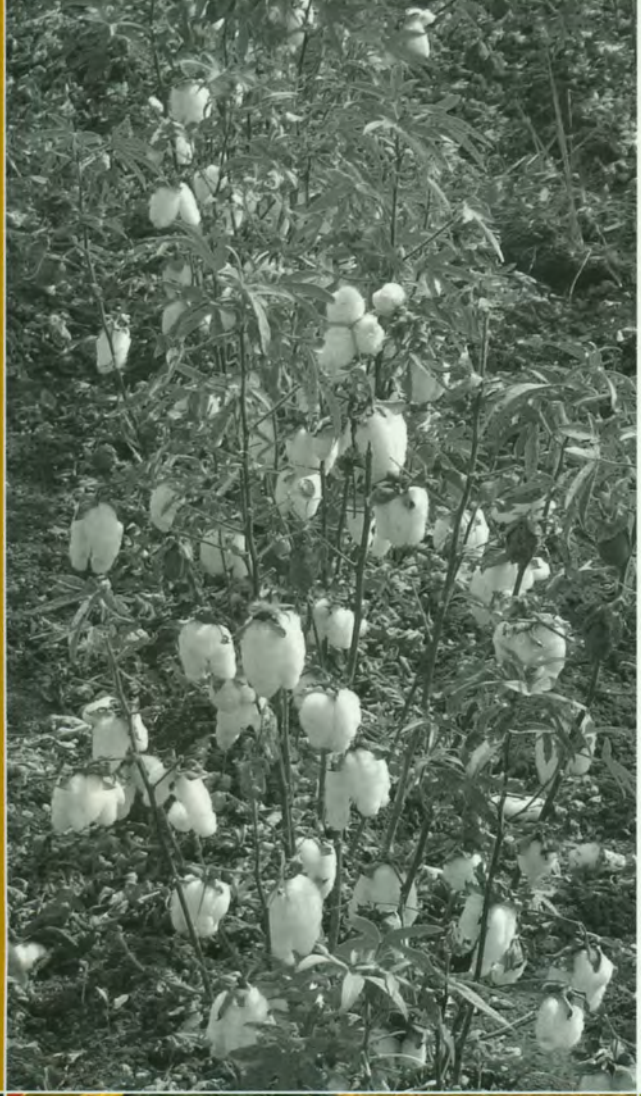

Annual Report
2015-16

भाकृअनुप
ICAR

CENTRAL INSTITUTE FOR
COTTON
RESEARCH, NAGPUR

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ICAR

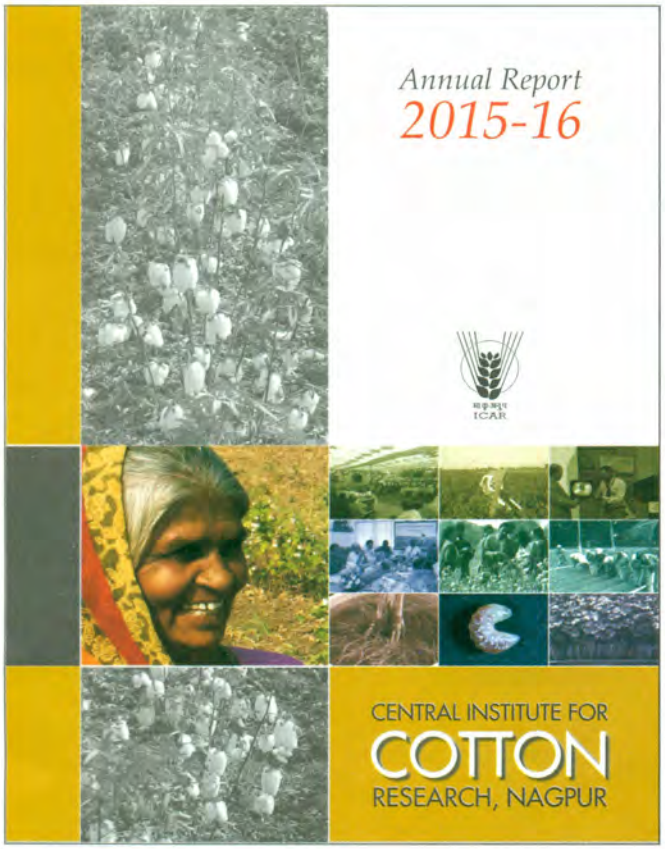
वार्षिक प्रतिवेदन

ANNUAL REPORT

2015-16

भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर

ICAR- CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR



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PREFACE

The year 2015-16 was productive on many counts from R&D perspective. The institute developed several exciting technologies, machinery, cotton varieties, cropping systems, new genes and new concepts. A small scale tractor mounted cotton picking prototype was developed in collaboration with ICAR-CIRCOT and Mahindra Pvt Ltd. The prototype machine was found to be promising. A simple hand held low cost device for instantaneous (10 seconds) detection of nitrogen deficiency in cotton leaves. The device instantaneously provides voice based recommendation of ameliorative measures in vernacular language based on diagnosis. Genotyping data for 2730 SNPs, mapped on 29 linkage groups, were used for QTL mapping. Ten QTLs were identified for staple length, tenacity and micronaire. Marker assisted breeding (MAB) for Bacterial Leaf Blight (BLB) Resistant Suraj using CIR 246 is in the Back-cross-2 (BC-2) stage. SSR markers BNL 3279 and NAU 2152 are being used (BC-1) in MAB for nematode resistance. More than 3000 germplasm accessions were evaluated and several new lines were identified for tolerance to drought, waterlogging, cotton leaf curl virus, whiteflies and leaf hoppers. Cry1Ac based Bt-cotton event Tg2E-13 event was obtained from Delhi University (DU) and first crosses were made with elite varieties. Gossypol detoxifying gene *cyp6ae14* was subcloned in to bacterial expression vector pET28c. Ten genes, ethylene-responsive element binding factor (ERF) 1, 2, 3. Trehalose-6-phosphate synthase (TPS) 1,2,3 Alpha pinene, Lipoxygense 1, Allene oxide synthase 6 and Methyl jasmonate transferase were characterized using real-time (RT) PCR to elucidate their role in systemic acquired resistance in cotton. Inter-specific variation in volatile emission in 3 species of *Gossypium* in response to leaf hopper, caterpillar and mechanical damage was investigated. Pink bollworm infested cotton flowers were found to have higher levels of β Caryophyllene, methyl ester of pentadecanoic acid and linolenic acid, which are precursors of jasmonic. Out of the Bioassays pink bollworm populations of 39 districts, evaluated for resistance to Bt-cotton, populations in 15 districts were confirmed to have developed resistance to Bollgard-II (Cry1Ac+Cry2Ab); 20 populations were resistant to Bollgard (Cry1Ac) and 18 populations were resistant to Cry2Ab. Under high density planting systems, LRK 516, Suraj JT, CNH 1111, CSH 3075, CNH 09-4, CSH 3075, AKA 8, RG-540, CNA375, Phule Dhanwantary, CNA 418, MDLABB and CISA 6 were found to most promising.

Twenty legumes were evaluated as intercrops for compatibility and N fixation. Cluster bean, soybean and groundnut and cowpea were found to enhance benefits of yield and nitrogen fixation. Structured water irrigated plots had higher cotton yield than the bore well irrigated plots. Cotton seedlings raised in paper tube rolls when transplanted in the field established quickly and yielded more than the direct sown cotton.

Last year, two major factors affected yields negatively. Whitefly outbreaks in Punjab and the pink bollworm resistance to Bt-cotton in Gujarat, Karnataka, AP, MP and parts of Maharashtra emerged as serious problems that needed attention. The institute played a stellar role to assist stakeholders in combating the crisis efficiently. Bt-cotton hybrids that were tolerant to whiteflies and the leaf curl virus were identified and the list provided to the concerned Government departments. Regular weekly advisories in 8 languages were issued on the institute web-site to assist farmers throughout the season. Under a programme called E-Kapas, regular voice mail weekly advisories were sent to more than 225,000 registered farmers in eight

vernacular languages. Situation was under control wherever the advisories were implemented.

As a research institute the ICAR-CICR has been working hard to identify best practices across the globe, that can be adapted for India and adopted to enhance yields. Additionally, focus has been on indigenous native species such as *Gossypium arboreum* in efforts to establish sustainable low cost high yielding cotton production systems for India. With the natural robustness of *Desi* species where there is tolerance to insects, diseases and drought, development of new premium fibre varieties with 30 mm fibre length makes them precious. The institute will be coordinating multi-location trials of eight *Desi* varieties (*Gossypium arboreum*) with long staple fibre varieties, during 2016-17 at 15 locations across the country. The premium fibre *Desi* varieties suitable for spinnable purpose will have a special place in north India where American cotton hybrids were found to be highly susceptible to the cotton leaf curl virus in stark contrast to the *Desi* cotton varieties which are immune to the virus.

Scientists of the institute spearheaded the 'Mera Gaon Mera Gaurav' in 65 villages. Soil health cards were distributed in the villages and remedial measures were taken up. Five hundred tribal families were adopted by the institute under Tribal Sub Plan.

I am grateful to Dr T. Mohapatra, Secretary, DARE & DG, ICAR; Dr S. Ayyappan, former Secretary, DARE & DG, ICAR; Dr J. S. Sandhu, DDG (CS); Dr N Gopalakrishnan, former ADG (CC) and Dr R. K. Singh, ADG (CC) for their constant encouragement, guidance and support. The Heads of Divisions Dr Sandhya Kranthi, Dr Blaise Desouza and Dr Suman Bala Singh and Dr D. Monga, Head, Regional Station, Sirsa, and Dr A. H. Prakash, PC and Head, Regional Station, Coimbatore have contributed immensely to the technical execution of research programmes and their documentation in this report. I thank them for all for the excellent camaraderie and support. Dr M. V. Venugopalan, Dr M. S. Yadav and Mrs Vandana Satish deserve to be highly commended for their outstanding inputs and commitment to all aspects related to this annual report.

Hope is not a just a dream, it is about faith for dreams to come true. Science has the power to give shape to dreams. I earnestly hope that all our scientific efforts at the institute will eventually make our dreams for the farmers turn into reality. Our endeavour is to develop 'India-centric technologies' that can help the cotton farmer to cultivate cotton in a sustainable manner without the need for any harmful chemicals, at low production costs to obtain highest possible yields in ecologically compatible production systems. We hope to succeed.

(K. R. Kranthi)
Director

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1. EXECUTIVE SUMMARY

Crop Improvement

Genetic Resources of *Gossypium*

- Fourteen perennials including nine of *Gossypium barbadense* and five of *Gossypium arboreum* were collected through exploration and collection surveys conducted in various districts of Maharashtra, Tamil Nadu and Andhra Pradesh.
- Among 838 accessions (including 38 exotic accessions) of *G. hirsutum* and 582 germplasm of *G. herbaceum* evaluated for economic and fibre quality traits, nine long linted exotic accessions with staple length 30.2– 31.8 mm and 22 accessions for high fibre strength (26.3– 28.4 g/tex) were identified and documented.
- One hundred and nineteen land races / perennials which include 80 *Gossypium arboreum*, 13 *G. herbaceum* and 26 *Gossypium barbadense* were evaluated for fibre quality. Morphological characterization including DUS characterization was completed for 19 germplasm accessions.
- Twenty four unique *G. arboreum* accessions were identified through diversity analysis using MEGA 6 software and established in the "Perennial Species Garden" at Panjari farm, ICAR-CICR, Nagpur.
- Seven thousand and fifty one (G. *hirsutum* – 4400, *G. arboreum* – 2063, *G. herbaceum* – 569 and wild species – seeds and cuttings – 19), 14 perennial and landraces (*Gossypium herbaceum)* were distributed to breeders/ scientists of CICR, State Agricultural Universities for utilization.
- Twenty six wild species were conserved in wild species garden. One new species (EC 669583), genetically distinct from others flowered under field condition.
- Five genetic stocks *viz*; CNA 405 (INGR 15005: Narrow leaf lobed and brown linted), CNA 407 (INGR 15024: Narrow leaf lobed, spotted petal and light brown linted), CNA 407 (SLP) (INGR 15025: Spotless petals and brown linted), CNA 1051 (INGR 15016: Distinct yellow top leaves virescent mutant) and CNH 1102 (INGR 15015: High ginning outturn, bacterial leaf blight resistance, long staple and high strength) were registered with ICAR – NBPGR, New Delhi.
- A set of 1100 accessions of *G. arboreum* evaluated for various morphological parameters. Principal Component Analysis (PCA) based on qualitative traits revealed traits *viz.,* boll shape, leaf shape and bract size distinguished all genotypes in higher order than the other traits.
- Three hundred and ten *G. barbadense* germplasm lines were maintained during 2015-16. Five new germplasm lines *viz*., NGB-555, NGB-556, NGB-557, NGB-558 and NGB-559 were evaluated. NGB-556, a hairy line, is moderately resistant to sucking pest. Of the eleven hairy germplasm accessions evaluated for wax content, EC-18 had the maximum amount of wax (343 µg/cm^2) followed by HAG-02 (305 µg/cm^2).

Genetic Improvement for Target Traits

- Based on plant width and number of monopodia, N 170, Pratima, CSH 3178, Anjali, CNH 09-7, Arogya, DSC 99, CNH 1102 and AKH 8828 were identified as most promising for compact plant architecture. KC-3, G.Cot 20, CNH 2034, NISC 44, AKH 081, JK-4, CNH 409-9, CNH O7-34, ADB 532 and NH 545 were found promising for jassid tolerance scoring lowest jassid grade and lower nymph number. Based on per cent open bolls at 150 DAS, Pratima, CNH 409-9, CNHO 12, Sahana, IC 359478, Arogya, G.Cot 18, JK-4, CNH 2028 and F1378 were identified as promising for earliness.
- Germplasm lines with high fibre strength were selected for developing a 10 × 10 diallel crosses without reciprocals. General combining ability variance (GCA) was higher than specific combining ability (SCA) for upper half mean length, uniformity index, micronaire and fibre strength indicating the predominance of additive gene action in the inheritance of all these traits. CCH 7122 and Suraj exhibited significant GCA effects for all fibre traits except micronaire.
- Two crosses *viz*; CSH-3119-10-30-60 (2960 kg/ha seed cotton, 1067 kg/ha lint yield and fiber strength 27.4 g/tex in HVI mode) and MMO.3 (39-

2-5)-3114-10-64 (2976 kg/ha seed cotton, 1020 kg/ha lint yield and fiber strength 26.7 g/tex) were early and yielded higher than the check H-1226.

- Based on the average performance of three years, seven progenies *viz*; P-68, 69, 70, 84, 139, 164 and 184 possessed GOT of more than 40%.
- Of the fourteen cultures tested, two genotypes CISA 10 and CISA-33-8 yielded more than 1700 kg/ha and have promise for spinning. CISA-6-350, CISA-6-295 and CISA-33-7 were having UHML (mm) >24.0 mm and strength >24.0 g/tex in HVI mode.
- Sixteen genotypes were evaluated under non-spinnable category CISA 310 and CISA 614, the seed cotton yield ranged from 2218 to 2641 kg/ha. Three genotypes CISA-6-2 (2641 kg/ha), CISA-33-3 (2593 kg/ha) and CISA-6-123 (2583 kg/ha) recorded higher seed cotton yield than local checks CISA 310 (2466 kg/ha) and CISA 614 (2570 kg/ha).
- From 15 stabilized advanced generation (BC_3F_9), four genotypes *viz*., CCB-51 (1633 kg/ha), CCB-64 (1572 kg/ha), CCB-66 (1541 kg/ha), and CCB-72 (1500 kg/ha) were significantly out yielded the check variety Suvin (910 kg/ha) and had better ELS fibre quality.
- Seven compact genotypes with super okra leaf were evaluated with three check varieties, Suraj, Anjali and Supriya under spacing of 30 cm x 10 cm. The culture Surabhi x MM02-19-1-8-2 was the highest yielder (2071 kg/ha). The culture MCU 13 x VNWH 1-7-2 was the best for fibre quality (2.5% span length of 33.1 mm and bundle strength of 23.0 g/tex in ICC mode).
- From F_6 generation, 50 single plants selected for further screening showed maximum boll weight of 5.4 g; similarly, 50 single plants selected for further screening showed the maximum lint index of 6.6 g. Apart from the above, 39 single plants selected for further screening showed maximum GOT of 47.1%.
- Based on the effect of drought stress on leaf temperature, photosynthetic rate, transpiration rate, NR activity, prolein, protein content, reducing sugar, phenol, amino acid and chlorophyll content, four genotypes namely DTS 4, DTS 6, DTS 9 and NHP 3 were identified for drought tolerance.
- One hundred and fifty identified tolerant accessions were evaluated for 48 days under waterlogged condition along with a control and morphological adaptations like lenticels and adventitious roots were prominently observed in tolerant accessions.

Heterosis Breeding

- Based on evaluation of six GMS *G. arboreum* hybrids for seed cotton yield with two check hybrids AAH 1 and CICR 2, three hybrids CISAA 15-38, CISAA 14-31 and CISAA 14-32 were identified for higher seed cotton yield.

Introgress Breeding

- In *G. arboreum* based introgressed derivatives, genotypes with fibre length from 23.2 to 26.5 mm and fibre strength from 20.0 to 23.2 g/tex were selected.
- Seed multiplication of colored cotton genotype MSH-53 (Vaidehi-95) was taken up and 650 kg seed was produced.
- Various breeding approaches were followed to develop populations / genotypes resistant to cotton leaf curl virus (CLCuV) *viz*; crossing of *G. hirsutum* lines with *G. arboreum* lines, colchicine treatment of *G. arboreum* and *G. hirsutum* genotypes, development of synthetic tetraploids of cultivated cotton by crossing *G. arboreum* and *G. herbaceum* with *G. raimondii,* crossing *G. hirsutum* lines with PAIG lines, crossing *G. hirsutum* lines with the registered genetic stock IS-376/14/21 reported to possess anatomical features of *desi* cotton in *G. hirsutum* background. Crossed bolls were harvested in all the approaches except *G. herbaceum* × *G. raimondii* crosses.

Varietal Development and Multi-location Testing

- Identification proposal of CSH-3075 for cultivation in North Zone under HDPS and long staple high strength culture CCH 4474 for South Zone states under irrigated conditions were submitted.
- The *G. hirsutum* cultures CSH 2920 and CSH 2932 in Br 02(a) National trial, CSH 3232 and CSH 3088 in Br 03(a) Zonal trial, GMS based *G. hirsutum* hybrid CSHG 2911 in Br 05(a) National trial, *G. hirsutum* hybrid CSHH 2012 in Br 05(a) Zonal trial, compact cultures CSHH 3158, CSH 5038 and CSH 6109 in Br 06(a) National trial, compact cultures CSH 3113, CSH 3178 and

CSH 73 in Br 06(a) Zonal trial, *G. arboreum* culture CISA-6-123 in Br 22(a/b) National trial, CISA-6-2 in Br 24(a) zonal trial and *G. arboreum* GMS based hybrids CISAA 14-31 and CISAA 14-32 in Br 25(a/b) National trial were sponsored/promoted during 2015.

- One *G. arboreum* GMS based hybrids CISAA 14-31 was promoted to zonal trial Br 25a and *G. arboreum* culture CISA-6-2 ranked 1st in zonal trial was further retained for large scale multi-location testing during 2015.
- The *G. hirsutum* hybrid CSHH 2012 was recommended for agronomy trial based on overall performance in AICRP on cotton trials during 2015.
- The culture Surabhi x M5Z2 18-5 (CCH 15-1) was tested in initial evaluation trial of *G. hirsutum* varieties under irrigated condition recorded an upper half mean length of 27.1 mm in north zone locations, 31.8 mm in central zone locations and 32.5 mm in south zone locations. It exhibited the highest bundle strength of 30.7 g/tex, 32.8 g/tex and 36.1 g/tex in HVI mode in north, central and south zone locations, respectively.
- The culture MM 03-40-4-3-1 (CCH 15-4) tested in initial evaluation trial of *G. hirsutum* varieties under rainfed condition in central and south zone locations recorded an upper half mean length of 31.2 mm in central zone locations and 30.9 mm in south zone locations with bundle strength of 30.5 g/tex and 31.5 g/tex in HVI mode respectively.
- Compact super okra culture Surabhi x M5Z2 4-2 (CCH 15-5) was tested in AICRP trials under irrigated conditions and cultures Surabhi x MM 02-16-5-2-3 (CCH 15-7) and MCU 13 X VNWH 1-7-2 (CCH 15-8) tested in rainfed situation were promoted for evaluation in coordinated varietal trial in central and south zone locations. All these cultures exhibited excellent fibre quality in the initial evaluation trial.
- An elite promising *barbadense* genotype CCB-29 ranked third and fourth in yield in central and south zone, respectively. With regards to quality parameters it ranked fourth in both the zones. In initial yield evaluation trial of AICRP (Br.12a), CCB-11a had ranked fourth in yield and third in fibre quality parameters.

Molecular Breeding

- Recombinant inbred lines (RILs) developed from a cross between EL 958 and UPA 57-17 following single seed decent method was used for genetic mapping. About 240 progenies were used for phenotyping of fibre quality traits while 188 progenies for SSR marker genotyping.
- 4417 SSR markers were screened for parental polymorphism. Seven hundred two were found to be polymorphic / informative which accounts for 15.9% polymorphism with the parental lines.
- Genomic DNA of 188 progenies was used for genotyping using 520 informative polymorphic SSRs. Finally, 227 anchor marker loci were used for making an integrated SSR-SNP genetic linkage map of AD genome (*G. hirsutum)*.
- Genotyping of 172 RIL progenies with 2730 SNP markers done and data analyzed. The preliminary analysis showed 29 linkage groups with 1.31 cM distance between the consecutive markers.
- Genotyping data for 2730 SNPs (mapped on 29 linkage groups) were used for QTL mapping. Ten QTLs were identified for staple length, tenacity and micronaire. For staple length, two QTLs were identified each on LG 18 and LG 4 with LOD score ranging from 3.72 - 5.15 and phenotypic variance (R^2) from 8.7 - 10.6%. Similarly, for tenacity, total six QTLs were identified, two on LG 3 and one each on LG 10, LG 4, LG 5 and LG 8, respectively. For micronaire, two QTLs were identified on LG 18 and LG 4, respectively with LOD score for these two QTLs ranged from 4.1 to 5.8 and phenotypic variance (R^2) from 9.8 to 14.3%.
- A set of 11 F_1 crosses were attempted among resistant/tolerant parents for gene pyramiding for CLCuD that includes CLCuD tolerant lines identified from the previous year and also tolerant Bt BGII hybrids.
- DNA was isolated from BC_1 plants and screened using SSR marker CIR 246. BC_1 plants were categorized as resistant and susceptible and compared with 101-102B which is universal resistant for BLB having 146 bp. Genomic DNA of individual F_2 and BC_1 plants was extracted and subjected to screening using SSR markers BNL 3279 and NAU 2152 for nematode resistant. The marker positive plants in BC_1 were backcrossed with recurrent parent Suraj to obtain BC_2 seeds.
- Sixty additional SSR markers screened for 48 public sector released tetraploid cotton varieties (*G. hirsutum* and *G. barbadense*) and 150

markers for 24 *G. arboreum* varieties. Twelve robust markers were obtained for *G. hirsutum.* Three markers found specific for *G. barbadense* varieties, Suvin and Sujatha, were further confirmed in 20 germplasm lines of *G. barbadense.*

- The parents of five hybrids (4 *G. hirsutum* and 1 *G. arboreum*) and two *G. arboreum* varieties were screened using 117 SSR markers with high PIC values. Distinctly polymorphic markers were identified among male and female parent of each of the five hybrids.

Biotechnology

- *G. hirsutum* cv. Coker 310 plants carrying Cry1Ac (Tg2E-13 event) were received from Delhi University after Memorandum of Understanding and Material Transfer Agreement.
- Six elite cotton varieties *viz*, AKH 081, Anjali, CISH 3178, LRA 5166, NH 615 and Suraj were used as recipients in marker assisted transgene introgression breeding and crossing between donor and recipients were attempted and hybrid seed of each cross was produced in the contained glasshouse facility.
- Analysis of real time data using geNORM, Norm finder and Best keeper algorithm aided in identification of RPL32 in *H. armigera* and Actin in *Gossypium arboreum* as suitable normalilzer for gene expression analysis of developmental stages.
- New event of Cry2Ab1Ac : Chitinase gene were generated by *in-planta* transformation methods. In all 111 T_0 bolls were harvested.
- Novel genes/transcription factors having probable functions in somatic embryogenesis were traced.
- 2831 sheet tip explants were subjected to transformation with CICR cry fusion gene. The 75 Kanamycin resistant *ex-plants* were regenerated into putative transformants by direct shoot organogenensis.
- Putative transformants for cotton leaf curl virus resistance using *G. hirsutum* cvs HS 6, H 777 and F 846 were screened for the presence of gene.
- The role of five identified candidate genes (*Ghces Al, Ghces A3, Ghces A7, Ghcobl4* and *Ghfla3*) in fibre development were used to validate lintless mutant (MCU 5) and its counterpart wild type cotton genotype. The candidate genes are radically expressed in wild type compare to mutant.

DUS Characterization

- 49 new candidate varieties of which 12 were VCK and one FV; 68 new candidate varieties of *G. hirsutum* for second year of testing and 19 each of EDV and Initial varieties were subjected to DUS characterization.

Seed Production and Quality Improvement

- Around 2235 kg seeds of various categories were produced. Resource of around Rs. 6 lakhs was generated through the sale of these seeds or its by-products.
- Exogenous application of plant growth hormones and other chemicals on seed yield and quality of cotton variety Suraj indicated that the total seed cotton yield was significantly higher in spermine (0.1 mM) followed by putrescine (4.0 mM) (22.15 q/ha). The fuzzy seed yield was highest in spermine (0.1 mM) (14.0 q/ha) followed by putrescine (4.0 mM) (13.92 q/ha) and spermidine (0.1 mM) (13.74 q/ha). Highest seed germination was recorded in spermine (0.1 mM) followed by salicylic acid (1.0 mM) while vigor in terms of seedling length was highest in 5-sulphosalicylic acid (0.5 mM) followed by putrescine (2.0 mM) and spermine (0.5 mM).
- To improve the seed and boll setting efficiency in cotton, highest boll setting of 85.5% was observed with hand pollination followed by treatment with CICR consortium (83.0%) and NPK 2% (82.3%). The seed setting efficiency (93.3%) and yield (3375 kg/ha) was also higher in hand pollination.

Crop Production

High Density Planting System (HDPS)

- American and *desi* cotton varieties / cultures were evaluated under HDPS. Among the American cotton varieties, the top five early yielders (yield at 165 DAS) at 60 x 10 cm spacing were LRK 516, Suraj JT, CNH 1111, CSH 3075 and CNH 09-4 at Nagpur. At Sirsa, CSH 3075 at 67.5 x 20 cm yielded 47% more than the Bt hybrid in large plot trials. AKA 8, RG-540, CNA 375, Phule Dhanwantary, CNA 418, MDLABB and CISA 6-256 yielded more than 2000 kg/ha among the *desi* cotton varieties. Phule Dhanwantary was early and compact in nature.

Productivity of Phule Dhanwantary could be enhanced with closer row spacing of 30-45 cm and 10-15 cm intra plant spacing. In general, high density had no influence on pest and disease incidence. Clorantraniliprole 18.5 SC and Indoxacarb 14.5 SC were most effective against bollworm (*H. armigera*) in terms of lowest per cent of fruiting bodies damage under HDPS.

Weed Management

- Cover crops as an alternative weed management strategy was evaluated at Nagpur and Coimbatore. Effective cover crops identified were sunnhemp, sorghum, sesame, bajra and desmodium at Nagpur. At Coimbatore, forage cowpea effectively smothered weeds and had the least weed density.

Nutrient Management

- To address nutrient stress during the crop season, a gadget to detect N stress, non-destructively was developed. Field evaluation of the gadget indicated a correlation coefficient of 0.795 for N content and greenness values.

Soil Biology

- Cry toxin was not in the detectable range in the rhizosphere soil samples of the Bt cotton hybrid plots. Microbial parameters such as beneficial micro flora, soil microbial, biomass carbon and enzyme activity (acid and alkaline phosphatase, urease, dehydrogenase, fluroscent di-acetate hydrolysis) peaked at flowering stage of the crop.

Abiotic Stress Management

- **Leaf reddening** : DNA laddering studies conclusively indicate that leaf reddening is not a death signal. Leaf reddening could be managed by spray of ICAR-CICR Nutrient Consortia, IBA at square initiation or 2 % DAP at 80 and 110 days after sowing.
- **Drought** : Phenotyping of 104 germplasm was done during summer of which 14 were identified as drought tolerant and 7 as susceptible. IC 357406 and Nagpur 9 were highly tolerant to drought.
- **Water logging** : Phenotyping of 2700 germplasm lines was done and 211 were short listed as tolerant.

Cropping Systems

- Twenty legumes were evaluated as intercrops for compatibility and N fixation. Rice bean and cluster bean were ideal intercrops in Suraj, an American cotton variety. In the *desi* cotton inter cropped with groundnut, cluster bean, soybean, alfalfa and mothbean had highest productivity. At Coimbatore, legume intercrops except vegetable cowpea and Dolichos, enhanced seed cotton yield.

Water Management

- Structured water irrigated plots had higher cotton yield than the bore well irrigated plots.

Paper Tube Nursery

- Cotton seedlings raised in paper tube rolls when transplanted in the field established quickly and yielded more than the direct sown cotton.

Cotton Mechanization

- Cotton harvester developed in collaboration ICAR-CICR-CIRCOT and Mahindra & Mahindra was field tested. The machine had a picking efficiency of 98% with a header loss of 11.5% to 12.5%. Field capacity of the machine was 2h / ha.

e-Kapas

- More than 28,000 farmers were registered by ICAR-CICR in 2015-16 under e-Kapas. With more than 10.5 lakh voice messages sent in Marathi, the local language with delivery success of 72%.

Crop Protection

Pest Dynamics

- Seasonal pest population dynamics data was generated under protected and pesticide free conditions on DCH 32. At Nagpur, hot spots of jassid, thrips and whitefly infestation were identified in >20% villages during the season. In Sirsa, whiteflies infestation were above ETL throughout the season on the 4 genotypes studied. 23 alternate hosts of whitefly were recorded during off-season.
- All the three bollworms *viz.*, *Helicoverpa armigera*, *Erias insulana*, *Pectinophora gossypiella* were seen to damage cotton. Unusual early incidence of pink bollworm was recorded this year.

Novel Technologies

- Gossypol detoxifying gene *cyp6ae14* in T/A cloning vector was successfully subcloned in to bacterial expression vector pET28c and confirmed through restriction digestion.
- Cotton seed cake (deoiled) treatment with

Enterobacter cloacae subspp. *cloacae* was found effective in reducing total gossypol content from 1.24% in control to 0.9% with treatment.

- Data regarding the suction efficacy of the ICAR CICR Whitefly Adult Suction Trap developed for whitefly management was generated and, the reduction in whitefly adults was up to 40% during the peak period of activity of whitefly adults. This suction trap is power operated, shoulder mounted portable and adjustable and helps in suction of whitefly adults available on the underside of the cotton leaves without any harm to the natural enemy flora and cotton crop itself. The trap is in the process of patenting.
- Application of ethylene inhibitors has no significant effect on pest population and cotton yield. Wilted plants were found emit significantly higher ethylene than healthy plants and treatments involving Cobalt chloride and Bavistin were not effective in recovery of wilted plants.
- Protocol was developed for production of Bt toxin on novel low cost solid medium, in cooperation with the Ginning Training Centre, Nagpur.
- Reverse Transcription loop mediated Isothermal amplification (RT-LAMP) protocol was developed and standardised for diagnosis of Tobacco Streak Virus of Cotton and Soybean.
- Five sprays of 4 exogenous waxes along with guar gum applied helped in 1.38-12.17% reduction in whitefly incidence.

Biological Control

- During surveys conducted to record diversity of Mealy bugs in Maharashtra and Madhya Pradesh, 6 mealy bug species *viz.*, *P. solenopsis*, *N. viridis, M. hirsutus, F. virgata* and *P. marginatus*, *M. hirsutus* belonging to Pseudococcidae family of order Hemiptera were recorded. *P. solenopsis* was the dominant species.
- Microcapsulation of *Bacillus thuringiensis* was attempted for improving efficiency as a biopesticides.
- Spraying of talc based formulation of *Lecanicillium lecanii* and *Metarhizium anisopliae* at the rate of 10 g/l significantly reduced the population of aphids, jassids and whitefly under field condition. Field evaluation of two talc based formulation of *L. lecanii* and *M. anisopliae* under AICRP on cotton centres revealed that they were safer to natural enemies (spiders and coccinnellids) and reduced the sucking pest population.
- Safety of biopesticides to natural enemies was studied. Spraying of Coccinellid beetle, *Cheilomenes sexmaculata* with spore suspension of *Lecanicillium lecanii* at 10^6-10^8 spores/ml in direct and indirect (residual toxicity) method was found to be safe for grubs and adults under lab and field condition. Soil application of *L. lecanii* at field even at ten times of field recommended dose was found safe to earth worm.
- Spraying of biopesticide formulation of *L. lecanii* with corn oil and skimmed milk powder recorded maximum persistence of spores on cotton leaves upto four days. Among 14 UV protectants tested, Starch, Tinopal and skimmed milk powder recorded more than 95 percent germination at 24 hours after inoculation.

Host Plant Resistance

- Single plant selections were made and raised as boll to row for development of Jassid tolerant Suraj. Jassid tolerant Suraj had similar fibre properties as Suraj.
- Inter-specific variation in volatile emission in 3 species of *Gossypium* in response to leaf hopper, caterpillar and mechanical damage was investigated. Ten genes, ERF 1, 2, 3. TPS 1,2,3 Alpha pinene, Lipoxygense 1, Allene oxide synthase 6, Methyl jasmonate transferase, involved in the signal transduction pathway were characterized using RT PCR to understand their role in volatile emissions that reportedly play a well defined role in inter plant communication in cotton.
- *G. arboreum* is tolerant to leaf hoppers by virtue of up-regulation of the methyl transferase gene (that governs conversion of jasmonic acid to methyl jasmonate) and this mechanism is absent in *G. hirsutum.*
- Volatiles emitted from pink bollworm damaged flower *vis a vis* undamaged flower were studied. Relative abundance of β Caryophyllene, methyl ester of pentadecanoic acid and linolenic acid, the precursor of jasmonic recorded was higher in PBW infested flowers than normal flowers.
- Role of epicuticular wax on whitefly and CLCuD incidence was investigated. Germplasm No. IC357886 exhibited higher wax content throughout the canopy and on both upper and

lower surfaces and recorded lowest whitefly incidence. Germplasm No. IC358823 had very low wax content across the canopy on both adaxial and abaxial sides and this line recorded highest whitefly incidence.

Resistance Monitoring

- Protocol was standardised for bioassays with pink bollworm using green bolls. Observations on exit holes, mines on epicarp, number of larvae and per cent locule damage were recorded 21 days after release. Neonates of resistant culture caused 67-100% loculi damage in non Bt control bolls while 25-50% loculi damage was caused on BGII green bolls.
- Insecticide resistance monitoring carried out against eight leaf hopper populations from Central and South India with four insecticides namely Flonicamid, Acetamiprid, Thiamethoxam and Imidacloprid. The resistance ratios of Flonicamid, Monocrotophos, Acephate, Imidaclorpid, Acetamiprid, Thiamethoxam ranged from 1-16, 1-7.7, 1-8.9, 1-19.6, 1-331 fold, respectively.
- Flubendiamide was the most effective insecticide (0.005 mg/L and 0.004 mg/L) against Nagpur and Wardha populations of *H. armigera*. Cypermethrin was the least effective.
- Cry toxin resistance monitoring recorded a variability of 50 fold and 78 fold in the LC_{50} and EC_{50} of Cry1Ac against *H. armigera* populations of Maharashtra and Andhra Pradesh.
- Cry2Ab did not cause significant dose dependent mortality on one day old larvae of *H. armigera*. A variability of 247 fold was recorded in the EC_{50} values of *H. armigera* populations from Maharashtra and Andhra Pradesh to Cry2Ab alone.
- ICAR-CICR has been monitoring bollworm resistance development to Bt cotton during the past 15 years. During 2015-16, resistance monitoring was carried out with pink bollworm larvae collected from 46 districts of cotton growing states across the country. Bioassays were conducted with pink bollworm populations collected from 39 districts. Results showed that pink bollworm populations in 15 districts have developed resistance to Bollgard-II (Cry1 Ac+ Cry2Ab); 20 populations were resistant to Bollgard (Cry1Ac) and 18 populations were resistant to Cry2Ab.
- In Gujarat, pink bollworm infestation was observed in flowers of different Bollgard-II hybrids ranging from 0 to 67.0 % in different districts of Gujarat. In November 2015, pink bollworm infestation was 72.0% in Surat, 64.0 to 92.0 % in Bharuch, 48.0 to 96.0 % in Vadodara, 50.0% in Ahmedabad, 56.0 to 84.0 % in Bhavnagar, 60.0 to 72.0 % in Amreli, 76.0 to 88.0 % in Junagadh and 60.0 to 64. 0 % in Rajkot. In the third week of January 2016, the per cent infestation on Bollgard–II in Vadodara 72.0 %, Surat 92.0%, Anand 82.0% Surendranagar 92.0% Ahmedabad 100%; Amreli 100%, Rajkot 64.0%; Bhavnagar 56.0% and Junagadh 100%.
- In Maharashtra, the intensity of pink bollworm was more in irrigated tracts of Khandesh region as compared to Vidarbha. Infestation of pink bollworm in green bolls of third-fourth picking on Bollgard–II cotton was 100% in Khandwa. In Andhra Pradesh, all the Bt hybrids were found to be susceptible to the pink bollworm. In Telangana by the second week of December 2015, the crop was terminated in 90% of the area in the state. Pink bollworm infestation in green bolls of the 2-3rd picking in residual crop in Adilabad was 52.0%-96.0%, Khamam 32.0%-100%, Warangal 60.0%-100% and Karimnagar 68.0%-96.0% respectively. Pink bollworm infestation in green bolls of Bollgard-II was 20.0% in Coimbatore and 24.0% in Srivilliputtur. The infestation of pink bollworm in green bolls of Bollgard–II in Raichur was 48.0%-92.0% while in Dharwad it was 8.0%.
- Monitoring for pink bollworm (PBW) resistance was done in North Zone during 2015-16 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. PBW larvae were not recovered in RCH 650 BGII from any location. But in non Bt genotypes, average recovery(%) of PBW larvae ranged from 8-20.0, 10-20.8 , 11.7-25.8 and 13-44.0 at 120, 140, 160 and 170 days after sowing, respectively, indicating pink bollworm activity in North India.
- The most commonly used insecticides with label claim for whitefly on cotton were studied for their resistance status in whitefly adult populations during 2015-16 from the four different locations. Out of the four locations studied (Sirsa, Sriganganagar, Hisar, Mansa), the Hisar

population was found highly resistant. The population from Nagpur was taken as susceptible population since it was not exposed to these insecticides during the season.

- The whitefly has acquired resistance to almost all insecticides and the resistance ratio varied from 98-1400 folds for Bifenthrin 10EC, 14-137 for Dinotefuran 20SG, 60-131 for Acephate 75SP, 21-331 for Acetamiprid 20SP, 153-340 for Fipronil 5SC, 371-2237 for Triazophos 40EC, 51-706 for Buprofezin 25SC, 9-512 for Imidacloprid 17.8SL, 40-347 for Diafenthiuron, 2-19 for Chlorpyriphos 20EC, 1-2 for Thiamethoxam 30FS, 2-7 for Clothianidin 50WDG, 2-23 for Pyriproxifen and 1-6 for Flonicamid.
- Cry toxin resistance monitoring was carried against *S. litura.* LC_{50} of Cry1C ranged from 14.90 to 19.19 ug/ml of diet for *Spodoptera exigua* population with highest C50 recorded with for population from Hisar (19.19 ug/ml of diet).
- Five hundred single pair matings of *H. armigera* populations collected from red gram/ chickpea in Maharashtra were set for Cry1Ac and 270 single pair matings were set up for Cry2Ab. In the F_3 generation 16 colonies demonstrated resistance to Cry1Ac and none of the colonies demonstrated larval mortality when exposed to the highest concentration of Cry2Ab.
- Single pair matings were set up with three hundred and thirty moths of which only 4 colonies demonstrated resistance to Cry1Ac in the F_3 generation in populations of *H. armigera* collected on redgram in Gujarat. Isofemale lines (70) from *Earias insulana* population of Mansa were screened at Sirsa for presence of rare resistance allele for Cry toxins.

Novel Genes

- For work on identification of new gene sources for pest management, full length *cyp6ae14* gene initially cloned in T/A cloning vector (pGEM-T easy vector) was further sub cloned in to bacterial expression vector pET28c and transformed in to *E.Coli* (αDH5) cells.
- The *Enterobacter cloacae* subspp. *cloacae* identified for glyphosate degradation was found to reduce total gossypol from 1.25 % (control) to 0.9 % of treated cotton seed cake.
- Suitable reference genes were identified for quantitative real-time PCR normalization in *Helicoverpa armigera* and *Gossypium arboreum.* RPL32 in *H. armigera* and Actin in *Gossypium arboreum* were identified as suitable normalizer for gene expression analysis of developmental stages.

Endophytes and Endosymbiots

- Seventeen bacteria were isolated as endophytes from stem and leaf parts of cotton plant and based on its virulence, nine isolates were selected for field evaluation. Application of *Bacillus subtilis*, *Bacillus* sp. E13 and *Bacillus cereus* B1 recorded low population of sucking pests.
- Out of eight *Beauveria bassiana* fungal endophytes evaluated, isolates, Bb2, Bb4, Bb3, Bb1 and Bb8 recorded low population of sucking pests.

Non-compliance of Refugia Guidelines

- Poor compliance of regulatory guidelines was recorded this year with some refuge seed packets carrying the Bt toxin.

Pest Disease and Nematode Management

- Natural enemies, parasites and parasitoids of cotton pests was recorded. Endoparasitoid *Bracon lefroyi* was recorded on pink bollworm larvae collected on RCH 2 BGII of Surat district .
- Four sprays of the formulation containing Curcumin 1% was most effective in reducing reniform nematode population by as much as 80 % and doubling seed cotton yield as compared to control, in field studies.
- *Lysnibacillus sphaericus* was found to induce systemic acquired resistance against nematode *Rotylenchulus reniformis.*
- Soil application of talc based formulation of a native nematode antagonistic fungus; *Purpureocillium lilacinus* significantly reduced the reniform nematode population in soil and root and increased plant growth of cotton.

Yield Modelling

- Software for cotton yield calculator was built using Java as the backend code and HTML as the front end code. The software is designed to run on all browsers present in Windows and Linux based operating systems. To integrate the backend resources with the browser, TOMCAT server installation which is an Open Source System was used. Software used in the development of this application have been Open Source Softwares. ECLIPSE was used to design the

Java code.

Price Forecasting

- Price modeling for price forecasting was tried using Artificial Neural Network with EXCEL and SPSS software. The forecasted price using Excel for 2016 was Rs. 4200 to Rs. 4800 in the North, Central and South cotton growing zones. The forecast accuracy was to the tune of 91 to 96 per cent in all the cotton growing states except in Madhya Pradesh, where it was 89 per cent. Alternative model ANN through SPSS showed better accuracy to the tune of 92 to 99 per cent.

Dissemination of Pest Management Strategies

- IRM strategies were disseminated to 9849 farmers in 26011 acres in a total of 345 villages of 19 districts from 12 different states across India. In IRM fields, farmers sprayed an average of 3.86 sprays/ha as compared to 6.07 sprays/ha by non-IRM lames. Average yield of IRM and non-IRM fields was 16.75 and 15.12 q/ha. Implementation of the IRM resulted in yield increases estimated at a net additional benefit of Rs 6.76 crores and a saving on reduction in insecticide use accounting for Rs 1.89 crores, thus adding up to a total additional benefit of Rs 8.65 crores due to the project.
- A total of 1375 acre was covered for the implementation of IRM strategies in four villages of Sirsa. The average yields obtained under IRM and Non IRM was 15.10 q/ha and 12.25 q/ha respectively. Reduction in number of sprays applied by IRM farmers was 20.27% recorded over Non IRM and 17.24% reduction in pesticide consumption was recorded.
- IRM strategies were successfully in eight districts of Tamilnadu namely Virudhunagar, Coimbatore, Vellore, Erode, Dharmapuri, Tirunelveli, Perambalur and Madurai districts covering 2000 acres and were successfully adopted by 667 farmers. Net profit of Rs. 51,525 and Rs. 38,026 was recorded in IRM and Non IRM fields respectively.
- Impact analysis of the dissemination of IRM strategies in eight districts of Tamilnadu indicated that an average number of sprays of 2.6 in IRM farmers fields was resorted to when compared 4.6 in Non IRM farmers' fields.
- Under Online Pest Monitoring and Advisory Services (NFSM-OPMAS) advisories were issued to the 1333 farmers belonging to 9 villages of district Sirsa and Fatehabad. Based on the data recording for pests and diseases from random and fixed locations advisories were issued to the farmers through E-Kapas network .
- Imidacloprid when used as seed treatment residues were nonelected in pollen and guttation fluid.

Glimpses of Achievements

Variety CSH-3129 (*G. hirsutum*) notified for irrigated north zone

Variety CCH 2623 (*G. hirsutum*) notified for irrigated south zone

Tractor mounted cotton harvester

A gadget to detect Nitrogen deficiency in leaves

ICAR-CICR Whitefly Adult Suction Trap

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 (N)	Longitude (E)
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

2.3 : Staff Position (as on 31st March, 2016)

Name of the Post	Sanctioned Cadre Strength				Post Filled Up			
	NGP	CBE	Sirsa	Total	NGP	CBE	Sirsa	Total
Director (RMP)	1	--	--	**1**	1	--	--	**1**
Scientific	51	21	8	**80**	39	18	7	**64**
Technical	46	16	10	**72**	24	11	6	**41**
Administrative	34	9	5	**48**	21	6	5	**32**
Supporting	43	17	10	**70**	31	13	11	**55**
Krishi Vigyan Kendra								
Training Organizer	1	--	--	1	1	--	--	1
Technical	11	--	--	11	9	--	--	9
Administrative	2	--	--	2	1	--	--	1
Supporting	2	--	--	2	--	--	--	--

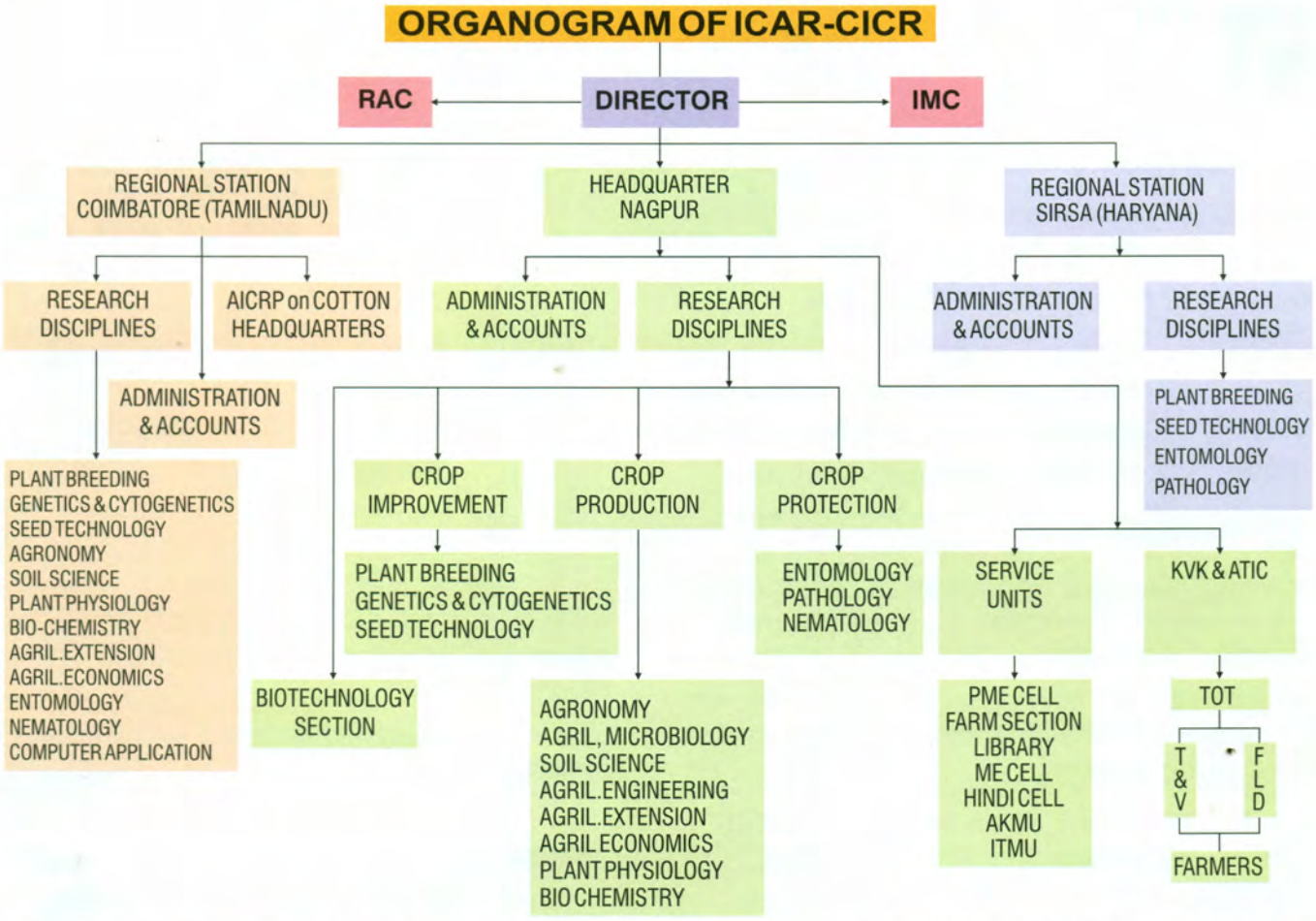
NGP – Nagpur; CBE - Coimbatore

2.4 : Financial Statement

The budget grant and actual expenditure for the year 2015-16 are furnished below: **(Rs. in Lakhs)**

S. No.	Scheme	Sanctioned	Expenditure
ICAR- CICR			
1	Plan	506.00	504.51
2	Non- Plan	3082.00	3040.93
Plan Schemes		2024.64	1992.68
Deposit Schemes funded by outside agencies		447.28	298.62

ORGANOGRAM OF ICAR-CICR



3. RESEARCH ACHIEVEMENTS

3.1: Cotton Genetic Resources

Nagpur

Exploration for perennials

Exploration and collection surveys were conducted in Wardha, Bhandara, Gondia and Yavatmal districts of Maharashtra, Kanyakumari district of Tamil Nadu and Nalgonda district of Andhra Pradesh. Fourteen perennials (Table 3.1.1) including nine of *Gossypium barbadense* and five of *Gossypium arboreum* were collected. They were established in pots and field conditions for further characterization and evaluation. The seeds were kept in the Gene Bank for conservation.

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

S. No.	Districts	State	No. of accessions	Species	Annual/Perennial/ Landrace
1.	Wardha, Bhandara, Gondia and Yavatmal	Maharashtra	2	*G. arboreum*	Perennials
			9	*G. barbadense*	Perennials
2.	Kanyakumari (Western Ghats)	Tamil Nadu	1	*G. arboreum*	Perennial
3.	Nalgonda	Telangana	2	*G. arboreum*	Perennials

Thirty-six exotic accessions of *G. hirsutum* from USA were procured through ICAR – NBPGR, New Delhi for enrichment of the cotton gene pool.

Germplasm Evaluation

G. hirsutum

A set of 838 accessions (including 38 exotic accessions) were evaluated for economic and fibre quality traits. Nine long linted exotic accessions with staple length (30.2 mm – 31.8 mm) and 21 accessions for high fibre strength (26.3 g/tex – 28.4 g/tex) were identified and documented.

Long fibre (>30 mm)	EC 838248, EC 838253, EC 838266, EC 838263, EC 838249, EC 838268, EC 838255, EC 838256, EC 838252
High fibre strength (>26 g/tex) (HVI mode)	EC 838256, EC 838252, EC 838264, EC 838253, EC 838270, EC 838251, EC 838267, EC 838263, EC 838272, EC 838271, EC 838255, EC 838260, EC 838265,EC 838248, EC 838254, EC 807817, EC 838259, EC 838266, EC 838257, EC 796545, EC 838249

G. arboreum

One hundred and thirteen single plant selections of brown colour lint were evaluated for identification of lines with low micronaire (< 4.55) and fourteen lines were identified.

G. herbaceum

Work was initiated to identify germplasm lines of *G. herbaceum* with early maturity traits and identify genetically distinct genotypes suitable to climate change and enhanced productivity under local conditions. Seedlings of 582 germplasm were raised in paper tubes on two dates (27 June and 28 July 2015). Fifteen days old seedlings were transplanted in the field with 60 x 30 cm spacing in augmented design. Three standard checks were used (Jaydhar, DDhC -11 and G.Cot-25).

Early maturity traits *viz.* germination, plant height, days to first squaring, days to first flowering, days to first boll opening and percentage of open bolls at first picking were correlated with seed cotton yield per plant and direct path coefficient effect was estimated. Significant and negative correlation was found between yield and days for germination (-0.589), plant height (-0.420), days to first squaring (-0.463) and days to first flowering (-0.449). Path coefficient analysis revealed positive direct effect of number of bolls/plant (0.811), boll weight (0.335) and days to first flowering (0.314) on seed cotton yield.

Out of 582 germplasm, 31 genotypes showed early maturity traits (tested above). More than 350 genotypes were grouped in a range of 20-60 g seed cotton yield per plant. Six genotypes *viz.*, IC – 371437, IC- 371602, IC- 371587, IC – 371560, IC-371582 and IC-371575 recorded high yield ranging from 164 to 182 g/plant. Seasonal effect of two sowing dates and genotypes was highly significant in relation to yield.

Landraces of *desi cotton and perennials*

Evaluation for fibre quality traits

Fibre quality analysis was done for 119 landraces / perennials which included 80 *Gossypium arboreum*, 13 *G. herbaceum* and 26 *Gossypium barbadense* (Table 3.1.2).

Table 3.1.2: Range of fibre properties (ICC mode)

Name of the species	Staple length (mm)	Micronaire 10^{-6} g/in	Strength (g/tex)
G. arboreum	15.78-24.71	3.28-7.26	15.42-19.09
G. herbaceum	18.31-23.74	3.10-5.62	15.77-17.70
G. barbadense	25.09-34.21	2.94-5.88	18.29-25.67

Characterization of perennials and landraces

Morphological characterization including DUS characterization was completed for 19 germplasm accessions.

Diversity analysis

Diversity analysis was done by using MEGA 6 software, 24 unique *G. arboreum* accessions were identified and established in the "Perennial Species Garden" at Panjari farm, ICAR-CICR, Nagpur.

Wild Species

Twenty six wild species were conse-rved in wild species. One new species (EC669583), genetically distinct from other wild species flowered under field condition.

Conservation in Long and Medium Term Storage

Seeds of 879 accessions (*G. hirsutum* – 294 and *G. herbaceum* – 585), 68 accessions of perennials and landraces (*G. arboreum*- 59 and *G. herbaceum*-9) were stored for Long Term conservation in the National Gene Bank facility for at ICAR-NBPGR, New Delhi as well as at medium term storage at ICAR – CICR, Nagpur.

Distribution of Germplasm

Seven thousand and fifty one (G. *hirsutum* – 4400, *G. arboreum* – 2063, *G. herbaceum* – 569 and Wild species – seeds and cuttings – 19), 14 perennial and landrace samples (*Gossypium herbaceum)* were distributed to breeders/scientists of CICR, state agricultural universities for utilization in cotton improvement programme.

Rejuvenation and Seed Multiplication

A set of five hundred accessions of *G. hirsutum* and 900 accessions of *G. arboreum* were grown for rejuvenation and seed multiplication.

Genetic Stock Registered

Five genetic stocks were registered with ICAR – NBPGR, New Delhi (Table 3.1.3).

Table 3.1.3: Features of unique genetic stocks registered

S. No.	Name of the stock	Species	Registration number	Uniqueness
1.	CNA 405	*G. arboreum*	INGR 15005	Narrow leaf lobed and brown linted
2.	CNA 407	*G. arboreum*	INGR 15024	Narrow leaf lobed, spotted petal blotch and light brown linted
3.	CNA 407 (SLP)	*G. arboreum*	INGR 15025	Spotless petals and brown linted
4.	CNA 1051	*G. arboreum*	INGR 15016	Distinct yellow top leaves virescent mutant
5.	CNH 1102	*G. hirsutum*	INGR 15015	High ginning outturn, resistant to bacterial leaf blight disease, long staple and high fibre strength

CNA 405

CNA 407

CNA 407 (SLP)

CNH 1102

Coimbatore

Germplasm evaluation

G. hirsutum

One thousand germplasm lines of *G. hirsutum* were characterized for various morphological parameters. Data were recorded on plant type, stem hairiness, stem colour, leaf shape, leaf lobing, leaf colour, leaf surface, gossypol glands on leaf, leaf nectary, flower bracts, petal colour, pollen colour, boll bearing habit, boll shape, boll surface, gossypol glands on bolls and loculi/boll.

Zero branching germplasm accessions

Six elite *G. hirsutum* germplasm lines were found to exhibit zero branching habit during 2013-14. Their single plant progenies were carried forward to fix the character.

G. arboreum

A set of 1059 accessions of *G. arboreum* were received from Gene bank of CICR, Nagpur. Forty one released genotypes were obtained from different centres of AICRP on Cotton; altogether 1100 genotypes were raised in a single row in augmented design. Traits namely number of monopodia, number of sympodia, days to fifty percent flowering, days to boll opening, leaf size, leaf shape, leaf texture, leaf colour, leaf lobing, stem colour, stem type, plant stature, gland and nectar glands, petal colour and lint colour were recorded. All these traits showed wide range of variation. Principal Component Analysis (PCA) based on qualitative traits revealed that traits *viz.*, boll shape, leaf shape and bract size distinguished all genotypes in higher order than the other traits. All the genotypes were grouped into six clusters.

G. barbadense

Three hundred and ten *G. barbadense* germplasm lines were maintained during 2015-16. Five new germplasm lines *viz.*, NGB-555, NGB-556, NGB-557, NGB-558 and NGB-559 were evaluated. NGB-556,

a hairy line, is moderately resistant to sucking pest. NGB- 556 and NGB-559 were high yielding with better fibre qualities compared to control Suvin. NGB-557 is a short branching type, however, square drying was observed in this line. Variability for flower colour and boll characters was also observed. Ten compact germplasm lines *viz.*, NDGB-1, NDGB-2, ICB-7, ICB-39, ICB-71, ICB-145, ICB-161, ICB-174, ICB-199 and ICB-244 were evaluated for yield and yield attributes. All the cultures were cluster boll bearing types and the cluster varied from 2 to 6 per axil. Seed cotton yield of ICB-174 (1209 kg/ha) and ICB-244 (1007 kg/ha) were higher than the check variety Suvin (804 kg/ha). Both these accessions had high ginning outturn of 31% and 32% respectively. ICB-264 exhibited highest seed cotton yield of 137g per plant with 31% followed by ICB-284 (132 g) with 27% GOT. It is observed that both accessions were comparatively tolerant to sucking pest.

Eleven hairy germplasm accessions were evaluated for wax content. EC-18 had the maximum amount of wax (343 µg/cm2) followed by HAG-02 (305 µg/cm^2). Yield performance of ICB-124 and ICB-284 were superior to the other hairy germplasm lines. Among the fifteen accessions, ICB-264 had highest seed cotton yield of 137 g per plant and recorded GOT of 31% followed by ICB-284 (132 g) with GOT of 27%. Both the accessions were comparatively tolerant to sucking pest.

Sirsa

Evaluation of *G. arboreum* and *G. hirsutum* germplasm

Eight hundred and twelve accessions of *G. hirsutum* and 815 accessions of *G. arboreum* were evaluated and superior accessions for various morphological and agronomic traits are summarized in Table 3.1.4.

Table 3.1.4: Accessions for superior morphological and agronomic traits

Character	*G. arboreum*		*G. hirsutum*	
	Range	Superior accessions	Range	Superior accessions
Earliness (days)	62- 97	G4-B-5 (62), Million Doller (62)	50-121	EC-700400 (50), EC-700280 (50)
Dwarf (cm)	84-187	355-E-6 (84), 78/1A(84)	39-115	EC-141677 (39); EC-142767 (39)
Monopodia	1-5	PBS 1549 (5), PBN 5664 (5)	0-4	EC-657087 (4), EC-657097 (4)
Sympodia	4-13	30816 (13), 30840-SP1(13)	2-9	EC-657097 (9), EC-158941 (9)
No. of bolls/plant	10-38	AKA62 (38), Desi-10 (38)	12-36	EC-158941 (34), EC-153524 (34)
Boll weight (g)	1.6-2.9	CC-2-1-11-15 (2.9), 1768 (2.9)	1.5-3.6	EC-692166 (3.6), EC-692161 (3.6)
Yield/plant (g)	12-94.4	1768 (94.4), 7444 (92.6)	18-104.7	EC-158941 (104.7), EC-700179 (102.0)
Ginning outturn (%)	28.8-36.6	AC-35P-1 (36.6), H503 (36.4)		

Fifteen compact *G. hirsutum* germplasm lines identified during the previous year were evaluated along with check (F 2383) at 67.5 x 10 cm. The number of bolls per plant, boll weight and yield per plant were significantly lower in compact lines than the checks. The closer spacing contributed significantly in increasing yield per unit area. Accessions SP-3897 (3400 kg/ha) and IC-358100 (3440 kg/ha) were superior than F 2383 (2850 kg/ha).

3.2: Hybrid Cotton

Sirsa

Evaluation of GMS based *G. arboreum* hybrids

Six GMS based *G. arboreum* hybrids were evaluated for seed cotton yield with two check hybrids AAH 1 and CICR 2. Three GMS based hybrids CISAA 15-38 (1841 kg/ha), CISAA 14-31 (1649 kg/ha) and CISAA 14-32 (1545 kg/ha) recorded significantly higher seed cotton yield than the highest yielder check hybrid CICR 2 (1366 kg/ha). CISAA 14-31 and CISAA 14-32 hybrids have been sponsored in National Br 25 (a/b) trial of AICRP on Cotton. Hybrid CISAA 14-31 is promoted to zonal trial Br 25(a) for further evaluation.

Maintenance of GMS lines

Three GMS lines DS5, CISA 2, GAK 413A and 16 newly identified GMS lines (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, CISG-19, CISG-21, CISG-22) were maintained through sib mating. A pigmented GMS

line CISG 20 has red flower colour with petal spot. The plant is robust, thermo-insensitive and no pollen shedders are reported.

3.3 : Genetic Improvement

G. arboreum

Nagpur

Individual Cernuum plants of 5 accessions collected from Mizoram were evaluated. It showed compactness with plant height of 50 cm and sympodial length of 5 cm.

Sirsa

Evaluation of spinnable *G. arboreum* cultures

Fourteen (14) cultures were tested in RBD along with two checks CISA 310 and CISA 614. The seed cotton yield ranged from 1442 to 2395 kg/ha. None of the genotypes could give higher yield than checks. However, two genotypes CISA-10 and CISA-33-8 yielded more than 1700 kg/ha and have promise for spinning. Other genotypes CISA-6-350, CISA-6-295 and CISA-33-7 were having UHML (mm) >24.0 mm and strength >24.0 g/tex in HVI mode.

Evaluation of high yielding non-spinnable *G. arboreum* genotypes

Sixteen (16) genotypes were evaluated in RBD with two check varieties CISA 310 and CISA 614. The seed cotton yield ranged from 2218 to 2641 kg/ha. Three genotypes CISA-6-2 (2641 kg/ha), CISA-33-3 (2593 kg/ha) and CISA-6-123 (2583 kg/ha) gave higher seed cotton yield than local checks CISA 310 (2466 kg/ha) and CISA 614 (2570 kg/ha). The genotype CISA-33-3 is sponsored in AICCIP Br22a/b national trial.

G. barbadense

Coimbatore

Identification of promising extra long staple genotypes

Yield evaluation was done with 15 stabilized advanced generation (BC_3 F_9) genotypes during 2015-16. Four genotypes *viz.*, CCB-51 (1633 kg/ha), CCB-64 (1572 kg/ha), CCB-66 (1541kg/ha), and CCB-72 (1500 kg/ha) significantly out yielded the check variety Suvin (910 kg/ha) and had better ELS fibre quality. The promising genotype CCB-51 had maximum yield of 1312 kg/ha with high fibre length of 38.1 mm of span length, bundle strength of 28 g/tex with 3.3 µ/inch and ranked first in the list. In order to sponsor for AICRP trial for the year 2016-17, seed multiplication of 5 promising cultures (CCB-51, CCB-64, CCB-66, CCB-67 and CCB-72) was done (Table 3.1.5).

Table 3.1.5: Promising extra long staple genotypes for AICRP 2016-17

S. No	Genotypes	SCY (kg/ha)	% yield incr. over Check	GOT (%)	2.5% SL (mm)	Strength (g/tex) (ICC mode)	Mic (µ/inch)	Earliness Index
1	CCB-51	1312	41.1	34	38.1	28.2	3.3	0.74
2	CCB-64	1205	30.4	35	37.2	26.9	3.0	0.75
3	CCB-66	1242	34.4	32	36.1	27.9	3.0	0.73
4	CCB-72	1191	28.9	35	36.9	27.3	3.3	0.58
5	CCB-67	1175	27.2	35	37.1	28.2	3.2	0.74
	Suvin ©	924	-	31	36.5	27.0	3.0	0.71

In another advanced generation trial (BC_2 F_8), 16 stabilized ELS genotypes were evaluated. Pooled data of three years (2013-14 to 2015-16) showed that among the 16 genotypes, the yield performance of 6 ELS genotypes *viz.*, CCB-143 (1281 kg/ha), CCB-93 (1272 kg/ha), CCB-142 (1207 kg/ha), CCB-141 (1119 kg/ha), CCB-140 (1118 kg/ha) and CCB-129 (1141 kg/ha) were significantly superior over the check Suvin (807 kg/ha). With respect to performance, fibre quality and earliness, CCB-143 was stable.

Evaluation of single plant selections from BC_2F_3

Twenty four single plant selections were made from 15 multiple cross combinations involving Suvin as one of the parent. Out of twenty four, six single plant progenies were found promising with high seed cotton yield. The single plant progeny from a cross

SN (SN x ICB 115) 2-7-1-1, SPS-3 produced 131 g seed cotton/plant respectively. A cleistogamous mutant in intra-*barbadense* cross (Suvin x ICB-125) x Pima S-4 was identified from the segregating population.

G. hirsutum

Nagpur

Improvement for earliness, compact type, jassid tolerance and fibre strength

Based on plant width (<60 cm) and number of monopodia (<1.5), N 170, Pratima, CSH 3178, Anjali, CNH 09-7, Arogya, DSC 99, CNH 1102 and AKH 8828 were identified as most promising for compact plant architecture. KC 3, G.Cot 20, CNH 2034, NISC 44, AKH 081, JK-4, CNH 409-9, CNH O7-34, ADB 532 and NH 545 were found promising for jassid tolerance as they had lowest jassid grade (=1) and lower nymph number (<1.8/3 leaves/plant). Based on percent bolls opened on 150 DAS (>95%), Pratima, CNH 409-9, CNHO 12, Sahana, IC 359478, Arogya, G.Cot 18, JK-4, CNH 2028 and F 1378 were identified as promising for earliness. Promising lines were also identified for boll weight, seed yield per plant and fibre quality attributes from 84 genotypes. Twenty-nine promising lines identified in the year 2014-15 were crossed in different combinations and hybrid seed was produced. Crosses attempted in 2014-15 were forwarded to F_2 generation. Evaluation of 154 selected F_3 families led to the identification of some of the promising segregants which matured within 130 DAS (>95% boll bursting), had jassid tolerance and compact plant architecture.

Compact plant architecture

Single crosses, backcrosses, three way crosses and double crosses made between high strength germplasm and high yielding varieties were evaluated for seed cotton yield and fibre properties. Nine hundred single plant selections were made in these segregating generations based on early maturity, tolerance to jassid and seed cotton yield per plant. These selected single plant selections were tested for fibre properties. Crosses (Suraj × CCH LS 2) × IC 359292, (Suraj × G-21-19-615) × (NH615 × CCH 4474), (Suraj × Suvin) × IC 292470, (Suraj × Suvin) × IC 356847 and (Suraj × CCH 4474) × IC 356847 recorded higher seed cotton yield with better fibre properties. Crosses (NH615 × CCH LS 2) × IC 359292, (NH615 × N 170) × (Suraj × CCH 7122), (NH615 × N 170) × (Suraj × CCH 4474), (NH615 × FS1) × IC 359292 were identified for tolerance to jassid coupled with higher yield and better fibre properties over check variety Suraj.

To improve fibre strength, germplasm with high fibre strength were selected for developing a 10 × 10 diallel crosses without reciprocals. Two high yielding varieties NH 615 and Suraj were also used. General combining ability variance (GCA) was higher than specific combining ability (SCA) for upper half mean length, uniformity index, micronaire and fibre strength indicating the predominance of additive gene action in the inheritance of all these traits. CCH 7122 and Suraj exhibited significant GCA effects for all fibre properties traits except micronaire. However, CCH 7122 had significant negative GCA effects for seed cotton yield. G 21-19-619 and IC 356751 recorded highly significant positive GCA effects for seed cotton yield.

Sirsa

Breeding for high strength

Evaluation of F_7 progenies of the two crosses *viz*; CSH 3119-10-30-60 (2960 kg/ha seed cotton, 1067 kg/ha lint yield and fiber strength 27.4 g/tex in HVI mode) and MMO.3 (39-2-5)-3114-10-64 (2976 kg/ha seed cotton, 1020 kg/ha lint yield and fiber strength 26.7 g/tex) were early in maturity and were significantly higher yielding than the check H 1226 (2056 kg/ha seed cotton yield and 723 kg/ha lint yield and fiber strength 24.0 g/tex).

Breeding for high GOT and high yield

Based on the average performance of three years, 13 F_6 (2013-14), F_7 (2014-15) and F_8 (2015-16) progenies [cross SA-977 (HG) x SA-112 (LG) *viz.* P-7(2019 kg/ha seed cotton yield, 780 kg/ha lint

yield and GOT 39%) and P-69 (2033 kg/ha seed cotton yield, 815 kg/ha lint yield and GOT 40.2%) were significantly higher than the check H 1226 (1839 kg/ha seed cotton yield, 625 kg/ha lint yield and GOT 34.4%) over three years. As many as seven progenies *viz.*; P-68, 69, 70, 84, 139, 164 and 184 possessed GOT of more than 40%.

Coimbatore

Identification of compact plants suitable for HDPS

Seven super okra leaf compact genotypes were evaluated with three check varieties, Suraj, Anjali and Supriya under spacing of 30 cm x 10 cm. The culture Surabhi x MM02-19-1-8-2 was the highest yielder (2071 kg/ha). The culture MCU 13 x VNWH 1-7-2 was the best for fibre quality (2.5% span length of 33.1 mm and bundle strength of 23.0 g/tex in ICC mode).

In another station trial with 13 normal leaf types, three cultures showed numerical superiority over the check variety Suraj and the highest seed cotton yield of 2315 kg/ha was recorded in the culture PI 36-3-5-2 as against 2053 kg/ha in Suraj. Quality wise PI 36-3-1-3 recorded 2.5% span length of 31.1 mm and bundle strength of 23.5 g/tex in ICC mode.

From the segregating population, brown colour linted progenies were identified from the cross MCU 13xVNWH-1-4-1-2, 44 single plant progenies were raised which showed four different shades of colour as cream, light brown, brown and dark brown visually. Progenies with good yield potential, big boll types, compact types, good length and strength were identified and selected for further evaluation.

From F_6 generation, 50 single plants were selected for further screening which showed maximum boll weight of 5.4 g. Similarly, 50 single plants were selected for further screening which showed the maximum lint index of 6.6 g. Apart from the above, 39 single plants were selected for further screening which showed the maximum GOT of 47.1%.

Genetic enhancement

Nagpur

In F_9-F_{10}, of the 55 cultures, a maximum of 1629 kg/ha seed cotton yield was recorded in SPS 9-32. Thirty six lines were tolerant to jassids (grade-1, score). BC_3F_7 generation of each cross LRK-516 x (LRK-516 x Deltapine-66) recorded GOT of 37%. Five entries in F_7 *viz.* SPS 8-19, SPS 8-22, SPS 8-59, SPS 8-1, SPS 8-17 recorded high fibre strength, a maximum of 30.4 g/tex and fibre length of 29.1 mm in HVI mode over the check, Suraj (fibre length-29.1 mm, fibre strength-24 g/tex). In F_8, a maximum of 2173 kg/ha seed cotton yield was recorded for SPS8-53 with a boll wt. of 3.9 g. Eight entries recorded >2000 kg/ha seed cotton yield in HDPS (60 x 10 cm) trials.

Among 149 F_3 families evaluated for compact and semi-compact types, eight entries recorded >2000 kg/ha seed cotton yield in HDPS (60 x 10 cm), with a maximum of 2800 kg/ha.

CLCuD resistance

Sirsa

Evaluation of advance cultures : In this trial, 15 *G. hirsutum* cultures were evaluated against the check variety RS 2013, LH 2076 and susceptible check HS 6 in RBD with three replications. The highest seed cotton yield was recorded in CSH 2931 (1818 kg/ha) followed by CSH 2837* (1574 kg/ha) as against the check variety LH 2076 (1495 kg/ha). Maximum GOT of 35.9% was recorded in the variety CSH 2924 as compared to local check varieties 32.4 % in RS 2013 and 32.6% in LH 2076. The culture CSH 2924 also recorded the highest 2.5 % span length of 25.7 mm and 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 a Line x Tester fashion. Out of 91 single plant progenies, six progenies having high yield potential and tolerance against CLCuV were selected in F_4 generation. The culture CSH 1607 recorded the highest yield of 2019 kg/ha followed by CSH 1603 (1898 kg/ha) and CSH 1601 (1806 kg/ha) as compare to check variety LH 2076 (1495 kg/ha). The cultures also have desirable fibre quality traits and lowest CLCuV reaction.

Selection of single plants from progeny row trials : From the fourth cycle of random mating, 102 single plants were selected and raised in plant to progeny row trials having 4 rows each. Based on CLCuV tolerance 65 single plants were selected for further evaluation for seed cotton yield and other economic characters.

Drought tolerance

Nagpur

Three set of experiments were conducted under rainfed and irrigated condition. First set comprised of 13 advance cultures and showed significant difference for seed cotton yield under both rainfed and irrigated condition which ranged from 432-1797 kg/ha and 926-2098 kg/ha. DTS 100 ranked first and second in performance under rainfed and irrigated conditions respectively followed by DTS 62, DTS 44 and DTS 104. Culture DTS 67 had recorded fibre strength of 25.6 g/tex (ICC mode) in the previous year, recorded seed cotton yield of 716 kg/ha and DTE (Drought Tolerant Efficiency) of 45%.

Second set of experiment comprised of 48 single plant selections in which thirty-three selections were similar to check LRA 5166 under rainfed and 10 selections under irrigated conditions, respectively. Top 10 performers recorded more than 40% increase over the check LRA 5166 under rainfed condition. Some of these single plant selections also recorded high drought tolerance efficiency (>91%). Seed cotton yield ranged from 454 – 1846 kg/ha under rainfed and 926 – 2098 kg/ha under irrigated conditions. DTS 150 was the best performer under rainfed conditions and ranked sixth in performance under irrigated conditions with 73% increase over the check LRA 5166 and DTE of 87.4%. DTS 86, DTS 15, DTS 75, DTS 110 were some of the other good selections. DTS 126 and DTS 67 possessed good fibre quality.

Among the F_3 generations of twelve crosses, eight crosses recorded more than 10% increase of yield over the check. Cross PH 93 x Rajat recorded highest seed cotton yield. High DTE was recorded for two crosses *viz*. LRA 5166 x N 170 (98.7%) and 28 I x Suraj (94%). Individual F_2 plants evaluated for fibre quality recorded maximum variability for fibre length (22.6-30.2 mm), fibre strength (19.4-26.7 g/tex), micronaire (2.9-4.3 g/in) and uniformity index (43-55%) in cross 28 I x Suraj in ICC mode followed by cross PKV 081 x P3 and PKV 081 x Suraj, respectively.

Evaluation of single, double, six and eight parental crosses under irrigated conditions recorded high GOT in some of the double and six parental crosses (>38%), UHML in these crosses ranged from 26.1 to 30.5 mm and fibre strength from 24.3 to 27.6 g/tex in HVI mode.

Evaluation of 19 cultures for biochemical and physiological parameters under field and pot conditions was carried out. Based on effect of drought stress on leaf temperature, photosynthetic rate, transpiration rate, NR activity, prolein, protein content, reducing sugar, phenol, amino acid and chlorophyll content, four genotypes DTS 4, DTS 6, DTS 9 and NHP 3 were identified for drought tolerance.

Waterlogging tolerance

Nagpur

In a pot experiment, the identified 150 tolerant accessions were evaluated in three replications for 48 days of waterlogged condition along with a control and morphological adaptations like lenticels and adventitious roots were prominently observed in tolerant accessions. Differences in root growth pattern were also very conspicuous.

Lenticel and adventitious roots in tolerant accessions IC 357477 and IC 359380

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 random mating population : In the previous year, all sterile plants in GMS based RM population were tagged at flowering, allowed open pollination and each plant was harvested separately. Seeds of all sterile plant were divided in two lots. One seed lot was used for planting as plant to row progenies during 2015-16 while the other seed lot reserved for next season sowing. Plants in each progeny were tagged (sterile and fertile) at flowering and observations were recorded on 3-5 fertile plants in each progeny for important economic and quality traits.

Evaluation of single plant selection : Large number of single plant selections from random mating population and reselected plants from the

segregating progenies (2676), were evaluated in plant to row progeny plots. Based on manual checking for fibre quality traits, 112 single plants were selected from the composite random mating population and about 1650 superior single plants were reselected from the segregating plant progenies. Twenty-two single plants of *G. hirsutum* and 48 of *G. arboreum* were identified for evaluation in replicated trial.

Evaluation of advance cultures: About 152 *G. arboreum* and 149 *G. hirsutum* selections identified in 2014-15 were evaluated in 16 replicated trials (4 rows plots in 2 replications) during 2015-16. In all, eight trials each of *G. arboreum* and *G. hirsutum* were conducted with a spacing of 60 x 45 cm and 60 x 60 cm, respectively. Seed cotton yield among the *G. arboreum* cultures ranged from 428 to 1466 kg/ha while in *G. hirsutum*, it ranged from 532 to 1600 kg/ha. Based on the significant seed cotton yield, 77 cultures of *G. arboreum* and 82 of *G. hirsutum* were retained for second year testing. Three cultures were identified for promotion in AICRP on cotton national trials.

Sirsa

GMS based random mating population: A GMS based composite random mating population of *G. hirsutum* was grown. At flowering, all plants in the population were monitored for sterility/fertility at anthesis. About 220 sterile plants were bulk harvested to constitute next cycle of random mating. Single plant selections (150 No.) were grown as plant to row progenies and further selection were made based on CLCuV tolerance and other yield components.

3.4 : Genetic Diversity through Introgression

Selection of introgressed derivatives

In *G hirsutum* based introgressed derivatives; genotypes with fibre length ranging from 25.7 to 28.9 mm and fibre strength ranging from 19.6 to 21.8 g/tex were selected. While in *G arboreum* based introgressed derivatives genotypes with fibre length ranging from 23.2 to 26.5 mm and fibre strength ranging from 20.0 to 23.2 g/tex were selected.

Naturally coloured cotton

Sixteen naturally coloured cotton introgressed genotypes (*G. hirsutum* and *G. arboreum*) were evaluated during the season. Seed multiplication of MSH-53 (Vaidehi-95) was also taken up and 650 kg seed was produced.

An experiment was conducted to record the effect of black cloth on development of lint colour of MSH-53 (Vaidehi-95). It was found that the bolls developed dark brown colour inspite of covering them with black cloth bag which indicates that the colour of lint is genetically controlled.

Development of CLCuV resistant genotypes through introgression

Nagpur

Various breeding approaches were followed to develop populations/genotypes resistant to cotton leaf curl virus (CLCuV) like crossing *G. hirsutum* lines (Suraj, AKH081, NH615 & KC3) with *G. arboreum* lines (Phule Dhanwantri, Cernnum, Roja and PA 255); Colchicine treatment of *G. arboreum* and *G. hirsutum* genotypes; development of synthetic tetraploids of cultivated cotton by crossing *G. arboreum* and *G. herbaceum* with *G. raimondii*; crossing *G. hirsutum* lines (Arogya, DSC 99, KC 3, AKH 081, Anjali, CNH 1102, G.Cot. 16 and Sahana) with PAIG lines (PAIG 62, PAIG 326 and PAIG 346; crossing *G. hirsutum* lines (AKH 081, Anjali, CISH3178, LRA5166, NH615 and Suraj) with the registered genetic stock, IS-376/14/21 (INGR No. 04106; IC427815) reported to possess anatomical features of *desi* cotton in *G. hirsutum* background. The crossed bolls were harvested in all the approaches except *G. herbaceum* × *G. raimondii* crosses.

Sirsa

Crosses involving *G. hirsutum* and *G. arboreum* were attempted and cross seed was obtained. The

autotetraplodization of *G. arboreum* was attempted.

3.5 : Development of Variety and Multi-location testing

Proposal for release of varieties

Sirsa

The proposal for CSH 3075 was submitted for consideration of Central Varietal Release Committee on the basis of average performance of 11 AICCIP HDPS trials (67.5 x 10 cm) conducted in north zone from 2012-13 to 2014-15. CSH-3075 recorded seed cotton yield of 2467 kg/ha. The proposed variety recorded mean fibre length of 26.7 mm, micronaire of 4.13 and fibre strength of 21.6 g/tex in the spinning test (35.5%). The proposed variety was similar to the check varieties for majority of diseases and showed field tolerance to jassids.

Coimbatore

The proposal for identification of long staple high strength culture CCH 4474 for South Zone states under irrigated conditions was submitted for consideration of Central Variety Identification Committee. The culture was found to combine good fibre length of 30.6 mm and bundle strength of 24.0 g/tex and was capable of spinning upto 60s count yarn.

Testing of cultures in AICRP on Cotton

Nagpur

Two entries, CNH 147-1, CNH 126 were entered in Br 02 (a). Four entries, CNH 09-9, CNH 07-16, CNH 1122, CNH 1123 were entered in Br-02(b). In HDPS (Br-06 (a/b) trial, eight entries namely, CNH 140-1, CNH 95-04, CNH 131, CNH 09-7, CNH 09-5, CNH 1124, CNH 20 and CNH 1560 were tested. Five *G. arboreum*, entries namely CNA 2023, CNA 2019, CSA 2043, CSA 1028 and CCA 2033 were tested in Br 22 (a / b). In south zone trials, the entries promoted/retained were CNH 1111 (Br 06 (b)), CNH 25 (Br 06 (a)) and CNA 449 (Br 24 (b)).

Coimbatore

Fourteen high yielding *G. hirsutum* cultures were sponsored for multi location evaluation in AICRP during 2015-16. Of these, eight were tested in National trials and the remaining six were in advanced stage of testing in zonal trials.

The culture Surabhi x M5Z2 18-5 (CCH 15-1) was tested in initial evaluation trial of *G. hirsutum* varieties under irrigated condition. It recorded an upper half mean length of 27.1 mm in North Zone locations, 31.8 mm in Central Zone locations and 32.5 mm in South Zone locations. Further, the culture also exhibited the highest bundle strength of 30.7 g/tex, 32.8 g/tex and 36.1 g/tex in HVI mode in North, Central and South Zone locations, respectively. At Bhawanipatna, the highest strength of 40.9 g/tex was recorded. When the fibre sample was analyzed in Advanced Fibre Information system, it was found to register the least immature fibre content of 4.5 % and the maximum maturity ratio of 0.92 and notably, the short fibre content (<12.7 mm) by weight was only 3.9%. All these factors might have contributed for the high strength in the culture.

The culture MM 03-40-4-3-1 (CCH 15-4) was tested in initial evaluation trial of *G. hirsutum* varieties under rainfed condition in central and south zone locations. The culture recorded an upper half mean length of 31.2 mm in Central Zone locations and 30.9 mm in South Zone locations with bundle strength of 30.5 g/tex and 31.5 g/tex in HVI mode respectively.

The long staple culture MM 03-39-4-2-3 (CCH 14-1) tested in preliminary yield trial under irrigated conditions of both central and south zones exhibited superior fibre quality combining good length (31.6 mm) and strength (33.3 g/tex to 33.8 g/tex).

The compact super okra culture Surabhi x M5Z2 4-2 (CCH 15-5) was tested in AICRP trials under irrigated conditions, and the cultures Surabhi x MM 02-16-5-2-3 (CCH 15-7) and MCU 13 X VNWH 1-7-2 (CCH 15-8) were tested in rainfed situations. All these cultures exhibited excellent fibre quality in the initial evaluation trial and were promoted for evaluation in coordinated varietal trial in central and south zone locations.

In preliminary varietal trial of AICRP 2015-16 (Br 13a), an elite promising *barbadense* genotype CCB-29 ranked third and fourth in yield in Central and South zone, respectively. With regards to quality parameters it ranked fourth in both the zones. In Initial yield evaluation trial of AICRP 2015-16 (Br 12a), a promising ELS selection from an intermated population- CCB-11a had ranked fourth in yield and third in fibre quality parameters.

Sirsa

G. hirsutum cultures CSH 2920 & CSH 2932 in Br 02(a) National trial, CSH 3232 & CSH 3088 in Br 03(a) Zonal trial, GMS based *G. hirsutum* hybrid CSHG 2911 in Br 05(a) National trial, *G. hirsutum* hybrid CSHH 2012 in Br 05(a) Zonal trial, compact cultures CSHH 3158, CSH 5038 and CSH 6109 in Br 06(a) National trial, compact cultures CSH3113, CSH 3178 & CSH 73 in Br 06(a) Zonal trial, *G. arboreum* culture CISA-6-123 in Br 22(a/b) National trial, CISA-6-2 in Br 24(a) zonal trial and *G. arboreum* GMS based hybrids CISAA 14-31 & CISAA 14-32 in Br 25(a/b) National trial were sponsored/promoted during 2015. The *G. hirsutum* hybrid CSHH 2012 was recommended for agronomy based on overall performance in AICRP trials during 2015.

3.6: State Multi-location Varietal Trial

Nagpur

A State Multi-location Varietal Trial (SMVT) of *G. arboreum* consisting of 19 genotypes and 4 control varieties and of *G. hirsutum* consisting of 13 genotypes+4 control varieties with three replications following recommended package of practices was conducted.

In *G. arboreum*, the range for seed cotton yield was 528 to 1114 kg/ha. The maximum seed cotton yield of 1114 kg/ha was obtained with PA-812 followed by JLA-0910 (1108 kg/ha) and CNA 1028 (9970 kg/ha). The control variety JLA 505 recorded highest seed cotton yield of 967 kg/ha which is quite higher than other control and genotypes under evaluation. PA 812 found to be promising with respect to fibre quality traits particularly for fibre length (31.9 mm) and uniformity index (83 %) combined with seed cotton yield. AKA-2004-29 and AKA-2010-10 recorded highest strength of 25.3 g/tex in HVI mode.

In *G. hirsutum*, seed cotton yield ranged from 895 to 1665 kg/ha. PH 1060 recorded significantly high seed cotton yield (1666 kg/ha) followed by culture Phule 688 (1594 kg/ha). Seed cotton yield of control variety NH 545 was 1512 kg/ha. AKH 2006-2 exhibited highest fibre length (31 mm) and strength (26.5 g/tex).

3.7: Molecular Breeding

Nagpur

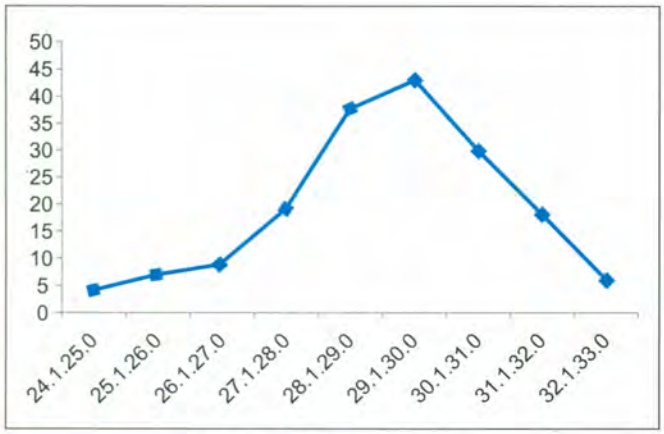
A set of recombinant inbred lines (RILs) developed from a cross between EL 958 and UPA 57-17 following single seed decent method was used for genetic mapping. About 240 progenies were used for phenotyping of fibre quality traits while 188 progenies for SSR marker genotyping.

Survey for informative SSR markers : During 2014-16, 4417 SSR markers were screened for parental polymorphism. Of the 4417 markers, 702 were found to be polymorphic/ informative which accounts for 15.9% polymorphism with the parental lines.

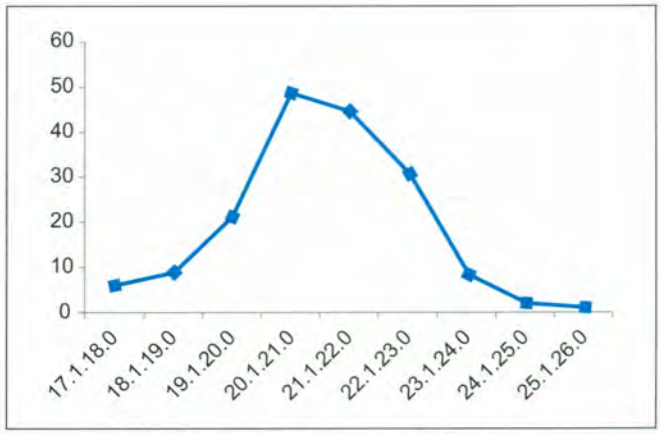
Genotyping of *G. hirsutum* RILs : Of the 240 progenies, the progenies showing more similarity for morphological and quality characters (based on early evaluation) were excluded, and the progenies showing distinct variation for morphological or quality traits were retained for genotyping with informative SSRs.

Genomic DNA of 188 progenies was used for genotyping using informative polymorphic SSRs. About 520 informative SSRs were used for genotyping a set of 188 RILs. Polyacrylamide gel electrophoresis (PAGE) with 8 to 10% concentration was used for fragment separation. About 50% of the markers appeared to be good and the polymorphic fragments were scorable. SSR markers showing polymorphism in parental screening using touchdown PCR turned out to be monomorphic while genotyping RILs and in cases where fragment size difference was very narrow, resolution of fragments was not proper making scoring of the genotypic marker data difficult in many instances and hence ambiguous marker scoring was avoided. The markers /segregating loci showing abnormal segregation pattern or drift in segregation were excluded from the final SSR marker data for linkage analysis. Finally, 227 anchor marker loci were used for making an integrated SSR-SNP genetic linkage map of AD genome *G. hirsutum* cotton. The purpose of the anchor loci was to identify linkage groups to specific chromosome and to make comparison with the already published linkage maps of AD genome.

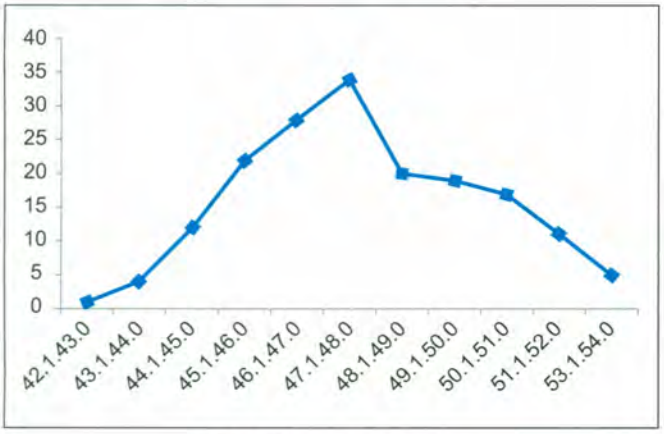
Phenotyping for fibre quality traits : The harvested seed cotton of each RIL progeny was ginned and the bulk lint of each RIL progeny was prepared separately for fibre quality evaluation at GTC, CIRCOT, Nagpur. All the fibre quality evaluation was carried out using HVI Uster using ICC mode for both the years 2013-14 and 2014-15. The frequency distribution for pooled data is shown in Fig. 3.7.1



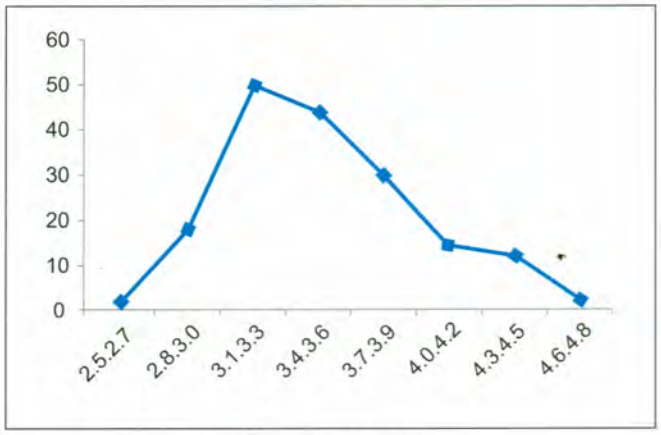
(a) Fibre Length (mm)



(b) Fibre Strength (g/tex)



(c) Uniformity Ratio



(d) Micronaire Value

Fig. 3.7.1: Frequency distribution for fibre quality parameters

The frequency distribution for fibre quality traits, namely fibre length, uniformity ratio, micronaire and fibre bundle strength, clearly indicates normal distribution pattern. It is to be noted that the data was not transformed for plotting the graphs. Normal distribution for all traits clearly indicates quantitative nature of fibre quality traits and merit of the population for linkage and QTL mapping particularly for the above fibre quality traits.

SNP genotyping : Genotyping of 172 RIL progenies with 2730 SNP markers was done by NBRI and data analyzed. The preliminary analysis showed 29 linkage groups with 1.31 cM distance between the consecutive markers.

QTL mapping for fiber traits : Phenotypic data for individual year as well as pooled over the years were used for QTL mapping. Genotyping data for 2730 SNPs (mapped on 29 linkage groups) were used for QTL mapping. QTLs were mapped using composite interval mapping (CIM) approach with the help of software QTL Cartographer. Threshold LOD was calculated for individual experiment. Peaks that qualified LOD threshold were considered as true QTL.

A total of 10 QTLs were identified for staple length, tenacity and micronaire. For staple length, two QTLs were identified each on LG 18 (year 2013/14) and LG 4 (pooled data) with LOD score ranging from 3.72–5.15 and phenotypic variance (R^2) from 8.7 – 10.6%. Similarly, for tenacity, total six QTLs were identified, two on LG 3 and one each on LG 10, LG 4, LG 5 and LG 8, respectively. Out of six QTLs, three were identified in the year 2013-14, two were identified in 2014-15 and one was identified in pooled data. LOD scores for these six QTLs ranged from 3.8 to 7.5 and phenotypic

variance (R^2) from 8.88 to 16.65 %. For micronaire, two QTLs were identified, each in year 2014/15 and pooled data, on LG 18 and LG 4, respectively with LOD score for these two QTLs ranged from 4.1 to 5.8 and phenotypic variance (R^2) from 9.8 to 14.3%.

Maintenance of RILs in diploid and tetraploid cotton: In *G. hirsutum*, 240 progenies were grown in 5 dibble rows for maintenance. Selfed bolls were obtained from each progeny for further maintenance. In *G. arboreum*, a set of 193 progenies were selfed and maintained by single seed descent method. Both the populations were put to use in genetic mapping.

Marker Assisted Breeding

Sirsa

Cotton Leaf Curl Disease (CLCuD)

Screening of new germplasm under field conditions : A total of 940 lines were screened against CLCuD under field conditions along with susceptible check variety HS 6 sown at every 10th line. Three lines which remained free from CLCuD were confirmed under pot conditions through artificial inoculation. Two lines *viz.* PIL 8 and PIL 43 were screened against CLCuD in polyhouse under artificial inoculation using viruliferous whiteflies showed least PDI of 14.5 & 11.4, respectively, as against 61.8 in the susceptible check HS 6.

Bacterial Leaf Blight (BLB)

Nagpur

Screening of segregating populations : Three each of F_2 and BC_1 populations were grown during 2015-16, the population size ranged 150- 200 plants for F_2 and 100-130 for BC_1. The F_2 populations include- LRA 5166 x S-295, Surabhi x S-295 and Surabhi x 102 B and their corresponding BC_1 populations. Individual F_2 and BC_1 plants were artificially inoculated with *Xam* bacterial culture twice. The inoculated plants were covered with transparent polythene bags spread on inner side with water for maintaining humidity inside the polythene bags. After 15-20 days, observations for bacterial blight incidence were recorded on individual plants. Variety Suraj (*G. hirsutum*) and three BC_1 populations were grown in the field. All three BC_1 populations were artificially screened after one month of sowing with *Xam* culture (race 18) sprayed on pin pricked plants in the field. The inoculated plants were covered with polythene bags. After 7 and 15 days of inoculation, water soaked lesions and BLB symptoms were recorded and BC_1 plants were categorized as resistant and susceptible based on symptoms.

Molecular screening : DNA was isolated from BC_1 plants and screened using SSR marker CIR 246. BC_1 plants were categorized as resistant (156 bp+146 bp) and susceptible (166 bp +156 bp) and compared with 101-102B which is universal resistant for BLB having 146 bp. On the basis of phenotypic and polymorphic marker screening, individual plants were selected for crossing. Backcrossing of positive BC_1 plants was done with Suraj to obtain BC_2 seeds during peak flowering. BC_2 crossed seeds were harvested for further advancement. Similarly, at CICR, Regional Station, Coimbatore, BC_2F_1 of the Suraj x CSH 3313 were raised and marker positive plants for BLB were backcrossed with Suraj.

Nematode resistance

The segregating populations namely F_2 and BC_1 developed using nematode resistant and susceptible lines were grown in the field. Genomic DNA of individual F_2 and BC_1 plants was extracted and subjected to screening using SSR markers BNL 3279 and NAU 2152. The marker positive plants in BC_1 were backcrossed with recurrent parent Suraj to obtain BC_2 seeds while F_2 marker positive plants (10 plants each) were tagged and selfed to get F_3 seeds.

Phenotyping of F_2 plants was carried out for reniform and rootknot nematode population. Marker positive plants were resistant to nematode and nematode reproduction rate in these plants was close to the resistant parent G. Cot 10. Further, genotyping and phenotyping of the additional population is being carried out.

At Coimbatore, crosses were attempted between G Cot-10 and American Nectariless (resistant) with susceptible cultivar (Suraj). F_2 population supplied from CICR, Nagpur was grown in pots and genomic DNA of 305 F_2 plants was extracted and the population continued to be genotyped for validation of marker with reniform nematode resistance.

DNA Fingerprinting of public sector released genotypes of cotton

Sixty additional SSR markers were screened for 48 public sector released tetraploid cotton varieties (*G. hirsutum* and *G. barbadense*) and 150 markers for 24 *G. arboreum* varieties during the year 2015-16. For tetraploid varieties, 12 robust markers were obtained, in addition to the 10 already identified during previous year. Thus a total of 22 useful markers found highly informative which are unambiguous, repeatable and able to distinguish each tetraploid cultivar. These markers when subjected to genetic diversity analysis (Darwin software) showed maximum dissimilarity for *G. barbadense* cultivars, Sujatha and Suvin from *G. hirsutum* varieties. Three markers found specific for *G. barbadense* varieties, Suvin and Sujatha; were further confirmed in 20 germpasm lines of *G. barbadense* (Fig. 3.7.2).

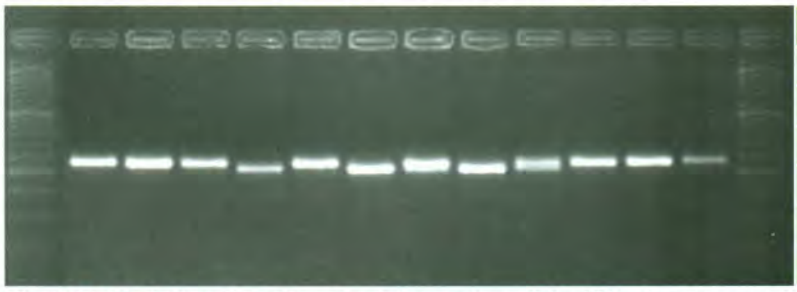
Fig. 3.7.2: DNA fp *barbadense*

Among *G. hirsutum* varieties, DHY 286, CNHO 12, Anjali and PKV Rajat were placed unique and showed maximum dissimilarity from other varieties.

For *G. arboreum*, only 20 markers were polymorphic of the 150 screened showing less genetic diversity (13%) among the varieties. Sixteen of 20 informative markers for *G. arboreum* were found robust and repeatable with PIC values ranging from 0.5-0.7. These markers were effective in distinguishing each *arboreum* variety (Fig. 3.7.3).

Fig. 3.7.3: DNA fp *arboreum*

Above varieties of both tetraploid and diploid cotton were also morphologically characterized for DUS traits. These are being maintained in perennial form in a Varietal Garden. Five CICR hybrids from RS Sirsa, were also characterized morphologically as well as at molecular level. The parents of five hybrids (4 *G. hirsutum* and 1 *G. arboreum*) and two *G. arboreum* varieties were screened using 117 SSR markers with high PIC values (as observed in initial studies). Distinctly polymorphic markers (ranged between 10 and 20) were identified among male and female parent of each of the five hybrids (Fig. 3.7.4). These would be further confirmed in respective hybrids so that a robust DNA fingerprint could be developed for these hybrids.



Lane #	Genotype	Lane #	Genotype
1	CICR2-M	7	CSHH243-M
2	CICR2-F	8	CSHH243-F
3	CSHH198-M	9	CSHH1862-M
4	CSHH198-F	10	CSHH1862-F
5	CSHH238-M	11	CICR1
6	CSHH238-F	12	CICR3

Fig. 3.7.4: Distinctly polymorphic markers identified among male and female parent of each of the hybrids

3.8 : Development of Transgenic Cotton

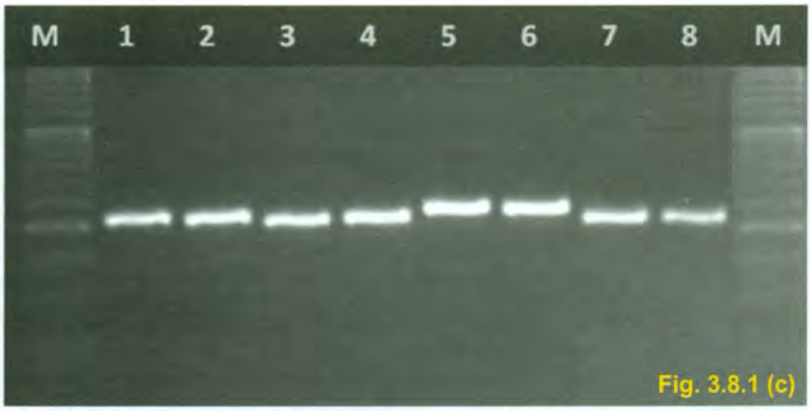
Development of Bt cotton varieties through marker assisted pyramiding of indigenous events

G. hirsutum cv. Coker 310 plants carrying Cry1 Ac (Tg2E-13 event) were received from Delhi University. The seedlings were raised into plants in a contained glass house facility (Fig. 3.8.1a). Six elite cotton genotypes *viz.*, AKH 081, Anjali, CISH 3178, LRA 5166, NH 615 and Suraj were also established to use them as recipients in marker assisted transgene introgression breeding. Presence of Cry1Ac gene in the event was confirmed using gene specific PCR and uniqueness of the event claimed was also confirmed through PCR using specific primers designed based on gene cassette/vector sequence (Fig. 3.8.1 b). Spatial and temporal variation in Cry toxin expression was carried out. Expression was consistent upto at 90 DAS. Leaf bioassays indicated larval mortality to range between 90-100%, 5 days after release of one day old larvae.

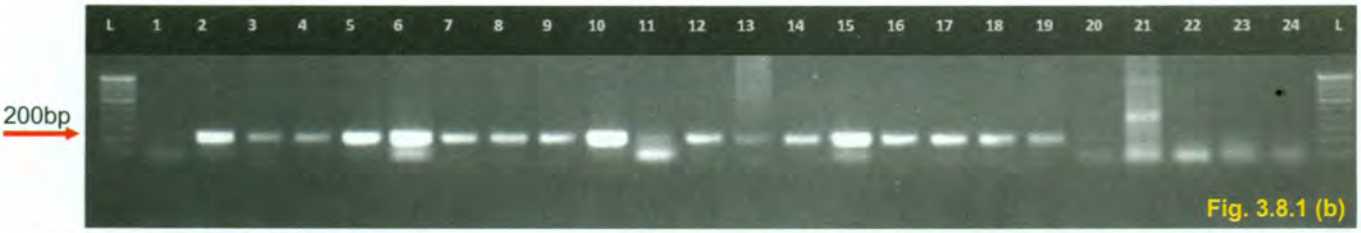
Crossing between donor and recipients were attempted and hybrid seed of each cross was produced in the contained glasshouse facility.

Parental polymorphism survey identified many polymorphic markers for marker assisted background selection (Fig. 3.8.1 c).

Transgenic Coker310 line carrying Cry1Ac gene (Tg2E-13 event)



Identification of polymorphic markers between donor and recipient genotype for marker assisted background selection [L: Ladder, 1:Coker310 with Cry1Ac (Tg2E-13 event), 2: AKH081, 3:Anjali, 4:CISH3178, 5: LRA5166, 6: NH615, 7: Suraj, 8: Coker310 (non-transgenic)]



PCR confirmation of Tg2E-13 events Octopine synthase terminator(ocsT) primers [L=Ladder, 1=No template control, 2-19=Tg2E-13 event samples, 20=Non transgenic sample, 21= JK Bt Sample, 22-24= Mon531 event samples]

In-planta transformation with *cry2Ab1Ac : Chitinase gene*

In the new *in-planta* transformation, two DAP flowers were selected and their corolla tube was removed exposing ovary without style. Transformation with Cry fusion gene was carried out by injecting suspension of Agrobacterium (500 µl Agrobacterium + 2 µl acetosyringone + 1 ml ¼ MS) with the help of syringe through the tip of ovary. Number of bolls set was observed and at maturity 111 open bolls were harvested.

Shoot tip meristem transformation with *cry2Ab1Ac : Chitinase gene*

For shoot tip transformation, during the year, 4020 seeds were surface sterilized and germinated under *in-vitro* conditions. Seven days germinated seedlings were used to isolate 2831 shoot tip meristem explants. These explants were inoculated for 30 min by direct shoot organogenesis and co-cultivated for four days, followed by regeneration of plants with Agrobacterium. In all, 75 plants were regenerated and established in polyhouse for screening.

Somatic embryogenesis of cotton

Hormonal regime for callus growth and proliferation of *in vitro* cultures for cotton genotypes was standardized. Based upon *in silico* studies, novel genes and transcription factor associated with cotton somatic embryogenesis were traced. Subsequent experimental studies have shown that those genes were differentially expressed in cotton callus and are being used to induce somatic embryogenesis followed by regeneration under *in vitro* culture conditions.

Development of protocol(s) for effective gene delivery into cotton

For *in vitro* transformation, complex mediated transgene delivery which was previously cloned virD2 gene from *Agrobacterium tumefactions*

LBA4404 is under expression optimization for designing *in vitro* transformation complex comprises of VirD2-SS T-DNA/ds T-DNA-recA protein for cotton transformation.

Development of transgenic cotton for cotton leaf curl virus resistance

CLCuV transgenic plants obtained by direct shoot organogenesis method were screened for the presence of the gene. Genomic DNA was isolated from the seedlings of genotypes HS 6, H 777 and F 846 with Sense coat protein (SCP), antisense coat protein (ACP), antisense replicase protein (ARep) grown in the polyhouse. The DNA template was used for PCR analysis with the gene specific primers.

F 846 with sense coat protein (SCP) 3 plants and antisense- replicase protein (ARep) 18 plants were positive. HS-6 with sense coat protein (SCP) 4 plants, antisense coat protein (ACP) 5 plants and antisense replicase protein (ARep) 1 plant were PCR positive. In H 777 with antisense coat protein (ACP), 12 plants and with antisense-replicase protein (ARep), 1 plant was PCR positive.

New events were generated in genotypes HS 6, H 777 and F 846 with Sense coat protein (SCP), antisense coat protein (ACP), and antisense replicase protein (ARep) through *Agrobacterium* - mediated transformation.

Validation of fiber strength genes using mutant variety

Lint-less mutant (MCU-5) and its counterpart wild type cotton was used to validate the role of identified candidate genes (*GhcesA1, GhcesA2, GhcesA7, Ghcobl4, and Ghfla3*) in fibre development. Relative gene expression of those genes were compared between wild and lintless mutant using leaf, square and ovules specific transcripts. The results showed that the selected candidate genes are radically expressed in wild type compared with mutant. Down regulation of gene expression in mutant fibre tissues at 10 and 20 dpa (days post anthesis) over wild type has established their role in fibre development. These results confirm our earlier selection of candidate genes based on Recombinant Inbred Lines (RILs) screening. Gene constructs for over expression and down regulation were synthesized with three potential genes such as *GhcesA1, GhcesA2,* and *Ghfla3* using plant transformation vector (pCAMBIA2300) driven by fibre specific promoter and the gene cassette was confirmed by restriction analysis. All the above genes are cloned under 990bp of *GhcesA1* promoter sequences which were chosen based on literature and bioinformatics analysis. To functionally characterize the promoter elements through deletion analysis, three gene cassettes in plant expression vector were generated by cloning 700bp, 990bp and 1.2 kb of promoter sequence in upstream of GUS reporter gene. Genetic transformation of cotton was initiated with all the above constructs for which *G. hirsutum* cultivars Suraj and Coker 310 hypocotyls calli were generated Embryogenic calli was subjected to genetic transformation with *GhcesA2* gene.

3.9 Seed Production and Technology

Seed Production

Nagpur

Around 2235 kg seeds of various categories were produced. Among these, 485 kg cotton seed (stock seed, hybrid seed, *G. arboreum* race cernuum seed etc.) was produced for further multiplication. For Gram cv. Vijay, 17.50 q of certified seed was produced for MSSC, Nagpur (Table 3.9.1).

Table 3.9.1: Seed Production

Crop	Stage	Production (kg)
Cotton -47 varieties (*G.arboreum*-31 & *G.hirsutum*-16)	TFL	274
Gram-Vijay	CS	1750
Cotton hybrid seed production	TFL	12
CICR-2 seed production	TFL	87
Germplasm (for maintenance)		33
Cernnum (for maintenance)		79
Total		**2235**

Seed cotton (15.5 q) of Suraj was obtained from seed producer and 6.87 q seed was processed for further distribution. Seed cotton of Phule Dhanwantry (10.75 q) was procured from farmers/ NGOs at the Institute and processed.

Resource of around Rs 6 lakhs was generated through the sale of these seeds or its by-products.

Sirsa

During 2015-16, 30 kg seed of female and 20 kg of male parent of CICR 2, 60 kg seed of *desi* cotton variety CISA 614 and 60 kg of variety CISA 310 were produced.

Coimbatore

Breeder seed production of Suvin, LRA 5166, Suraj, Surabhi, Sumangala and MCU-5VT was undertaken. During the year 2015-16, a total of 128 kg of breeder seed was distributed to various seed producers.

Seed Quality Improvement

Nagpur

Exogenous application of plant growth hormones and other chemicals on seed yield and quality of cotton variety Suraj was conducted during the season. The experiment included two foliar sprays at 65 and 85 days after sowing for all the treatments. Results indicated that the total seed cotton yield was significantly higher in spermine (0.1 mM) followed by putrescine (4.0 mM) (22.15 q/ha). The cotton seed yield was highest in spermine (0.1 mM) (14.0 q/ha) followed by putrescine (4.0 mM) (13.92 q/ha) and spermidine (0.1 mM) (13.74 q/ha) as compared to unsprayed control (12.31 q/ha).

Seed quality parameters indicated that the highest seed germination was in spermine (0.1 mM) followed by salicylic acid (1.0 mM). Vigour in terms of seedling length was highest in 5-sulphosalicylic acid (0.5 mM) followed by putrescine (2.0 mM) and spermine (0.5 mM). Lint quality parameters were non significant with respect to exogenous application of plant growth hormones.

Sirsa

In studies to improve the seed and boll setting efficiency in cotton, the effect of growth hormones, pollinator attractants and weather parameters were observed on boll setting and seed setting percentage. Highest boll setting of 85.5% were observed with hand pollination. Among other treatments significantly higher boll setting with CICR consortium (83.0%), NPK 2% (82.3%) were observed over control (80.0%). The seed setting efficiency (93.3%) and 3375 kg/ha yield was also higher in hand pollination.

Among the pollen attractants experiment the boll setting was 84.4% with hand pollination and 82.7% with mollases (10%) as against 80.4% in control. The seed setting was also significantly higher in hand pollinations system (93.1%) than all the attractant treatments.

The contribution of pollinators towards percent boll and seed setting in sterile parents GMS-DS-5 and GMS-16-A was estimated. In sterile plants, the boll and seed setting was 18% and 64% in GMSDS-5 and 17% and 59% in GMS-16-A than in fertile-80% and 84% in DS-5 and 85% and 91% in GMS-16-A, respectively.

Coimbatore

Effect of pulsed magnetic seed treatment on cotton seed quality enhancement

A laboratory experiment was conducted with differentially aged *viz.*, 12, 24 and 36 months aged seeds of five cotton genotypes namely Sahana, Supriya, Surabhi, JLH-168 and JCC-1 which were treated with pulsed magnetic field strength of 500 nT, 750 nT and 1500 nT for five hours a day for 15 days continuously. Seeds subjected to 1500 nT (15 days), 750 nT+1500 nT (30 days), 500 nT+750 nT+1500 nT (45 days) were evaluated for seed viability, seedling vigour and biochemical status along with control seeds. The mean data on germination of 36 months stored Sahana seeds indicated a significant improvement of 22%, 22% and 29% respectively when seeds were exposed to 1500 nT, 750 nT+1500 nT and 500 nT+750 nT+1500 nT pulsed magnetic field strength, over untreated seeds. Whereas, in 24 months stored seeds the improvement was 17, 20 and 24%, respectively for the same treatments. In respect of 12 months stored seeds this was 14, 11 and 11 % respectively indicating less response to treatments as against the highly aged seeds. The seedling growth measured in terms of root length, shoot length and dry matter of seedling expressed a similar trend as that of seed germination. The seedling vigour improvement was recorded in all

levels of seed treatment in 36, 24 and 12 months stored seeds, however, the rate of improvement was less in 36 months stored when compared to 24 and 12 months stored seeds. This indicated that seeds maintain vigour proportional to their period of storage. The same pattern of observation was recorded in Supriya, Surabhi, JLH-168 and JCC-1 genotypes and indicated non selective response of seeds to pulsed magnetic treatments due to genotypes.

Another experiment with seeds of ten genotypes (Sahana, Supriya, JCC 1, Abadhita, Surabhi, Pratima, JLH 168, NH 545, Narasimha, Laxmi) with initial vigour levels ranging from low to high was subject to pulsed magnetic field strength of 500 nT, 500 nT+750 nT, 500 nT+750 nT+1500 nT, 750 nT, 750 nT+1500 nT and 1500 nT. Significant improvement was observed in germination of seeds of Sahana, Supriya, JCC 1, Abadhita, Surabhi, Pratima, JLH 168 to the tune of 19,19,22,18,19,6 and 13% respectively over untreated seeds, when subjected to magnetic field strength of 500 nT for 15 days followed by at 750 nT for another 15 days (Fig. 3.9.1). The seedling growth and vigour index also expressed positive response to seed treatment with magnetic field strength of 500 nT for 15 days followed by at 750 nT for another 15 days.

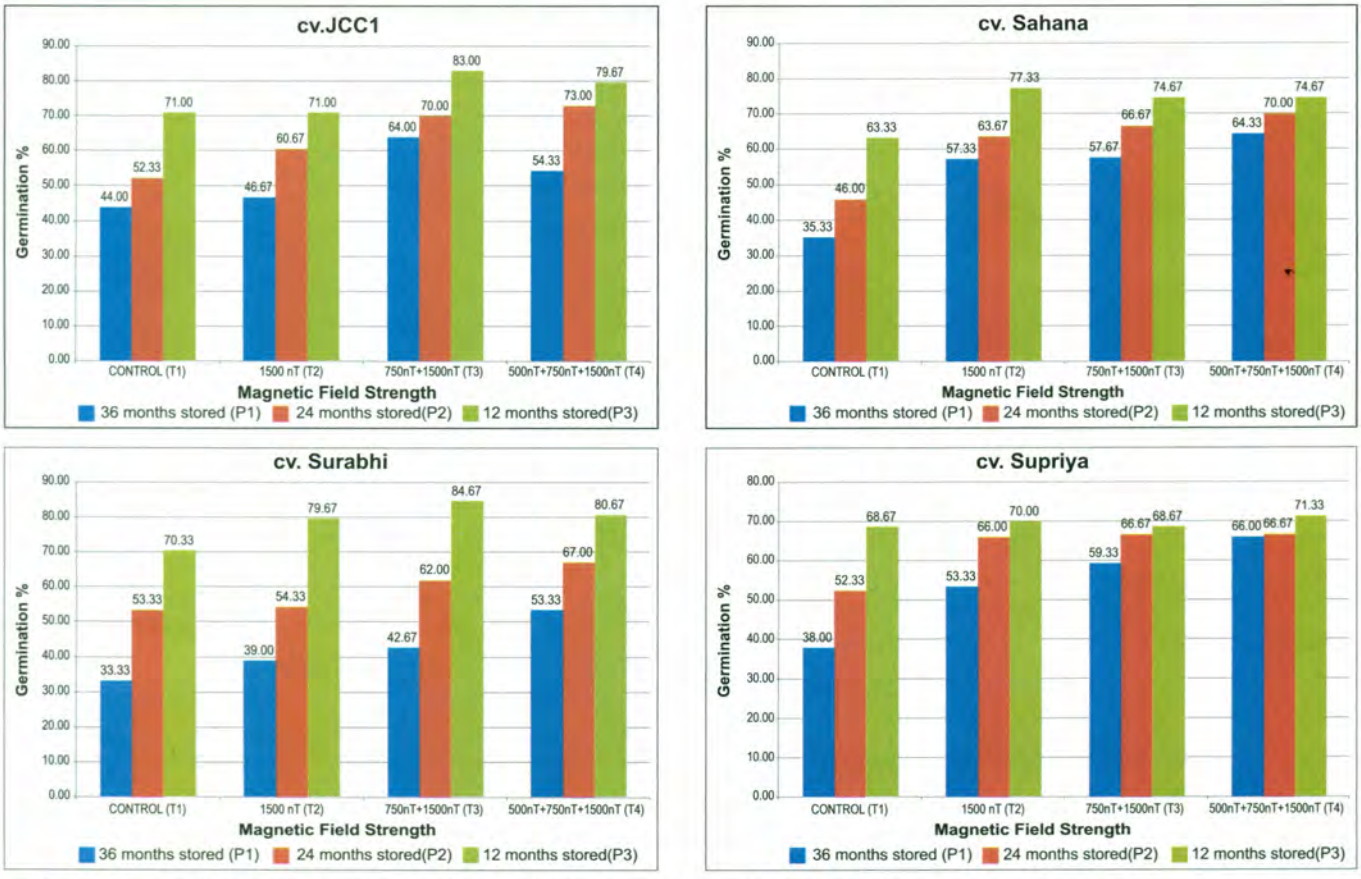


Fig. 3.9.1: Effect of pulsed magnetic seed treatment on germination of stored cotton seeds

Studies on the performance of pink pigmented facultative methylotrops (PPFM) seed treatment on germination enhancement under differential soil moisture

A pot culture experiment was conducted under ambient condition using delinted Suraj cotton seeds with an objective to find out the efficacy of seed priming with PPFM bacterial formulation and subsequent establishment of seedling under regulated soil moisture as per the formulation of TNAU. Delinted cotton seeds were primed with one percent PPFM culture formulation by taking equal volume of seed and solution. Parallely, untreated seeds were sown for all the soil moisture levels. The observation on seed germination, shoot and root length of seedling, vigour index and dry matter

production of seedling was recorded. The mean data showed an improvement in seed germination of 71.5% as against 57.5 % in untreated seeds at 10% soil moisture, maintained throughout growth period. The arithmetic increase of seed germination of primed seeds was noticed up to 35% soil moisture. Sowing primed seeds in 15 to 25% soil moisture followed by watering once in two days also favoured seed germination. Though there was a marginal increase in germination over untreated seeds, when watering was done once in five days in different soil moisture levels, they were significantly low when compared to germination enhancement under continuous maintenance of soil moisture. Therefore, cotton seed priming with PPFM would be useful for taking up seed sowing even when soil moisture is sub optimal provided that the same soil moisture would be maintained till the end of germination period.

DUS testing

Nagpur

Five trials were taken up for DUS characterization which include seven Essentially Derived Varieties and their respective Initial varieties; 13 genotypes under Varieties of Common Knowledge (VCK), 23 new genotypes under first year of testing and 54 genotypes under second year of testing.

In addition to the regular phenotyping of genotypes as per DUS test guidelines, additional traits were studied for its suitability in variety characterization. These included leaf petiole length (4th leaf from top), peduncle length, marginal bract trichome density, seed fuzz percentage. Considerable variability was observed for above traits among the tested genotypes and they could be classified into high, medium and low groups. The method of leaf trichome stain was improvised and a new staining method using toluene blue was developed for a better determination of the density count.

Coimbatore

Three field trials for the establishment of Distinctness, Uniformity and Stability (DUS) of new cotton genotypes, varieties of common knowledge (VCK), farmers variety (FV) and essentially derived varieties (EDV) were conducted as per the test guidelines of tetraploid and diploid cotton. First year testing had 49 new candidate varieties of which 12 were VCK and one FV; 68 new candidate varieties of *G. hirsutum* for second year of testing trial and 19 each of EDV and Initial varieties were taken up in two environment *viz.*, unprotected and protected in third trial. Expression of characteristics of candidate varieties were compared with 60 reference varieties in the trial one and two for establishment of DUS.

One application for registration of extant cotton variety, under PPV&FR Act, 2001 was submitted through NBPGR and the database on varieties released through CVRC and available in public domain, varieties of common knowledge, farmer's varieties, etc., was updated.

In addition to above, seed multiplication and maintenance breeding of 70 cotton varieties of all four cotton species were taken up and the harvested seed cotton was preserved for future use as reference seeds.

3.10 : Nutrient Management

Nagpur

Gadget to detect N stress and correlation of leaf colour transmittance with soil / plant nutrient status

Sand culture experiments were conducted twice from December 2014 to May 2015 and from June 2015 to December 2015 with varying levels of nitrogen (N) to obtain a range of foliar leaf N deficiency symptoms. The first sand culture experiment was used to correlate nitrogen, chlorophyll and anthocyanin contents of third, fourth, fifth and eight position leaves of plants subjected to varying levels of N ranging from 0 to 100% to RGB values of leaves. Digital images were taken in transmittance mode. Good correlation was obtained between

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Nagpur

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RGB values with N and pigment contents of leaves. Based on these observations, a gadget was developed to detect N deficiency in cotton. The gadget was calibrated using data obtained from the second sand culture experiment with varying levels of N and another field experiment conducted using different levels of N and P. Studies indicated a correlation coefficient (R^2) of 0.795 between N content and greenness values obtained by the gadget.

Expression studies of DOF1 (DNA-binding with one finger) transcription factor and downstream genes involved in Nitrogen (N) assimilation

Nitrogen assimilation in plants requires carbon skeleton (2-oxoglutarate, 2-OG), produced from photosynthetic metabolic intermediates in addition to inorganic N present in soil. DOF1 (DNA-binding with one finger) transcription factor regulates the key enzymes linking C and N metabolism and was found to improve Nitrogen Use Efficiency (NUE) under N limiting conditions. An attempt was made to study the expression of *DOF1* transcription factor and downstream genes such as Pyruvate Phosphate Dikinase (*PPDK*), Pyruvate Kinase (*PK*) involved in carbon metabolism and Nitrate Reductase (*NR*), Nitrite Reductase (*NiR*), Glutamate Synthase (*GT*), Glutamine Synthetase *(GS)* involved in N metabolism in plants grown under varying levels of N in sand culture. DOF1 transcription factor expression was low under no N when compared to 100% N. However, at 25 % N the expression level of DOF1 transcription factor and other downstream genes were high, indicating the possibility of increased NUE under N limiting conditions by overexpressing *DOF1* in cotton. The *NR* and *NiR* expression levels were higher in cotton irrespective of the expression levels of *DOF1*. The expression levels of chlorophyll ab binding protein were high in N limiting conditions when compared to 100% N indicating N deficiency induced senescence of cotton leaves.

Coimbatore

During the year, commercially available combined and single forms of micronutrient nanofertilizers were evaluated for its effects on cotton growth and yield. Among the combined form of commercially available nanofertilizers (Richfield, Agriklik, Nualgi and Nanomol), seed cotton yield increased significantly (11 – 20.7 %) with foliar application of recommended dose of Nualgi and Nanomol nanofertilizer at 30 and 90 days after sowing along with basal NPK fertilizers. This was followed by Agriklik and Richfield nanofertilizers. Single micronutrient nanofertilizers *viz.*, Nanobor, Nanomag and Nanozinc were also observed as very good nanofertilizers than combined form of micronutrients nanofertilizers for increasing the number of bolls, boll weight and seed cotton yield.

In a field experiment, normal and nano form of metal oxides like magnesium, zinc, copper and iron were compared with normal sulphate form fertilizers. Averaged over two years, more than 22, 33 and 18 per cent of seed cotton yield was obtained by application of metal oxide nano-particles *viz.*, MgO, ZnO and CuO respectively than control. However, sulphate form of fertilizers like magnesium, zinc and copper increased seed cotton yield by 13, 24 and 11 per cent respectively over control. Seed cotton yield increased with application of normal and nano form of oxide type fertilizers as compared to sulphate form of fertilizers. Moreover, fibre quality para-meters like uniformity ratio and fibre strength were improved by the application of metal oxide nano-particles than control.

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

Nagpur

On deep black soils (Typic Haplusterts), 13 *G. hirsutum* genotypes were evaluated for their amenability to HDPS at 45 x 10 cm, 60 x 10 cm (both high density) and 60 x 30 cm (normal) spacing at Nagpur. The effect of spacing was not significant but significant difference between genotypes and genotype x spacing was observed for seed cotton yield at 165 and 195 days after sowing (DAS). At 165 DAS, the seed cotton yield of the top 6 genotypes planted at 60 x 10 cm spacing were-LRK 516 (2056 kg/ha), Suraj JT (1960 kg/ha), CNH 1111 (1659 kg/ha), CSH 3075 (1651 kg/ha), CNH 09-4 (1645 kg/ha) and CNH 28I (1608 kg/ha). The effect of spacing on the incidence and damage by sucking pests or bollworms was not significant indicating that planting at high density did not aggravate the pest attack. However, differences among genotypes with reference to both sucking pests and bollworms was evident (Table 3.11.1).

Table 3.11.1: Ranking of genotypes on the basis of pest incidence (Lowest incidence is given top rank)

Pests incidence and/or damage in various genotypes under HDPS (Rank)						
Rank	**Aphids**	**Jassids**	**Whitefly**	**Thrips**	**% Square damage by bollworms**	**Pink bollworm**
I	NH-615	Suraj (JT)	CSH-3075	CCH-4474	Suraj (JT)	Suraj (JT)
II	Suraj (JR)	CNH-1110	Suraj (JT), CNH-1111, 28I	CNH-28I	CNH-09-04	CSH-3075
III	CCH-4474	Suraj	Suraj	Suraj	CSH-3178	CNH-1111
IV	CNH-1111, 28I	CNH-1111	CNH-615	LRK-5166	CNH-1111	CSH-3178
V	CNH-09-04	CNH-139, CNH-09-04	CSH-3178	CNH-1110	Super Okra-1	LRK-516

The pink bollworm infestation in rosette flowers was observed at 60-70 DAS. At 90 DAS the per cent disease incidence differed significantly among genotypes but the spacing effect was not significant. Lowest incidence of bacterial leaf blight was observed in CSH 3075 and Suraj JT. The incidence of *Alternaria* leaf spot and *Myrothecium* leaf spot was lowest in CNH 1111. The boll weight was high in CNH 09-4 (3.9 g) and CNH 39 (3.4 g). Genotypes LRK 516, Suraj JT, CNH 09-04 and NH 615 were early and in these genotypes more than 65 % of the total cotton was picked at 135 days and more than 80% of the cotton was picked by 165 days (Fig. 3.11.1).

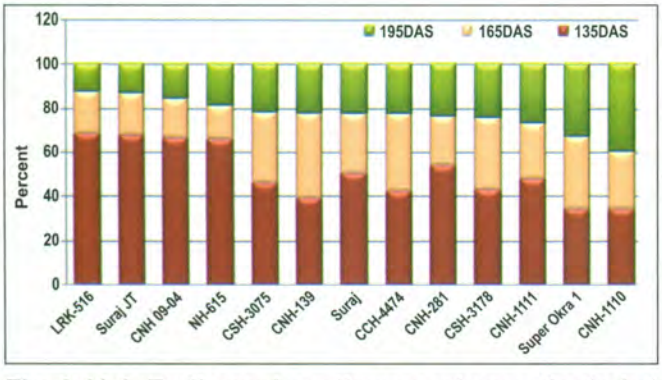


Fig. 3.11.1: Earliness in cotton genotypes planted at 60 x 10 cm spacing expressed as percentage of cotton picked at 135, 165 & 195 days

In another trial 5 genotypes were evaluated at 60 x 10 cm and 60 x 30 cm spacing. The mean yield was 12 % higher at 60 x 10 cm spacing over 60 x 30 cm spacing. The genotypes CNH 25 (2036 kg/ha) and Super Okra 2 (1685 kg/ha) were the highest yielders at 60 x 10 cm spacing.

On rainfed Vertisols, there was a reduction in boll weight at high planting density and 2 sprays of Mepiquat chloride (25 g ai/ha per spray), KNO_3 (3%) and ICAR-CICR nutrient consortia increased boll weight of HDPS cotton and helped to realize equivalent yield to that realized with 125% of RDF (60:30:30).

Clorantraniliprole 18.5 SC and Indoxacarb 14.5 SC were best for the management of bollworms in HDPS. Chlorimuron ethyl 0.07 g L^{-1} as post emergence application was found to be a cheaper alternative herbicide to Pyrithiobac sodium for the control of broad leaf weeds in HDPS. Further, there is no advantage of staggered herbicide application over tank mixture of graminicides and herbicides for broad leaf weed control unless the weed flora is known beforehand.

On deep black soils under rainfed conditions, four *G. hirsutum* entries *viz*., SPS-9.1 ,SPS 27.1, SPS 7.1 and AR-27 were superior to check NH-615 for yield when sown at 60 x 10 cm spacing. Nine entries recorded boll wt. > 3.0 g (maximum 3.8 g). In addition 12 compact type lines (< 60 cm tall) were identified.

Productivity of *G. arboreum* variety Phule Dhanwantary, identified for surgical end use was highest at a spacing of 30 x 15 cm followed by 45 x 15. Among 16 *G. arboreum* genotypes evaluated on rainfed Vertisols at 60 x 10 cm spacing, the seed cotton yield was the maximum with AKA-8 followed by RG-540, CNA-375, Phule Dhanwantary, CNA-418, CNA-423, MDLABB and CISA-6-256. Among these, 11 genotypes *viz*. Phule Dhanwantary, RG-8, RG-540, HD-123, HD-432, CISA-1793, CISA-294, CISA-6-256, MDLABB and CISA-504 were suitable for surgical end use.

Fibre properties of six *G. arboreum* single plant selections *viz*. CNA 2014-2 to 4 and CNA 2014-7 to 9 were analyzed. These cultures were short/ short-

medium staple, coarse cottons with 2.5% span length value between 19.7 to 24.8 mm and micronaire value greater than 5.5. These are thus suitable for making absorbent/surgical cotton and may not be suitable for conventional application of spinning into yarns due to high micronaire and low tenacity (< 20 g/tex).

Coimbatore

Amongst land configurations evaluated for HDPS under winter irrigated conditions with *G. hirsutum* variety Suraj, ridges and furrow method gave significantly higher seed cotton yield (2900 kg/ha) followed by raised bed methods (2820 kg/ha). The control yielded (2370 kg/ha). The gross and net return followed the same trend. Amongst different planters evaluated, inclined plate planter and pneumatic planter distributed seeds within a row uniformly at optimum depth. Manual sowing gave highest yield (2520 kg/ha) but it was statistically at par with inclined plate planter (2450 kg/ha) and pneumatic planter (2430 kg/ha).

Sirsa

Under irrigated conditions on alluvial soils of Sirsa, at 67.5 x 10 cm spacing, the *G. hirsutum* genotypes CPT-50, CSH 3075, CSH 3088, CSH 3114, CSH 3129, SA 1647 and LH 900 out yielded the Bt check Bio-6588. In demonstrations on large plots, CSH 3075 at 67.5 x 10 cm gave 47% increase in yield over Bt check (Bio-6588). Similarly, at 60 cm row spacing, *G. arboreum* cultures CISA 614 and CISA 310 gave 14% and 24% increase in yield respectively when sown in closer (20 cm) intra-row spacing compared to wider (30 cm) intra-row spacing.

3.12 : Weed management

Allelopathy as an alternative weed management strategy for cotton

Nagpur

In the black cotton soils, timely weeding may be difficult during the monsoon season as the soil becomes sticky and wet. Allelopathic cover crop is an option. Twelve cover crops were evaluated for the third consecutive year *vis-à-vis* newspaper and polythene mulch. Weed density and biomass was lower in the cover crop mulched plots than the weedy check and plots without any cover. Effective cover crops were sunnhemp, jowar, bajra, sesame and desmodium. Seed cotton yield was significantly lower in the sorghum and bajra cover crops possibly due to the competitive effects. However, when the same were mulched from the neighbouring plots resulted in the highest seed cotton yields. Methanolic extracts of the effective cover crops were analysed on the GC-MS and major constituents were determined. The maximum relative abundance observed was linolenic acid, methyl ester in jowar and desmodium; ethyl iso-allocholate in pearlmillet; linoleic acid in sunhemp and all trans-squalene, a tri-terpene in sesame.


Newspaper Mulching


Cover Crop Mulching

Coimbatore

Stale seed bed technology (SSBT) and leguminous cover crops (thornless mimosa, sunnhemp, daincha, forage cowpea and Desmanthus) were evaluated as a tool in integrated weed management against the recommended practice of pre-emergence application of pendimethalin and hand weeding done twice. All the cover crop treatments with SSBT recorded significant reduction in weed count ranging from 27 to 42.5 weeds/m^2 as against

163 weeds/m^2 recorded under no SSBT, no cover crop treated with pre-emergence pendimethalin (1.0 kg). Among the cover crops, forage cowpea smothered the weeds efficiently with the lowest weed count of 27/m^2. Seed cotton yield ranged from 3240 to 3581 kg/ha with the cover crops as against pendimethalin (2862 kg/ha).

Survey and identification of weeds of culinary use in cotton based farming system

Survey of the cotton- based farming systems was done and weeds of culinary use were identified. Specimens of weeds were collected from adjoining villages of Nagpur. Some prominent weeds observed were *Celosia argentia*, *Euphorbia hirta*, *Portulaca oleracea*, *Tridax procumbens*, *Commelina bengalensis* and *Digera muricata* (L.) Mart.

3.13: Soil Biology and Biochemistry

Impact of Bt cotton and pesticides on nitrogen fixing soil bacteria

To study the impact of Bt cotton and pesticides on nitrogen fixing soil bacteria in cotton-legume intercropping systems, an experiment with cotton as main crop (Bt and Non-Bt), pigeonpea and soybean as intercrop with three pesticides (Imidacloprid, Thiamethoxam and Monocrotophos) applied as treatments was laid out in replicated strip plot design along with control and respective monocrops. In each plot of intercropping system, two rhizosphere samples each at main crop and intercrop were sampled at various stages of crop growth. Different parameters like beneficial microflora, urease activity, alkaline phosphatase activity, acid phosphatase activity, soil respiration, glomalin content, fluroscent di-acetate hydrolysis, total available nitrogen, Cry toxin and soil microbial biomass carbon were determined. It was found that there was no significant difference between Bt cotton and non Bt cotton, and among different pesticides (Imidacloprid, Thiamethoxam and Monocrotophos) on nitrogen fixing bacteria in cotton-soybean and cotton-pigeonpea inter-cropping systems at different stages of crop growth (60, 90 and 120 DAS and at Harvest). Cry toxins extracted from the rhizosphere soil was not in the detectable range using Bt quant plates. Most of the microbial parameters showed high activity at vegetative and flowering stage.

3.14: Abiotic Stress Management

Role of leaf phytochemicals in cotton leaf reddening and plant response to management

Leaf reddening in cotton hybrid RCH2BG II occurred after first picking during the current season. During the previous season, the mean night temperature reached the lowest (10.8^{0}C) in December and hence severe leaf reddening was observed at peak boll development stage. Contrary to the previous season, the lowest mean night temperature of 11.2^{0}C was recorded during the month of January in the current season and leaf reddening was delayed and occurred mildly only after first picking. Hence yield reduction due to low temperature induced leaf reddening was not pronounced. Differential gene expression studies in complete green and red leaves of cotton confirmed that low temperature induced decline in RUBISCO activity, degradation of chlorophyll ab binding proteins, light harvesting complex II. Subsequent anthocyanin accumulation offered protection to leaves by reduced free radical production as reflected by lower lipoxygenase activity and by enhancing chlorophyll stability index in red leaves. DNA laddering studies indicated that leaf reddening is possibly not a death signal as no fragmentation of DNA was observed.

Response of leaf reddening to management practices was evaluated under field conditions that included 32 treatments comprising of foliar spray of combination of hormones and nutrients at 80 and 110 DAS, spraying of ICAR-CICR Nutrient Consortia resulted in higher yield (3328 kg/ha) when compared to control (2561 kg/ha) which was followed by 2.0 ml/l of Sea Weed Extract (3167 kg/ha) and combination of foliar spray of IBA (10 ppm) at square initiation stage and 2% DAP at 80 and 110 DAS (3042 kg/ha).

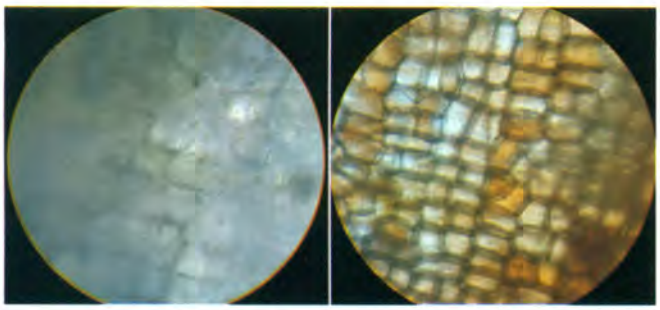
Phenotyping for germplasm lines for drought tolerance

Phenotyping of 104 germplasm lines was done during summer for traits such as mid-day wilting, relative water content and epicuticular wax contents. Fourteen drought tolerant lines and 7 susceptible lines were identified. IC 357406 and Nagpur 9 were found to be highly tolerant to drought. During the regular season, 481 germplasm lines were analysed for epicuticular wax content to correlate with drought tolerance.

Four lines were identified to have high epicuticular wax content of above 200 µg/cm^2.

Marker assisted selection for waterlogging in cotton

Phenotyping of 2700 germplasm lines was done using the following parameters like plant height, height to node ratio, timing of lenticel formation, formation of adventitious roots, number of red leaves and yellow leaves, stem girth and yield and yield components. Two hundred eleven lines were shortlisted as tolerant and forty four lines were shortlisted as susceptible ones. Fifty lines were found to have adventitious roots, nine hundred eighty nine lines developed lenticels and thirty lines developed both lenticels and adventitious roots. Highly tolerant lines have higher stem girth and highly susceptible lines have lower stem girth. Anatomy of lenticels and normal stem area indicated more or less spherical cells with thin cell walls in lenticels when compared to normal stem area of hexagonal cells with thick cell wall. Thin cell walls facilitate the diffusion of oxygen into the roots and exit of toxic chemicals like ethanol from roots which otherwise would be toxic to the plant.



Section of lenticels **Section of normal stem surface**

Effect of elevated CO_2 and temperature on productivity of cotton

Coimbatore

Cotton variety (Anjali) raised under elevated CO_2 atmosphere of 450 ±50 ppm with temperature of 0.5, 1.0 and 1.5°C above ambient in open top chambers revealed that morphological, physiological and yield attributes were found to be very favourable in cotton plants grown under elevated CO_2 atmosphere of 450 ± 50 ppm with 1°C temperature above ambient. Further increase in temperature affected cotton growth and development. For instance, the fruiting coefficient was superior in plants grown at 1°C above ambient with 30.1% while further increase of 1.5°C above ambient reduced the fruiting coefficient significantly to 23.5%. These attributes reflected finally on the yield at harvest. With increase in temperature, yield per plant also increased from 55.1 g in 0.5°C to 61.2 g/plant at 1°C above ambient. However, further increase in temperature of 1.5°C above ambient reduced the yield significantly to 43.1 g/plant.

3.15 : Cropping Systems

Efficient nitrogen fixing legumes for cotton based cropping systems

Nagpur

Twenty different N fixing legumes (food, forage, oil seed and pasture) were evaluated as intercrops in American cotton var Suraj (90 x 10 cm) and *desi cotton* var. Phule Dhanwantry (90 x 10 cm and 60 x 10 cm) to identify compatible legume intercrop for rainfed cotton under deep black soil. Available N status of the soil, morphological and yield parameters were recorded for cotton and the legume during the cropping season. Among intercrops, seed cotton yield was the highest with cluster bean (1408 kg/ha) followed by groundnut and green gram (Fig. 3.15.1a).

Desi cotton when intercropped with groundnut (Fig 3.15.1b) had higher seed cotton yield (2723 kg/ha) followed by intercropping with cluster bean (2455 kg/ha) and soybean (2379 kg/ha).

***Desi cotton* + groundnut**

Coimbatore

Fourteen legume crops were grown as intercrop with Suraj under HDPS (90x10 cm). Intercropping of legumes is beneficial, except vegetable cowpea and Dolichos, which reduced seed cotton yield

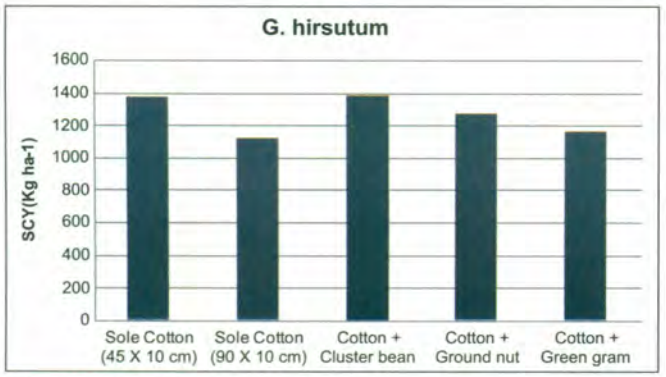


Fig. 3.15.1a: Effect of N fixing legume intercrops on seed cotton yield (kg ha^{-1}) of *G. hirsutum* var. Suraj (90 x 10 cm)

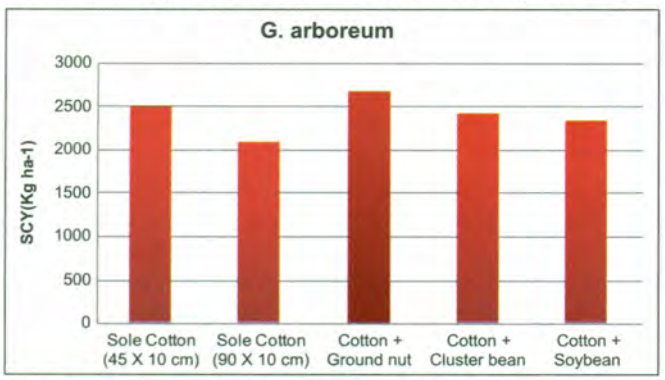


Fig. 3.15.1b: Effect of N fixing legume intercrops on seed cotton yield (kg ha^{-1}) of *G. arboreum* var. Phule Dhanwantry (90 x 10 cm)

significantly. Yield enhancement in cotton due to legumenous intercropping ranged from 1.38 to 13.8 %. Among intercrops, *Desmanthus*, alfalfa and sunnhemp recorded 13.8%, 10.2% and 10.1% enhancement in seed cotton yield due to complementary effect. Cluster bean and redgram enhanced seed cotton yield by 7.86% and 5.82% in addition to 2.83 t and 0.61 t/ha of green pods of cluster bean and 0.61 t/ha of redgram.

Conservation agriculture for cotton-based cropping systems

Coimbatore

Field experiment was conducted with cotton using a strip plot design with three replication. The main plots included conventional system (M_1: Farmer's practice), conservation agriculture (CA) system with minimal land reshaping and partial residue recycling (M_2: 50% of residue from above ground biomass and 100% roots) and CA system with 100% residue recycling (M_3). Beds and furrows system and ridges and furrows systems were used for CA and conventional systems, respectively. 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); S_3: Cotton - Groundnut (for table purpose) + Pigeon pea (Strip cropping) and S_4: Cotton - Fallow (Control). Results of 1st year experiment indicated that there was no significant difference in plant height, dry matter production, number of monopodia per plant, number of sympodia per plant and number of bolls per plant among the treatments. Similarly, analysis of seed cotton yield indicated no significant yield difference in land shaping treatments *viz.*, ridges and furrows (M_1: 3156 kg ha^{-1}), beds and furrows (3059 kg ha^{-1} in M_2 & 3183 kg ha^{-1} in M_3).

3.16: Water Management

Coimbatore

Field experiment was conducted in a split plot design with five replications. Irrigation treatments *viz.*, structured water and bore well water in main plot with four treatments of bio-inoculants in the sub-plot. The structured water irrigated cotton crop was taller, produced more number of leaves had higher chlorophyll content, root cation exchange capacity, nutrient uptake and accumulated higher dry matter production. The structured water irrigated cotton produced significantly higher boll numbers (49.9/plant) as against bore well irrigated cotton (40.1 bolls/plant). The boll weight was also high (5.83 g/boll) as against 5.66 g/boll under bore well irrigation. Averaged over bio-inoculant treatments (sub-plots), the yield gain due to irrigation with structured water was 337 kg/ha. The seed cotton yield with bore well irrigated water was 2836 kg/ha. Irrespective of irrigation treatments, the plots which received combined (seed treatment and soil) application of bio-inoculants + foliar spray of PPFM gave the highest seed cotton yield (Fig. 3.16.1).

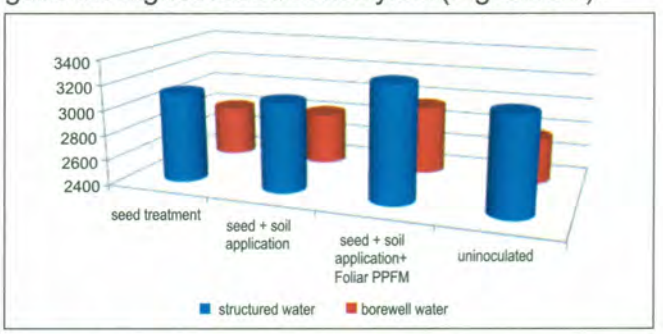


Fig. 3.16.1 : Effect of irrigation treatments and bio-inoculants application methods on seed cotton yield (kg/ha)

3.17 : Morpho-frame / Boll Load Management

Pruning Technique

Coimbatore

Effect of pruning height and time of pruning in cotton

BG II hybrid cotton Bunny, RCH530 and RCH20 were subjected to pruning soon after harvest at various heights at 5, 15, 30, 45 and 60 cm above the soil, while newly seeded crop was raised in an adjacent plot. Study revealed that pruning at 45 cm above soil was characterized with better morphological, physiological and yield attributes at harvest. For instance, yield per plant was 145 g/plant in plants pruned at 45 cm above soil compared to 83.7 g/plant in plants pruned 5 cm above soil. Similarly Bt BG II cotton hybrids namely RCH 530, Bunny and RCH 20 were subjected to pruning at 60, 75 and 90 days after sowing under field condition. Pruning at 60 days after sowing yielded better yield (75.6 g/plant) than pruning at 90 days with 66.2 g/plant while normal crop yielded 89.2 g/plant. The study revealed that in case of complete crop failure during the initial or later stage of crop growth, pruning the whole crop stimulated re-growth with good harvestable yield.

Effect of pruning and seeded crop on yield of cotton

Cotton responded favourably to pruning in both summer and winter crop. Large scale trial revealed that pruning the summer grown crop yielded better than pruned winter crop. Thus one cycle of seeded and pruned crop within a year (winter grown pruned in summer) yielded about 48 q/ha compared to 28 q/ha in single seeded crop. On the contrary, summer grown seeded crop if pruned in winter yielded about 53 q/ha cumulatively while one single seeded summer crop alone yielded 26 q/ha. In both ways, pruning resulted with a beneficial effect not only to increase yield but also double the dry matter production, consequently mitigating climate change by sequestering about 9 tonnes of carbon from atmosphere and fixing in the biomass.

3.18 : Transplanting of Cotton Seedlings

Cotton Transplanting

Coimbatore

Although transplanting technique for cotton has since long been tried and found useful for cotton, cost of raising seedlings remained the main bottleneck in its adoption. A cheap paper-tube technique has been developed to transplant the cotton seedling without disturbing the tap root. Paper tube with size of 1 cm diameter and height of 20 cm were filled (top 1 cm left unfilled to store moisture) with equal portion of vermin-compost, sand and soil and packed gently and compacted. The compactness of the substrate media in every tube is essential for proper germination. Single, healthy seed was dibbled in each tube and water was sprinkled from the top. The tubes were kept in iron tray filled with moist sand (moisture is maintained by sprinkling water) at bottom and covered with wire mesh to keep the paper tubes upright. The seedling at the age of 20 days were transplanted in the main field by planting them in a hole made by crow bar, pressed gently and irrigated immediately. The establishment was quick and complete.

3.19 : Mechanization of Cotton Production

Nagpur

The conceptual mini cotton harvester developed earlier was extended to make a tractor mounted cotton harvester using a 55 hp tractor fitted with a comb type header, a belt conveyor, an onboard field cleaner and a storage tank, under PPP mode with collaboration from ICAR-CICR-CIRCOT and Mahindra & Mahindra tractors. Harvester was evaluated on Bt F_2 hybrid planted at 60 x 10 cm spacing. Machine had a picking efficiency of 97.9% leaving only 2.1% bolls unpicked. However, the header + cleaner + shattering losses were found to be 11.5% with a comb spacing of 16 mm and 12.5 % with a comb spacing of 18 mm. Field capacity of the machine was about 2 h/ha including unloading and idle time of the machine. Onboard cleaner head had an overall efficiency of 54% trash removal lint

basis. It was most efficient in removing bur at 64% lint basis as the bur constituted a significant part of the harvested load at header at about 26.6% of the total mass including seed cotton (68.7%) and sticks + leaves + other debris (4.7%). Variables tested in the onboard settings were (1) various grid bar settings i.e., Normal (14-9.5 mm), Uniform 13 mm, Uniform 15 mm and Maximum (16-12.7 mm) and (2) various speed of drum rotation by changing pulley sizes from 200, 175 and 150 mm. Increasing the rpm of drum by replacing the 200 mm pulley with 175 mm pulley could bring down the fibre neps and seed coat neps favourably within acceptable limits, however increasing the rpm of the drum further with a 150 mm diameter pulley had a deteriorating effect on the fibre properties. Keeping this rotational speed and the 175 mm pulley size constant, the various grid bar spacing resulted in least trash content of 10.5% seed cotton basis with the normal grid bar spacing albeit greatly sacrificing the fibre properties. Uniform spacing (15 mm) resulted in 14% trash content. However, Uniform 13 mm grid bar spacing yielded an acceptable trash content of 12.3% with no loss of fibre properties from the manual picking of cotton. When the machine harvested seed cotton was recycled through the onboard cleaner the first time the bur in the harvested seed cotton came down to 12% from 17%. Yet another pass of this recycled cotton through the onboard cleaner brought down the bur to 6% level.

3.20 : Socio Economic Dimensions of Cotton Farming

e-Kapas

ICAR-Central Institute for Cotton Research, Nagpur has introduced the novel extension mechanism 'e-Kapas Network' project in April, 2012. The project is implemented with involvement of scientists of 18 participating centres in eleven cotton growing states of the country including three centres of CICR *viz*. Nagpur, Coimbatore, Sirsa and 15 AICRP- SAUs centres. The aim is to provide cotton growers 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 & anytime' to users. The components of e-Kapas includes farmers' database, FAQs (Frequently Asked Questions) on cotton, content development & recording of voice messages, information delivery as voice calls on mobile numbers, kapas panchang and cotton apps.

Farmer's registration & e-Kapas farmers' database : During 2015-16 total of 65,142 new cotton farmers with their mobile numbers were enrolled from participating centers from major cotton- growing districts. Overall, a total of farmers registered were 2,14,687 as e-Kapas beneficiary from the 18 cooperating centers. Out of these, a total number of 62,097 farmers were registered from CICR (28,163 - CICR Nagpur; 22,947 - CICR Sirsa & 10,987 - CICR Coimbatore).

Information delivery through mobile based voice messages : ICAR-CICR along with cooperating centers are providing appropriate information timely through Mobile technology on mobile numbers of registered cotton growers. The service is provided to all farmers irrespective of telecom network. During the crop season 2015-16, CICR Nagpur sent 10,50,862 voice SMS in Marathi and 7,12,867 attempted successfully. The system was also adopted in case the phone is engaged or outside the coverage area when the voice message is sent, the calls were repeated later a couple of times to ensure that the farmer does not miss the message.

During the year 2015-16, a total of 9274 cotton growers from major cotton growing districts of Tamil Nadu were identified and registered in e-Kapas network. To the beneficiaries, a total of 72 messages, each of 30 seconds were developed and disseminated. The total number of voice SMS alerts pushed during 2015-16 on 72 content was 6,39,445 out of that 4,19,748 were received successfully by the e-Kapas beneficiaries.

Gender Knowledge System in Agriculture

Women are the major source of knowledge for cotton farming and they have accumulated a variety of indigenous technical knowledge. Women perform many tasks in cotton farming. They constitute almost half of the work force engaged in cotton farms. They participate in a broad range of activities in cotton farms such as production, processing, preservation and marketing. They play key roles in

the entire cropping system, starting from the selection of seeds through sowing, manuring, weeding, harvesting, cleaning, drying, stacking and storing to marketing. In the decision making process at the farm household level regarding the choice of cotton varieties / hybrids as well as the performing the crop protection measures women are active and play major role. The share of farm women in operations *viz*., land preparation, seed cleaning and sowing, inter cultivation activities, harvesting and post harvesting of cotton are tremendous in cotton farming. During their involvement in farm activities such as spraying, dusting and seed treatment, farm women get exposed directly or indirectly to poisonous plant protection chemicals. They became the head of the families of self murdered farmers and owned more responsibilities. In general, and in particular in cotton sector, the unavailability of Gender Disaggregated Data (GDD) is felt as an important constraint and a limiting factor in properly assessing the women's role and contribution in cotton sector and also for studying the gender issues in cotton. The GDD in cotton is crucial for planning, monitoring and evaluation of gender issues in cotton sector contextually. In order to provide better GDD to cotton researchers, development / extension workers and policy makers in cotton sector the project on Gender Knowledge System in Agriculture is being implemented in the institute. The objectives of the project are to develop gender related data / knowledge bases in Cotton, to facilitate wider sharing of gendered information / knowledge in cotton through appropriate modules and user friendly interfaces and to bring out knowledge products on various issues concerning women in cotton. During the year 2015-16, the frontier technologies in cotton which can empower the farm women from the websites of ICAR- CICR and ICAR-CIRCOT were documented along with the studies, programs and policies from the websites of MoA, DOCD and other State Agricultural Departments.

3.21 : Seasonal Dynamics of Insect Pest and Diseases

Nagpur

Sucking pests

Seasonal pest population dynamics data was generated under protected and pesticide free conditions by taking weekly sucking insect counts on DCH 32. Average highest population of aphids and whiteflies (that were negligible) was recorded during second fortnight of August. Jassids were above ETL throughout second week of Aug. to last week of October, peaking during the second fortnight of September. Thrips population was highest between first week of August to first week of September (Fig 3.21.1).

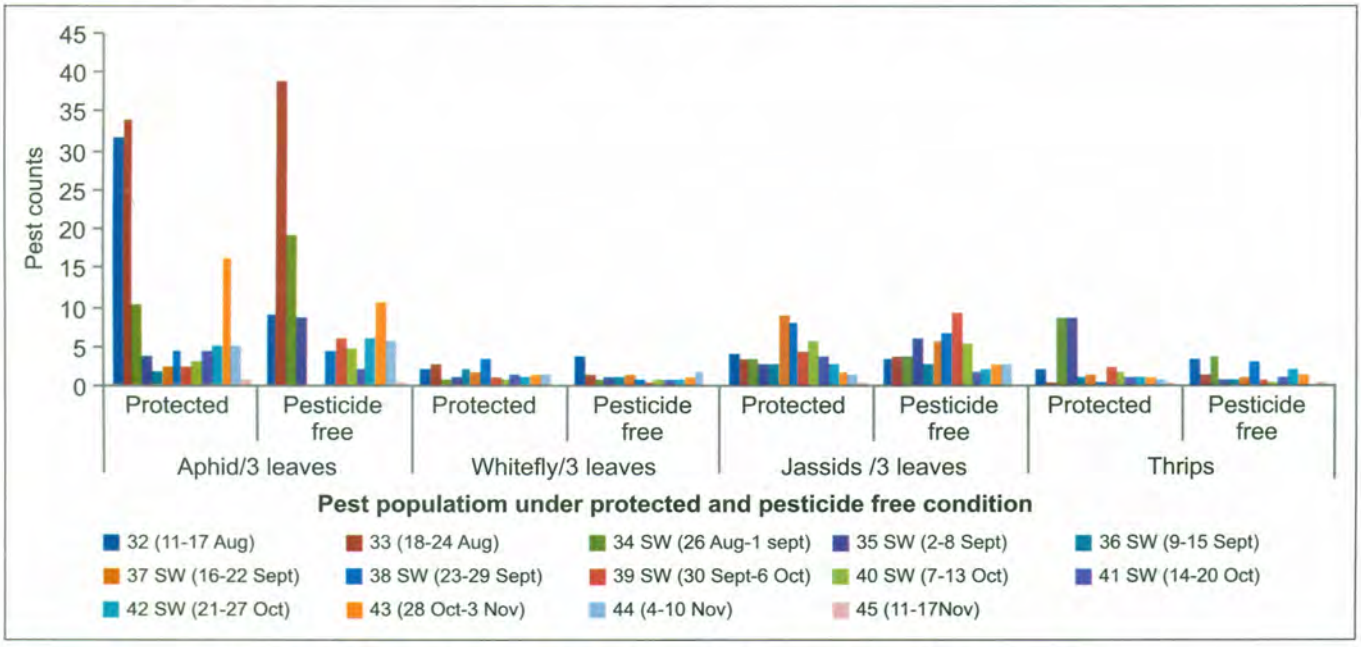


Fig 3.21.1: Seasonal dynamics of sucking pests during 2015-16 at Nagpur

Hot spots of sucking pests in Maharashtra

Jassids : Identified hot spots of jassid infestation where jassid infestation crossed ETL in >20% villages during the season : Akola, Amravati, Yeotmal, Aurangabad, Beed, Jalna, Nanded, Parbhani, Hingoli, Wardha, Nagpur, Chandrapur and Dhule. Second fortnight of August was the peak infestation period of jassid infestation wherein the pest crossed ETL in majority of villages. During the season leaf hoppers exceeded ETL in 1297 and 1479 villages during 17-23 and 24-30 August, respectively.

Thrips : Out of 28 districts, villages in only 4 districts *viz.*, Akola. Amravati, Yavatmal and Jalna were found to be infested with thrips between last week of August to last week of Sept.

Whitefly : Whitefly infestation was seen in several villages of Amravati, Yavatmal and Wardha during second week of September to first week of November.

Bollworms

Pheromone trap catches

Highest moth catches of American bollworm (11 moths/trap/week), spotted bollworm (16 moths / trap /week), pink bollworm (100 moths / trap / week) and tobacco caterpillar (40 moths / trap / week) was recorded at 48 Standard week (SW) (2-9 Dec), 45 SW (11-17 Nov), 44 SW (4-10 Nov) and 45 SW (11-17 Nov), respectively (Fig 3.21.2).

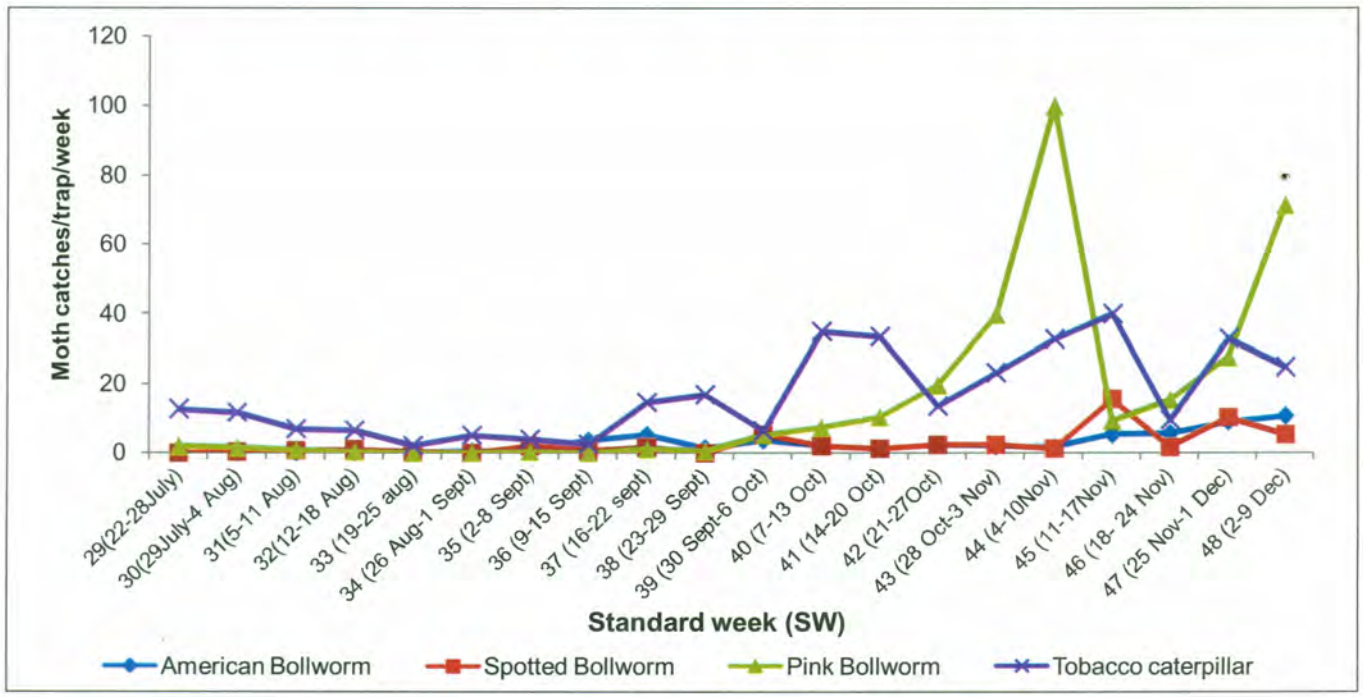


Fig.3.21.2 : Pheromone trap catches of bollworms and tobacco caterpillar at Nagpur

Hot spots of leaf reddening

Leaf reddening : Leaf reddening was seen throughout the season in Ahmednagar district. Leaf reddening was prominently observed during the first week of October to second week of November in Akola, Amravati, Buldhana, Washim, Yavatmal, Aurangabad, Beed, Jalna, Nanded, Parbhani, Wardha, Nagpur, Chandrapur, Gadchiroli and Dhule districts.

Sirsa

Sucking pests

Whiteflies were above ETL throughout the season on the 4 genotypes studied. Leaf hopper and thrips activity was recorded between 27-35 SW and 29 to 35 SW, respectively (Fig. 3.21.3 a, b, c).

Scouting of whitefly population with use of yellow sticky trap was done, where the first treatment i.e. yellow sticky trap (30x22 cm) installed as stationary

units at recommended rates being replaced at recommended intervals accompanied by manual scouting trapped maximum number of whitefly (average 490 whitefly adults)/trap after 24 hours of installation. The second treatment i.e. yellow sticky traps attached by rod on either side of the wheels of a plough so as to move just above the canopy, the average whitefly recorded 210/trap immediately after the operation. The population of whitefly adults available on the plant recorded before and after treatments resulted in non significant reduction in whitefly population except the treatment where need based recommended insecticidal intervention was applied.

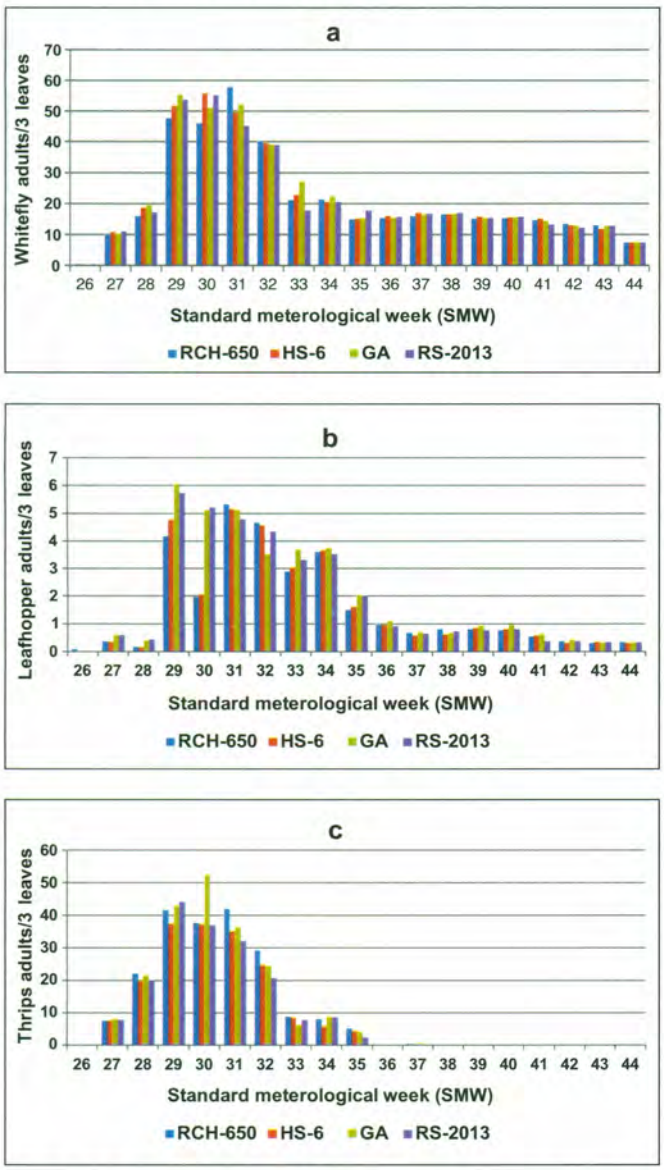


Fig. 3.21.3: Population dynamics of sucking pests in Sirsa a: whiteflies b: leafhoppers c: thrips

Bollworms

Pheromone trap catches

Two distinct *H. armigera* peaks were recorded in 13-16 SW and 40-46 SW while pink bollworm moth activity peaked at the 45 SW (Fig. 3.21.4a). Tobacco caterpillar moth activity was seen throughout the season while spotted bollworm occurred as a late season pest (Fig. 3.21.4b).

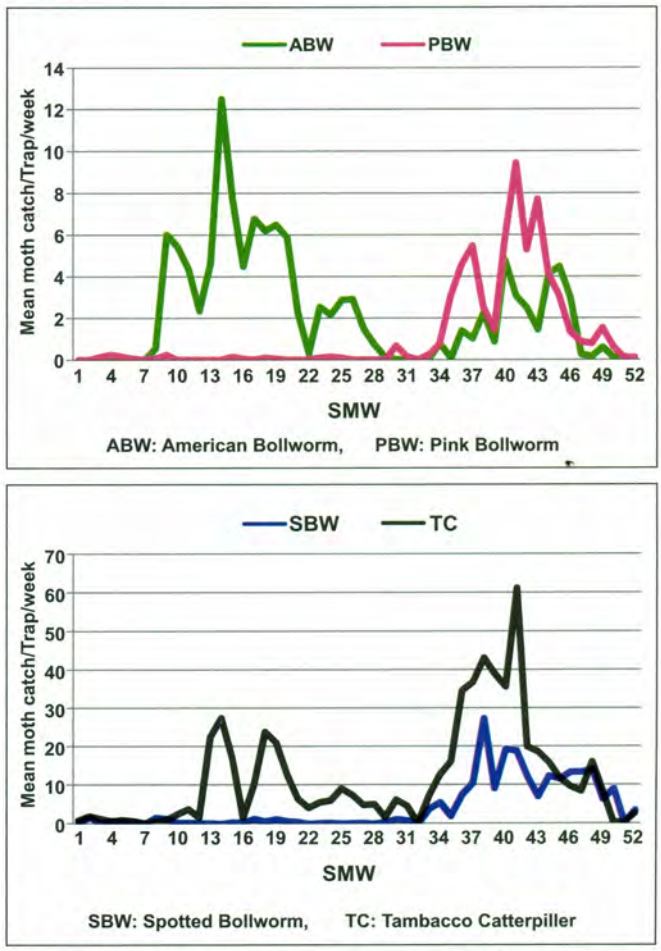


Fig. 3.21.4 : Population dynamics of bollworms and Tobacco caterpillar

Evaluation of ICAR-CICR Whitefly Suction Trap

ICAR-CICR Whitefly Adult Suction Trap is power operated, shoulder mounted, portable and adjustable and helps in suction of whitefly adults available on the underside of the cotton leaves without any harm to the natural enemies flora and cotton crop itself. Data regarding the suction efficacy of the trap was collected during the season. On an average, trap reduced whitefly adults by 26%. However, during peak period, the reduction was up to the extent of 40%.

3.22: Diversity of Insect Pests

Nagpur

Diversity of Mealy bugs

Twelve surveys were conducted covering 91 fields from 5 districts of Maharashtra (Nagpur, Wardha, Amravati, Yavatmal, and Akola) and one district (Chindwara) of Madhya Pradesh during 2015-16. In these surveys, 6 mealy bug species *viz.*, *P. solenopsis*, *N. viridis, M. hirsutus, F. virgata*, *P. marginatus* and *M. hirsutus* belonging to Pseudococcidae family of order Hemiptera were recorded. *P. solenopsis* was dominant species. In most of the places mealy bug population was under control.

Bollworms

All the three bollworms *viz.*, *Helicoverpa armigera*, *Erias insulana*, *Pectinophora gossypiella* were seen to damage cotton. Unusual early incidence of pink bollworm was recorded this year. A small peak of *P. gossypiella* was seen during month of August. Infested flowers turn into rosette shape. September end onwards heavy infestation of pink bollworm was recorded. RCH2 BG-II, RCH2Bt, Ajeet 155-BG-II and Jadoo BG-II and their counterparts were examined starting 135 days after sowing at 10 day interval during *Kharif* 2015-2016. The larval population, number of exit holes and per cent locule damage observed were zero in RCH2 BG-II, Ajeet 155-BG-II and Jadoo BG-II hybrids through out the crop growth period compared to non Bt and BG hybrids. Locule damage was noticed on non Bt and RCH2 Bt cotton hybrids 135 DAS to 175 DAS.

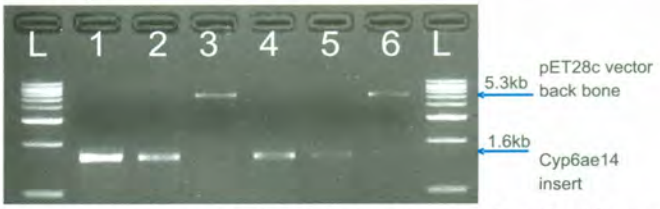
Sirsa

Total 23 alternate hosts of whitefly were recorded during off-season.

3.23: New Genes and Gene Sources for Pest Management

Detoxification method for gossypol reduction using *cyp6ae14*

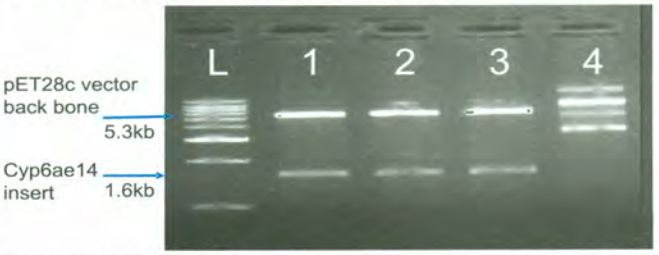
Full length *cyp6ae14* gene initially cloned in T/A cloning vector (pGEM-T easy vector) was further sub cloned into bacterial expression vector pET28c and transformed in to *E.Coli* (αDH5) cells. In order to provide better environment for expression of eukaryotic proteins that contain codons rarely used in *E. coli*, the pET28c with *cyp6ae14* was mobilized into Rosetta gami2 (DE3) cells. The sub cloned gene in pET28c was confirmed through colony PCR and restriction digestion of the plasmid isolated from both the host cells (Fig 3.23.1 & 3.23.2).



Restriction digested (NotI) and dephosphorylated *cyp6ae14* gene and pET28c vector

Lane : L= 1kb ladder, 1,2 & 4,5= *cyp6ae14* gene,3 &6= pET28c vector

Fig. 3.23.1: Restriction digested (NotI) and dephosphorylated *cyp6ae14* gene and pET28c vector



Restriction confirmation of pET28c vector for presence of *cyp6ae14* gene

L-1kb ladder, 1-3: pET28c digested with NotI ; 4: Uncut plasmid

Fig. 3.23.2: Restriction confirmation of pET28c vector for presence of *cyp6ae14* gene

Enterobacter cloacae and gossypol detoxification

The *Enterobacter cloacae* subspp. *cloacae* identified for glyphosate degradation was utilized to assess the possible effect on gossypol detoxification. The overnight grown bacterium was inoculated on known amount of deoiled cotton seed cake and the gossypol content was estimated after 48 hrs of incubation. It was found that, total gossypol reduced from 1.25 % (control) to 0.9 % of treated cotton seed cake.

Identification of suitable reference genes in *Helicoverpa armigera* and *Gossypium arboreum*

Selection of reference gene was been considered an important factor for quantitative gene expression analysis of the target gene. Accuracy and reliability of qPCR results is mainly affected by variation due to different amount of starting material, reverse transcription and PCR amplification efficiency. Hence, an important factor that determines the quantification of qRT-PCR data is the choice of suitable reference genes for normalization. Experiment was carried out by employing the known reference genes for identification of suitable normaliser for gene expression studies at different developmental stages of insect *H. armigera* and cotton *Gossypium arboreum*. Analysis of real time data using geNORM, Norm finder and Best keeper algorithm aided in identification of RPL32 in *H. armigera* and Actin in *Gossypium arboreum* as suitable normalizer for gene expression analysis of developmental stages (Fig.3.23.3).

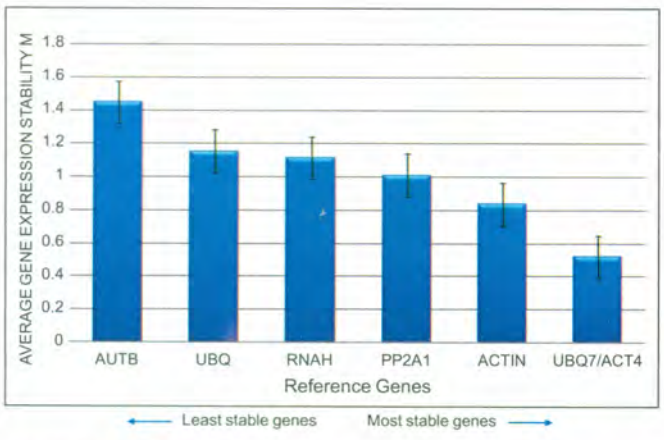


Fig.3.23.3: Stability analysis of reference genes (Normaliser) using geNORM software

Coimbatore

Cotton endophytes for pest management

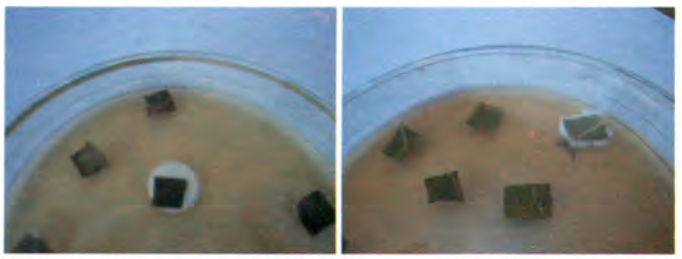
Evaluation of bacterial endophyte inoculated cotton plants

Seventeen bacteria were isolated as endophytes from stem and leaf parts of cotton plant. Of the 17, nine virulence isolates were in the three methods *viz*., seed coating, soil drenching and foliar spray were followed to inoculate the bacterial endophytes into cotton plants in field. Under unprotected conditions, all the treatments recorded significantly lower population of sucking pests *viz*., aphid, jassid, whitefly and thrips than the control upto 120 days after sowing. Among the different bacterial isolates, *Bacillus subtilis*, *Bacillus* sp. E13 and *Bacillus cereus* B1 were recorded with low population of sucking pests. Larval incidence of *Earias* spp and *H. armigera* were almost nil, larval population of *P. gossypiella* was low with a mean of 0.4 to 0.5 numbers/10 bolls. Lowest square damage was observed in *B. subtilis*, *Bacillus* sp. E13 and *B. cereus* B1 inoculated plot. In pot culture, the mortality of aphid, 21% was observed in *B. subtilis* inoculated plant followed by 19% in *B. cereus* strain S-11 inoculated plant. For *P. gossypiella*, mortality of 17% recorded in *B. subtilis* and *B. cereus* strain Z2 inoculated plant. Mortality of 13% for *S. litura* in *B. subtilis* and *B. cereus* B1 inoculated plants was 13% in leaves, foliar application method yielded higher colonization by the isolate *B. subtilis*. In stem portion, seed coating followed by soil drenching gave high colonization by *B. cereus* strain S-1.

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

Eight *Beauveria bassiana* fungal endophytes were inoculated into cotton plant by three methods *viz*., seed coating, soil drenching and foliar spray under field condition (Suraj variety). All the treatments recorded significantly reduced population of sucking pests compared to control under unprotected condition. Among the different *B. bassiana* (Bb) isolates, Bb2, Bb4, Bb3, Bb1 and Bb8 recorded low population of sucking pests. Larval population of *P. gossypiella* was 0.7 to 1.4 in all the treatments. Lowest square damage and larval population/10 bolls observed in Bb8, Bb6,

Bb7 and Bb4 inoculated plots. Under pot culture condition, inoculated plants were artificially infested with aphids, *P. gossypiella* and *S. litura*. The mortality of aphid, was 15% observed in Bb4 inoculated plant followed by 14% in Bb3 inoculated plant. For *P. gossypiella,* mortality of 17% was recorded in Bb4 inoculated plant followed by 15% in Bb1 inoculated plant. Among the four different inoculation methods, foliar spray method resulted in more colonization efficiency (43%) in cotton leaf parts and 40% in stem parts by seed coating method in the Bb4 inoculated plants. Soil drenching method resulted in colonisation upto 30% in leaf and 20% in stem and upto 17% in leaf and 13% in stem with seed immersion method. Irrespective of the methods and isolates, *B. bassiana* colonization was observed in leaf and stem parts of the cotton plant.



Colonisation of inoculated *B. bassiana* in cotton leaf parts

Colonisation of inoculated *B. bassiana* in cotton stem parts

3.24 : Assessment of Refugia Seed Packets Procured from Open Market

Nagpur

Trait purity in Commercial Bt packets

Thirty Bt seed packets were procured from open seed market in 2015-16. Single gene Bt i.e. Bollgard was not available commercially. Bt packets carried seed with the trait claimed on label. Non Bt packets also carried either Cry1Ac, Cry2Ab or Cry1Ac + Cry2Ab. Germination of seeds of refuge was poor. Non Bt refuge seeds of 25 hybrids showed asynchrony in flowering in relation to Bt hybrids when sown in the field during 2014-15 (Table 3.24.1). Field studies to ascertain synchrony was not carried out this year.

Table 3.24.1: Assessment of refugia seed packets procured from open market

Year	2014-15			2015-16	
Bt vs Non Bt	Bt-cotton	Refuge		Bt-cotton	Refuge
Species	*G. hirsutum*	*G. hirsutum*	*G. herbaceum*	*G. hirsutum*	*G. hirsutum*
Mon 531 event (BG)	10/10	3/10	0/0	-	-
Mon15985 event (BGII)	81/81	23/80	0/1	30/30	12/30
Cry1Ac	91/91	26/90	0/1	30/30	12/30
Cry2Ab	81/81	23/80	0/1	30/30	12/30
Germination					
>75%	45/45	39/44	1/1	30/30	9/30
50% - 75%	-	-	-		14/30
25% - 50%	-	-	-		6/30
<25%	-	5/44	-		1/30
Flowering window					
≈ 45-70 days	3/40	-	-		
≈ 55-80 days	27/40	17/38	-		
≈ 65-90 days	10/40	22/38	1/1		

3.25 : Development of New Methods, Tools and Protocols

Nagpur

Effect of ethylene inhibitors on pest infestation, squares and bolls retention, period of boll development, maturity and yield in cotton

Five ethylene inhibitors *viz.*, potassium permanganate (100 ppm), paraclostrobin (1 gm/l), cobalt chloride (10 ppm), potassium nitrate (200 ppm), silver nitrate (50 ppm) were applied twice, first spray at 86 DAS (days after sowing) and second 121 DAS on cotton sown in HDPS (60 x 10 cm) with straight variety Suraj. Results indicated that application of ethylene inhibitors had no significant effect on pest population (aphids, whitefly, jassid, thrips, mirids and *Helicoverpa*), square and boll retention, per cent square and boll damage and yield in cotton. Period of boll development was not statistically different with the application of ethylene inhibitors. There was no significant difference in boll opening when observed at 121 DAS, however, at 130 DAS, delayed boll opening was recorded with the application of cobalt chloride (10 ppm), silver nitrate (50 ppm) and water sprays. Boll opening with in paraclostrobin was nearly 50%.

Ethylene emission reduction in wilted plants

To record the recovery of wilted plants of Bt hybrid (RC-2 BG II) six treatments *viz.*, cobalt chloride (100 ppm) spray, bavistin drenching (1 g/l), cobalt chloride (10 ppm) spray + bavistin drenching (1 g/l), water spray, water drenching, water spray + drenching and healthy plant as control were imposed on 5 plants in each treatment. Pre-treatment of ethylene emission readings were taken 24 hours before treatment and post treatment readings at 48 hours after treatment. None of the wilted plants recovered even after imposing these treatments when observed after 3 weeks later. Wilted plants emitted significantly higher ethylene than healthy plants.

Production of Bt toxin on solid medium

Cry toxin was produced on a novel low cost solid medium. Bt K HD1 was cultured on solid substrate to yield Cry toxin (1 ug/ml). At a concentration of 0.1 ug/ml of diet of this toxin, mortality of *H. armigera* neonates was 50% while mortality caused by the standard toxin at a concentration of 1.97 ug/ml of diet was 70%. Growth regulation at the same dose was 60% and 100%, respectively. Mortality of 4 day old *S. litura* was negligible with the test (0.1ug/ml of diet) and standard (1.97 ug/ml of diet) toxins while the growth regulation was 71% and 75%, respectively.

Boll Bioassays with pink bollworm

One day old larvae were released on green bolls of 100 day old plants of BGII. Green bolls were covered with paper bags. Observations on exit holes, mines on epicarp, number of larvae and percent locule damage were recorded 21 days after release. Putative Cry2Ab resistant culture as neonates caused 67-100% loculi damage in non Bt control bolls while 25-50% loculi damage was caused on BGII green bolls.

3.26 : Natural Enemies and Biological Control for Insect Pests

Nagpur

Biological control agents of mealy bugs : Five biological control agents *viz. A. bombawalei, T. radiata, P. mexicana, P. unfasciativentris, A. kamali* were recorded on mealybugs (*P. solenopsis*, *N. viridis,* and *P. marginatus)* in 7 districts of Maharashtra. *A. bambawalei* was dominant species while remaining was observed in traces on *P. solenopsis*.

Natural enemies of cotton pests : Parasitoids *Apanteles angaleti Muesebeck*, *Apanteles glomeratus* (L.), *Palexorista laxa Curran* were recorded on cotton semilooper, *Aphelinus mali* on aphids while *Encarsia hayati* was recorded on whitefly. General predators of cotton pests *viz.*, lady bird beetle *Cheilomenes sexmaculata* (Fab.), transverse ladybird beetle *Coccinella transversalis 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.

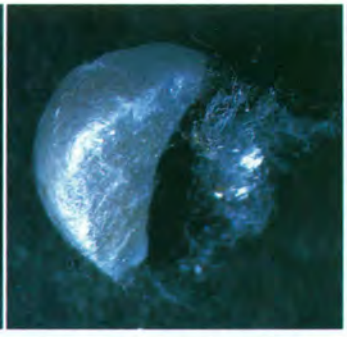
***Bracon lefroyi* on Pink bollworm from Bollgard –II**

Endoparasitoid *Bracon lefroyi* Dudgeon & Gough (Braconidae: Hymenoptera) was recorded on pink bollworm larvae collected on RCH 2BGII of Surat district. The total larval recovery in RCH2 BGII was 52% as compared to 20% on non Bt. Dead larvae

were observed inside a large number of green bolls dissected. Collected larvae placed in vials showed braconid parasitoid developing to pupae and later to adult.

Dead PBW Larva

Bracon lefroyi Larva



Bracon lefroyi cocoon

Bracon lefroyi adults

Development and standardization of Reverse Transcription loop mediated Isothermal amplifica-tion (RT-LAMP) Protocol

Tobacco Streak Virus (TSV) belongs to the genus Illarvirus of the family Bromoviridae and transmitted by thrips is an emerging pathogen posing threat to the cotton growing belt of south and central India.

Symptoms of TSV on cotton

It has a wide host range infecting more than 200 plant species belonging to 30 plant families. These characteristics make it one of the economically most important plant viruses in commercially grown crops. Also symptoms developed due to TSV infection in cotton plant resembled with physio-logical or nutritional disorders and herbicide phyto-toxicity which is very difficult to distinguish. However, detection based on symptoms alone is unreliable and inaccurate. These observations strongly demand proper evaluation and diagnosis of TSV infection. Therefore, confirmatory testing by nucleic acid-based diagnostic assay is necessary. Considering the above facts, single tube, reverse transcription loop-mediated isothermal amplifica-tion (RT-LAMP) assay was employed to develop a simple and efficient technique for the detection of TSV in diseased cotton (*Gossypium hirsutum*) and soybean (*Glycin max*) plants. RT-LAMP assay is a novel method of gene amplifica-tion that amplifies nucleic acid with high specificity, efficiency, and rapidity under isothermal conditions. Detection of target sequence amplifica-tion was accomplished by 1.5% agarose gel electrophoresis to confirm the amplification (Fig. 3.26.1). Also the colorimetric detection by using different chemical dyes was standardized (Fig.3.26.2). Results indicate that the RT-LAMP assay is extremely rapid and highly sensitive and has potential usefulness for rapid and easy detec-tion of TSV virus and their surveillance.

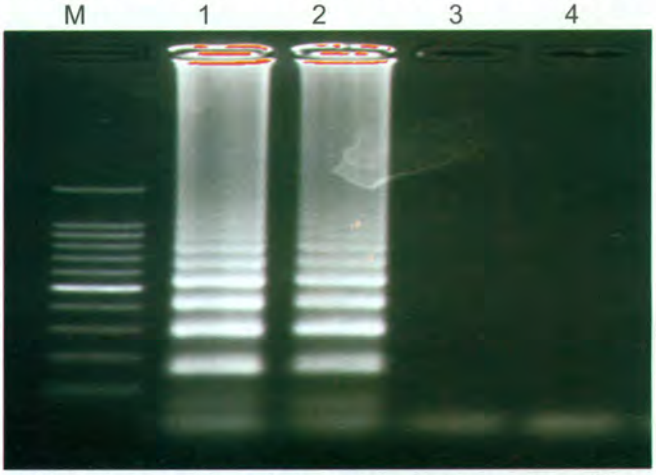


Fig.3.26.1 : Detection of single tube isothermal amplifica-tion by 1.5% gel electrophoresis

Where 1 = soybean sample, 2 = cotton sample, 3 = No template control, 4 = Blank (H20) Control

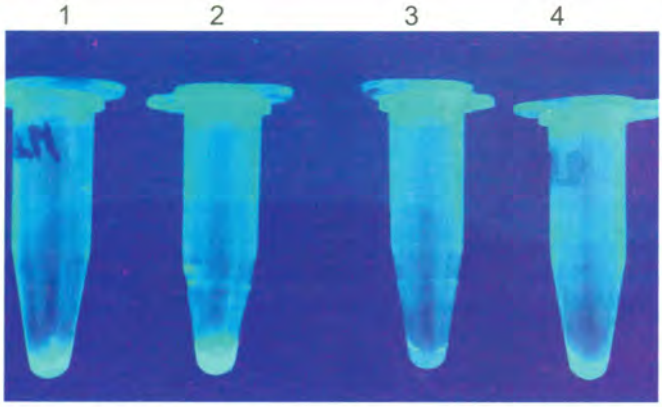


Fig.3.26.2 : Colorimetric detection of LAMP by using Syber safe DNA gel stain

Where 1 = Positive soybean sample, 2 = Positive cotton sample, 3 = No template control, 4 = Blank (H20) Control

Microencapsulation of Bt toxin for management of cotton bollworm

Coimbatore

Bacillus thuringiensis (Bt) is used as biopesticides because of its toxicity to the insect larval stages. Variable environmental stress, such as UV radiation, rain, and temperature, leads to inactivation or rain-washed of the crystal proteins. Several methods was investigated to protect as well as improve the activity and efficiency of these toxins. Attempts were made to extend the activity of Bt toxins through micro-capsulation method. Poly allyaamine hydrochloride (PAH) and poly styrene sulfonate (PSS) were fabricated through layer-by-layer self-assembly based on a $CaCO_3$ core. Cry1Ac protoxins were loaded into microcapsule through layer-by-layer self assembly at low pH (pH 3), and the encapsulated product was stored in distilled water. Scanning electron microscopy (SEM) was used to observe the morphology of the capsules (Fig. 3.26.3 and Fig. 3.26.4)

Calcium core was prepared by using Na_2CO_3 and $CaCl_2$ in distilled water under magnetic agitation and PSS was added as an additive to enhance the core formation. The adsorption of polyelectrolytes on to the $CaCO_3$ microparticles was carried out by Tris-HCl buffer (pH 7.0). Subsequently PAH layer was coated on the $CaCO_3$ microparticles. This process was repeated once for achieving bi-layers of PSS/PAH/PSS/PAH. Further, the polymer coated $CaCO_3$ particles were dissolved in EDTA solution under agitation to remove the $CaCO_3$ core and polymeric hollow microcapsules were prepared.

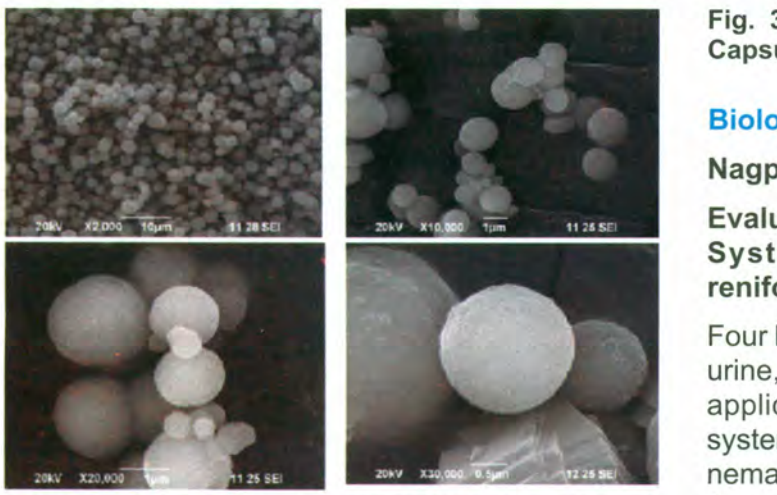


Fig. 3.26.3 : SEM Photograph of prepared microcapsule with $CaCO_3$ core at different magnifications

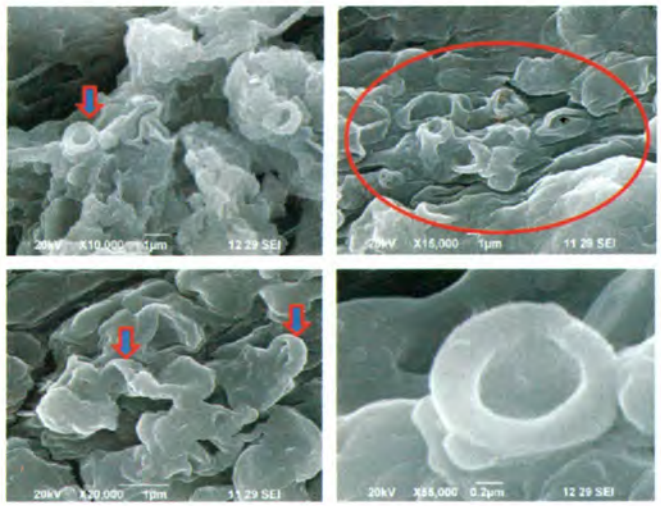


Fig. 3.26.4 : Capsules after dissociation (Empty) Capsules of the $CaCO_3$ capsules.

Biological Control

Nagpur

Evaluation of bioformulations for induction of Systemic Acquired Resistance against reniform nematode

Four bio formulations (curcumin, turmeric raw, cow urine, neem cake) applied as spray or soil application were evaluated for induction of systemic acquired resistance against reniform nematode under field condition. Effect of bio formulation on nematode population in field and on final cotton yield was evaluated. Four sprays of the

formulation containing Curcumin 1% was most effective in reducing reniform nematode population to the time of 80 % and almost 11.63 q / acre doubling seed cotton yield as compared to control (6.6 q/acre). The spray treatments were better than the corresponding treatments applied to soil in reducing nematode population and increasing seed cotton yield.

Bacteria *Lysinibacillus sphaericus* was isolated as endosymbiont from females of *R. reniformis*. It was identified and characterized based on rRNA. Cell free filtrate of this bacterial suspension 108 per µl was found to cause mortality of *R. reniformis* pre-adults in the range of 75-87%. Efficacy of *L. sphaericus* was evaluated as seed treatment on *R. renifomis* under pot conditions. Cotton seed cv Suraj was dipped in bacterial suspension alongwith sticker and partially dried. Sowing was done in 15 cm pots with sterile soil. Pots were inoculated with 1500 *R. reniformis* pre-adults per pot at time of sowing. Plants were harvested after two months and total population of *R. reniformis* in soil and roots was estimated. Results indicate that nematode population reduced by 35% in seed treated with *L. sphericus*. In split-root experiments, *L. sphaericus* was used as inducer on one root half and other half was inoculated with the reniform nematode. A significant reduction in nematode infection was detected indicating induction of systemic acquired resistance by bacteria.

Coimbatore

Epizootic occurrence of *Cladosporium cladosporioides* on *Aphis gossypii* in Cotton

Natural occurrence of *Cladosporium cladosporioides* on *Aphis gossypii* in field condition was positively correlated with relative humidity and negatively correlated with temperature. Maximum mycosed insects were recovered in 39 and 45-46th standard week in cotton.

During field survey natural infestation of cotton aphid to the extent of 45 per cent by an entomopathogenic fungus was recorded on farmers field in village Virugalpatti of Taluk Udumalpet. The fungus was identified as *Fusarium semitectum* = *Fusarium incarnatum* (Desm.) Sacc. at Agharkar Research Institute , Pune.

Safety of biopesticides to natural enemies

Spraying of Coccinellid beetle, *Cheilomenes sexmaculata* with spore suspension of *Lecanicillium lecanii* at 10^6-10^8 spores/ml in direct and indirect (residual toxicity) method was found to be safe for grubs and adults under lab and field condition. Soil application of *L. lecanii* at field recommended dose, ten times of field recommended dose and culture filtrate as such was found safe to earth worm. Irrespective of the treatments tested, no reduction in weight of the worms, was recorded over control.

Persistence of biopesticide formulation under field condition

Spraying of biopesticide formulation of *L. lecanii* with corn oil and skimmed milk powder recorded maximum persistence of spores on cotton leaves for four days. Spores could be isolated from leaves upto seven days after spraying also. Among seven oils tested for the development of oil based formulation of *L. lecanii,* corn oil at 10 % recorded maximum spore germination at 24 hours after inoculation whereas least germination was recorded in coconut oil. Among 14 UV protectants tested, starch, tinopal, mango leaf extract and skimmed milk powder recorded more than 95 per cent germination at 24 hours after inoculation. But mango leaf extract significantly reduced the growth of fungus.

Field evaluation of biopesticides

Spraying of talc-based formulation of *L. lecanii* and *M. anisopliae* at the rate of 10 g/l significantly reduced the population of aphids, jassids and whitefly under field condition. Among different treatment tested, insecticides ranked first followed by biopesticides in reducing the sucking pests under field condition. Field evaluation of two talc-based formulation of *L. lecanii* and *M. anisopliae* under AICRP on cotton centres revealed that they were safer to natural enemies (spiders and coccinnellids) and reduced the sucking pest population.

Pathogenicity of native entomopathogenic fungi to whitefly

Native isolate of five entomopathogenic fungi (*L. lecanii, Metarhizium anisopliae, Fusarium pallidoroseum, C cladosporioides and F. semitectum*) were tested against whitefly nymphs under laboratory condition. Spraying of fungal

suspension at 1×10^4, 1×10^5, 1×10^6, 1×10^7, 1×10^8 and 1×10^9 spores/ml significantly reduced the survival of nymphs. Among them, *L. lecanii* recorded maximum mortality of nymphs.

Evaluation of bionematicide formulation

Soil application of talc-based formulation of a native nematode antagonistic fungus; *Purpureocillium lilacinus* significantly reduced the reniform nematode population in soil and root and increased plant growth of cotton.

3.27 Integrated Pest Management

Insecticides for bollworm management

Nagpur

The field experiment was conducted to study the effects of Clorantraniliprole 18.5 SC, Flubendiamide 480 SC, Spinosad 45% SC, Indoxacarb 14.5 SC and Emamectin benzoate 5 % SG against bollworm (*H. armigera*) of cotton under high density planting system (HDPS) of Suraj. The lowest per cent of fruiting bodies damage was observed in Clorantraniliprole 18.5 SC and Indoxacarb 14.5 SC with significant difference over other treatments (Fig. 3.27.1). Natural enemy populations were not significantly different between treatments.

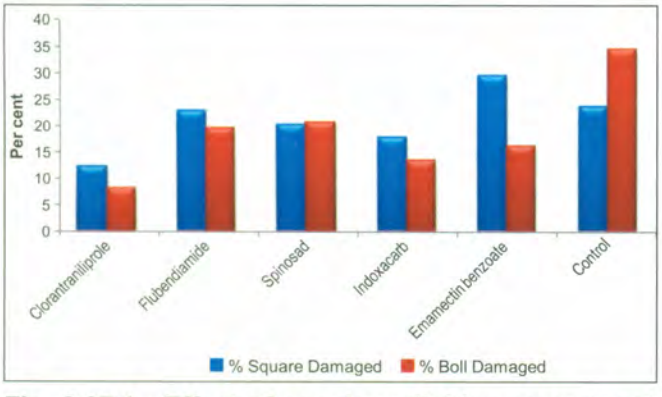


Fig. 3.27.1 : Effect of new insecticides on per cent square and boll damage by bollworms under HDPS

Insecticide resistance monitoring

Nagpur and Coimbatore

Insecticide resistance monitoring studies against cotton leaf hopper

Insecticide resistance monitoring against leaf hopper population with four insecticides namely Flonicamid, Acetamiprid, Thiamethoxam and Imidacloprid at four concentrations (10 ppm, 50 ppm, 200 ppm and 1000 ppm) was carried outwith leaf hopper populations from 8 locations of Central and South India. The resistance ratios of Flonicamid, Monocrotophos, Acephate, Imidaclorpid, Acetamiprid, Thiamethoxam ranged from 1-16, 1-7.7, 1-8.9. 1-19.6, 1-331 fold, respectively.

Nagpur

Insecticides for *H. armigera*

Flubendiamide was the most effective insecticide (0.005 mg/L and 0.004 mg/L against *H. armigera* populations of Nagpur and Wardha district out of 7 insecticides namely, Flubendiamide, Profenophos, Cypermethrin, Chlorpyriphos, Quinalphos, Deltamethrin, Acephate and Spinosad tested against two populations of *H. armigera*. Cypermethrin was the least effective.

Insecticides for *Spodoptera litura*

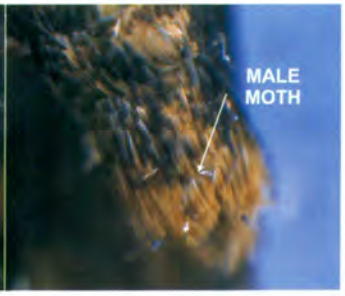
Quinalphos was the most effective (0.471, 0.373 mg/L against Mansa and Guntur populations) insecticide when 7 insecticides (Flubendiamide, Profenophos, Cypermethrin, Chlorpyriphos, Quinalphos, Deltamethrin, Acephate and Spinosad) were tested against two populations of *S. litura* (from Mansa and Guntur).

Cry toxin resistance monitoring against *H. armigera*

A variability of 50 fold and 78 fold was recorded in the LC_{50} and EC_{50} of Cry1Ac in *H. armigera*

Pink bollworm larvae

Exit hole of Pink bollworm



populations of Maharashtra and Andhra Pradesh.

Cry2Ab did not cause significant dose dependent mortality on one day old larvae of *H. armigera*. A variability of 247 fold was recorded in the EC_{50} values of *H. armigera* populations from Maharashtra and AP for Cry2Ab alone.

Cry toxin resistance monitoring *P. gossypiella*

The ICAR-CICR has been monitoring bollworm resistance development to Bt cotton during the past 15 years. During 2015-16, resistance monitoring was carried out with pink bollworm larvae collected from 46 districts of cotton-growing states across the country.

North India (9 districts): Hisar, Fatehabad and Sirsa of Haryana, Mansa, Abohar, Bathinda and Faridkot of Punjab, Sriganganagar and Hanumangarh of Rajasthan.

Central India (24 districts): Wardha, Yavatmal Washim, Hingoli, Nanded, Parbhani, Aurangabad, Buldana, Akola, Amravati, Rahuri, Jalgaon districts of Maharashtra; Khandwa and Pandhurna of Madhya Pradesh, Surat, Bharuch, Vadodara, Anand, Ahmedabad, Bhavnagar, Amreli Junagadh, Rajkot and Surendranagar districts of Gujarat

South India (13 districts): Guntur, Cuddapah, Anantapur, Kurnool and Krishna in Andhra Pradesh; Karimnagar, Adilabad, Warangal and Khammam in Telangana; Sirivilliputtur and Coimbatore in Tamil Nadu and Dharwad and Raichur in Kharnataka.

Resistance monitoring of pink bollworm to Bollgard-II

Bioassays were conducted with pink bollworm populations collected from 39 districts. Results showed that pink bollworm populations in 15 districts have developed resistance to Bollgard-II (Cry1Ac+Cry2Ab); 20 populations were resistant to Bollgard (Cry1Ac) and 18 populations were resistant to Cry2Ab.

Pink bollworm infestation in Bollgard-II

Pink bollworm infestation was recorded from green bolls. The per cent infestation in green bolls indicates the presence of live larvae in the green bolls which damage only a few seeds in the boll. Thus the extent of yield loss would depend on the number of seeds damaged by larvae in each boll. Therefore, the extent of pink bollworm infestation in green bolls cannot be interpreted as the extent of yield loss.

Gujarat :

Survey in the first week of August 2015 : Pink bollworm infestation was observed in flowers of different Bollgard-II hybrids ranging from 0 to 21.0 % in Bharuch, 5 to 58 % in Vadodara, 0 to 11 % in Anand, 20 to 80% in Bhavnagar, 11 to 67% in Amreli, 24 to 37% in Junagadh, 3 to 29% in Rajkot, 0 to 6% in Surendranagar and 0 to 53% in Ahmedabad. Grown up (3rd to 4th instar) larvae were recovered from flowers.

Survey in the first week of November 2015 : The crop was 120-150 days old. All the Bollgard-II hybrids were affected with pink bollworm, but to variable extents, depending on time of boll maturity. Early maturing crop and cotton picked in late October were less affected with pink bollworm. Infestation was higher in green bolls of second picking. Data on the residual bolls after first picking showed that the pink bollworm infestation was 72% in Surat, 64 to 92% in Bharuch, 48 to 96% in Vadodara, 50% in Ahmedabad, 56 to 84% in Bhavnagar, 60 to 72% in Amreli, 76 to 88% in Junagadh and 60 to 64% in Rajkot.

Survey in the third week of January 2016 : The per cent infestation on Bollgard –II in Vadodara was 72 %, Surat 92%, Anand 82% Surendranagar 92% Ahmedabad 100%; Amreli 100%, Rajkot 64%; Bhavnagar 56% and Junagadh 100%.

Maharashtra:

Survey in the second week of December 2015 : Pink bollworm infestation in green bolls of second-third picking on Bollgard–II hybrids was 25% in Aurangabad; Jalna 24-72%, Dhule 82-96%, Jalgaon 36-60%, Nandurbar 64 -100%, Yavatmal 40-72%, Wardha 60-76%, Amravati 24-88%, Akola 36-76%, Buldhana 19-86%, Rahuri 20-60%, Nanded 40 -100% and Nagpur 4%. The intensity of pink bollworm was more in Khandesh region as compared to Vidarbha region because of Khandesh region especially in the irrigated tracts.

Madhya Pradesh:

Survey in the first week of January 2016 : Infestation of Pink bollworm in green bolls of third-fourth picking on Bollgard–II cotton was 100% in Khandwa.

Andhra Pradesh:

Survey in the second week of December 2015 : All the Bt hybrids were found to be susceptible to the pink bollworm in Andhra Pradesh. The extent of infestation in green bolls of 3rd and 4th picking was 65.6% in Guntur, 55.7% in Kurnool, 41.5% in Anantapur, 33.6% in Prakasam, 29.3% in Kadapa and 6.6% in Krishna. The per cent infestation in open bolls was 37.5% in Guntur, 36.8% in Anantapur, 27.9% in Kurnool, 23% in Prakasam, 19.9 % in Cuddapah and 1.11%.

Telangana:

Survey in the second week of December 2015 : The crop was terminated in 90% of the area in the state. Pink bollworm infestation in green bolls of the 2-3rd picking in residual crop in Adilabad was 52-96%, Khamam 32-100%, Warangal 60-100% and Karimnagar 68-96% respectively.

Karnataka:

Survey in the second week of December 2015 : The infestation of pink bollworm in green bolls of Bollgard–II in Raichur was 48-92% while in Dharwad it was 8%.

Tamil Nadu:

Survey in the third week of December 2015 : Pink bollworm infestation in green bolls of Bollgard-II was 20% in Coimbatore and 24% in Srivilliputtur.

Sirsa

Monitoring of Pink Bollworm (PBW)

Monitoring of Pink Bollworm (PBW) was done in North Zone during 2015-16 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. Green bolls (60-150) 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. But in non Bt genotypes, average recovery(%) of PBW larvae ranged from 8-20, 10-20.8 , 11.7-25.8 and 13-44 at 120, 140, 160 and 170 days after sowing, respectively.

Sirsa and Nagpur

Whitefly resistance monitoring

The most commonly used insecticides with label claim for whitefly on cotton were studied for their resistance status in whitefly adults population during 2015-16 from four different locations of North cotton-growing zone of India. Out of four locations studied (Sirsa, Sriganganagar, Hisar, Mansa), the Hisar population was found highly resistant , the population from Nagpur was taken as susceptible population since it was not exposed to these insecticides during this season. The whitefly has acquired resistance to almost all insecticides and the resistance ratio varied from 98-1400 folds for Bifenthrin 10EC, 14-137 for Dinotefuran 20SG, 60-131 for Acephate 75SP, 21-331 for Acetamiprid 20SP, 153-340 for Fipronil 5SC, 371-2237 for Triazophos 40EC, 51-706 for Buprofezin 25SC, 9-512 for Imidacloprid17.8SL, 40-347 for Diafenthiuron, 2-19 for Chlorpyriphos 20EC, 1-2 for Thiamethoxam 30FS, 2-7 for Clothianidin 50WDG, 2-23 for Pyriproxifen and 1-6 for Flonicamid.

Cry toxin resistance monitoring against *S. litura*

LC_{50} of Cry1Ac ranged from 1.03-19.0 ug/ml of diet for *Spodoptera exigua* population. LC_{50} of Cry1Ac for *Spodoptera exigua* population from Hisar district was found to be the highest (19 ug/ml of diet). LC_{50} of Cry1C ranged from 14.90 to 19.19 ug/ml of diet for *Spodoptera exigua* population and highest being found for population from Hisar (19.19 ug/ml of diet).

Novel strategies for whitefly management

Sirsa

Five sprays of 4 exogenous waxes along with guar gum helped in 1.38-12.17% reduction in whitefly incidence.

3.28 : Simulation Models

Coimbatore

A field experiment was conducted with nine different dates of sowing (D1. 21st July, D2. 28th July,

D3. 4th August, D4.11th August, D5. 18th August, D6. 25th August, D7. 1st Sep. D8. 8th Sep. D9. 15th Sep.), two genotypes (Mallika BGII, and Suraj) with objective of standardization of sowing window and selection of superior genotypes. Seed cotton yield was influenced significantly by genotypes and date of sowing but interaction effect of genotypes with date of sowing was not significant. Amongst different dates of sowing, 28th July sowing (3107 kg/ha) registered numerically higher seed cotton yield and was on par with 21st July (3017 kg/ha) and further delay in sowing significantly reduced yields {(4th Aug.(2566 kg/ha), 11th August(2491 kg/ha), and 18th August(2619 kg/ha)}.

Cotton Yield Predictor Model

Software Development

The historical data was analysed and yield influencing factors were identified. Through statistical tools the factors were converted to numerical values and were used to develop algorithms. The Cotton yield calculator was built using Java as the backend code and HTML as the front end code. The software is designed to run on all browsers present in Windows and Linux based operating systems. To integrate the backend resources with the browser, TOMCAT server installation which is an Open Source System was used. Software used in the development of this application have been Open Source Softwares. ECLIPSE was used to design the java code.

Price Modelling

Price forecasting was tried using Artificial Neural Network with EXCEL and SPSS software. Using Excel, 15 variables were selected *viz.*, Indian cotton production, Mill Use, Exports, Imports, Beginning stock, Ending stock, World cotton production, Mill use, Export, Import, Beginning stock, Import of cotton by China, MSP of cotton, Production of crude oil in India, Production of crude oil at world level. The forecasted price for 2016 was Rs. 4200 to Rs. 4800 in the north, central and south cotton growing zones. The forecast accuracy was to the tune of 91 to 96 per cent in all the cotton growing states except Madhya Pradesh where it was 89 per cent. Alternative model ANN through SPSS was used to forecast the cotton prices with the same set of 15 variables. The forecast accuracy was to the tune of 92 to 99 per cent. The second model of ANN showed higher accuracy than the first one.

For refinement to fit the appropriate structural price forecasting model, regression diagnostics were used and R square was improved to 0.72. However, among 51 factors influencing cotton price India's exports, USA cotton mill use, USA cotton imports, USA beginning stocks, soybean prices and China's cotton area were found statistically significant. By using the structural model the cotton price predicted for the year 2015-16 was Rs 3892.64/ quintal.

Pest Modelling

Nagpur

Screening F_2 of Cry toxins with *H. armigera*

Five hundred single pair matings with populations collected from red gram/ chickpea from 6 districts in Maharashtra were set for Cry1Ac and 270 single pair matings were set up for Cry2Ab. In the F_3 generation 16 colonies demonstrated resistance to Cry1Ac and none of the colonies demonstrated larval mortality when exposed to the highest concentration of Cry2Ab.

Single pair matings were set up with three hundred and thirty moths of which only 4 colonies demonstrated resistance to Cry1Ac in the F_3 generation in populations of *H. armigera* collected on redgram from 10 districts in Gujarat.

Sirsa

Screening F_2 of Cry toxins with *E. vittella*

Isofemale lines (70) from *Earias insulana* population of Mansa have been screened for presence of rare resistance allele. Screening on F_2 generation results in 0-35.0% survival at dose 0.11 ug/ml by 13th day but all the lines died by 19th day after bioassay.

3.29 : Host Plant Resistance

Nagpur

Development of Jassid tolerant Suraj

Single plant selections were made from a one acre plot of Suraj where plants showed differences in leaf hopper numbers and symptoms. Such plants

were selfed and boll to row progeny were raised and tolerant plants were selfed. DCH 32, a leaf hopper susceptible hybrid and IMACD 408 a leaf hopper susceptible variety and Suraj were raised as checks for every 5 rows. Seeds were not treated with imidacloprid. Jassid tolerant Suraj had similar fibre properties as Suraj.

Leaf hopper tolerant culture repository

Twenty four cultures were confirmed to be jassid tolerant and compact from 116 cultures of breeding material that were evaluated, using DCH 32 as the infestor rows.

Inter-specific variation in volatile emission in 3 species of *Gossypium* in response to leaf hopper, caterpillar and mechanical damage

Ten genes, ERF 1, 2, 3. TPS 1,2,3 Alpha pinene, Lipoxygense 1, Allene oxide synthase 6, Methyl jasmonate transferase, involved in the signal transduction pathway were characterized using RT PCR to understand their role in volatile emissions that in-turn reportedly play a well defined role in inter plant communication in cotton. This was carried out across 2 years using *G. hirsutum*, *G. arboreum* and *G. barbadense*, 45 day old plants raised from untreated seeds on which different treatments were imposed under caged conditions. Genes governing volatile emissions were studied at different days after release of semiloopers, leaf hoppers and mechanical damage but the results obtained 72h after release is being reported herein. Ubiqutin and Actin were used as reference genes.

Amongst the three species, *G. arboreum* alone demonstrated this typical response to leaf hoppers.

G. arboreum is tolerant to leaf hoppers by virtue of up-regulation of the methyl transferase gene (that governs conversion of jasmonic acid to methyl jasmonate) and methyl jasmonate is a volatile that aids in inter plant communication, facilitating the step up of signal transduction pathway in the *G. arboreum* challenged with leaf hoppers, can result in leaf hopper management in *G. hirsutum* when the former is used between rows.

Volatiles emitted from pink bollworm damaged flower *vis-a-vis* undamaged flower

Floral Volatiles from flowers infested by pink bollworm

Normal flowers and pink boll worm (PBW) infested flowers were collected from *Gossypium hirsutum* variety Suraj. Methanolic floral extract were collected from individual flowers. Average terpene content in PBW infested flowers was higher (9.7 mg/g linalool equivalents) when compared to 6 mg/g linalool equivalents in normal flowers. Organic compounds in the methanolic extract of PBW infested flowers and normal flowers were identified using GC-MS. Relative abundance of β Caryophyllene was two-fold higher in PBW infested flowers than normal flowers. In PBW infested flowers slightly higher relative abundance of methyl ester of pentadecanoic acid and linolenic acid, the precursor of jasmonic acid, was seen than in normal flowers. The terpenes, 2,thujene, copaene, α guaiene, epizonarene which are found in normal flowers are not detected in PBW infested flowers. The terpenes, cubebene and the fatty acid esters, 2-methyl octadecane and 11-butyl docosane which are found in PBW infested flowers were not detected in non-infested flowers.

Sirsa and Nagpur

Role of epicuticular wax on whitefly and CLCuD incidence : Total of 399 germplasm lines were screened for whitefly, CLCuD during 2015-2016. Based on 10 observations, whitefly ranged between 0.3 to 24.9/3 leaves. Sixty lines were selected for wax extraction. Quantity of wax in lines selected for wax extraction varied between 15.55 to 277.92, 7.33 to 342.86, 12.80 to 304.82 μg/cm^2 area of leaf in upper, middle and lower leaves respectively. At later age of crop, quantity of wax in same lines selected for wax extraction varied between 43.62 to 263.33, 33.92-201.14, 34.17-315.0 μg/cm^2 area of leaf in upper, middle and lower leaves respectively. Germplasm No. IC357886 exhibited higher wax content throughout the canopy and on both upper and lower surfaces. It is classified as one of the lines with lowest whitefly incidence. Germplasm No. IC358823 had very low wax content across the canopy on both adaxial and abaxial sides and this line is classified as one with highest whitefly incidence. Temporal variation of wax content was also studied from samples collected at different growth stages of cotton. There is slight to huge variation in epicuticular wax content with different sampling dates.

Dissemination of Insecticide Resistance Management Programme

Nagpur

During crop season 2015-16, the IRM strategies were disseminated to 9849 farmers in 26011.42 acres in a total of 345 villages of 19 districts from 12 different states across India. In IRM fields, farmers sprayed on an average 3.86 sprays/ha as compared to 6.07 sprays/ha over non-IRM fields. Average yield of IRM and non-IRM fields was 16.75 and 15.12 q/ha. Implementation of the programme resulted an increase in yield estimated at a net additional benefit of Rs 6.76 crores and a saving in insecticide use accounting for Rs 1.89 crores, thus adding up to a total additional benefit of Rs 8.65 crores. A total of 984 field visits, 388 group meetings, 25 field days and 126 training programmes were organized for dissemination of the IRM strategies.

Sirsa

A total of 1375 acre area was covered for the implementation of IRM strategies in four villages of Sirsa. The weekly data on insect pest and beneficial insects was recorded in villages and used for decision making interventions. Major emphasis was given on the management of resistance in sucking pests against insecticides and bollworms against cry toxins and farmers were encouraged to grow refugia around Bt cotton hybrids. This was followed by collecting information on insecticide consumption and number of sprays. On the basis of 9 observations recorded under IRM field with Bt genotype, the population (per 3 leaves) of whitefly ranged between 16.28-36.28, thrips between 0.00-7.49 and leafhopper ranged between 0.04-2.43 where as in Non-IRM field the population of whitefly, thrips and leafhopper recorded was 28.65-56.2, 0.00-8.10 and 1.05-3.85/3 leaves. The average yields obtained under IRM and Non IRM was 15.10 q/ha and 12.25 q/ha respectively. Reduction in number of sprays applied by IRM farmers was 20.27% recorded over Non IRM and 17.24% reduction in pesticide consumption was recorded.

Under high density planting system, in *G. arboreum* varieties (normal sown) population of whitefly, thrips and leaf hopper ranged between 1.69 to 27.9; 0.00 to 4.88 and 0.00 to 3.05 and while in HDPS it was 1.14 to 22.3; 0.00 to 5.5 and 0.00 to 2.36 / 3 leaves respectively. The average yield obtained under HDPS in CICR-1 was 7.2 q/acre (5.0-9.2 q/acre), CICR-3 was 9.50 q/acre (7.0-12.50 q/acre). In case of HDPS CICR-3, 8.75- 27.37% increase in yield was recorded over normal sown Bt cotton hybrid whereas under CICR-1, the percent increase in yield obtained was 6.67-20.0 %.

Under Online Pest Monitoring and Advisory Services (NFSM-OPMAS) advisories were issued to 1333 farmers belonging to 9 villages of district Sirsa and Fatehabad. Based on the data recorded for pests and diseases from random and fixed locations the advisory were issued to the farmers through E-Kapas network. The population of sucking pests was less in adopted farmer's fields. Average number of spray applied by adopted farmers was 5.06 to 5.95/ha and by nonparticipatory farmers was 6.46 to 6.91/ha. The yield obtained in adopted farmers fields (1527 and 1641 kg/ha in Sirsa and Fatehabad) was higher than non participatory farmers field (1340 and 1410 kg/ha in Sirsa and Fatehabad).

Coimbatore

Tamil Nadu : IRM strategies were successfully disseminated in eight districts of Tamilnadu namely Virudhunagar, Coimbatore, Vellore, Erode, Dharmapuri, Tirunelveli, Perambalur and Madurai districts covering 2000 acres and were successfully adopted by 667 farmers. Impact analysis of the dissemination of IRM strategies in these districts indicated an average number of sprays of 2.6 in IRM farmers fields when compared 4.6 in Non-IRM farmers' fields. A gross income of Rs. 75,500 and Rs. 70,166 and a net profit of Rs 51,525 and Rs. 38,026 plant protection cost of Rs. 3,270 and Rs. 7,508 in IRM and Non-IRM fields was recorded respectively. Extension programmes such as field visits, training programmes and farmer group meetings enhanced the farmer's knowledge about the cotton pests, symptoms, natural enemies and the IRM strategies of pest management. Overall progress of the project was satisfactory and adop-

tion of the technologies by the farmers was encouraging. Knowledge about the pests of cotton, their symptom, and the natural enemies are the additional gain by the farmers apart from the economic advantage by adopting IRM strategies under HDPS.

Front Line Demonstrations (FLDs)

Integrated Cotton Management

Nagpur

Sixty five FLDs on interventions of Integrated Cotton Management (ICM) (41), *Desi* Cotton (15) and intercropping (9) on farmers field in villages, Shivanfad, Pipri, Khandala, Ashta, Girad, Govindpur in Samudrapur and Vijaygopal in Deoli tehsils of Wardha district and Navarmati in Nagpur tehsil of Nagpur district. The ICM technologies included integrated nutrient management in cotton, control of leaf reddening by foliar application of DAP and $MgSO_4$, plant protection and weed management. *Desi* varieties included Phule Dhanwantary and Roja while in cotton intercropping, Suraj was intercropped with soybean, green gram and black gram. The seeds of Suraj, Phule Dhanwantary and Roja along with the package of practices was provided to farmers. The data on yields of FLD interventions and farmers practices was recorded. Average productivity of 718 kg/ha was recorded in ICM as compared to the farmers practice of 682 kg/ha. In *desi* cotton FLD's productivity of 1013 kg/ha was recorded as against the farmers practice of 809 kg/ha. With intercropping system, productivity of cotton was 910 kg/ha with additional yield of intercrop (177 kg/ha) as compared to sole cotton of farmers practice 875 kg/ha. Thus, additional profit of Rs 8434/ha was recorded under cotton intercropping technology compared to sole cotton.

Coimbatore

Under winter irrigated condition, 25 demonstrations on cotton ICM were conducted on 10 hectares area in twenty five farmers' fields of Erode district. 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. The average seed cotton yield obtained in FLD on ICM was 1235 kg/ha as against the farmers' practice yield of 1094 kg/ha.

HDPS Planter

Coimbatore

High Density planting system in cotton for rainfed crop was demonstrated under National Food Security Mission (NFSM) sponsored Front Line Demonstration (FLD) programmme by Central Institute for Cotton Research, Regional Station, Coimbatore with the collaboration of MYRADA, Krishi Vigyan Kendra (KVK) at Anthiyur, Gopichettipalayam taluk, Erode district on 10th September 2015. The farmers gathering was addressed by Dr. (Mrs.) B. Dhara Jothi, Principal Scientist about the High Density planting System in cotton and its advantages over normal cotton planting system. She also spoke on effective pest management strategies to be followed for the management of cotton pests. Dr. K. Sanakarnarayanan, Principal Scientist, briefed about the effective fertilizer usage under High Density Planting System and the methods to be followed for the sustainable cotton production. Dr. T. Senthil Kumar, Senior Scientist, Central Institute of Agricultural Engineering, Coimbatore explained about the mechanization methods developed for sowing, weeding and for other cultural operations for cotton under HDPS. Non- Bt cotton seeds as input were distributed to the farmers and a field demonstration was conducted by sowing cotton using tractor drawn mechanical device.

On Farm Demonstrations

Coimbatore

During the year 2015-16, a total of ten varieties, one production technology on multi tier cropping system and one protection technology of application of bio-pesticides for management of sucking pests were assessed and demonstrated in the institute farm at CICR, Regional Station, Coimbatore. The varieties demonstrated were Suvin, LRA 5166, MCU 5 VT, Supriya, Anjali, Surabhi, Sumangala, Suraj, CCH 2623 and CCH 4474. The bio-pesticides demonstrated were *Metarhizium anisopliae* and *Lecanicillium lecanii* for the management of sucking pests in cotton. Under the multitier cropping system along with cotton, vegetable crops *viz.*, beetroot, radish, coriander and cluster bean were demonstrated.

5. TRAINING AND CAPACITY BUILDING

5.1: Education

i. Kunal Pradip Gawande carried out research work on "Distribution and characterization of endosymbionts in geographical populations of pink bollworm (*Pectinophora gossypiella*)" under the guidance of Dr. Sandhya Kranthi, Principal Scientist & Head of Crop Protection Division, CICR, Nagpur for his M.Sc.(Ag) Biotechnology thesis for submission to Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad.

ii. Sandip Agale carried out research work on "Efficacy of Cry toxins on agro-ecological populations of *Spodoptera litura* (Fabricius)" under the guidance of Dr. Sandhya Kranthi, Principal Scientist & Head of Crop Protection Division, CICR, Nagpur for his M.Sc. thesis that was submitted to Indira Gandhi Krishi Vishwa Vidyalaya, Raipur during 2015.

The aim was to compare the relative efficacy of Cry1Ac, Cry2Ab and Cry1Ac + Cry2Ab and non Bt on *Spodoptera litura* from different zones using *in planta* and standard toxin bioassays.

It was concluded that :

a) Intraspecific variability in susceptibility of *S. litura* populations to Cry toxins existed.

b) Cry1Ac +Cry2Ab is superior to Cry1 Ac alone in *in planta* bioassays against this pest especially at mid reproductive stage.

c) Bollgard and Bollgard II are equally vulnerable to early season *S. litura* incidence and damage.

Fellowship programme

Dr. Ahmed Mohamed Abd El-Moghny Abd El-Baky, Researcher (Cotton Breeder), from Central Research Institute (CRI), Agricultural Research Centre (ARC), Giza, Egypt underwent a training fellowship programme for developing country during the period 2nd June to 25th November 2015. The research work was on `Genetic, physiological and molecular basis of drought tolerance in cotton' and successfully completed the fellowship at this Institute. The training programme was coordinated by Dr. S.B. Singh, I/c Head & Principal Scientist and Dr. H. B. Santosh, Scientist, Division of Crop Improvement, ICAR-CICR, Nagpur.

5.2: Training

5.2.1: Training Received

Name of the Officials	Name of the course/training	Place	Period
Dr. S. Manickam	Monitoring Confined Field Trials for Regulatory Compliance	DBT, New Delhi,	25.05.2015 to 26.05.2015
Dr. G. Balasubramani Dr. V. Nagrare	Biosafety Compliance Readiness Training of ICAR Scientists	BCIL, New Delhi	27.05.2015 to 28.05.2015
Dr. Santosh H. B.	Monitoring Confined Field Trials for Regulatory Compliance	ICAR–NAARM, Hyderabad	03.06.2015 to 04.06.2015
Dr. M. Saravanan	Mendelian Genetics to Molecular Genetics in relevance to Plant Breeding	PAU, Ludhiana	06.08.2015 to 26.08.2015
Dr. A. Manivannan Dr. Santosh H. B.	Quality Evaluation of Cotton	ICAR- CIRCOT Mumbai	25.08.2015 to 27.08.2015
Dr. Raghavendra K.P.	Developing Winning Research Proposals in Agricultural Research	ICAR-NAARM, Hyderabad	25.08.2015 to 29.08.2015

Name of the Officials	Name of the course/training	Place	Period
Dr. A.Manivannan	Risk Communication under UNEP-GEF supported phase-II capacity building project on biosafety	ICRISAT, Hyderabad	29.10.2015 to 31.10.2015
Mr. Joy Das Mr. Rakesh Kumar	TILLING in Crop Plants	University of Hyderabad, Hyderabad	07.12.2015 to 17.12.2015
Dr.S.B. Nandeshwar	Competency Development for HRD Nodal Officers of ICAR	NAARM, Hyderabad,	10.02.2016 to 12.02.2016

5.2.2: Training Imparted

International training

In-country training on 'Modern Cotton Production Technologies'

Under the Cotton TAP, two-day in-country training was conducted from 29 February to 1 March 2016. Dr. D. Monga and Dr. D. Blaise from ICAR-CICR delivered lectures on various aspects of 'Modern Cotton Production Technologies'. The training was organized in the Institute for Agricultural Research, Ahmadu Bello University, Zaria. Dr. AbuBaker, Executive Director of IAR, Samaru was the Chief Guest. Mr. Yerima, Nodal Officer of Cotton TAP in Nigeria co-ordinated the training.

Group photo of the participants attending the in-country training at Zaria, Nigeria

National Training

Nagpur

Farmers' Training on the cultivation of *desi* cotton "Phule Dhanwantary"

ICAR-CICR , Nagpur in coordination with the YUVA Rural Association, Nagpur organized a one day training on the cultivation of *desi* cotton variety "Phule Dhanwantary" under High Density Planting system on 27th May 2015. Around 40 farmers from Nagpur, Wardha, Amravati, Buldhana, Washim, Akola and Jalna districts of Maharashtra were the beneficiaries. Shri Datta Patil, Founder, YUVA Rural Association welcomed the farmers and officials and stated that the objective of the training was to understand the package of practices for the cultivation of *Desi* cotton and re-inforce the do's and dont's in its cultivation. Dr. K. R. Kranthi, Director, ICAR-CICR narrated the recent R&D efforts on *desi* cotton and the appreciated the new initiative leading to the formation of Vidarbha *Desi* Cotton Growers' Association under the stewardship of Yuva Rural Association. Dr. Vinita Gotmare, Principal Scientist, CICR made a detailed presentation through slide show explaining the complete production and protection technology for profitable cultivation of Phule Dhanwantary. Dr. Sandhya Kranthi HOD, Crop Protection, Dr. D. Blaize, HOD, Crop Production, Dr. Suman Bala Singh, HOD, Crop Improvement and Dr. M. V. Venugopalan responded to various questions raised by the farmers regarding weed control, pest management, seed production, economics and marketing. Later Dr. Laximikant Padole, Director, Neem Foundation, Nagpur made a presentation on

the preparation of Neem Seed Kernal extract and its use for pest management in cotton and other crops. Representatives from surgical cotton industry also attended the training workshop. Seeds to participating farmers were also supplied at a nominal cost. Apart from this, Better Cotton Initiative also took up this *desi* cotton on 50 farmers' fields in the various districts of Vidarbha. Surveys were conducted by Dr. D. Blaise, Dr. S.N. Rokde, Dr. Anuradha Narala and Sh. Chaturvedi. It was observed that, in general despite being a drought year, the farmers who cultivated Phule Dhanwantary following the recommended package of practices and obtained yields in excess of 6 q/acre and as high as 10 q/acre. However, low yields (2 q/acre) were reported from few farmers who cultivated the cotton on very shallow and stony soils without adequate plant stand and due to late planting. All the participating farmers were provided with 5 kilograms of seeds of Phule Dhanwantary, sufficient for planting in one acre, along with a leaflet containing the package of practices.

Awareness training on cotton - soybean intercropping

ICAR-CICR, Nagpur is implementing FLDs on cotton - soybean intercropping in Nagpur and Wardha districts at farmers field. To create awareness about intercropping a one-day awareness training was organised at village Jogingumpha near Girad in Samudrapur tahsil of Wardha district on 19.6.2015. Dr S.M. Wasnik, Principal Scientist (Agricultural Extension), CICR, Nagpur highlighted the importance of intercropping and advised the farmers to take short duration intercrops of green gram, black gram in between two rows of cotton. On the occassion, 35 packets of *Bradyrhizobium japonicum* were supplied to farmers for soybean seed treatment for intercropping trials.

One-day Training Camp Under ATMA

A team of CICR scientists comprising of Director, Dr. K. R. Kranthi, Dr. Sandhya, Dr. M.V. Venugopalan, Dr. Vinita Gotmare and Dr.V. Santhy conducted a one-day training camp for more than 100 farmers in the Krushi Jagruthi Saptah on 6th July 2015 at Jamb, Wardha district organized by ATMA. Dr. Vinita in her detailed presentation described the strategies of the HDPS program in Marathi, while Dr. Kranthi gave a brief history on the inception of HDPS. Dr. S. Kranthi, Dr. Venugopalan and Dr. Santhy spoke on protection, production and seed production aspects of HDPS, respectively. The programme was coordinated by Shri Rajesh Chandewar, BTM Samudrapur.

Training cum field demonstration on HDPS technology

A training cum field demonstration on HDPS was organized at ICAR-CICR Nagpur for 25 participants from BCI (Better Cotton Initiative) and few other stakeholders. The programme was co-ordinated by Dr. Blaise Desouza, Head, Crop Production. Dr. K. R. Kranthi, Director, ICAR-CICR, gave an overview of HDPS and its relevance in the present day context. He highlighted the ills of spraying pesticides unnecessarily that are creating resurgence of sucking pests such as whiteflies. He insisted that the indigenous varieties are more robust and able to withstand most of the biotic and abiotic stresses. Further, these involve a much lower cost of cultivation. A field visit was organized to demonstrate the HDPS. The importance of

appropriate spacing and selection of compact, early genotypes was explained by Ms. Shubangi Lakde. Dr. Blaise explained about the various inter-crops grown from the view point of saving fertilizer N, obtaining additional returns and more importantly meeting the pulse requirement of the country. Some legumes and oilseeds such as groundnut and soybean were also being tried. The participants shared their experience about the on-going trials on HDPS implemented by BCI in Maharashtra. Several questions raised by the participants were also addressed by Dr. Sandhya Kranthi, Head, Crop Protection and Dr. M.V. Venugopalan, Principal Scientist. Dr. S. N. Rokde, Dr. Anuradha Narala and Dr. A. Manikandan were also present.

Training Camp Sponsored by DCD, Min. of Agri., GOI

The training programme sponsored by the Directorate of Cotton Development (DCD), Ministry of Agriculture, GOI was organized at CICR, Nagpur on 28 September 2015 for the farmers of Wardha and Nagpur district of Vidharbha adopted under 'Mera Gaon Mera Gaurav' programme. Dr. K. R. Kranthi, Director, CICR stressed the need of building strong relationships and trust between farmers and scientists. He said that this programme can help scientists to strengthen their understanding of farmer problems so that research work can be oriented accordingly. He asked scientists and farmers to be in constant touch so that a model example of 'Lab to Land' can be developed. He said that the 'e-Kapas' programme which sends weekly 'voice mail' advisories to 1.25 lakh farmers, should be utilized fully by the farmers. Dr S. M. Wasnik, Principal Scientist, Extension and Nodal Officer of MGMG programme highlighted the importance of the 'Mera Gaon Mera Gaurav' programme. Dr R.P. Singh, Director DCD, GOI outlined the schemes of his department for cotton farmers. Dr. D. Blaise, Head Crop Production and Dr Suman Bala Singh, Head, Crop Improvement, spoke on production technologies and choice of appropriate varieties in cotton. Scientists took farmers to the experimental fields and explained research work being undertaken. Participants were taken to experiments of HDPS, intercropping, pest and disease management, goat farming, etc. Literature in local Marathi language on improved cotton cultivation and other aspects were distributed. Films on package of practices on cotton, HDPS, nutrient management, pests and diseases, physiological disorders were shown. Question- answer session organised to clear the doubts of farmers. Around 230 farmers from villages adopted by ICAR-CICR scientists under MGMG programme attended training.

Farmers Training program under NFSM-IRM-HDPS

A one-day farmers training camp was organized by Dr. S. Kranthi and Dr. J. Meshram at ICAR-CICR, Nagpur on 31 October, 2015 for the farmers of Wardha District on Insecticide Resistance Management (IRM) in High Density Planting System (HDPS) under National Food Security Mission (NFSM). Around 70 NFSM-IRM-HDPS farmers attended. In Wardha district, in collaboration with Ramkrishna Bajaj College of Agriculture, Pipri, IRM/ HDPS programme is taken up in 35 villages in 174 acres on 154 farmers fields

with variety Suraj. Dr. Sandhya Kranthi, Head, Crop Protection Division, ICAR-CICR Nagpur delivered a lecture on the importance of HDPS and Insects-Pest management in cotton while Dr J. H. Meshram delivered talk on abiotic stress in cotton. The farmers were also shown the experiments and demonstration plots of HDPS. During farmer - scientist interaction, farmers reported that some fields had off type plants and bollworm attack was severe in some fields. Farmers were asked to take corrective measures using the right chemicals.

Field Experience Training (FET) Programme for ARS trainees

A 21 days FET programme for ARS Scientist trainees from NAARM, Hyderabad was conducted from 8.02.2016 to 28.02.2016 at ICAR-CICR, Nagpur. The FET studies were undertaken at Mangali village located at 25 km from Nagpur which is one of the adopted village of CICR under Mera Gaon Mera Gaurav. On the concluding day, the trainee scientists presented the general socio-economic and agro-ecological scenario of the village, constraints identified using PRA tools and suggestions offered to redress them. They also interacted with the Director and scientists of the institute. Dr. R.B. Singandhube, Head I/c, KVK, CICR, Nagpur and Dr. V. Santhy, Senior Scientist, Crop Improvement were the local co-ordinators.

Coimbatore

Training Programmes for Tribal Cotton Growers under Tribal Sub Plan

The first training program on "Integrated Crop Management Practices in Cotton" for Tribal Cotton growers was conducted on 19 & 20 November 2015. Sixteen tribal cotton growers from Jolarpet, Vellore district of Tamil Nadu participated. Dr. N. Gopalakrishnan, Project Coordinator (Cotton) and Head I/c, CICR, RS, Coimbatore, in his inaugural address, elaborated the scenario of cotton in the world and India and especially in Tamil Nadu. Then, the trainees were exposed to various cotton improvement, production and protection technologies by the scientists.

The second training program on "Integrated Crop Management Practices in Cotton" was conducted on 18.01.2016 & 19.01.2016. Twelve tribal cotton growers from Kalvarayan hills, Salem District of Tamil Nadu have participated. The programme was inaugurated by Dr. S.E.S.A. Khadar, Principal Scientist and Project Coordinator and Head I/c on 18.1.2016. In his inaugural address, he elaborated the scenario of cotton and explained about pruning techniques in cotton and CICR- Nutrients consortia in detail. The trainees were also exposed to various cotton improvement, production and protection technologies by the scientists. Training kits and participation certificates was distributed.

Sirsa

Farmers Training program under NFSM-IRM-HDPS

In Sirsa district, the IRM program was taken up in four villages in 1600 acres area and the HDPS demonstration programme was conducted on 200 acres. Under HDPS programme, *Desi* cotton varieties (CICR-1 & CICR-3) were demonstrated under HDPS with 30,000 plants/ acre as against normal planting of 20,000/per acre. One day farmer training camp was also organized on 1st August in which 80 NFSM-IRM-HDPS farmers from different villages of Sirsa district attended. Dr D. Monga, Head of the station delivered a lecture on the importance of HDPS and diseases management in cotton, Dr R. A. Meena delivered a lecture on seed production in cotton and genotypic suitability under HDPS and Dr Rishi Kumar delivered a lecture on

pest management in cotton. Dr S. L. Ahuja, also interacted with the farmers. The farmers were also shown the demonstration plot of HDPS.

Training Workshop on Cotton Production

A training workshop on cotton production and protection technologies was organized on 23 October, 2015 in collaboration with United Farmers Empowerment Initiative (UFEI). Around 80 progressive farmers representing regional farmer associations of Haryana, Punjab and Rajasthan participated. At the outset Dr Monga, Head of the Regional Station highlighted the major issues concerning cotton farmers in the north zone. He focussed on the damage caused by whitefly during the season, cotton leaf curl virus disease and stressed on the strategies developed by the station and their dissemination. He also informed the farmers about the thrust areas of the station like high density planting system and promotion of *desi* cotton varieties and hybrids. Shri P P S Pangali, Chairman UFEI discussed about the objectives of the organization and highlighted its initiatives.

Dr Anil Mehta, Professor of Agronomy at CCSHAU, Sirsa delivered a lecture on recent advances in cotton production technologies. Dr D Monga and Dr Rishi Kumar talked about cotton diseases, insect pests and their management. The farmers actively participated and shared their experiences in an open house discussion on the recent issue of whitefly incidence, losses and lessons for the future. This was followed by a field visit where CICR technologies were showcased. The farmers took keen interest in *desi* (*G. arboreum*) cotton varieties developed by the station.

Farmer's Training program cum exposure

A training programme cum exposure visit for the farmers adopted by the Ambuja Cement Foundation was organised on 10.11.2015. Twenty five participants including farmers and workers of foundation participated. Dr Rishi Kumar, Principal Scientist, CICR, delivered a lecture on whitefly management in cotton and other alternate hosts. The farmers visited the demonstrations on high density planting system in cotton and various *Desi* cotton genotypes.

Mera Gaon Mera Gaurav Programme

'Mera Gaon Mera Gaurav (My Village My pride)' programme launched by the Hon'ble Prime Minister on July 25, 2015 during 87th Foundation Day of ICAR and KVK conference at Patna has been initiated at CICR Nagpur from September 2015 with a view to hasten the process of Lab to Land. Under the scheme, as per the guidelines the scientists remain in touch with the adopted villages and provide information to farmers on technical and other related aspects in the time frame through personal visits and other means. ICAR- CICR along with its Regional Stations CICR, Coimbatore and CICR, Sirsa implementing the programme through the team of scientists; each team comprises of four scientists with five clusters of villages as per guidelines. Accordingly, 65 villages were adopted from 13 clusters villages i.e. eight, four and one respectively from Nagpur, Coimbatore and Sirsa and the lists of team comprising of Nodal Officer, Scientist's team and cluster villages adopted are as given in Table 5.2.2.1.

Table 5.2.2.1: **CICR, Nagpur and Regional Stations Team of Scientists and Villages Adopted Base line survey**

Team	Name of Scientists	Designation	Villages Adopted
Nodal Officer: Dr S. M. Wasnik, Principal Scientist, Extension			
CICR, Nagpur, Maharashtra			
1.	Dr. Sunil Rokde	Principal Scientist	Ganeshpur cluster, Wardha
	Dr. Punit Mohan	Principal Scientist	1. Ganeshpur
	Dr. G. Balasubramani	Principal Scientist	2. Digras
	Dr. J. H. Meshram	Scientist	3. Zadgaon 4. Belgaon 5. Borgaon (Sawli)
2.	Dr. R. B. Singandhupe	Principal Scientist	Parseoni cluster, Nagpur
	Dr. P. R. Vijyakumari	Principal Scientist	1. Narhar
	Dr. T. R. Loknathan	Principal Scientist	2. Kolitmara
	Dr. K. P. Raghavendra	Scientist	3. Nehra 4. Banera 5. Dhawalapur
3.	Dr. Nandini Narkhedkar	Principal Scientist	Girad cluster, Wardha
	Dr. M. Saravanan	Scientist	1. Jogingumpha
	Dr. Shailesh Gawande	Scientist	2. Shivanphal
	Dr. Joy Das	Scientist	3. Arvi 4. Faridpur 5. Mohgaon
4.	Dr. S. M. Palve	Principal Scientist	Nandura cluster, Wardha
	Dr. M. V. Venugopalan	Principal Scientist	1. Nandura
	Dr. V. Santhy	Senior Scientist	2. Nagapur
	Dr. V. S. Nagrare	Senior Scientist	3. Karanji (Bhoge) 4. Karanji (Kaji) 5. Pujai
5.	Dr. V. N. Waghmare	Principal Scientist	Hingna cluster, Nagpur
	Dr. H. B. Santosh	Scientist	1. Mangali
	Dr. Rakesh Kumar	Scientist	2. Mandavghorad
	Dr. Savitha Santosh	Scientist	3. Junewani 4. Nanda Khurd 5. Ukhali
6.	Dr. S. B. Nandeshwar	Principal Scientist	Godhani cluster, Umred, Nagpur
	Dr. Vinita Gotmare	Principal Scientist	1. Godhani
	Dr. A. Manikandan	Scientist	2. Mhasala
	Dr. Prabhulinga T.	Scientist	3. Mohpa 4. Sukali 5. Telkavads
7.	Dr. A. R. Raju	Principal Scientist	Kalmeshwar cluster, Nagpur
	Dr. J. Amudha	Senior Scientist	1. Sonegaon
	Er. G. Majumdar	Scientist	2. Pohi
	Dr. Anuradha Narala	Scientist	3. Ladai 4. Linga 5. Uparwahi

Team	Name of Scientists	Designation	Villages Adopted
Nodal Officer: Dr S. M. Wasnik, Principal Scientist, Extension			
CICR, Nagpur, Maharashtra			
8.	Dr. D. V. Patil	Senior Scientist	Navegaon cluster, Umred, Nagpur 1. Navegaon Sadhu 2. Tirkhura 3. Karhandla 4. Thana 5. Sev
	Dr. Sunil Mahajan	Senior Scientist	
	Dr. Chinna babu Naik	Scientist	
	Dr. Annie Sheeba	Scientist	
CICR- Regional Station, Coimbatore, Tamil Nadu			
9.	Dr. N. Gopalakrishnan	Principal Scientist	**Vadapudur Panchayat,** Kinathukadavu block, Coimbatore District 1. Vadapudur 2. Singaiyanpudur 3. Sikkalampalayam 4. Yelur 5. Kallapuram
	Dr. K.P.M. Damayanthi	Principal Scientist	
	Dr. K. Sankaranarayanan	Principal Scientist	
	Dr. Isabella Agarwal	Principal Scientist	
10.	Dr. K. Rathinavel	Principal Scientist	**Sokkanur panchayat,** Kinathukadavu block, Coimbatore district 1. Sokkanur 2. Muthugoundanpudur 3. Palapathy 4. Veerappagoundanur 5. Venkaiyagoundanpudur
	Dr. M. Amutha	Scientist	
	Dr. C. Karpagam	Senior Scientist	
	Dr. M. Sabesh	Scientist	
11.	Dr. P. Nalayini	Principal Scientist	**Kanjapalli Panchayat,** Annur Block, Coimbatore District 1. Kanjapalli 2. Dhasarpalayam 3. Oothupalayam 4. Kumaragounderpudur 5. Neelagoundarpudur
	Dr. S. Manickam	Principal Scientist	
	Dr. D. Kanjana	Scientist	
	Dr. J. Gulsarbanu	Principal Scientist	
12.	Dr. S.E.S.A.Khader	Principal Scientist	**Allapalayam Panchayat** Annur Block, Coimbatore District 1. Allapalayam 2. Konarpalayam 3. Uthirampalayam 4. Mathireddypalayam 5. Akravachengapalli
	Dr. B. Dharajothi	Principal Scientist	
	Dr. R. Raja	Senior Scientist	
	Dr. S. Usha Rani	Senior Scientist	
	Dr. Manivannan	Scientist	
CICR- Regional Station, Sirsa, Haryana			
13	Dr O.P.Tuteja	Principal Scientist	1. Jhonpra 2. Alleekan 3. Nejadela Kalan 4. Rangari 5. Begu
	Dr. R.A.Meena	Principal Scientist	
	Dr. S.K.Verma	Principal Scientist	
	Dr. Rishi Kumar	Principal Scientist	

Base line survey

For assessing the ground realities and for base line survey, all the team had discussion with Panchayat President, Vice President, Ex. Vice President, Executive Secretary, Village Administrative Officer and other members and several farmers in the villages and collected the base line information of the villages for formulation and further implementation of strategies. Parseoni cluster in Nagpur district adopted villages are situated under forest area and dominated by tribal. The farmers are resources poor and are not in a position to adopt new technological interventions unless it is supported by the line department. Again, they are totally dependent on rainfall, on many occasions due to erratic distribution of monsoon rains their *kharif* crop suffers. Based on the exploration and discussion with various clients, each teams in cluster formulated the programme and following strategies for further implementation.

- To create awareness among the farmers about modern scientific agricultural practices especially for vegetable cultivation and dairy enterprises
- To create awareness among the farmers about sanitation, climate change, good agricultural practices
- Strengthen the interface with farmers by holding regular meeting and visits in the villages
- To promote cotton cultivation in the study area
- To provide demand driven technical literature in local language for knowledge updating
- To create linkage with other organization and utilizing their services for development of the adopted MG-MG villages
- To create awareness among school children about various developmental programme of the government
- To provide regular technological back stopping for further development of the villages

Scientists-Farmers interactions

The various teams organize an interactive meet with farmers at MGMG villages and discussed current cropping scenario and related issues. Imparted training regarding collection of soil samples from the field for analysis to prepare soil health cards and also suggested control measures for insect pests of important crops including cotton. The farmers and scientists interacted on various issues related to insect pest management of agricultural, horticultural crops and animal husbandry issues. Large number of villagers including women actively participated in the seminar and discussion organised at different places.

6. AWARDS AND RECOGNITIONS

Awards

Best Supporting Staff Award

Shri P. Chidambaram, Supporting staff, ICAR-CICR-RS, Coimbatore received the Best Supporting staff Award -2014 during the 87th ICAR Foundation Day & Award ceremony and National Conference of KVKs held on 25th July, 2015 at Patna, Bihar. Sh P. Chidambar received the award from Dr Sanjeev Kumar Balyan, Hon'ble Union Minister of State for Agriculture.

Young Scientist Award

Dr. H. B. Santosh, Scientist, Division of Crop Improvement was awarded '*Young Scientist Award*' from the Society of Scientific Development In Agriculture & Technology (SSDAT) for "*Genetic Diversity Analysis for Productivity Enhancement through Desi-Kabuli Introgression Breeding in Chickpea*" in National Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2015) held at Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior during December 12-13, 2015.

Gold Medals for academic excellence

Dr. A. Manivannan, Scientist, CICR, RS, Coimbatore has received two Gold medals namely "The President of India Award" for the best Ph.D. student for the research work in poverty alleviation and "Thiru D.R.Thirunavukkarasu Award" for the best Ph.D. student of the University during 36th

Convocation held at Tamil Nadu Agricultural University(TNAU), Coimbatore on 17/08/2015.

Best Book Award

A book titled "Extension" authored by Dr. C. Karpagam and Dr. S. Usha Rani has been bestowed with "Best Book Award" by Agricultural Scientific Tamil Society, New Delhi. The book has been written in Tamil language for the benefits of Diploma Agri. students and it was released by Hon'ble Vice-Chancellor, Tamil Nadu Agricultural University. It contains ten chapters, deals with basics of agricultural extension management. This book will serve as a valuable reference for Diploma Agri. students and other stake holders involved in transfer of technologies.

Best Oral Paper Presentation Award

Dr. Savitha Santosh and Dr. A. Manikandan were awarded "Best Oral Presentation Award" at International Conference on "Emerging Trends in Applied Science and Mathematics" (Techscientia-16) held at Tulsiramji Gaikwad-Patil College of Engineering and Technology (TGPET), Nagpur during January 22-23, 2016

Best Poster paper Presentation Awards

Dr S. M. Wasnik and Dr. V. Chinna Babu Naik were awarded "Best Poster Presentations" at the National Symposium on "*Future Technologies: Indian Cotton in the Next Decade*" held at Acharya Nagarjuna University, Guntur during December 17-19, 2015.

7. LINKAGES AND COLLABORATIONS

Memorandum of Understanding for PG research and training

- Department of Botany and Biotechnology, Telangana University, Dichpally, Nizamabad has signed MoU with ICAR-CICR, Nagpur on 5 Dec 2015 for facilitating student training/post graduate research/guidance.
- Amar Sewa Mandal, Kamla Nehru Mahavidyalaya, Nagpur has signed an MoU with ICAR-CICR, Nagpur on 22 March 2016 for facilitating students training/ post graduate research.

Linkages

Areas of Linkages	Institution
NATIONAL	
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 University, Delhi; CMERI-CoEFM, Ludhiana
HDPS and sustainable pest management strategies	Better Cotton Initiative

8. AICRP ON COTTON

Identification of Cotton Genotypes for Release

During the year 2014-15, fifteen cotton cultivars / hybrids have been identified by the Variety Identification Committee for various agro-climatic zones.

Cultivar	*Species*	Institution that developed
LH 2256	*G. hirsutum*	PAU, Ludhiana
SVHH 139	*G.hir X G.hir*	Shaktivardak Seeds
RHB 0711	*G.hir x G. bar*	MPKV, Rahuri
NHH 250	*G.hir X G.hir*	MAU, Nanded
NH 635	*G. hirsutum*	MAU, Nanded
NDLH 1938	*G. hirsutum*	ANGRAU, Nandyal
TSHH 0629	*G.hir X G.hir*	TNAU, Srivilliputur
MRC 7377	*G.hir X G.hir*	Mahyco Seeds
RHH 0707	*G.hir X G.hir*	MPKV, Rahuri
MCHB 7945	*G.hir x G. bar*	Mahyco Seeds
MRC 7385	*G.hir X G.hir*	Mahyco Seeds
RAHH 455	*G.hir X G.hir*	UAS, Raichur
MRDC 235	*G.arb x G.arb*	Mahyco Seeds
JLA 505	*G. arboreum*	MPKV, Jalgaon
MR 68	*G. hirsutum*	MR Seeds

Recommendation on crop improvement/ agronomy/physiology/pathology/ entomology)

Crop improvement

- Under irrigated condition, HS 296, GSHV 172 and CPD 1501 were the best *G. hirsutum* genotypes in North, Central and South Zone respectively. For Upper Half Mean Length, TCH 1716 was the best in all the zones and CCH 15-1 was the best for bundle strength in all the zones. Under rainfed situations, BGDS 1033 was the best culture in Central zone, whereas, NDLH - 2028-2 was the best in South Zone. For fibre quality, CCH 15-4 was found promising in both the zones.
- In the preliminary intra *G. hirsutum* hybrids trial under irrigated conditions, GTHH-217 was the best for seed cotton yield in North Zone while GJHH-5 was the best in central and south zones. Under rainfed situation, GTHH 215 was the best hybrid in the Central zone, whereas, NCS 5657 was the best in south zone.
- Among compact genotypes, RS 2814 was the best in North zone, whereas in Central Zone, DSC1501 and in South Zone, RS 2821 was the best for total yield in irrigated conditions. Under rainfed situation, GTHV-13/32 was the best in Central zone, whereas in South Zone, ARBC 1551 was the best.
- ARBB-1502 was the best *G. barbadense* culture in central zone and ARBB-1501 in south zone. Quality wise, CCB-11a was the best in both the zones.
- RHB 1008 was found to be the best inter-specific hybrid in Central Zone and THB 1243 was the best in South Zone.
- Among the *G. arboreum* cultures, PBD 17 was the top yielder in North Zone, while in Central Zone JLA-0906 was the best and in South Zone GAM-235 recorded the highest yield. Quality wise, PA 812 was the best in all the zones in respect of length and strength and is comparable to long staple *G. hirsutum* cotton.
- Among the *desi* hybrids, FMDH 36 (2897 kg/ha) was the best in North Zone and NACH 433 (1808 kg/ha) was the top performer in Central Zone.
- Among the *G. herbaceum* cultures tested under rainfed condition Central Zone locations, the Zonal Check was the best for seed cotton yield, whereas, RAHS 814 was the best in south zone.
- In North zone, Shakti Sultan (SSGR 105) was the best *G. hirsutum* culture in normal spacing, while, RS 2727 was the best under closer spacing. Among the hybrids, FHH 261 was the best. Among G. arboreum cultures, CISA 6-2 was marginally superior to zonal check.
- In Central Zone irrigated trial, GJHV 497 was the best in PVT, while GJHV-516 was the best in CVT, whereas, SCS 1207 showed superiority in rainfed trial under normal spacing. In closer spacing, GSHV 180 and DSC-1352 were superior in irrigated and rainfed conditions, respectively. Similarly, hybrids like RHH-1007, RHH-1015, GSHH-2595, NHH 715, RHB1014 and NACH 433 were found to exhibit better yield performance.
- In South Zone, the cultures HS 292, TSH 04/115, CCH 13-2, ARBC-1301, DSC-1302, IH 11, SCS 1206, GSB-44, JLA-0603, PA 740 and the

hybrids like BGDHH 821, RHH-1007, SHH 818, NHH 715 and RHB-1014 were found superior in various trials.

Crop production

- Agronomic requirements of FHH 209, HSHH 31, F2381, CSH 3075 & F2383 in North Zone; SCS 1062, GISV-267, Phule-688, GBHV 180, AKH 9916, DDH1251, RHH-0917, RHH 0622, BHH 326, RHB0812, RHB0708, ARBC-19 in Central Zone; SCS-1062, BGDS-1063, SCS-793, DB 39, DB 40, RHB 0812, DHB 912 TCH-1705, LH-2298 in South Zone were worked out.
- Recommended Bt hybrid + closer spacing (25% less than Rec.) + 125% RDF + Recommended foliar spray + micronutrient soil application + location specific measures for control of reddening gave significantly higher seed cotton yield at Akola, Nanded, Junagarh and Indore whereas recommended Bt hybrid + closer spacing (25% less than Rec.) + 125% RDF + recommended foliar spray out yielded at Surat.
- Different drip irrigation schedules were tried and results indicated that 0.6 ET at Lam, 0.8 ET at Faridkot and 1.0 ET at Rahuri and Banswara gave significantly higher seed cotton yield.
- Moisture conservation and control treatments were at par at Indore and Junagarh. At Akola, the highest plant height, sympodia, boll numbers, boll weight and seed cotton yield was recorded with poly mulching on BBF with drip irrigation.
- Recommended dose of nitrogen through inorganic sources gave significantly higher seed cotton yield in both central and south zone in the experiment on technology for organic cotton.
- Cross sub soiling at 1.0 m x 1.0 m distance gave significantly higher seed cotton yield at Faridkot, Bhatinda and Abohar whereas non significant results were recorded at Surat.
- The entries *viz*; L 603, BS 39, AKH09-5, SCS 1213, CNH 1110,L 770 and RAH 806 recoded higher seed cotton yield under rainfed conditions and expressed more than two contributing characters of drought tolerance in addition to yield attributing characters.
- Three genotypes *viz*., TSH-04/115, NDLH-1943 and NDLH-1938 had yields on par under irrigated and rainfed condition at Dharwad.
- G.Cot-16, GSHV-177 and AKH-095 recorded higher (12% more than average) yield under stress at Surat. Significantly negative correlation was observed between drought susceptibility index (S) and yield stability index (YSI). YSI was significantly correlated with yield under stress (YUS), Plant height stress index (PHSI) and dry matter stress index (DMSI).
- Based on the performance in lab and pot culture conditions, entries BS 39, PH 1060, SCS 1213 and NDLH 1943 can be considered as saline tolerant at Lam.
- Delay in sowing by every 10 days from 1st June, resulted in reduction of seed cotton yield and the extent of reduction between successive ten days varied between 9.68 to 37.32% at Dharwad.

Crop protection

Entomology

- Genotypes tolerant to sucking pests were identified from national and zonal breeding trials of the three cotton growing zones of India as follows:

I. From North zone, seven and 16 entries were identified as tolerant to leafhoppers in National and Zonal trials, respectively.

II. From Central zone, 33 and 17 entries were identified in National and Zonal trials, respectively against leafhopper.

III. From South zone, 9 and 22 tolerant entries were indentified against leafhopper through National and Zonal trials, respectively.

IV. Through advanced screening of promising entries, 18 from North zone and 9 from Central zones were identified as tolerant against leaf hopper.

- Occurrence of key pests of cotton in relation to climatic conditions was recorded at weekly intervals for both sucking pests and bollworms for analyzing pest dynamics in various participating centers.
- Pest situation was analyzed weekly under farmer's field conditions for publishing weekly advisory for all the zones.
- For the management of whitefly in North, a separate trial was conducted with insecticides and bio-pesticides as a module and in isolation against whitefly. However, none of the treatments was found effective to suppress the whitefly population because of the severe infestation of whitefly during this year.
- Through the trial on efficacy of insecticides against sucking pests, Flonicamid 50 WG @ 100 and 75 g a.i/ha were identified as suitable

insecticide for the management of sucking pests in central and south zones. The maximum seed cotton yield was observed in Flonicamid 50 WG @ 100 and 75 g a.i/ha trials of central and south zone, respectively.

- In the trial on IPM for HDPS, module I (IPM) recorded less pest infestation, weed flora and increased the soil fertility than module II (farmer's practice) in central and south zones.
- Study on the impact of seed treatment on pollinators indicated that *Apis dorsata, Apis florea, Apis mellifera* and *Apis cerana* were frequent flower visitors in Hisar. *Apis cerana* was found as the most frequent flower visitor, followed by *Apis florea* and *Melipona irridipennis* in Coimbatore. Imidacloprid FS 600 residue in soil sample, guttation fluid and pollen was below detectable level, though out the crop season.

Pathology

- Screening of Bt cotton hybrids (Released hybrids 1st Year trial-51; Pre-release hybrids 1st Year trial-34; Released hybrids+ Pre-release hybrids 2nd year trial-45) against cotton leaf curl virus disease was carried out at five locations (Hisar, Sirsa, Faridkot, Bhatinda and Sriganganagar) with normal sowing conditions and data of their reaction was reported separately.
- Cotton leaf curl virus in north zone, Alternaria leaf blight, bacterial blight and grey mildew in central zone and Alternaria leaf blight, bacterial blight, grey mildew, rust and tobacco streak virus in south zone were the major diseases reported during 2015-16 crop season.
- Cotton leaf curl virus disease (CLCuD) appeared in 23rd met week (4-10 June) at Hisar, during the 24th met week at Sirsa and in 26th met week at Faridkot and Sriganganagar in screening nurseries. Whereas in farmer fields in all three states, based on survey conducted under AICCIP, the maximum PDI of 34.4, 14.8 and 45.3 was recorded in Sirsa (Haryana), Sriganganagar (Rajasthan) and Fazilka (Punjab) respectively.
- Tobacco streak virus (TSV) incidence was only up to five per cent during the season at Rahuri, Maharashtra. During the surveys conducted in cotton growing districts by Guntur center, Tobacco Streak Virus disease was recorded on different hybrids from 0% to 12%. Survey for the occurrence of viral diseases by TNAU, Coimbatore revealed that Tobacco streak virus disease incidence was observed in all cotton growing tracts surveyed in Tamil Nadu which varied from 1.0 to 11.0%.
- In confirmation and maintenance of disease resistant entries trial, two entries *viz*., Suflum and Bihani-251 showed moderately resistant reaction against CLCuD at Faridkot.
- At Akola, it was observed that during 2014-15 and 2015-16, among 12 genotypes tested, 3 genotypes were resistant to bacterial blight i.e. NDLH-1943, P-2151, ADB- 542. Entries *viz*., GSHH 2729 and GSHV 162 were observed free from bacterial blight at Surat under artificial screening. Five varieties *viz*., ARBB 1401, DB 1402, CCB 36, ARBB 1402 and DB 1302 showed resistant reaction to grey mildew disease and moderately resistant reaction to Alternaria leaf spot at Guntur.
- Based on pooled results of three years (2012-14), the minimum seedling mortality was observed with maximum seed cotton yield when seed was treated with Carboxin 37.5%+ Thiram 37.5%DS at 4.5 g /kg at Dharwad, Guntur and Coimbatore.
- At Pune center, TrichoCASH@10 g/kg seed + Thiram @ 3 g/kg showed maximum (45.26%) disease control of cotton wilt, followed by Tricho CASH @ 5 g/kg seed + Thiram @ 3 g/kg (43.33%) disease control.
- At Junagadh center, out of seven modules including the control, module-6 [ST: *Pseudomonas fluorescens* (PF-CICR) @ 10 g/kg seed; SA: of *T. viride* (TV-TNAU) @ 2.5 kg/ha in 250 kg of FYM ; FS: with Ergon @ 1ml/lit followed by Taqat @ 1.5 g/lit for fungal diseases or COC (0.3%) + Streptocycline (0.01%) for BLB] recorded significantly minimum Alternaria leaf spot as compared to Control in RCH-2 BG-II hybrid.
- Seed treatment with *Pseudomonas fluorescens* (PF-CICR) @ 10 g/kg of seed, soil application of *Pseudomonas fluorescens* (PF-CICR) @ 2.5 kg/ha in 250 kg of Compost or FYM and foliar spray with *P. fluorescens* @ 1%(PF-CICR) was the best module at Dharwad for the management of foliar diseases.
- Innovative interventions for the management of CLCuD trial at Sirsa, Hisar, Sriganganagar, Faridkot and Bhatinda showed minimum CLCuD PDI in Polo spray @ 0.1% followed by cow urine @ 5%, neem oil and cow urine + calcium nitrate combination.

ICAR-CIRCOT fibre data :

ICAR-CIRCOT undertakes the fibre and yarn quality assessment of ICAR-AICRP on cotton samples. During the year 2015-15, the Annual Technological Report containing the quality parameter data was generated on the cotton samples received from the cotton breeders throughout the country at ICAR-CIRCOT HQ Mumbai and its regional units at Sirsa, Surat, Nagpur, Coimbatore, Dharwad and Guntur. In all, the technological data on 3755 samples have been reported of which 2644 samples belong to National trials while 1058 cotton samples correspond to zonal trials. Out of the zonal trials, 210 cotton samples belong to North zone, 466 cotton samples belong to Central zone and 382 belong to South zone. Under agronomy trial 53 samples were received. The fibre quality data of 3702 cotton samples and yarn quality data of 53 samples are presented in this report. The quality parameters of all cotton fiber samples were measured by using the High Volume Instrument operated in the HVI Mode.

Front Line Demonstrations (FLD) under NFSM-Commercial Crops

Since 1996-97, the All India Coordinated Research Project on Cotton has been conducting FLD on cotton through its network centers in various State Agricultural Universities and through ICAR- Central Institute for Cotton Research and its regional stations in Coimbatore and Sirsa. The objectives of the program are demonstrating the usefulness of the latest improved crop production and protection technologies to the farmers, reducing the time gap between technology generation and its adoption, enabling the scientists to obtain direct feedback from cotton farmers and suitably reorient their research programmes to develop appropriate technology packages and creating effective linkage among scientists, extension personnel and farmers. Until 2013, these demonstrations were conducted on Production Technology, Integrated Pest Management and on Farm implements under Technology Mission on Cotton, Mini Mission II. From 2014-15 onwards, these FLDs have been conducted under National Food Security Mission (NFSM) (Commercial Crops).

During the year 2015-16, under National Food Security Mission (NFSM) (Commercial Crops), 245 Front Line Demonstrations on Integrated Crop Management (ICM) on cotton, 157 Front Line Demonstrations on *Desi* / ELS cotton / ELS cotton seed production and 136 Front Line Demonstrations on intercropping with cotton were conducted by sixteen centres of All India Coordinated Research Project on Cotton with a budget outlay of 35.00 lakh rupees as against the proposed budget of 47.50 lakhs.

Tribal Sub-Plan Programme

Under the AICRP on Cotton- Tribal Sub Plan (TSP), a sum of Rs. 14 lakh was utilised to conduct training programme, demonstrations and other extension programs to disseminate the cotton production technologies exclusively to the tribal cotton farmers for improving their livelihood status

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

During the year 2015-16, seed multiplication, characterization and purification of Reference and Example varieties have been done in 77 varieties. Reference collection of 65 *G. hirsutum*, 3 *G. barbadense*, 8 *G. arboreum* genotypes were characterized and are being maintained.

At ICAR-CICR, Regional station, Coimbatore , field trials for the establishment of Distinctiveness, Uniformity and Stability of new cotton genotypes, varieties of common knowledge, farmers Variety and Essentially derived variety were conducted in tetraploid and diploid cotton. There were 68 new candidate varieties in second year of testing trial, which were *G. hirsutum*. In the first of testing there were 49 new candidate varieties, 12 varieties of common knowledge, one farmers variety and 19 essentially derived varieties along with 19 initial varieties were taken up. Sixty reference varieties were grown along with above trials for comparison of essential characteristics of candidate varieties. Essentially derived varieties and their corresponding Initial varieties were grown in unprotected and protected environment.

During 2015-16, one application for variety CCH 2623 developed by ICAR-CICR, was submitted through NBPGR for registration under PPV & FR Act, 2001. Monitoring of DUS trials was conducted on 7.11.2015 at MPKV Rahuri, on 19.11.2015 at CICR, Nagpur and on 13.1.2016 at CICR, Regional station, Coimbatore under the Chairmanship of Dr. K.R. Kranthi, Director, CICR, Nagpur.

9. KRISHI VIGYAN KENDRA

Training Achievements

Ninety nine short duration (1 to 3 days) on and off-campus training courses were conducted in different disciplines for practicing farmers, rural youth and extension functionaries. Out of 3150 participants 989 SC/ST farmers were benefited from the training programs conducted by Subject Matter Specialists (SMS) and Programme Assistants of KVK.

In addition to the above trainings, 17 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, Maharashtra, ATMA, CIPMC, Nagpur, RCF, MAFSU Nagpur, MCED and ICDS Nagpur, NGOs. In all, 853 participants attended these training programmes.

S. No.	Disciplines	No. of courses	No. of Total participants	SC/ST participants
1	Crop Production	14	517	138
2	Horticulture	06	212	55
3	Plant Protection	18	442	128
4	Veterinary Science	20	812	242
5	Soil Science	05	282	112
6	Home Science	19	448	199
7	Extension	17	437	115
	Total	**99**	**3150**	**989**

High Density Planting System (HDPS)

High Density Planting System in cotton was implemented in 6 talukas of Nagpur district *viz.*, Katol, Kalmeshwar, Saoner, Ramtek, Parshioni and Umred in collaboration with State Department of Agriculture. Cotton variety (Suraj) was demonstrated on 350 farmers field. Frequent visits were made and farmers were guided on production and protection aspects. Director and HODs CICR visited and guided the farmers.

A Scientist- farmer's group discussion on HDPS was arranged in Chargaon village of Parshioni taluka on September 22, 2015 and Taluka Agriculture Officer in this programme.

Fruits crops at KVK farm

Krishi Vigyan Kendra, CICR, Nagpur has established fruit crops such as Guava (L-49), Pomegranate (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.

Front Line Demonstrations (FLDs)

Four FLDs on crops and five FLDs on other aspects were demonstrated on farmer's field in adopted villages of Nagpur district *viz.*, Boruzwada, Angewada, Junewani, Patkakhedi, Tirkhura, Karhandla and Patansawangi. Several extension activities like field day, field visit of farmers, group discussions and scientist-farmer meet etc. were arranged for effective implementation of FLDs. Data on important production parameters as well as feedback from the farmers and visitors were recorded.

Details of Assessment of technologies under Front Line Demonstrations and On Farm Trials

S. No.	Crop	Technology demonstrated	No. of farmers	Area (ha)	Yield (q/ha)		Increase over FP (%)
					FLD	FP	
1	Cotton	HDPS/IPM	50	20	8.75	8.1	7.43
2	Chickpea (Cluster FLD)	IPM/Production technology	50	20	17.17	14.25	17.01
3	Cotton	Management of sucking pests in Bt-cotton	12	4.8	18.74	15.56	16.96
4	Soybean	Management of Girdle beetle in soybean	12	4.8	18.13	14.73	18.75

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 by-pass fat @ 200 g/cow/day	Jersey Crossbred cows	10	20	a) Avg. Milk yield (lit/cow/day) b) fat % c) BC Ratio	11.43 4.3 1:1.75	9.62 3.86 1:1.62	19.18 11.45 --
Goat (Oral administration of single dose of liquid closantel 15% @ 10 kg body wt. for Ecto-endo parasite control)	Local goat	10	40	Body weight gain in kg/2 months C:B ratio	4.43 1:1.76	3.45 1:1.38	28.77 --

Performance of FLD Under Home Science

S. No.	Name of Technology	No. of farmers	Crop	Performance Evaluation of different parameter								
				ΔHR beats min^{-1}			Area covered m$^{2/h}$			Yield picked kg / hour		
				Demo	Local check	Percent Reduction in drudgery over local	Demo	Local check	% increase in area	Demo	Local check	Increase in yield picked (%)
1	Bhindi/Brinjal plucker	20	Bhindi plucker	15	18	20	33	26	27	5.06	4.1	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 On Farm Trial (OFT) on farmer's field-

S. No.	Animal	Technology demonstrated	No. of farmers	No. of animals	Yield		% Increase over Farmers Practice
					Demonstration	Farmers Practice	
1	Cows	Feeding of area specific mineral mixture @ 50 gm/cow/day	30	60	Milk yield-9.10 lit/cow/day	Milk yield-8.63 lit/cow/day	5.41
2	Lactating dose (Cow)	Feeding of bag silage to milking cow Fat content in milk	10	20	Milk yield-7.56 lit/Cow/day Fat content in milk 4.27	Milk yield-7.00 lit/Cow/day Fat content in milk 3.96	8.00 7.8

Assessment of cotton pellets an alternative cooking fuel

S. No.	Description N=10	Cooking with cotton stalk briquettes		% saving over farmers practice
		Local	Demonstration	
1	Rice and 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 (%)	05	2.5	58

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

IRM in Nagpur district

The IRM project was implemented successfully in five major cotton growing blocks of Nagpur district, covering 45 villages. In all 1150 farmers were enrolled as district beneficiaries to implement IRM strategies in 2250 acre area. The IRM strategies were widely accepted by all farmers across various blocks in district wherever introduced and made positive impact on reduction in insecticide usage, associated with significant yield and ecological benefits. On an average, the number of insecticide sprays were reduced to 3.25 in IRM fields as compared to 5.20 sprays in non-IRM fields resulting in an overall 37.50% decrease in number of sprays. Across all the participating villages, IRM farmers harvested on an average 13.50 q/ha seed cotton yield compared to 12.80 q/ha by non-practicing farmers. This amount to 5.46% increase in yield and additional profit of Rs. 5830/ha over non-practicing farmers.

Diagnostics Surveys Conducted

S. No.	Discipline	Date	Crop	Title	Area Covered (ha)	No. of farmers benefitted
1	Plant Protection	24.07.15	Bt-cotton	Sucking pests under ETL	15	38
2	Horticulture	06.08.15	Chilli	Dying of seedlings in nursery	8 nurseries	25
3	Plant Protection	18.08.15	Bt-cotton	Sucking pest incidence	19	27
4	Agronomy	20.08.15	Cotton	INM in cotton	4	20
5	Vet. Science	25.08.15	Cows	Infertility in cows	32 cows	17
6	Vet. Science	15.09.15	Cows	Low milk yield in cross breed cows	42 cows	26
7	Agronomy	22.09.15	Cotton	Parawilt in cotton	5.6	14
8	Agronomy	28.10.15	Cotton	Leaf reddening in cotton	5	12
9	Horticulture	06.10.15	Nagpur mandarin	Pre harvest fruit drop in Nagpur mandarin	10 orchards	28
10	Plant Protection	07.10.15	Redgram	Less incidence of wilting	9	25
11	Plant Protection	20.10.15	Bt-cotton	Sucking pest incidence	10	15
12	Plant Protection	17.11.15	Redgram	Helicoverpa incidence	6	18
13	Plant Protection	12.12.15	Chickpea	Helicoverpa incidence	11	22
14	Plant Protection	05.01.16	Chickpea	Helicoverpa incidence	20	50
15	Plant Protection	08.01.16	Nagpur Mandarin	Sucking pest incidence, fruit drop	8.5	10
16	Home Science	12.01.16	Soybean processing	Curdling of Soymilk	-	11

S. No.	Discipline	Date	Crop	Title	Area Covered (ha)	No. of farmers benefitted
17	Home Science	22.01.16	Soybean processing	Hardening of Tofu	-	15
18	Home Science	07.02.16	Fruit processing	Colour maintenance of lemon squash	-	32
19	Vet. Science	12.02.16	Goats	Low weight gain in kids	40 kids	20

World Soil Day Organized

Krishi Vigyan Kendra CICR, Nagpur organized "World Soil Day" at village Gumthala, taluka Kampthee on 5th December, 2015. On this occasion Dr. M. S. Kairon, Ex-Director, CICR, Nagpur was the Chief Guest. Distributed 250 soil health cards to farmers.

Kisan Goshti

Krishi Vigyan Kendra CICR, Nagpur organized "Kisan Ghoshti" on the occasion of "Jai Kisan Jai Vigyan Diwas at Panchgaon, Umred on December 29, 2015.

Jal Jagruti Saptah Programme

On the eve of World Water Day (March 22nd) as per the United Nations General Assembly Declaration of 1993 and directives of Government of India, the Krishi Vigyan Kendra, CICR Nagpur organized one week campaign from 16th-22nd March, 2016 for effective utilization of water resources in agriculture and other sectors like domestic, industry, energy and power. More than 450 participants, comprising college students, farmers, farm women, staff of Krishi Vigyan Kendra, staff of Taluka Agriculture Office, Umred, Kamptee and ATMA Nagpur,

World Soil Day Organized

members of Panchyat Samiti, Umred and Kamptee were present. The Jal Shiwar activities were carried out in Umred and Kamptee block in association with Taluka Agriculture Office of respective block and DD ATMA, Nagpur. In Kamptee block, village Bhovari, Shri Ghawte, Joint Director Agriculture, Nagpur and Mrs. Kadu, Superintendent Agriculture Officer and Dr. R. B. Singandhupe explained various schemes being implemented in Nagpur district on water related activities. Dr. S. S. Patil, (SMS), Dr Ulhas Galkate(SMS) and Smt Sunita Chauhan (SMS) of Krishi Vigyan Kendra, CICR Nagpur and Shri Pandey, Taluka Agriculture Officer from Umred and Shri Dixit from Kamptee block contributed to the programme.

Soil Testing

One thousand seven hundred and forty soil samples were collected from Umred, Bhivapur, Katol, Kalmeshwar, Kamptee, Saoner, Ramtek, Narkhed, Kuhi and Parshioni 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 parameters and soil health cards depicting soil test based fertilizer recommendation for different crops were distributed to the beneficiaries.

Participation in Exhibitions

KVK, CICR Nagpur participated in the following events to display various research findings of CICR. Visitors interacted with KVK and CICR officials on various issues related to technologies developed at CICR Nagpur.

1) Krishi Vigyan Kendra, CICR, Nagpur participated in exhibition in "Santra Mahotsav" held at Warud, dist. Amravati from 1st-4th, October, 2015.
2) On event of "Dharmmachakra Pravartan Din" at Deekshabhoomi, Nagpur during 21st-23rd October, 2015, KVK, CICR, Nagpur participated and exhibited the achievement on various activities of cotton production technologies.
3) Krishi Vigyan Kendra, CICR, Nagpur participated in "Agro-Vision" exhibition held at Reshimbagh, Nagpur from 11th to 14th December, 2015.
4) Krishi Vigyan Kendra CICR, Nagpur participated in exhibition on the occasion of "Youth Empowerment Summit" from 1st-4th February, 2016.
5) Krishi Vigyan Kendra CICR, Nagpur participated in exhibition held at Dr. Ambedkar College, Nagpur on the occasion of National Conference on "Innovations in Agri-Sciences and Bio-technologies" from 25th-27th February, 2016.
6) Krishi Vigyan Kendra CICR, Nagpur participated in Exhibition held at VNIT, Nagpur on the occasion.

KVK staff as Guest Speaker

1. Dr. R. B. Singandhupe participated and delivered talk on 'Cotton Production Technology, Cotton Varieties and Irrigation Management in Cotton' at KVK, Kharpudi, Jalna on 05.05.2015 (500 farmers).
2. Dr. R. B. Singandhupe participated and delivered talk on 'HDPS Cotton Production Technology and Issues Related to Cultivation of HDPS Cotton' at Chargaon Village of Parshioni taluka on 20.09.2015 (150 farmers).

3. Dr. U. V. Galkate delivered talk on 'Role of KVK in livestock development' at VANAMATI, Nagpur on 28.10.2015 (30 Extension Functionaries).
4. Shri. Gulbir Singh, delivered a lecture on cultivation of flowers for enhancing income of the farmers on 15.07.2015 at Umred farmers meet, organized by World Vision India.
5. Dr. S. S. Patil delivered talk on "Package of Practices on Cotton Crop Production" at Bhora village on 19.03.2015 (100 rural youths farmers).

Participated in AGRO VISION 11th-14th December 2015

Winter School Attended

- Dr. S. S. Patil attended winter school on "Precision Citriculture for Sustainable Production and Post-harvest Management" at CCRI, Nagpur from15th October to 4th November, 2015

Meetings Attended

1. Dr. R. B. Singandhupe attended meeting with Agriculture Secretary Govt. of Maharashtra at Mumbai on 21.08.2015.
2. Dr. R. B. Singandhupe attended the meeting at ATARI, Hyderabad on 26.09.2015 to discuss and make strategies for drought mitigation in Vidharbha region.
3. Dr. R. B. Singandhupe attended the IMC meeting of ATARI, Hyderabad on 20.01.2016 and reviewed the activities of ATARI Zone-V.
4. Dr. R. B. Singandhupe attended the IMC meeting of NBSS&LUP, Nagpur on 17.02.2016.
5. Dr. R. B. Singandhupe attended the ARYA Project meeting at NAAS Complex, New Delhi on 27-28th Jan, 2016.

Workshop Conference Attended

1. Programme Coordinator, SMSs and Programme Assistant, of Krishi Vigyan Kendra, Nagpur participated in 'Action Plan Workshop 2015-16 of all KVKs of Vidharbha organized by Zonal Project Directorate, Zone-V, Hyderabad on 26th May 2015at Dr. PDKV, Akola.
2. Dr. R. B. Singandhupe, Programme Coordinator attended ZREAC Kharif Workshop held 6th June, 2015at Yavatmal.
3. Dr. R. B. Singandhupe, Programme Coordinator attended Annual Zonal Workshop Zone-V held from 26-28th June, 2015 at Jalgaon.
4. Dr. R. B. Singandhupe, Programme Coordinator attended 7th National conference of KVK from 25-26th July, 2015 at Patna (Bihar).
5. Dr. R. B. Singandhupe Programme Coordinator attended ZREAC Rabi Workshop held on 27th October, 2015 at Yavatmal.

List of publications

1. Chauhan, Sunita (2015). Ergonomics of Bt cotton picking bags. *Agriculture Mechanisation in Asia, Latin America and Africa (AMA)*, 46(4): 67-71.
2. Galkate U.V. and Rokde S. N. *Dudharu Pashuoko Khilaye Azola.* Krushak Jagat, p 16-22 March, 2015

Radio and T.V. Talks

- Smt. Sunita Chauhan delivered a radio talk on "Krushi Apshistapasun Jaiv kolse" in Marathi, AIR, Nagpur on 17.11.2015.
- Dr. U. V. Galkate delivered a radio talk on "Diseases of Goat and their prophylaxis" in Marathi, AIR, Nagpur on 15.09.2015.
- Dr. U. V. Galkate delivered a live in programme on "Pashu Vishyak Prashnanchi Uttare" in Marathi, AIR, Nagpur on 25.02.2016, 01.03.2016 and 08.03.2016.
- Smt. Sunita Chauhan delivered T.V. Talk on "Mahilanche Sharirik Shram kami karnari Awzar" in Marathi, Sheti Darshan telecasted by Nagpur Doordashan on 17.11.2015
- Smt. Sunita Chauhan delivered T.V. Talk on "Mahilao ke liye krushi upyogi upkaran aur yantra" in Hindi, Sheti Darshan telecasted by Nagpur Doordashan on 21.02.2016

Advisory Services Provided

KVK provided advisory services to 23582 clients comprising of farmers, rural youth and extension works, through personnel guidance, telephonic calls and mobile services on Agricultural production, protection technology and allied fields.

10.1 List of Publications

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

1. Ahuja, S. L., Monga, D., Meena, R. A., Kumar, R. and Saxena, N. (2016). Effect of intra row spacing's on estimates of phenotypic and genotypic correlation coefficients in *G. arboreum* cotton. *Indian Journal of Agricultural Sciences,* 86(2): 173-7. (NAAS Rating: 6.00)
2. Amutha M. and Gulsar Banu J. (2015). Variation in mycosis of entomopathogenic fungi on mealybug, *Paracoccus marginatus* (Homoptera: Pseudococcidae). *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences,* DOI 10.1007/s40011-015-0624-8. (NAAS Rating: 6.40)
3. Blaise D., Wanjari R., Singh R.K. and Hati K.M. (2015). The response of weed community in soybean with conventional and conservation tillage systems on rainfed Vertisols. *Archives of Agronomy and Soil Science,* 61:1289-1301. (NAAS Rating: 6.55)
4. Desouza N.D., Blaise D., Kurchania R. and Qureshi M.S. (2015). Dust emission from different soil types in the northwest and the Indo-Gangetic Plains of north India. *Atmosfera,* 28: 251-260. (NAAS Rating: 6.88)
5. Kumar Rishi, Monga D., Nitharwal Mukesh, Swami Dinesh and Singh Satnam (2015). Incidence of non-target pest species and validation of IPM strategies in Bt .cotton hybrids deployed with different events of cry genes. *Indian Journal of Agricultural Sciences,* 85 (11): 1448–54. (NAAS Rating: 6.00)
6. Mukherjee A.K., Mukherjee P.K. and Kranthi Sandhya (2015). Identification of *Sclerotium delphinii* causing seed rot and seedling disease in cotton. *Journal of Plant Pathology*, 97(2): 303-305. (NAAS rating: 6.77)
7. Nagrare V. S., Deshmukh Vrushali, Naikwadi Bhausaheb, Bhoyar Paresh and Khadakkar Suvarna (2015). Spider diversity in transgenic and non-transgenic cotton in rainfed agro ecosystem of central India. *Research Journal of Biotechnology,* 10(12):76-84. (NAAS Rating: 6.28)
8. Rao S. S., Kumar D., Wadodkar M. R., Nagaraju M. S. S., Chattaraj S., Joseph W., Rajankar P., Sengupta Titu, Venugopalan M. V., Das S. N., Joshi A. K., Sharma J. R. and Amminedu E. (2016). Performance of global soil moisture products in crop growing region of Central India. *Journal of the Indian Society of Remote Sensing*. DOI 10.1007/s12524-015-0496-7. (NAAS rating: 6.93)
9. Santhy V. and Mithila M. (2015). Widening the character base for distinctness in cotton: Emerging perspective. *Current Science,* 109(11): 1913. (NAAS Rating: 6.83)
10. Tuteja O. P. and Agrawal Manish (2015). Combining ability estimates and genetic variance for yield and quality traits of parents and crosses in upland cotton (*Gossypium hirsutum). Indian Journal of Agricultural Sciences*, 85(12):1643-46. (NAAS Rating: 6.00)
11. Venugopalan M. V., Kranthi K. R., Lakde Shubhangi and Tandulkar N. R. (2016). Development of agro-technology to increase yields of a shy-bearer *desi* cotton species, *Gossypium arboreum* race *cernuum* in a non-traditional area of cultivation. *Current Science*, 110(4): 692-695. (NAAS rating: 6.93)

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

12. Agarwal Isabella (2016). Economic implications of indian cotton economy under WTO regime. *Journal of Cotton Research and Development,* 30(1): 135-142. (NAAS rating: 3.41)
13. Agarwal Isabella, Reddy A.R., Singh Sukhpal and Yelekar Sachita M. (2015). Yield gap and constraints analysis of cotton in India, *Journal of Cotton Research and Development*, 29(2): 333-338. (NAAS rating: 3.41)
14. Amutha M. and Gulsar Banu. J. (2015). Pathogenesis of entomopathogenic fungus,

Metarhizium anisopliae (Metsch.) Sorokin., on mealybug, *Paracoccus marginatus* (Williams and Granara de Willink) (Homoptera: Pseudococcidae). *Journal of Biological Control*, 29(3): 134-138. (NAAS Rating: 3.96).

15. Amutha M. and Dharajothi. B. (2015). Life table of *Phenacoccus solenopsis* (Homoptera: Pseudococcidae) on cotton. *Indian Journal of Entomology*, 77(1): 1-10. DOI. 10.5958/0974-8172.2015.00001.2. (NAAS Rating: 4.30).
16. Angadi C, Manjula S.M., Patil S.S., Madhura C., Basavaradder A.B. and Santosh H.B. (2016). Correlation and path coefficient analysis of yield component and fiber quality traits of upland cotton (*Gossypium hirsutum* L.) *International Journal of Agricultural Science and Research,* 6(1): 171-176. (NAAS Rating: 3.53)
17. Bhattacharyya T., Mandal C., Mandal D. K., Jagdish Prasad, Tiwary P., Venugopalan M. V. and Pal D. K. (2015). Agro-eco sub-region based crop planning in the black soil regions and indo-gangetic plains - application of soil information system. *Proceedings of the Indian National Science Academy,* 81(5): 1151-1170. DOI: 10.16943/ptinsa/2015/v81i5/48335. (NAAS rating: 3.93)
18. Blaise D. (2015). Influence of seasonal variability and conservation tillage on flower production and boll retention of *Bt* cotton. *Indian Journal of Agronomy,* 60: 594-600. (NAAS Rating: 5.00)
19. Dharajothi B., Naik C.B., Kranthi S., Kranthi K.R., Valarmathi R. (2016). Viable mass production method for cotton pink bollworm, *Pectinophora gossypiella* (Saunders). *The Journal of Basic and Applied Zoology*, 73: 9-12.
20. Kanjana D. (2015). Potential Application of Nanotechnology in major Agriculture Divisions – A Review. *International Journal of Agriculture, Environment and Biotechnology*, 8 (3): 699–714. (NAAS rating: 4.10)
21. Kumar Rishi, Monga D., Lal Madan, Kumar Sandeep and Shivangi (2015). Field and laboratory evaluation of neem based and synthetic insecticides for the management of whitefly in cotton. *Cotton Research Journal*, 6(1): 1-6. (NAAS Rating: 2.27)
22. Manikandan A. and Subramanian K.S. (2015). Ability of urea impregnated biochar fertilizers for securing the slow release of nitrogen in soils - preliminary study. *International Journal of Agricultural Sciences*, 7(11): 750-756. (NAAS rating: 2.37)
23. Manikandan A. and Subramanian K.S. (2016). Evaluation of zeolite based nitrogen nano-fertilizers on maize growth, yield and quality on Inceptisols and Alfisols. *International Journal of Plant & Soil Science*, 9(4): 1-9.
24. Monga D., Kumar Rishi, Solanki Priyanka and Kayasth Monika (2015). Management of cotton leaf curl virus disease through innovative interventions. *Cotton Research Journal,* 6:7-12. (NAAS Rating: 2.27)
25. Nalayini, P. and Suveetha (2016). Exhausting weed seed bank before sowing through stale seedbed technique for managing weeds in winter irrigated Bt cotton (*Gossypium hirsutum*) based intercropping system. *Journal of Cotton Research and Development,* 30(1): 49-53. (NAAS rating: 3.41)
26. Pable Dhanashree, Chatterji S., Venugopalan M. V., Sen T. K., Giri J. D. and Sarkar Dipak (2014). Soil quality assessment using fuzzy modelling – A case study in rainfed cotton growing agro-ecological sub regions of Vidarbha, Maharashtra. *Cotton Research Journal*, 5(2):120-125. (NAAS rating: 2.27)
27. Palve S. M. (2015). Breeding for earliness in *hirsutum* cotton- a review. *Cotton Research Journal,* 7: 13-18. (NAAS Rating: 2.27)
28. Rathinavel K. (2015). Extension of shelf life of cotton (*Gossypium hirsutum* L.) seeds through polymer coating under ambient storage condition. *Indian Journal of Agricultural Research*, 49(5): 447-451. (NAAS rating: 3.86)
29. Sethi K., Siwach P., Verma S.K. and Sihag M. (2015). Assessing genetic diversity among *Gossypium arboreum* L. genotypes using ISSR markers. *International Journal of Pharma and Bio Sciences,* 6(1):201-208.
30. Verma S.K., Dhanda Muniya and Salar Raj Kumar (2015). Analysis of genetic diversity among Asiatic cotton (*Gossypium arboreum* L.) cultivars and breeding lines using RAPD and SSR markers. *Int. J. Adv. Res. Biol.Sci.,* 2(3):114–122.

10.2 : List of on-going Projects

S.N.	Project title & Investigators	Duration
	Crop Improvement	
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 (PA)	2000-20
	CBP 2: Studies on Genetic Enhancement of *G. hirsutum.* T. R. Loknathan (PI)	2002-16
	CBP 3: Development of drought tolerant genotypes with good fibre quality in *G. hirsutum.* 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)	2005-16
	CBP 5: Development of long staple *G. hirsutum* 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 *G. hirsutum* 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 *G. barbadense* 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. Vinita 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. Sarvanan (PA)	2012-17
	CBP12 : Development of cotton leaf curl virus resistant genotypes using *G.arboreum*/ *G.herbaceum* through introgression. S.K. Verma (PI),O. P. Tuteja (PA), D.Monga (PA), Rishi Kumar (PA), Vinita Gotmare (PA), H. B. Santosh (PA)	2015-21
	CBP 13: Breeding to improve performance of *Gossypium herbaceum* 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 (*Gossypium arboreum)* genotypes suitable to south Zone A. Manivannan (PI), Punit Mohan (PA)	2015-20
2.	Cotton Germplasm Management Program (CGMP)	
	CGMP 1 : Collection, conservation, evaluation, documentation and maintenance of germplasm of cultivated species of *Gossypium.* Punit Mohan (PL), S. Manickam (PA), R. A. Meena (PA), K. P. M. Damayannthi (PA)	2006-17
	CGMP 2 : Conservation, characterization and utilization of wild species, races of cultivated species and synthetic polyploids of *Gossypium.* Vinita Gotmare (PL), G. Balasubramani (PA).	2008-18
	CGMP 3: Exploration, collection and conservation of landraces of *desi* cotton and perennials and from different regions of India. M. Saravanan (PL)	2011-16
3.	DUS characterization and DNA finger printing of public sector cotton varieties. V. Santhy (PL), H. B. Santosh (PA)	2012-17

S.N.	Project title & Investigators	Duration
4.	Studies on genetic purity of public released cotton hybrids and its parents with the help of SDS-PAGE. P. R. Vijayakumari (PL), K. R. Kranthi (PA)	2013-16
5.	Studies to improve the seed and boll setting efficiency in cotton. R. A. Meena (PL), Rishi Kumar (PA), K. Rathinavel (PA)	2012-18
6.	Evaluation of exogenous application of plant growth hormones and other chemicals on seed yield and quality of cotton. Sunil Mahajan (PI)	2015-17
	Biotechnology	
7.	Deployment of biotechnological tools for enhancing cotton seed by-product utilization: Reduction of gossypol content using CYP6AE14 gene. K. P. Raghavendra (PI),Sandhya Kranthi (PA), G.Balasubramani (PA), K. Velmourougane (PA)	2014-17
8.	Basic Studies on Somatic embryogenesis of Cotton. Joy Das (PI), Rakesh Kumar(PA), S.B. Nandeshwar (PA)	2015-17
9.	Development of novel methods for gene delivery into cotton. Rakesh Kumar (PI), Joy Das (PA)	2015-17
	Crop Production	
10.	Allelopathy as an alternative weed management strategy in cotton. Blaise Desouza (PI), P. Nalayini (PA), A. Manikandan (PA)	2012-17
11.	Correlation of leaf colour transmittance with relation to soil/plant nutrient status. J. Annie Sheeba (PI)	2014-17
12.	Evaluation of structured water for cotton production. P. Nalayini (PI)	2014-19
13.	Role of leaf phytochemicals in cotton leaf reddening and plant responses to management through growth chemicals, nutrients and insecticides. J. Annie Sheeba (PI), A. Manikandan (PA)	2012-17
14.	MCDA based decision support system for selecting cotton cultivars for different agro climatic conditions. M. Sabesh (PI)	2011-16
15.	Evaluation of nano-formulated micronutrients foliar spray for yield maximization in different cotton genotypes. D. Kanjana (PI)	2012-17
16.	Efficient nitrogen fixing legumes for cotton based cropping systems. A. Manikandan (PI), P. Nalayini (PA)	2015-20
17.	Development of cotton nursery techniques and validation (Ad hoc project). K. Sankaranarayanan (PI), A.H. Prakash (PA)	2015-16
18.	Impact of Bt cotton and pesticides on nitrogen fixing soil bacteria in cotton-legume intercropping systems. Savitha Santosh (PI)	2015-16
19.	Development of remunerative cotton based cropping systems based on conservation agriculture principles. R. Raja (PI), D. Kanjana (PA)	2015-19
20.	Survey, surveillance and identification of weeds of economic value in cotton based cropping system. S N Rokde (PI)	2015-17
	Crop Protection	
21.	Gene discovery for useful traits. K. R. Kranthi (PI), Sandhya Kranthi (PA), K. P. Raghavendra (PA), K. Velmourougane (PA), J. Annie Sheeba (PA), A. Sampathkumar (PA)	2014-19
22.	Role of epicuticular wax in reaction of cotton genotypes to whitefly/ CLCuD. Rishi Kumar (PI), D. Monga (PA), Sandhya Kranthi (PA), J. Annie Sheeba (PA)	2014-17
23.	Isolation and characterization of endophytes in cotton and endo -symbionts in bollworms. M. Amutha (PI)	2012-17

S.N.	Project title & Investigators	Duration
24.	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
25.	Development of reverse transcription loop mediated isothermal amplification (RT- LAMP) for early detection of cotton leaf curl and tobacco streak viruses of cotton (*G. hirsutum*). S. P. Gawande (PI), Dilip Monga (PA)	2015-16
26.	**Technology Mission on Cotton Mini Mission (TMC-MM) I**	2012-17
	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)	
	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), H. B. Santosh (PA)	
	TMC MM 1.4: Evaluation of genotypes and a grotechniques for high density planting system and surgical cotton varieties. M. V. Venugopalan (PI), Blaise DeSouza (PA), V. Chinna Babu Naik (PA), Punit Mohan (PA), T. R. Lokanathan (PA), A. R. Raju (PA) A. Sąmpath 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 Sandhya 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. Annie 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)	
	Externally funded projects	
27.	DBT: Development of saturated genetic linkage map for *Gossypium hirsutum* L. using SSR and SNP markers. V. N. Waghmare (PI), Punit Mohan (PA)	2012-16
28.	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
29.	Consortia research platform on biodiversity. Punit Mohan (PI), Vinita Gotmare (PA), J. H. Meshram (PA), S. Manickam (PA), R. A. Meena (PA)	2014-17
30.	UGC: Association mapping of fiber traits in *Gossypium arboreum* L. accessions using SSR, ISSR and AFLP markers. S. K. Verma (PI)	2012-16
31.	NSP: National Seed Project (Crops). K. Rathinavel (PI)	1999-17
32.	DUS: Implementation of PVP legislation 2001 and DUS testing of cotton under ICAR-SAU system. K. Rathinavel (PI)	2003-17
33.	MSP: ICAR project on seed production in agricultural crops and fisheries. P. R. Vijayakumari (Nodal Officer), V. Santhy (PA), K. Rathinavel (PA), R. A. Meena (PA)	2007-17
34.	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

S.N.	Project title & Investigators	Duration
35.	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
36.	NICRA: Climate change - adaptation and mitigation strategies in cotton. S.E.S.A Khader (PI), A. H. Prakash (CoPI), Blaise Desouza (CoPI), M.V. Venugopalan (CoPI)	2013-17
37.	DST: Design and development of a cotton picking head. G. Majumdar (PI)	2012-16
38.	DST: Development of vision based expert system for vacuum picking of cotton. G. Majumdar (PI)	2013-16
39.	Mahyco: Monitoring changes in baseline susceptibility to Cry toxins in the cotton bollworm, *H. armigera,* pink bollworm and *Spodoptera litura.* Sandhya Kranthi (PI), K. R. Kranthi (CoPI), V. Chinna Babu Naik (CoPI)	2012-16
40.	GEAC: Event based approval mechanism. Sandhya Kranthi (PI), K. R. Kranthi (CCPI)	2010-16
41.	TMC MM II: Dissemination of IRM strategies in India. K. R. Kranthi (PI), Sandhya Kranthi (PA), D. Monga (PA), B. Dharajothi (PA), Rishi Kumar (PA)	2007-16
42.	DST: Entomopathogenic -endophytes mediated plant defense as a novel approach for the management of bollworms in cotton. M. Amutha (PI)	2013-17
43.	Consortia research platform IIHR (Lead centre): ORP on management of sucking pests in horticultural crops. Sandhya Kranthi (PI), M. Amutha (PA)	2014-16
44.	Maha. Govt : Crop pest surveillance and advisory project (CROPSAP) in Maharashtra. V. S. Nagrare (PI)	2010-16
45.	NFSM-OPMAS: On line pest monitoring and advisory services (OPMAS) under NFSM –commercial crops. R. K. Tanwar (PI), D. Monga (PA), Rishi Kumar (PA)	2012-17
46.	DST: Engineering root -knot nematode resistance in cotton by RNAi mediated silencing of parasitism genes of *Meloidogyne incognita.* N. G. Narkhedkar (PI), S. B. Nandeshwar (CoPI)	2013-16
47.	ICAR Extramural: Introgression of genes for whitefly and CLCuD resistance in upland cotton (*G. hirsutum*). 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

10.3: Consultancy, Patents, Commercialization of Technology

Revenue Generation

Particular	Amount (Rs.)
Sale of Farms Produce	2615743.00
License Fee	288786.00
Application fee from candidates	28200.00
Income generated from internal resource generation	1500.00
Net profit in Revolving Funds	223667.00
Miscellaneous Receipts	1154367.00
Total	**4312263.00**

MoU signed by ICAR-CICR

- Material Transfer Agreement and Commercial Use Agreement was signed between ICAR-CICR and University of Delhi on 15th June, 2015 for "Cotton transgenic event Tg2E-13
- Better Cotton Initiative on 24th April 2015 for "High Density Planting System (HDPS)" on farmers' fields
- Tierra Seed Science Pvt Ltd, Hyderabad on 21st April 2015 for "Utilization of CICR released varieties for making hybrid and commercialization".
- Kohinoor Seed Field India Pvt. Ltd, New Delhi on 28th July 2015 for "Production and commercialization of selected parents of hybrids and varieties of ICAR-CICR".
- Bharat Seeds on 4th Dec. 2015 for "Production and marketing of seeds of *Desi* cotton variety, CICR-3 and Hybrid CICR-2 released from CICR-Sirsa".

10.4 : Significant Decisions of RAC, IRC, IMC

Research Advisory Committee Review Meeting

Research Advisory Committee meeting was held at ICAR-CICR, Nagpur from 16-17 October 2015. Dr. K. R. Kranthi, Director, ICAR–CICR, Nagpur welcomed the Chairman and members of RAC and briefed the house about emerging issues in cotton cultivation with special mention of whitefly menace in North India, Pink Bollworm resistance to Bollgard II in Gujarat and leaf reddening in central India. He also informed the RAC about salient research findings of the institute. Dr. M. V. Venugopalan, Head, PME and Member Secretary RAC, presented the Action Taken Report. Dr. B. V. Patil, Chairman, RAC expressed satisfaction on ATR and appreciated the research efforts of the institute. He called for focusing the efforts on research in early maturity, jassid tolerance, compact plant architecture and mechanical picking. He recalled 2015 as 'International Year of Soils' and asked the CICR scientific fraternity to work on aspects of soil health, seed quality biofortification, conservation agriculture, climate change and whitefly management. Dr. A. K. Dhawan called for promotion of *desi* varieties which are resistant to whiteflies and superior *G. hirsutum* varieties which are better

than *Bt* hybrids in north India through SAUs and KVKs. He also stressed the importance of basic research on the aspects of sucking pest tolerance in cotton. Dr. T. Pradeep, Member, RAC appreciated the efforts of cotton breeders and suggested to consolidate the research gains with appropriate breeding strategies to develop an ideal plant type with reasonable tolerance to biotic and abiotic stresses. Dr. Sunil Mukherjee stressed the need of utilizing the available cotton genome sequence information to achieve stress tolerance through biotechnological and molecular breeding approaches. Dr. A. J. Shaikh appreciated the efforts of CICR in identifying the varieties suitable for surgical purpose and also stressed the importance of lower trash content in mechanical picking and removal of gossypol in seed processing. Dr. Sandhya Kranthi, Head, Divison of Crop Protection, Dr. D. Blaise, Head, Division of Crop Production, Dr. Suman Bala Singh, I/c Head, Division of Crop Improvement, Dr. Dilip Monga, Head, CICR RS, Sirsa, Dr. N. Gopalakrishnan, former ADG, Commercial Crops, RS, Coimbatore and Dr. S. B. Nandeshwar, CICR CICR I/c, Biotechnology Section, briefed the achievements of their respective Divisions / Stations. Recommendations were suggested by the Chairman and members of the RAC based on field visits, lab visits and the presentations made for the respective Divisions / Regional Stations. The recommendations subsequently approved by the Council is as follows-

Recommendations of RAC

1. Chloroplast specific markers for DNA fingerprinting. SSR specific unique amplicons to be linked to quality traits using genome sequence data

2. Elite genotypes to be screened under different spacing and fertility levels to validate the architecture of the genotype for HDPS
3. Studies should be carried out to ascertain whether leaf reddening is a death signal
4. Resistance development of PBW to Cry proteins – should be addressed on priority.
5. Real-time PCR analysis of somatic embryogenesis related genes and micro RNAs involved in regeneration of cotton may be explored for transgenic cotton development.
6. Validation of fiber specific GhcesA1 promoter with GUS, over expression and down regulation gene constructs (GhcesA1, GhcesA2, Ghfla3, Ghcobl4) may be examine through transient Agro-infiltration technique.
7. The role of epicuticular waxes in resistance to whiteflies & CLCuD and the role of weather and management interventions on whitefly outbreak should be studied.
8. Experiments on conservation agriculture at CICR, Regional Station (Coimbatore) should be fine tuned.

Institute Management Committee Meeting

The 53rd Institute Management Committee was held on 30 October, 2015 under the Chairmanship of Dr. K.R. Kranthi, Director, ICAR - CICR, Nagpur. At the outset, Sh. Sachin Agnihotri, Senior Administrative Officer, Member Secretary welcomed Dr. K.R. Kranthi, Director ICAR - CICR & Chairman, IMC, Dr. R.G. Dani, Vice Chancellor, Dr. PDKV, Akola and other members of IMC including special invitees.

Dr. K.R. Kranthi, Director CICR and Chairman IMC gave his introductory remarks and briefed IMC members regarding significance of this meeting. He apprised the IMC Members about the present status of EFC approved items like construction of compound wall and roads at Hqrs Nagpur, status of purchase of equipments approved under the EFC. The IMC members also recommended for construction of compound wall at Headquarters Nagpur on priority keeping in view the security of the institute. Dr M.V. Venugopalan, In-charge PME Cell, briefed about the salient research achievements and these were further substantiated by the Heads of the Divisions. The meeting ended with vote of thanks proposed by Member Secretary.

Institute Research Committee (IRC) meeting

The Annual Institute Research Committee (IRC 2016) meeting of CICR was held during 17 -19 & 24 March 2016 at CICR, Nagpur. Dr K.R. Kranthi Director CICR Nagpur chaired the meeting. Chairman in his introductory speech, lauded the remarkable contributions by scientists in cotton R & D especially developing cotton picker, nitrogen Guru, light traps etc. Chairman expressed concern over current year national issues like whitefly menace in north India and development of resistance by pink bollworm to Bt cotton in several states of central and south India. Dr M.V. Venugopalan presented recommendations of Research Advisory Committee meeting held on 16-17 October 2015. Dr Vinita Gotmare presented report of Research Framework Document (RFD) of the Institute. Dr V.S. Nagrare presented Action Taken Report of the IRC 2015. All the completed, ongoing and new projects were reviewed critically. On this occasion IRC felicitated Dr SESA Khader, Principal Scientist (Plant Physiology) CICR, RS, Coimbatore who is due to retire in the month of May 2016. All the scientists from CICR, Nagpur, CICR RS, Coimbatore and CICR RS, Sirsa attended the meeting. All the scientists took active part in the discussions on the progress of on-going projects and formulation of new projects as well as plan of work for 2016-17. Dr Sunil Mahajan & Dr H.B. Santosh of Crop Improvement, Dr Anuradha Narala & Dr A. Manikanadan of Crop Production, Dr Shailesh Gawande & Mr T. Prabhulinga Crop Protection and Mr Joy Das & Mr Rakesh Kumar of Biotechnology section served as Rapporteurs. Dr V.S. Nagrare, Secretary IRC and Dr J.H. Meshram Joint Secretary IRC coordinated the meeting.

Project Monitoring and Evaluation Committee (PMC)

Coimbatore

The Project Monitoring and Evaluation Committee chaired by Dr. K.R. Kranthi, Chairman & Director CICR, Nagpur; consisting of Dr. M.V. Venugopalan, Principal Scientist (Agronomy) & Head, PME Cell; Dr. (Mrs) Suman Bala Singh, I/c Head Crop Improvement reviewed the on-going research projects at CICR, Regional Station, Coimbatore during 12-13, January 2016. All the Scientist of the regional station presented the research findings of on-going projects. The committee visited and reviewed the experimental fields at new research farm on 12 January 2016 and interacted with the scientists on the progress of work against the objectives outlined in the projects. On 13 January 2016, the committee reviewed the experiments conducted at the main farm. At the end, the vote of thanks was proposed by Dr. S. Usha Rani, Senior Scientist.

10.5 : Other Important Workshop / Symposia / Meetings

Review meeting on *desi* cotton (*G. arboreum*)

A meeting to review the performance of *desi* cotton (*G. arboreum*) variety Phule Dhanwantary, being popularized under high density planting system, for promotion of surgical cotton in Vidarbha was held on 30 November 2015 at ICAR-Central Institute for Cotton Research, Nagpur. The meeting was jointly organized by CICR and Yuva Rural Association (YRA), Nagpur. Director, CICR, Head of Divisions and scientists from CICR, Shri Datta Patil, Director General, YRA, Shailandra Bhaisare, Manager, Vidarbha Agriculture Farmer Producer Company, Officials from seed industry, Neem Foundation, Nagpur and farmers who cultivated Phule Dhanwantry under technical support from CICR were present. Around 45 farmers and other stake-holders participated in the meeting. Shri Datta Patil, explained the purpose of the meeting was to get feedback from farmers, enable farmers share their experience in cultivation of Phule Dhanwantary and also to plan a way forward, procure produce from farmers, process the same and upscale the programme for the next year. Dr. K.R. Kranthi, Director, ICAR-CICR wished and realized his vision of chemical free cotton production through Phule Dhanwantary. He stressed the possibility of using the lint from Phule Dhanwantary (apart from surgical end use) to the production of antibacterial bed sheets, using nano-ZnO coating. He desired that the entire cotton value to be up-scaled into a mini-industry and transform this movement into a true 'Make in India' enterprise. The farmers narrated their experience of cultivating Phule Dhanwantary. The realized / expected yields across locations (Nagpur, Amravati, Wardha, Yavatmal, Akola, Buldhana) ranged from 5 to 18 q/acre. The farmers expect higher yields when Phule Dhanwantary is cultivated using organic inputs. They also narrated some novel intercropping systems and innovative crop management technologies adopted. All the farmers observed that the cost of production was low, however, their main apprehension was the sale of cotton in the market. Drs. Blaise Desouza and Anuradha Narala shared their observations on the performance of Phule Dhanwantary during the survey made in Vidarbha region. The reasons for wide variation in yield were analyzed. It was noticed that most often farmers took up wider row spacing than desired. Dr M.V. Venugopalan, Principal Scientist (Agronomy) narrated his experiences on HDPS and replied to various questions raised by the farmers. After a prolonged discussion, it was decided that Vidarbha Agriculture Farmer Producer Company will procure seed cotton from the farmers and provide the seeds to ICAR-CICR for seed processing and testing. VAPC and YRA will take up distribution of seeds to farmers during the next season. Dr. (Mrs) Sandhya Kranthi, Head, Crop Protection Division proposed the vote of thanks.

Institute Biosafety Committee (IBSC) meeting

IBSC meeting was held on 14 Aug. 2015. The newly constituted committee with DBT nominee Dr. Ashok

Giri, NCL, Pune, Medical Officer Dr. B.D. Deshmukh, external Expert Dr. C. N. Rao, CCRI under the chairmanship of Dr. K.R. Kranthi, Director ICAR-CICR with internal members Dr. Sandhya Kranthi, HoD Division of Crop Protection, Dr. S.B. Nandeshwar, Head, Biotechnology Section, Dr. V. Nagrare, IBO, Dr. K.P. Raghavendra, Scientist (Biotech), Dr. H.B. Santosh, Scientist (Plant Breeding & Genetics) and Dr. G. Balasubramani, Member Secretary got approved by RCGM. The committee approved the Delhi University proposal of transgenic cotton event Tg2E-13 with Cry1Ac for evaluation and commercialization. Proposals from TNAU, Coimbatore for Cotton event CH12 carrying *Cry*2AX1 gene and NBRI, Lucknow for cotton event carrying *Cry*1EC were approved for Material Transfer Agreement (MTA). The committee also permitted for screening of CICR events at contained condition and exchange or share the multi-gene construct developed by ICAR-CICR, Nagpur with collaborating institutes such as PDKV Akola, MAU Parbhani, and MPKV Rahuri under MTA.

IIEFA-2016

ITMU coordinated 1st All India Conference of Industries, Innovators, Entrepreneurs, Facilitators, and Academia (IIEFA-2016) – held from 5-7 Feb. 2016 at VNIT, Nagpur. All ICAR patented/ commercialized technologies were showcased in the conference for budding entrepreneur. Shri Nitin Gadkari, Hon'ble Minister of Road Transport and Highways inaugurated the conference. ITMU also participated and showcased all CICR technologies to the public in 5th Science Expo held at Raman Science Centre, Nagpur from 9-13 Jan. 2016.

10.6 : Results – Framework Document (RFD) Committee

The RFD Committee was re-constituted with the following officials of this institute.

Name	Designation
Dr. K.R. Kranthi, Director	Chairman
Dr. (Mrs.) Vinita Gotmare, Pr. Scientist	**Nodal Officer**
Dr. V. Santhy, Pr. Scientist	**Co – Nodal Officer**
Shri. Sachin Agnihotri, SAO	Member
Finance & Accounts Officer	Member
Dr. M.V. Venugopalan, Principal Scientist & Head, PME Cell	Co –opted member
Dr. H.B. Santosh, Scientist	Co –opted member
Dr. V.S. Nagrare, Sr. Scientist	Co –opted member
Dr. J. Annie Sheeba, Scientist	Co –opted member
Dr. K. P. Raghavendra, Scientist	Co –opted member

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

The Institute set a high performance standard and achieved a total composite score of 99.5% (Ranked in Excellent category) in the Annual Performance Evaluation Report (April 1, 2014 to March 31, 2015).

10.7 : Participation of Scientists in Seminars / Symposia / Workshops / Meetings

Sr. No.	Seminars/Conferences/Symposia/ Workshops/Meetings	Place and Date	Participants
1.	Annual Group Meeting of NSP (Crops)	ICAR-DSR, Mau 3 - 5 April, 2015	Sunil S. Mahajan
2.	AICCIP annual workshop	TNAU, Coimbatore 8-10 April, 2015	K.R. Kranthi*
3.	Standing committee meeting of RCGM for processing the release proposals of Transgenic cotton for North zone	DBT, New Delhi 15-16 April, 2015	A.H. Prakash
4.	Standing committee meeting of RCGM for processing the release proposals of Transgenic cotton for Central and South zone	DBT, New Delhi 1 May, 2015	A.H. Prakash
5.	Workshop on Application of RNAi in Crop Improvement	ICAR-NRCPB, New Delhi 5 May, 2015	K.P. Raghavendra
6.	72nd Central Sub-committee on Crop Standards, Notification and Release of varieties for Agricultural Crops	Krishi Bhavan, New Delhi 25 June, 2015	A.H. Prakash
7.	Inception workshop of the flagship project Gender Knowledge System in Agriculture	ICAR-CIWA, Bhubaneswar 29-30 June, 2015	Mrs. S. Usha Rani Mrs. A. Narala
8.	8th meeting on Advising Maharashtra Government to issue No Objection certificate (NOC) to conduct confined field trials of GM crops	ATMA, Pune 15 July, 2015	G. Balasubramani
9.	National Conference of KVKs	Patna, Bihar 25-26 July, 2015	K. R. Kranthi
10.	10th Annual Review Meeting of ICAR Seed Project	ICAR-CCARI, Goa 24-25 August, 2015	K. Rathinavel
11.	Meeting on Whitefly management	Krishi Bahvan, New Delhi 8 Sept., 2015	K.R. Kranthi A.H. Prakash
12.	Training workshop on Environmental Risk Assessment (ERA) of Genetically Engineered (GE) plants	New Delhi, 15-17 Sept., 2015	V.S. Nagrare
13.	Workshop on Agro climatic zone –IV	CSSRI, Karnal 5 Oct., 2015	O P Tuteja Rishi Kumar
14.	12th meeting of the Inter Regional Network on the Mediterranean and Middle East regions	Sharm-el-Sheikh, Egypt 7-9 Oct., 2015	K.R. Kranthi Mrs. S. Usha Rani
15.	73nd Central Sub-committee on Crop Standards, Notification and Release of varieties for Agricultural Crops	Krishi Bhavan, New Delhi 12 Oct., 2015	A.H. Prakash
16.	Meeting on Whitefly infestation on cotton in North zone	ICAR, New Delhi 13 Oct., 2015	K.R. Kranthi, A.H. Prakash Mrs. Suman Bala Singh

Sr. No.	Seminars/Conferences/Symposia/ Workshops/Meetings	Place and Date	Participants
17.	Meeting on status of whitefly infestation on cotton crop in Haryana & Punjab & meeting of IRM HDPS	ICAR, New Delhi 27 Oct., 2015	K.R. Kranthi
18.	Interactive session of scientists from AICRP on Cotton & Soybean	NASC, New Delhi 27, Oct., 2015	V.S. Nagrare
19.	National Seed Congress	Hyderabad 28 Oct., 2015	K.R. Kranthi
20.	Workshop on developing a road map for agricultural development in ACZ IX (Western Plateau and Hills)	ICAR-DSR Indore 4 Nov., 2015	M.V. Venugoplan
21.	3rd Asian Conference of Archeology	Amravati 16-19 Nov., 2015	V. S. Nagrare
22.	DUS Workshop	NASC Complex New Delhi 23-24 Nov, 2015	K. Rathinavel
23.	Standing committee meeting of RCGM discuss the protocol finalization for BG-III field trials	DST, New Delhi 26 Nov., 2015	A.H. Prakash
24.	74th Plenary Meeting of the ICAC	Mumbai 06-10 Dec., 2015	K.R. Kranthi, M.V. Venugoplan and G. Majumdar
25.	Workshop on refuge strategies for biotech crops-adoption, challenges and alternative towards achieving technology sustenance	NASC Complex New Delhi 7 Dec., 2015	Rishi Kumar
26.	Workshop on the RIB	NASC Complex, New Delhi 8 Dec., 2015	A.H. Prakash
27.	International Symposium on Biodiversity, Agriculture, Environment and Forestry to be held at Ooty, Tamil Nadu	Ooty, Tamil Nadu 11-12 Dec., 2015)	Mrs. S. Usha Rani, Mrs. D. Kanjana, Mrs. M.Amutha, Mrs. Gulsar banu
28.	'Agro – Vision' the biggest National agricultural exhibition for farmers of Central India	Nagpur 11-14 Dec., 2015,	D.V. Patil
29.	National Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2015)	R V S K V V, Gwalior; 12-13 Dec., 2015	Santosh, H. B.
30.	Meeting on Pink Bollworm organized by ANGRAU, Hyderabad	NAARM, Hyderabad 13 Dec., 2015	A.H. Prakash
31.	National Symposium on Future Technologies: Indian Cotton in the Next Decade	A N U, Guntur; 17-19 Dec., 2015	Santosh H. B., D.Monga, O.P. Tuteja, Rishi Kumar, Mrs. D. Kanjana, K.Sankaranarayanan, N. Gopalakrishnan, A. Manivannan, V.S. Nagrare, V. Chinna babu

Sr. No.	Seminars/Conferences/Symposia/ Workshops/Meetings	Place and Date	Participants
32.	Techscientia-16: 2nd International Con ference on Emerging Trends in Applied Science & Mathematics	Nagpur, 22-23Jan., 2016	D. Blaise, Mrs. Savitha Santosh, Mrs. J. Annie Sheeba, A. Manikandan, Santosh, H. B. Joy Das, Rakesh Kumar, KP Raghavendra
33.	ICAR Directors conference	New Delhi 23-24Jan., 2016	K.R. Kranthi
34.	Mid-term review workshop of CRP-Natural fibre	ICAR-CIRCOT, Mumbai 30 Jan., 2016	SB. Nandeshwar, Rakesh Kumar, Joy Das
35.	Workshop on Forward Thinking for Agricultural Development in Western India	Sardar Krushinagar 8-10 Feb., 2016	K. Rathinavel
36.	Workshop on Management of Pink Bollworm and Parawilt	Nanded 10 Feb., 2016	K.R. Kranthi
37.	International Conference-2016 on Natural Resource Management : Ecological Perspectives	Jammu 20 Feb., 2016	K.R. Kranthi
38.	6th International Conference on Plant, Pathogens and People	NASC New Delhi 23-27 Feb., 2016	Satish K Sain
39.	Workshop on Dossier preparation of GE plants organized by ICAR in collaboration with ILSI Research Foundation, USA and BCIL, New Delhi	BCIL, New Delhi. 25 Feb., 2016	G. Balasubramani
40.	National Conference on Innovations in Agri-Biosciences (NCIABS-2016)	Nagpur 26-27 Feb., 2016	K.R. Kranthi **
41.	10th DUS Review Workshop	MPKV Rahuri 26-27 Feb., 2016	Mrs. V. Santhy K. Rathinavel
42.	Workshop on cotton production	Sewagram, Wardha 2 Mar., 2016	MV Venugopalan, SM Palve, V Santhy VS Nagrare
43.	Annual Chemical Engineering Symposium	IIT, Mumbai 13 Mar., 2016	K.R. Kranthi
44.	Annual workshop of CRP - Natural fibre	ICAR-CIAE Bhopal 9-11 Mar., 2016	S.B. Nandeshwar, Rakesh Kumar, Joy Das
45.	Textile Meet on Promoting Trade and Investment in Cotton and Textile Sector in Africa	New Delhi 21 Mar., 2016	D. Blaise
46.	Seminar on awareness on whitefly & best practices for growing cotton	Abohar, Punjab 21 Mar., 2016	D Monga Rishi Kumar

* M.V. Venugoplan, Mrs. S. B. Singh, T.R. Loknathan,. S. M. Palve, Punit Mohan,. M. Palve, V.N. Waghmare, Mrs. Vinita Gotmare, Mrs V. Santhy, M. Saravanan, V.S. Nagrare, D Monga, O P Tuteja, R A Meena, Rishi Kumar, A.H. Prakash, N. Gopalakrishanan, SESA Khader, S. Manickam, Mrs. Dhamayanthi, Mrs. P. Nalayini, Mrs Dharajothi, Mrs. S. Usha Rani, K.Sankaranarayanan, Mrs. Isabella Agarwal, Mrs. Amutha, Mrs. D. Kanjana, Mrs. Gulsar banu

** Joy Das, Rakesh Kumar, KP Raghavendra, S. B Nandeshwar, Mrs. S. B. Singh, T.R. Loknathan, S. M. Palve, Punit Mohan, V.N. Waghmare, D. V. Patil, Mrs. Vinita Gotmare, M. Saravanan, Sunil Mahajan, H.B. Santosh , Mrs. Nandini Gokte Narkhedkar, V.S. Nagrare, V.S. Chinna babu Naik, Mrs. J. Annie Sheeba, A. Manikandan

10.8: Distinguished Visitors

Name & Designation	Organisation	Date
Nagpur		
Dr. Kavita Gupta, Textile Commissioner	Ministry of Textiles, Government of India, Mumbai	26.12.2015
Coimbatore		
Dr. J.S. Sandhu, DDG (Crop Science)	ICAR, New Delhi	15.07.2015
Dr. S. Ayyappan Director General	ICAR, New Delhi	27.08.2015
Dr. A.K. Basu and Dr. V. Santhanam	Former Director Former FAO consultant	09.03.2016

10.9: Personnel

Director

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Project Coordinator (Cotton)

Coimbatore

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Neeraj Anand, Scientist (joined 12.10.15 & resigned 20.02.2016)

Genetics & Plant Breeding

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Coimbatore

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Microbiology (PS)

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Smt. Savitha Santosh, Scientist (joined on 10.04.2015), abdhi2050@gmail.com

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Coimbatore

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KVK

Nagpur

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PME CELL

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Administration

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10.10 : Other Information

Visit to Giza, Egypt

Dr Kranthi Director, Central Institute for Cotton Research was invited as chief guest of the inaugural session of the 12th Meeting of the Inter-Regional Cooperative Research Network on Cotton for the Mediterranean and Middle East Regions at Sharm El-Sheikh, EGYPT, October 07-09, 2015. Dr Kranthi was felicitated for his outstanding contributions to cotton research, by Dr Rafiq Chaudhary, Head Technical Information and International Cotton Advisory Committee Washington. In the inaugural session Dr Kranthi presented the key note address on 'Future of biotechnology in cotton'. The Inter-regional meeting on cotton was organized by the cotton research institute Giza, Egypt, in collaboration with ICAC Washington. A total of 90 delegates from 15 countries participated in the meeting. Dr Kranthi presented his deputation report and his impressions of the visit on 4th November 2015 before the scientists of CICR.

Delegation from African Countries

The society SABC has arranged a study tour of 30 key officials from East African cotton growing countries including Kenya, Ethiopia, Zambia, Zimbabwe, Swaziland and Malawi from 27 Sept to 2 Oct 2015. Participants include Parliamentarians, key regulators, and senior most government officials from agriculture and environment ministries. The members of the team visited Sirsa on the late afternoon of Monday, 28 September 2015.

Dr. Rishi Kumar, Principal Scientists (Entomology)

made a presentation regarding the mandate and ongoing activities of the centre and the team also visited the demonstrations plot of varieties and hybrids developed by the centre and hybrids sown under High Density Planting in Cotton. The team members interacted with the scientists of the centre on various issues.

Visit of foreign students

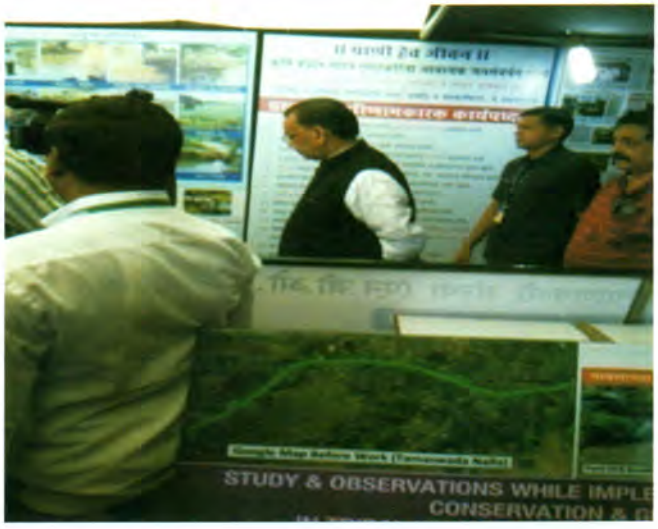
Fourteen students and two faculty members from the Department of Fiber Science and Apparel Design (FSAD) Cornell University New York, USA along with one representative from Sathguru Management and Consultants Pvt Ltd, India, which represents Cornell University's College of Agriculture and Life Sciences (CALS) in India, had visited Central Institute for Cotton Research (CICR), Coimbatore on 13.01.2016. Special lectures were delivered by Dr. N. Gopalakrishnan, Former ADG (CC), Dr. S. Manickam, Principal Scientist and Dr (MRs) S. Usha Rani, Senior Scientist.

Visit of International Trainees

As a part of their two months course in "Agricultural Project Management" sponsored by Ministry of External Affairs, Government of India under the TCS of Colombo Plan at Kothari Agricultural Management Centre (KAMC), Coonoor, The Nilgries, fourteen international trainees from six countries *viz.*, Afghanistan, Bangladesh, Fiji, Indonesia, Malaysia and Myanmar visited the ICAR-CICR, Regional Station, Coimbatore on 23.01.2016. Dr A. Manivannan, Scientist (Plant Breeding and Genetics) spoke on "Beneficial Agriculture for All with Special Reference to Cotton". Dr. S. Manickam, Principal Scientist (Plant Breeding and Genetics) delivered a lecture on "Varieties and Hybrids Released from ICAR-CICR" and also clarified the queries raised by the delegates about Bt cotton. Finally, Dr (Mrs) S. Usha Rani, Senior Scientist (Agricultural Extension) spoke on "The origin, activities and achievements of ICAR-CICR, Coimbatore". The program was ended with a vote of thanks proposed by Dr (Mrs) S. Usha Rani.

Agro-Vision 2016

A stall showcasing the technologies of ICAR-Central Institute for Cotton Research, Nagpur was kept in "7th Agro Vision" the biggest Agriculture Summit of Central during 11-14 December, 2015. In this mega event nearly 5 Lakh farmers visited the exhibition site put up by over 300 exhibitors. Around 60,000 farmers attended the day to day workshops in which 52 experts comprising of various sectors particularly from agriculture across the country guided as resource persons. The event was inaugurated by Shri. Radha Mohan Singh,



Honourable Minister for Agriculture and Farmers Welfare, Govt. of India. Shri Nitin Gadkari, Honourable Minister for Road and Transport and many other VIPs were present on the occasion. Dr. K.R. Kranthi, Director, ICAR- CICR also shared the dais. Large number of farmers also visited CICR stall and appreciated the research and extension educational activities, also good number of farmers registered themselves for getting regularly 'e-Kapas' advisories from CICR. Dr. R.B. Singndhupe, Programme Coordinator, KVK; Dr. S.M. Wasnik, Principal Scientist (Extension); Dr. V.N. Waghmare, Principal Scientist (Plant Breeding); Dr. D.V. Patil, Senior Scientist (Plant Breeding); Dr. J.H. Meshram; Dr. S. P. Gawande; Dr. Manikandan; Dr. S.S. Patil; Dr. P.B. Deolkar and Smt. Sunita Chauhan actively participated.

CICR Foundation Day Celebration

CICR celebrated its 39th Foundation Day on 1st April 2015 with bliss and fervor. Dr. K. R. Kranthi, Director, CICR, presided over the function. Dr C. D. Mayee, Former Chairman ASRB graced the occasion as Chief Guest. Ex-Directors of CICR, Dr M. S. Kairon, Dr N. D. Mannikar, Dr K. D. Koranne and Dr Phundan Singh were invited as Special Guests of the day. Food Stalls and games were conducted by Crop Improvement, Crop Protection, Crop Production, Biotechnology, KVK and Administration Divisions/Sections. Various competitions like Singing, Jokes, Humorous Poetry etc. were conducted by Dr G. Balasubramani,

Principal Scientist, Biotechnology. During the Valedictory function, welcome address was given by Dr. Sandhya Kranthi, Head, Crop Protection Division. Dr. K. R. Kranthi, Director, CICR, felicitated the Chief Guest and the Special Guests of Honour. Awards were given to Er. Gautam Majumdar-Scientist of the year, Dr. MS Yadav, Technical Officer of the year, Sh.V.D. Bende - Administrative staff of the year and Sh. N.R. Titarmare, Skilled Supporting Staff of the year. Prizes were distributed to Winners and Runner-up of various competitions held. Dr. C. D. Mayee, Chief Guest of the day gave a brief talk and encouraged all the staff. Shri Sachin Agnihotri, Senior Administrative Officer, proposed the vote of thanks. All the CICR staff participated in the celebrations.

CICR Bagged Medals in ICAR-Central Zone Tournaments

Sh Sujit Kumbhare, Technical Assistant T 1, Crop Protection Division, CICR Nagpur bagged two Silver Medals in running competition of 800 m (2.33 sec) and 1500 m (5.48) during ICAR-Central Zone Tournaments organized at ICAR-Directorate of Weed Sciences, Jabalpur from 7-11th December, 2015.

Library

Additions

In the period from 2015-16, the Library purchased 57 new books and 27 Hindi books. The Library subscribed to 10 Foreign Journals and 17 Indian Journals.

During the period, approximately 3000 books were acquired and added to the CICR Library existing collection from DCD Mumbai (Department of Cotton Development) according to the directives issued by the Ministry of Agriculture for transferring books and monographs from DCD Mumbai to CICR Nagpur. The collection comprises of a variety of literature not only on Cotton and Agriculture, but also on Economics, Geology, Horticulture, Textiles, and related facts. The golden collection is actually a readers' delight and gives a panoramic view of the scientific methods deployed in the study of agriculture. Extremely rare books which would be any libraries' pride have added to the glory. To quote a few books such as, *Mendel's Principles of Heredity, Physiology of the ascent of sap by J C Bose, Commercial plants of India by George Watt, Structural Botany by Gray and Short history of the Empress Mill Nagpur published in 1877*. Several books on Cotton in different countries, Cotton Physiology, Cotton Genetics and many more related subjects are a part of this exhaustive collection.

Publications ranging back to the 19th century in the form of Memoirs, Reviews, Investigation Records, Bulletins and Minutes, Yearbooks and Gazetteers sit with pride today in the Library collection. Books published in the years 1840, 1879, 1880 and 1898 are no less than a treasure which is a part of our Library today.

This plethora of golden old books and publications surely give an insight on the acumen of those scientists whose contributions have paved a bright way for agriculturists today.

DOCUMENTATION SERVICES

- Library has developed computerized bibliographic database on Cotton to provide comprehensive and updated information on cotton. About 4675 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 (V29, (No. 1-4), January – December 2015)* 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-OPAC Link http:// 10.0.0.52/w20/

Progressive Use of Hindi

केन्द्र सरकार की राजभाषा नीति को लागू करने के तहत राजभाषा विभाग (गृह मंत्रालय) तथा भारतीय कृषि अनुसंधान परिषद, नई दिल्ली द्वारा तैयार और जारी वार्षिक कार्यक्रम को ध्यान में रखते हुए, केन्द्रीय कपास अनुसंधान संस्थान ने वर्ष 2015–16 के दौरान शासकीय कार्यों में हिन्दी के व्यापक प्रयोग में काफी प्रगति की है। भारतीय कृषि अनुसंधान परिषद में हिन्दी के प्रगामी प्रयोग संबंधी कार्य निदेशक (रा.भा.) के प्रशासकीय नियंत्रण में है। निदेशक के सीधे नियंत्रण में हिंदी अनुभाग राजभाषा नीति के कार्यान्वयन से संबंधित कार्य देखता है और इसमें एक प्रभारी, हिन्दी अनुभाग को नियुक्त किया गया हैं।

निदेशक तथा प्रभारी, हिन्दी अनुभाग के अधीन संस्थान राजभाषा कार्यान्वयन समिति है। यह समिति इसके अधीन सार्वजनिक क्षेत्र के उपक्रमों में हिन्दी के प्रयोग में हुई प्रगति की समीक्षा करती हैं। समिति की बैठकें नियमित रूप से आयोजित की जाती हैं। वर्ष 2015–16 के दौरान ऐसी चार बैठकें आयोजित की गई। संस्थान

हिन्दी सलाहकार समिति निदेशक की अध्यक्षता में संस्थान हिन्दी सलाहकार समिति कार्यरत है जिसका मुख्य उद्देश्य संस्थान के सरकारी कामकाज में हिन्दी के प्रगामी प्रयोग को बढ़ावा देने के लिए परामर्श देना है।

राजभाषा अधिनियम, 1963 की धारा 3(3) का कार्यान्वयन भारत सरकार की राजभाषा नीति के अनुसरण में, राजभाषा अधिनियम, 1963 की धारा 3(3) के अंतर्गत आने वाले लगभग सभी दस्तावेजों को हिन्दी और अंग्रेजी में तैयार किया जाता है। क्षेत्र 'क', 'ख' और 'ग' क्षेत्रों में स्थित केन्द्र सरकार के कार्यालयों में हिन्दी में पत्र भेजना सुनिश्चित करने के लिए जांच बिन्दु बनाए गए हैं।

वर्ष 2015–16 के दौरान गृह मंत्रालय, राजभाषा विभाग, हिन्दी शिक्षण योजना द्वारा आयोजित नवंबर,15 में पारंगत परीक्षा में संस्थान से 31 एवं प्रबोध तथा प्रवीण में 04 अधिकारी तथा कर्मचारी पास हुए। तथा मई में होनेवाली परीक्षा में 39 पारंगत, 2 प्रबोध, 01 प्रवीण तथा 08 प्राज्ञ के लिए आवेदन कर चुके है। सन 2015 के लिए शवेत स्वर्णिमा का विमोचन मा.ना.श्री नितिनजी गडकरी केंद्रीय मंत्री, परिवहन, महामार्ग, जहाजबांधणी विभाग के करकमलों द्वारा हुआ।

हिन्दी दिवस / हिन्दी पखवाड़ा

संस्थान के अधिकारियों/कर्मचारियों को शासकीय कार्य हिन्दी में करने के लिए प्रोत्साहित करने हेतु हिन्दी दिवस का आयोजन 14 सितंबर, 2015 को संस्थान के निदेशक एवं संस्थान राजभाषा कार्यान्वयन समिति के अध्यक्ष डा. केशव राज क्रांति तथा मुख्य अतिथि डा. एम. एस. लदानिया, निदेशक, केन्द्रीय निम्बुवर्गीय अनुसंधान संस्थान, नागपुर की प्रमुख उपस्थिती में सम्पन्न हुआ। इस कार्यक्रम में संस्थान के विभिन्न विभागों के अध्यक्ष तथा वैज्ञानिक, अधिकारी एवं कर्मचारियों ने उत्साह पूर्वक भाग लिया। इस दौरान संस्थान के निदेशक ने अपने स्वलिखित कविता द्वारा सभी का मन मोह लिया। डा. लदानिया ने आज के दौर में हिन्दी का कार्यालयीन कामकाज में महत्व के बारे में अवगत कराया। संस्थान राजभाषा कार्यान्वयन समिति के सदस्यों तथा संयोजक के परिचयात्मक एवं औपचारिक संबोधन के बाद निदेशक महोदय ने हिन्दी पखवाड़ा–2015 की विधिवत शुभारंभ की घोषणा की।

हिन्दी पखवाड़ा–2015 के अंतर्गत हिंदी में सामाजिक जनजागृति निर्माण करने के उद्देश्य से विभिन्न प्रतियोगिताओं का आयोजन किया गया। जिन प्रतियोगिताओं का आयोजन किया गया, वे इस प्रकार हैं– हिन्दी हास्य कविता पाठ, अंग्रेजी समाचारों का हिन्दी अनुवाद, हिन्दी भाषण प्रतियोगिता (स्वच्छ भारत–स्वस्थ भारत), हिन्दी पथ–नाट्य मंचन (सूरज सी.आई.सी.आर. का नया आविष्कार, देशी कपास लगाओ–देश बचाओ तथा आत्महत्या ग्रस्त किसान–एक आत्मावलोकन जैसे विषयों का प्रस्तुतीकरण हुआ), हिन्दी गीत अनुवाद, स्व–रचित हिन्दी कविता पाठ और हिन्दी सिनेमा गीत अंताक्षरी। इन प्रतियोगिताओं में संस्थान के सभी वर्ग के कर्मचारियों द्वारा बड़ी संख्या में बढ़–चढ़ कर भाग लिया। विभिन्न कार्यक्रमों का आंकलन विभाग प्रमुखों, प्रधान वैज्ञानिकों, वारिष्ठ वैज्ञानिक तथा तकनीकी अधिकारियों ने किया।

हिन्दी पखवाड़ा–2015 का समापन समारोह दिनांक 03 अक्टूबर, 2015 को सम्पन्न हुआ। इस कार्यक्रम के मुख्य अतिथि डा. सी. डी. मायी, संस्थान के पूर्व निदेशक एवं पूर्व अध्यक्ष, कृषि वैज्ञानिक चयन मंडल, कृषि अनुसंधान एवं शिक्षा विभाग, भा.कृ. अनु.प., कृषि मंत्रालय, भारत सरकार उपस्थित थे। आपने संस्थान के सभी कर्मचारियों को अधिक से अधिक कार्य हिन्दी में करने के लिये प्रेरित किया। आपने आगे कहा कि सरकारी कामकाज अधिक से अधिक हिन्दी में किया जाए तो हिन्दी दिवस मनाने की आवश्यकता ही नहीं पड़ेगी। इस अवसर पर कपास संस्थान के निदेशक डा. क्रांति द्वारा संस्थान में ही निर्मित तथा स्वयं के द्वारा निर्देशित कपास पर लघु वीडिओ फिल्म दिखाई गयी। उसके बाद विजेता प्रतिभागियों को पुरस्कार के रूप में नगद धनराशि और प्रमाणपत्र मुख्य अतिथि के हस्ते प्रदान किए गए।

10.11: Weather

Nagpur

Month	Temperature (°C)		Relative Humidity (%)		Rain fall (mm)	No. of Rainy Days
	Max	Min	Max	Min		
June, 2015	36.74	25.54	77.62	51.70	340	13
July, 2015	32.60	25.35	83.44	67.41	178	11
August, 2015	30.75	24.44	87.86	72.25	369	7
September, 2015	33.44	23.85	88.40	62.86	235	7
October, 2015	33.97	21.03	87.25	58.89	16	1
November, 2015	32.04	16.91	79.24	48.90	0	0
December, 2015	29.72	13.23	76.67	39.98	0	0
January, 2016	29.96	11.13	78.88	38.99	0	0
February, 2016	33.01	16.78	68.87	43.58	2	1
				Total	1140	40

Coimbatore

Month	Temperature(°C)		Relative Humidity (%)		Rain fall (mm)
	Max	Min	Max	Min	
July, 2015	32.2	22.9	85.2	49.9	5.1
Aug.2015	32.3	23.2	86.0	51.5	28.1
Sept. 2015	33.0	23.8	82.9	47.2	66.2
Oct. 2015	31.6	23.3	86.9	52.4	65.2
Nov. 2015	28.6	22.0	93.3	70.5	191.3
Dec. 2015	29.0	21.5	89.9	61.6	24.1
Jan.2016	30.2	19.5	86.1	45.7	0.2
Feb. 2016	33.4	21.5	80.5	35.7	0 .0
Total					380.2

Sirsa

Month	Temperature (°C)		Rain Fall (mm)	Rainy days
	Maximum	Minimum		
April 2015	41.7	15.4	25.6	3
May 2015	45.0	21.0	3.0	1
June 2015	43.8	22.6	22.8	3
July 2015	40.0	22.2	90.4	7
August 2015	37.2	25.0	44.6	3
September 2015	38.2	20.0	17.2	2
October 2015	37.5	12.0	0.0	0
November 2015	30.2	8.5	4.2	1
Total Rainfall			207.8	20

10.12: Cotton Scenario

State-Wise Cotton Area, Production and Productivity

Zone/State	2014-2015			2015-2016*		
	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)
Punjab	4.2	12.00	486	4.5	8.00	302
Haryana	6.48	20.50	538	5.76	16.00	472
Rajasthan	4.87	17.00	593	4.47	15.00	570
North Zone	**15.55**	**49.50**	**541**	**14.73**	**39.00**	**450**
Gujarat	27.73	108.00	662	27.61	102.00	628
Maharashtra	41.9	78.00	316	38.27	79.00	351
Madhya Pradesh	5.47	18.00	559	5.47	18.00	559
Central Zone	**75.10**	**204.00**	**462**	**71.35**	**199.00**	**474**
Telangana	17.13	57.00	566	16.94	59.00	592
Andhra Pradesh	8.21	27.00	559	6.63	23.00	590
Karnataka	8.75	31.50	612	6.12	22.00	611
Tamil Nadu	1.87	5.00	455	1.29	5.00	659
South Zone	**35.96**	**120.50**	**570**	**30.98**	**109.00**	**598**
Others	1.58	6.00	646	1.75	5.00	486
Grand Total	**128.19**	**380.00**	**504**	**118.81**	**352.00**	**504**
1 bale= 170 kg.						

Source: Cotton Advisory Board, Ministry of Textile, Govt. of India.