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2018-19

ICAR-CENTRAL INSTITUTE FOR COTTON RESEARCH

NAGPUR

An ISO 9001:2015 Certified Organisation

भाकृअनुप
ICAR

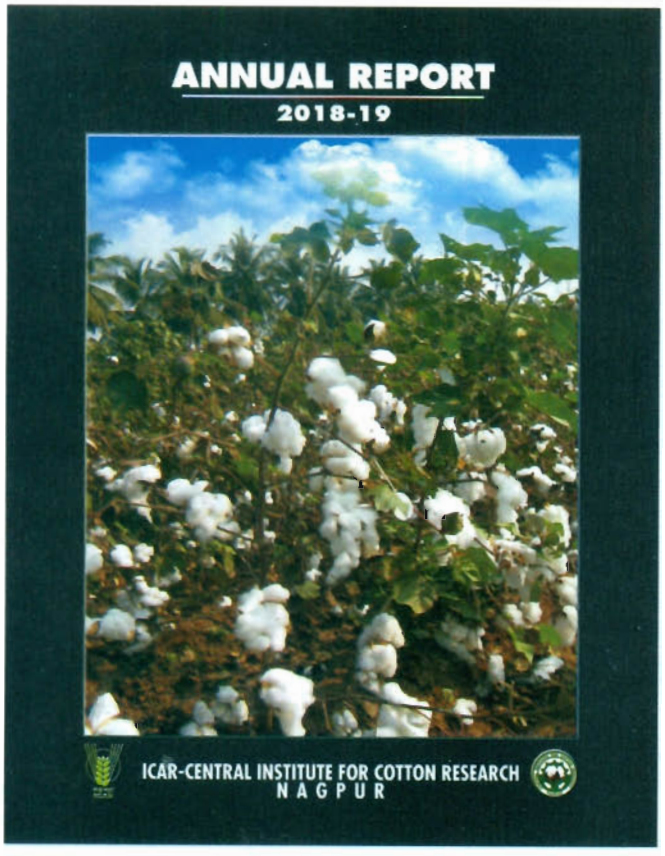
वार्षिक प्रतिवेदन

ANNUAL REPORT

2018-19

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

ICAR- CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR



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PREFACE

Cotton is the most significant commercial crop grown for its natural fibre, protein rich feed and oil. The area under cotton cultivation remained almost static (12.58 m.ha.) as was in 2017-18 with slight decline (12.35 m.ha.) in 2018-19. For the first time, 5 Bt varieties carrying Bt *Cry1Ac* gene developed by this Institute were provided to the farmers for commercial cultivation in Haryana and Maharashtra. With the ongoing evaluation across different ICAR-AICRP centers and ICAR-CICR, more promising Bt and non-Bt varieties will be made available for cultivation and farmers will have options to retain seeds from the produce, thereby reducing cost on seed and cotton production. Two *G. hirsutum* varieties, CCH 12-2 (Suchitra) and CCH 4474 (Subhiksha) were released and notified for Central and South zone under irrigated condition. In addition, one *G. arboreum* variety namely, CNA 1028 (Ravi) has been identified for Central zone under rainfed conditions. CNA 1032 has been promoted to Agronomy trial for rainfed conditions of central zone. Cotton - Blackgram – Maize was identified as suitable cropping system for conservation tillage under rainfed conditions of Tamil Nadu. Across the soil types and genotypes, the HDPS showed an increased seed cotton yield of long linted *desi* cotton cultivars by 375 kg/ha.

The ICAR-CICR is maintaining 12335 germplasm accessions and wild genetic resources of *Gossypium* and during the year has also enriched its Germplasm Bank by adding 674 exotic accessions that includes 346 of *G. hirsutum*, 211 of *G. barbadense* and 117 of *G. arboreum*. A standardized protocol for somatic embryogenesis in Coker genotypes namely 310 and 312 is being used for transformation using indigenous gene construct *Cry*2Ab*Cry*1Ac fusion gene and *Cry*2Ab*Cry*1Ac: lectin gene which will pave way to development of indigenous transgenics in future. The resistance development of pink bollworm on BG-II and non Bt cotton fields was continuously monitored across all cotton growing states. This year, the pink bollworm infestation has also been detected on BG II cotton in the Jind district of Haryana and also one or two locations in Faridkot (Punjab) which otherwise was free from pink bollworm infestation. Tobacco Streak Virus (TSV) on *G. hirsutum* is still an emerging threat in Punjab and Haryana and also on *G. barbadense* cotton in Tamil Nadu.

The Institute is being questioned for its contribution in cotton research, particularly, with reference to the management of bollworm infestations in BG cotton. The Institute has provided leadership and spearheaded the implementation of strategies to manage pink bollworm in Maharashtra and other central and southern states. Proactive strategies were put in place for management of this dreaded pest in the states of Maharashtra, Telangana, Andhra Pradesh, Karnataka and Madhya Pradesh. As a result of

adoption of strategies by all the stakeholders, the PBW infestation reduced by 70 per cent, pesticide use reduced significantly and the quality of cotton produced has improved. Our all out efforts to outreach to the farmers were vigorously pursued through the '*Mera Gaon Mera Gaurav*' (MGMG), Tribal Sub Plan (TSP) and IRM Pink Bollworm Management Project sponsored by GEAC under National Food Security Mission – Commercial Crops (NFSM-CC) in major 21 districts of seven cotton growing states. Weekly advisories on various improved production and protection technologies for the benefit of cotton farmers were disseminated through the mobile voice messages, popular articles in agricultural daily newspaper in Marathi / local languages through bulletins, radio talks and farmers meets and ICAR-CICR Mobile App.

I am grateful to Dr Trilochan Mohapatra, Hon'ble Secretary DARE & DG ICAR; Dr. A. K. Singh, DDG (CS) and Dr R. K. Singh, ADG (CC) for their unstinted encouragement, guidance and support throughout. Contribution of Dr A. H. Prakash, PC and Head I/c, Regional Station, Coimbatore; Dr. D. Monga, Head, Regional Station, Sirsa; Heads of Divisions I/c Dr Blaise D'souza and Dr Nandini Gokte Narkhedkar in the execution of research programmes and their significant contribution in finalization of this report is gratefully acknowledged. Dr M. V. Venugopalan, Principal Scientist & I/c PME Cell has immensely contributed in making of this report and needs special gratitude. Thanks are also due to all the Editorial Committee members for their sincere efforts in bringing out this publication. Mrs. Rama Iyer, Sh. Sameer Chalkhure and Dr. Jimmy Vaidya deserve special appreciation for their strenuous efforts, dedication, sincerity and commitment in bringing out this Annual Report to a beautiful shape in a short span of time.

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1. EXECUTIVE SUMMARY

Crop Improvement

Genetic Resources

- A total base collection of 12335 accessions of cotton germplasm including *G.hirsutum* (8851), *G. barbadense* (536), *G. arboreum* (2053), *G. herbaceum* (565) are being maintained in the National Cotton Gene Bank at ICAR-CICR Nagpur.
- The cotton gene bank was enriched with exotic collections of 346 *G. hirsutum*, 211 *G. barbadense* and 117 *G.arboreum* procured from USA through NBPGR.
- One high yielding hairy accession of *G. barbadense* with moderate tolerance to sucking pests was identified which can be used for development of sucking pest tolerance.
- A stable cleistogamous mutant was identified in the segregating population of intra-*barbadense* cross (Giza-45 x Suvin 3-7-2)

Germplasm evaluation and characterization

- Evaluation under 67.5 cm x 10 cm spacing revealed two promising high yielding compact accessions in *G. arboreum* and three in *G. hirsutum*.
- Evaluation of 114 perennials and landraces of *desi* cotton for fibre quality traits resulted in identification of 6 lines with medium staple (24.5-26.0 mm) and 14 lines with high fibre strength (25.0-28.4g/tex).
- From a set of 25 early maturing *G. herbaceum* germplasm lines evaluated for three years, 7 genotypes were identified for further utilization in the breeding programme.
- Study on inheritance of bracteoles in F_2 population of *G.herbaceum* x *G.arboreum* crosses revealed duplicate gene action where genes of both the species / genotypes act independently
- Evaluation of 1100 *G. arboreum* accessions was done for yield at ICAR-CICR RS Coimbatore, and 13 high yielding accessions were identified with early maturity.
- Thirty nine primitive cotton cultivars collected from West Bengal, Orissa, Karnataka and 16 *G. herbaceum* accessions collected from Gujarat and Tamil Nadu were characterized for morphological traits.
- Molecular characterization of 470 accessions from 771 core assembly has been completed using 52 polymorphic markers to develop mini core based on dissimilarity index matrix.

Wild Species

- Wild genetic resources including 24 wild species, 15 races of cultivated species, 45 synthetic polyploids were conserved in the wild species garden of the Institute.
- Four wild species were obtained from MPKV, Rahuri which included *G. thurberi*, *G. armourianum*, *G. triphyllum* and *G. trilobum* as well as one cutting of BC_1F_1 obtained from cross *G. hirsutum* and G. *armourianum* from ICAR-CICR RS Sirsa were established at wild species garden.
- Diversity studies among 19 wild species, 5 races of *G. hirsutum* and 4 cultivated species clearly distinguished diploid wild species, tetraploid species, races of *G. hirsutum*, *G. arbroeum* and exotic collections
- Three hundred introgressed derivatives were evaluated for yield, fibre properties and biotic stress tolerance and superior ones were identified.

Evaluation of cultivars for yield and fibre quality

- Evaluation of 8 GMS based *G. arboreum* hybrids at ICAR-CICR RS, Sirsa revealed five significantly high yielding with superior fibre quality
- Fourteen spinnable *G. arboreum* cultures were evaluated and identified six high yielding cultures were identified for spinning.
- An extra-long staple culture CCH 15-1 with yield potential of 4019 kg/ha and excellent fibre quality (34.3 g/tex tenacity, 32.4 mm Upper Half Mean Length and 3.7 micronaire) and can spin up to 70s count yarn was identified in AICRP multilocation trials. The culture showed resistance to leaf hopper and Alternaria leaf blight in AICRP centres.
- Three single plant progenies of *G. barbadense* possessing high yield potential ranging from 13-15q/ha, 34-36% GOT and fibre quality parameters have been identified for further evaluation.
- Thirteen high yielding early maturing ELS genotypes were evaluated and promising cultures CCB 54, CCB

129, CCB 51 and CCB 51-2 showing high yield and superior fibre qualities were identified for further evaluation.

- Of the 12 long staple cultures evaluated in a station trial at ICAR-CICR RS, Coimbatore, three promising cultures namely YLS 15-1, YLS 21-4 and YLS 21-3 with significant yield superiority and good fibre quality attributes were identified.
- Of the 16 *G. hirsutum* and *G. arboreum* based introgressed derivatives of colour cotton were evaluated for colour parameters, colour fastness and fibre properties, 6 lines showed comparatively high fastness, no fading with high fibre quality for textile applications.

Population Improvement

- A total of 1508 superior single plants (897 of *G. arbroeum* and 611 of *G. hirsutum*) were selected from random mating population. Based on agronomic performance, 45 progenies of *G. arboreum* and 36 of *G. hirsutum* were identified for evaluation in replicated trial.
- Ninety two advance cultures of *G. arboreum* and 76 of *G. hirsutum* were evaluated. Fifty six of *G. arboreum* and 53 of *G. hirsutum* were retained for second year evaluation based on yield and fibre quality. From the advance selections, 3 cultures of *G. hirsutum* and 6 cultures of *G. arboreum* were entered in AICRP National trials.
- Promising single plants with high yield potential and tolerance against CLCuV were selected at ICAR-CICR RS Sirsa in the random mating population of *G. hirsutum*. Six progenies with high yield (upto 16 q/ha.) and CLCuV tolerance were advanced for further evaluation.

Early maturity

- From segregating generations of various *G. hirsutum* crosses, two lines with compact plant type, early maturity and tolerance to jassid were identified.
- Comparative evaluation of early maturing breeding lines revealed two promising lines with seed cotton yield up to 14 q/ha. Both had recorded Barlett's earliness index of 0.7 identifying them early maturing.
- In another study, promising progenies and single plant selections having 120-150 days of maturity (more than 90% boll bursting), zero monopodia, boll weight ranging from 4.25g -5.10 g and per plant yield of 80-130 g were selected for stabilization and generation advancement.

Abiotic stress tolerance

- Evaluation of 13 advance cultures for drought tolerance resulted in identification of one stable culture which consistently showed drought tolerance over the years. On evaluation of F6 generation from 15 crosses, two entries with good fibre quality and drought tolerance were identified. Cluster bearing, compact drought tolerant progenies have also been identified from segregating population of various crosses.
- For development of MAGIC RILs of 10 parental lines, 2972 plant to row progenies were raised and 1310 lines were evaluated for proline content.
- Single plant progenies with higher boll weight (>5g), superior fibre length and strength (up to 30 g/tex) and compact plant types were identified.
- Four water logging tolerant and four susceptible accessions were identified based on lenticels and adventitious root formation. These had higher nitrate reductase activity and root length. Analysis revealed considerable genetic diversity present among the identified accessions.

Transgene introgression

- BC3F1 of three crosses with Tg2E13 event were raised along with recipient genotypes. Bt positive plants with high protein expression were further used in backcrossing with respective recurrent genotypes. Generation advancement through embryo culture was achieved. Plants from BC4F1 of three crosses with high protein expression were selected and selfed to stabilize.
- Among the 23 plants with UASD78 event, 20 plants were found positive for ELISA and PCR and toxin expression ranged from 0.5 -7.0 ppm at 45 days after sowing and 0.3-5.0 ppm at 100 days.
- For Cry2Ax1 event, positive plants from segregating BC_1 plants of different crosses were further advanced for crossing with recurrent parents.

Genomics

- Confirmed organ specific expression pattern and phylogeny of GaLIM genes. Identified GaDA2 as putative candidate gene among plant specific Lin genes in response to challenge of *F. oxysporum*.

Varieties released

- Two *G. hirsutum* varieties namely CCH 4474 (Subhiksha) and CCH 12-2 (Suchitra) have been released from ICAR-CICR RS, Coimbatore for

commercial cultivation under irrigated conditions in South and Central zone respectively. The variety Subhiksha is compact, suitable for HDPS, yield up to 4201Kg/ha with Upper Half Mean Length of 32.4 mm and tenacity of 33.8 g/tex. The variety Suchitra has yield potential of 2598 kg/ha with an upper half mean length of 28.0 mm, tenacity of 29.0 g/tex and spins up to 30s cultivation in Central zone under irrigated conditions. The variety showed tolerance to grey mildew and jassids

ICAR-AICRP entries (non-GM) sponsored in National Trials (2018-19)

- Cultures CSH 1721, CSH 3012 sponsored in Br 02 (a); CNH 2052, CNH 1131, CNH 2073, CNH 09/11, CNH 09/73, CNH 16300 in Br 02 (b); CSH 3158, CSH 3622 in Br 06 (a); CNH 09-45, CNH 1129, CNH 2039, CNH 6170, CNH 09-11, CNH 41-09, CNH 1130 in Br 06 (b); CCB 26, CCB 28 in Br 12 (a); CISA 90, CNA 2023, CNA 1036, CNA 1040, CNA 16383 in Br 22 (a/b) ; CISA-10, CISA 33-8, CNA 1064, CNA 1065, CNA 1066 in Br 22 (a/b) LL (*G. arboreum*); CNA 1091, CNA 17522 in Br 22 (a/b) CC (*G. arboreum*) and CISAA 18-1, CISAA 18-2 in Br 25 (a/b), respectively.

Entries retained in AICRP Bt Varietal trial

- Seventeen ICAR-CICR Bt cultures were sponsored for AICRP Bt cotton variety trial.
- Six release proposals of ICAR-CICR Bt varieties identified for Central Zone under irrigated as well as rain fed have been submitted to the AICRP on Cotton.

Entries Promoted in AICRP (2019-20)

- **North zone**: CISAA 17-1 and CISAA 17-2 in Br25(a/b), CISAA 33-3 and CISA 6-2 in Br24(a)
- **Central Zone**: CNH 11-11 and CNH09-70 in Br03(b), CNH09-9 in Br 06(b), CCB 51-2, CCB 64, CCB 129 and CCB 143-B in Br 13 (a)PVT *G. barbadense*, CCB 51 in Br 14(a)CVT *G. barbadense*, CNA 2031, CNA 1054 and CNA 1058 in Br 24(b) CVT *G. arboreum*, CNA1037 and CNA 1034 in Br24(b), CISAA 17-2 in Br 25 (b)
- **South Zone** : CSH 1613 in Br 06(a), CCB 143B, CCB 64, CCB 129, CCB 51-2 in Br 13(a), CNH 09-70 in Br 03(b), CNH 1128 in Br 06(b), CNA 1054, CNA 1058 in Br24 (b) CVT *G. arboreum*, CNA 1037 and CNA 1033 in Br 24bLL CVT- *G. arboreum*
- **Colour Cotton Trial:** 16301 DB and 16337 LB in *G. hirsutum*, CNA 407 SLP, 16378 LB-A, CNA 405, CNA 407, 16377LB-A in *G. arbroeum*

Entries proposed for agronomy trial

- Central Zone: CCH 15-1 of *G. hirsutum* for irrigated conditions and CSA 1028 of *G. arboreum* for rainfed conditions.
- South Zone: CCH 15-1 of *G. hirsutum* for irrigated conditions.

DUS Characterization

- DUS characterization of five entries in first year, one variety under common knowledge and 4 entries under second year along with 15 reference genotypes were conducted at ICAR-CICR, Nagpur. Maintenance breeding of 155 extant cotton varieties (108 in *G. hirsutum*, 36 in *G. arboreum, 4 in G. herbaceum and 7 in G. barbadense* were carried out at ICAR-CICR RS, Coimbatore.

Seed production

- Nucleus seed production of 5 released *Bt* varieties (ICAR-CICR Bt 1, ICAR-CICR Bt-2, ICAR-CICR Bt-3 ICAR-CICR Bt-6 and ICAR-CICR Bt-12) was taken up and 4.0 q fuzzy seeds were produced.
- A total of 34.0 q TFL Seeds of 5 CICR Bt varieties produced at ICAR-CICR, Nagpur
- Breeder seed production of ICAR-CICR released non *Bt* varieties (Suraj, LRA-5166, LRK 516 and Surabhi, Roja, Suvin, parents of *G. arboreum* hybrid CICR-2, CISA310, CISA614, CSH3075, CSH 2931) was taken up and 11.0 q seeds were produced. Certified seeds of wheat cv. PBW 550 and Red Gram BSMR-736 was also produced accounting to a total of 259.20 q
- TFL seeds of 6.9 q of non *Bt* cotton varieties were also produced under Farmers Participatory mode.
- At CICR RS Coimbatore, 92 kg breeder seed of different non-Bt varieties was produced

Seed quality Improvement

- Fresh seed lots of varieties were found to have superior seed quality compared to the revalidated seed lots of same varieties.
- Seed priming treatments using KH_2PO_4 and *Trichoderma viride* showed superior performance over control with respect of germination, speed of germination, highest index.
- Foliar spray of micronutrient mixture followed by neem kernel extract were found highly promising in obtaining higher quantity of delinted seed yield.

Seed Storage

- Among the treatments, seeds stored under vacuum packing showed higher viability and lower electrical conductivity after 24 months of storage compared to non vacuum packing. Similarly seeds packed in airtight acrylic box along with Zeolite beads and stored at 5°C temperature maintained initial seed viability compared to those kept without zeolite beads.

Crop Production

Climate smart agro-techniques to enhance resource use efficiency

- **Desi cotton** cultivars are re-emerging as potential alternative to obtain sustainable yields during the era of climatic uncertainties. Seven cultivars were evaluated and the long-linted *desi* cotton cultivars, PA528 and CNA1041 were identified to be the most productive. Planting under high density planting systems, was found to increase seed cotton yield by 275 kg/ha. Detopping along with side shoot removal and foliar application of mepiquat chloride (500 mg/kg), was found to improve vigour index.
- **Calcareous soils** suffer from multiple nutrient deficiencies and acute water stress. For such soils, application of S and Zn along with RDF improved productivity of Bt hybrids by 24% and the use efficiency of fertilizers by 15% when provided with two protective irrigations as compared to those not receiving irrigation. *Desi* cottons were also found to be a better alternative than the Upland cotton for the calcareous soils.
- **Row-orientation effects** on cotton were tried and the diagonal row orientation improved seedcotton yield of cultivar K11 at Coimbatore. This indicates that productivity of some cultivars can be enhanced by adjusting the row directional sowing.
- **C Flux tower** data for radiation and surface energy balance, hourly air temperature, soil moisture and rainfall, carbon flux were collected at 30 minutes interval and analyzed to improve understanding in the cotton based systems. Temporal data collected during the first year after installation indicated variations across fields. Across different fields, the LAI ranged from 1.70 to 3.46 during the peak flowering period and from 1.22 to 1.65 during boll opening period. The values for chlorophyll index ranged from 1.22 to 1.65 during the peak flowering stage. Seed cotton yield ranged from 576 to 3301 kg/ha.
- **Nutrient Expert Decision Support System** can be utilized to improve the productivity as well as bring about a saving in fertilizer. In a participatory trial, seedc otton yield was 3051 kg/ha with the Nutrient Expert System compared to 2097 kg/ha with the farmers fertilizer practice.

Sustainable farming systems through conservation agriculture and precision techniques

- **Soil compaction** is increasingly being experienced due to excessive use of machinery to ensure timely operation but this leads to sub-soil compaction. Consequently, root and crop growth are adversely affected. Among the deep rooted rotation crops, pigeonpea had significantly greater yield levels (35.3 q/ha) followed by sunnhemp and sesbania (28 to 29 q/ha) with similar yield levels. Increase in bulk density beyond 1.6 g/cc resulted in a drastic reduction in root length of the Bt hybrid but that of the varieties showed a decline beyond 1.7 g/cc.
- **Conservation agricultural (CA)** practices are promoted as a solution to land degradation and improving productivity. CA system with 100% residue recycling had significantly higher CEY than Farmer's practice. CA system with 100% residue recycling significantly reduced the soil penetration resistance upto 9" soil depth *vis-à-vis* Farmer's practice. Among cropping systems under CA, cotton-black gram - maize is a potential candidate cropping system under the irrigated conditions as it registered significantly higher Cotton Equivalent Yield (CEY) than the conventional cotton – fallow system.
- **Legumes as intercrop** to reduce the input cost of N fertilizers under rainfed cotton *(G. hirsutum* var Suraj and *G. arboreum* var Phule Dhanwantary*)*. For American cotton variety Suraj, better performing intercrops are soybean (2718 kg/ha) and blackgram (2652 kg/ha) whereas for the desi cotton variety Phule Dhanwantary, greengram (2519 kg/ha) and cowpea (2429 kg/ha) were the best.
- **Alley cropping** of *Desmanthes virgatus* with cotton resulted in significant yield enhancement (2796 kg/ha) as against sole cotton (1935 kg/ha at 100 % RDF) and a potential to save 50% N fertilizer in Coimbatore. Seed cotton yield of 2265 kg/ha with 75% RDN and *Desmanthus* was compared to 2037 kg/ha recorded at 125 % RDN under sole cotton.
- **Epigenetic regulating chemicals** (ERC) treated Suraj and LRA 5166 cotton plants were screened for drought tolerance in the second generation. The plants were subjected to drought stress during pin head stage of squaring by withholding irrigation for 10 days. 5-Azacytidine (10 µM) and sulfamethazine (10 µM)

treated plants recorded high relative water content of 86.1% and 84.7%, respectively as against control (68.7%) under stress conditions in Suraj. Treated plants also had greater proline content, higher epicuticular wax content than the control plants that were not treated.

- **Microbial bio-films:** One hundered and seventy bacterial strains were isolated from cotton ecosystem and from *Helicoverpa*, *Pectinophora* and *Spodoptera* using soil baiting technique. The maximum mortality recorded were 77%, 96% and 85%, respectively *for Helicoverpa*, *Pectinophora* and *Spodoptera*. The shortlisted bacterial partners will be used for development of biofilm with proven fungal partner *Trichoderma*, *Metarhizium*, *Beauveria*, *Paecilomyces*.
- Accessions IC-356876, DTS-108-09, CNH-09-7 performed better under drought stress with efficient root traits such as root length, root dry weight and lateral root length than control.
- **Alarm Photosynthesis** pathway in cotton was explored along with characterizing the effect of drought stress on metabolites at different growth stages. Temporal expression analysis (qRT-PCR), indicated more GLP1/oxalate oxidase expression in leaves during day time when compared to the night time. Oxalate content was more in the stressed leaf samples collected during the night time as compared to the ones collected during day time, thus validating the day-night variation observed for OxO expression and activity in respective samples.

Economics and extension research and e-communication tools

- **Cropping patterns**: Thirteen districts were analyzed with five districts (Amravati, Akola, Washim, Buldhana and Yavatmal) recorded a decline in cotton area. Increase in cotton area was seen in four districts, Aurangabad, Beed, Jalna and Dhule. Simpson index decreased in almost all the districts during the study period indicating a slowly changing trend towards specialization.
- **Decadal trends in cotton area** (2007-2018) showed an increase of 17 to 25% in the South Zone. In the North zone though Haryana and Rajasthan showed an increasing trend this was offset by a decrease in Punjab. In Central zone a slight reduction to the tune of 6% was observed during the same period. Percentage increase in area was higher in all the zones during the first period when compared to the second period which shows the saturation of cotton area during the latter period.
- e-Kapas for dissemination of cotton production technology to 1.5 lakh farmers of Nagpur, Coimbatore and Sirsa. Uploaded more than 64 lakh noise free and clear recorded voice messages in the form of automatic phone calls to the registered cotton farmers of ICAR-CICR.
- Cotton App was also developed and now is available on Google PlayStore providing information on the cultivars, production and protection technologies besides the Weekly Advisories. Android mobile based interactive decision support systems for cotton pest management "Grow Good Cotton" with pre-recorded voice modules was also developed.
- Gaps between potential, attainable and actual yields in cotton was determined on a 1-acre trial at Coimbatore and simultaneously on the farmers' field with Suraj and Bt cotton hybrid Mallika BGII. Yield gap between potential yield and attainable yield was 521 kg/ha (Suraj) and 242 kg/ha (Mallika BGII). The yield gap between attainable yield and actual yield (farmer's practice) was 347 kg/ha (Suraj) and 370 kg/ha (Mallika BGII).

Crop Protection

Dynamics of insect infestation

- The station trial, pink bollworm infestation was negligible till September, and increased with progress of the season. Both Bt and non Bt cotton were found to be infested by PBW. However, comparatively higher infestation was recorded in non-Bt cotton..
- Bollworm infestation was not observed on RCH-650 BG II at Sirsa but in non Bt varieties HS-6, GA & RS-2013 first incidence of bollworm was observed in the 35th SMW and peak fruiting body damage was observed in 44th SMW. Overall fruiting body damage ranged from 0.84 to 12.08% due to *Earias spp* in non-Bt genotypes.
- In north zone 3.3-12.43 % Pink Bollworms larval recovery was observed in non-Bt cotton at 160DAS. Though no larval recovery was recorded in BG-II cotton but at single locations of Haryana (Jind) and Punjab (Bathinda) adjoining to ginneries recovery from BG-II cotton was also recorded .
- Peak activity of thrips respectively observed during 25 SMW in HS-6, RS-2013 in 29th SMW in RCH650 BG-II and Ganganagar Ageti whereas whitefly peak activity was observed between in 28th -30th SMW, leafhopper peak activity was recorded during 29th and 33rd SMW in all genotypes.

- Two peaks of jassids population were recorded at Nagpur, first during second fortnight of August and another during first week of October. Thrip population was higher during second week of August till August month end and thereafter it declined.
- Historical data analysis indicates peak occurrence of whitefly advanced by 7 weeks during 2010-11 to 2017-18 as compared to 2005-06 to 2009-10. Average whitefly population in the cropping season increased to 8.60/3 leaves in 2010-11 to 2017-18 from 2.56/3 leaves in 2005-06 to 2009-10 with an increase of 235%.

Dynamics of disease incidence

- TSV infestation in germplasm of *Gossypium barbadense* was recorded. Per cent disease incidence was maximum in SP (35.8 %) and ICB-71 (26.6%) with disease grade of 3. The maximum disease incidence was observed at 60 to 75 days after sowing.
- Symptoms like chlorotic lesions, necrotic lesions, necrotic spots, veinal necrosis, systemic symptoms, necrosis on petioles, stem necrosis and total necrosis were observed on cowpea seedlings at 3 to 7 days after inoculation of TSV inoculum.

Nematode Incidence

- Eleven districts of Vidarbha region were sampled for prevalence of plant parasitic nematodes. Reniform nematode *Rotylenchulus reniformis* was the most prevalent nematode on cotton followed by *Hoplolaimus* and *Pratylenchus sp.*
- Based on population densities exceeding damage threshold of *R.reniformis* areas were identified where nematode damage may become evident in years to come.

Molecular Diversity in Pink bollworm populations

- Alignments of all 214 COI sequences of Pink bollworm revealed that 27 haplotypes are present in overall populations including 11 in north, 14 in central and 6 in south region.The haplotype H1 and H2 are most common haplotypes present in 143 and 32 populations respectively and could be proposed as ancestral/original haplotypes.
- Zone-wise clustering revealed Central zone having low level of Haplotype diversity (0.499) as compared to south (0.560) and north (0.595).
- Neutrality tests were performed for analysis of demography history in Indian pink bollworm populations. All the three neutrality test values were negative for populations of India which indicate that there is an excess of rare mutations favouring population expansion or growth.

Eco-compatible strategies for insect management

- Eco-compatible strategies for pink bollworm management based on integration of different methods viz., cultural, regular monitoring, biopesticides, behavioral, biocontrol agents, chemical, mechanical, legal etc. were devised.
- The fatty acids and their methyl esters identified earlier as potential oviposition deterrent in the faecal pellet extract of pink bollworm were quantified using standards. Two fatty acids, oleic and linoleic acid were found to be promising with a significant reduction in egg laying over control.
- For identification of attractant volatiles, squares and bolls from all the four cultivated species of cotton were directly collected in five different solvents, out of these acetone and methanol were found to be best solvents.
- The major compounds identified as possible attractant volatiles were α/β pinene, carene, γ terpinene, α copaene, caryophyllene and humulene.
- Four major fatty acids *Viz.,* linoleic acid (9,12-octadecadienoic acid), palmitic acid (hexadecanoic acid), myristic (Tetradecanoic acid) and stearic acid (Octadecanoic acid) were identified as potential ovipositional deterrant for *H.armigera.* In all the compounds per cent deterrence was higher than 68 per cent.
- Muslin cloth treatment with deterrent compounds was the most acceptable as female prefer to lay eggs on muslin cloth under laboratory condition. two male and 2 female pairing was best for conducting bio-assay.
- 9-Octadecenoic acid esters were identified as major compound followed by 9,12-Octadecadienoic acid (Z,Z), methyl ester, hexadecanoic acid, methyl ester and methyl stearate as possible chemical cues mediating interaction with natural enemies in both sucking pests (jassids and whitefly). The compounds need to be reconfirmed and evaluated for their response against natural enemies.

Insecticide Resistance Monitoring

- Bioassay results in F_1 generation for various locations in India was carried out for Cry1Ac and Cry2Ab. Cry1Ac resistance ratio in the populations of Faridkot and Jalna was 2.6 and 6.8 fold respectively which is considered as very low.

- The highest Cry1Ac resistance ratio was noticed in Kurnool populations of Andhra Pradesh (899.8) while highest Cry2Ab resistance ratio was observed in population of Vadodara district of Gujarat (3831.43).
- Bioassays to study whiteflyr esistance to commonly used insecticides from Abohar, Sirsa and Ganganagar recorded thiamethoxam (14.8-22.6 folds), triazophos(20.4-37.6 fold) and diafenthiuron (48-66.8folds) with highest resistance ratios but comparatively less than observed during 2017-18.

Insecticide Resistance Management : Dissemination of Pink Bollworm management strategies" was implementated with the participation of ICAR-CICR, 10 State Agricultural Universities and 3 KVKs in 105 villages covering 21 districts from seven selected major cotton growing states of the country.

- With concerted efforts of all cotton production stakeholders, it was possible to reduce the pink bollworm infestation during 2019-20. The level of infestation in Maharashtra, Gujarat, Madhya Pradesh, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu was 2.8-48, 5-15, 5-35, 5-20, 5-57, 4-29 and 7-20 %, respectively. Pink bollworm infestation across cotton growing states recorded overall reduction in infestation by 70%.
- Resistance monitoring was carried on four populations of Leafhopper in Maharashtra with eight insecticides. The population of leaf hopper from Wardha was more susceptible to Flonicamid, Thiamethoxam, Acetamiprid, Imidacloprid, Acephate and Clothianidin as compared to other populations.

Natural enemies of Pink Bollworm

- The emergence of parasitoid ***Apanteles angaleti*** ranged from 7.25 to 62.50 and was highest in Gujarat. *Bracon lefroyi* with 33.33 per cent parasitisation was found in Nagpur population only.
- Among the three species of egg parasitoid *Trichogramma bactrae, Trichogramma brasiliensis* and *Trichogramma chilonis* evaluated in field trial, *T.bactrae* with 13.05 per cent locule damage was most effective.

Integrated Pest Management

- The label claimed insecticides and plant derived oils tested against thrips under laboratory and field conditions recorded fipronil (82.89%), spinosad (80%), spinetoram (68.0%), profenphos (61.11%) as superior treatments among chemical insecticides and among oils castor, sesame and pongamia oils reduced whitefly population more than the neem based insecticides.
- Insecticide Spinoteram followed by Fipronil recorded highest efficacy against thrips. Among biopesticides, *Metarhizium anisoplae* and among essential oils, neem oil followed by castor oil recorded higher efficacy against thrips.
- Among the demonstrations conducted on most prominent BG-II hybrids at ICAR-CICR experimental farm highest yield was obtained in US-21(33.25q/ha) followed by RCH650 BG-II,US-51 BG-II,RCH776 BG-II and RCH773 BG-II. The minimum whitefly population (17.1/3leaves) was recorded in RCH653 BG-II.

Phermone traps for Pink bollworm

- The polypropylene recorded the highest mean catch of 46.30/week, while the silicon and rubber dispensers provided a weekly mean trap catch of 41.18 and 34.85 males, respectively.

Sticky trapa for thrips

- Blue colour sticky trap attracted more number of thrips followed by yellow colour sticky trap.

Bioagents against insect pests

- Entomopathogenic fungal strains were evaluated for efficacy against whitefly nymphs. At Sirsa the highest nymphal mortalityon the seventh days after spray was recorded with *Beauveria bassiana* -4511 followed by *Isaria javanica* CICR-RSS -0102 and Pyriproxyfen (2.5ml/L), while at Nagpur, the highest nymphal mortality at 10 DAI were recorded with *Fusarium moniliformae* CICR-RSS-083 followed by *B. bassiana*-4511, *I. javanica* -CICR-RSS -0102.
- Two strains of *A. papayae* were evaluated for sustainable management of papaya mealybug, *Paracoccus marginatus,* strain A.
- Effect of thermal stress on fitness traits of two mealybug pests, *Phenacoccus solenopsis* and *Paracoccus marginatus* and their parasitoids *Aenasius bambawalei* and *Acerophagus papaya* was studied. Increase in temperature above 32^{0}C reduced the duration of pre-oviposition and oviposition period as well fecundity of individual mealybugs.

Bioagents against pathogens

- Forty five endophytes have been identified from *G. arboreum* (25) and *G. hirsutum* (20). Promising endophytes identified based on in vitro antagonistic study were CEL 2, CEL 5, CEL 19, CEL 38, CEL 41,

CEL 48, CEL 55 and belonged to genera *Fusarium* sp., *Isaria* sp. and *Nigrospora* sp.

- Four antimicrobial VOCs; 1, 3-diethyl benzene, 1, 4-diethyl benzene, cymene-7-ol and ethylacetophenone were identified from CEL 19 through GC-MS analysis.
- GC-MS analysis of bioactive metabolites produced by a native isolate of nematophagous fungus, *Purpureocillium lilacinum* revealed production of 13 different compounds.
- Nematicidal/nematostatic compounds viz Actinomycin C2,2-Pentanone, 4-hydroxy-4-methyl-(CAS), Hexanoic acid, 2-ethyl-,oxybis(2,1-ethanediyloxy-2,1-ethanediyl) ester (CAS), 2-benzyl-3,6-dioxo-5-methylpiperazine,Nonacosanol (CAS), 1-Docosanol (CAS), 2,5-Piperazinedione, 3,6-bis(2-methylpropyl) recorded from *P.lilacinum* .
- Highest recovery from sudden wilt manifestation was recorded with 50 ppm sodium benzoate (75%), followed by 10 ppm cobalt chloride (56.5%).
- Combined seed treatment with *Trichoderma harzianum* (10g/kg), *Pseudomonas fluorescens* (10g/kg) and Mycorrhiza (20g/kg) gave the highest reduction in root rot over control in both the cultivars CICR-2 (*G. abrobeum*) and CSH-3129 (*G. hirsutum*) (57.5 and 51%) at 60 days after sowing.

Host plant resistance

- Field screening of 54 genotypes of *G.hirsutum* for identification of resistance/ tolerance against cotton leafhopper indicated 13 genotypes to be superior than resistant check .
- In general branched trichomes were predominantly observed over non branched trichomes in the tolerant genotypes.
- Marker assisted selection by validated marker CIR246 was carried out and plants showing resistance both genotypicaly and phenotypically by artificial inoculation were selected. Total of 33 BC4-F1 plants have been selected for further advancement of generation to develop bacterial blight resistant variety.

Induction of acquired systemic resistance

- In 2018-19 three spray of Aspirin + Curcumine was found to reduce reniform nematode population in soil by up to 55% giving an increase of seed cotton yield by 4 q/ha over control.
- French marigold, *T.patula* was most effective in reducing galls by root knot nematode. Preplanting of Tagetes by one week before planting of host plant was found to be better than planting both *Tagetes* and host plant together. Also influence of *Tagetes* as nematode repellent was most pronounced within diameter of 10 cm from the *Tagetes* plant.

New methods/protocols

- A simple and inexpensive method that uses freshly excised green bolls (~10 d old) of cotton (*Gossypium hirsutum* L.) was developed for laboratory rearing of pink bollworm, *Pectinophora gossypiella* (Saunders). Up to five generations of pink bollworm could be raised by this method.
- A novel method for isolation of wax degrading bacteria from mealybug was standardized with substitution of mealywax with bee wax in Davis minimal media.

2. INTRODUCTION

2.1 : Brief History

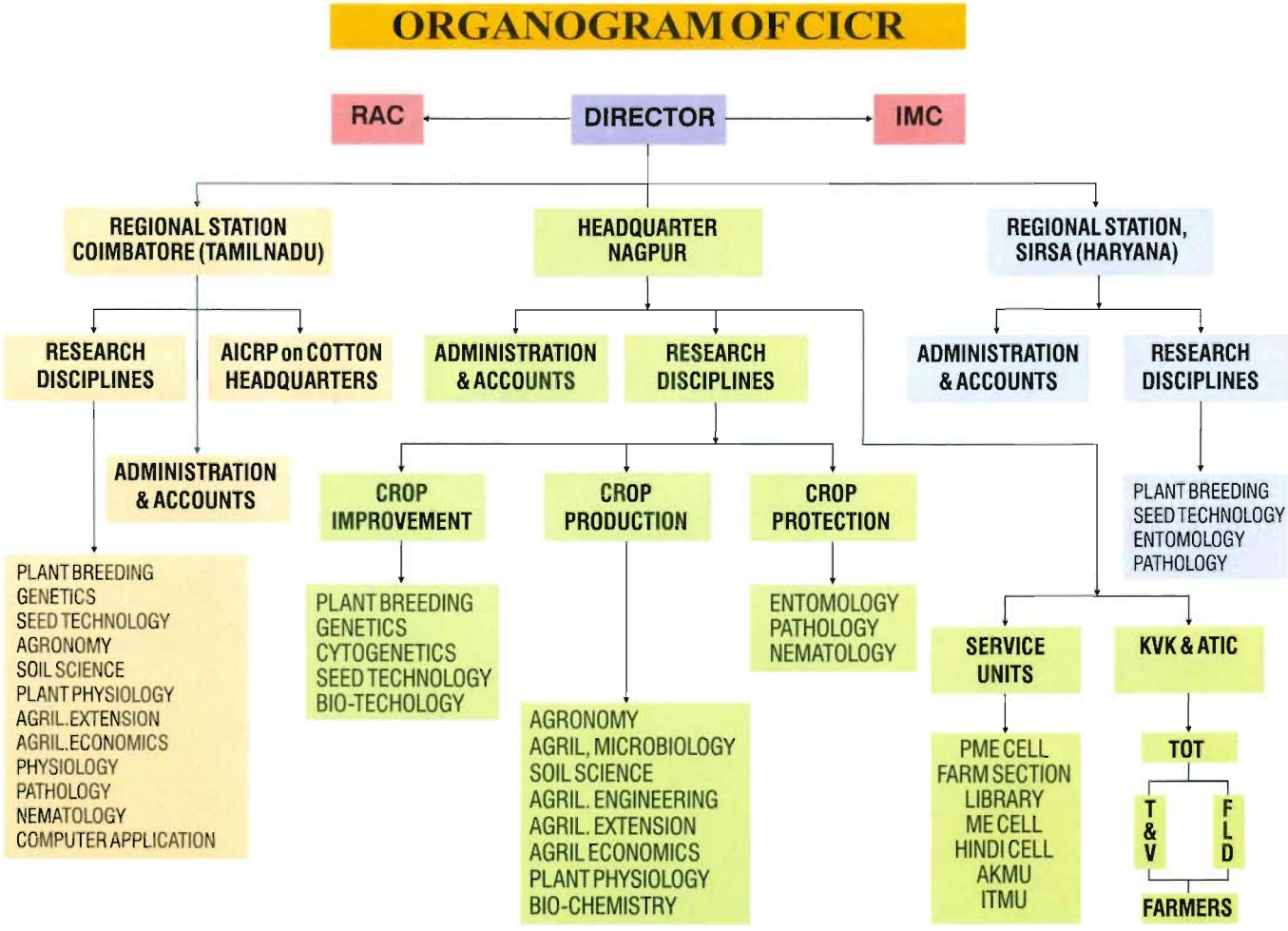
The ICAR-Central Institute for Cotton Research (CICR) was established at Nagpur in 1976. The two regional stations of IARI located at Sirsa (Haryana) and Coimbatore (Tamil Nadu) were transferred to CICR to cater to the needs of north and south India, respectively.

Location of the of ICAR-CICR Institute

Center	Latitude	Longitude
ICAR-CICR, Head Quarters, Nagpur, Maharashtra	21.037	79.056
ICAR-CICR, Regional Station, Coimbatore, Tamil Nadu	11.014	76.929
ICAR-CICR, Regional Station, Sirsa, Haryana	29.543	75.038

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, 2019)

Name of the Post	Sanctioned Cadre Strength				Post Filled Up			
	NGP	CBE	Sirsa	Total	NGP	CBE	Sirsa	Total
Director (RMP)	1	--	--	**1**	--	--	--	--
Scientific	51	22	8	**81**	44	22	7	**73**
Technical	46	16	10	**72**	27	13	10	**50**
Administrative	34	9	5	**48**	21	6	5	**32**
Supporting	43	17	10	**70**	29	10	9	**48**
Krishi Vigyan Kendra								
Training Organizer	1	--	--	1	--	--	--	--
Technical	11	--	--	11	8	--	--	8
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 2018-19 are furnished below:

(Rs. in Lakhs)

Name of Scheme	2018-19	
	Sanction	Expenditure
Plan Scheme	1997.10	1995.55
Deposit Scheme	1222.04	955.45
Revolving Fund	18.85	13.64
Govt. Grants (Non-Plan & Plan merged from 2018-19)	5333.33	5332.30
Total (in lakhs)	**8572.31**	**8296.94**
Revenue Generation (Revenue Receipts)	84.68	0.00

3. RESEARCH ACHIEVEMENTS

3.1 Consolidation and characterization of genetic diversity

Status of cotton germplasm

ICAR-CICR, Nagpur maintains one of the largest cotton gene bank, germplasm collection of the world with 12,335 accessions of the cultivated and wild species of *Gossypium* including perennials, landraces and inter-specific derivatives (Table 3.1.1).

Table 3.1.1 : Germplasm collection at ICAR-CICR, Nagpur

Species	No. of accessions
G. hirsutum	8851
G. barbadense	536
G. arboreum	2053
G. herbaceum	565
Wild Species	24
Interspecific Derivatives	40
Perennials and land races	254
Races and derivatives of all cultivated species	12
Total Collection	**12335**

Enrichment of cotton genetic stocks

Six hundred seventy four (674) quality exotic accessions consisting 346 *G. hirsutum,* 211 *G. barbadense* and 117 G. *arboreum* were procured from USA through ICAR-NBPGR, New Delhi. A set of 56 exotic accessions including 2 CLCuD resistant accessions were multiplied in the pots. Eight exotic varieties of *G. hirsutum* were multiplied in the field and evaluated for economic and fibre quality traits.

Evaluation of germplasm

A part of base collection that include 2852 accessions of *G. hirsutum,* 142 of *G. arboreum* and 34 Coker variants were rejuvenated in the field and 140 accessions were rejuvenated in pots. Seven hundred and seventy one geographically and genetically diverse accessions of core assembly were grown for seed multiplication and DUS characterization. Molecular characterization of 470 accessions from this core assembly was done using 52 polymorphic markers for the development of Mini Core Group based on dissimilarity index matrix.

Evaluation and maintenance of *G. barbadense* germplasm

Three hundred and twenty five *G. barbadense* germplasm lines were grown and maintained at ICAR-CICR, Regional Station, Coimbatore. Two new *G. barbadense* germplasm lines were evaluated for yield, ginning outturn and fibre quality traits (Table 3.1.2).

Conservation of germplasm in long term storage

Seeds of 15 accessions of *G. barbadense* were submitted to ICAR-NBPGR, New Delhi for long term storage

Table 3.1.2 : Yield, GOT and fibre quality traits of new *G. barbadense* lines alongwith Suvin

S. No	Germplasm Lines	SCY (kg/ha)	GOT (%)	2.5% S.L (mm)	Bundle Strength g/tex	Mic (µ/inch)
1	EC-929595	711	34	35.2	29.3	3.2
2	EC-929596	546	30	33.2	31.2	3.3
3	Suvin (c)	785	30	37.4	31	3.2

Performance evaluation of hairy germplasm lines of *G. barbadense*

A set of 11 hairy germplasm lines of *G barbadense* were evaluated for their performance and fibre quality traits at ICAR-CICR, Coimbatore. Based on superiority for specific traits, ICB-124 was identified as promising one for highest seed cotton yield, high GOT, staple length and moderate tolerance to sucking pests. This line shall be useful for development of superior *G. barbadense* genotypes with high yield and sucking pest tolerance/resistance.

Plate 3.1.1 (A) Hairy germplasm lines, ICB-124(B) Non hairy type Suvin

Evaluation of compact *desi* germplasm

Thirteen compact accessions of *G. arboreum* were evaluated at 67.5 x 10 cm spacing against promising checks in 3 replications for yield and yield contributing parameters at ICAR-CICR, Regional Station, Sirsa. Accessions 412540 (29.8 q/ha) and CISA 6-256 (29.7 q/ha) were superior in comparison to check HD432 (28.2 q/ha) and CICR-1 (27.8 q/ha).

Evaluation of compact *G. hirsutum* germplasm

Fifteen compact accessions of *G hirsutum* germplasm (15 + 3 checks) were evaluated at 67.5 x 10 cm. spacing against Bt and Non-Bt promising checks in 3 replications at Sirsa. Data on yield and yield contributing traits were recorded. The accessions namely N-100 (29.7 q/ha), AZON 148 (28.5 q/ha), EC 700140 (28.2 q/ha) were found significantly superior for yield against check F1861 (24.6 q/ha) and CSH 3075 (27.6 q/ha).

Distribution of cotton germplasm

Forty-five germplasm accessions of G. *hirsutum*; *G. arboreum* and wild species were distributed to the breeders/ scientists of CICR, SAUs and Private stake holders.

Characterization of the collected landraces of desi cotton and perennials

Morphological (DUS) characterization was done for 39 primitive cotton cultivars / accessions collected from Sundarbans of West Bengal, three from Odisha and one from Karnataka. Molecular characterization was performed for 114 *G. arboreum* lines along with 5 checks using 83 SSR markers of which 34 markers

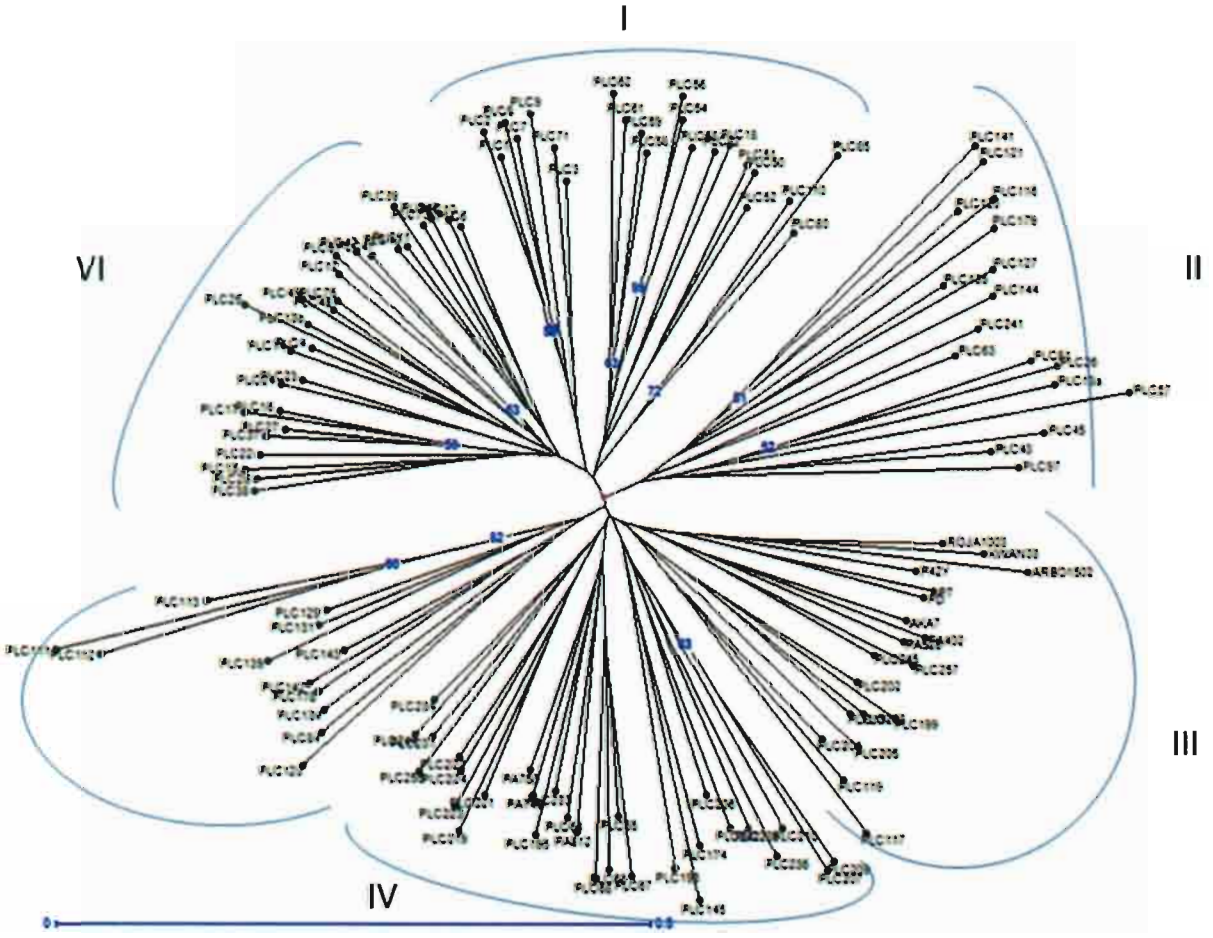


Fig. 3.1.1. Dendrogram showing genetic relationships among *G. arboreum* accessions of the perennials and landraces of *desi* cotton (Bootstrap values >50% are shown)

showed polymorphism (41%). The genetic relatedness among accessions was studied using DARwin statistical package which grouped them into six major clusters (Fig. 3.1.1).

Morphological (DUS) characterization has also been completed for traditional cultivars of 16 G. herbaceum accessions collected from Gujarat and Tamil Nadu along with 3 checks. Molecular characterization was done for all 19 accessions using 34 polymorphic markers. The analysis done using DARwin statistical package grouped these into 4 clusters (Fig. 3.1.2).

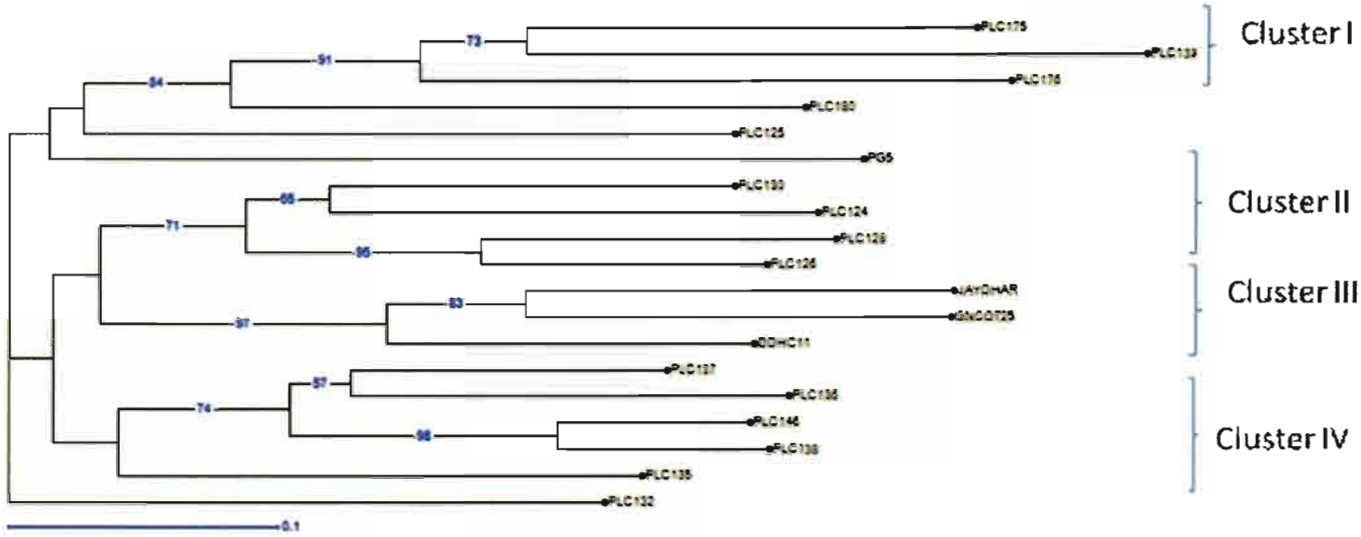


Fig.3.1.2. Dendrogram showing genetic relationships among traditional cultivars of *G. herbaceum* accessions (Bootstrap values >50% are shown)

Evaluation of perennials and landraces of *desi* cotton (*G. arboreum*)

One hundred and fourteen accessions were evaluated for fibre quality traits. Six medium staple length (24.5-26.0 mm) and fourteen high fibre strength (25.0-28.4 g/tex) lines were identified and documented.

Fibre length (>24.5 mm)	PLC42, PLC135, PLC140, PLC141, PLC180, PLC202
Fibre Strength (>25 g/tex)	PLC42, PLC56, PLC80, PLC126, PLC136, PLC139, PLC140, PLC141, PLC142, PLC180, PLC192, PLC194, PLC202, PLC207

Wild and unadapted germplasm for cotton improvement

Twenty four wild species, fifteen races of cultivated species and more than 45 synthetic polyploids were conserved in the wild species garden. Seeds of four wild species were obtained from MPKV, Rahuri which included *G. thurberi, G. armourianum, G. triphyllum* and *G. trilobum*. Plants of *G. thurberi* were established. Another cutting (1/6) of BC_1F_1 of *a cross between G. hirsutum* and *G. armourianum* obtained from ICAR-CICR RS, Sirsa was also established and will be utilized in CLCuV resistance breeding program (**Plate 3.1.1**).

Plate 3.1.1. BC_1F_1 plant of a cross *G. hirsutum* x *G. armourianum* in pot

Molecular characterization of wild germplasm

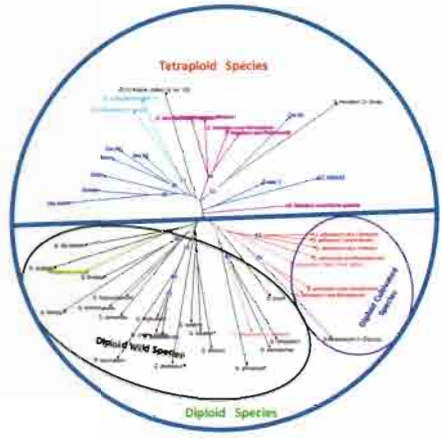


Fig.3.1.2 : Clustering of *Gossypium species* based on molecular markers

Nineteen diploid wild species of Gossypium (*G. africanum, G. anomalum, G. triphyllum, G. captis virides, G. barbosanum, G. sturtianum, G. australe, G. thruberi, G. armourianum, G. davidsonii,*

G. klotzschianum, G. aridum, G. raimondii, G. lobatum, G. trilobum, G. stocksii, G. somalense, G. longicalyx, G. bickii), 6 races of *G. arboreum* (*Indicum, Burmanicum, Bengalense, Cernuum, Sinense, Soudanense*), 5 races of *G. hirsutum* (*Latifolium, Palmeri, Marie-galante, Richmondii, Mexicanum*),10 exotic accessions of *G. hirsutum* (Exotic 3, Diu 90, Diu 91, Moco, Diu 92, Diu 93, Serido, Diu 4494, EC 669583, RCW Kidney cotton), 4 varieties of cultivated species of cotton (*G. herbaceum* cv Digvijay, *G. arboreum* cv AKA 8401, *G. hirsutum* cv Suraj, *G. barbadense* cv Suvin) along with other important accessions (*G. barbadense* GBP-1, *G. arboreum* CNA5) and related species (*Thespesia lumpas*) were profiled to assess the genetic diversity using identified polymorphic SSR markers. The microsatellite markers clearly distinguished the diploid wild species of cotton from tetraploid species. Clustering pattern revealed separate grouping of diploid wild species, tetraploid species, races of *G. hirsutum* cotton, *G. arboreum* cotton, exotic collections of *G. hirsutum* with very few exceptions/outliers (Fig. 3.1.3).

Eight new crosses for broadening the genetic diversity were established viz. *G. arboreum* x *G. barbosanum, G. arboreum* x *G. capitis viridis, G. arboreum* x *G. barbosanum* (Fertile), *G. arboreum* x *G. barbosanum* (Sterile), *G. arboreum* (cv Roja) x *G. stocksii* (sterile), *G. arboreum* (Sinense) x *G. stocksii* (sterile), *G. hirsutum* cv. JK4 x *G. aridum* and *G. hirsutum* cv. MCU5 x *G. barbosanum* (Plate 3.1.3). In one cross with *G. barbosanum*; both sterile and fertile plant were observed.

Plate 3.1.3: A. G. arboreum* x *G. barbosanum, B. G.arboreum* x *G. capitis viridis, C.G.arboreum* x *G. barbosanum Fertile, D. G.arboreum* x B4 Sterile, *E. G. arboreum (cv Roja) x stocksii Sterile, F. G. arboreum (sinense) x stocksii Sterile, G. JK4 x G. aridum Sterile, H. MCU5 x G.barbosanum Sterile

Eleven fresh crosses were attempted using *G. bickii*, *G. stocksii*, *G. trilobum* and *G. arboreum* race *soudanense* with cultivated species. Generation was advanced from F5 to F6 for crosses viz. *G. arboreum* x *G. longicalyx*, *G. arboreum* race indicum x *G. davidsonii*, *G. arboreum* x *G. thurberi* and *G. arboreum* (Cv AKA8401) x *G davidsonii* and progenies were evaluated in the field for morphological and fibre traits.

Evaluation of introgressed derivatives

Total of 366 introgressed derivatives (295 *G. hirsutum* & 71 *G. arboreum*) were evaluated for yield, fibre properties and biotic stress tolerance while 763 single plants selected from the segregating progenies. The seed cotton yield among the *G. hirsutum* derivatives ranged from 1194-3749 kg/ha while in *G. arboreum* it ranged from 728-2766 kg/ha, the range of variability for other economic characters is given in Table 3.1.3.

Table 3.1.3 : Range in Seed cotton yield and fibre parameters in introgressed derivatives

Particulars	*G. hirsutum*	*G. arboreum*
Seed cotton yield(kg/ha)	1194 – 3749	728 – 2766
Ginning percent (%)	28.4 – 39.4	29.1 – 41.1
UHML (mm)	21.7 – 31.7	20.6 – 27.2
UI (%)	78 – 83	73 – 81
Micronaire (µ/inch)	3.2 – 6.1	3.8 – 6.7
Bundle strength (g/tex)	22 – 30.4	20.3 – 23.4

All the introgressed derivatives including colour cotton were evaluated for pest infestation and it was found that whitefly and jassid population was below ETL, Bollworms were not observed while, the population density of natural enemies like lady bird beetle and spider per plant ranged from 0-1 in 162 lines.

Table 3.1.4: Colour Cotton entries sponsored for AICRP 2018-19

Genotype	UHML (mm)	BS (g/tex)	Mic (µ/inch)
CICR 16301 (DB)	23.7	22.4	3.8
CICR 16315 (LB)	26.20	28.26	3.17
CICR 16337 (LB)	26.73	28.73	3.42
CICR 16377 (LB-A)	23.0	23.6	5.0
CICR 16378 (LB-A)	23.4	24.4	5.1

One hundred forty seven colour cotton cultures (*G. hirstum* - 143 & *G. arboreum* - 4) were evaluated in field condition for various shades of brown lint, seed cotton yield and fibre traits.

Sixteen *G. hirsutum* and *G. arboreum* based introgressed derivatives of colour cotton were evaluated for colour parameters, colour fastness and fibre properties at ICAR-CIRCOT, Mumbai. Six samples namely CICR 17395 (Vaidehi-95/ MSH-53), CICR 17505, CICR 508, CICR 17513, CICR 17521 and CICR 17522 comparatively had higher colour fastness. No fading was observed in any of the samples and their fastness was classified as exceeding 5, on a scale of 1-8 which can be considered to be very good for textile applications. Colour fastness of five of these samples to washing was excellent with highest rating of 5 (on a scale of 1-5) indicating no change in colour. No staining of cotton or wool sample was observed for any of the test sample. The color pigments in the lint of naturally coloured cotton were found quite stable to fading by light and washing.

The yield ranged from 1631 to 2272 kg/ha, fibre length (UHML) 21.4 – 29.6 mm, micronaire 2.8 – 4.6 µg/inch, fibre strength 19.4 – 28.2 g/tex, elongation 4.5 – 6.6 % and SFI 8.5 – 31.5%. Seed cotton of 8 q and lint of 3.5 q was obtained for Dark Brown linted genotype, Vaidehi-95/ MSH-53 which was supplied to ICAR-CIRCOT for value addition.

Three registered genetic stocks of *desi* cotton were retained for the crop season 2018-19 in South Zone Trial viz; CNA-405 (Narrow leaf lobed & brown linted), CNA-407 (Spotted petal blotch and light brown linted) & CNA-407 SPL (Spotless petals & light brown linted)

Development of consensus genetic linkage map of *Gossypium*

Field trial of all the five RIL mapping populations (one population of CICR and 4 provided by participating centers; two inter specific populations of *G. arboreum* x *G. hirsutum*, two intra-*hirsutum* populations and one interspecific *G. hirsutum* x *G. barbadense* population) in two replications were evaluated for morphological, yield and fibre quality traits at ICAR-CICR Nagpur. Genomic DNA of RIL mapping population i.e. KWAN-3 x JAYADHAR, developed by ICAR-CICR was isolated and supplied to NBRI, Lucknow for SNP genotyping.

Evaluation of *G. herbaceum* germplasm

A set of 25 early maturing G. *herbaceum* germplasm lines were evaluated along with standard checks (Jayadhar, DDhC-11 and GN. Cot 25). Three crop seasons pooled data was analysed statistically. The interaction of genotype x seasons were highly significant (Fig.3.1.4). The genotype IC 371437 had the highest yield. Days to harvest was shortest in Baluchistan 1 (180 ± 12.4 days) followed by IC 371437 (190 ± 10.4 days) as compared to standard checks G. Cot 25 (220 ± 23.5 days), DDhC-11 (215 ± 24.2 days) and Jayadhar (225 ± 18.1 days). Based on mean performance of three years, seven genotypes identified for utilization in breeding programme are Baluchistan 1, IC 371437, IC 371587, IC 371560, IC 371602, IC 371360 and IC 371136.

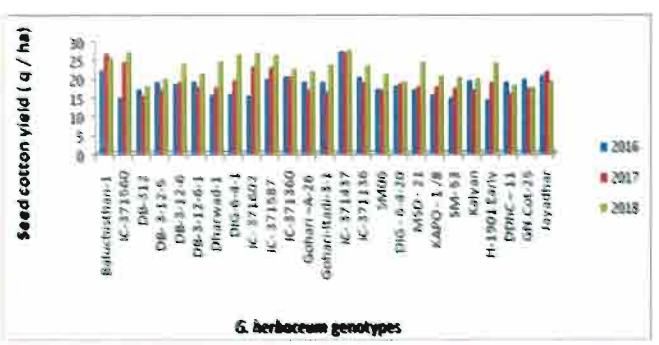


Fig.: 3.1.4: Pooled data for SCY (three crop seasons) among *G. herbaceum* genotypes

Interspecific hybridization in *G. herbaceum x G. arboreum*

Twenty-one inter specific F2 crosses of *G. herbaceum* x *G. arboreum* were evaluated along with identified seven *herbaceum* lines (GVHV- 655, IC 371437, IC 371152, IC 371158, Baluchistan 1, IC 371136 and IC 371360) and three *arboreum* testers (PA 740, PA 785 and PA 812). In the combining ability analysis of variance for seed cotton yield per plant, 12 crosses and 4 parents showed significant difference for the trait. The female *G. herbaceum* parents IC 371437, IC 371152 and Baluchistan 1 and *arboreum* male parents PA 785 and PA 812 showed high general combining ability. Cross combinations IC 371437 x PA 785, Baluchistan 1 x PA 785, IC 371136 x PA 785 and IC 371360 x PA 785 showed high SCA. The magnitude of variance (σ^2) resulting from GCA was lesser than SCA indicating that variation was affected by dominant gene effect for number of bolls per plant (V_D GE = 26.5), boll weight (V_D GE = 0.16), seed cotton yield per plant (V_D GE = 1,059) and days to harvest (V_D GE = 267).

Inheritance of bracteoles in F_2 population of *G. herbaceum* x *G. arboreum* crosses was studied. In cross IC 371437 x PA 785, total 2296 bolls showed good fit of 3: 1 (1734 flared bracteoles and 562 closed bracteoles) with non-significant χ^2 test (0.33) indicating action of a single dominant gene. A total of 3298 bolls were studied in reciprocal cross PA 785 x IC 371437. The χ^2 test was non–significant (χ^2 = 0.38) with good fit of 15: 1 (3083 closed bracteoles and 215 flared bracteoles) indicating duplicate genes action where genes of both genotypes act independently.

Plate 3.1.4 A. Flared away bracteole from green boll of *G. herbaceum* (IC-371437)

Plate 3.1.4B. Flared away bracteole from pink boll of *G. herbaceum* (IC – 371560)

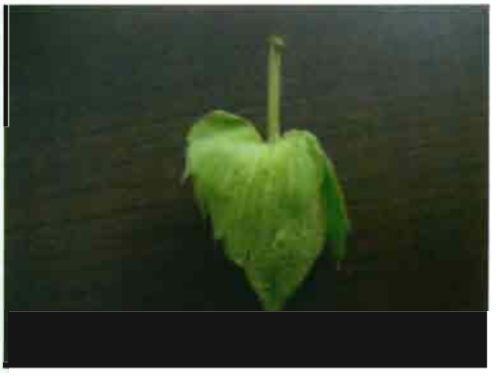


Plate 3.1.4 C. Closed bracteole from green boll of *G. arboreum* (PA-785)

Evaluation of intra *herbaceum* F_3 population

F_3 populations of five intra *G. herbaceum* crosses (Baluchstan-1 x IC – 371437, IC – 371560 x Baluchistan-1 ; IC – 371437 x Baluchistan-1 ; IC – 371437 x IC – 371587; IC – 371602 x IC – 371587) were raised. Each cross consisted of 576 plants. Segregation pattern was recorded with respect to dwarf type, early maturity, boll openings and seed cotton yield. Variation for boll number per plant (from 29.4 ± 11.2 to 58.71 ± 18.5), seed cotton yield (g/plant) (from 69.6 ± 8.5 to 156.3 ±28.2) and days to harvest (from 180 ± 12.4 to 230 ±20.30 was observed. F4 seeds were collected.

Evaluation of intra *G. arboreum* F_2 population

F2 populations of 3 direct intraspecific crosses of *G. arboreum* (PA 740 x PA 785 , PA 740 x PA 812 and PA 785 x PA 812) and their reciprocals (PA 785 x PA 740, PA 812 x PA 740 and PA 812 x PA 785) were evaluated. Each cross consisted of 144 plants. Observations were recorded for plant height, days to harvest, boll number, boll weight and seed cotton yield. Variation for boll number per plant was observed in the range of 23.23 ± 22.14 to 48.33 ± 17.54, seed cotton yield (g/plant) 74.19 ± 10.23 to 136.66 ± 14.23 and days to harvest 140 ± 20.433 to 160 ± 25.33. F_3 seeds were collected for further evaluation.

Transfer of CLCuD resistance from *G. arboreum, G. herbaceum* and wild species to *G. hirsutum:* Interspecific plant *(G. hirsutum x G. arboreum)* established at CICR, Nagpur. The plant is sterile. It was crossed with *G. hirsutum* but no cross ball was obtained. Crosses were also attempted between BC1F1 (F1861 x *G. armourianum)* x CSH 3129, CSH 3075. *G. arboreum (CISA 310 and CISA 614) treated with colchicine 0.5% and four plants with changed morphological features were obtained.*

Development of high yielding Asiatic cotton for South zone

At Coimbatore, based on two year screening and evaluation of 1100 *G. arboreum* accessions for yield and yield attributing traits, 13 accessions namely AC 3265,

AKH 496, PBS 1127-SP1, AC 3522 B, AC 3216, H 503, H 509, AC 3097, AKA 13-SP1, N 11-54-31-32, H173, PBN 565 and 3930A which showed high yield and early maturity were identified. Crossed in diallel matting design and F_1 evaluated. Highest SCA and Standard heterosis (SH) with *per se* performance was observed for single plant yield in the crosses *viz.* AC 3265 × PBS 1127–SP1, AKA 496 × H 509, AKA 496 × AC 3097, PBS 1127–SP1 × N 11-54-31-32, AC 3216 × AKA 13-SP1, H 503 × N 11-54-31-32, H 509 × AKA 13-SP1, boll weight and boll numbers in crosses *viz.* AC 3265 × AKA 13-SP1, AC 3265 × H 173, AKA 496 × H 509, AKA 496 × AC 3097, PBS 1127–SP1 × N 11-54-31-32, AC 3216 × 3930A, H 503 × N 11-54-31-32, H 509 × AKA 13-SP1; days to fifty per cent flowering in crosses *viz.*, AC 3265 × PBS 1127–SP1, AC 3265 × AKA 13-SP1, AC 3216 × AKA 13-SP1, AC 3216 × 3930A, H 509 × AKA 13-SP1, H 173 × PBN 563, H 173 × 3930A were identified.

Improvement of fibre qualities of *G. arboreum* and generation advancement from segregating population has been carried out at Nagpur. Total 120 single plants of BC_2F_1, 250 single plants of F_3 and 120 single plants of BC_1F_2 were selected for further advancement.

F_1 of cross H509 x AKA 13-SP1

Single plant selection for fibre quality traits in advanced generation of *G.arboreum*

F_1 of cross AC 3216 x AKA 13-SP1

Field view of advanced generation lines of *G.arboreum*

Plate 3.1.5 Promising crosses and progenies of *G.arboreum* with improved fibre traits

3.2 Breeding for premium fibre quality and high yield as per global needs

(a) Diploid cotton trials :

Evaluation of GMS based *G. arboreum* hybrids: Eight GMS based *G.arboreum* hybrids were evaluated for seed cotton yield with two check hybrids AAH 1 and CICR 2. Five hybrids CISAA 18-11(3567kg/ha), CISAA 18-12, CISAA 18-13, CISAA 18-10 and CISAA 18-8 recorded significantly higher seed cotton yield than the check hybrid CICR 2. The hybrids, CISAA 18-1 and

CISAA 18-2 were sponsored in National Br 25 a/b Trial (Table 3.2.1).

Table 3.2.1: Performance of GMS based *G. arboreum* hybrids in replicated trial at Sirsa

Entry Name	SCY (Kg/ha)	Boll wt (g)	GOT (%)	Boll No	UHML (mm)	MIC	Strength (g/tex)
CISAA18-6	2972	1.7	41.3	58.7	23.6	5.8	23.5
CISAA 18-7	2538	1.7	39.8	60.7	25.2	5.8	24.8
CISAA 18-8	3086	1.9	40.0	53.3	26.2	5.8	24.7
CISAA 18-9	2846	1.9	39.4	55.3	24.1	5.8	23.9
CISAA 18-10	3201	1.9	38.1	59.7	23.6	6.1	24.2
CISAA 18-11	3567	2.0	39.5	50.0	23.5	6.1	23.8
CISAA 18-12	3384	1.9	42.3	60.3	21.7	6.2	22.7
CISAA 18-13	3384	1.9	41.8	55.3	22.4	6.2	23.0
AAH1 (check)	1829	2.1	41.7	49.7	19.8	6.4	22.1
CICR 2 (check)	2744	1.9	45.3	55.0	21.0	6.2	22.4
CD	283.2						
CV (%)	5.75						

Evaluation of spinnable *G. arboreum* cultures: Under this trial, 14 cultures along with two checks CISA 614 and PA255 were evaluated at ICAR-CICR RS, Sirsa. None of the genotypes could give significantly higher yield than the check CISA 614 but all the genotypes gave significantly higher seed cotton yield than the quality check PA 255 except CISA 33-6 (1578 kg/ha.). None of the genotypes could possess quality parameters equal to or higher than quality check (PA 255). However, CISA 33-8 (2675kg/ha) having UHML 25.1mm, strength (25.0g/tex) and MIC 5.6 showed promise for spinning. CISA 33-8 and CISA 10 were sponsored in Br 22a/b LL trial.

Evaluation of high yielding *G. arboreum* genotypes: Under this trial 14 genotypes were evaluated in RBD with two check varieties CISA 614 and Phule Dhanvantri. One genotype CISA-6-2 recorded significantly higher seed cotton yield than high yielding local checks CISA 614 and Phule Dhanwantari (Table 3.2.2).

Table 3.2.2: Evaluation of *G. arboreum* genotypes for yield and fibre quality

Entry Name	SCY (Kg/ha)	Boll wt(g)	GOT (%)	No of Boll/Plant	UHML	MIC	Strength (g/tex)
CISA-6-165	2263	1.7	37.0	57.3	18.9	6.5	21.9
CISA-6-2	2446	2.0	38.6	57.0	19.7	6.3	22.2
CISA-6-123	1875	1.8	38.4	57.3	20.7	6.1	22.4
CISA-6-187	2081	1.8	37.0	52.7	19.5	6.5	22.4
CISA-6-214	1966	2.1	37.9	47.3	23.9	5.9	23.4
CISA 33-9	2058	2.0	42.6	52.3	20.0	6.3	22.4
CISA 6	2126	1.9	39.4	57.3	20.1	6.3	22.3
CISA 405	2195	2.0	42.7	58.0	19.8	6.3	22.3
CISA -8	1829	2.0	43.0	47.7	19.3	6.4	22.1
CISA-7	2081	2.0	43.3	39.7	22.5	6.0	23.3
CISA 9	1852	1.8	41.0	42.7	20.9	6.4	22.7
CISA 294	1646	1.9	43.1	52.3	20.6	6.1	22.4
CISA 33-7	2058	1.9	41.0	35.3	22.4	5.7	23.3
CISA 33-5	2058	2.0	38.0	38.0	19.7	6.3	22.3
Phule Dhanvantri (C)	2058	2.1	38.2	38.0	21.6	6.2	23.0
CISA 614 (C)	2172	1.8	41.7	30.7	19.2	6.4	22.1
CD	**210.7**						
CV (%)	**6.3**						

Evaluation of single plant progenies : Under this trial 8 single plant progenies were tested along with two checks CISA 310 and quality check PA255. None of the progenies showed significant performance over check CISA 310 (2766 kg/ha). None of the progenies possessed fibre quality traits equal to or higher than the quality check PA 255.

(b) Tetraploid cotton trials

Development of high yielding good quality varieties: A high fibre strength quality variety Central Cotton CCH 4474 (Subhiksha) was released for commercial cultivation in south zone states of Karnataka, Andhra Pradesh and Tamil Nadu under irrigated conditions. The variety is compact and is suitable for High Density Planting System with yield potential of 4201 kg/ha. It has recorded GOT of 35.4 %, 2.5 % Span length of 32.4 mm, micronaire of 3.6 in the spinning test in ICC mode and UHML of 32.7 mm, micronaire of 3.7 and tenacity of 33.8 g/tex in the spinning test in HVI mode. It has recorded a CSP value of 2376 in 50s count and 2322 in 60s count and was found to spin up to 60s count yarn. It also showed field tolerance to jassids.

Plate 3.2.1 (a) Central Cotton CCH 4474 (Subhiksha)

A high yielding good quality variety Central Cotton CCH 12-2 (Suchitra) has been released for commercial cultivation in Central Zone States of Gujarat, Maharashtra and Madhya Pradesh under irrigated conditions. The variety has a yield potential of 2598 kg/ha. It has an Upper Half Mean length of 28.0 mm, Micronaire of 4.2 and tenacity of 29.0 in HVI mode matching the CIRCOT norm for 30s count yarn. It also showed tolerance to grey mildew and moderate tolerance to jassids in field conditions.

(b) Central Cotton CCH 12 (Suchitra)

Plate 3.2.1 (a & b)High yielding varieties of *G. hirsutum* released for commercial cultivation in South and central zones

G. hirsutum cultures with superior fibre quality

The extra-long staple good quality culture CCH 15-1 showed excellent fibre quality in AICRP multilocation trials with a yield potential of 4019 kg/ha. The culture showed yield superiority in closer spacing with 125% RDF at Srivilliputhur in South Zone and at Rahuri in Central Zone in agronomic study. It has been rated as one of the best entry for fibre quality in both south and central zone locations by ICAR-CIRCOT. The average values of Upper Half Mean length of 32.4 mm, Micronaire of 3.7 and tenacity of 34.3 g/tex in HVI mode in South Zone and Upper Half Mean length of 31.9 mm, Micronaire of 4.4 and tenacity of 33.5 g/tex in HVI mode in Central Zone indicates overall superiority for fibre quality traits. The full spinning test indicates that it is capable of spinning up to 70s count yarn. The culture is identified as resistant to leaf hopper and Alternaria Leaf Blight in advanced screening trials in AICRP centres.

Evaluation of advance cultures of *G. hirsutum*: The trial at Sirsa consisted of 17 *G. hirsutum* cultures evaluated with the check variety RS 2013, CSH 3129 and susceptible check F1861 in RBD with three replications. The highest seed cotton yield was recorded in the culture CSH 2933 (1996 kg/ha) followed by CSH 1602 (1872 kg/ha) as against the check variety CSH 3129 (1646 kg/ha). Maximum ginning out turn of 40.1% was recorded in the variety CSH 2837 & CSH 2924 as compared to local check varieties RS 2013 (35.8%) and CSH 3129 (36.5%). Most of the cultures in trial recorded a CLCuD incidence less than 20 PDI (Table 3.2.3).

Table 3.2.3: Performance of promising advance cultures of *G. hirsutum* cotton.

Variety	Plant ht (cm)	Bolls no	Boll wt (g)	GOT (%)	SCY (kg/ha)	CLCuD PDI
CSH 2933	109.4	25.8	3.01	39.0	1996	19.4
CSH 1602	120.0	25.8	3.15	36.0	1872	17.9
CSH 2931	114.4	29.2	2.70	38.1	1728	19.2
CSH 2924	112.8	25.1	2.99	40.1	1584	17.9
RS 2013	122.8	26.3	2.67	35.8	1049	20.6
CSH 3129	126.1	30.2	3.37	36.5	1646	18.6
F 1861	117.7	28.0	2.84	36.0	1214	19.1
CD @ 5%	18.2	5.34	0.29	1.13	278	
CV %	9	12	6	2	11	

Trial 2 consisted of 21 *G. hirsutum* cultures and three check varieties. In this trial, only one culture CSH 1624 recorded the higher seed cotton yield of 1728 kg/ha as compared to check variety CSH 3129 (1646 kg/ha). Maximum ginning out turn of 39.7 % was recorded in CSH 1623 as compared to local check varieties RS 2013 (35.2%) and CSH 3129 (37.6%).The culture CSH 1615 recorded minimum CLCuD incidence of (17.1 PDI) as compared to susceptible check (30.0 PDI).

In Trial 3, 16 *G. hirsutum* cultures were evaluated alongwith 3 check varieties in three replications. The highest seed cotton yield was recorded in the advance culture CSH 1717 (1728 kg/ha) followed by CSH 1715 (1667 kg/ha) as against the check variety CSH 3129 (1646 kg/ha). Maximum ginning outturn of 40.1% was recorded in the variety CSH 1717 as compared to local check varieties RS 2013 (35.8%) and CSH 3129 (36.5%). All 16 cultures recorded CLCuD incidence less than 20 PDI (Table 3.2.4).

Table 3.2.4: Performance of promising advance cultures of *G. hirsutum* cotton

Variety	Plant ht (cm)	Bolls no	Boll wt (g)	GOT (%)	SCY (kg/ha)	CLCuD PDI
CSH 1711	113.3	28	2.93	37.4	1564	17.6
CSH 1712	114.4	27	3.03	38.1	1564	18.1
CSH 1714	109.9	29	3.05	37.4	1605	19.1
CSH 1715	116.7	23	3.20	38.8	1667	19.7
CSH 1717	108.3	24	2.85	40.1	1728	26.4
RS 2013	122.8	26.3	2.67	35.8	1049	20.6
CSH 3129	126.1	30.2	3.37	36.5	1646	18.6
F 1861	117.7	28.0	2.84	36.0	1214	19.1
CD @ 5%	18.2	5.34	0.29	1.13	278	
CV %	9	12	6	2	11	

Selection of Single Plants Progenies from segregating populations : To develop the segregation 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, 23 progenies having high yield potential and tolerance against CLCuV were selected in F_6 generation. Among the progenies the seed cotton yield ranged from 814 to 2716 kg/ha while GOT ranged from 35.2 to 40.5 per cent. CLCuD incidence ranged from 14.4 to 32.7 PDI (Table 3.2.5).

Table 3.2.5: Performance of progenies selected from CLCuD tolerant x tolerant crosses

Entry Name	SCY (kg/ha)	Boll wt (g)	GOT (%)	CLCuD PDI
CSH 56	2099	3.06	38.4	21.7
CSH 57	2222	3.20	35.2	18.4
CSH 60	2222	2.60	37.1	19.7
CSH 61	2346	2.65	38.8	20.6
CSH 64	2593	2.68	37.9	23.5
CSH 65	1481	2.62	38.3	25.0
CSH 66	1481	2.82	38.0	26.2
CSH 68	2716	3.20	38.8	22.2
CSH 71	2469	2.70	36.1	24.4
CSH 72	2222	2.72	37.0	26.2
CSH 73	2346	2.60	35.0	22.0
CSH 3129 (LC)	2333	2.98	36.5	23.5

Evaluation of single plant selections of *G. barbadense*

Among the 5 superior back crossed progenies, 3 single plants/progenies have been identified (**CCB-12** (SN x ICB 75)1-2-1-3), **CCB-14**, (SN (SN x ICB 155) 2-7-2-4 and **CCB-15** (SN (SN x ICB 179) 3-1-3-7). They possesse high yield potential ranging from 13-15 q/ha, 34-36% GOT and exhibited high fibre quality parameters which fit into the ELS category.

The single plant progenies of the promising cross combination ICB-124 x Suvin and ICB- 264 x Suvin exhibited high seed cotton yield of 1134 kg/ha and 1207 kg/ha respectively and showed moderate resistance to jassids. Sixty seven plants have been earmarked for sucking pest tolerance which shall be further confirmed during forthcoming crop season **(Table 3.2.6)**.

Table 3.2.6. Performance of single plant progenies of crosses between hairy *G.barbadense* lines and Suvin

Cotton hairy lines	SCY (Kg/ha)	Mean population of jassids (per 3 leaves in cotton)		Leafhopper resistance index	Resistance category
		45 DAS	90 DAS		
HAG-02 S	862	2.1(1.51)	3.3 (1.94)	**2.4**	MR
EC-18 S	709	4.3 (2.16)	6.7 (2.67)	2.6	S
ICB-85 S	893	5.7 (2.49)	3.3 (1.93)	2.7	S
ICB-87 Suvin	669	5.5 (2.43)	2.9 (1.83)	**2.5**	MR
ICB-105 S	1053	4.9 (2.29)	4.1 (2.13)	3.1	S
ICB-124	1134*	3.6 (2.01)	2.5 (1.6)	**2.4**	MR
ICB-264	1207*	3.9 (2.08)	3.7 (2.03)	**2.4**	MR
ICB-281	1032	4.2 (2.16)	4.6 (2.25)	2.7	S
ICB-284	997	1.7 (1.45)	1.6 (1.43)	**2.4**	MR
ICB-288	786	3.7 (2.04)	3.9 (2.07)	2.7	S
Suvin (c)	688	5.3 (2.39)	4.7 (2.27)	2.8	S
C.D.	113	0.576	0.535	-	-
SE (m)	0.433	0.194	0.187	-	-
SE (d)	0.126	0.274	0.261	-	-
C.V.	11.3	14.17	11.92	-	-

Cleistogamous mutant in *G. barbadense*

A stable completely cleistogamous spontaneous mutant has been identified in the segregating populations of *intra-barbadense* crosses CCB-12 (SN(SN x ICB-75) 7-1-6-2. The mutant identified was stable and found in the progeny from an intra *barbadense* cross (Giza -45 x Suvin- 3-7-2). This cleistogamous trait is highly useful in pure seed production and pure line breeding.

Plate 3.2.2 Cleistogamous spontaneous mutant identified in the segregating populations of *intra-g.barbadense* cross

Identification of promising extra-long staple genotypes

A total of thirteen high yielding, early maturing ELS genotypes were evaluated during 2018-19 crop season for further confirmation and seed multiplication. The top ranking promising culture CCB-64 showed significantly higher seed cotton yield (1564 kg/ha) with 39 mm of 2.5 span length, 40 g/tex and 3.3 µ/inch micronaire followed by CCB-129 (1507 kg/ha) with 38 mm length, 37 g/tex and 3.4 micronaire, CCB-51(1437 kg/ha) and CCB-51-2 (1420 kg/ha), 39 mm span length 33.4 g/tex of bundle strength, 3.3 µ/inch micronaire. The check variety, Suvin gave seed cotton yield of 817 kg/ha with 30 % GOT, 37 mm span length, 31 g/tex bundle strength and 3.1 µ/inch micronaire.

Development of high strength cotton genotypes by reducing the short fiber content

In a station trial, 12 long staple cultures were evaluated at Coimbatore along with Surabhi and Suraj as check varieties. The culture YLS 15-1 showed significant yield superiority (4376 kg/ha) over both the check varieties with good fibre quality attributes. The culture YLS 21-4 and YLS 21-3 showed consistently better fibre quality attributes over the years as compared to the long staple check varieties viz., Surabhi and Suraj (Table **3.2.7**).

Table 3.2.7: Yield and fibre quality attributes of YLS 15-1 *vis-à-vis* checks

Culture	Seed Cotton Yield (kg/ha)	Upper Half Mean Length (mm)	Micronaire (µg/in)	Strength (g/tex)	Short Fibre Content (w) %
YLS 15-1	4376*	30.3	3.9	28.2	4.7
Suraj	3667	30.9	4.3	27.0	5.7
Surabhi	2790	30.8	3.3	31.8	5.5
CD@5%	448				
CV%	8				

Table 3.2.8: Fibre quality traits of YLS 21-4 and YLS 21-3 *vis-à-vis* checks

Culture	Upper Half Mean Length (mm)			Strength (g/tex)			Short Fibre Content (w) %		
	2017-18	2018-19	Mean	2017-18	2018-19	Mean	2017-18	2018-19	Mean
YLS 21-4	34.1	30.9	32.5	29.7	33.8	31.7	4.0	5.4	4.7
YLS 21-3	34.1	30.7	32.4	29.6	33.4	31.5	5.8	5.9	5.9
Surabhi [C]	32.8	30.8	31.8	31.8	30.9	31.4	5.5	4.7	5.1
Suraj [C]	32.7	30.9	31.8	27.0	31.3	29.1	5.7	4.4	5.1

Thirty progeny bulks with better fibre quality and boll weight were evaluated along with long staple check varieties. Nine progenies recorded higher bundle strength as compared to the best check variety Surabhi **(Table 3.2.9).** All these progenies combined big boll size (boll weight >4.3 g.), better UHML and stronger fibre.

Table 3.2.9: Evaluation of identified progeny bulks along with long staple check varieties

Progenies	Boll Weight (g)	Upper Half Mean Length (mm)	Micronaire (µg/in)	Strength (g/tex)
7-2-1	4.8	32.5	3.1	30.8
1-1-1	4.9	31.5	3.8	29.4
9-1-1	5.7	30.4	4.5	29.2
16-1-1	4.3	28.0	4.4	29.2
2-2-1	5.4	30.1	3.9	29.1
13-1-2	6.5	30.5	4.3	29.1
6-1-2	5.1	28.5	3.6	29.0
13-1-1	6.1	28.4	4.2	28.6
15-1-2	4.9	29.2	4.3	28.5
Surabhi [C]	3.8	30.7	4.7	28.5
Suraj [C]	4.8	31.1	3.4	27.5
1-2-1	6.8	30.4	4.7	26.6
Max	6.8	32.5	5.2	30.8
Min	3.8	28.0	3.0	25.4

Population Improvement

Evaluation of single plant selections: A total of 1508 superior single plants (897 of *G. arboreum* and 611 of *G. hirsutum*) were selected from random mating population. About 1650 single plants were reselected from the segregating progenies for further evaluation in plant to row progeny plots. All the single plant progenies were monitored for segregation, if any, and also evaluated for uniformity, economic and fibre quality traits. Based on agronomic performance, uniformity and fibre quality of plant progenies 45 progenies of *G. arboreum* and 36 of *G. hirsutum* were identified for evaluation in replicated trial.

Evaluation of advance cultures:

Ninety two cultures of *G. arboreum* and 76 of *G. hirsutum* were evaluated in 6 replicated trials (4 rows /plot in 2 replications). In all, 3 trials of *G. arboreum* and 3 of *G. hirsutum* were conducted following a spacing of 60cm x 45cm. The seed cotton yield among the *G. arboreum* cultures ranged from 818 to 3180.6 kg/ha while in *G. hirsutum* it ranged from 1607.8 to 3080.5 kg/ha. Based on yield and fibre quality traits about 56 selections of *G. arboreum* and 53 of *G. hirsutum* were retained for second year evaluation during 2019-20 **(Table 3.2.10).**

Table 3.2.10 : Range of yield, yield attributes and fibre quality trait in advance selections of *G. arboreum* and *G. hirsutum*.

Particulars	Range in *G.arboreum* selections	Range in *G.hirsutum* selections
Seed Cotton Yield (kg/ha)	818-3180.6	1607.8-3080.5
Ginning percent	29.5 – 42.2	28.9 – 39.5
Boll weight (g)	1.65 – 2.90	2.6 -4.3
Fibre length (mm)	22.7 -28.2	23.2 – 31.2
Uniformity Index (%)	79 - 85	80 – 84
Micronaire value	4.2 – 6.1	3.4 – 5.2
Fibre strength (g/tex)	24.4 – 31.9	24.6 – 32.8

From the advanced evaluated selections, three *G. hirsutum* and six *G. arboreum* cultures entered in AICRP National trials. The cultures entered in AICRP trials were grown on large plots for seed multiplication. *G. arboreum* cultures CNA 1036 and CNA 1040 entered in Br. 22(a/b) National trial; CNA 1064, CNA 1065 and CNA 1066 to Br.22 (a/b)LL trial and CNA1091 a colour linted culture sponsored to Br. 22(a/b)CC trials. Among the *G. hirsutum* entries CNH 1131 was entered to Br. 02(b) trial; two cultures CNH 1129 and CNH 1130 were sponsored for evaluation under Br. 06(b) rainfed trial.

Plant with high boll number and Big boll size; and Compact plant type selection from random mating population *G. hirsutum*

3. 3. Breeding for Climate resilience and biotic stress tolerance

Biotic stress

In F_3, F_4 and F_5 segregating generations of single, three way and multiple crosses, 1200 single plant selections were made based on plants having early maturity of 140-150 days, compact plant type and tolerance to jassid for further evaluation as progeny rows.

Plate 3.3.1 Promising progenies showing early maturity and compact plant type

Twenty two entries were evaluated in replicated trial for seed cotton yield and fibre properties. CNH 09-69 had recorded highest seed cotton yield of 1513 kg/ha followed by CNH 09-31 (1465 kg/ha) and CNH 09-23 (1347 kg/ha) compared to Suraj (1252 kg/ha) and NH615 (991 kg/ha).

For transferring quality traits from *G. barbadense* to *G. hirsutum*, inter-specific population was developed. Four hundred twenty five (425) promising inter-specific single plant selection progenies in F4 generation with characteristics of *G. hirsutum* and *G. barbadense* were evaluated for seed cotton yield and quality traits. BC_1F_4 progenies (CNH 32-1, CNH 40-3) showed ginning outturn of 42.1 % to 43.8 % as compared to Suvin (30.9%) and Suraj (37.6%).

Plate 3.3.2 Introgressed lines with high boll weight

Fifty eight F_4 lines were identified with staple length of 32 mm and above. Additionally, 270 F_4 inter-specific lines having naked seeds were also selected for evaluating as progeny rows for yield and quality traits.

Early maturity, compact plant type and jassid tolerance in cotton

Early maturing breeding lines CNH 09-7 and CNH 09-9 were sown for comparative evaluation and generating data on earliness. CNH 09-7 had recorded seed cotton yield of 1416 kg/ha while CNH 09-9 recorded a seed cotton yield of 1421 kg/ha. The first picked seed cotton out of total seed cotton yield was 38% in CNH 09-7and 35% in CNH 09-9. Both the entries recorded Bartlett's earliness index of 0.7 identifying as early maturing genotypes.

Another trial including promising progenies (15 F_6, 14 F_5, 29 F_4 and 13 F_3, 7 F_2 populations) and 83 single plant selections were evaluated for early maturity, compact plant architecture and jassid tolerance apart from yield and fibre quality traits. The early maturity of 120-130 days and jassid tolerance (Grade I) was observed in most of progenies in spite of late sowing and heavy incidence of jassids. Many promising progenies and single plant selections having early maturity of 120-150days (>90% boll bursting), plant width of 20-30cm, plant height of 80-100 cm with zero monopodia, boll weight of 4.25-5.10g and per plant yield of 80-130g were selected from different populations for stabilization, generation advancement and seed multiplication.

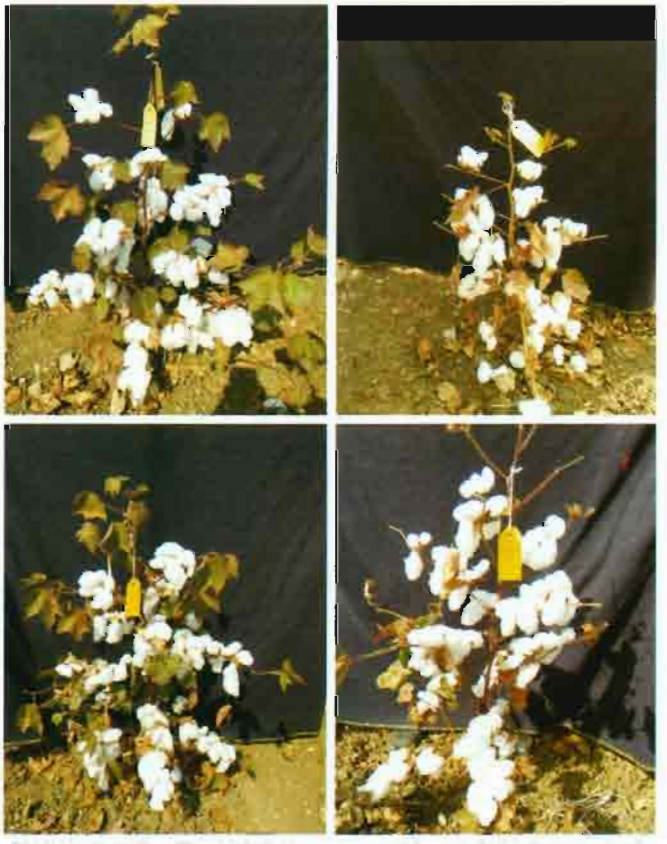


Plate 3.3.3 Promising progenies showing early maturity and compact plant type

Screening of Random Mating population of *G.hirsutum* for CLCuV tolerance

At flowering, the individual plant in the population were monitored for sterility/fertility at anthesis repeatedly at an interval of a week and all the 500 sterile plants were tagged. All the out-crossed bolls from the sterile plants in the population were bulk harvested and ginned to constitute the next cycle of GMS based random mating population. After the 7th cycle of random mating 63 fertile plants having high yield potential and tolerance against CLCuV were selected for evaluation in progeny to row trial. **(Table 3.3.1).**

Table 3.3.1: Performance of promising single plants selected from random mating population

Plant Number	Plant height (cm)	No. of Bolls / plant	Seed Cotton Yield (g)
P8	150	110	165
P10	115	61	144
P12	165	75	149
P17	135	70	175
P21	165	58	180
P22	135	103	142
P31	140	90	160
P34	135	98	177
P35	165	65	247
P37	150	89	216
P47	120	52	153
P48	140	85	175
P52	125	85	223
P57	130	90	174

Evaluation of progenies selected from random mating population of *G. hirsutum*

Out of 91 single plants progenies, six progenies having high yield potential and tolerance against CLCuV were selected and advanced for further evaluation. Culture CSH 1717 recorded the highest yield of 1728 kg/ha followed by CSH 1715 (1667 kg/ha) as compared to check variety CSH 3129 (1646 kg/ha). The cultures also have desirable fibre quality traits and lowest CLCuV incidence **(Table 3.3.2).**

Table 3.3.2 : Performance of promising advance cultures of *G. hirsutum* cotton

Code	Plant height (cm)	Number of monopods	Number of sympods	Number of bolls / plant	Boll weight (g)	Ginning outturn (%)	Seed Cotton Yield (Kg/ha)	PDI
CSH 1711	113.3	0.7	15.4	28	2.93	37.4	1564	
CSH 1712	114.4	0.9	15.2	27	3.03	38.1	1564	
CSH 1713	112.2	3.4	8.4	21	2.67	37.0	1296	
CSH 1714	109.9	2.0	12.2	29	3.05	37.4	1605	
CSH 1715	116.7	1.9	12.2	23	3.20	38.8	**1667**	19.7
CSH 1716	110.6	1.7	11.9	26	2.62	37.6	1481	
CSH 1717	108.3	5.0	7.3	24	2.85	40.1	**1728**	26.4
CSH 1718	103.3	6.6	8.1	25	2.88	37.0	1276	
CSH 1719	119.4	7.0	7.8	26	2.79	37.0	1070	
CSH 1720	119.4	5.3	8.6	24	3.11	36.4	1173	
CSH 1721	112.8	6.2	8.9	24	2.58	35.5	1564	
CSH 1722	120.0	3.2	12.0	24	3.04	37.3	1379	
CSH 1723	103.2	6.9	8.3	24	2.73	36.5	1173	
CSH 1724	112.2	2.7	11.2	22	2.59	36.9	1317	
CSH 1725	102.3	6.4	9.4	31	2.57	38.0	1317	

Code	Plant height (cm)	Number of monopods	Number of sympods	Number of bolls / plant	Boll weight (g)	Ginning outturn (%)	Seed Cotton Yield (Kg/ha)	PDI
CSH 1726	112.3	5.6	8.3	25	3.14	38.3	1235	
RS 2013	101.7	5.0	9.6	26	2.29	38.2	1049	21.0
CSH 3129	111.7	4.9	8.4	25	2.28	37.6	1646	23.5
F 1861	105.6	6.0	7.0	23	2.63	35.9	1214	24.0
CD @ 5%	19.52	0.94	2.03	5.99	0.43	5.02	216.04	-
CV %	11	13	12	14	9	8	9	-

Marker Assisted Selection for Bacterial Leaf Blight

In field, both phenotypically and genotypically resistant BC4 populations were sown along with susceptible elite cultivar Suraj. Marker assisted selection by validated marker CIR246 was carried out and plants showing presence of marker and resistance acertained by artificial inoculation were selected. Total of 33 BC4-F1 plants have been selected for further advancement of generation.

Improvement for Abiotic Stress : Drought Tolerance

Four sets of experiments were conducted during 2018-19. In the first set, 13 advance cultures were tested in replicated trial with LRA 5166 as a check. The seed cotton yield ranged from 918.64 to 1982.15 kg/ha. Ten genotypes were at par to the check LRA 5166 which recorded SCY of 1195.41 kg/ha and nine of them recorded >22 per cent increase in SCY over the check. DTS 39 was the highest yielder (1982.15 kg/ha) followed by DTS 417 (1829.01 kg/ha), DTS 415 (1792.37 kg/ha) and DTS 155 (1665.92 kg/ha). DTS 67 had very good fibre quality with fibre length of 29.6 mm, fibre strength of 28.7 g/tex and micronaire of 3.9 µg/in and GOT of 38.23 per cent. DTS 417 has been identified as drought tolerant in the previous year trial as well.

In second set, 15 crosses in F6 generation were tested along with parents and checks. There was significant difference for seed cotton yield among genotypes that ranged from 1172.50 – 1699.33 kg/ha. Ten of these crosses recorded 17 % yield increase over the check. DTS 401 was the highest performer (SCY of 1699.33 kg/ha) showing 41 % increase over the check, boll weight of 4.08 g, GOT of 36.65%, UHML of 29.0 mm, fibre strength of 28.1 g/tex, micronaire of 4.1 µg/in, UI of 83 % and elongation of 5.7. It was followed by DTS 420 (1684.01 kg/ha), DTS 414 (1627.07 kg/ha), DTS 404 (1615.72 kg/ha), DTS 421 (1612.06 kg/ha) and DTS 412 (1596.65 kg/ha). All entries possessed good fibre quality with S/L ratio ranging from 0.8 to 1.0. DTS 405 and DTS 413 have been identified as drought tolerant.

In the third set, F4 generation of single, double, three-way, six and eight parental crosses were tested along with four checks. The crosses showed significant differences for SCY which ranged from 1009.2 – 2134.60 kg/ha. Twenty three crosses were at par with the check NH 615 which recorded SCY of 1369.87 kg/ha. DTS 501 a double cross recorded highest SCY of 2134.60 kg/ha with 55 % increase over the check NH615 followed by DTS 505, DTS 508, DTS 513 and DTS 509. DTS 513 also possessed good fibre quality with fibre length of 28.5 mm, fibre strength of 28.8 g/tex, micronaire of 3.6 µg/in, UI of 86 and 6.3 elongation percentage.

In the fourth set, F2 and F3 generation of three-way and single crosses were attempted using cluster bearing genotypes to develop compact genotypes for high density planting system. The crosses showed highly significant differences for SCY. The cross (CB 228 x EC 700118) x (Surabhi x M5Z2-18-7) recorded SCY of 1857.31 kg/ha with 48 % increase over the check LRA 5166. Single cross CB 211 x EC 700181 and CB 228 x EC 697618 recorded good fibre quality.

To improve the fibre quality of drought tolerant culture CNH 28 I, crosses were attempted with four lines possessing good fibre quality attributes (length and strength). Ten back crosses along with parents and checks were tested in replicated trial. The genotypes showed highly significant differences for SCY ranging from 1149 – 1864.08 kg/ha. Eleven crosses were at par with the check Suraj which recorded SCY of 1210.99 kg/ha. BC 101 recorded highest yield of 1864.08 kg/ha with 39% increase over the check and GOT of 39.3 %.

For advanced development of MAGIC RILs of ten parental lines, 2972 single plant progenies were raised. Out of 2972 lines, 1310 lines were evaluated for proline content for identifying drought tolerant lines. Fresh leaf samples were taken to estimate the proline content and the lines showing high proline content were then subjected to artificial stress using Poly Ethylene Glycol (PEG) under three concentrations. Few lines were identified which recorded high proline content at all the three levels. The identified progenies namely 4-2, 65-2, 107-5, 117-1, 231-1, 235-1, 321-1, and 327-1 will be further evaluated. About 1000 single plant progenies were also screened for leaf temperature using infrared thermometer which varied from 22 to 29°C.

Fifteen advance cultures were tested under rainfed and irrigated condition and leaf temperature recorded ranged from 28.7 to 32.4°C under rainfed condition. Two

genotypes DTS 405 and DTS 417 were identified as drought tolerant as they maintained normal leaf temperature of 29.2.and 29.5°C and recorded high SCY of 34.73 and 36.18 g/plant respectively. However, two other cultures DTS 407 and DTS 415 recorded high LT of 31.9 and 31.3°C and SCY of 33.3 and 35.2 g/plant indicating that some other parameter than LT might be playing crucial role in imparting tolerance to drought and contributing to high yield.

In an effort to develop another set of MAGIC RILs from eight parental crosses, 3031 single plant progenies were raised. In 350 progenies, boll weight of > 4 g and in two selections > 5 g were recorded. Fibre length and strength in 218 selections ranged from 22 to 29 mm and 25 to 30 g/tex. One hundred seventy three compact plant types were identified where the plant height ranged from53 to 87 cm, sympodial length from 7 to 15 cm inter boll distance of 3 to 10 cm and single plant yield from 21.4 to 174.8 g. Individual plant progenies were maintained through selfing.

Tolerance to waterlogging

Based on lenticels and adventitious roots formation, four tolerant (IC 359979, IC359245, IC357235, INGR08093) and four susceptible (IC357556, IC359242, IC357607 and IC35678) accessions were identified and diversity analysis was carried out using 38 polymorphic SSR markers. Neighbour Joining tree showed three major clusters with varying bootstrap support. Cluster I consisted two susceptible accessions (IC357558 & IC359242) and tolerant check LRA5166; Cluster II consisted three tolerant accessions (IC563998, IC359245 & IC357235) and Cluster III consisted one tolerant (IC359979) and two susceptible accessions (IC357607 & IC356708). The dendrogram showed considerable genetic diversity present in the accessions used in the study.

Based on the dissimilarity index, 2 tolerant accessions namely LRA 5166 & IC 563998 and two susceptible accessions namely IC 357607 & IC 356708 have been shortlisted for further analysis and crossing with elite genotypes *viz.*, Suraj and NH615 for introgression of water logging tolerance. F1s obtained during the previous year were selfed to develop F2 mapping population **(Table 3.3.3).**

Table 3.3.3: Dissimilarity index among the identified *G.hirsutum* accessions

	IC357558	IC359242	LRA5166	IC563998	IC359245	IC357235	IC359979	IC357607
IC359242	0.58							
LRA5166	0.62	0.40						
IC563998	0.57	0.40	0.40					
IC359245	0.60	0.43	0.34	0.27				
IC357235	0.53	0.36	0.35	0.37	0.36			
IC359979	0.59	0.40	0.43	0.39	0.36	0.28		
IC357607	0.63	0.51	0.45	0.44	0.44	0.39	0.35	
IC356708	0.61	0.46	0.41	0.46	0.47	0.41	0.49	0.43

At ICAR-CICR RS, Coimbatore, two each accessions of susceptible and tolerant *Gossypium hirsutum*, were shortlisted. Waterlogging was initiated at 50 DAS and continued for 25 days. The leaf samples were analysed for Nitrate reductase activity and chlorophyll contents at 6 days after water logging (DAWL). Nitrate reductase activity was higher in tolerant accessions. However, SPAD values and chlorophyll contents showed variable results among tolerant and susceptible accessions. Root length was higher in tolerant accessions.

3.4Gene discovery, genomics and trait improvement

Somatic embryogenesis and cotton transformation

Cotton is highly recalcitrant to somatic embryogenesis mediated regeneration. Somatic embryogenesis mediated regeneration protocol for *G. hirsutum* genotypes Coker 312 and Coker 310 was standardized. The healthy regenerated plantlets were initially established in soilrite followed by earthen pots in polyhouse. The flowers from the early somatic embryo regenerative plants were selfed and opened bolls were harvested. The selfed seeds from the Coker 312 was used for *Agrobacterium* mediated genetic transformation with *CICR-Cry2Ab1Ac* and *CICR-Cry2Ab1Ac::chitinase* gene constructs. Hypocotyl and cotyledanary explants from seven to ten days old seedlings were used for transformation. The explants were either incubated in Pre Induction Medium (PIM) for 30 minutes with *A. tumefaciens* suspension containing gene cassettes (OD 600: 0.3-1.0) or applied with pre-induced *Agrobacterium* suspension (OD 600: 0.3-1.0) of 5 & 10 µl to the cut side of the cotyledonary and hypocotyl explants followed by co-cultivation for 48hr at 23°C in dark. The co-cultivated explants were

transferred to MS medium supplemented with 2, 4-D (0.1mg/l) and kinetin (0.5mg/l), and containing antibiotics carbencillin (400 mg/l) and kanamycin (25 mg/l). Transformed callus produced from the cutting edges of the individual explants are being sub-cultured at 3-4 weeks intervals. Sub-cultures are being continued in hormone free medium to induce somatic embryos from the cells of putative transformants.

Plate 3.4.1: Somatic embryos and transformants of Coker 312 with CICR : Cry2Ab1Ac gene. a. Callus and Globular structure callus transformed; b. Globular and Heart shaped callus; c. Regeneration of transformed callus.

Response of Plant specific G. arboreum LIM: Plant specific LIM groups on comparison with animal Cysteine Rich proteins are larger in size of proteins with single LIM domain, with or without UIMs (GaDA-1/DAR) and with domain of unknown function. Four members were identified under this group comprising three GaDA1 members and one GaDAR member. Pairwise aminoacid similarity among the members varied from 51.7 to 85.6 %. Response of plant specific *LIM* genes expression in response to challenge of *F. oxysporum* following root dip inoculation method was quantified at different time interval using quantitative RT-PCR. The GaDA1-2 showed significant induction in its expression in response to the challenge of *F.oxysporum*. Contrary to this, GaDAR1 though showed induction response in early hours of treatment, there was drastic reduction of transcript level after 24 hours of treatment (Fig. 3.4.1).

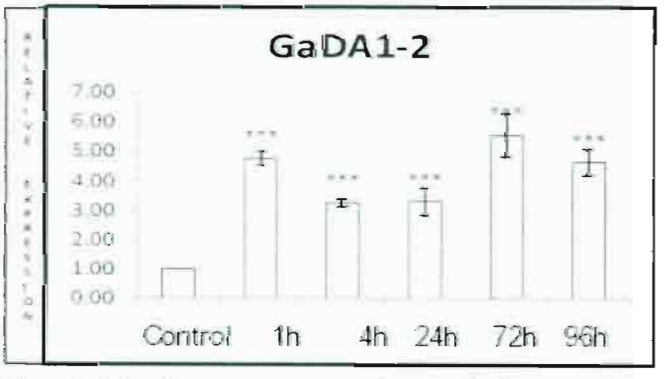
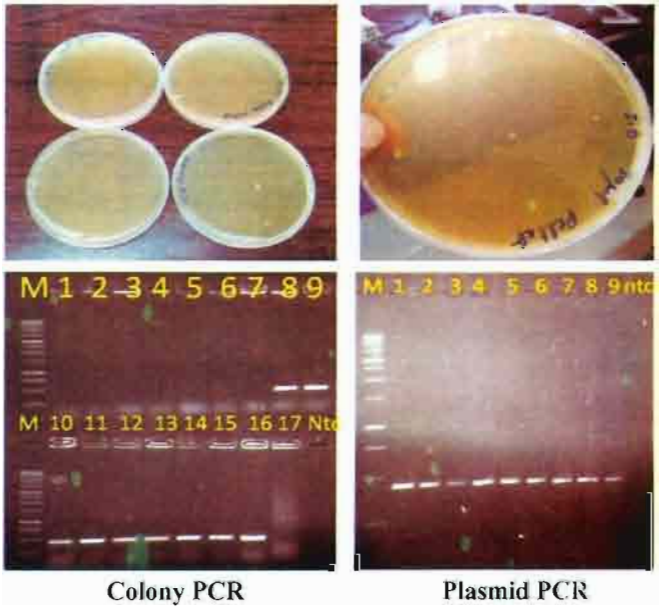


Fig. 3.4.1: Relative expression of GaDA1-1 in response to challenge of *F. oxysporum*

Construction of CRISPR/Cas9 gene targeting vector/s for the targeted mutagenesis of *GhPHYA1*

Escherichia coli DH 5α chemical competent cells were prepared. Restriction and Ligations was performed for the construction of sgRNA*GhPHYA1*::CRISPR/Cas9 gene targeting vector construct. Ligation products were mobilised into competent cells through heat shock method of bacterial transformation. Putative recombinant colonies were analysed for the presence of sgRNA*GhPHYA1*::CRISPR/Cas9 gene targeting vector construct through colony PCR as well as plasmid PCR.

Bacterial transformation and putative transformed colonies



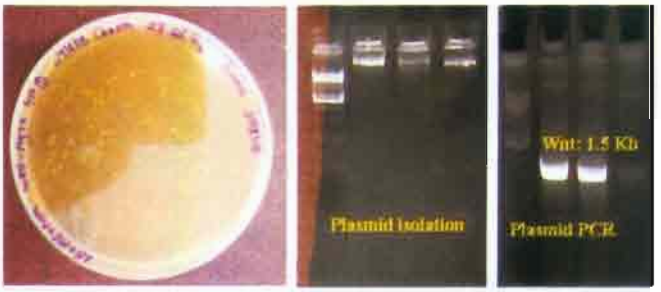
Colony PCR **Plasmid PCR**

Plate 3.4.2 Bacterial transformation and confirmation of sgRNA*GhPHYA1*:: CRISPR/Cas9 gene targeting vector construct

***Transformation of cotton using* pBI121::Wnt 3A gene construct**

The recombinant plasmid pBI121::Wnt present in *E. coli* has been isolated and reconfirmed for its purity through

restriction digestion and PCR. The isolated recombinant plasmid has been mobilised into EHA105 strain of *Agrobacterium tumefaciens* competent cells through freeze thaw method of bacterial transformation.



Putative recombinant colonies were confirmed through plasmid PCR before proceeding with cotton transformation. Transformation of cotton hypocotyls and callus cultures were performed by using recombinant EHA105 with pBI121::Wnt 3A gene construct. Callus cultures are in induction stage which shall be forwarded through sub culturing for molecular analysis and somatic embryogenesis.

Plate 3.4.3 *Agrobacterium* mobilization of pBI121::Wnt 3A gene construct

Plate 3.4.4 Process of *Agrobacterium* mediated cotton hypocotyl transformarion and callus induction

***In planta* transformation using cotton shoot tips**

Shoot apex mediated transformation was also performed in three batches; out of around 60 plantlets 8 plants survived and are in developmental stages. Seeds from these plants will be screened for the presence of transgene and, if found positive, they will be advanced and Wnt mediated somatic embryogenesis will be evaluated.

Plate 3.4.5 Process of *In planta* transformation using cotton shoot tips and plant development

Development of consensus genetic linkage map of *Gossypium*

Field trial of all the five RIL mapping populations (one population of CICR and 4 provided by participating centers; two interspecific populations of *G. arboreum* x *G.herbaceum*, two intra-*hirsutum* populations and one interspecific *G. hirsutum* x *G. barbadense* population) in two replications were evaluated for morphological, yield and fibre quality traits at CICR Nagpur. Genomic DNA of RIL mapping population i.e. KWAN-3 x JAYADHAR, developed by ICAR-CICR was isolated and supplied to NBRI, Lucknow for SNP genotyping.

Introgression of Non-deregulated Bt events into elite cotton genotypes

Event Tg2E13 (*Cry*1Ac gene)

In order to introgress the Tg2E13 event (cry1Ac gene) sourced from Delhi University into elite cotton genotypes, backcross population (BC_1F_1) of three crosses *viz.*, Suraj × Coker 310 (Tg2E13), NH 615 × Coker 310 (Tg2E13) and CISH 3178 × Coker 310 (Tg2E13) were raised at contained facility of ICAR-CICR, Nagpur along with the recipient genotypes (Suraj, NH615 and CISH 3178) in seedling trays. ELISA was conducted at 20-30DAS and non-Bt plants from the segregating backcross populations were removed. ELISA and event specific PCR was conducted again at 60 DAS to identify event (Tg2E13) positive plants having high toxin expression which were further used in backcrossing with their respective recipient genotypes. Rapid generation advancement was achieved through embryo culture technique wherein 30-40 days old crossed bolls were explored to produce BC_4F_1 populations. The BC_4F_1 populations of the three crosses were tested for transgene expression through ELISA and non-Bt plants from individual backcross populations were removed. The identified high toxin expressing plants in each of the BC_4F_1 populations were selfed to produce BC_4F_2 populations for their further evaluation and stabilization (Table 3.4.1). As a part of standardization of zygosity for Tg2E13 event, left border flanking sequence of Tg2E13 was sourced from cotton genome database and the PCR product comprising genomic flanking region of an event on D_9 chromosome and *nos* promoter region of gene cassette

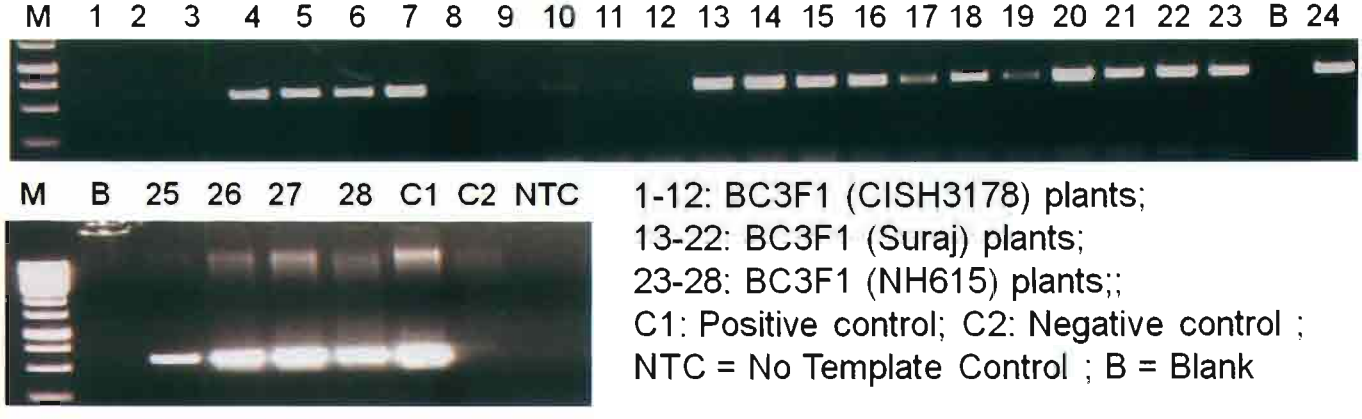


Plate 3.4.6 : Event (Tg2E13) confirmation of high Bt toxin expressing BC3F1 plants using event specific PCR.

Table 3.4.1 Establishment of BC_4F_1 plants of three back cross population through embryo culture

Backcross (BC_4F_1)	Number of BC_4F_1 plants	Cry1Ac/ELISA Positive Plants
Suraj × Coker310 (Tg2E13)	145	49
NH615 × Coker310 (Tg2E13)	138	80
CISH3178 × Coker310 (Tg2E13)	140	84

UASD Event No. 78

Molecular and Biochemical analysis of the event UASD 78 by gene specific primers and ELISA

The Institute received seeds and seed cotton (*Kapas*) of UASD Bt cotton event No 78 from University of Agricultural Sciences, Dharwad. Twenty three Bt-plants could be established on which biochemical and molecular analysis was carried out through ELISA and PCR. Twenty plants were found positive for both ELISA and PCR. Cry toxin expression ranged from 0.5 ppm to 7.0 ppm at 45 days after sowing (DAS) and 0.3 to 5.0 ppm at 100 DAS.

	No of plants analysed	Number of positive plants	Number of negative plants
PCR	23	20	3
ELISA	23	20	3
Cry1Ac Expression range	0.5-7.0 ppm (45 days) 0.3 to 5.0 ppm (100 days)		

Controls: Coker 310, PKV081 Bt (BG I) and Ajeeth 155 (BG II)

✓PCR protocol standardized for the amplification of UASD 78 event by gene specific primers.

✓PCR and ELISA has been performed

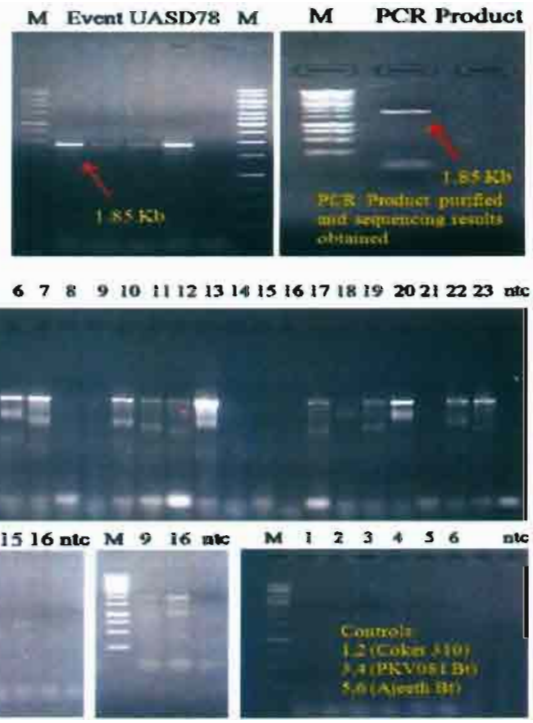
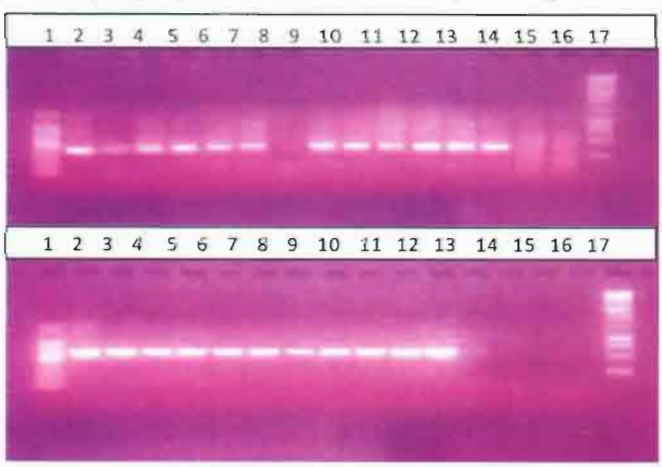


Plate 3.4.7: ***Screening of UASD Event 78 Bt positive plants by ELISA and PCR Event CH12***

Molecular confirmation of the CH 12 backcrossing progenies for Cry2AX1 gene.

During 2018-19, BC_2 crosses attempted after identification of *Cry*2AX1 positive plants from segregating BC1 plants of crosses namely Suraj, NH 615 and CISH 3178. The presence of gene was confirmed by using *Cry*2AX1 primer and Actin primer. Crossed BC_2 seeds were collected for further advancement and crossing with recurrent parents.

Plate 3.4.8.: Electrophoresis of the PCR products of CH 12 progeny lines for Actin and *Cry2AX1* gene



Legends: Well No. 1:100 bps Ladder, 2: 21B1, 3:31 A2, 4:28A1, 5:43D, 6:42 D2, 7:42 B, 8:49A2, 9:63 E2, 10:62 A, 11:Positive control D2 seed DNA, 12:Positive control D2 seed DNA, 13: Negative control NBT Suraj, 14:Negative control NBT Suraj, 15: No template control, 16:No template control, 17:1 Kb Ladder

Development of Bt genotypes using deregulated event (MON 531)

At Nagpur, nucleus seed production of the five released Bt varieties (ICAR-CICR Bt 1, ICAR-CICR Bt 2, ICAR-CICR Bt 3, ICAR-CICR Bt 6 & ICAR-CICR Bt 12) was taken up in one acre each and 4 q fuzzy seed was produced. The nucleus seed production plots were tested for presence of Bt using Elisa kit and individual plants checked for morphological features such as petal and pollen colour and maintained through selfing. Four hundred Bt positive plants from individual plots were also tested for homozygosity of *Cry*1Ac gene and 97.56 - 99.89 % plants were found positive.

Nine Bt genotypes were sponsored for testing in AICRP Bt first year trial while 11 genotypes were under second year of testing. Out of three Bt entries tested in north zone under first year trial, CICR 17 Bt has been promoted for testing in advance trial, it recorded seed cotton yield of 27.70 q/ha UHML of 26.0 mm, fibre strength of 30.0 g/tex (HVI mode), moderately resistant to CLCuD with mean *Helicoverpa armigera* larval mortality of 89.9.%. The Bt check PAU Bt1 (Bt ZC) recorded seed cotton yield of 24.80 q/ha and local non Bt check recorded SCY of 25.50 q/ha. In advance Bt trial, six Bt entries were sponsored for testing in north zone of which, CICR 861 Bt ranked 6th and CICR 38 Bt ranked 8th

with a SCY of 21.60 and 19.4 q/ha respectively compared to Bt check PAU Bt 1 which recorded SCY of 18.30 q/ha i.e. these two genotypes showed 18 and 6 per cent increase respectively over the check for SCY. CICR 861 Bt also recorded good fibre quality with UHML of 24.8 mm, fibre strength of 30.5 g/tex, resistant to CLCuD with 79.6% mean *Helicoverpa armigera* larval mortality and mean *Cry*1Ac expression of 1.70 ppm.

Development of early maturing, compact, jassid tolerant Bt cotton (*G. hirsutum*) varieties:

Promising progenies (76 F_5, 54 F_6 and 56 F_5) and 51 single plant selections were evaluated for early maturity, compact plant architecture and jassid tolerance apart from yield and fibre quality traits. ELISA was conducted among 27 most promising progenies to identify the Bt positive plants. Bt positive and non-Bt progenies and single plant selections have been separately advanced through selfing. Five entries which are early in maturity (120-140 days), compact in plant architecture and jassid tolerant were sponsored for testing under AICCIP during 2018-19. One of the sponsored entry, CICR Bt 183059-5 yielded an average of 3037 kg/ha seed cotton (Fig. 3.4.2) under the high density planting (60×15cm spacing) in the trial conducted at ICAR-CICR, Nagpur. New entries which have early maturity (130-150 days), jassid tolerance, compact plant architecture along with better fibre quality (more than 26mm length and 26 g/tex strength) were identified for sponsoring to AICCIP for testing during 2019-20.

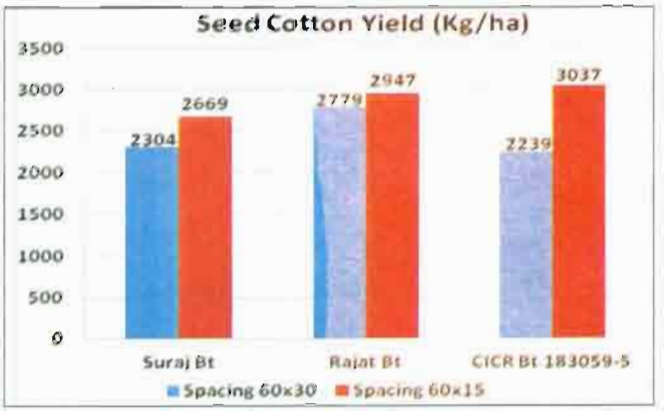


Fig. 3.4.2: Assessment of yield superiority of early maturing, compact, jassid tolerant Bt cotton entries under HDPS

At Sirsa, two Bt varieties CICRS 20Bt and CICRS 21Bt sponsored in AICRP trial for 2nd year testing were found to be promising. Three Bt varieties of *hirsutum* cotton were sponsored in Initial Evaluation Varietal Trial of North zone (Table 3.4.2). Two varieties CICRS 25Bt and CICRS 26Bt were promoted for 2nd year of AICRP trial for multi-locations Testing.

Following crosses were raised in F2 during 2018-19 and CLCD free plants were selected from BHIYANI-251 x CSH-27, BHIYANI-251 x CSH-46, BHIYANI-251 x CSH-538, MR-786 x CSH-27, MR-786 x CSH-46 and MR-786 x CSH-538.The presence of Bt event will be tested in the ensuing season.

Table 3.4.2 Performance of Bt *hirsutum* varieties in North Zone

Name of the variety	Seed Cotton Yield (q/ha)	Upper Half Mean Length (mm)	Tenacity (g/tex)	Mean Cry 1Ac (ppm)	Mean % of Mortality	CLCuD Reaction
Initial Evaluation Trial (IET)						
CICRS Bt 23	28.40	26.2	29.4	2.41	78.0	R
CICRS Bt 28	25.80	25.5	29.4	2.13	85.8	R
CICRS Bt 27	24.60	27.7	30.8	1.27	89.4	R
Local Check Non Bt	25.50	27.1	29.5	0.00	20.3	R
PAU Bt 1 (Bt ZC)	24.80	28.0	30.4	2.34	88.1	R
F 2228 (Non Bt ZC)	22.90	27.5	29.1	0.02	18.2	MR
Advance Varietal Trial (AET)						
CICRS 21 Bt	26.60	26.6	26.9	1.26	92.1	MR
CICRS 20 Bt	22.40	26.5	30.3	1.82	90.2	MR
F 2228 (Non Bt ZC)	21.20	28.2	28.7	0.00	20.7	MR
PAU Bt 1 (ZC)	18.30	28.5	29.2	2.28	85.6	R
Local Check Non Bt	26.20	27.7	31.0	0.00	20.6	MR

3.5: Seed production and quality improvement

During the year, a total of 311.518 q quality seeds of Cotton, Red Gram and Wheat was produced at ICAR-CICR, Nagpur and its Regional Stations, Sirsa and Coimbatore.

At ICAR-CICR Nagpur, TFL seeds of Bt cotton varieties (ICAR-CICR Bt 1, ICAR-CICR Bt 2, ICAR-CICR Bt 3, ICAR-CICR Bt 6 & ICAR-CICR Bt 12), breeder seeds of non Bt varieties (Suraj, LRA-5166, LRK 516 and Surabhi, Roja, Suvin, parents of *G. arboreum* hybrid CICR-2, CISA310, CISA 614, CSH 3075, CSH 2931) as well as stock seeds of 61 varieties were produced (Table 3.5.1).

Table 3.5.1: Seed production undertaken during 2018-19

Crop	Location	Variety	Stage	Seed Yield (Qtl)
Cotton	ICAR-CICR, Nagpur	**Non Bt Varieties** - Suraj, LRA-5166, LRK 516, Surabhi, Roja, Suvin, parents of CICR-2 hybrid, CISA310, 614, CSH3075, 2931	BS	11.00
		Bt Varieties - ICAR-CICR Bt 1, Bt2, Bt3, Bt 6, Bt12(5)	TFL	34.10
		Stock seed -61 varieties+ *G. arboreum cernuum* variants	TFL	0.318
	Farmers Participatory	Non Bt Suraj, NH 615 & Phule Dhanwantari	TFL	6.90
Other Crops				
Wheat		PBW-550	CS	250
Red gram		BSMR-736	CS	9.2

Under Farmer Participatory mode, 6.9 q TFL seeds of non Bt cotton varieties including Suraj, NH 615 and Phule Dhanwantari were produced. Certified Seed of Wheat cv. PBW 550 and Red Gram cv. BSMR-736 was also taken up and a total of 259.20q seeds were produced for State Seed Corporations of Haryana and Maharashtra.

Revenue generated in Revolving Fund under ICAR Seed Project was Rs 11.10 lakhs through the sale of the seeds or it's by products.

Plate 3.5.1 A. Visit of Central zone monitoring team and Join Inspection team visit to Seed production plots

B. Field inspection of Certified seed plot of red gram

Seed quality improvement

Eight foliar spray treatments (given at 45 DAS, 60 DAS and 80 DAS) were tested in a seed production plot of Suraj. The treatments comprised of micronutrient mixture (Zinc, Copper, Iron, Manganese, Magnesium, Molybdenum, Boron), a new Organic formulation (Agri Friend Win-Ea-Crop), Cow Urine, Neem Kernel extract, Salicylic acid, recommended practice (NAA 10 ppm, Urea 2% and KNO3 2%), Water control and untreated control. Foliar spray of micronuntrient mixture followed by recommended package of practice and neem kernel extract were highly promising in obtaining high seed yield (Table 3.5.2). Inspite of low seed cotton yield, the final delinted seed yield was high for recommended package of practice.

Table 3.5.2: Foliar interventions to enhance seed yield in cotton variety: Suraj

Name of the foliar treatment	SCY (Kg/Plot)	Lint yield (Kg)	Final seed yield (Delinted) (Kg)
Micronutrient mixture (RP1)	3.07 [a]	1.12 [a]	1.10 [a]
New Organic formulation	2.89 [abc]	1.08 [ab]	0.83 [b]
Recommended practice	2.62 [bc]	0.96 [c]	1.07 [a]
Cow urine	2.91 [ab]	1.07 [ab]	0.98 [ab]
Neem kernel	3.03 [a]	1.12 [a]	1.06 [a]
Salicyclic acid	2.77 [abc]	1.03 [abc]	0.84 [b]
Untreated control	2.58 [c]	0.97 [bc]	0.82 [b]
CD (0.05)	0.31	0.11	0.17

Under NSP, an experiment to validate the validity periods of certified seeds of field crops was conducted at Regional Station, Coimbatore. Seeds produced at CICR, Regional Station during 2016-17 and 2017-18 for cotton variety, Surabhi and Suraj has been utilized. Seeds of 2017-18 were kept as fresh seed lot, whereas seeds of 2016-17 stored under ambient condition were assumed as revalidated seed lot. The seed quality evaluation was conducted at bimonthly intervals from July 2018 to January 2019. Evaluation of seed quality was done for field emergence (%), speed of emergence, seedling length (cm), vigour Index I & II, dry matter accumulation of seedling and final plant stand establishment at 45th day after sowing in a miniature plot.

The initial germination was higher in the fresh lots of two varieties when compared to revalidated lots. Between varieties, Suraj recorded higher germination % over Surabhi. The storage period influenced the germination and other seedling parameters in a decreasing trend in both the varieties fresh seed lots with of both varieties showed superior germination compared to revalidated seed lots. The speed of emergence, field emergence % and vigor index were also higher in fresh seed lots of both varieties.

Another experiment on seed priming was conducted on two cotton varieties Surabhi and LRA 5166, with two seed lots of 2016-17 and 2017-18 and seventeen (17) treatments. In both varieties, fresh seeds showed superiority compared to revalidated lots. The promising treatments which showed significantly higher germination were KH_2PO_4 (85), *Trichoderma viride* (84), *Pseudomonas fluorescens* (84), BioNPK (84), drought alleviating Bacteria + BioNPK (82) over the control (76). The above treatments also showed superior performance in root length, shoot length, vigour index I and II and dry matter production over the control. These were superior in the field study too.

Storability studies of cotton seed

At ICAR-CICR Nagpur, seed different packaging materials were evaluated for better storability at quarterly intervals. Genotypic differences were observed for Suraj (*G. hirsutum*) and *Phule Dhanwantari* (*G. arboreum*) when stored for 24 months. Suraj maintained initial seed viability (81%) compared to *Phule Dhanwantari* which showed only 76% germination from its initial 85% viability at the end of 24 months storage. Seeds stored in polylined aluminium bag followed by sealed polybags maintained germination indicating them to be better packaging material as compared to brown paper and orange paper packet when stored under cold conditions. Seeds of both Suraj and *Phule Dhanwantari* stored under vacuum containers and kept in refrigeration condition maintained the initial seed viability (85%) and showed lowest EC values (0.3 $\mu Scm^{-1}g^{-1}$) as compared to those kept under non-vacuum conditions and stored in refrigerated as well as ambient condition. Similarly, seeds packed in airtight acrylic box along with zeolite beads and stored at 30% RH and stored at 5°C temperature maintained the initial seed viability (83%) as compared to those kept without zeolite beads and stored in cold as well as ambient conditions.

DUS Testing

Under the programme of Implementation of PVP Legislation, 2001 funded by Protection of Plant Varieties and Farmers' Rights Authority, New Delhi, Govt. of India, four trials were laid out at ICAR-CICR, Nagpur for DUS Testing. Different trials comprising of varying number of genotypes were conducted i.e. five under New/First Year Trial, one genotype under Varieties of Common Knowledge, 4 under Second Year Trial and 15 genotypes under reference varieties trial. Maintenance

of 35 varieties of *G. hirsutum*, 22 varieties of *G. arboreum*, one variety of *G. herbaceum* was undertaken. During the course of study, it was observed that longer peduncle length and distinct boll tip were expressed as unique traits in few of tested genotypes.

Plate 3.5.2 (A) Distinctly longer peduncle length (B) Distinct boll tip

At ICAR-CICR, Regional station, Coimbatore, a nodal centre for implementation of PVP legislation 2001, seed multiplication, characterization and maintenance breeding of 155 extant cotton varieties were carried out. Reference varieties maintained included 108 in *G. hirsutum*, 36 of *G. arboreum*, *4 of G.herbaceum and 7 of G.barbadense*. There were 2 new candidate varieties in the second year testing trial, 4 in first year trial and 2 varieties of common knowledge.

Trials at both the centres were conducted as per test guidelines of tetraploid and diploid cottons in randomized block design with 3 replications. Germination count at 12 DAS in corresponding field was recorded in all the entries and morphological characters were recorded from seedling to fiber. The data received from participating centers were compiled and submitted to PPV&FRA for issue of registration certificate.

State Multi Varietal Trial (SMVT) at ICAR-CICR, Nagpur

A State Multi-location Varietal Trial (SMVT) of *G.arboreum* consisting of 18 + 3 (control varieties) genotypes and of *G. hirsutum* consisting of 19+ 3 (control varieties) genotypes with three replications following recommended package of practices was conducted at ICAR-CICR, Nagpur during 2018-19. The crop suffered on account of terminal stress at boll development stage because of monsoon withdrawal from mid September onwards.

In *G. arboreum*, seed cotton yield ranged from 1099.2 to 2875.8 kg/ha. The highest seed cotton yield was obtained with CNA2033 (2875.8 kg/ha) followed by JLA 1313 (2840.8 Kg/ha). The control variety PA08 recorded an yield of 2439 Kg/ha which is quite higher than the genotypes under evaluation as well as other two check varieties namely AKA 7 (1099.2 kg/ha) and AKA 8 (2194.7 ka/ha).

In *G. hirsutum*, the seed cotton yield ranged from 1195.3 to 4067.8 kg/ha and the highest was obtained with NH635 (4067.8 kg/ha) followed by NH 678 (3293.2 kg/ha). A control variety, Rajat, recorded highest seed cotton yield of 3112.2 kg/ha.

Testing of entries of *G hirsutum and G. arboreum* in Institute Common Trial

Based on the Institute Common Trial, *G. hirsutum*, entries CNH09-11, CNH 17393, CNDTS 283 and CNH 2077 were identified for sponsoring for Br 02 (b) AICRP trial 2019-20. In case of *G. arboreum*, entries CNA 2035, CNA 1034, CNA2037 and CNA 2036 were identified for sponsoring for Br 22 (a/b) AICRP trial 2019-20.

Testing of entries in ICAR-AICRP on Cotton

Table 3.5.3 ICAR-AICRP entries (Non GM) sponsored in National Trials (2018-19)

Name of the trial	Entries sponsored
National Trials	
Br 02 (a)	CSH 1721, CSH 3012
Br 02 (b)	CNH 2052, CNH 1131, CNH 2073, CNH 09/11, CNH 09/73, CNH 16300
Br 06 (a)	CSH 3158, CSH 3622
Br 06 (b)	CNH 09-45, CNH 1129, CNH 2039, CNH 6170, CNH 09-11, CNH 41-09, CNH 1130
Br 12 (a)	CCB 26, CCB 28
Br 22 (a/b)	CISA 90, CNA 2023, CNA 1036, CNA 1040, CNA 16383
Br 22 (a/b) LL (*G. arboreum*)	CISA-10, CISA 33-8, CNA 1064, CNA 1065, CNA 1066
Br 22 (a/b) CC (*G. arboreum*)	CNA 1091, CNA 17522
Br 25 (a/b)	CISAA 18-1, CISAA 18-2

Table 3.5.4 ICAR-AICRP Entries (Non GM) promoted, retained for evaluation in Coordinated trials (2018-19)

Name of the trial	Entries promoted	Entries retained
NORTH ZONE TRIAL		
Br 25 (a/b)	CISAA 17-1, CISAA 17-2	
Br 06 (a)	-	CSH 31292
Br 24 (a)	CISAA 33-3	-
Br 24 (a)	CISA 6-2	-
CENTRAL ZONE TRIAL		
Br 03 (b)	CNH 11-11, CNH 09-70	-
Br 06 (b)	CNH09-9	CNH09-4
Br 13 (a) PVT *G. barbadense*	CCB 51-2, CCB 64, CCB 129, CCB 143-B	-
Br 14 (a) CVT *G. barbadense*	CCB 51	-
Br-24 b CVT – *G. arboreum*	CNA 2031, CNA 1054, CNA 1058	CNA 1031, CNA 1032
Br-24 b CVT -LL– *G. arboreum*	CNA1037, CNA1034	-
Br25 (b)	CISAA 17-2	-
SOUTH ZONE TRIAL		
Br-03 a	-	CCH 16-1
Br-06a	CSH 1613	CSH 31292, CCH 16-5
Br 13 a	CCB 143 B, CCB 64, CCB 129,CCB 51-2	CCB 29, CCB 51
Br-03b	CNH09-70	-
Br06 b	CNH 1128	CNH 09-62
Br-24 b: CVT – *G. arboreum*	CNA 1054, CNA 1058	CNA 1031
Br-24 bLL: CVT – *G. arboreum*	CNA1037, CNA 1033	-
Coloured Cotton Trial *G. hirsutum*	16315 LB	-
	16301 DB	-
	16337 LB	-
Coloured Cotton Trial *G. arboreum*	CNA 407SLP, 16378 LB-A	-
	CNA 405, CNA 407, 16377 LB-A	-
Entries tested under Agronomy trial		
Central zone		
G. hirsutum, Variety, Irrigated	CCH 15-1	
G. *arboreum*, Variety, Rainfed	CSA 1028	
South zone		
G. hirsutum, Variety, Irrigated	CCH 15-1	

Entries sponsored in AICRP Bt varietal trial (2018-19)

Name of entry	Seed Cotton Yield (kg/ha)	GOT (%)	UHML (mm)	Tenacity (g/tex)	Micron aire	Uniformity Index
South Zone (Irrigated)						
CICR25Bt	1848	35.8	25.6	25.9	4.3	82.4
CICR 26Bt	1717	33.2	29.3	28.0	3.9	84.0
CICR 24 Bt	1598	33.8	28.4	29.6	4.0	84.8
Suraj (C)	1716	35.3	30.9	31.1	4.1	85.8

Name of entry	Seed Cotton Yield (kg/ha)	GOT (%)	UHML (mm)	Tenacity (g/tex)	Micron aire	Uniformity Index
Central Zone (Irrigated)						
CICR 22 Bt	981	32.9	27.4	29.4	3.8	82.5
CICR 20 Bt	1099	36.4	25.5	27.7	4.2	81.5
CICR 21 Bt	1240	36.6	24.9	24.4	4.3	80.0
Suraj Bt (C)	1130	34.7	26.0	26.7	4.5	82.0
Central Zone (Rainfed)						
CICR 20Bt	1136	37.5	26.3	25.6	4.5	81.8
183059-5 Bt	784	37.2	26.1	25.8	4.7	81.8
183059-3 Bt	673	37.7	24.3	24.9	5.2	80.5
CICR 21 Bt	1059	36.9	25.7	26.4	4.0	81.1
CICR 22 Bt	1229	35.0	25.8	26.1	4.3	80.6
183059-4 Bt	620	37.4	26.1	25.3	4.2	81.5
Suraj Bt (C)	1090	35.1	25.8	24.9	4.3	80.9
North Zone						
CICR 17 Bt	2770	33.9	26.0	30.0	4.4	82.2
CICR 18 Bt	1960	35.9	25.8	28.0	4.3	81.8
CICR 183059-1 Bt	1370	34.0	26.1	28.6	4.5	81.6
CICR 19 Bt	470	38.4	22.2	25.7	5.3	79.2
CICRS 23 Bt	2840	33.9	26.2	29.4	5.0	82.0
CICRS 28 Bt	2460	34.0	27.7	30.8	4.3	82.8
CICRS 27 Bt	2580	32.4	25.5	29.4	5.0	81.8
PAU Bt (C)	2480	39.3	28.0	30.4	4.2	83.6

ICAR-CICR Bt cotton entries retained in AICRP Bt Varietal trial

Zone	Entries retained
South Zone (Irrigated)	CICR 25 Bt, CICR 26 Bt
South Zone (Rainfed)	CICR 25 Bt , CICR 24 Bt
Central Zone (Irrigated)	CICR 20 Bt, CICR 21 Bt
Central Zone (Rainfed)	CICR 20 Bt, CICR 22 Bt
North Zone	CICR 17 Bt

Release proposals of six of ICAR-CICR Bt varieties namely CICR 16 Bt, CICR 81 Bt and CICR 2017 Bt. identified for Central Zone Irrigated as well as Rainfed.

3.6: Enhancing Resource Use Efficiency through climate smart agro-techniques

3.6.1.Exploring productivity potential of long-linted *G. arboreum* cotton

Desi cotton (*G. arboreum*) is re-emerging as a potential alternative to obtain sustainable yields during the era of climatic uncertainties. However, non-availability of long staple *G. arboreum*, with comparable fibre properties of their hirsutum counterparts is an impediment in popularizing them. This project was conceived to provide location specific long linted desi cotton tailored with an agronomic package to maximize the cotton productivity and climate proof the cotton growers.

Nagpur:

Seven *G. arboreum* genotypes (6 long linted - DLSA 17, PA 528, PA 402, PA 812, PA 760, CNA 1041 and short stapled Phule Dhanwantary were evaluated under rainfed conditions at 2 spacings (60x10-HDPS and 60x 30 cm-normal) on a shallow Inceptisol (Typic Haplustept) and a deep Vertisol (Typic Haplustert) on two sowing dates - June 21 and July 5, 2018. The results are summarized below-

- Averaged across spacing, soil types and sowing dates - PA 528 (3532 kg/ha) and CNA 1041 (3579 kg/ha) were more productive than the rest. Across soil types, spacings and genotypes a delay in sowing by 2 weeks reduced the mean seed cotton yield by 600kg. Averaged across genotypes; sowing dates and soil types the yield gain due to HDPS was 275 kg/ha. The yield of Ajeet BGII was 2400 kg/ha and 1621 kg/ha on the Inceptisol under normal and delayed sowing, respectively. The corresponding yield on Vertisol was

Name of entry	Seed Cotton Yield (kg/ha)	GOT (%)	UHML (mm)	Tenacity (g/tex)	Micron aire	Uniformity Index
Central Zone (Irrigated)						
CICR 22 Bt	981	32.9	27.4	29.4	3.8	82.5
CICR 20 Bt	1099	36.4	25.5	27.7	4.2	81.5
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PAU Bt (C)	2480	39.3	28.0	30.4	4.2	83.6

ICAR-CICR Bt cotton entries retained in AICRP Bt Varietal trial

Zone	Entries retained
South Zone (Irrigated)	CICR 25 Bt, CICR 26 Bt
South Zone (Rainfed)	CICR 25 Bt , CICR 24 Bt
Central Zone (Irrigated)	CICR 20 Bt, CICR 21 Bt
Central Zone (Rainfed)	CICR 20 Bt, CICR 22 Bt
North Zone	CICR 17 Bt

Release proposals of six of ICAR-CICR Bt varieties namely CICR 16 Bt, CICR 81 Bt and CICR 2017 Bt. identified for Central Zone Irrigated as well as Rainfed.

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- Averaged across spacing, soil types and sowing dates - PA 528 (3532 kg/ha) and CNA 1041 (3579 kg/ha) were more productive than the rest. Across soil types, spacings and genotypes a delay in sowing by 2 weeks reduced the mean seed cotton yield by 600kg. Averaged across genotypes; sowing dates and soil types the yield gain due to HDPS was 275 kg/ha. The yield of Ajeet BGII was 2400 kg/ha and 1621 kg/ha on the Inceptisol under normal and delayed sowing, respectively. The corresponding yield on Vertisol was

2696 and 2022 kg/ha. respectively.

- Due to better hydraulic conductivity, cotton sown on Inceptisols was more productive than that on Vertisols. Averaged over sowing dates, spacing and the genotypes yield gain in Inceptisol was 319 kg/ha.
- Averaged over spacing and genotypes, a delay in sowing by two weeks reduced seed cotton yield by 910 kg/ha in Inceptisol (depth limitation) but only by 173 kg/ha in the deep Vertisol indicating a significant interaction effect between sowing time and soil type **(Figure 3.6.1).**

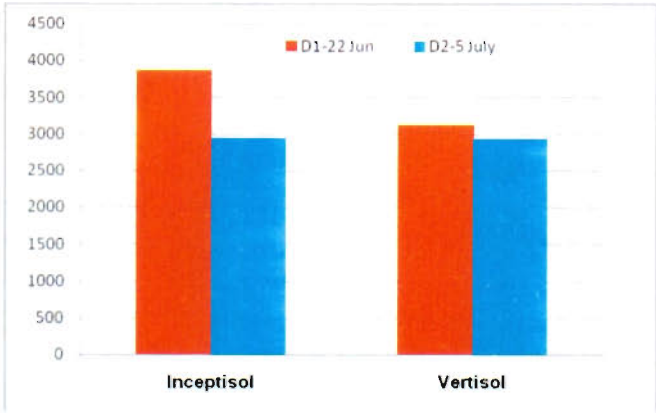


Fig.3.6.1: Influence of soil type on mean seed cotton yield (kg/ha) of *G arboreum* genotypes sown on two dates of sowing

- Expression analysis of two genes of ethylene biosynthesis pathway, coding for key enzymes ACCS (1-aminocyclopropane-1-carboxylic acid synthase) and ACCO (1-aminocyclopropane-1-carboxylic acid oxidase) was performed to correlate their expression with fibre length. The expression of *ACCS* was maximum in PA812, that had the longest fibre length followed by PA528, where as PA402 had minimum expression. There was also a significant difference for *ACCO* transcript level among the genotypes where PA812 showed maximum expression followed by PA760 and PA402 was observed to have minimum ACCO level among all.
- To establish a correlation between few already known genes involved in cell elongation (*Bonzai*, *Myb25* and *Pex1*) and ethylene expression, transcript level of these selected genes were measured at 0, 7 & 14 days post anthesis (DPA)in the ovules of PA812 and Phule Dhanwantary. At all stages, PA812 had more expression of all these genes compared to Phule Dhanwantary, a short stapled genotype. *Myb25* was found to be involved specifically in fibre elongation (7 DPA), whereas *Bonzai* and *Pex1* were more at fibre initiation stage (0 DPA).
- Two cultivars namely PA 255 and Phule Dhanwantary were planted in four row directions. In PA 255, there was no effect of different row direction on seed cotton yield whereas in Phule Dhanwantary, east-west direction of row orientation significantly improved yield over other row orientations. There was no significant effect of row direction planting on soil temperature recorded at forenoon and afternoon in both the varieties.
- Long-linted *G. arboreum* genotypes were evaluated at regular intervals for bacterial blight, grey mildew, root rot and leaf spot diseases. Root rot was negligible during initial stages; it appeared in severe form during September. Grey mildew disease was observed during August-September with severity ranging from 8.53 to 41.07%, and maximum severity in PA 402.
- Seed treatment in *G. arboreum* genotype PA-255 with mycorrizal biofertiliser grown in acrylic tubes showed higher root length and root dry weight compared to untreated plants.
- Foliar application of mepiquat chloride (MC) @500 ppm had significantly improved germination, length and vigour index of fuzzy seeds of cotton variety PA 255.
- Detopping, detopping+side shoot removal, side shoot removal and foliar application of MC significantly improved germination over control. The other quality traits remained non-significant in delinted seeds of cotton variety PA 255.

Coimbatore:

- Normal date of sowing of six long linted *G. arboreum* genotypes viz. DLSA 17, PA 760, PA 812, PA 402,PA 528, K12 along with a short staple genotype Phule Dhanwantary produced significantly higher seed cotton yield (2450 kg/ha) than late planted cotton to the tune of 680 kg/ha.
- Two contrasting genotypes (K 11 and DLSA 17) were planted under HDPS in three row directions, north-south, east – west and diagonal. Significant interaction effect was observed wherein diagonal sowing of K 11 registered significantly highest seed cotton yield (1720 kg/ha).

3.6.2 : Agronomic studies on ELS cotton

3.6.2.1 : Effect of sowing time and foliar nutrition

A field experiment was conducted at Coimbatore with three dates of sowings (9 July, 4 August & 29 August),

three foliar spraying of nutrients (N1: Recommended Dose of nutrients (RDN), N2. RDN+Foliar application of K_2SO_4 @1% at 75,100,125 DAS and N3.RDN+Foliar application of KNO_3@1% at 75,100,125 DAS) with two genotypes (Suvin, MRC 7918 BG II) to assess the effect of environment and foliar spraying of nutrient on seed cotton yield and quality parameters. Seed cotton yield was significantly influenced by dates of sowing, genotypes and foliar spraying of nutrients. Sowing on 4 August registered significantly higher seed cotton yield (19.1 q/ha) which was on par with 9 July (19.0) but was significantly higher than 29 August. (7.3 q/ha) sowing. The genotype, MRC 7918 BG II registered significantly higher yield (21.1 q/ha) than Suvin (9.1 q/ha). Amongst foliar spraying of nutrients. application of RDN with KNO_3 (1%) in 75,100,125 DAS registered significantly higher yield (17.1 q/ha). The interaction results revealed that planting of MRC 7918 BG II on 4 August and RDN + foliar application of KNO_3 (1%) in 75,100,125 DAS registered the highest yield of 23.8 q/ha.

The late sowing (29 August) registered the least 2.5% span length (34.5mm) and fibre strength (25.0 g/tex) and micronaire. The application of recommended nutrients with foliar spray of KNO_3 (1%) at 75, 100, 125 DAS observed significant improvement in micronaire in second (3.4) and third (3.0) picking and fibre strength in second (28.7 g/tex) and third picking (27.2 g/tex).

3.6.2.2 : Effect of edaphic factors on quality parameters

Soil properties of three soil series (Palladam, Irugur and Peelamedu) located at Vadaputhur village of Kinathukadavu, Coimbatore were correlated with quality parameters of ELS cotton with objective to find out influence of edaphic factors on quality parameters. Analysis indicated that 2.5% span length was significantly and positively influenced by soil productivity grades (r=0.839), and available potassium (r=0.699). Fibre strength (g) was significantly influenced by land capability class (r=0.884) and available potassium (0.928). Micronaire was positively significantly influenced by soil productivity grades (r=0.793)

3.6.2.3 : Relationship between Crop phenology with quality parameters

An experiment was conducted with *G. barbadense* genotypes (Suvin & CCB 29) with inter specific (MRC 7918 BG II, Ankur HB2210 BGII and RCH 625 BGII) and intra hirsutum hybrid (RCH 659 BGII) to find out the influence of duration of phenological phase on quality parameters at Coimbatore. The seed cotton yield of RCH659 BGII (Hx H) (28.4 q/ha) had out performed MRC 7918 BG II (26.84 q/ha), Suvin non Bt (11.4 q/ha), RCH 625 BG II (20.1q/ha), Ankur HB2210 BG II (19.58 q/ha) and CCB 29 non Bt (12.8 q/ha). The duration to first squaring, 50% flowering, and 50% boll were significantly and positively correlated with fibre 2.5% span length and strength.

3.6.3 : Improving the productivity of cotton on calcareous soils

3.6.3.1 : Secondary and micronutrient management under irrigated conditions

Highly calcareous soils have multiple nutrient deficiencies (N, P, K, S, Zn and Fe). Therefore, farmers apply high doses of sulphur containing P fertilizers in 2-3 splits. Chelated micronutrients applied to soil (2.5 kg ha^{-1}) and 1% foliar application along with biofertilizers consortia (N, P, K, Zn solubilisers) as seed treatment and split soil application of sulphur containing 125% RDF significantly outperformed 125% RDF and conventional micro and secondary nutrients (N, P, K, Mg, S, Fe, Zn) soil application. In highly calcareous Vertisols, sulphur and $ZnSO_4$ soil application (20 kg^{-1}) with two supplemental irrigations improved seed cotton yields by 15% and FUE and net returns by 24% compared to without S in Bt hybrid cotton + pigeon pea strip cropping system.

3.6.3.2 : Mitigating soil moisture and nutrient constraints under rainfed conditions

In order to improve the cotton yield and address the soil moisture and nutrient constraints on rainfed calcareous soils, on-station experiment was conducted with *G. hirsutum* var PKV081 and and BGII hybrid Ankur 3028. In Ankur BG II 3028, opening of ridges and furrows during first intercultural operation and strengthening them at 45 DAS improved soil moisture availability and produced 249 kg/ha more seed cotton than where no moisture conservation measures was adopted. The effect of fertilizer management practices, was non- significant for variety but it was significant for hybrid. In hybrid, compared to the application of RDF+limiting micronutrient, significantly higher seed cotton yield was obtained in the treatments **T12** (125% RDF alone), **T10** (Seed treatment with biofertilizers + 125% RDF (NPK)+ Mg,S (10,10kg ha^{-1})+Micronutrients (Fe,Mn,Zn,B) as per soil test+Opening of ridges & furrows after 1st interculture+Chelated micronutrients 0.5% (Foliar Spray) @ 45 DAS + Humic acid seed treatment + 0.5% Foliar Spray of Chelated micronutrients) and **T9** (Seed

treatment with biofertilizers + 125% RDF (NPK)+ Mg,S (10,10kg ha^{-1})+Micronutrients (Fe,Mn,Zn,B) as per soil test + Opening of ridges & furrows after 1st interculture + Humic acid seed treatment + Chelated micronutrients soil application 2 kg ha^{-1})

Ridges and furrows strengthened at 45DAS of cotton in black calcareous soil

3.6.3.3 : Performance of diploid cotton for rainfed calcareous soils

Seven desi cotton varieties (HD-123, HD-432, CISA-614, CISA-310, PA-255, Phule Dhanwantary, AKA-7) were tested in 60 x 30 cm spacing with seven different fertilizer treatments under shallow to medium deep black calcareous soil **(Table 3.6.1).**

Table 3.6.1: Seed cotton yield (kg/ha) of *desi* cotton varieties under different input management regimes on a rainfed black calcareous soil (2018-19)

	Control	RF only	(100%) +MN	(100%) +MN+RF	(100 +25 % Split) +RF	(125%) +MN+AM+ RF	(125%) +CMN +RF	Mean
HD-123	1046	1750	2018	2794	2887	2427	2301	2175
HD-432	1273	1723	2118	1890	2199	2265	1401	1838
CISA-614	1576	1730	2093	2882	3006	2605	2068	2280
CISA-310	2059	1817	2709	3497	3449	2908	2684	2732
PA-255	2324	2957	3044	4040	4735	4147	3728	3568
Phule Dhanwantary	2181	2318	3624	2427	2828	3495	3829	2957
AKA-7	2080	2304	3193	2364	2883	3107	3275	2744
Mean	1791	2086	2686	2842	3141	2993	2755	

CD 5% varieites and input management = 87.0

RF- Ridges & furrows, MN-Micronutrients Zn(125 kg/ha+B (5 kg/ha), AM- Animal Manure @ 2 t/ha in the root zone, CMN-Chelated micronutrient (Zn & B)

The varieties recommended for central zone (PA 255, Phule Dhanwantary and AKA 7) significantly out yielded the varieties recommended for the north zone (HD 123, HD 432, CISA 614 and CISA 310). Averaged over varieties among input management practices, soil moisture conservation through ridges and furrows gave an additional yield of 295 kg/ha over control. Compared to the application of 100% RDF + limiting micronutients alone, the application of 25% higher fertilizer dose along with animal manure @ 2 t/ha and soil moisture conservation through ridge and furrows resulted in an additional yield of 307 kg/ha.

3.6.4: Validation of inputs for Bt hybrid cotton + pigeon pea stripcropping on marginal soils

Performance of NPK solubilisers as a seed treatment alongwith 75% recommended dose of fertilizers (RDF) was at par with 100% RDF i.e. 90:45:45 kg ha^{-1} N: P_2O_5 and K_2O in shallow, stony and marginal soils at Nagpur.

- Seed treatment with *Sagarika* (a sea weed extract based metabolic bio enhancer) alone produced 5% more seed cotton yield over 100% RDF. *Sagarika* granules (25 kg ha^{-1}) application alongwith 100% RDF improved yield by 8%. *Sagarka* contains 60 ppm GA and 40 ppm cytokinin which promotes root/ shoot proliferation, produces dark green foliage and delays senescence. It improved plant height, biomass and boll numbers by better apportioning of nutrients towards bolls.
- NPK solubilisers as seed treatment were effective in improving seed cotton yield. *Sagarika* seed treatment along with 75% RDF and foliar application of water soluble fertilizer produced 14% more seed cotton yield over seed treatment alone.

$ZnSO_4$ (20 kg ha^{-1}) soil application produced 16% more seed cotton yield over control. *Sagarika* and foliar application of (2%) water soluble fertilizer had positive effect only when soils were fertilized with at least 90%

RDF. Soil application of $ZnSO_4$ (12 kg ha^{-1}) under two supplemental irrigations and *Sagarika* granules + foliar application of *Sagarika* once (2ml L^{-1}) water at vegetative stage improved seed cotton yield by 3.0 q ha^{-1} in medium deep soils at recommended fertilizer levels. Soil application of conventional fertilizers @ RDF 120:60:60 $N:P_2O_5:K_2O$ and fertigation with additional 40% RDF of water soluble fertilizers (NPK,. NP, NK) along with chelated micronutrients 5 kg ha^{-1}, Mg SO 20 kg ha^{-1} produced 35 and 55 q ha^{-1} seed cotton yields in red soil and calcareous *vertisols respectively*.

3.6.5 : Quantitative estimation of carbon and moisture fluxes over the cotton based agro-ecosystem

- Cotton crop growth and crop performance were monitored in 11 fields in the fetch area of flux tower over ICAR-CICR farm, Nagpur. Temporal data on LAI and chlorophyll index and yield variations across fields were documented. Across different fields, the LAI ranged from 1.70 to 3.46 during the peak flowering period and from 1.22 to 1.65 during boll opening period. The values for chlorophyll index ranged from 1.22 to 1.65 during the peak flowering stage. Seed cotton yield ranged from 576 to 3301 kg/ha.
- Flux tower data for radiation and surface energy balance, hourly air temperature, soil moisture and rainfall, carbon flux were collected at 30 minutes interval and analyzed. Seasonal account of carbon flux components viz. Gross Primary Productivity, Ecosystem Respiration (R_{eco}) and Net Ecosystem Exchange (NEE) were calculated for different phenophases and for the whole season **(Fig.3.6.2)**. It was observed that during the entire crop season, the NEE was negative and the values ranged from -0.95 during last picking to -2.99 during the period between first open boll to first picking.

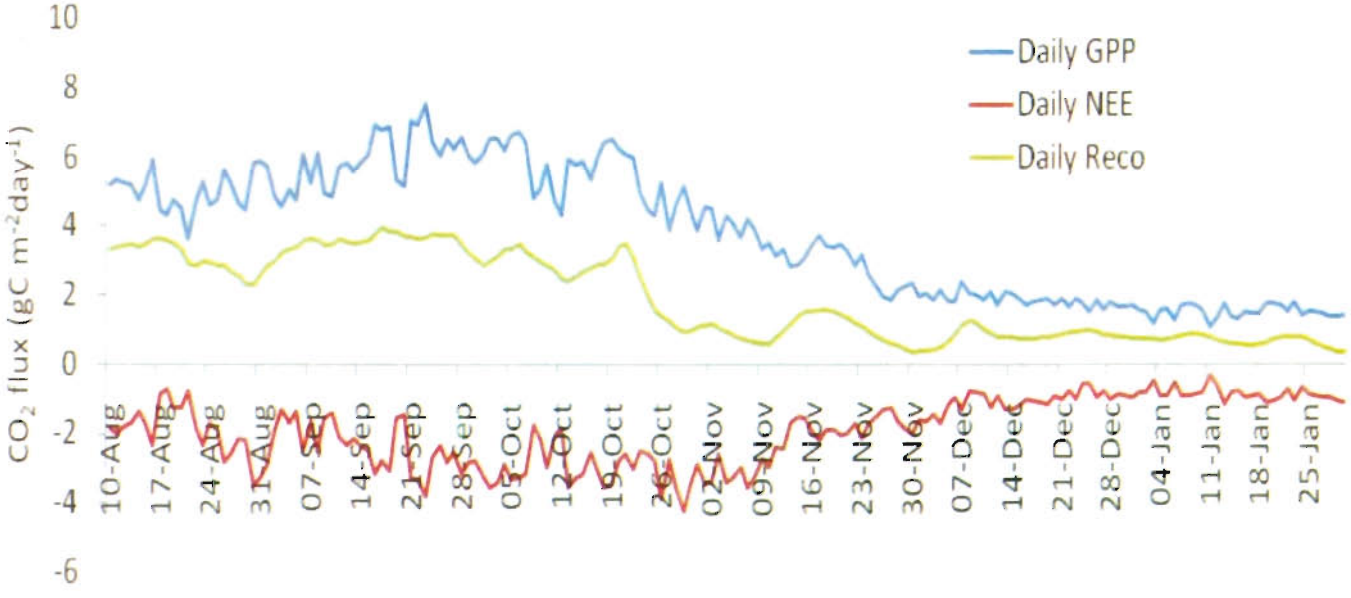
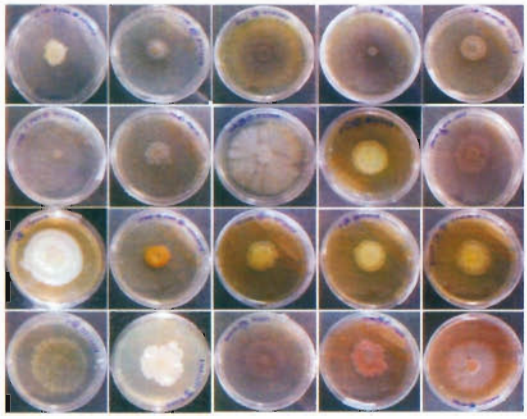


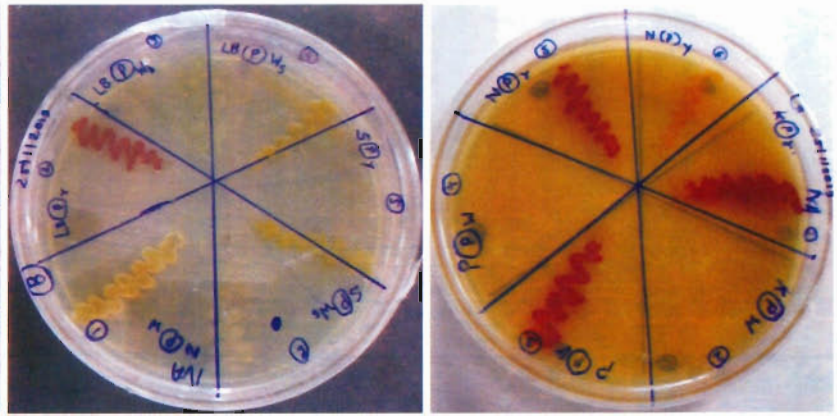
Fig.3.6.2: Seasonal account of the carbon fluxes (NEE, GPP, R_{eco}) over cotton ecosystem

3.6.6: Microbial biofilm formulations for cotton

One hundered and seventy bacterial strains were isolated from cotton rhizosphere and from *Helicoverpa*, *Pectinophora* and *Spodoptera* using soil baiting technique. The bacterial isolates were purified and submitted for identification (16 S rRNA sequencing). To short list bacterial partners for biofilm development, these bacterial isolates were tested for their biocontrol potential against the major cotton pests (*Helicoverpa*, *Pectinophora* and *Spodoptera*) through insect bioassays (two sets of experiments with 24 larvae/treatment in three replicates). The maximum mortality recorded were 77%, 96% and 85%, respectively *for Helicoverpa*, *Pectinophora* and *Spodoptera*. Presently the microbial isolates are being tested against major cotton pathogens (*Fusarium*, *Rhizoctonia*, *Xanthomonas*, *Macrophomina*, *Corynespora*, *Sclerotium*, *Colletotrichum*). The shortlisted bacterial partners will be used for development of biofilm with proven fungal partner *Trichoderma*, *Metarhizium*, *Beauveria*, *Paecilomyces*).



Native bacterial strains isolated from cotton rhizosphere



Bacterial strains isolated from *Helicoverpa*, *Pectinophora* and *Spodoptera*

3.6.7: Response of hybrid Bt-cotton to Smartchem Technologies Limited (STL) Complex CNS Fertilizer

A field trial was conducted to study the response of hybrid Bt-cotton to the STL complex CNS fertilizer under rainfed conditions with six treatments and four replications. The results indicated no significant difference among fertilizer practices and CNS grade fertilizers (Complex CNS grade-STL practise recommendation) and RDF 100:50:50 kg NPK ha^{-1}, However, CNS grade fertilizers and RDF produced significantly higher yield than the farmers practice.

Field view of complex fertilizer

3.6.8: Evaluation of Nutrient Expert Fertilizer Decision Support System of IPNI

Nutrient Expert Fertilizer Decision Support System for hybrid cotton was evaluated alongwith other nutrient management options. viz., CICR-recommended fertilizer dose (RDF), soil test crop response (STCR) and farmer fertilizer practice (FP). Differences were observed (0-120DAS) among the treatments in all the morphological parameters. Variations in the extent of deficiency was greater in farmers fertilizer practice. Leaf reddening was also observed in farmers fertilizer practice. Nutrient Expert system improved SCY of on-station (3240 kg ha^{-1}) trial than farmers fertilizer practice (2376 kg ha^{-1}). The average seed cotton yield with Nutrient Expert was 3051 kg ha compared to 2097 kg ha^{-1} with farmers fertilizer practice.

Evaluation of nano-formulated micronutrients

3.6.9 : Evaluation of structured water for cotton production

A field experiment was conducted at Coimbatore to find out the efficacy of structured water irrigation through drip. Structured water and bore well water treatments were allotted to main plot and scientific scheduling of irrigation at 0.4, 0.6, 0.8 and 1.0 ETC with conventional irritation were allocated to sub plot. The cropping season received a very high rain fall of 452 mm and the effective rainfall worked out to be 220mm. The total evaporative demand as recorded from class A open pan evaporimeter during the cropping period was 731.4 mm. The total water requirement at 1.0 ETc of Mallika BGII cotton for various growth stages were 158.3 mm (0-25 DAS), 262.7 mm (26-70 DAS), 282 mm (71-120 DAS) and 28.4 mm (121-125 DAS). The total water requirement for Mallika BG II cotton at 0.4,0.6,0.8,1.0 ETC and conventional irrigation were 381.5mm,

442.2mm, 502.8mm, 563.4mm and 947mm respectively. Saving of water due to drip ranged from 383 to 565mm (40-60 per cent) over conventional irrigation. The seed cotton yield due to structured water irrigation ranged from 2937 to 3613 kg/ha as compared to 2707 to 3336 kg/ha under bore well irrigation (Table 3.6.2.) Structured water irrigation recorded an average 2.7 q/ha additional seed cotton than bore well water irrigation but differences were not significant. Among the irrigation schedule, 0.6 ETC through drip was on par with 0.8 and 1.0 ETc through drip and significantly superior to 0.4 ETc through drip and conventional irrigation, The water use efficiency due to structured water irrigation ranged from 32.8-76.9 kg/ha cm as against 29.6 – 70.9 kg/ha cm under bore well irrigation.

Table 3.6.2.: Seed cotton yield (kg/ha) of Mallika BG II cotton as influenced by irrigation treatments

Irrigation Scheduling	Structured water	Bore well water	Mean
Drip at 1.0 ETc	3613	3336	**3474**
Drip at 0.8 ETc	3440	3104	**3272**
Drip at 0.6 ETc	3223	3009	**3116**
Drip at 0.4 ETc	2937	2707	2822
Conventional Irrigation	3104	2812	2958
Mean	3263	2994	

CD 5% - Irrigation scheduling: 421*, Structured vs borewell water: NS, Interaction: NS

3.6.10: Evaluation of nano-formulated micronutrients foliar spray for yield maximization in different cotton genotypes

To evaluate the effectiveness of different dosages of best performed commercially available nanofertilizers like Nualgi and Nanomol with or without surfactant on cotton, field experiments were carried out during 2016-17 and 2018-19 at ICAR-CICR (RS), Coimbatore. Results indicated that application of normal recommended dose (100 %) of Nualgi with surfactant and Nanomol without surfactant showed significant improvement in nitrate reductase activity, reducing sugar content and seed cotton yield.

Field experiments were also carried out 2016-17 & 2018-19 at Coimbatore to study the interaction effect of best metal oxide nano-particles of zinc, iron, copper and magnesium along with organic fertilizer (seaweed liquid fertilizers). Among the single form of metal oxide nanoparticles like Zn, Mg, Cu and Fe, the highest average seed cotton yield was produced by foliar application of 100 ppm of ZnO nanoparticles (50 nm) (1662 kg/ha). Likewise, among the combined form metal oxide nanoparticles, foliar application of ZnO+MgO+CuO showed a significant increase in average seed cotton yield (1604 kg/ha) which was on par with ZnO+CuO (1523 kg/ha), ZnO+Fe_3O_4 (1535 kg/ha), ZnO+MgO+Fe_3O_4 (1513 kg/ha) and ZnO+MgO+CuO+Fe_3O_4 (1547 kg/ha) except ZnO + MgO (1334 kg/ha). The performance of inorganic form of metal oxide nanoparticles either single or combined were superior in increasing the seed cotton yield than combined sources of inorganic (metal oxide nanoparticles) and organic (seaweed liquid fertilizer) sources of fertilizers

3.7: Sustainable farming systems through conservation agriculture and precision techniques

3.7.1 : Alleviating soil compaction – a production constraint in cotton

Problems of soil compaction are increasingly being experienced due to excessive use of machinery but this leads to sub-soil compaction. Consequently, root and crop growth are adversely affected. Field studies were conducted to alleviate sub-soil compaction either by mechanical sub-soiling or using deep rooted crops as a rotation crop to cotton. Deep rooted rotation crops such as pigeonpea, radish, sesbania and sunnhemp effectively broke the hard pan. Among the rotation crops, seed cotton yield was the least (24.8 q/ha) with radish. Pigeonpea had significantly greater yield levels (35.3 q/ha) and was followed by sunnhemp and sesbania (28 to 29 q/ha) with similar yield levels. Random sub-soiling did not differ with the control plots. However, sub-soiling the planting row resulted in significantly greater yields than the control. Crop root growth was also adversely affected by the sub-soil compaction. Laboratory studies also clearly indicated a reduction in the rooting depth, root dry matter as well as the plant dry matter. Root length of the American cotton variety (Suraj) or the desi variety (AKA-8) and the BGII Bt hybrid (Ajeet 155) were not affected at normal soil bulk density. Increase in bulk density beyond 1.6 g/cc resulted in a drastic reduction in root length of the Bt hybrid but the varieties showed a decline beyond 1.7 g/cc. Comparing the desi variety and the BGII hybrid, plant growth of the desi cotton variety was not affected with increase in soil bulk density, but the reverse was the case with the BGII hybrid **(Fig.3.7.1).**

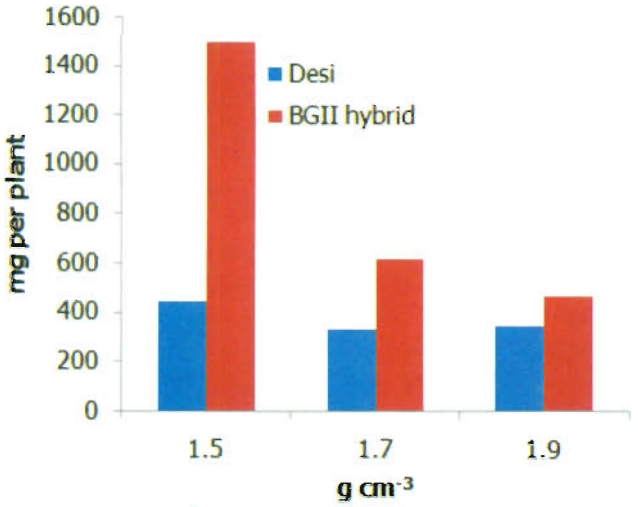


Fig. 3.7.1: Effect of increasing soil bulk density on the plant dry matter

3.7.2: Cotton based cropping systems under conservation agriculture

Coimbatore

Conservation agriculture based field experiments were conducted with cotton based cropping system from 2015 onwards for improving system productivity and soil quality under irrigated condition with Farmer's practice, [M_1], CA system with minimal land reshaping and partial (50% of residue from above ground biomass and 100% roots) residue recycling [M_2] and CA system with 100% residue recycling [M_3] as main plots and cropping systems viz., Cotton-Black gram-Maize (for grain purpose) [S_1], Cotton-Maize (for green cobs)+Pigeon pea (Strip cropping@4:2 ratio) [S_2], Cotton-Groundnut (for table purpose)+Pigeon pea (Strip cropping@8:2 ratio) [S_3], Cotton-Fallow (Control) [S_4] as sub plots. For CA treatments, beds and furrow system (60 x 30 cm) was used while for conventional system, ridges and furrows system for cotton and flat beds for other crops was used. The plots involving CA treatments are being maintained on permanent basis.

The results indicated that cotton-black gram - Maize (for grain purpose) is a potential candidate cropping system to implement conservation agricultural practices under irrigated conditions as it registered significantly higher Cotton Equivalent Yield (4247 kg ha^{-1}) than the conventional Cotton – Fallow system (CEY 1996 kg ha^{-1}) (Fig. 3.7.2). The results also indicated that beds and furrows system is suitable for raising cotton and other component crops under conservation agricultural practices viz., minimum tillage and residue recycling. CA system with 100% residue recycling registered significantly higher CEY of 3438 kg ha^{-1} than Farmer's practice (CEY of 3128 kg ha^{-1}).

Soil penetration resistance (Cone index) was recorded using cone penetrometer. Pooled analysis of depth wise soil penetration resistance using MSTATC over three cropping sequences revealed that CA system with 100% residue recycling significantly reduced the soil penetration resistance upto 9" soil depth vis-à-vis Farmer's practice (Fig. 3.7.3).

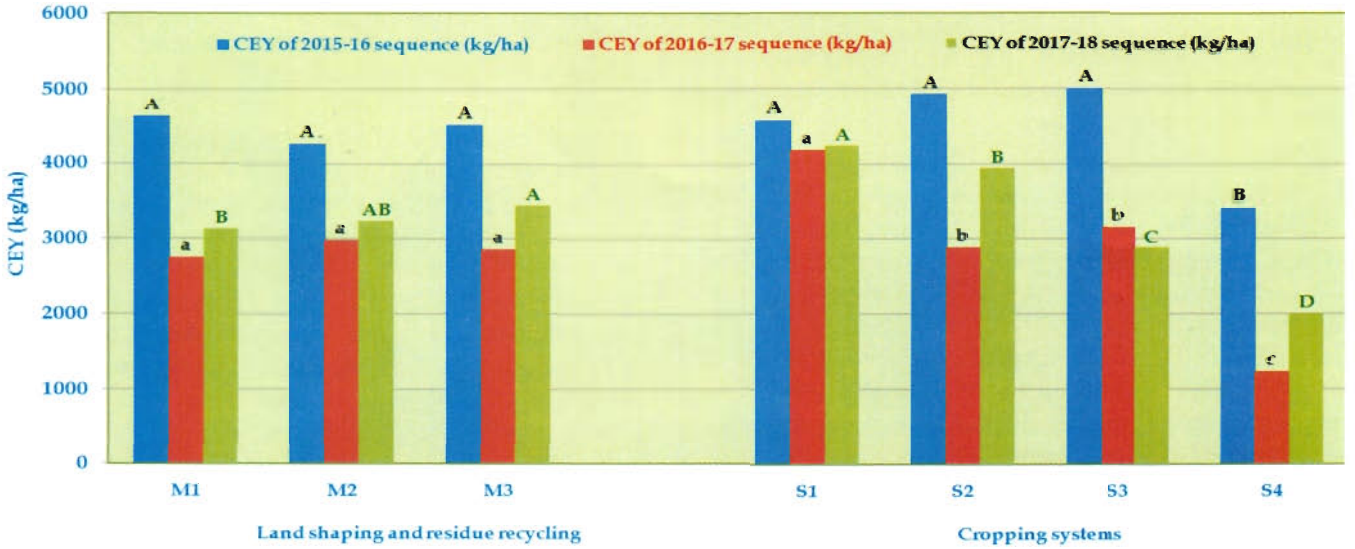


Fig 3.7.2: Cotton Equivalent Yield (CEY) of the system (kg CEY ha^{-1}) during 2015-16, 2016-17 and 2017-18 cropping sequences *(Different upper case, lower case and coloured alphabet indicate significant difference among treatments within the group; M1: Farmer's practice, M2: CA system with minimal land reshaping & partial residue recycling, M3: CA system with 100% residue recycling; S1: Cotton - Black gram - Maize (for grain purpose); S2: Cotton - Maize (for green cobs) + Pigeon pea (Strip cropping@ 4:2 ratio); S3: Cotton - Groundnut (for table purpose) + Pigeon pea (Strip cropping @ 8:2 ratio) and S4: Cotton - Fallow (Control))*

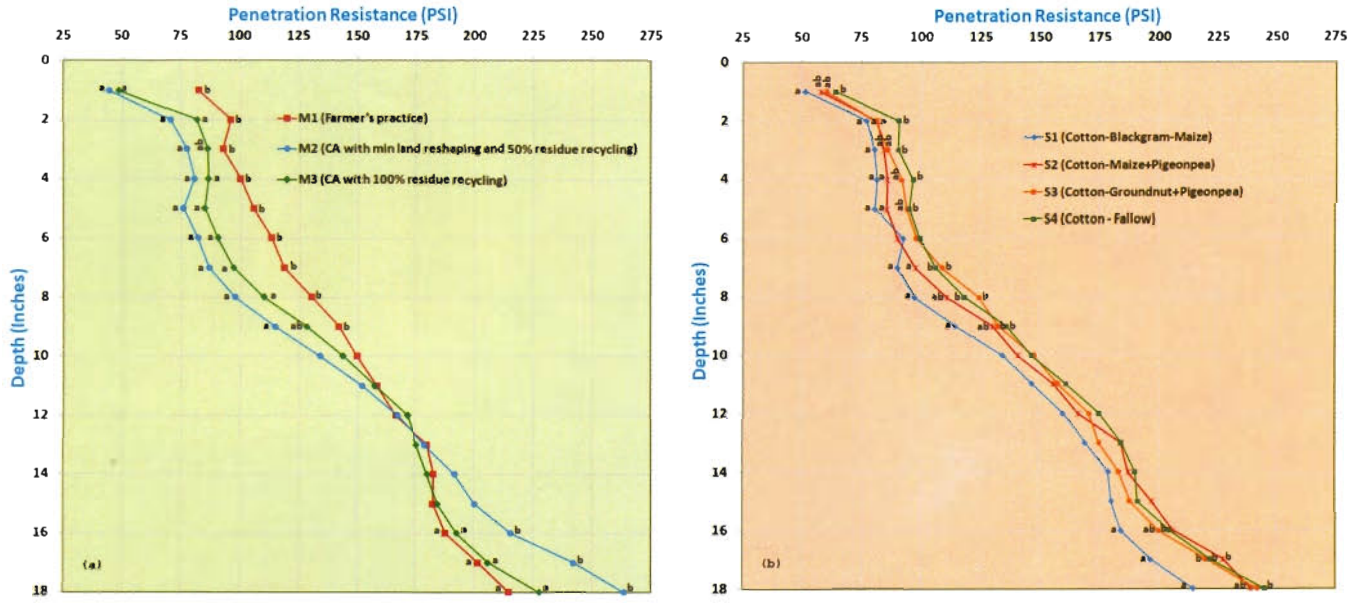


Fig 3.7.3:. **Soil Penetration Resistance (PSI) recorded at different soil depths (inches) in (a) different land shaping & residue recycling treatments and (b) cropping systems (Different lower case letter indicate significant difference among treatments within the group)**

Sirsa

- A new experiment with permanent / fixed lay out plan was initiated at experimental farm of ICAR-CICR, Regional Station, Sirsa, Haryana during the 2018-19 cropping season. The experiment was planned under split-plot design with six main plot treatments and cotton based cropping systems (seven numbers) involved as sub-plot treatments and three replications. As 2018-19 cropping season is the 1st year (starting year) of the experimentation, thus zero tillage / permanent narrow raised bed system as well as crop residue retention / incorporation of various crops during sowing of cotton crop could not be applied as the entire field was deep ploughed with mould board plough and then laser levelled before start of the experiment. Bt-cotton Hybrid RCH 776 (BG-II) was cultivated with recommended package of practices except the applied treatments. Non-significant differences among the tillage, land configuration and cropping systems were observed for othe plant growth parameters and yield.

3.7.3 : Efficient N fixing legumes based cotton production systems

3.7.1: Nagpur : Cotton + legume intercropping

Legumes (blackgram, clusterbean, cowpea, greengram, groundnut and soybean) of short, medium and long duration were sown as intercrop to reduce the input cost of N fertilizers under rainfed cotton *(G. hirsutum var Suraj* and *G. arboreum var Phule Dhanwantary)*. On deep black soil, cotton was raised under high density planting system (HDPS) with a spacing of 90 x 10 cm in randomized block design and intercropped with legume. Intercropping, irrespective of the duration of legume improved soil organic carbon and reduced soil pH and EC. After harvest of legume, in legumes rows, the soil N was comparatively high than cotton rows. However, due to shortage of moisture at 120 DAS the transport of this N was not evident . Sucking pest dynamics during the *kharif* season indicated that legumes were efficient component of integrated pest management. Under rainfed, short duration legumes had synergistic effect on seed cotton yield compared to medium and long duration legumes. For *G. hirsutum var Suraj,* better performing intercropping system is cotton + soybean (2718 kg ha^{-1}) and cotton

+blackgram (2652 kg ha^{-1}). For *G. arboreum var Phule Dhanwantary*, the identified intercropping system is cotton+greengram (2519 kg ha^{-1}) and cotton+cowpea (2429 kg ha^{-1}).

Coimbatore

3.7.4: Cotton + *Desmanthus* virgates alley cropping

Field experiment was conducted in randomized block design with four replications to find out the feasibility and sustainability of growing perennial legume, *Desmanthus virgatus* (DV) as alley cropping with cotton under graded levels of N (75 %, 100% and 125% RDN) at Coimbatore. Alley cropping with DV added 61.6 t/ha of fresh biomass in 32 months since 2016 which was 19.9 t on dry weight basis with the average nitrogen content of 3.15% that translates to 625 kg N/ha. Soil organic carbon status improved to 0.69% from 0.57% under sole cotton. The average leaf chlorophyll content across perennial legume treatments was 2.14 mg/g of leaf on 110 DAS as against 1.96 mg/g. of leaf under sole cotton. Alley cropping of DV with cotton resulted in significant yield enhancement of 2796 kg/ha **(Fig. 3.7.4)** as against sole cotton (1935 kg/ha at 100 % RDF). The seed cotton yield at 75% RDN with Desmanthus was 2265 kg/ha as compared to 2037 kg/ha recorded at 125% RDN under sole cotton (Fig.) Boll numbers /plant was significantly higher due to alley cropping of DV over sole cotton. The boll weight was also higher due to addition of pruned biomass of DV. The fiber quality index, integrating fiber length, strength and micronaire was higher (452) due to alley cropping of *Desmanthus* as compared to lower fibre quality index (409) recorded with sole cotton.

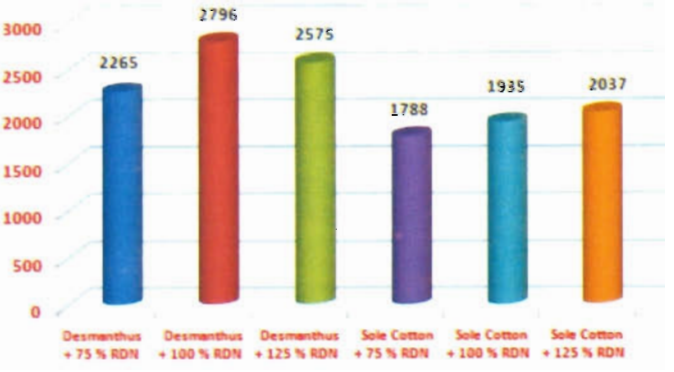


Fig. 3.7.4 : Seed cotton yields (kg/ha) as influenced by alley cropping of Desmanthus and graded levels of N

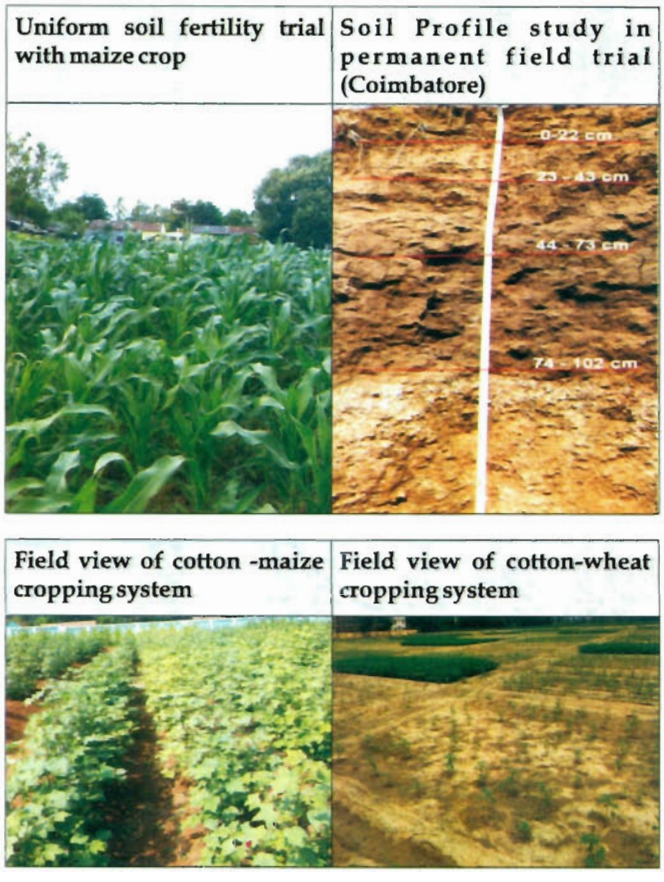
Healthy cotton with* alley cropping *of Desmanthus

3.7.4: Long term trial on cropping system

3.7.4.1: Coimbatore

Long term nutrient management project was initiated in 2018-19 in south zone with cotton – maize. Before cotton sowing, uniform soil fertility trial was carried out by sowing of maize to bring the same fertility status in the selected field. Soil profile of experimental field was studied. The depth of soil profile was >170 cm. Soil samples collected from each soil layer were analyzed for physico chemical and chemical properties which showed that available nutrients like nitrogen, phosphorus and potassium decreased but alkalinity increased with increased soil depth however (upto 102 cm), there were no change in electrical conductivity. At 103 – 135 cm soil depth, soil characters were varied due to the presence of Lime.

First year of the study indicated that application of NPK + secondary nutrients ($MgSO_4$) and micro nutrients ($ZnSO_4$ + Borax) + FYM (5 t/ha) once in two years significantly improved plant growth (plant height, root volume, shoot and root dry matter production) and seed cotton yield.



3.7.4.2: Sirsa

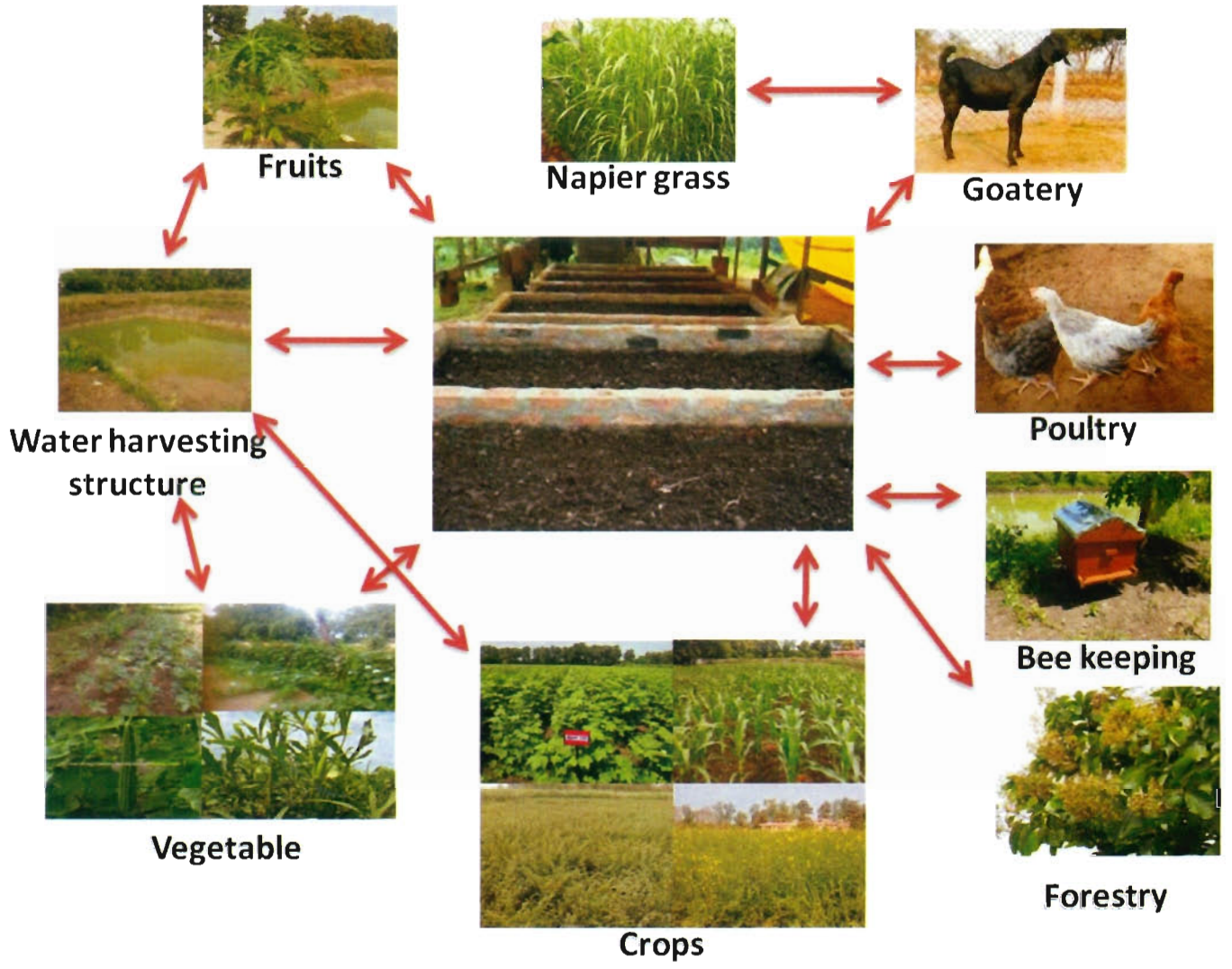
Long-term trial with five cropping systems (as main plot) and five sources of nutrients (as sub plot) was laid out at Sirsa. The yield attributes as well as seed cotton yield of Bt cotton hybrid was significantly superior over both Bt as well as non Bt cotton varieties, but was at par with non Bt cotton hybrid. Significantly higher values of plant height, yield attributes (except boll weight) and seed cotton yield were obtained with application of recommended dose of NPK along with $MgSO_4$ and micro nutrients $ZnSO_4$ and borax) than all other treatment combinations including absolute control.

3.7.5: Cotton based Integrated Farming System (IFS) model for Nagpur

Pigeon pea was planted as intercrop in cotton with 6:2 ratio in 0.4 ha area. Seed cotton yield was 21.0 q/ha and pigeonpea as intercrop yielded 3.76 q/ha. During *kharif* season, soybean and maize were sown in 0.4 ha area but due to wild boar and blue bull problem, no crop yield was obtained. Chickpea (2036 kg/ha), mustard (2026 kg/ha) and linseed (915 kg/ha) crop were cultivated during *rabi* season. A pond (of size 30m x 30m) was developed in the farm. Rain water was harvested in the pond and used for life saving irrigation during dry spell. In vegetables, 85 kg *bhindi* was harvested from 200 m^2 area and 40 kg brinjal harvested from 25 m^2 area on pond dyke. Bottle gourd and ridge gourd were planted on field fence. Seed cotton equivalent yield (SCEY) from 0.8 ha area was 1659 kg from crop and horticultural components. Data recording of goat (Usmanabadi) farming is in progress at KVK farm where four kids took birth during the year. Poultry (Giriraja) unit was taken to farmers' field and first batch of poultry gave farmer Rs 5092 net profit with 15 birds in four months. Second batch was given in February. Three honeybee colonies were established under beekeeping unit during September 2018. Data on number of foragers/2minute were recorded to make assure that colony was in active condition. Number of foragers/2minute ranged from 20 to 34 in all three colonies at different time period. Fruit plants (papaya, aonla, guava and ber) were planted on the pond dyke.

3.7.6: Field validation of Nitrogen Guru

A replicated pot culture experiment was set up taking ten different N concentrations (10-100 %). Split doses of N were provided using Hoagland solution. Nitrogen Guru was modified based on transmittance mode and the IR/LED. (IR: Infra red (940 nm); LED: Light Emitting Diode (650 nm)) ratios were recorded under varying N concentrations. To correlate, N content was estimated in the same leaves. An R^2 of 0.8 was observed between N content and IR/LED ratio (**Fig.3.7.1**).



Components in cotton based IFS model

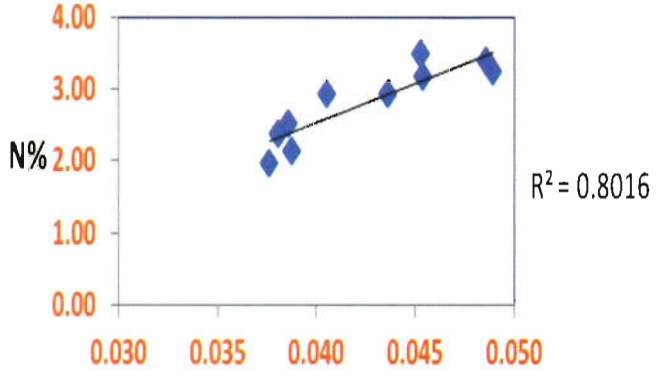


Fig. **3.7.1:** Correlation between nitrogen content of cotton leaf and IR/LED value of N Guru

3.7.7: Phenotyping of root system architecture in cotton (*Gossypium hirsutum* L.) for adaption to drought tolerance

Forty five cotton genotypes were evaluated for studying their root architecture in acrylic glass tubes. Cotton genotypes were grown in the tubes and water was with held for a week period after 20, 30, 40 DAS along with control up to 60 days. The mixture used for growing cotton seedling in acrylic tubes was sand, FYM and vermicompost in 2:1:1:1 (w/w) ratio. After 60 days of sowing, plant characters were recorded and best genotypes were identified based on root architecture (Table 3.7.1).

Table 3.7.1: Root /shoot characteristics of cotton accessions (60 day after sowing) grown in acrylic

Sr. No.	Root /shoot characteristics of cotton accessions (average of 12 plants)	
1	Highest root length	PKV 081 - 58.6 cm IC 359834 - 56.5 cm IC 359240 - 55.8 cm Nagpur 9 - 55.0 cm
2	Highest fresh shoot weight	Nagpur-9 - 16.8 gm IC 359834 – 15.49 gm PKV 081 - 14.58 gm
3	Highest fresh root weight	PKV 081 – 7.45 gm IC 359240 – 6.0 cm DTS 108-09 – 5.95 gm
4	Highest shoot dry weight	Nagpur 9 - 4.25 gm IC 359834 - 4.21 gm PKV-08 - 4.04 gm
5	Highest root dry weight	Nagpur 9 - 1.31 gm PKV 081 - 1.23 gm Suraj – 1.03 gm
6	Highest root/shoot dry weight ratio	LRA-ZFP, F 1226 and Suraj – 0.33 Nagpur 9 and PKV 081- 0.31 IC 377103 – 0.29
7	Highest root/shoot fresh weight ratio	4376 – 0.8 F 1226 and LRA-DREB/A – 0.7 LRA-ZFP and 4480 – 0.62
8	Highest root/shoot ratio on length basis	Nagpur 9 – 1.64 1993 – 1.63 LRA-ZFP and IC 359528 1.60

Root characters in different germplasm accessions at initial growth stage of *G.hirsutum*

3.7.8 : Evaluation of root traits in PVC pipes in rainout shelter.

Hundred *G.hirsutum* germplasm accessions were grown in PVC Pipes and evaluated. Accessions IC-356876, DTS-108-09, CNH-09-7 performed better under drought stress with efficient root traits such as root length, root dry weight and lateral root length than control **(Table 3.7.2).**

Root characters in different germplasm accessions at initial growth stage of *G.hirsutum*

Table 3.7.2: Mean Root/Shoot characteristics of cotton accessions (80 DAS) & 15 days drought treatment in PVC Pipes

S. No.	Cotton Accessions	Root /Shoot Characteristics
1.	Nagpur 9,1791, CNH09-7	highest tap root length in water deficit : 53.9 cm
2.	DTS-108-09, 1791,2678	highest shoot dry weight inwater deficit: 31.9 g
3.	DTS-108-09,1791	highest dry root weight in water deficit: 2.5 g
4.	DTS-108-09,1791, IC-356876	highest fresh root weight in water deficit: 8.2 g
5.	DTS-108-09, Nagpur 9, CNH09-7	highest root/shoot dryweight ratio water deficit 0.24 g

3.7.9: Metabolite Exploration of Drought stress in Cotton

A study was initiated to explore the existence of "Alarm Photosynthesis" pathway in cotton along with characterizing the effect of drought stress on metabolites at different stages of growth. All the four *Gossypium* spp. (*G. hirsutum*: DTS-44, DTS-155 and DTS-108 as drought tolerant & IC-357637, IC-359834 and IC-357055 as drought susceptible, *G. arboreum*: Phule Dhanwantary, *G. barbadense*: Suvin, *G. herbaceum*: G-Cot 25) were subjected to drought stress and samples were collected. As per temporal (day-night) expression analysis (qRT-PCR), the GLP1/oxalate oxidase expression was more in leaves during day time when compared with the leaf samples collected during night (Fig.3.7.2). Oxalate content, which is supposed to be broken down by oxalate oxidase (OxO), was more in stressed leaf samples collected during the night time as compared to the ones collected during day time, thus validating the day night variation observed for OxO expression and activity in respective samples. For its confirmation at protein level, *In-gel* activity assay of OxO was first standardized with positive control (purified OxO from barley seedlings) and then performed with leaf samples of cotton but could not show its presence in cotton samples so far. Further, to identify all the *GLP1* isoforms present in cotton, a genome-wide scan was performed and 37 such *GLP1* isoforms were identified for *G. arboreum*.

For identification of metabolites in cotton, three different protocols for GC-MS were used and standardized. A difference in relative abundance of various compounds such as, caryophyllene, squalene, bergamotene, fatty acids and their esterified forms, neophytadiene were observed for control and water stressed leaves of cotton

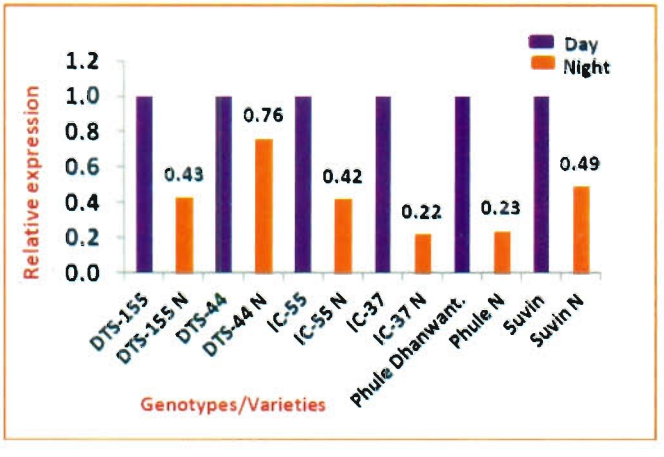


Fig:3.7.2: Day night variation in expression of *OxO/GLP1*

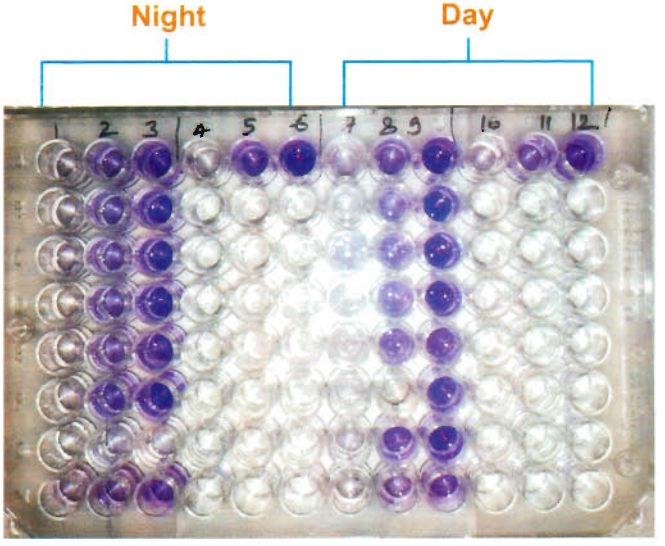


Fig:3.7.3: Oxalate content estimation in leaves of Cotton

3.7.10: Exploiting the epigenetic transgenerational inheritance of stress responsive traits for imparting abiotic stress tolerance to cotton

The epigenetic regulating chemicals (ERC) treated Suraj and LRA 5166 cotton plants were screened for drought tolerance in the second generation. The plants were subjected to drought stress during pin head stage of squaring by withholding irrigation for 10 days (**Fig 3.7.4:**). Control plants were maintained for each treatment. 5- Azacytidine (5-AZC) @ 10 µM and sulfamethazine (SMT) @ 10 µM treated plants recorded high relative water content of 86.1% and 84.7% respectively as against control (68.7%) under stress conditions in Suraj. In LRA 5166 sulfamethazine @ 10 µM and 5- Azacytidine @ 40 µM recorded high relative water content of 69.7% and 68.3% respectively under stress conditions as against control (51.5%). 5-Azacytidine @ 40 µM treated plants exhibited high proline content **(Fig. 3.7.4a)** under stress conditions as against control (LRA 5166). In case of Suraj, 5-Azacytidine 10 µM treated plants recorded high proline content **(Fig.3.7.4b)** under stress conditions as against control and also high epicuticular wax content **(Fig. 3.7.4c)** **(Fig. 3.7.4d)** under stress conditions as compared to the control. Sulfamethazine (10 µM) treated plants exhibited high peroxidase activity in both Suraj and LRA 5166. Thus ERCs like 5- Azacytidine and sulfamethazine improved drought tolerance by maintaining high water content in tissues, by conserving water through increased epicuticular wax content, by improving osmotyte production and by scavenging free radicals.

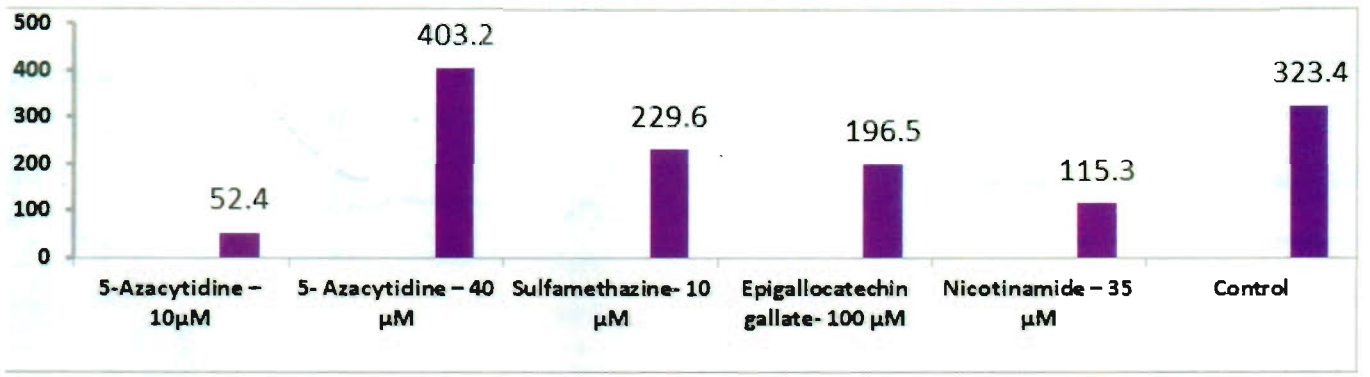


Fig3.7.4a. Effect of ERCs on proline content ug/g fresh weight of cotton leaves (var. LRA 5166) under stress conditions

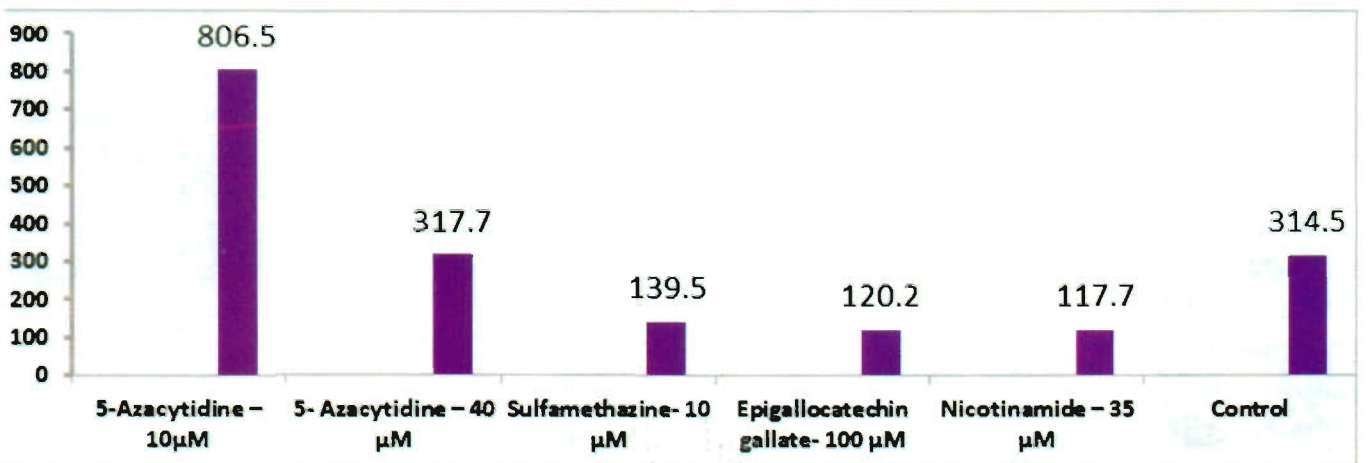


Fig 3.7.4b. Effect of ERCs on proline content ug/g fresh weight of cotton leaves (var. Suraj) under stress conditions

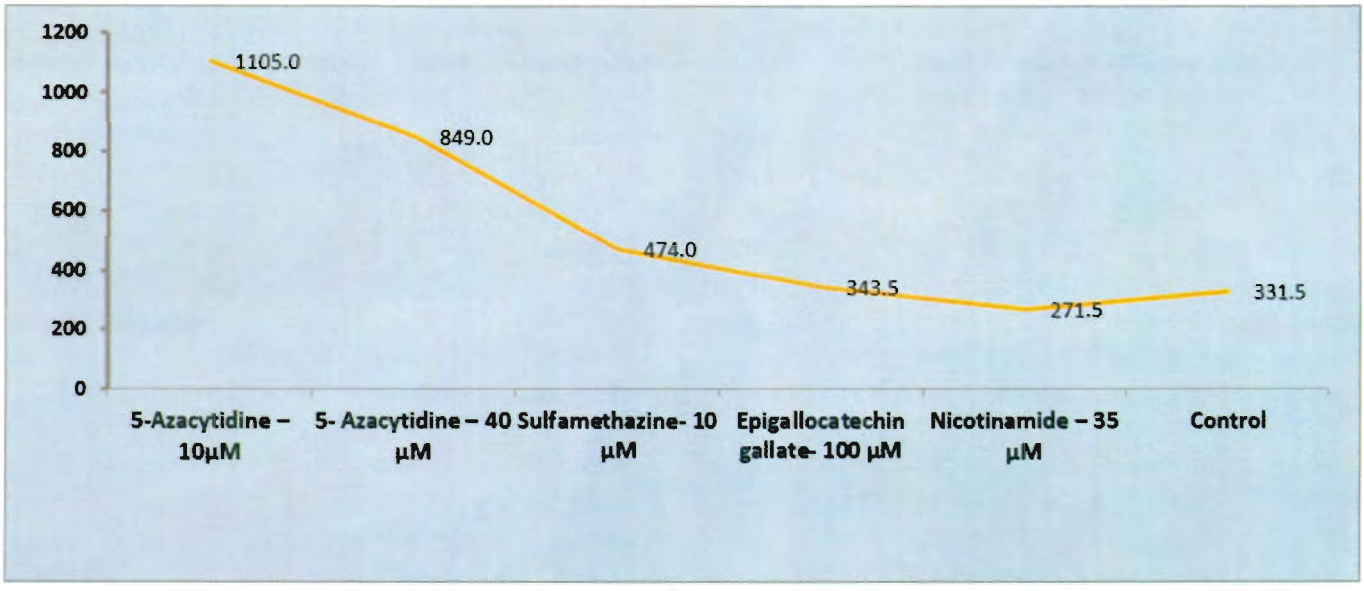


Fig 3.7.4c. Effect of ERCs on epicuticular wax content ug/g sq. cm of cotton leaves (var. LRA 5166) under stress conditions

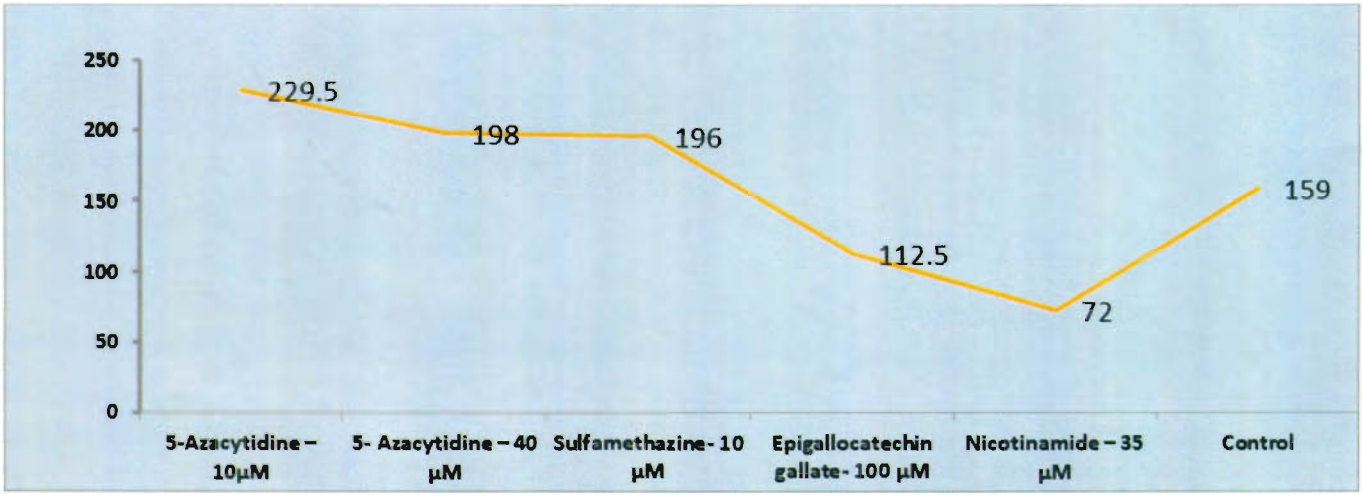


Fig 3.7.4d. Effect of ERCs on epicuticular wax content ug/ sq. cm of cotton leaves (var. Suraj) under stress conditions

3.8: Economics and extension research and e-communication tools

3.8.1: Dynamics of Cropping Pattern in cotton growing districts of Maharashtra

The cropping pattern of a particular area is largely determined by agro-climatic factors. Economic, technical as well as policy related factors can influence its dynamics.

The analysis of secondary data for the period 2000-02 to 2014-15 indicated that cotton area increased in 13 districts (Aurangabad, Beed, Jalna, Dhule, Jalgaon, Nanded, Ahmednagar, Nandurbar, Chandrapur, Parbhani, Wardha, Nagpur and Nashik). In five districts (Amravati, Akola, Washim, Buldhana and Yavatmal) a decrease in cotton area during the study period was recorded. Highest increase was observed in Aurangabad followed by Beed, Jalna and Dhule. Highest decrease in cotton area was observed in Amravati, followed by Akola, and Washim.

Cropping pattern in all the 18 cotton growing districts is highly diversified as indicated by the Simpson index of crop diversification. As the value

of Simpson index decreased in almost all the districts during the study period indicating a trend slowly changing towards specialization.

Markov Chain Analysis indicated that cotton area is most stable with an average retaining probability of 0.81 in all the cotton growing districts except Nashik. The analysis indicated that the cotton is gaining area from arhar, minor pulses, maize, urad and castor. Similarly whenever there is a decrease in cotton area it is losing to arhar, maize, soybean, moong and urid. The reasons for preference of cotton by the farmers over other crops include, stable and better price, stable yield, easy to market, less crop losses, better performance in drought conditions and guaranteed income

3.8.2: Impact analysis of shift in global cotton trade on Indian cotton scenario.

The decadal trends in area under cotton from 2007-2018 showed an increase of 17% to 25% of total cotton area in the South Zone (AP, Karnataka and Tamil Nadu). In the North zone though Haryana and Rajasthan showed an increasing trend this was offset by decrease in Punjab. In the Central zone a slight reduction to the tune of 6% was observed during the same period. Odisha registered an increasing trend over the years. While comparing the two periods between 2007-12 and 2012-18, the percentage increase in area was higher in all the zones during the first period when compared to the second period. In case of yield, Central zone showed an increasing trend, while a negative trend in North zone was seen for second period. South zone, a negative trend observed in both the periods though AP showed a positive trend during the second period. The scenario changed during 2012-2018 wherein most of the traditional cotton growing states showed negative trends. Indices were worked based on cost C2 (cost plus imputed value of rent plus interest on own land and capital) A2 VOP (value of product) from 2007-11 and 2011-16 based on CACP data. The results showed that the cotton farmers were able to make profits over cost C2 in almost all the four years with the ratio of 1.25 during the first period. But during the second period, farmers of Maharashtra, Odisha and AP could not reap profits during four years out of five. Whereas, cotton farmers of Rajasthan and Gujarat reaped profits in both the periods. In relation to cost A2 (actual paid out cost) the cotton farmers of all the states reaped profits from 2007-16 except Punjab which incurred loss during one year. Domestic production was found to be significant factor affecting the exports of raw cotton from India.

A unit increase in the domestic production would increase demand export of Indian cotton by about 6%. As the domestic production increases, the surplus cotton after meeting the domestic demand is exported. The export price of Indian cotton had negative impact on the export of cotton. The exchange rate showed negative impact on the exports of cotton from India but it is found to be non-significant. Decomposition analysis was done to find the sources of growth of average export value and variants of export value of Indian cotton. The results indicate that the contribution of change in mean export quantity of Indian cotton was the dominant source for the change in average export value to the tune of 75.80 % during the period 2007 to 2018. Effects of all components of change are to be judiciously taken care of to improve the export and reduce instability of cotton export.

The Nominal Protection Co-efficient (NPC) for cotton export to different destinations.

This technique explains the comparative advantage enjoyed by the commodity in the context of free trade. The estimated NPCs in general indicated that all the countries taken up for the study were found to be competitive for cotton export from India as NPC values are less than one. (Table 3.8.1.) China and Pakistan are highly competitive markets. Gravity model was estimated for 5 country pairs of major importing countries from 2012 to 2018.The explanatory variables included in the model explained 59% of the total variation in export value of Indian cotton. Most of the factors were significant. Distance variable was not a matter of concern for Indian cotton export.

Table 3.8.1 : Nominal protection Co-efficient (NPC) for cotton export for the year 2017

S.No.	Particulars	Unit	Bangladesh	China	Indonesia	Pakistan	Vietnam
1	Wholesale price (Mumbai)	Rs./q	5320	5320	5320	5320	5320
2	Marketing margin (5%)	Rs./q	266	266	266	266	266
3	Port clearing and handling charges	Rs./q	990	990	990	990	990
4	FOB Price	Rs./q	6576	6576	6576	6576	6576
5	Freight charge	Rs./q	690	780	810	670	880
6	Insurance at 2 % of price	Rs./q	106.4	106.4	106.4	106.4	106.4
7	Landed cost	Rs./q	7372.4	7462.4	7492.4	7352.4	7562.4
8	Exchange rate	1$ = Rs.	68.96	68.96	68.96	68.96	68.96
9	CIF price	US $/q	106.91	108.21	108.65	106.62	109.66
10	Reference price	US $ q	128	175	125	145	130
11	NPC		0.84	0.62	0.87	0.74	0.81

The changing pattern of raw cotton exports were estimated by obtaining the transitional probability matrices for the annual export data of raw cotton (in terms of volume) for the period 2007-08 to 2016-17. China was one of the stable importers of Indian cotton with high probability of retention of 91%.

The present study suggests that the sharp decline in the export of raw cotton from India reflects our inability to retain the share in the traditional markets and explore new markets. This call for appropriate policy measures and marketing efforts to sustain in these growing markets. We need to improve our export competitiveness by decreasing costs and improving yield and quality. Varietal development has to be given impetus to meet the international demand of quality cotton. Export promotion with stabilization should be thrusted upon. High dependence on few markets would be risky in the long run. So new markets are to be tapped to export our Indian cotton.

3.8.3 : e-Communication: dissemination of cotton production technology

ICAR-Central Institute for Cotton Research, Nagpur continued the efforts of e-Kapas in the form of e-Communication for dissemination of cotton production technology with the objectives to register new farmers for voice message services/delivery, to issue regular voice messages to 1.5 lakh farmers of Nagpur, Coimbatore and Sirsa, develop Cotton App, document success stories of e-Kapas beneficiary farmers. During the year 4972 new farmers with mobile numbers from Nagpur centre were registered. Uploaded 64,10,034 noise free and clear recorded voice messages i.e. 55,70,280 (Nagpur), 2,69,035 (Sirsa) and 5,70,519 (Coimbatore) in the form of automatic phone calls on 1,39,671 registered farmers mobile numbers. Out of that 15, 11,751 were received successfully (Nagpur 12, 69,716, Sirsa 68,090 & Coimbatore 1,73,945)

Mobile Applications for Cotton

Android mobile based interactive decision support systems for cotton pest management "Grow Good Cotton" with pre-recorded voice modules has been developed. The system has detailed information of major pests and diseases of cotton, including life cycle, ETL, symptoms of damage on leaf, stem, square, flower, boll, open boll etc. Also management options such as chemical control, bio-control, natural or cultural control for each of the pest has been incorporated and discuss. For the chemical control, the list of recommended chemicals with dosage information, along with available brands in the market and their approximate price is provided. The interactive DSS has been embedded with voice module for clear understanding of the information for the users.

The DSS aims to aid the farmers to identify the pests based on the damage symptoms and also help to choose the appropriate pest control measures including selection of brand of pesticide of their choice.

Cotton Portal

ICAR-CICR Cotton Portal was launched in 2001. Later on, another three sites were added in the cotton portal. The portal has a wide variety of information for various stakeholders.

CICR website

KVK Nagpur website

AICRP on Cotton website

3.8.4: Development of Transfer of Technology Innovations for Bridging up the Yield and Knowledge Gap in Cotton

To know the yield gap between potential, attainable and actual yield in cotton, potential yield trial was conducted in an area of one acre in the station and simultaneously FLD was conducted on the farmers' field. Suraj and Bt cotton hybrid Mallika Bt BG II gave seed cotton yield of 2081 kg/ha and 2062 kg/ha respectively on the research farm. The same variety and hybrid yielded 1560 kg/ha and 1820 kg/ha in the FLDs and 1213 kg/ha and 1450 kg/ha in the farmers' practice. This trial revealed that the yield gap between potential yield (Station yield) and attainable yield (FLD) was 521 kg/ha for Suraj and 242 kg/ha for Mallika Bt BGII. The yield gap between attainable yield and actual yield (farmer's practice) was 347 kg/ha (Suraj) and 370 kg/ha (Mallika Bt BGII).

To assess the impact of long running cotton extension program for bridging up the yield and knowledge gap in cotton, primary data were collected from 94 FLD farmers in Dharwad and Belgaum districts of Karnataka through Focussed Group Discussion and individual case studies. Average seed cotton yield in FLD ranged from 1269 kg/ha to 2750 kg/ha. Similarly, average seed cotton yield obtained in farmers' own practices ranged from 1108 to 2610 kg/ha. Yield gap between the attainable yield (FLD) and actual yield (Farmers' practices) ranged from 160 to 350 kg/ha. The net profit in FLD ranged from Rs. 32714 to Rs.70200 and in farmers' practice ranged from Rs. 26230 to Rs. 63200. The additional benefit due to adoption of technologies disseminated through FLD ranged from Rs. 3285 to Rs. 18,400/-. The data collected on the FLD farmers' perception on assessment of FLD as a cotton extension mechanism revealed that majority of the farmers (> 80%) perceived FLD program as an efficient, compatible, observable, trialable and a program with multiple advantage as well as risks. The data collected on the desirable changes happened in the cultivation behaviour of FLD farmers revealed that majority of them adopted the appropriate cotton varieties and hybrids after FLD. There were also desirable changes in adoption of management strategies for weeds, diseases, pests, physiological disorders and in harvesting & post harvesting practices. But the knowledge test conducted among them revealed that more than half of them could not tell the correct answers as regards to (i) how to do? and (ii) principle behind the technologies viz., cotton varieties and hybrids,

management strategies for weeds, diseases, pests, physiological disorders and in harvesting & post harvesting practices. This explains the existence of knowledge gap even among the FLD farmers Taking into consideration of the constraint and suggestion expressed as regards Extension Methodology, majority of the (> 95%) of the FLD farmers expressed that continuous information flow is lacking in FLD extension model. So, they suggested for an extension approach which could supply the information continuously during the entire season and suggested extension components which are to be included in the new approach.

To assess the yield gap in major cotton growing districts of south zone and to identify the causes for yield gap at farm level, the secondary data on area, production and productivity were analyzed. For the analysis, district-wise cotton area for the years 2013-14 to 2015-16 were taken into account. The total area under cotton was classified into four production zones, namely, primary, secondary, tertiary and 'others' based upon the area under the crop in each district. Fig. 3.8.1. Top districts covering 50% of the total cropped area were categorized into primary production zone. Next group of districts covering 35 per cent (50 to 85 per cent) of the total area were categorized into secondary production zone. Simultaneously to quantify the yield gap, the mean lint yield of districts (2013-14 to 2015-16) (Fig.3.8.2) under various AESR was worked out. The highest yield among the districts of same ASER was regarded as potential yield for that AESR. The difference between potential yield and yield of target district is regarded as untapped yield potential. Among the districts in primary production zone, Guntur had the highest average lint yield (736 kg/ha) and Mahabubnagar had the highest untapped yield gap (453 kg/ha). In the secondary zone, Gulbarga had the highest average lint yield (674 kg/ha) and Dharwad had the highest untapped yield gap (427 kg/ha). In the tertiary zone, Krishna had the highest average lint yield (697 kg/ha) and Chikmagalur had the highest untapped yield gap (466 kg/ha).

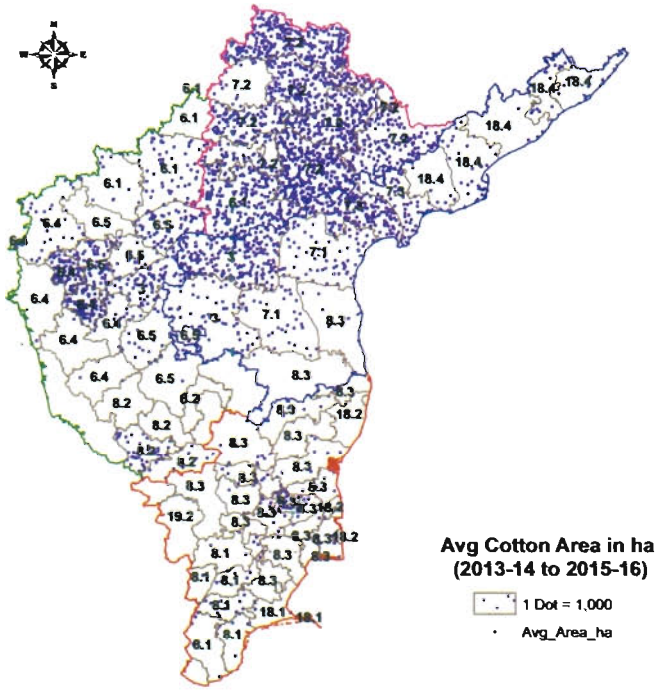


Fig 3.8.1: South Zone Mean Cotton Area (ha) of 2013-14 to 2015-16

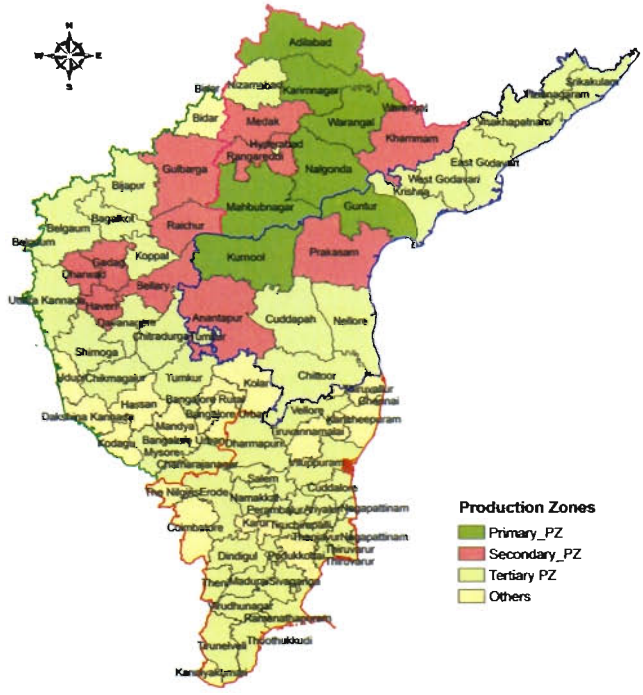


Fig 3.8.2:Cotton Production Zones in South Zone

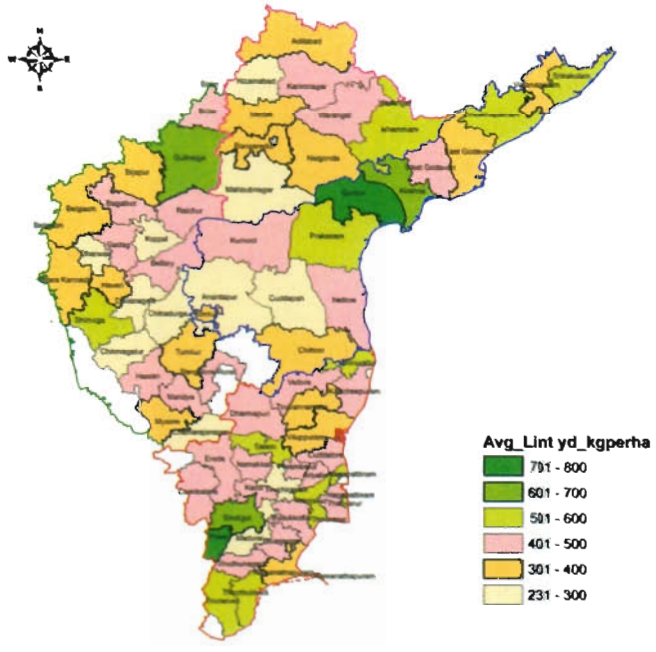


Fig 3.8.3: District Mean Cotton Lint Yield (Kg/ha) of 2013-14 to 2015-16 of South Zone

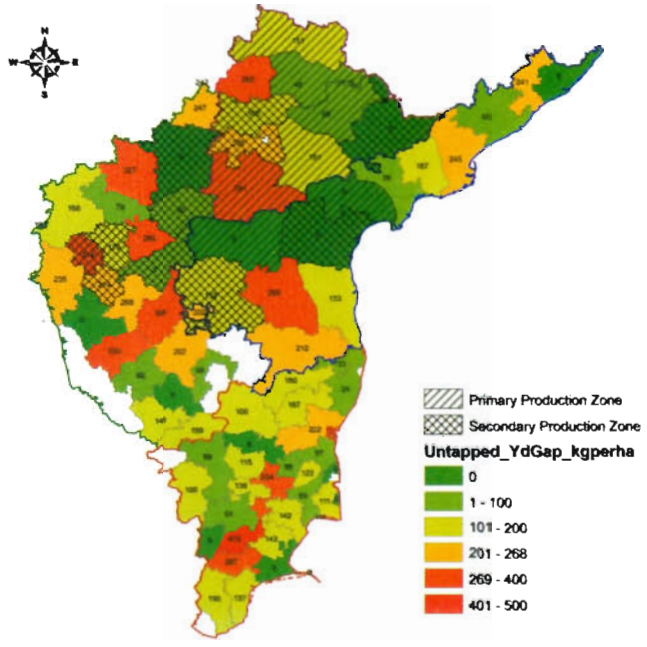


Fig 3.8.4: Untapped Yield Potential (Kglint /ha) of different Production Zones in South Zone

3.8.5: Socio-technological analysis of drip irrigation in cotton cultivation

Field survey was conducted in two districts of Maharashtra states Viz., Jalgaon and Jalna. Major research observations made about drip irrigation from the districts are; a) extending cotton crop beyond the season is a common feature in the two districts. The reasons for extending the crop as reported by farmers are; (i) if the main cotton crop does not gives good yield they extend the crop to get some additional yield, (ii) since water is not available for a second crop they are extending the period of cotton crop, (iii) additional yield during the extended period gives additional profit for them. Regarding the second crop; where ever the water availability is more farmers go for any one short duration crop followed by cotton. Majority of the farmers are cultivating cotton with a spacing of 5x3 / 5x2 / 4x3, average number of drippers for one acre is 6000-7000 and the general discharge level of drip irrigation system differing from 2 LPH to 12 LPH, It was observed that extension of the crop beyond the season and late sowing, led to increased pink bollworm infestation in majority of the farmers' field. Majority of the farmers prefer cotton cultivation because, cotton is the only crop that gives some yield even under drought condition other crops are very sensitive to drought. Average yield in the study area as reported by the farmers under rainfed condition is 3-4 q/ac and that under drip irrigation is 8-9 q/ac.

Major constraints reported by the cotton drip farmers beyond the regular constraints like clogging and rat bite are; a) comparatively less subsidy amount from the government, majority of the farmers going bank loan for drip installation and the banks are providing the loans under term loan basis for five years, b) Whether they irrigate or not, once farmers get EB connection they have to pay Rs. 5000 per year as electricity cost to the government, c) the farmers received electricity only for 8 hours per day and the time schedule also change each week. Therefore, farmers have to go for irrigation even during the night time based on the electricity availability.

Further, the data analysis of socio technological status of Tamil Nadu state revealed that majority of the small and marginal farmers are adopting drip irrigation for cotton cultivation. The reason may be that the subsidy amount for small and marginal farmers is comparatively more. Majority of old age category farmers (55%) are adopting drip irrigation

more when compared to middle (41%) and young (3%) farmers. Majority of the farmers 62.5% had 2 to 8 years experience in drip irrigation . The impact analysis indicated significant impact of drip irrigation on yield efficiency, income efficiency, water use efficiency, labour use efficiency and input use efficiency. The constraint analysis revealed that majority (91%) of the farmers reported that clogging of emitters is the foremost problem in drip irrigation followed by rat biting (72%) and high investment despite subsidy (68%).

Field survey in Maharashtra

Field survey in Jalgon district of Maharashtra state

Field survey in Jalna district of Maharashtra state

3.9: New eco-compatible pest management strategies

3.9.1: Bollworms

Push-Pull strategy for management of pink bollworm Pectinophora gossypiella Saunders

The 'push-pull' approach is an ecological based novel pest management tool that utilizes attractant and repellent (deterrent) components in combination. Fatty acids and their methyl esters identified in the previous year were quantified using 99.99% purity standards and evaluated for oviposition deterrent effect. Upon quantification oleic, linoleic and palmitic acid were identified as major compounds from the faecal pellet extract

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using methanol. Five moth pairs with two days mating period followed by ten days egg laying was standardized for bioassay. Bioassays were carried out under laboratory conditions using individual compounds with 99.99% purity.

A significant difference was observed with increasing concentration of individual compound in case of oleic and linoleic acid. The test of significance did not hold good for palmitic acid where all concentrations were at par with control. The mean number of eggs laid in each set of experiments with three different fatty acids has been depicted in Figure 3.9.1. Palmitic acid did not show any significant difference across all the concentrations.

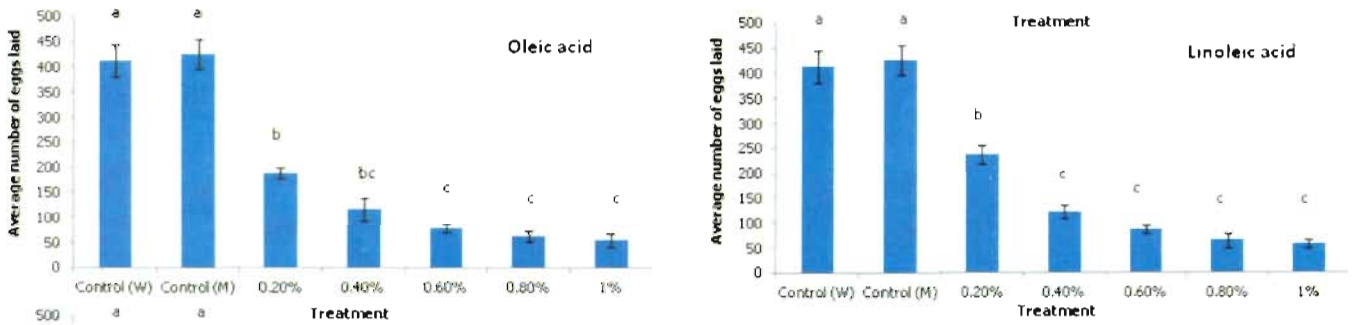


Fig 3.9.1: Evaluation of fatty acids as oviposition deterrent for Pink bollworm

Note: Bars followed by same letters are not significant at P= 0.05 Tukey's HSD (honest significant difference)

GC-MS protocol for extraction of plant volatiles that may play a role as attractants was standardized. For identification of attractant volatiles, squares and bolls from all the four cultivated species of cotton were directly collected in five different solvents. Acetone and methanol were found to be the best solvents for extraction of volatiles. The major compounds identified were α/β pinene, carene, γ terpinene, α copaene, caryophyllene and humulene.

Identification of oviposition deterrent for management of Cotton Bollworm *Helicoverpa armigera*

Semiochemicals are acceptable alternative for the management of insect pests as they alter the behavior of insects. Among the semiochemicals, oviposition deterrents are the most explored.

In previous year volatiles were identified from the feacal pellets of *H. armigera*. These compounds were quantified using the pure compound. The quantification showed the presence of four major fatty acids Viz., linoleic acid (9,12-octadecadienoic acid), palmitic acid (hexadecanoic acid), myristic (Tetradecanoic acid) and stearic acid (Octadecanoic acid). The methyl ester derivatives were quantitatively negligible.

Two male and two female pairing was found optimum for conducting bioassay. Muslin cloth treated with desired concentration of identified compound was used as oviposition substrate with suitable control. Five different concentrations (0.2%, 0.4%, 0.6%, 0.8% and 1.0%) of each compound was tested.

The average number of eggs laid across all replications in each set of experiments with four different fatty acids are presented in Figure 3.9.2. The per cent deterrence in four major fatty acid treatments varied from 16.5-73.5% for palmitic, 27.3 - 68.2% for linoleic, 33.9 - 69.8% for myristic and 34.5 - 68.9% for stearic acid. Almost similar values were obtained when compared with methanol control.

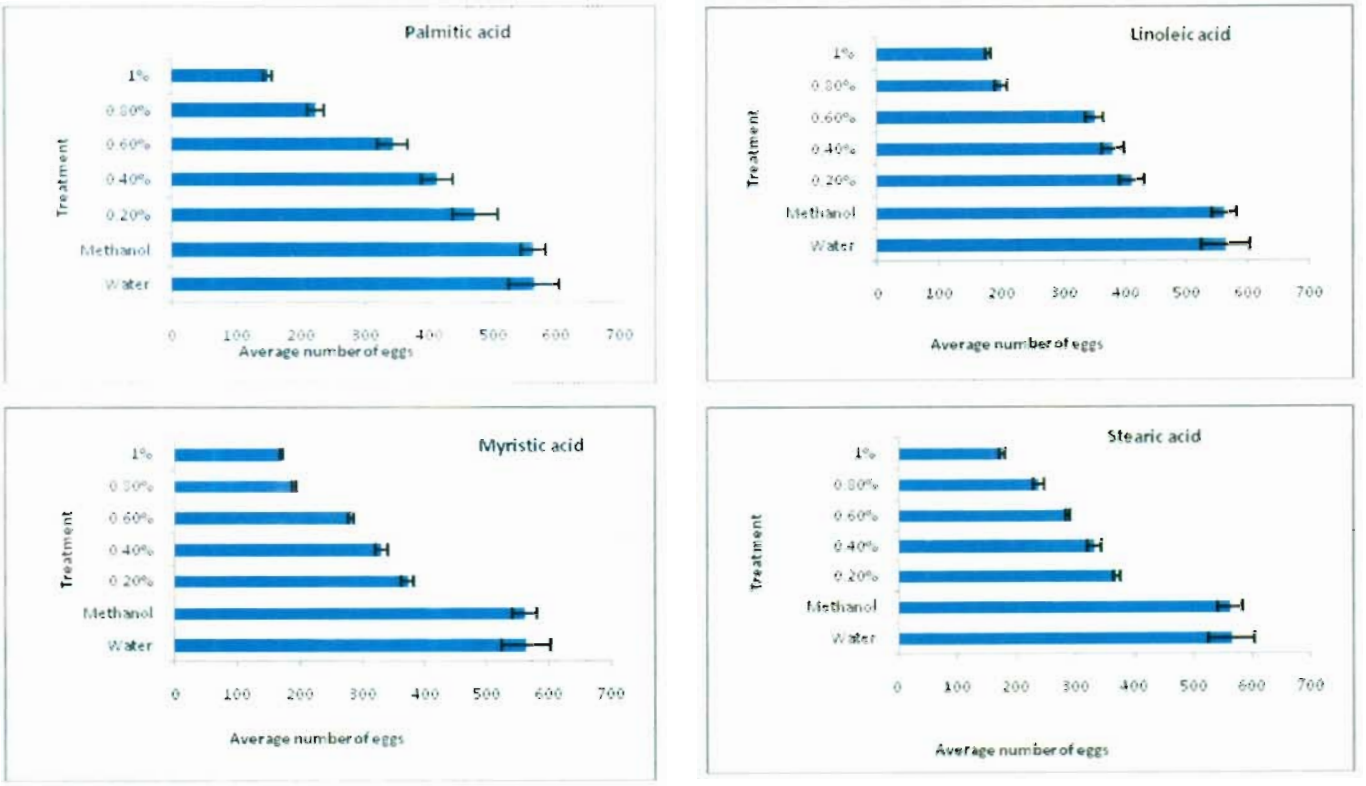


Fig 3.9.2: Average number of eggs laid in different fatty acids

Novel dispensers to enhance the trapping efficacy of gossyplure in managing pink bollworm

Gossyplure, the pheromone compound of pink bollworm viz., was tested with new dispensers and trap designs in two separate field experiments during 2018-19 at Coimbatore. In the first field experiment, eight dispensers made of neoprene, polypropylene, polyvinylpyrrolidone, cellulose acetate, zeolite, silicone, paraffin wax and rubber were evaluated for their efficacy (Fig.3.9.3). The dispenser made of silicone (9.5 adult/trap/week) and polypropylene (9.1 adult/trap/week) were significantly superior to the standard rubber dispenser (7.3 adult/trap/week) in attracting the male moths of pink bollworm. The neoprene dispenser had highest catch (6.3 adult/trap/week) in first four weeks but had short persistence (7 weeks) compared to that of standard dispenser (13 weeks). Two successful dispensers (silicone and polypropylene) selected from the previous year's experiments were evaluated in larger plots of one acre under farmers' field in Solavampalayam village, Coimbatore and compared with the standard rubber dispenser. The polypropylene recorded the highest mean catch of 46.3 /week, while the silicon and rubber dispensers provided a weekly mean trap catch of 41.2 and 34.9 males, respectively.

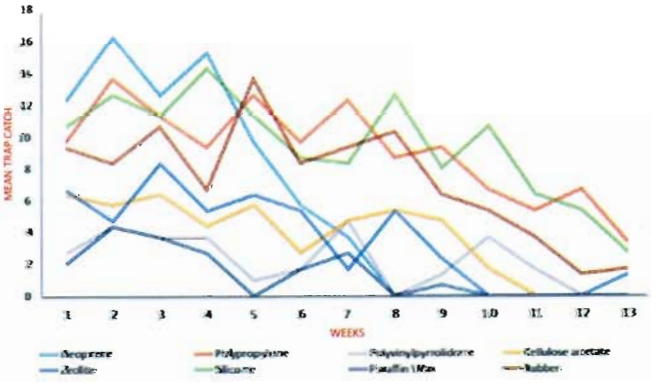


Fig 3.9.3: Efficacy of different dispensers in mass trapping pink bollworm males on cotton (2018-19)

In the second field trial, eight different trap designs viz., wing trap, LED combo trap, funnel trap, delta sticky trap, bottle trap, PET trap, water trap and cone trap fitted with standard rubber dispenser were evaluated PBW (Fig. 3.9.4). The weekly mean catches of PBW adult

males were in the order of delta sticky trap, (13.15) >LED combo trap (12.69)>wing trap (11.39)>funnel trap (10.97) > bottle trap (5.67)>PET trap (4.21)>cone trap (3.64)> water trap (2.87).

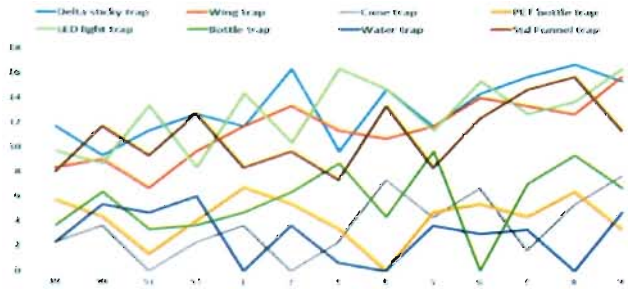


Fig 3.9.4: Efficacy of different trap designs in mass trapping pink bollworm males on cotton (2018-19)

3.9.2: Sucking pests

Chemical cues mediating natural enemy and sucking pest interaction in cotton

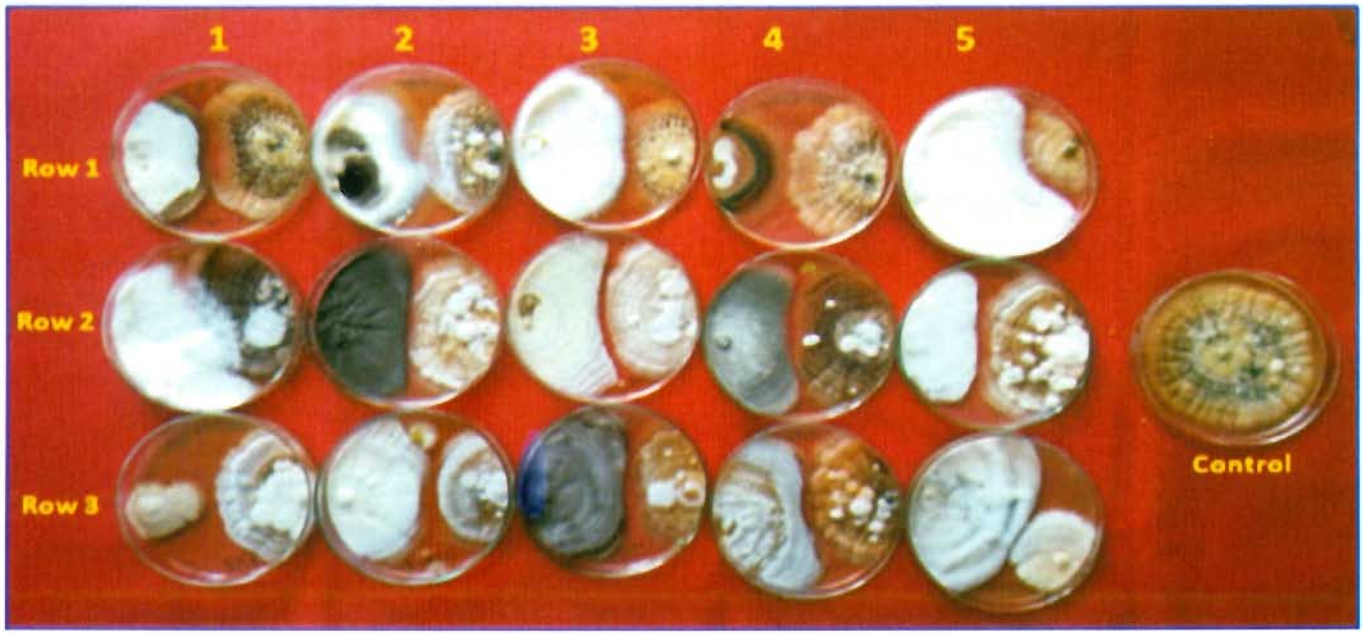
Identification of volatiles emitting from the sucking pests that attract natural enemies have potential for field deployment to enhance natural enemies and helping in eco-friendly pest management practices.

Sucking pests (jassids and whitefly) were collected from the cotton field and volatiles extracted with solvent methanol. 9-Octadecenoic acid esters were major compounds in both sucking pests followed by 9,12-Octadecadienoic acid (Z,Z)-, methyl ester, hexadecanoic acid, methyl ester and methyl stearate.

3.9.3: Diseases

Identification of cotton endophytes with potential biocontrol activity against major diseases

Fungal endophytes were isolated from *G. arboreum* and *G. hirsutum* and identified through morphological characters and ITS analysis. Among the endophytes *Curvularia sp.*(10), *Macrophomina sp.* (08) and *Alternaria sp.* (05) were found to be dominant. Antagonistic potential of endophytic fungi was tested against *Corynespora cassiicola*, Alternaria sp. and *Fusarium sp.* Among all the endophytes CEL 2 (*Nigrospora sp.*), CEL 5 and CEL 19 (*N. sphaerica*), CEL 38, CEL 41 (*Diaporthe longicolla*), CEL 48, CEL 55, *Fusarium sp.*, *Isaria sp.* and *Nigrospora sp.* were found promising in inhibiting growth of the test pathogens. Colony inhibition was highest in CEL 41 followed by CEL 48 against *C. cassiicola*.



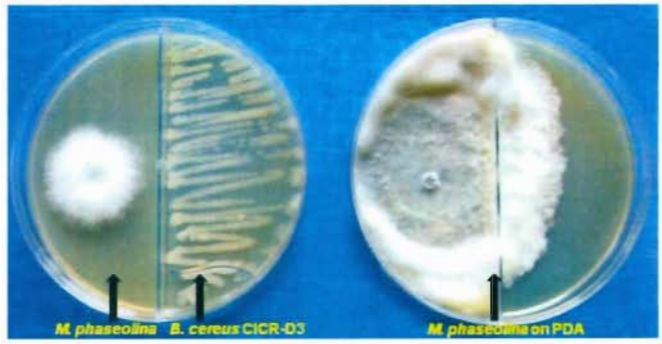
Antagonistic potential of different fungal endophytes against Corynespora cassiicola under dual culture technique. Endophytes as, Row 1: 1- CEL 1, 2- CEL 2, 3- CEL 3, 4- CEL 4, 5- CEL 5; Row 2: 1- CEL 11, 2- CEL 12, 3- CEL 13, 4- CEL 15, 5- CEL 16 and Row 3: 1- CEL 17, 2- CEL 19, 3- CEL 20, 4- CEL 21, 5- CEL 22

Standardization of GC-MS protocol for identification of antimicrobial volatile organic compounds (VOCs)

GC-MS protocol for identification of antimicrobial VOCs was standardized using three different methods viz., Headspace based identification, Solvent based Extraction and Matrix based Extraction: Using these three methods, fungal endophyte CEL 19 (*N. sphaerica*) was tested for the production of VOCs. The total ion chromatogram of CEL 19 revealed a list of different VOCs wherein, four major compounds identified viz 1, 3 diethyl benzene, 1, 4 diethyl benzene, p-Cymen-7-ol and m-Ethylacetophenone were found to be antimicrobial.

Biological control potential of cotton PGPR mediated through mVOC's

Microbial Volatile Organic Compounds (mVOC's) produced by promising and well characterized species of *Bacillus* strains of PGPR's were identified. Total 9 mVOC's were identified including 3 benzenes, 2 ketones, one each from alcohol, aldehyde, naphthyl and phenol group compound. The analysis of mVOC's spectra indicated that relative abundance and type of compounds produced are strain specific. Benzene, 1,3-diethyl- and Benzene, 1,4-diethyl- were the major antifungal compounds (identity >95%) detected from cotton PGPR strains *Bacillus cereus* CICR-D3, *Bacillus aryabhattai* CICR-D5 and *Bacillus tequilensis* CICR-H3. Additionally, insect repellent compound Naphthalene and nematicidal compounds i.e. m-Ethylacetophenone and Ethanone,1-(4-ethylphenyl) were also detected. Under sealed plate bioassay test conditions, *Bacillus cereus* CICR-D3 imparted significant mycelial inhibition after 5 days followed by *Bacillus aryabhattai* CICR-D5 and *Bacillus tequilensis* CICR-H3 against fungal pathogen, *M. phaseolina*



Volatile bioassay co-inoculated with *Bacillus cereus* CICR-D3 strain and *Macrophomina phaseolina*

3.9.4: Nematodes

Induction of Systemic Acquired Resistance against phyto nematodes.

Bio formulations (Curcumin, neem oil, aspirin and cow urine in different combinations) were evaluated for induction of systemic acquired resistance against reniform nematode under field conditions. Effect of bio formulations on nematode population in field and cotton yield was evaluated. Best formulation observed was Aspirin + Curcumine followed by curcumin alone. Reduction in reniform nematode population in soil was up to 55% giving an increase of seed cotton yield by 4 q/ha over untreated control.

Use of Marigold species for management of root knot nematode

Three species of marigold, *Tagetes erecta, T.patula* and *T.tenuifolia* were evaluated against root knot nematode. T.patula was most effective in reducing galls by root knot nematode. Planting of marigold by one week before planting of host plant was found to be better than planting both Tagetes and host plant together. Influence of marigold as nematode repellent was most pronounced within diameter of 10 cm from the marigold plant.

Extraction and evaluation of bioactive metabolitcs produced by *Purpureocillium lilacinum*

Studies were conducted to extract and evaluate the

bioactive metabolites produced by a native isolate of nematophagous fungus, *Purpureocillium lilacinum* isolated from nematode suppressive soil in cotton ecosystem. Ethyl acetate extract of the culture filtrate (CF) caused maximum of 100% juvenile mortality and inhibition in egg hatching of Reniform nematode, *Rotylenchulus reniformis* under in vitro condition. GC-MS analysis of ethyl acetate fraction of CFC indicated the presence of 13 different compounds, some of which are known to have nematicidal, antimicrobial, cytotoxic and insecticidal properties. Actinomycin C2,2-Pentanone, 4-hydroxy-4-methyl- (CAS), Hexanoic acid, 2-ethyl-,oxybis(2,1-ethanediyloxy-2,1-ethanediyl) ester (CAS), 2-benzyl-3,6-dioxo-5-methylpiperazine, Nonacosanol (CAS), 1-Docosanol (CAS), 2,5-Piperazinedione, 3,6-bis(2-methylpropyl) are known to have nematicidal/ nematostatic properties.

3.10: Bio-diversity of pests and natural enemies in cotton ecosystem

3.10.1: Bollworms

Population dynamics of Pink bollworm in North India

Monitoring of Pink bollworm (PBW) is regularly done in North Zone since 2012-13 from 5 districts (Faridkot and Bhatinda in Punjab; Sriganganagar in Rajasthan; Hisar and Sirsa in Haryana) for larval recovery at various stage of crop growth from different varieties. During 2018-19 in North zone, based on green boll destructive sampling no PBW larvae were recovered in Bollgard-II hybrids . In Non Bt varieties HS-6, Ganganagar Ageti and RS-2013 first incidence of bollworm was observed in the 35th SMW which ranged from 1.5 to 12.1, 1.96 to 10.3 and 1.1 to 7.3 respectively based on percent fruiting bodies damage. Larval recovery(%) ranged between 3.3-12.4 in 2018-19 at 140, 160 & 175 days after sowing.

Incidence of PBW on BG-II hybrids was recorded from village Palwan (Distt. Jind, Haryana). The incidence of PBW was confined around the Vardhaman Cotton Mills, Palwan. Infestation ranged from 10-100% in green and opened bolls and depending on distance from the cotton mill. Infestation was recorded only up to 1 km radius.

Monitoring of Pink bollworm field incidence in India

The per cent infestation of PBW in green bolls of BG-II at 90-100 days after sowing was observed in the cotton growing districts of Maharashtra Viz., Aurangabad (3.3%), Parbhani (2.2%), Buldhana (2.2%) while there was no incidence in Akola and Amravati. Infestation of BG II cotton in Gujarat was in range of 0 to 7.2% and was highest in Surendranagar district (7.2%). Similarly, infestation of PBW in BG-II cotton fields of South India (Telangana, Andhra Pradesh and Karnataka) was more or less same as that of central India.

Survey teams from ICAR-CICR, Nagpur visited 16 districts of Maharashtra (Yavatmal, Wardha, Nagpur, Chandrapur, Gadchiroli, Amravati, Akola, Buldana, Jalana, Jalgaon, Dhule, Nandurbar, Aurangabad, Nanded, Hingoli and Parbhani), 1 a district of Telangana (Adilabad) and 1 district of Madhya Pradesh (Chhindwada) during 15 Sept to 12 October 2018 (90-120DAS). The teams collected about 20 green bolls from randomly selected plants one acre area of each field. Total 315 locations from 60 talukas of 18 districts of 3 states were surveyed and 6502 green bolls were collected. The green bolls were dissected for presence of live PBW larvae in the laboratory. Out of 6502 green bolls, 114 bolls were found to be infested with PBW indicating overall 1.75% (Maharashtra-1.88%, Telangana-0.80% and Madhya Pradesh 0.45%) infestation. Out of 315 location surveyed, the infestation in only 23 locations were found to have crossed the ETL (≥ 10%infestation).

In the station trial at Nagpur, PBW infestation was negligible till September, however it started increasing with the progress of season. Both Bt and non Bt cotton were found to be infested by PBW however, higher infestation was recorded in the non-Bt cotton (Fig. 3.10.1).

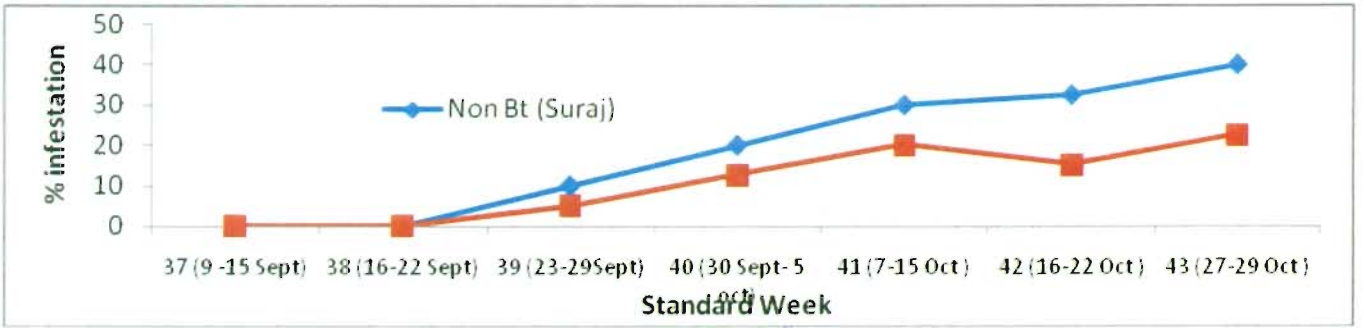


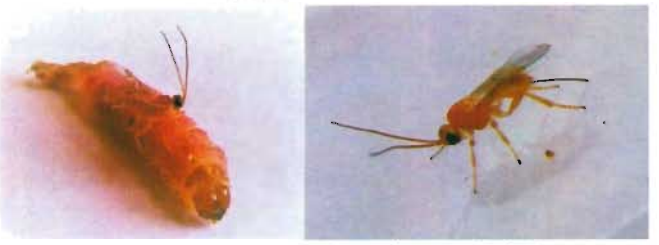
Fig. 3.10.1: Pink bollworm infestation in non-Bt and Bt cotton during 2018-19 (Nagpur)

Genetic Diversity of pink bollworm: Sequence analys were done with good quality sequence of COI fragment 686 bp portion of COI region of 214 PBW populations from different regions of India (South-52, Central-129 & North-33) to determine the population genetic structure, distribution and genetic diversity in all three cotton-growing zones. Edited unique sequences were deposited in Gene Bank using Bankit (Accession numbers: MK652512-MK652704, MK775533-MK775550). Alignments of all 214 COI sequences revealed that 27 haplotypes are present in overall populations including 11 in north, 14 in central and 6 in south region. The H1 and H2 are most common haplotypes present respectively in 143 and 32 populations and hence these two haplotypes could be proposed as ancestral/ original haplotypes. The presence of a star-shaped haplotype network linked by one or two mutations together with the multiple common haplotypes support this hypothesis. In this study zone-wise clustering revealed that central zone recorded low level of Haplotype diversity (0.499) as compared to south (0.560) and north (0.595).

Parasitization of Pink bollworm:

Pink bollworm infested green bolls were collected from different cotton growing districts of India. Parasitization by *Apanteles angaleti* in Maharashtra was found in the range of 1.28 (Wardha) to 10 % (Nagpur). In Gujarat, highest parasitization was recorded in Junagadh population (62.5%) and lowest in Anand (7.3). In Telangana, Warangal location was highest parasitized (25.9%) followed by populations from Mahabubnagar (6.25%) and Nalgonda (4.65%). PBW larvae collected from Nagpur was also parasitized (33.33%) by *Bracon lefroyi*.

Apanteles *angaleti*



Bracon sp.on pink bollworm larva Larval parasitiods Bracon sp.

Natural infestation of larval parasitiod, *Bracon* sp. (Hymenoptera: Braconidae) at 3.8% was also recorded on PBW larvae at CICR Regional Station, Main farm, Coimbatore.

3.10.2: Sucking Pests

Population dynamics of sucking pests of Nagpur (Central India)

Jassid population peaked twice first in second fortnight of August and another in the first week of October. Thrip population was higher during second week of August till the month end followed by a decline. Natural enemies viz. spider and Coccinellids were few in number (**Fig. 3.10.2**)

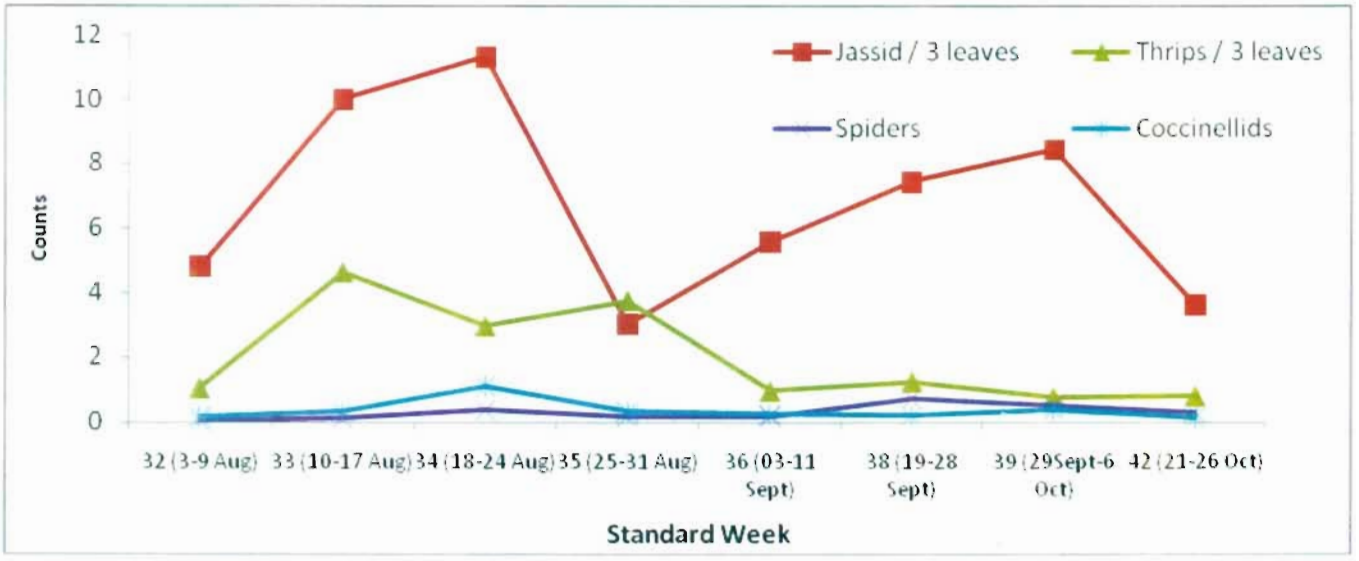


Fig. 3.10.2: Population dynamics of cotton pests over the season in DCH 32

Significant variation was observed in jassid and thrips population among the genotypes. Significantly higher population of jassid (6.90 jassid/ 3leaves) and aphid (11.49 aphids/ 3 leaves) was recorded on Suvin and Suraj, respectively. Comparatively more thrips were found on Suraj (4.96 thrips/ 3 leaves) followed by RCH 2 (3.61 thrips/ 3 leaves). Populations of whitefly, mirid bugs and spiders were negligible during the crop season (**Fig. 3.10.3**).

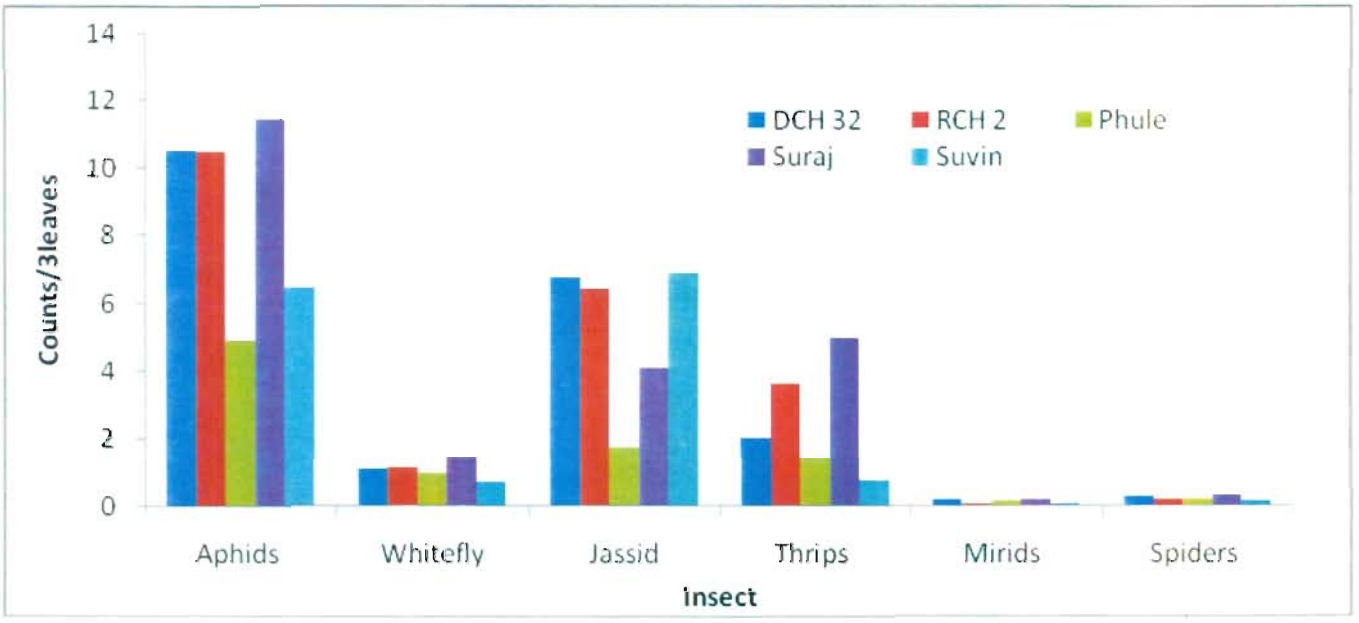


Fig. 3.10.3 : Pest and natural enemies' population on five genotypes over the season

Population dynamics of sucking pest at Sirsa (North India)

In RCH-650 BG-II hybrid jassid population ranged from 0.2-5.5.5/3 leaves with peak population between 29th and 33rd SMW. Population of whitefly was initially observed in 22nd SMW (2.6 / 3 leaves) and peak activity occurred in 29th SMW (31.2 / 3 leaves). Population of thrips ranged from 0-36.3 / 3 leaves which were first noted in 22th SMW and peak activity was observed in 29th SMW **(Fig 3.10.4)**

In HS-6, leafhopper population ranged fro
3 leaves and peak activity was observec
SMW. Population of whitefly was i

observed in 22nd SMW and peak activity occurred in 30th SMW (36.4 / 3 leaves). Thrips population ranged from 0-41.5 / 3 leaves with peak activity in 25th SMW

In Ganganagar Ageti, jassid population ranged between 0-5.8/3 leaves and peak activity was observed in 33th SMW. Population of whitefly was initially observed in 22th SMW and peak activity was in 28th SMW (28.1 / 3 leaves). Thrips population ranged from 0-36.8 / 3 leaves and peak activity was observed in 29th SMW

In RS-2013, jassid population ranged from 0-5.2 / 3 leaves and peak activity was observed in 33st and 36th SMW. Population of whitefly was initially observed in 22nd SMW and peak activity occurred in 28th SMW (29.5 / 3 leaves).Thrips population ranged from 0-26.6 / 3 leaves and peak activity was observed in 26th SMW.

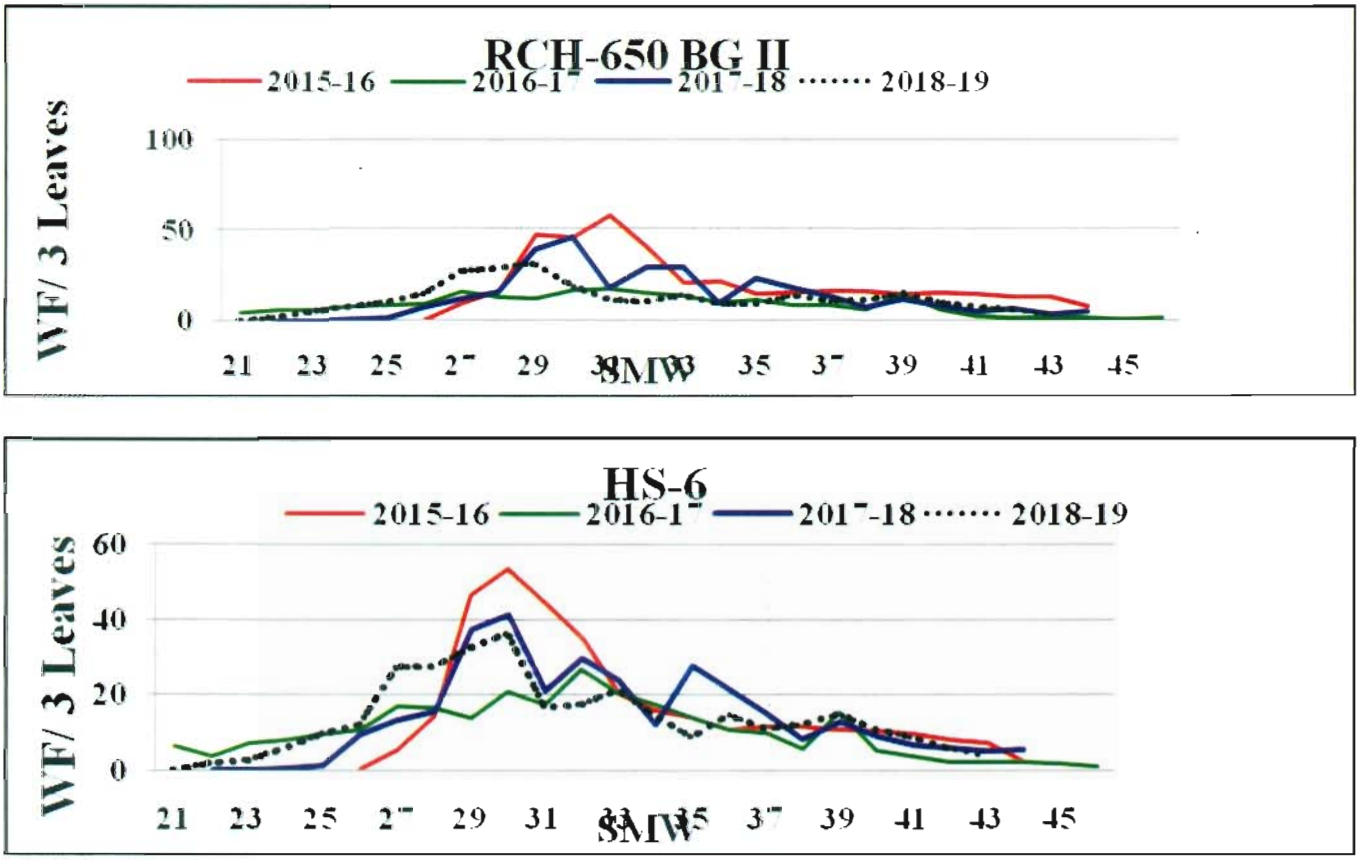


Fig. 3.10.4: Population dynamics of whitefly under unprotected conditions at Sirsa.

Within plant, distribution of whitefly indicated that the whitefly prefers to feed on lower canopy of the plant as compared to middle and upper canopy. Mean whitefly adults population/leaf recorded during the entire season of 2018-19 on upper, middle and lower strata was 13.8 (7.5-28.5) & 4.6 (3.3-5.6) respectively during different part of the day RCH650BG-II and 4.09 (2.5-6.1) & 2.8 (2.0-4.), 9.9 (6.08-20.25) & 4.97(2.82-8.13), 13.75 (6.7-30.2) & 4.4 (3.2-8.8) respectively on HS-6. Though whitefly prefer to lay eggs on the fresh leaves, the nymphal pattern indicated equal preference for fresh leaves located both in middle and lower strata as compared to upper strata leaves.

The life table analysis of whitefly starting from 34-44 SMW indicated maximum natural mortality of nymphal stage due to fungal/bacterial infection 13.4(8.0-26.1%) followed by dislodgement 12.5 (2.6-29.4%) followed by parasitization 10.1 (4.6-25.0%).

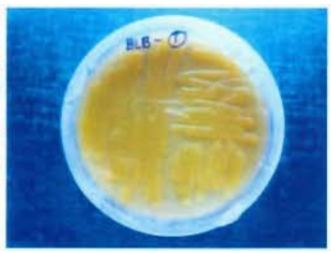
Species diversity of thrips

Samples were collected from one district of Haryana (Sirsa), 8 Districts of Maharashtra (Nagpur, Washim, Amravati, Akola, Buldhana, Jalgaon, Rahuri & Wardha) and 4 Districts Tamil Nadu (Coimbatore, Salem, Ariyalur & Perambalur) and documentation of important taxonomical characters is under progress.

3.10.3 : Diseases

Prevalance of *Xanthomonas citri* pv. *malvacearum* races of Cotton

Bacterial leaf Blight (BLB) caused by *Xanthomonas citri* pv. *malvacearum* is an important disease of cotton and cause considerable yield losses. Ten BLB infected cotton leaf samples were collected from different cotton growing areas of Maharashtra (6 no.), Gujarat (2 no.) and North India (2 no.) to study race diversity. Biochemical and molecular characterisation of collected isolates and marker assisted selection by validated marker CIR246 was carried out.



Leaves showing the typical symptoms of angular leaf spot

Yellowish slimy bacterial colonies of Xam on Yeast Dextrose Chalk Agar (YDCA) mediun

Occurrence and distribution of *Tobacco Streak Virus* (TSV) in Cotton

TSV infestation in germplasm of *Gossypium barbadense* was estimated. Per cent disease incidence was maximum in SP (35.8 %) andICB-71 (26.6%) with disease grade of 3. The maximum disease incidence was observed at 60 to 75 days after sowing. The symptoms of TSV infection were very distinct with necrotic spots dark purple in colour and also drying of squares. The per cent disease incidences observed at 55 DAS in *Gossypium hirustum* (RCH 659 BG-II was 35.2% and Suraj Bt was 31.7%. Maximum disease incidence of TSV was observed at 70 days after sowing (DAS) in Mallika BG-II with 47.2 % with higher thrip population.

Infected leaves of CCB 29, ICB 25 and Suvin showing typical symptoms were used for sap transmission studies on cowpea seedlings (CO 7) **(Fig.3.10.5).** Symptoms like chlorotic lesions, necrotic lesions, necrotic spots, veinal necrosis, systemic symptoms, necrosis on petioles, stem necrosis and total necrosis were observed on cowpea seedlings at 3 to 7 days after inoculation. Viral inoculum was maintained artificially in different hosts under insect proof net house conditions **(Fig.3.10.6).** Necrotic lesions were observed in greengram, black gram and soybean.

Fig. 3.10.5 : Sap transmission studies on local lesion host- Cowpea CO 7

(Artificial inoculation)

Fig. 3.10.6: Maintenance of virus inoculum (Artificial inoculation)

3.10.4 : Nematodes

Prevalence of plant parasitic nematodes in Vidarbha region of Maharashtra

Eleven districts of Vidarbha region of Maharashtra were sampled for prevalence of plant parasitic nematodes. Reniform nematode *Rotylenchulus reniformis* was the most prevalent nematode on cotton followed by *Hoplolaimus* and *Pratylenchus sp.* The prevalence has indicated that due to intensive cultivation and monocropping, the intensity of plant parasitic nematodes may increase in future. Based on damage threshold of *R. reniformis*, hot spot areas were identified where nematode damage may become evident in years to come.

3.11: Integrated Pest Management

3.11.1: Bollworms

Resistance monitoring in Pink bollworm

For monitoring resistance against Cry1Ac and Cry2Ab, PBW populations were collected from different locations across India. The resistance development of PBW on BGII and non-Bt cotton fields was monitored. In North India, 9 districts

from three states (Hisar, Fatehabad and Sirsa of Haryana, Mansa, Abohar, Bathinda and Faridkot of Punjab, Sriganganagar and Hanumangarh of Rajasthan), in Central India 24 districts from three states (Wardha, Yavatmal Washim, Hingoli, Nanded, Parbhani, Aurangabad, Buldana, Akola, Amravati, Rahuri, Jalgaon districts of Maharashtra; Khandwa and Pandhurna districts of Madhya Pradesh. Surat, Bharuch, Vadodara, Anand, Ahmedabad, Bhavnagar, Amreli Junagadh, Rajkot and Surendranagar districts of Gujarat), in South India 12 districts of four states (Guntur, Prakasham, Kurnool and Krishna in Andhra Pradesh; Karimnagar, Adilabad, Warangal and Khammam in Telangana, Srivelliputtur and Coimbatore in Tamil Nadu and Dharwad and Raichur in Kharnataka were surveyed.

The population from North India was susceptible to Bt toxins except population of Jind district of Haryana. Field infestation of PBW was nil across the season on Bt cotton in north India. Thirty five population of PBW was subjected to Cry1Ac and thirty two populations were subjected to Cry2Ab log dose probit assays. PBW populations from Parbhani, Bellari, Akola, Amreli, Khandwa, Aurangabad, Prakasham. Guntur, Nalgunda and Kurnool recorded 143, 148, 159, 191, 248, 250, 294, 295, 434 and 899 fold resistances to Cry1Ac over susceptible check. Akola, Amravati, Nalgonda, Bellari, Guntur, Yadgiri, Khandwa, Amreli, Surendranagar, Aurangabad, Jind, Rahuri, Jalgaon, Kurnool and Vadodara recorded 158, 230, 274, 385, 425, 428, 548, 560, 628, 638, 1070, 1350, 1411, 3074 and 3831 fold resistance to Cry2Ab over the susceptible check.

Evaluation of egg parasitoid *Trichogramma species* to control Pink bollworm

A field trial was conducted to evaluate egg parasitoid *Trichogramma bactrae, Trichogramma brasiliensis* and *Trichogramma chilonis* through inundative release in cotton. Two releases at flowering (40-55 DAS) and two releases at boll maturation (60-75 DAS) stage at weekly interval along with a botanical, a microbial and two insecticides at 60-70 DAS, 70-80 DAS and 80-90 DAS. The observation was taken at ten days interval from 100DAS.

On green bolls, observations were recorded on number of exit hole, number of mines on the epicarp, number of larvae and per cent locule damage at ten days interval for all the treatments. Most effective was cypermethrin 4%EC + profenophos 40% (T-7) with 12.24% locule damage. T.bactrae with 13.05 per cent locule damage was most effective among three tested *Trichogramma species*. Neem oil and Beauveria bassiana also were promising for controlling PBW (Fig. 3.11.1).

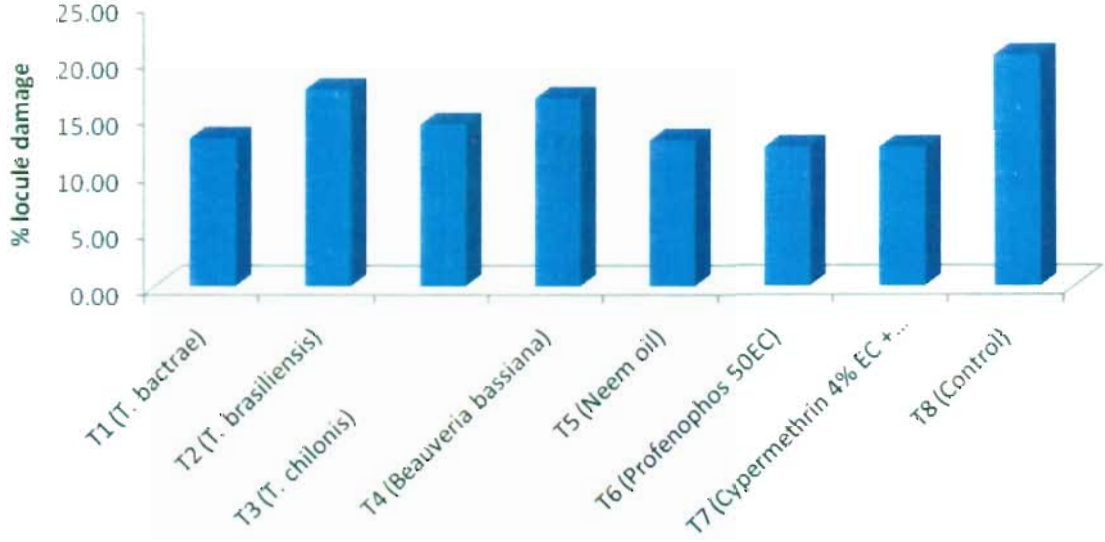


Fig. 3.11.1: Evaluation of egg parasitoid Trichogramma species to control pink bollworm Pectinophora gossypiella (Saunders) in field conditions

3.11.2: Sucking Pest

Insecticide resistance monitoring against Jassid

In order to determine the resistance of jassid to different insecticides in Maharashtra, jassid samples from four locations were subjected to bioassays using eight insecticides. The results indicated that, LC_{50} of Flonicamid ranged from 0.009 mg/L (Nagpur) to 0.111 mg/L (Wardha), Monocrotophos 0.010 mg/L (Nagpur) to 0.045 mg/L (Wardha), Acephate 0.010 mg/L (Wardha) to 0.037 mg/L (Amravati), Imidacloprid 0.005 mg/L (Wardha) to 0.044 mg/L (Amravati.), Acetamiprid 0.015 mg/L (Wardha) to 0.039 mg/L (Nagpur), Thiamethoxam 0.0012 mg/L (Wardha) to 0.054 mg/L (Chandrapur), Spiromeifen 0.004 mg/L (Nagpur) to 0.048 mg/L (Wardha), and Clothianidin 0.009 mg/L (Wardha) to 0.038 mg/L (Amravati). Wardha populations were more susceptible to Flonicamid, Thiomethoxam, Acetamiprid, Imidachlopride, Acephate and Clothianidin.

Insecticide resistance monitoring in whitefly in North India

Organophosphate: The change in resistance ratio is affected not only by the insecticide use pattern in main crop (cotton) but on other alternate hosts also. Resistance ratio obtained in case of ethion (2.6-7.4, 1.8-11.0 & 3.9-5.1), Chlorpyriphos (3.6-11.3 ,7.7-10.5 & 3.9-6.0), Triazophos (28.9-43.2, 11.8-54.6 & 20.4-37.1) during 2016-17 , 2017-18 & 2018-19 was attributed to the pesticide use pattern on cotton as well as on other alternate hosts crops. In case of monocrotophos it was 2.7-4.7 during 2018-19. The resistance ratio was comparatively less during 2018-19.

Neonicotinoid: The high resistance recorded in our study at CICR Regional Station, Sirsa for thiamethoxam (12.8-58.9,10.3-51.5 & 14.8-22.6 fold resistance ratio during 2016-17, 2017-18 & 2018-19) at different locations of the north zone low resistance Acetamiprid (1.0-7.3, 6.9-10.3 & 5.7-10.6) and Imidacloprid (1.03-2.6 during 2018-19) insecticide use pattern. Low resistance ratio was recorded in our study at CICR Dinotefuran (0.9-17.8, 1.5-9.8 & 1-4.2 during 2016-17, 2017-18 & 2018-19), and Clothianidin (0.78-1.07 & 0.72-0.98 during 2017-18 & 2018-19).

Synthetic Pyrethroid: As pyrethroid use is being discouraged. Low to moderate resistances to cypermethrin have been reported in the B. tabaci populations .Very low or minimal resistance for Bifenthirin (0.63-28.2, 22.7-24.1 & 0.62-28.2 during 2016-17, 2017-18 and 2018-19) followed by Fenpropathrin in the studies conducted by CICR is again a resultant of insecticide use pattern in cotton and other crops.

Insect Growth Regulator: Younger stages are generally more sensitive to this group of insecticides as compared to older stages. Among these insecticides Difenthiuron (70.7-163.3 , 33.3-128 & 48-66.8 fold resistance ratio during 2016-17, 2017-18 & 2018-19) was found with highest resistance ratio followed by Flonicamid (1.27-2.8, 0.47-2.8 & 0.6-2.8) during the last three years.

Identification of resistant genetic sources with mechanism of resistance against Jassid

Field screening of 54 genotypes of G. Hirsutum for identification of resistance/ tolerance against cotton leafhopper indicated that 13 and 24 genotypes were found superior and numerically on par with resistant check respectively in terms of leafhopper population. Leaf anatomical characters namely distance of phloem from the lower epidermis, phloem length, length of the palisade cell, leaf thickness, trichome type, length and density, the parameters linked with resistance for the hoppers, were analysed using leaf section. In general branched trichomes have predominantly been observed over non branched trichomes in the tolerant genotypes. Very sparse trichome hairs were observed in the susceptible line DCH 32. In comparative anatomical measurements genotypes namely NDLH 2010, AKH 2012-8, RS 2711, H 1454, H 1464 Pusa 5760, GISV 216 and F2164 were distinctly identified for jassid tolerance among all other genotypes **(Fig. 3.11.3).** No significant difference in the biochemical parameters (chlorophyll a, total chlorophyll, leaf moisture) between the genotypes and the resistant check under protected and unprotected conditions were recorded except free amino acid content in 12 genotypes were lesser than the resistant check.

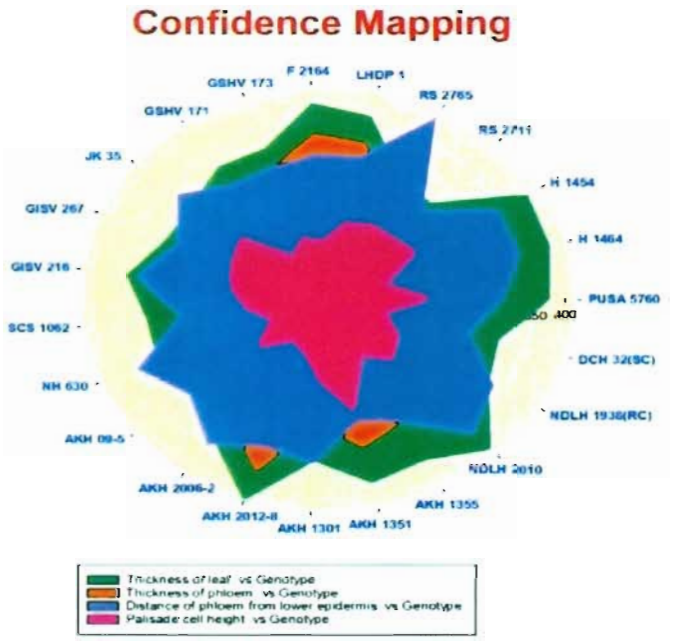
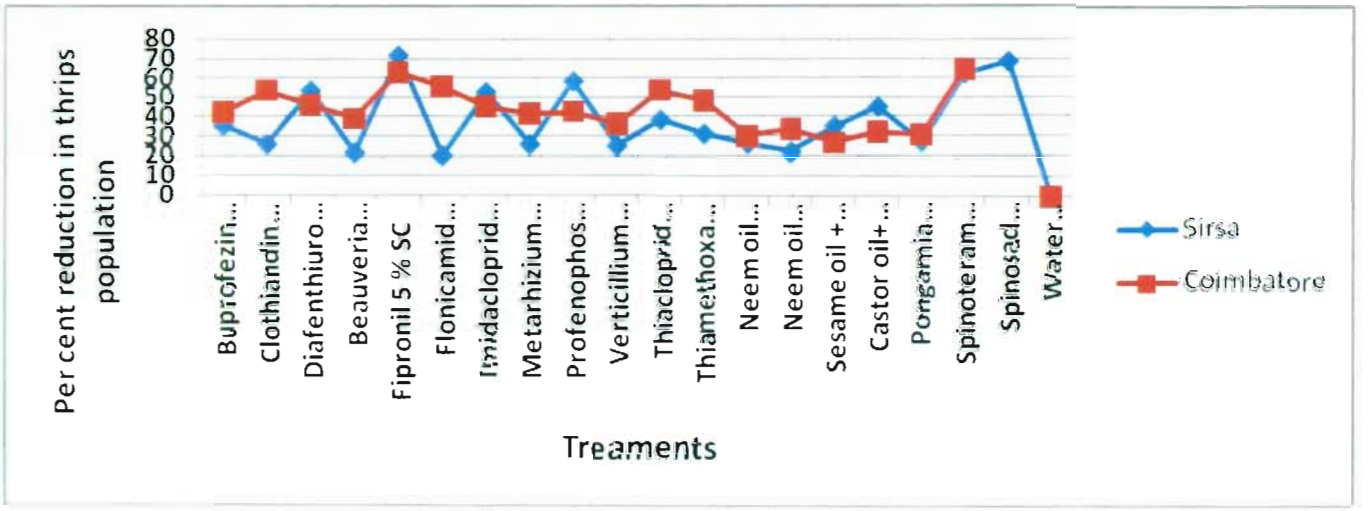


Fig. 3.11.2: Comparison of leaf anatomical characters

Evaluation of different groups of insecticides against thrips in cotton

Efficacy of different group of insecticides (10), biopesticides (3) and essential oils (5) were evaluated against thrips at Coimbatore and at Sirsa. Among insecticides, Spinoteram (64% reduction over control) followed by Fipronil (62% reduction over control) found highest efficacy against thrips. Among biopesticides, *Metarrhizium anisopliae* and among essential oils, neem oil followed by castor oil recorded higher efficacy against thrips. Biopesticides and essential oils were found safe against natural enemies viz., coccinellids and spiders.



*Mean value of two sprays

Fig. 3.11.3 : Efficacy of different insecticides against Thrips under field condition

Evaluation of different colour sticky traps against thrips in cotton

Six colour sticky traps (Yellow, Blue, Red, Orange, Green and White) were evaluated against thrips. Among them blue colour followed by yellow attracted more number of thrips.

Bioefficacy of insecticides and biorationals against thrips

Under the common trials conducted for GEAC approved genotypes and testing of agrochemicals during 2018-19, the efficacy of 12 label claim insecticides and five biorational interventions (castor oil, pongamia oil, sesame oil, 2 neem based formulation) were tested under laboratory conditions against thrips at three dosages during 2017-18 & 2018-19. Among the insecticides Spinosad (78 & 80%), Fipronil (72 & 82 %), Spinoteram 11.7% SC (68 & 72.2%) and Diafenthiuron (66 & 61.1%) followed by Profenphos gave highest mortality. Whereas among the biorational approaches sesame oil (58 &

41.1%), castor oil (50 & 50.1 %), pongamia oil (32 & 56.7%) were recorded with moderate mortality against thrips.

Under field conditions among the insecticides Spinosad (68.1% reduction),fipronil (71.3%), spinoteram 11.7% SC(62.0%) and diafenthiuron (53.3%) and profenphos (58.1%) gave highest reduction in thrips count. Whereas among the biorational approaches sesame oil (35.2%), castor oil (44.9%), pongamia oil (27.0%) were recorded with moderate mortality against thrips.

Comparative field study of bio-insecticides and chemical insecticides

The field trials conducted at Sirsa revealed that the bioformulation of entomopathogenic fungal strain and chemical treatments were significantly superior over control in terms of whitefly nymphal mortality. The highest nymphal mortality at Sirsa on the seventh day after spray was recorded with *Beauveria bassiana* -4511 followed by *Isaria javanica* CICR-RSS -0102 and Pyriproxyfen (2.5ml/L), while at Nagpur, the highest nymphal mortality at 10 DAI were recorded with *Fusarium moniliformae* CICR-RSS-083 followed by *B. bassiana*-4511, I. *javanica* -CICR-RSS -0102 and Pyriproxyfen (2.5 ml/L). These treatments were significantly superior to Diafenthiuron 50% WP (1 g/L), Neem oil (300 ppm) and commercial formulation of *L. lecanii* (0.1% WP) (Fig. 3.11.4).

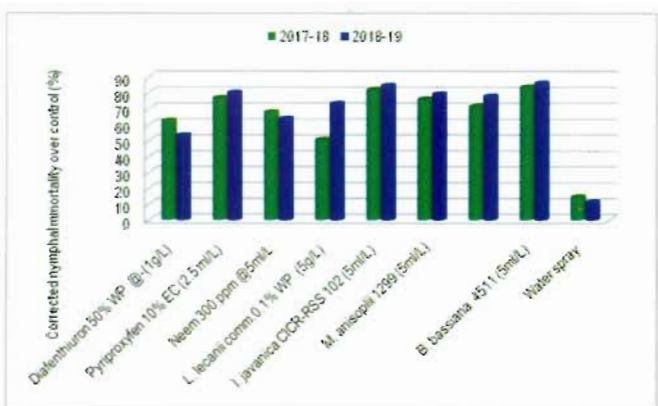


Fig. 3.11.4: Effect of selected entomopathogenic fungal strains and pesticides on whitefly nymphal mortality under field conditions at CICR RS Sirsa (2017-18 and 2018-19)

Development of thermal tolerant strain of biocontrol agent, *Acerophagus papayae* for sustainable management of papaya mealybug, *Paracoccus marginatus*

Parasitization potential of two strains of *A. papayae* were evaluated at 35°C. Constant exposure of mealybug to high temperature severely affected the growth and development. However, the parasitoid could survive and develop in the second instar mealybugs at the same temperature. The Strain A was able to develop and emerge at 35°C. Evaluation of parasitization potential of high temperature selected *A. papayae* under net house conditions revealed that the strain A showed better efficiency in terms of parasitization and emergence. Mean percent parasitization and emergence was high in host plant papaya, the sex ratio of female to male ratio was also high in papaya and tapioca than in cotton.

Evaluation of selectivity of insecticides against different mealybug species and their major natural enemies associated with cotton, tomato, brinjal and papaya

The cultures of *Paracoccus marginatus, Phenacoccus solenopsis, Maconellicoccus hirsutus, Aenasius arizonensis, Cryptolaemus montrozerii, Acerophagus papayae* and *Chrysoperla zastrowii sillamii* were maintained under laboratory condition. Safety evaluation of 14 different insecticides against *Aenasius arizonensis* was studied by glass vial residue method. The results revealed that the insecticides *viz.*, Imidacloprid, Thiamethoxam, Profenofos, Acetamiprid, Cypermethrin, lambda cyhalothrin, Pyriproxyfen + Fenpropathrin, Clothionidin were found to be highly toxic to the parasitoids, whereas diafenthiuron and thiodicarb were less toxic.

Two mealybug species (*Phenacoccus solenopsis, Paracoccus marginatus*), and their predators *Chrysoperla zastrowii sillamii and Cryptolaemus montrouzieri* used for enzyme assay were exposed to different insecticide groups. Insecticide exposure influences the level of detoxifying enzymes present in the mealybug. The activities of detoxifying enzymes such as esterase (EST), mixed function oxidase (MFO) and glutathione s-

transferase (GST) were estimated in insecticide exposed mealybugs, *P. solenopsis and P. marginatus*. Esterase activity was significantly higher in *P. solenopsis* exposed to Diafenthiuron (9.22 µM napthol/min/mg protein) followed by Acetamiprid (8.487 µM napthol/min/mg protein) and the lowest activity was observed in *P. solenopsis* exposed to Profenofos (2.039 µM napthol/min/mg protein and Cypermethrin (2.744 µM napthol/min/mg protein). The activity of MFO was more in *P. solenopsis* exposed to Pyriproxifen + fenpropathrin(129.88 nM cyto/min/mg protein) combination products followed by Acetamiprid (67.40 nM cyto/min/mg protein). Highest activity of GST was recorded in Triazophos treated (0.0240 µmol/ml/min) *P.solenopsis. In P.marginatus*, significant increase in EST was observed in triazofos treatment (8.709 µM napthol/min/mg protein) followed by Imidacloiprid (5.782 uM napthol/min/mg protein). Increased MFO activity was noticed in Acetamiprid (99.47 nM cyto/min/mg protein) treated *P.marginatus* followed by Profenofos (85.28 nM cyto/min/mg protein). The specific activity of GST was significantly more in *P. marginatus* exposed to Cypermethrin (0.0178 µmol/ml/min) followed by Triazofos (0.0157 µmol/ml/min. However, all three target enzymes EST, MFO and GSTs were totally nil in *P. marginatus* exposed to pyriproxifen, flonicamid, pyriproxifen + fenpropathrin and diafenthiuron.

Effect of thermal stress on fitness traits of two mealybug pests, *Phenacoccus solenopsis* and *Paracoccus marginatus* and their parasitoids *Aenasius bambawalei* and *Acerophagus papayae*.

The developmental biology of mealybugs, *P. solenopsis*, *P. marginatus* under different temperature regimes *viz*., 25, 28, 30, 32 and 35°C was studied. The temperature above 32°C hamper the development of *P. marginatus*. Increase in temperature reduced the duration of pre - oviposition and oviposition period and as well fecundity of individual mealybugs. Threshold of development from egg to adult decreased gradually in both male and female insects. The threshold of development for egg and first instar was at par and it decreased in succeeding stages of development.

3.11.3: Diseases

Survey to identify the biotic and abiotic problems and cultural practices adopted by cotton growers

A field survey was conducted to understand the current cultivation practices being followed by cotton farmers and the biotic and abiotic problems being faced in North India especially sudden wilt and root rot. Survey data from 50 farmers of Rajasthan, Haryana and Punjab indicated that 94.6% of farmers have not done deep ploughing since last 5 years or more, 70% of farmers are following cotton-wheat-cotton cropping system, 48.6% of farmers have applied the first irrigation before 30 days as against the recommendation of 45-50 days after sowing. Among these, 35.1% farmers have followed all three practices- i.e. cotton-wheat-cotton cropping system, no deep ploughing and early irrigation. Twenty per cent of the farmers fields had the soil hard pan conditions, 11% have followed mustard-cotton-mustard cropping system, 5.4% fields were had high soil moisture and they were in paddy growing areas. Such fields also had the biotic problems 32.4% having root rot & nematode infection, 10.8% root rot, 8.1% root rot & termite and in 24.3% fungal foliar spots during the month of September onwards, while 29.7% cotton field were observed with the sudden wilting problem. Among the 29.7% cotton fields, sudden wilting problems during the month of September onwards were recorded associated with no deep ploughing, cotton-wheat-cotton cropping system and early irrigation (before 30 DAS), in last more than 5 years. The soil EC and pH in these fields ranged between 2.5 to 4.5 dS/m and 7.6 to 7.9 respectively. These conditions appeared to be the main reasons for parawil/sudden wilt followed by a biotic problems such as root rot, vulnerability nematodes, fungal foliar spots (71.4%), and termites/root rot (28.6%).

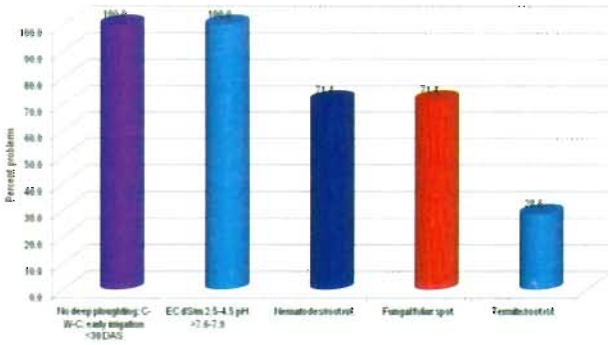


Fig. 3.11.5: Predominant factors found to be responsible for wilting in cotton fields

Sudden wilt management in cotton during water logging condition

A field experiment was conducted at CICR RS Sirsa to evaluate different treatments for the management of sudden wilt in cotton during water logging situations. Two sprays of each treatment were applied at an interval of 24 hours with first spray immediately after symptom initiation (within 24 h). The observations were recorded seven days after the second spray. Highest wilt recovery was recorded with 50 ppm sodium benzoate (75%), followed by 10 ppm cobalt chloride (56.5%) (**Fig. 3.11.6:**).

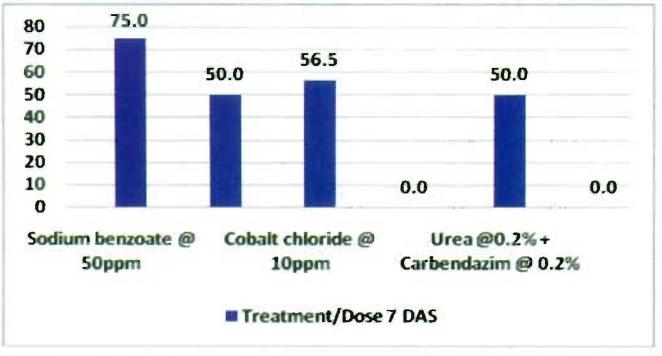


Fig. 3.11.6: Sudden wilt recovery percent at 7 days post spray

Management of root rot in *G. arboreum* and *G.hirsutum* cotton

Field experiments was conducted during 2017-18 and 2018-19 to evaluate the comparative effect of seed treatment with biological, chemical fungicides and their combination on management of root rot under sick field conditions at CICR RS Sirsa. Twelve biological and chemical treatments were applied as seed treatment on two cultivars namely CICR-2 (*G. abrobeum*) and CSH-3129 (*G. hirsutum*) grown in root rot sick field. The pooled data of two years trials revealed that the combination of seed treatment with *Trichoderma harzianum* (10g/kg), *Pseudomonas fluorescens* (10g/kg) and mycorrhiza (20g/kg) gave the highest root rot reduction over control in both the cultivars (57.5 and 51%) upto 60 days after sowing. Next best treatments were seed treatment with *T. harzianum* and combined application of *T. harzianum* & *P. fluorescens* (**Fig. 3.11.7**).

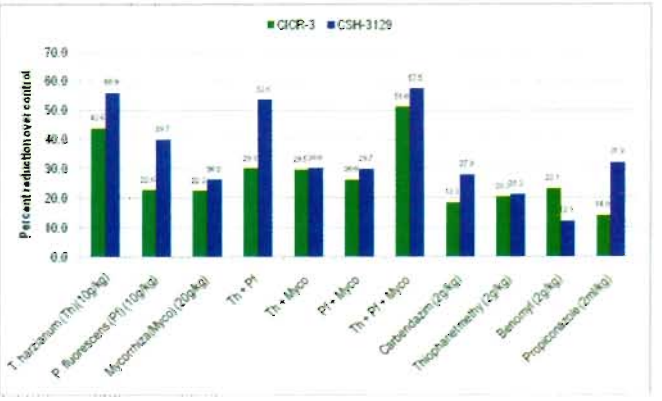


Fig. 3.11.7: Effect of seed treatment with biocontrol agents and chemical fungicide on management of root rot under sick field experiment (Pooled data) at CICR RS Sirsa

3.12: Development of new Detection Methods, Tools and Protocols

Novel method for isolation of wax degrading bacteria

A novel method for isolation of wax degrading bacteria from mealybug was standardized. The media identified was equally effective in extraction of bacteria and it is quick and labour saving. No difference in virulence of bacteria isolated from this media was recorded.

Development of a simple and low-cost laboratory rearing technique for cotton pink bollworm

A simple and inexpensive method laboratory rearing of PBW was using freshly excised green bolls (~10 d old) of cotton (*Gossypium hirsutum* L.) was developed (Figure 1). The adult females of

PBW preferred to lay eggs on the bracts and sometimes also on the bolls rind , either singly or in a group of 2-3 eggs. The larvae fed and pupated within the bolls itself. The developing larvae can be removed at any stage of their development for morphometric studies, conducting bioassays, etc. The newly formed pupae can easily be removed and maintained till adult emergence. All the biological parameters of PBW reared by this method were reasonably comparable with literature reports on its rearing using different natural and artificial diets. The egg hatching and adult emergence were 89.9 ± 3.6% and 92.3 ± 2.3%, respectively with a mean fecundity of 203.7 ± 38.8 per female and a mean generation time of 34.4 ± 0.6 days. The insect raised by this method retained its ability to infest field grown cotton. Up to five generations of PBW could be raised by this method. This method is easily applicable and less expensive, and it would be highly useful in understanding the impacts of climate change on *P. gossypiella* phenology mediated through alterations and or aberrations in nutritional status of its host crop i.e. cotton **Fig.3.12.1**.

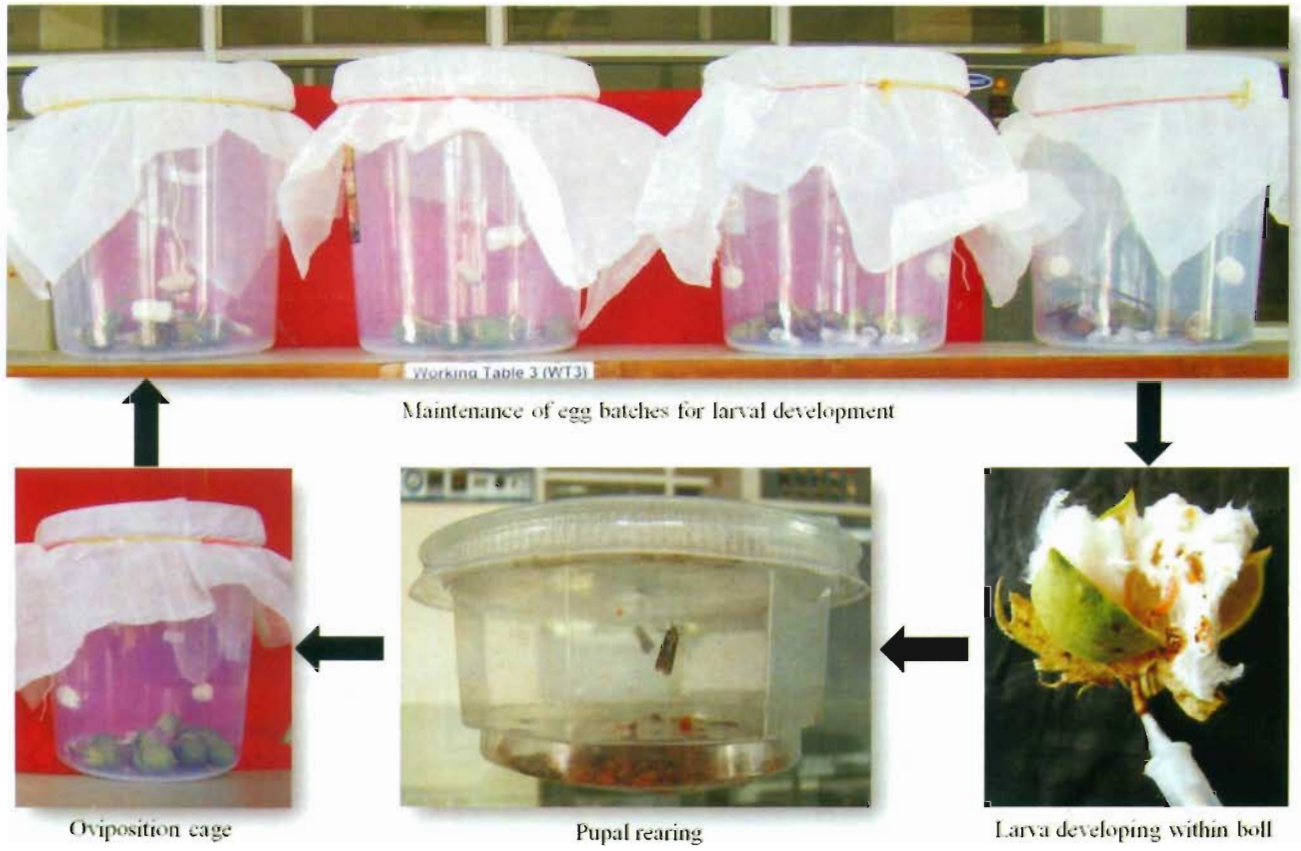


Fig. 3.12.1: Laboratory rearing of PBW on detached green bolls of cotton

4. TECHNOLOGIES ASSESSED AND TRANSFERRED

4.1: Varieties released

4.1.1: Central Cotton CCH 12-2 (Suchitra)

The high yielding good quality variety Suchitra has been released for commercial cultivation in Central Zone States of Gujarat, Maharashtra and Madhya Pradesh under irrigated conditions during December, 2018. The variety recorded a mean seed cotton yield of 1767 kg/ha as against 1644 kg/ha of the Zonal check variety. However, the yield potential of the variety is 2598 kg/ha as has been recorded in the Preliminary Variety Trial at Junagadh centre during 2014-15. The long staple variety has an Upper Half Mean length of 28.0 mm, Micronaire of 4.2 and tenacity of 29.0 in HVI mode and is capable of spinning to 30s count yarn. The variety has a mean boll weight of 3.7 g/boll and it showed at par incidence majority of pest and diseases check varieties. The variety was tolerant to grey mildew and moderately tolerant to jassids. The new variety combines high yield potential, big boll size and basic tolerance to pests and diseases and the farmers will be highly benefitted by cultivating this genotype.

4.1.2: Central Cotton CCH 4474 (Subhiksha)

The high strength good quality variety Subhiksha has been released for commercial cultivation in South Zone States of Karnataka, Andhra Pradesh and Tamil Nadu under irrigated conditions during December, 2018. It recorded a mean seed cotton yield of 1542 kg/ha as against 1305 kg/ha of the Zonal check variety Surabhi under conventional spacing in AICRP multi location trials with 24.7 per cent yield increase over check varieties. However, the variety was found to be compact and yielded better under closer spacing as evident in agronomic trial with to yield as high as 3325 kg/ha at Coimbatore and 4201 kg/ha at Guntur. In the large scale demonstration trial at ICAR-CICR, Regional Station, Coimbatore, the variety recorded higher seed cotton yield of 2800 kg/ha during 2015-16 and 2640 kg/ha during 2016-17 with good fibre quality as compared to the other long staple varieties viz., Surabhi and Suraj.

The variety recorded a mean Ginning Out turn of 35.4% as against 32.2% of the zonal check variety Surabhi. Because of the higher ginning out turn, the variety has recorded 38% higher lint yield over the zonal check variety. The variety has a 2.5 % Span length of 32.4 mm, Micronaire of 3.6 in the spinning test in ICC mode and Upper Half Mean Length of 32.7 mm, Micronaire of 3.7 and Tenacity of 33.8 g/tex in the spinning test in HVI mode and was found to spin up to 60s count yarn. The variety showed of pest and diseases at par with incidence vis-à-vis check varieties and showed field tolerance to jassids.

4.2.: On Farm Demonstration

During 2018-19, on farm demonstration of cotton variety Suraj with all recommended technologies of CICR and Bt cotton hybrid Mallika Bt BG II (half an acre each) were conducted at Coimbatore.

- Variety Suraj with all recommended technologies of CICR yielded 2081 kg/ha and the Bt cotton hybrid Mallika Bt BG II gave 2062 kg/ha of seed cotton yield.

- Around 1438 visitors viz., Scientists, Extension officials, Farmers, Farm women, Research scholars and Students visited the institute and the demonstration plot.

Fig 41. On farm Demonstrations: Coimbatore

4.3: Front Line Demonstrations

4.3.1: Nagpur

One hundred cotton FLDs on Integrated Crop Management (ICM) and remunerative intercropping systems in Bt cotton was conducted in the districts of Wardha and Nagpur in Vidaharbha—region of Maharashtra. Under ICM, Bt cotton hybrid H8 and in intercropping systems Moong var Utkarsha in between Bt cotton rows was demonstrated. Adopted farmers harvested seed cotton yields between 741-1976 kg/ha with an average yield of 1411 kg/ha under ICM cotton FLDs whereas it was 617 to 1729 kg/ha with an average yield of 1095 kg/ha under farmers' practice. Under remunerative intercropping systems in Bt cotton v/s sole Bt cotton, the yields ranged from 741 to 2779 kg/ha with an average yield of 11293 kg/ha of cotton while the intercrop moong yields ranged from 12 to 154 kg/h with an average yield of 70 kg/ha. Continuous rains during July affected intercrops adversely. Also early termination of rains in the second week of September affected the cotton crop.

4.3.2.: Sirsa

Front Line Demonstrations (FLDs) of ICM on *Gossypium hirsutum* varieties CSH-3129 (67.5 x 30 cm normal spacing) on 20 hectares and CSH 3075 (67.5 x 10 cm under HDPS) on 40 hectares were conducted in the cotton growing districts of Punjab, Haryana and Rajasthan.

Average seed cotton yield of 40 FLD's (one acre each) on CSH-3129 was 2,154 kg/hectare with a cost benefit ratio of 1.99. Whereas average seed cotton yield of Bt hybrids at farmers' field was 2,115 kg/hectare with accost benefit ratio of 1.74. The additional monitory benefit in the demonstrations was Rs 2067/- per ha.

Average seed cotton yield of 90 FLD's (one acre each) on CSH-3075 (HDPS) was 2,088 kg/hectare with a cost benefit ratio of 1.92. Whereas average seed cotton yield of Bt hybrids at farmers field was 2,013 kg/hectare with a cost benefit ratio of 1.66. The additional monitory benefit by growing CSH-3075 under HDPS system was Rs 3975/- per ha.

4.3.3.: Coimbatore

Fifteen NFSM-FLD demonstrations in 43 farmers' fields were conducted in Ariyalur district during winter irrigated season. The technologies demonstrated were cotton variety Suraj, Integrated Weed Management, Integrated Nutrient Management and Integrated Pest Management in cotton. The average seed cotton yield obtained was 1275 kg/ha as against the average yield 970 kg/ha under farmers' practice. Similarly, ten demonstrations on cotton variety Suraj with intercrop black gram were conducted in 25 farmers' fields in Senthurai taluk of Ariyalur district. The average seed cotton yield obtained was 1298 kg /ha seed cotton yield with 156 kg/ha intercrop yield in FLDs and 1043 kg/ha seed cotton yield in farmers'

practice of cultivating cotton alone.

During the summer irrigated season, 10 demonstrations on cotton variety Surabhi conducted in twenty five farmers' fields of Vennanthur block of Namakkal district in Tamil Nadu. The technologies viz., Integrated Weed Management, Integrated Nutrient Management and Integrated Pest Management, application of growth regulators and soil test based fertilizer recommendation are being demonstrated in 25 farmers' fields.

Fig 40. Front Line Demonstrations: Coimbatore

4.4: Implementation of TSP

Under Tribal Sub Plan (TSP), High Density Planting System (HDPS) technology for cotton was demonstrated to 20 tribal farmers in village of Umred Taluka, Nagpur district under MGMG.

On-Farm training/advice was given to the tribal farmers during crop season from time to time in 6 adopted villages (Dhwalapur (Gram Panchayat), Narhar, Kolitmara (Gram Panchayat), Ambazarighat, Saleghat and Ghatpendri of Parsheoni tehsil through Institute's farmer outreach programme Mera Gaon Mera Gaurav (MGMG). Inputs like Seeds of Public sector Bt hybrid Cotton G. Cot Hy8 Bt alongwith Red Gram and Cluster bean were distributed to 103 Tribal Farmers in 6 villages. TFL seed production of cotton was taken up for non-Bt varieties like Suraj, LRK 516, NH 615, PKV 081, Phule Dhanvantari & AKA-7 in Participatory mode in 21 acres including 6 tribal Farmers. The necessary inputs were timely provided from TSP fund under NSP. They were trained in various aspects of Cotton Seed Production including maintenance of isolation distance, rouging and other care to be taken during seed production. Most of the area is rainfed hence the yields were minimal and also flood like situation during rainy season reduced the yields. The yields ranged from 6 q/acre in *G.hirsutum* varieties and 7 q per acre in *G.arboreum* variety. It was noticed that farmers were satisfied with the seeds of supplied cotton varieties and are volunteering to take up cotton seed production. As per MOU, they have been paid 10% extra for seed cotton over the market price prevailing during that time.

4.5:Insecticide Resistance Management: Dissemination of Pink Bollworm Management Strategies

"Insecticide Resistance Management: Dissemination of Pink Bollworm management strategies" under Centrally sponsored scheme on "NFSM: Commercial Crops" was implemented during 2018-19. ICAR-CICR, Nagpur served as the Nodal Institute for implementation and overall coordination of the project through 100 State Agricultural Universities and KVKs in 105 villages covering 21 districts from seven selected major cotton growing States of the country. The major outputs of this programme were

- Skill Enhancement of 1050 beneficiary farmers, input dealers, and other stakeholders
- Reduction in pink bollworm damage by 70% due to timely interventions and integrated management approach
- Increased cost: benefit ratio (1:2.16) for IRM adapted farmers
- Improvement in quality of cotton for textile industry
- Reduced environment health hazards

4.6: Mera Gaon Mera Gaurav

Mera Gaon Mera Gaurav is being implemented by ICAR- CICR Nagpur and its Regional Stations ICAR-CICR, Coimbatore and ICAR-CICR, Sirsa as per the guidelines. The Scientists remained in touch with the adopted villages and provided information to farmers on technical and other related aspects in the time frame through personal visits to hasten the process of Lab to Land. During the year the programme was implemented in 71 adopted villages in 14 clusters (nine, four and one from Nagpur, Coimbatore and Sirsa respectively). Dr S. M. Wasnik, Principal Scientist, Extension as a Nodal Officer Coordinated the MGMG activities implemented by scientists in clusters of adopted villages.

Broad areas of activities undertaken

- Field crop demonstrations on tribal farmers fields
- Extending technical advices on integrated cotton production to the farmers of adopted villages
- Monitoring of insects/pests, updating with latest measures of controlling diseases and insect pests of major crops of locality
- Delivering need based weekly mobile advisory also to the farmers registered with Institute e-Kapas/Communication advisory system
- Organising meetings/ Gosthies at villages
- Providing literature support to farmers
- Creating linkages with other Departments/ Organizations/NGOs
- Updating farmers about soil health card importance
- Creating awareness about Pradhan Mantri Fasal Bima Yojana
- Providing technical inputs related to Goat farming for better farm profitability
- Creating awareness about cleanliness of village premises

Demonstrations at farmer's fields

During kharif 2018-19, one packet (450g each) of Bt Cotton hybrid (H-8) BGII seeds was given to 250 farmers of Nagpur and Wardha district of Maharashtra for demonstrations in tribal farmers fields of Umred (Nagpur), Samudrapur (Wardha), Parshivani (Nagpur), Hingna (Nagpur), Ganeshpur (Wardha), Nandura (Wardha), Kalmeshwar (Nagpur), Navegaon (Nagpur) and Dongargaon (Nagpur) clusters. During the crop season, pheromone traps were also distributed to the farmers for monitoring of pink bollworm infestation, Awareness camps were organised for the management of pink bollworm. Weeds were severe in shallow soils and most difficult to control even after using herbicides. Farmers were satisfied with the performance of Bt Cotton Hybrid H8 BGII as it gave yields ranging from 10-20 q/ha. Pheromone traps and implementation of plant protection strategy was effective in management of pink bollworm during the cropping season.

S. No.	Name of activity	No. of activities conducted	No. of farmers participated & benefitted
1.	Visit to villages by teams	35	1289
2.	Interface meeting/ *Goshthies*	50	2159
3.	Training organized/ workshops	25	2750
4.	Demonstrations conducted	250	250
5.	Mobile based advisories (No of message)	39	6950
6.	Literature support provided (No)	8	1600
7.	Awareness created (No)	19	1810
8	Linkage developed with other agencies	6	8775
9	Facilitation for new varieties	36	36
10.	Other, if any	1	25
	Encouraged farmers to participate in Kisan Samriddhi Mela organised by ICAR during 24 - 26th August, 2018 at CODISSIA Trade Fair Complex, Avinashi Road, Coimbatore		Mr. Selvaraj from Allapalayam Village was bestowed with best farmer award during the Mela
	Total	**454**	**25644**

Other activities:

The various teams organised interactive meets with farmers to have Scientists – farmers interface on the issues i.e. soil health management, crop residue composting, weed and nutrient management, whitefly management in Sirsa locations, mobile based advisories under e-kapas/ communication, Cotton IPM & Package of Practices, fertilizers applications, plant protection, physiological disorders, various pests and disease management options, technologies on flowering and post pink bollworm management and parawilt management in cotton, workshops also held on integrated management of pink bollworm. The other various activities organised are given in **Table 1.**

Girad Cluster

Ganeshpur Cluster

Hingna Cluster

Dongargaon Cluster

Parsheoni Cluster

Sirsa Cluster

Coimbatore Cluster

5.1: Update on student research

5.1.1 : M.Sc. Students/ Ph.D Students

Nagpur

Name of Student : Mr. Swapnil B. Matikhaye

Advisor Name : Prof. (Dr.) P. W. Ramteke

Name of Co-advisor : Dr. J. H. Meshram

Title of thesis: "Screening of cotton germplasm accessions for drought stress tolerance using (Polyethylene glycol) PEG- 6000 and acetic acid"

Abstract: Pot experiments were conducted in the ICAR- Central Institute of Cotton Research (CICR), Nagpur to study the "Screening of cotton germplasm accessions for drought stress tolerance using (polyethylene glycol) PEG- 6000 and acetic acid". Genotypes of *G. hirsutum* with 12 different lines were selected (6 susceptible and 6 tolerant) and studied by giving stress in two different experiments consisting of (exp-1) treated with acetic acid, water spray, control and (exp-2) PEG-6000 at 5%, 10%, 15% and control. The dosage given to seeds along with control were evaluated for their morpho-physiological growth, and biochemical parameters under laboratory and pot conditions. The study revealed (experiment 1), there was an increase in plant height, no. of flowers/plant, no. of squares/plant, leaf temperature, stomatal density, relative water content. Biochemical parameters such as chl-a, chl-b total chlorophyll content, proline (µg/g), protein (µg/g), SOD, leaf epicuticular wax, leaf potassium and catalyze. In experiment 2, it was observed that out of PEG-6000 with 10% concentration was suitable and best compared to other two different concentrations (5% &15%) and control. It was found that increasing concentration of PEG resulted in a decrease in overall parameters of the crop. The parameters which were favourable including germination percentage, root length, shoot length and root to shoot ratio increased even under drought conditions at 10% concentration of PEG treatment. But we found to be declined while the concentration increased.

Name of Student : Mr. Satish Achutrao Raut

Advisor Name : Prof. Dr. (Mrs.) E. P. Lal

Name of Co-advisor : Dr. J. H. Meshram

Title of thesis : "Effect of mepiquat chloride on cotton shoot and root growth behavior"

Abstract : The growth regulator mepiquat chloride (1, 1-dimethyl-piperidinium chloride) is globally used in cotton (*Gossypium hirsutum L.*) for canopy manipulation to avoid excess vegetative growth. The pot study (Experiment 1) and laboratory study (Experiment 2) was conducted at ICAR-CICR, Nagpur during 2018 to study the effect of mepiquat chloride (MC) on cotton shoot and root growth behaviour". The experiment was arranged in a randomized block design with seven treatments and four replications. In Experiment 1, T_0 was control, T_2, T_3, T_4, T_5 and T_6 (7.5, 15, 22.5, 30, 37.5 and 45 g a.i. ha^{-1} respectively at 45 DAS) and for second experiment T_0 was control, T_2, T_3 and T_4 (200, 300, 400 and 500 mg $litre^{-1}$ seed soaked in MC solutions for 12 hours), respectively. Foliar application of MC @ 45 g a.i ha^{-1} (T_6) significantly reduced plant height, height to node ratio, sympodial branches, number of square $plant^{-1}$ and shoot fresh weight, while main stem node, stem diameter, leaf area, shoot dry weight also reduced in same concentration of mepiquat chloride as compared to control. Root length and root dry weight increased in treatment T_6 (45 g a.i ha^{-1}) significantly. Biochemical parameter like starch content and nitrate reductase activity was significantly higher in treatment T_4 (30 g a.i ha^{-1}) compared to control while chlorophyll content (a, b and total) was significantly higher at same concentration at 15 DAT compared to control. In experiment 2, seed soaking in MC solution for 12 hours, @ 500 mg $litre^{-1}$ (T_4) reduced shoot length and significantly increased shoot and root fresh weight compared to control while in treatment T_2 (300 mg $litre^{-1}$) number of lateral roots increased significantly compared to control.

Name of Student : Mr. Dinesh Kumar Sahu

Advisor Name : Dr. P.K Shukla

Name of Co-advisor : Dr. A. Manikandan

Title of thesis : Studies on Morpho-Physiological Characteristics of Cotton (Gossypium sp.) Under Artificial Salt Stress Conditions

Abstract: Salinity induces several stresses in cotton, however, the sodium chloride (NaCl) induced physiological changes in cotton has not been studied. A pot study using NaCl as an artificial stress inducer was conducted to understand the morphological and physiological changes in cotton due to exogenous application of NaCl. The pot study was conducted at ICAR-CICR, Nagpur during summer-2018. Six cotton cultivars (G Cot 25, Jayadhar, Phule Dhanwanatry, Roja, Suraj and LRA-5166), belonging to *G.hirsutum*, *G.herbaceum* and *G.arboreum* species were compared at different NaCl concentrations (100 mM, 150 mM, and 200 mM) along with a standard control. The experiment was arranged in a factorial randomized block design with three replications. In morphological parameters, the NaCl treatment was found to affect seed germination, shoot and root length, salt injury index, seedling vigour index, leaf area, number of leaves, squares, flowers, sympodial branches and plant biomass, while the root:shoot ratio and number of monopodial branches were unaffected. G-Cot 25 adapted better to salt concentrations as compared to other cotton species. In general, the biochemical and physiological parameters got affected by the salt concentrations. Higher salt concentrations reduced the chlorophyll (a,b and total), carotenoids, protein, nitrate reductase activity and relative water, while salt in higher concentrations increased total soluble sugar content in the leaves. Among the cultivars, Jaydhar showed improvement in biochemical and physiological functions under high salinity conditions. Among the antioxidants, proline, peroxidase and superoxidase dismutase activity increased with NaCl concentrations, while the catalase showed decrease activity. Higher salt concentrations increased the uptake of and Cl^- ions in the leaves, while the ions such as NA^+, $MG^{2}+$, and K^+ uptake declined with increased in salt concentrations. Higher salt concentrations (NaCl - 200 mM) negatively affects the cotton morphology and physiology. However, the tested cotton cultivars showed morphological and physiological adaptations in response to the salt concentrations. Among the cotton cultivars, G-Cot 25 and Jayadhar (*G. herbaceum*) adapted better to the salinity conditions as compared to Suraj, LRA-5166 (*G. hirsutum*) and Phule Dhanwantary and Roja (*G. arboreum*).

Name of Student : Mr. Himanshu Kumar

Advisor Name : Dr. S. A. John

Name of Co-advisor : Dr. Pooja Verma

Title of thesis: "Evaluation of elicitors for physio-biochemical changes in relation to drought stress in cotton"

Abstract: Water stress causes detrimental effects on plant growth and development, which are likely to alter their physio-biochemical activities. The study was conducted to assess the role of seed priming effects of elicitors; methyl jasmonate and paclobutrazol in cotton by means of studying the physio-biochemical changes which gets altered under drought stress condition including some of the gene expression analysis. Investigations were carried out in two cotton genotypes DTS-155 (drought tolerant) and IC-357055 (drought susceptible) under pot condition. Standardization of the dose and time of application of two respective elicitors methyl jasmonate and paclobutrazol was initiated in the preliminary experiments, where priming of elicitors with different concentrations; 50mM, 100mM, 150mM, and 200mM for different time intervals 1.5 h and 2.5 h was performed separately. Based on the germination, seedling growth and vigour (fresh biomass), seed-priming with 150 mM with 1.5 hour time interval was found to be the best. Results of biochemical and physiological parameters confirmed that there was an increase in RWC, SMC, total antioxidant activities, chlorophyll, SOD, catalase and proline, while there was a decrease in level of lipid peroxidation under drought stress in both the genotypes. Whereas comparing the priming treatments, methyl jasmonate presented better results in improving the tolerance under drought stress. It was further confirmed with gene expression studies where we did expression analysis of major photosynthetic

genes (Rub-S, & Rub-L) and one drought responsive gene (osmotin). The transcript abundance of osmotin & Rub-L was found to increase under drought stress in both the genotypes and it was highest in methyl jasmonate primed samples under stress. Seed priming effect of cotton with methyl jasmonate was better as compared to others, which can be utilized further to improve the drought tolerance in cotton.

Coimbatore

Name of Student: Dr. S. A. Ramyabharathi

Advisor Name: Dr. B. Dhara Jothi

Student Project: Exploring the potential of biofilm forming PGPR with cuticle degrading entomopathogenic fungus for the management of root rot (*Rhizoctonia sp.*) and American boll worm (*Helicoverpa armigera*) in cotton - NPDF under SERB. Twenty isolates of Beauveria bassiana were collected and isolated from different ecosystems of Tamil Nadu. All the isolates of *B. bassiana* showed pathogenicity towards American bollworm (*Helicoverpa armigera*) with varied percentage of mortality ranging from 70 to 100%. Cotton plants showing typical root rot symptoms were collected from five conventional cotton growing areas viz., Coimbatore, Srivillputhur, Salem and Erode districts of Tamil Nadu and the pathogenic isolates were isolated and purified. Totally 55 strains of bacteria were isolated from rhizosphere soils of cotton from Coimbatore, Virudhunagar, Erode, Madurai and Salem districts of Tamil Nadu. All the 55 strains were tentatively identified as *Bacillus sp.* Among these 55 strains, 15 strains were found to be effective against *M. phaseolina*.

5.2: Training and Capacity Building

5.2.1: Training Received

International

Name of the Scientist	Name of the course/training	Place	Period
Dr. Meshram J.H.	Best Production Practices for Yield Enhancement	International Cotton Advisory Committee (ICAC), Washington D.C, USA	10-20, Sept., 2018

National

Scientists:

Sr. No	Name	Training	Place	Period (Days)
1.	Dr. M. Saravanan	Analysis of Experimental Data	ICAR - NAARM, Hyderabad	6-11, Sept., 2018 (6 Days)
2.	Dr. S. M. Palve	Quality Evaluation of Cotton	CIRCOT, Mumbai	24-26Sept., 2018 (3 Days)
3.	Dr. Vinita Gotmare	Leadership and Organization Development for Women Scientist / Technologist	Centre for Organization Development, Madhapur, Hyderabad	8-12, Oct., 2018 (5 Days)
4.	Dr. P. Valarmathi	Facets in biopesticide and botanical formulation production	TNAU, Coimbatore	28 Nov., to 18, Dec., 2018 (21 Days)
5.	Dr. Anuradha Narala	"Impact assessment of Agricultural Research and Technologies"	ICAR - NAARM, Hyderabad	4-7, Dec., 2018 (4 Days)
6.	Dr. V. Chinna Babu Naik	DNA - Bar-coding and Bioinformatics Applications in Entomology	ICAR- National Bureau of Agricultural Insects Resources, Bangalore	25 Feb., to 3 Mar., 2019 (7 Days)
7.	Dr. Bhargavi B	Professional attachment training for ICAR scientists	ICRISAT, Patancheru, Hyderabad	19 Nov, 2018 to 21 Feb., 2019

Technical Staff:

Sr. No.	Name	Training	Place	Period (Days)
1.	Dr. U. A. Nandankar	Farm Management	ICAR-IIFSR, Modipuram	14-20, Sept., 2018 (7 Days)
2.	Mrs. Swati Dixit	J Gate @ CeRA Regional Ambassador Training Program	Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan	5,October 2018 (One Day)
3.	Dr. P. B. Deulkar	Strategies to overcome the challenges in diseases, nutritional and management practices for poultry production	Centre of Advanced Faculty training in Avian Science (ICAR), Veterinary College and Research Institute, Namakkal, TN	6-26, February 2019 (21 Days)
4.	Mr. S. N. Ingle	Automobile Maintenance, Road Safety and Behavioral Skills	ICAR-CIAE, Bhopal, MP	19-25, Feb., 2019 (7 Days)
5.	Mrs. Chetali Rodge	KOHA for Library Staff of ICAR	ICAR-NAARM, Hyderabad	21-26, Feb., 2019 (6 Days)
6.	Dr. H. B. Kumbhalkar	Motivation, Positive Thinking and Communication Skills for Technical Officers of ICAR (T-5 and above)	ICAR-IISWC, Dehradun	13-19, Mar., 2019 (7 Days)

Administrative Staff:

Sr. No.	Name	Training	Place	Period
1.	Mr. Manas Aswal	Organization Specific Programme (OSP) for newly recruited Assistants of ICAR Institutes	ISTM, New Delhi	14 May to 8 Jun., 2018 (26 Days)
2.	Mr. Sanjay Kumar	Organization Specific Programme (OSP) for newly recruited Assistants of ICAR Institutes	ISTM, New Delhi	11 Jun. to 6 Jul., 2018 (26 Days)
3.	Mr. S. S. Chalkhure	"Enhancing Efficiency and Behavioral Skills" of PA/PS/Steno	ICAR - CIFE, Mumbai	24-29, Sept. 2018 (6 Days)
4.	Mr. Praveen Ambade			

5.2.2 Training Imparted

Students:

Scientists of ICAR-CICR imparted hands on training to the following students to upgrade their skills.

Sr. No	Name	Training Co-coordinators & Supervisors	Duration	Topic	University
1.	Ms. Ankita Dilip Gedam	Dr. Mrs. J. Amudha	15 May to 30 Jun., 2018 (45 Days)	Hands on training on Basic Plant Biotechnology techniques like PCR, ELISA and DNA isolation	RTMNU, Nagpur
2.	Ms. Shubhangi Ramkrushna Ghodichor				
3.	Ms. Ashwini Anil Umale				
4.	Ms. Kalyani Onkarrao Ganorkar				
5.	Mr. Siddharth Prashant Bagde	Dr. K. P. Raghvendra	1 Dec., 2018 to 30 Apr., 2019 (Five months)	Hands on Training cum research project on Plant Biotechnology	College of Agricultural Biotechnology, Vidyanagar, Baramati, Dist-Pune, Maharashtra

Skilled supporting staff

Sr. No	Name of Training	Organized by	Total no. of participants	Date of Training
1.	Skill Upgradation training program for skilled support staff of ICAR-CICR, Nagpur	Human Resource Development (HRD Cell), ICAR-CICR, Nagpur	29	13-15 Feb., 2019 (3 Days)

5.2.3: NFSM sponsored collaborative training of DCD (GOI)

One day National Food Security Mission (NFSM) - Commercial Crops sponsored collaborative training programme of Directorate of Cotton Development (DCD) was organized by ICAR-CICR Nagpur on 29th March, 2019 for cotton farmers of Nagpur district. Sixty farmers from Nagpur district attended the training and acquainted about Bt varieties, integrated pests, diseases, weeds management, safe use of pesticides and e-communication dissemination system. Lab visits and question-answer session was also held. Farmers showed keen interest in ICAR-CICR technologies. Dr S.M. Wasnik Principal Scientist (Extension) coordinated the activities.

5.2.4: Farmer Workshop/Training Conducted:

Name of Workshop/ Trainig	Place	Date	No. of Beneficiaries
Nagpur			
Integrated Management of Pink bollworm, FLD seed distribution programme and "Beejmohostav"	Magan Sangrahalaya, Natural Farming Development Center, Girad, Dist. Wardha.	5 Jun., 2018	500
Importance of maintaining isolation distance and rouging in Cotton Seed Production and use of pheromone traps for Pink Boll worm Management	Dhwalapur (Gram Panchyat), Narhar, Kolitmara(Gram panchyat), Ambazarighat, Saleghat and Ghatpendri of Parsheoni tehsil	July, 2018	27
Integrated Management of Pink bollworm (under TSP and MGMG)	Magan Sangrahalaya , Girad Tal. Samudrapur, Dist. Wardha	31 Jul., 2018	80 farmers
Awareness camp on PBW Management in Cotton (IRM-PBW Project)	Gram Panchayat Sabhagruha, Temurda, Warora, Chandrapur	25 Aug., 2018	125
Pink bollworm management training ((IRM-PBW Project))	Warora, Chandrapur	15 Sept. 2018	150
Integrated management of pink bollworm in cotton	Talegaon Thakur Village, Tivsa Amravati	27 Sept. 2018	50
One day Farmer's field training	Warora, Chandrapur	2 Nov., 2018	200
Mill and Ginners training	Warora	4 Feb., 2019	1000
Farmer's fair cum workshop on Integrated Management of Pink bollworm	Natural farming development Centre, Magan Sangrahalaya Girad Dist. Wardha.	4 Dec., 2018	650
Farmers Field Training IRM : Dissemination of Pink Bollworm Management Strategies	Vadaputhur Village	15 Dec., 2018	60 farmers
Coimbatore			
Farmers, Field Training	Vadaputhur Village, Coimbatore	15 Dec. 2018	60
Management of *Paracoccus marginatus*in cotton, tapioca and papaya with temperature tolerant Encyrtid parasitoid, *Acerophaguspapayae*" under the DST-SEED	ICAR-CICR, Regional Station, Coimbatore	31 Jan., 2019	51 farmers
Farmers' Mela	Vadaputhur village, Kinathukadavu	08 Mar., 2019	60 farmers
Sirsa			
Field day on cotton	ICAR-CICR Sirsa	25 Oct., 2018	70 farmers
Cotton production and protection technology (champion farmers adopted by Bayer Crop Sciences)	ICAR-CICR Sirsa	16-21, Apr. 2018	360 champion farmers
Training for Supervisors of Agriculture Department	ICAR-CICR Sirsa	02 Jul., 2018	
Collaborative cotton training programme (with Ichiban Crop Sciences)	ICAR-CICR Sirsa	16 Jul., 2018	100 progressive farmers

Name of Workshop/ Trainig	Place	Date	No. of Beneficiaries
In service training on Survey & Surveillance for Agriculture officers of Haryana (ATM/BTM/ADOs/SMS/APPOs)	ICAR-CICR Sirsa	24-25, Jul., 2018	60
Exposure visit cum training of Ambuja Cement Foundation (BCI) from Punjab and Rajasthan	ICAR-CICR Sirsa	24 Oct., 2018.	38 Scouts

Farmers' Field Trainings under IRM : Dissemination of Pink Bollworm Management Strategies

Student Educations tour and field visit

Nagpur:

Sr. No	College / School Name	No. of students	Class	Date
Nagpur				
1.	Smt. Anusaya Meghe Agriculture College, Bhugaon, Dist. Wardha, Maharashtra	53	B. Sc. (Agri.)	7-6-2018
2.	Manoharbhai Patel College of Agriculture, Hiratola, Tah-Goregaon, Dist-Gondia, Maharashtra	120	B. Sc. (Agri.)	23-07-2018

Sr. No	College / School Name	No. of students	Class	Date
3.	Ramkrishna Bajaj College of Agriculture, Pipri-Wardha, Maharashtra	102	Rural Agriculture Work Experience (RAWE)	11-10-2018
4.	St. Vincent Pallotti College of Engineering & Technology, Gavsi Manapur, Wardha Road, Nagpur, Maharashtra	18	B. E. (Electrical Engg.)	12-10-2018
5.	Al-Hijrah Islamic School, Nagpur, Maharashtra	41	Class 5th to 8th	24-10-2018
6.	Buty Public School, Old Kamptee Road, Kalamna, Nagpur, Maharashtra	44	Class 9th & 10th	07-12-2018
7.	Shri Mathuradas Mohota College of Science Umred Road, Nagpur, Maharashtra	32	M. Sc. Botany	14-12-2018
8.	College of Agriculture, Nagpur, Maharashtra	13	M. Sc.	09-01-2019
9.	Krishi Vigyan Kendra, Durgapur (Badnera), Dist-Amravati, Maharashtra	28	Agro Dealers, DAESI Participants	24-01-2019
10.	R. R. Lahoti Science College, Morshi, Dist-Amravati, Maharashtra	46	B. Sc.	01-03-2019
11.	Arts, Commerce & Science College, Kiran Nagar, Dist - Amravati, Maharashtra	43	B. Sc.	12-03-2019
12.	Mahatma Phule Krishi Vidyapeeth, Rahuri College of Agriculture, Nandurbar, Maharashtra	53	B. Sc. (Agril.)	18-03-2018
13.	Vasantrao Naik College of Agricultural Biotechnology, Waghapur Road, Yavatmal, Maharashtra	03	B. Sc. (Agril.)	19-03-2019
14.	Shri Shivaji Agriculture College, Amravati, Maharashtra	57	B. Sc.	27-03-2019
Coimbatore				
15.	PGP college of Agricultural Sciences, Palani Nagar, Namakkal	109 + 3 staff	B. Sc (Agri)	23.04.18
16.	Nalanda College of Agriculture	51	B. Sc (Agri)	24.04. 18
17.	Adhiparasakthi college of Agriculture, G.B. Nagar, Kalavai, Vellore district	98 + 3 staff	B. Sc (Agri)	28.04.18
18.	Agricultural College and Research Institute, Madurai	123	B. Sc (Agri)	19.06.18
19.	Priest University, Thanjavur	66	B. Sc (Agri)	21.06.18
20.	PSG college of Technology, Department of Textiles, Coimbatore	33 + 5 staff	B.Tech	07.08.18
21.	PSG college of Technology, Department of Textiles, Coimbatore	34 + 4 staff	B.Tech	09.08.18
22.	Department of Agronomy, TNAU, Coimbatore	40	B. Sc (Agri)	05.10.18
23.	Dr MSSRF, Taramani, Chennai	16	Plant doctors	24.10.18
24.	Adhiparasakthi college of Agriculture, Kalavai, Vellore district	121 + 4 staff	B. Sc (Agri)	26.10.18
16.	PGP college of Agricultural Sciences, Palani Nagar, Namakkal	54 + 1 staff	B. Sc (Agri)	26.10.18

Sr. No	College / School Name	No. of students	Class	Date
17.	Kumarakuru Institute of Agriculture, Erode	55 + 2 staff	B. Sc (Agri)	30.10.18
18.	Institute of Agricultural Technology and Regional Agricultural Research Station, Palakkad District, Kerala	49 + 3 staff	B. Sc (Agri)	30.10.18
19.	Adhiyaman College of Agriculture and Research, Krishnagiri, Hosur	103 + 4 staff	B. Sc (Agri)	31.10.18
20.	Department of Botany, University of Kerala, Trivandrum	12 + 2 staff	B.Sc	1.11.18
21.	Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore	60	B. Sc (Agri)	20.11.18
22.	Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore	60	B. Sc (Agri)	26.11.18
23.	Vanavarayar Institute of Agriculture, Pollachi	100	B. Sc (Agri)	28.11.18
24.	Don Bosco College of Agriculture, Takkolam, Vellore	15	Dip. In Agri	28.11.18
25.	Dhanalakshmi Srinivasan Agriculture College, Perambalur	58	B. Sc (Agri)	03.12.18
26.	Department of Agronomy, Tam il Nadu Agricultural University, Coimbatore	40	B. Sc (Agri)	14.12.18
27.	AC and RI, Eachangkottai, Tanjore	70	B. Sc (Agri)	22.12.18
28.	ADAC & RI, Trichy	98	B. Sc (Agri)	28.12.18
29.	Priest University, Tanjore	54	B. Sc (Agri)	05.02.19
30.	Department of Botany, Government Arts College, Coimbatore	32	B.Sc	04.03.19

Fig 44. Student Educations tour and field visit to ICAR- CICR, Regional Station, Coimbatore

6. AWARDS AND RECOGNITIONS

- Dr M.V. Venugopalan, Principal Scientist (Agronomy) was elected as Fellow of Maharashtra Academy of Sciences, Pune for the year 2018 on 31-12-2018 for his significant contribution in the field of Agricultural Sciences including Rural Engineering and Technology

- Dr. K. Rameash, Principal Scientist and Dr. K. Shankarganesh, Scientist were awarded as the Fellow of the Society of Plant Protection Sciences, ICAR -NCIPM, Pusa Campus New Delhi (2018).

- Dr.Gulsar Banu has been admitted as Fellow of Society for Bio control advancement, Bengaluru, India from 2019.

- Dr. V. Chinna Babu Naik received Vasantrao Naik Smruti Pratishthan Award 2018 awarded by Vasantrao Naik Smruti Pratishthan, Pusad, Yavtmal, Maharashtra, India for outstanding Research Contribution on Pink bollworm in India on 30-9-2018.

- Dr M.V. Venugopalan, Principal Scientist (Agronomy) received the Vasantrao Naik Gold Medal awarded jointly by Dr PDKV, Akola and Vasantrao Naik Smruthi Pratishtan, Pusad for the best oral presentation "Avenues to improve farm income from cotton under changing climatic scenario" during the XVII Shri. Vasantrao Naik Memorial National Seminar on Potential, Prospects & Strategies for Doubling Farmers' Income on 16-12-2018

- Dr. Dipak Nagrale received best oral paper presentation award for paper entitled "Biocontrol potential mediated through VOC's produced by upland cotton PGPR" in Indian Phytopathological Society (IPS), West Zone; symposium on "Current and Emerging trends in Plant Health Management"

organized during 23rd-24th August, 2018 in Goa

- Dr A. Manikandan received third Prize for Oral presentation at International Conference on Multifunctional Advanced Materials - ICMAM-2018 at Kamala Nehru Mahavidyalaya, Nagpur on 5-10-2018
- Dr. V. Chinna Babu Naik received VANHARTI Award on 30/12/2018 at Government Institutes of Arts and Social Sciences at Nagpur.
- Dr. Rishi Kumar, Principal scientist (Entomology), ICAR-CICR, Regional Station, Sirsa (Haryana) was admitted as Fellow of Cotton Research and Development Association by the Executive Council. He has been presented with certificate of recognition in the Annual Workshop of AICRP on cotton held during 9-20 April, 2018 at CCSHAU, Hisar.
- Dr. S.Gawande received Best Oral Paper Presentation Award *for* the paper entitled "RT-LAMP - a new biotechnological tool for Diagnosis of Tobacco streak virus an emerging threat to cotton growing belt of Central and South India" in National Symposium organized by Indian Phytopathological Society (IPS), West Zone, during 23rd-24th August, 2018 in Goa.
- Dr. Neelkant Hiremani awarded Best Oral presentation award for the paper 'Evaluation of cotton endophytes for biological control of diseases' presented at Western Zone Symposium of Indian Phytopathological Society on "Current and Emerging Trends in Plant Health Management during Aug. 23-24, 2018 held at Goa.
- Dr. A. Manivannan, Scientist, ICAR-CICR, RS, Coimbatore has been elected as Editorial Board Member (2018-19) for Madras Agriculture Journal, MASU, TNAU, Coimbatore and Electronic Journal of Plant Breeding by Indian Society of Plant Breeders, CPBG, TNAU, Coimbatore.
- Dr. Sunil S. Mahajan, Sr. Scientist awarded Best oral presentation for the paper 'Conservation of cotton (*G. arboreum* race *cernuum*) in North-East India: Problems and Prospects' presented at National Seed Seminar on "*Strengthening of Seed Systems in the North Eastern and Unreached Regions-Problems, Prospects and Policies*" Organised by Indian Society of Seed Technology during February 3-5, 2019.
- Dr. K. Bhagyalakshmi, Scientist awarded Best Research Paper award' for the paper '*Orobanche* menace in crop plants: Host resistance as a potential tool to control' presented at National Conference on Farmers Orientation Towards Climate Change and upgrading to sustainable Agriculture (FOCUS 2019), National College, Trichirapalli during 23-24th Feb 2019.

7. LINKAGES AND COLLABORATIONS

Linkages were established with 10 SAUs for implementation of project on Insecticide Resistance Management : Dissemination of Pink Bollworm Management Strategies 2018-19 which include Dr PDKV Akola, VNMKV Parbhani, MPKV Rahuri, NAU Surat, JAU Junagarh, RVSKVV Gwalior, UAS Dharwad, UAS Raichur, PITSAU Hyderabad, ANGRAU Guntur.8. ICAR-AICRP ON COTTON

5. TRAINING AND CAPACITY BUILDING

5.1: Training

5.1.1: Training Received

i) Participation in training (category-wise)

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

15.	Mr. Bhausaheb Naikwadi	Agrometeoroligical data collection, analysis and management	CRIDA, Hyd.	25 Jul to 6 Aug-16
16.	Mrs. Subashree K.	Competence enhancement programme for technical officers of ICAR.	NAARM, Hyd.	1-10 June-16
Administration				
17.	Mr. N.V. Dhande	Enhancing efficiency and behaviour skill of PA/PS/PRS	NAARM, Hyderabad	24-30 Nov-16
18.	Mrs. Shubhangi Kharche, Mr. N. Ramesh	Pension and other retirements benefits	ISTM, New Delhi	5-8 Sep-16

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

Skilled Supporting Staff

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

iii) HRD fund allocation and utilization

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

5.1.2: Training Imparted

International training

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

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

respective countries. Er. Majumdar, Course Leader of the programme gave detailed presentation of the agri-implements and also demonstrated these implements in the field and conducted an out-door activity to visit the farmers fields. Dr. Sandhya Kranthi, I/c Director briefed the participants about the Institutional activities and hoped that it would be useful to the participants. All the participants appreciated the training programme and thanked the organizers, the Government of India, New Delhi and their respective Governments for sponsoring their nomination for this training programme.

National Training

Nagpur

Tribal Sub-Plan

Under Tribal Sub-Plan (TSP) of NSP, 6 trainings were organized for tribal farmers in 6 villages adopted under Mera Gaon Mera Gaurav programme. They are Ladai (Lingala), Wathoda, Nimboli, Budhla of Kalmeshwar tehsil; Murdapur of Bela tehsil and Narhar of Parseoni tehsil. Nearly 2000 tribal farmers and women got benefited by these trainings.

Ladai (Lingala)

Wathoda

Narhar

Cultivation of *Desi* Cotton

A training program on *"Desi Kapus Lagwad Prashikshan Shibir"* (Training Program on Cultivation of *Desi* Cotton) for farmers of four districts was organized by ICAR-Central Institute for Cotton Research, Nagpur with the special help of Yuva Rural Association (Y.R.A.) on 28.04.2016. Around 65 farmers from different villages of Nagpur, Wardha, Amravati and Bhandara districts of Maharashtra attended the program. The function was chaired by Dr. K. R. Kranthi, Director, CICR, Nagpur while it was graced by Shri. Datta Patil (Y.R.A.). Other participants Shri Padole (Neem Foundation), Dr. Blaise Desouza, Head,

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

Implementation of Cotton FLDs

A training programme was held in Shivanphal in Girad cluster of Samudrapur tahsil of Wardha district on June 18, 2016 for undertaking cotton FLD interventions on *Desi* cotton, cotton intercropping and integrated cotton management under the aegis of AICRP on cotton. 40 Farmers were motivated for cotton intercropping system. The benefits and role played by intercrops in improving soil fertility status of soil especially cotton- cluster bean intercropping system was discussed with the farmers. FLDs trials on cotton (H-8) BG II and cluster bean were conducted in one acre plot. Dr. S. M. Wasnik, Principal Scientist Extension, coordinated the FLD activities.

Protection of cotton plant varieties and farmers Right

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

Soil Testing and Fertilizer Recommendations

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

Coimbatore

Tribal Sub-Plan

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

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

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

Sirsa

IPM/IRM under NFSM

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

Low-cost on-farm production technique of Trichoderma

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

On 25.01.2017, Dr. D Monga and Dr. SK Sain delivered talk on Trichoderma: Introduction, its uses and technique for low-cost on-farm production. The technology was also demonstrated. A total of 30 progressive farmers from eight villages, and technical persons from Art of Living Foundation were trained in this training.

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

Mera Gaon Mera Gaurav Programme

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

Maharashtra

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

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

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

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

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

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

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

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

Tumdi, Sukali, Navarmari, Lodhi panjri, Mangrul

Tamil Nadu

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

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

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

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

Haryana

Jhonpra, Alleekan, Nejadela Kalan, Rangari, Begu

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

Training to Tribal Farmers on "Enhancing Cotton Productivity"

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

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

CICR scientists trained tribal farmers of Bela under MGMG programme

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

Scientists-Farmers Interface

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

Soil Health Awareness Training

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

Tribal Farmers Meet - cum- Trainings organizes at Villages

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

Swachhta Pakhawara and Farmers Meeting at Sirsa Villages

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

6. AWARDS AND RECOGNITIONS

Awards

Fellowship of the Maharashtra Academy of Sciences

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

Fellow of Indian Society of Agronomy

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

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

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

Fellow of the Society for Bio-control Advancement

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

Young Scientist Award

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

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

Distinguished Scientist Award

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

Best paper award

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

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

Best oral presentation award

Dr N. Arunkumar, undergoing NPDF (DST-SERB) under the mentorship of Dr. N. Gopalakrishnan and Dr. J. Gulsar Banu participated and presented a paper entitled "Screening and Quantification of Microbial Surfactants Produced by Wax Degrading Bacteria Isolated from Cotton Mealybugs" in the National Symposium on Advances in Agriculture through Sustainable Technologies and Holistic Approaches (AASTHA) organized by Society for Advancement of Human and Nature (SADHNA), Solan, HP and ICAR-Central Coastal Agricultural Research Institute, Ela, Old Goa from 15 – 17, February, 2017. The research paper was adjudged as Best oral presentation.

7. LINKAGES AND COLLABORATIONS

Areas of Linkages	Institution
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 Univ., Delhi; CMERI-CoEFM, Ludhiana
HDPS and sustainable pest management strategies	Better Cotton Initiative
Desi cotton production	Yuva Rural Association

8. ICAR-AICRP ON COTTON

8.1.: Genotypes/Hybrids sponsored in AICCIP Trials (2017-18)

Name of the trial	Particulars	No. of entries
National Trials		
Br 02 (a)	IET – *G. hirsutum* – Irrigated	37
Br 02 (b)	IET – *G. hirsutum* – Rainfed	27
Br 06 (a)	IET – *G. hirsutum* – Irrigated	20
Br 06 (b)	IET – Compact genotypes – *G. hirstuum*	20
Br 12 (a)	IET – *G. barbadense*	04
Br 15 (a)	PHT – H x B	06
Br 22 (a/b)	IET – *G. arboreum* – Irrigated/Rainfed	30
Br 22 (a/b) LL	IET – LL *G. arboreum*	15
Br 22 (a/b) CC	IET - CC (*G. arboreum*)	07
Br 25 (a/b)	PHT – *desi* cotton – Irrigated/Rainfed	10
Br 32 (b)	PHT – *desi* hybrids	10

8.2: All India Coordinated Research Project on Cotton (Entomology)

Ent 1a-Preliminary screening of breeding material for their reaction to key pests of Cotton in north zone (Br 22a b), (Br 22LL), (Br 24), (Br 24LL), (Br 25), (Br 02a), (Br 06a)

Ent. 1b-Advance screening and confirmation of host plant resistance under control conditions

Ent 2-Population dynamics to develop suitable forecasting model (sucking pest) of cotton in north zone

Ent 3-Survey for key and emerging pests in cotton in farmer's field for weekly advisory

Ent 4-ETL determination for PBW based on rosette flower and boll damage

8.3: All India Coordinated Research Project on Cotton (Plant pathology)

-The following experiments were conducted at the station:

Path.1: Epidemiological studies on cotton disease:

Path 1(b): Disease progress in relation to weather factors.

Path.2: Screening of AICRP entries for disease reaction:

Path 2(a) : Screening of breeding lines for disease reaction.

Path 2 (b) : Confirmation and maintenance of disease resistant lines (2009-10).

Path.3: Management of Diseases:

Path. 3 (f): Management of sooty mould (*Capnodium* spp.) in cotton (2017-20)

8.4.:Evaluation of ICAR Bt cotton hybrids and varieties (initial and advanced) trial under unprotected conditions.

8.5.: All India Coordinated Research Project on Cotton (Crop Production)

The following experiment was conducted at the station:

PHY 3b. Stress management through use of different Osmo-protectants.

8.6: Front Line Demonstrations under NFSM – Commercial Crops

A total of 437 Front Line Demonstrations on Integrated Crop Management (ICM) on cotton, 171 Front Line Demonstrations on *Desi* / ELS cotton / ELS cotton seed production and 186 Front Line Demonstrations on intercropping with cotton were conducted by sixteen centers of ICAR - All India

Coordinated Research Project on Cotton and ICAR-CICR and its regional stations at Coimbatore and Sirsa. Main emphasis was given to the demonstrations for enhancing the production of cotton in low productivity areas / problematic areas. Altogether, 1563 farmers participated in demonstrations conducted in an area of 794 hectares. A total of 314 SC/ST farmers, 354 OBC farmers and 149 farmwomen were benefitted. **In all the centers, the FLDs could obtain more yield than the local farmers' practices.** A total of 238 visits by the Scientists, 94 farmers' meetings, 20 field days and 42 awareness programs were conducted to popularize the cotton production technologies among the growers.

Fig 45. Project Coordinator interacting with FLD cotton farmers of PAU, Faridkot

Fig 46. FLD conducted by ICAR- CICR, Nagpur

Fig 47. FLD conducted by ICAR- CICR, Sirsa

Fig 48. FLD conducted by ICAR- CICR, Coimbatore

9. KRISHI VIGYAN KENDRA

On Farm Trials (OFT)

Veterinary Science

- **Supplementation of probiotics (*Saccharomyces cervisiue*) to pre-ruminant crossbreed calves**- 20gm of probiotic was fed to 30 pre-ruminant crossbreed calves in addition to their daily milk and feed intake for 90 days. Result revealed increase in body weight and feed intake of treated calf with lowered incidence of scours than local check.
- **Supplementary feeding for improving production performances of lactating does.** 150gm of concentrate feed was supplemented for 3 months in the diet of 30 lactating does which was maintained by extensive method by 15 farmers. Results indicated an increase in average body weight and milk yield with cascading increase in pre-weaned body weights of kids.
- **Inclusion of 100gm flax in diet of pre-partum cross bred cows-** 100gm of flax included in the diet of pre-partum cows which resulted into increase in milk yield, reproductive performance, conception rate and early onset of estrous after parturition.
- **Evaluation of fodder hybrid napier-** Two varieties of hybrid napier i.e. DHN-10 and BHN-6 was compared with local prevalent variety CO-4 on 12 farmers field on 9 ha area. The evaluated varieties outyielded the check in terms of plant height, no. of tillers/dump and green fodder yield.

Home Science

- **Assessment of Cotton Pellets: An alternative cooking fuel-** Food cooked through cotton pallets is cost effective and eco-friendly by 49% & 58% respectively
- **Assessment on management of PEM among preschoolers (3-6 yrs) by supplementation with recommended protein foods-** Combination of Regular diet + Anganwadi food supplement + soya *poha* laddu (30 g/ child/day for 3 months) increased height; Hb % and head circumference

Front Line Demonstrations

Livestock Enterprises conducted in villages of Ramtek tahsil of Nagpur district

1. Feeding of 50gm of area specific mineral mixture to cows- Results of 30 demonstrations conducted in 15 farmers' fields indicated a 5.91% increase in milk yield, 7.31% increase in fat content and a 100% conception rate

2. Supplementation of mineral lick block to the local goats- Results of 40 demonstrations conducted in 10 farmers' fields indicated a 17.1% weight gain and 11.2% increase in milk yield

3. Administration of single dose oral-ecteno-parasiticidal drug - Results of 40 demonstrations conducted in 10 farmers' fields indicated a reduction in Endoparasitic infestation by 100% and improvement in body weight & luster

4. Inclusion of bypass fat @ 200gm/day for 90 days in the diet of just calved cross bred cows- Results of 20 demonstrations conducted in 10 farmers' fields indicated an increase in milk yield by 19.4% and fat content by 12.2%

Feeding of 50gm of area specific mineral mixture to the cows of Nagpur district


Single dose oral administration of ecteno parasiticidal drug for effective control of ecto & endo parasities


Inclusion of bypass fat @ 200gm/day for 90 days in the diet of just calved cows

Home Science Enterprises

Enterprise	Name of the technology demonstrated	No. of farmers	No. of units	Data on parameter in relation to technology demonstrated		% change in the parameter
				Demo	Local check	
Nutrition management	Nutrition garden	16	-	Rs. 120 (week/family earning/100 m^2)	Rs. 86 (week/family earning/100 m2)	39
Recycling of agro residue	Cotton pellet as alternative cooking fuel	18	18	2.5g (ash recovered/200g cotton pellet)	6 g (ash recovered/200 g coal)	50
Pomegranate sheller	Pomegranate shelling	18	18	3 min	3.89 min	20.7

Crop enterprises

Cluster Front Line Demonstrations (CFLD) on Oilseed and Pulses

Four CFLDs on oilseeds (i.e. Soybean (MAUS-158), Summer Groundnut) & pulses (i.e. Pigeonpea (PKV-Tara), Chickpea (Digvijay)) were conducted on 200 farmers' field covering 80 ha area in Chargaon, Muradpur, Hiwra, Saleghat, Narhar and Ambazhari villages of Nagpur district. Several extension activities like field day, field visit of farmers and extension functionaries, group discussion and scientist farmers meet etc. were conducted for effective implementation of technologies.

FLD on chickpea at village Hiwra, Umred block

FLD on redgram at Ambazari village Parseoni block

FLD on soybean at village Hiwra, Umred block

FLD on groundnut at Hiwra village Katol block

Trainings organized

Sr. No.	Disciplines	No. of courses	No. of Total Participants	SC/ST Participants
1	Crop Production	15	686	216
2	Horticulture	10	422	112
3	Plant Protection	15	462	121
4	Veterinary Science	16	667	223
5	Home Science	14	320	139
6	Extension	20	667	215
	Total	**90**	**3224**	**1026**

KVK expert delivering lecture to farmers in a training program sponsored by Ambuja Cement Foundation,

KVK expert delivering lecture to the farmers in a training program sponsored by ATMA

Training Programme on Soil Testing

KVK-CICR, Nagpur organized 5-days training programme in collaboration with RAMETI, Nagpur for 25 soil analysts from Vidarbha region on "Soil Testing and Fertilizer Recommendation" during 21-25, January 2019. The experts Dr. Blase D'esuza, Dr. G. L. Ramkrushna, Dr. R. B. Singandhupe delivered the lectures on soil testing, soil sampling and fertilizer management aspects. Dr. A. Manikandan and Dr. H. B. Kumbhalkar explained the analytical procedure to the trainees.

Attracting and retaining rural youth in Agriculture (ARYA)

Attracting and Retaining rural Youth in Agriculture (ARYA) project was initiated in the year 2015-16. KVK-CICR, Nagpur is one of the centre operating two enterprises for lively-hood of rural youth. 1) Development of disease free sampling of pomegranate and Nagpur mandarin 2) Fruits and vegetable processing.

During the year 2018-19, the KVK trained 57 rural youths for production of disease free seedlings of pomegranate and Nagpur mandarin, 74 rural youth of different self help groups for custard apple processing, its value addition, preparation of pickels, citrus juice and solar drying of vegetables. Additionally, KVK provided technical support to rural youth of Katol block for multiplication of Nagpur mandarin seedlings. Twenty one rural youth beneficiaries later developed their nursery on Nagpur mandarin and are generating significant income.

Five rural youths from Ladgoan village, Tahsil Katol also established their disease free nursery of citrus and Nagpur mandarin after acquiring training under ARYA.

Solar Drying of Vegetables

Value addition of Custard Apple

Development of Nagpur Mandarin Seedlings

Dissemination of IRM Strategies for Pink Bollworm in Cotton in Nagpur district

KVK, ICAR-CICR, Nagpur implemented "IRM-Dissemination of Pink Bollworm Mangement Strategies" project under Centrally sponsored NFSM: Commercial Crops in Nagpur district. Five villages near Bela viz. (Muradpur, Surabardi, Chargaon, Bothli and Bendoli) in Umred tahsil have been identified. Field day, field visit of farmers and extension functionaries, Group discussion and Scientist-farmers meet were conducted for effective implementation of technologies for management of pink bollworm in cotton.

Impact of IRM on number of sprays and yield

No. of Farmers	Area in ha	Average No. of insecticide spray.						Yield q/ha	
		IRM		Total	Non-IRM		Total	IRM	Non-IRM
		Sucking pest	Bollworm		Sucking pest	Bollworm			
50	20	1.5	1.98	3.46	1.6	2.4	4	18.85	15.41

GKMS Scheme of IMD

An IMD and ICAR collaborative project on Gramin Krishi Mausam Sewa has started at KVK for issuing location specific weather based agro-advisories for cultivation of the crops which will benefit the farming community of Nagpur district. The weather data on minimum/maximum temperature, relative humidity, rainfall, evaporation and wind direction is recorded and provided to the farmers through voice mails/messages.

Extension Activities Conducted by KVK

Various field days, farmers meet, treatment camps were organized by KVK. The details are as below.

Sr. No.	Title of programme	Date	Venue	No. of participants	Dignitaries attended the programme
1	Kisan Kalyan Diwas	02/05/2018	CICR, Nagpur	200	MLA. Shri Sunil Kedar, MLA. Saoner.
2	Webcasting of Hon'ble Prime Ministers interaction with farmers	20/06/2018	CICR, Nagpur	182	Dr. V.N. Waghmare Director ICAR-CICR, Nagpur.
3	Webcasting of Hon'ble Prime Ministers interaction with members of Self Help Group and Women Groups	12/07/2018	CICR, Nagpur	26 Self Help Groups 50 farmers	Dr. V.N. Waghmare Director ICAR-CICR, Nagpur.
4	Mahila Kisan Diwas	15/10/2018	CICR, Nagpur	80	Dr. V.N. Waghm are Director ICAR-CICR, Nagpur
5	Nutrition Week	1-8/09/2018	Utty village of Umred tahasil, dist. Nagpur	150	Shri.Aratkayare Sarpanch, Utti, Tah. Umred, Dist. Nagpur.
6	World Soil Day	05/12/2018	Village Mangrul, Dist. Nagpur	300	Sh. Pramod Shingane (Member Z.P., Nagpur)
7	Livestock Treatment & Vaccination Camp	23/03/2018	Village Gumgaon, Dist. Nagpur	42	Dr. Avinash Jumde LDO, Veterinary Dispensary Grade I, Gumgaon, Tah. Hingna.
8	Pradhan Mantri Kisan Samman Nidhi Yojna	24/02/2019	CICR, Nagpur	269	Sh. Krupalji Tumane (Member of Parliament)

Webcasting of Hon'ble Prime Ministers interaction with farmers

Webcasting of Hon'ble Prime Ministers interaction with members of Self Help Group and Women Groups

Smt. Sunita Chauhan addressing the gathering on the occasion of Mahila Kisan Diwas

Shri Krupalji Tumane, Hon'ble Member of Parliament addressing the gathering on the Pradhan Mantri Kisan Samman Niddhi on Feb 24, 2019

Diagnostics Surveys Conducted

Twenty one diagnostic surveys were conducted in different villages of Nagpur district covering 939 farmers, crop area of 350 ha 130 goats, 57 large animal and 91 poultry. During the survey problems in crops, livestock, poultry were identified and remedies were suggested to farmers.

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.

Soil Testing Activities of KVK

Two thousand four hundred seventy five (2475) soil samples were collected from 75 villages of the Ramtek block of Nagpur district and also from the field of adopted farmers of KVK. The soil samples were analyzed for 12 different and 7833 Soil Health Cards were generated.

Development of fodder cafeteria at KVK's Farm:

KVK has established fodder cafeteria in its instructional farm with six perennial varieties of hybrid napier fodder crop viz. Phule Jaywant (RBN-13) and Phule Yashwant (RBN-9) developed by MPKV, Rahuri, BHN-6 developed by BAIF, Karnataka,

Hybrid napier CO4

Hybrid napier DHN-10

DHN-10 developed by IGFRI, Regional Research Station, Dharwad, HBN-100 and CO4 developed by TNAU. Several farmers, rural youth, extension functionaries and trainees visited these demonstration plots during this year.

KVK generated a resource of Rs 57,200/- by selling 57,200 Stem cuttings/root slips of Hybrid Napier fodder crop to 30 farmers of Nagpur and surrounding districts during 2018-19. Besides that, 50,000 stem cuttings costing Rs.50,000/- was supplied to the 50 beneficiaries.

Management of Osmanabadi Goat Unit:

KVK is managing a goat unit of Osmanabadi breed on scientific line at KVK's campus. Several goat owners and rural youths were benefited by acquiring practical skills from the goat unit. In addition, this goat unit has generated a resource of Rs.1,06,972/- during the year 2018-19 by selling 9 breeding bucks and 13 females which are bringing about genetic improvement in local goats.

Advisory Services

KVK has provided advisory services to the farmers, rural youth and extension functionaries through personnel guidance, telephonic calls and mobile services on agricultural production, protection technology and allied fields. Around 27,672 clients in Nagpur district were benefited.

Participation in Exhibitions:

Name of event	Location	Date
State Level Exhibition	Deekshabhoomi, Nagpur	17-19 October, 2018
Kisan Mela Exhibition	CICR, Nagpur	30 October, 2018
Agro-Vision	Reshimbagh, Nagpur	23-26 November, 2018
Agro-Tech	Dr. PDKV, Akola	27-31 December, 2018
Zhilla Krushi Mohostav Exhibition	Agriculture College Ground, Nagpur	12-16 January, 2019

Meetings Attended

Name of the officials	Name of event	Venue	Date
Meetings			
	State Specific Action Plan for Assessment of Water Resources and Demand Scenario of India.	New Delhi	10.01.2019
	State Specific Action Plan on Water Management	Pune	14.9.2018
Dr. R. B. Singandhupe	CROP-SAP meeting	Collector Office, Nagpur	21.8.2018
	Zonal (ZREAC) pre-kharif and pre-rabi	Yeotmal	12. 10. 2018
	ARYA meeting	NASC complex, New Delhi KVK Bhavnagar	24-25.08.2018 7-8.12.2018
Dr. S. S. Patil	District planning committee meeting	Collector Office, Nagpur	25.06.2018
Smt. Sunita Chauhan	ATMA Governing Body meeting	Nagpur	02.04.2018
	Quarterly meeting of All India Radio	AIR, Nagpur	31.05.2018 30.08.2018 29.11.2018

Name of the officials	Name of event	Venue	Date
Workshop/Conference/Training			
Dr. R. B. Singandhupe	Zonal Annual Workshop	MPKV, Rahuri	04.07.2018
Dr. R. B. Singandhupe Dr. S. S. Patil Dr. U. V. Galkate Smt. S. N. Chauhan	Action Plan Workshop	Dr. PDKV, Akola	19-20,04.2018
Dr. R. B. Singandhupe	Action Plan Review Workshop	ATARI, Pune	5-7.05.2018
Dr. S. S. Patil	Workshop on Pink Bollworm Management and Scientific use of Pesticide on Major Crops of Vidharbha	Dr. PDKV, Akola	09.06.2018
	Orientation training cum workshop on preparation and dissemination of Agromet Advisories at block level	ICAR-ATARI, Pune & IMD, Pune	6-7.07.2018
	Workshop on IPM for Kharif crop with special focus to pink bollworm in cotton	KVK, Washim	30-31.08.2018
	Review cum Training Workshop of CFLD Oilseed & Pulses	BSKKV, Dapoli	24-25.11.2018
Dr. S. M. Wasnik Dr. S. S. Patil	Review workshop of insecticide resistance management (IRM): Dissemination of Pink Bollworm Management Strategies.	ICAR-CICR, Nagpur	23.02.2019
DR. S. M. Wasnik Dr. S. S. Patil Dr. U. V. Galkate Smt. S. N. Chauhan	Action plan workshop of KVKs for Vidharbha region	Dr. PDKV, Akola	6-7.03.2019
Dr. S. M. Wasnik Dr. S. S. Patil	Action plan workshop of KVKs of Maharashtra & Goa	KVK, Baramati	15-16.03.2019
Guest Speaker			
Dr. S. S. Patil	Integrated pest management in cotton	GTC, CIRCOT, Nagpur	30.05.2018, 05.07.2018 12.07.2018
Dr. U. V. Galkate	Best method for cottonseed feeding to livestock	GTC, CIRCOT, Nagpur	05.05.2018, 16.05.2018, 23.08.2018, 30.08.2018, 12.09.2018, 19.09.2018
	Scientific goat farming for rural employment generation	Hinganghat, district Wardha	24.12.2018
	Rural goat farming	Bhandara	25.12.2018

List of publications

1. Deulkar P. B. (2018) "Osmanabadi Sheli Palan" Folder.
2. Wasnik, S. M. and Waghmare Vijay (2018) e-Kapas mobile phone voice advisory : An efficient ICT Tool of CICR for Technology Out-reach. AFITA Abstract during WCCA 2018. Conference on Research Frontiers in Precision Agriculture organized at IIT, Mumbai on 24-26 October, 2018, page No. 50.

Radio Talks:

- Smt. Sunita Chauhan delivered a radio talk on **"Mushroom Production"** broadcasted by AIR, Nagpur on 17, August, 2018.
- Smt. Sunita Chauhan delivered a radio talk on **"Value added products from Sorghum and income generation** broadcasted by AIR, Nagpur on 11th January, 2019.

❖ Dr. H. B. Kumbhalkar delivered a radio talk on "**Gahu Lagawadinantarche Vyavasthapan**" broadcasted by AIR, Nagpur on 23rd December, 2018.

❖ Dr. U. V. Galkate delivered a radio talk on " **Samrudhiche Dalan – Sheli Palan**" broadcasted by AIR, Nagpur on 12th September, 2018.

TV Programme Telecasted:

- Dr. S. M. Wasnik, Principal Scientist delivered television talk on "**e-Kapas**" telecasted by DD Sahayadari on 11th May, 2018.
- Smt. Sunita Chauhan, SMS, Home Science, KVK, Nagpur. "**Success story on Organic Vegetable Production**" telecasted by DD Sahayadari on 12.12.2018.
- Smt. Sunita Chauhan, SMS, Home Science, KVK, Nagpur. on "**Organic Guava Production – a success story**" telecasted by DD Sahayadari on 19.12.2018.

Video Film Prepared

- A Film Black Rice processing and its importance was prepared by Smt. Sunita Chauhan, SMS, Home Science, KVK, Nagpur. in collaboration with ATMA, Nagpur. The film was released by Collector, Nagpur on 12.01.2019 at Krishi Dhany Mohostav organized by ATMA, Nagpur from 12.01.2019 – 16.01.2019

AGRICULTURE TECHNOLOGY INFORMATION CENTRE (ATIC)

The Agriculture Technology Information Centre (ATIC) was established at ICAR-Central Institute for Cotton Research, Nagpur during **2001**, as a **'single window support system'** to make available all the information to the farmers under one roof.

Services provided

- Diagnostic services for soil and water testing.
- Diagnosis of plant/animal/crop problems.
- Supply technology/products such as cotton seed and other planting materials, livestock breeds, etc. emerging from the institution and ICAR-CICR, KVK for testing and adaptation.
- Sale of publications and communication materials

A. Farmers / Extension Personnel / Stakeholders Visits:

During the period under report, a total of **15405** farmers, **1613** extension personnel and **4389** other stakeholders visited ATIC. Altogether, **21407** persons visited the ATIC, out of which, **17574** visited for information and **3833** visited for technology products.

B. Communication with Stakeholders:

A total of **17574** farmers contacted ATIC through various means of communication like phone calls, video shows, letters received and letters replied and participation in training.

C. Publication:

Under publications, **04** books, **42** technical bulletins and DVDs were produced and provided to the ATIC visitors or those requested by mail. Totally, **3695** farmers and other stakeholders were benefited by these publications and documents.

D. Technology Services Provided:

During the reporting period, **2475** soil and water samples were tested by ATIC.

E. Technology Products Provided:

Among different technology products, **3.49** quintals of cotton seeds, **22 No. of Goats** and **1,07,200** number of planting material (fodder) worth **4.93** lakh, Rs. **1.07** lakh, and **Rs. 0.57** lakh respectively were provided to farmers.

F. Revenue Generated:

An amount of Rs. **13.43** lakh was generated through various technologies, products/ publications and services provided by ATIC.

List of publications available for sale through ATIC

Sr. No.	Name of Bulletin /Publication	CICR Bulletin No.	Price (Rs).
1	मध्य भारतातील कपाशीची लागवड : किटकनाशक प्रतिकार शक्तीचे नियोजन / मार्गदर्शिका (मराठी)	1	20=00
2	Aboitic Stresses in Cotton: A Physiological Approach (in English)	2	25=00
3	Naturally Coloured Cotton (in English)	4	25=00
4	Wild and cultivated Species of Cotton (in English)	5	100=00
5	Nutrient Management in Rainfed Cotton (in English)	6	25=00
6	An Evolving Systems Approach of IPM in Cotton : Perception and prescription (in English)	9	25=00
7	Cotton Biotechnology (in English)	10	40=00
8	Glanded and Glandless Cotton (in English)	12	25=00
9	Cotton Varieties and Hybrids (in English)	13	40=00
10	Breeding Hybrid Cotton (in English)	14	40=00
11	Use of Rainfall Analysis in the Planning and Management Of Rainfed Cotton (in English)	15	40=00
12	Cotton Genome Mapping For Crop Improvement	16	50=00
13	Biotechnological Approaches for Cotton Improvement	17	50=00
14	Training,Consultancy,Contract Research and Contract Service in Cotton Production: An Information Brochure	18A	50=00
15	Constraints to Cotton Production in India	19	25=00
16	Mechanisation of Cotton Production in India	20A	40=00
17	Genetic Improvement of cotton seed oil	21	25=00
18	Nematode infested seed and planting Material: Denematization and salving Techniques	20	50=00
19	Technology Transfer in Cotton	23	25=00
20	Male Sterility In Cotton	24	25=00
21	पराजीनी बीटी कपास (मराठी)	25	20=00
22	Cotton Seed Oil Quality, Utilisation and Processing	25A	25=00
23	Genetic Enhancement in Cotton	26	25=00
24	Plant Parasitic Nematodes of Cotton-farmer's hidden enemy	27	25=00
25	Physiological Disorders in Cotton	28	50=00
26	Mirco –Irrigation Management in Cotton	31	60=00
27	Epitome of Agro –Meteorology : Nagpur (1916-2002)	32	50=00
28	Rainwater Management Techniques for Cotton Based Cropping System.	33	50=00
29	Twenty five years Achievements in Cotton Pathology At CICR (1976-2001)	33A	50=00
30	Cotton – March Towards New Millennium	33B	100=00
31	उस्मानाबादी भोळी	----	5=00
32	भोळयासांठी पौष्टीक हिरवा चारा लसूनघास	-----	5=00
33	Indentification of sources of Resistance to Gray mildew disease (Ramularia Areola) in diploid cotton Gossypium arboreum	34	40=00
34	Bharat Mein kapas Anusandhan and vikas (in Hindi)	34A	350=00
35	Fibre Quality Traits of G.Arboreum Germplasm	35	100=00
36	Fibre Quality Traits of G.herbaceum Germplasm	36	100=00
37	Nector Glands in Gossypium	37	50=00
38	कपाशीवरील मिलीबगचे व्यवस्थापन	-----	10=00
39	कपास मे मिलीबग का प्रकोप और इसका प्रबंधन	----	10=00
40	Compendium of Cotton Mealybugs (English)	2011/1	50=00
41	Handbook of Cotton Plant Health (English)	Book	200=00
42	कपाशीवरील किडी व रोगांचे प्रभावी व्यवस्थापन (मराठी)	-----	60=00
43	Crop Growth Calender for Rainfed Cotton Pest Management	-----	10=00
44	कापूस पिकात एकात्मिक किड व्यवस्थापनातील नूतन सशोधन (मराठी)	-----	60=00
45	कपास के नाशीकीटो का प्रभावी प्रबंधन (हिंदी)	Folder	5=00
46	कपाशीवरील गुलाबी बोंडअळी व्यवस्थापन (मराठी)	------	10=00

10.1 List of Publications

Research papers (NAAS rating> 6)

1. Chinna Babu Naik, Nagaharish Giri, Kumbare Sujit, Kranthi S. and Nirmall Kumar (2019). New report of *Oxycetonia versicolor* Fabricius, as a pest on cotton from Central India *National Academy Science Letters-India* (NAAS Rating: 6.35)
2. Chinna Babu Naik., Kumbhare S., Kranthi S., Satija U. and Kranthi K.R (2018). Field evolved resistance of pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) to transgenic Bt-cotton expressing Cry1Ac and Cry2Ab in India. *Pest Management Science*, 74(4) (NAAS rating: 9.26).
3. Gawande S.P., Raghavendra K.P., Dilip Monga, Nagrale Dipak T. and Kranthi S. (2019) Rapid detection of Tobacco streak virus (TSV) in cotton (*Gossypium hirsutum*) based on Reverse Transcription Loop Mediated Isothermal Amplification (RT-LAMP). *Journal of Virological Methods*. (Accepted) (NAAS rating 7.76)
4. Kumar G., Jyothsna M. P., Valarmathi S., Roy A., Banerjee J., Tarafdar B.K., Senapati S., Robin Manonmani S., Rabindran R., and Dasgupta I. (2019). Assessment of Resistance to Rice Tungro Disease in Popular Rice Varieties in India by Introgression of a Transgene against *Rice Tungro Bacilliform Virus*. *Archives of Virology*. *https://doi.org/10.1007/s00705-019-04159-3* (NAAS rating: 8.16)
5. Kumar R., Choudhary A., Kumar S. & Shivangi. (2019). Frequency of alleles conferring resistance to Bt cotton in North Zone population of the spotted bollworm, *Earias insulana* (Boisduval). *African Entomology* 27(1) : 58-65. (NAAS rating -6.51)
6. Nagrare V.S., Naikwadi Bhausaheb, Deshmukh Vrushali and Kranthi S. (2018) Biology and population growth parameters of the cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on five host plant species *Animal Biology*, DOI 10.1163/15707563-17000080 (NAAS rating 6.57)
7. Narkhedkar Gokte N., Bhanare K., Nawkarkar P., Chilliveri P., Fand B.B., Kranthi S. (2019). Parasitic potential of entomopathogenic nematode *Heterorhabditis indica* against two Lepidopteran insect pests of cotton, *Helicoverpa armigera* (Hubner) and *Spodoptera litura* (Fabricious). *Phytoparasitica*, 47 (1): 31-41. (NAAS rating: 7.01)
8. Rishi Kumar, Kranthi S, Monga D., Sandeep Kumar, Sain S.K. and Chaudhary Alka. (2019). Evaluation of moving Yellow Sticky Traps for Monitoring and Management of Whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) infesting cotton. *Indian Journal of Agricultural Sciences* (Accepted) (NAAS Rating 6.23)
9. Sain S.K., Monga Dilip, Rishi Kumar, Dipak T. Nagrale, Neelakanth S. Hiremani, Kranthi S. (2019) Compatibility of entomopathogenic fungi with insecticides and their efficacy for IPM of *Bemisia tabaci* in cotton. *Journal of Pesticide Science*, Article ID D18-067, [Advance publication] Released March 15, 2019, Online ISSN 1349-0923, Print ISSN 1348-589X, https://doi.org/10.1584/jpestics. D18-067 (NAAS rating IF=7.02)
10. Salunkhe V. N., Gawande S. P., Nagrale D. T., Narkhedkar N. G., Hiremani N. S. and Waghmare V. N. First report of Corynespora leaf spot of cotton caused by *Corynespora cassiicola* in Central India. *Plant Disease* (Accepted; NAAS rating 8.94)
11. Singandhupe R. B. and Manikandan A. (2018) Crop water demand, climatic variables and their effect on seed cotton yield in semi- arid region of India: A Case Study of Gujarat and Maharashtra, *Journal of Agriculture Science and Technology* (Accepted)
12. Velmourougane K., Prasanna R., Chawla G., Nain L., Kumar A., Saxena A.K. (2019). *Trichoderma-Azotobacter* biofilm inoculation improves soil

nutrient availability and plant growth in wheat and cotton. *Journal of Basic Microbiology*. https://doi.org/10.1002/jobm.201900009 (NAAS rating: 7.58).

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1. Agarwal Isabella and Majumdar Gautam (2018). Needs and Gaps of Cotton Mechanisation in India. *Journal of Cotton Research and Development*, 32(2):292-299 (NAAS rating :3.41)
2. Blaise, D. (2018). Conservation agriculture for sustainable cotton production in Africa. *ICAC Recorder* 36(4): 23-28. (NAAS Rating: Nil).
3. Chinna Babu Naik V., Dabhade P. L., Kranthi S., Venugopalan M. V. and Subbireddy K. B. (2018). Intensity of Insect Pests in *Gossypium hirsutum* Cultivars under High Density Planting System (HDPS) in India. *International Journal of Current Microbiology and Applied Sciences*, 7(12), 125-134. (NAAS rating: 5.38)
4. Chinna Babu Naik., Kranthi S., Gharade S., Kumbhare S., Nagrare V.S. and Singh Roni Kumar (2018). Endoparasitoid: *Bracon lefroyi* (Dudgeon and Gough) of pink bollworm *Pectinophora gossypiella* (saunders) on cotton. *Indian Journal of Entomology*, 80(2): 359-364(NAAS rating: 5.89)
5. Dhamayanthi K.P.M., Manivannan A. and Saravanan M. (2018). Evaluation of New Germplasm of Egyptian cotton (*G. barbadense*) through Multivariate Genetic Component Analysis. *Electronic Journal of Plant Breeding*, 9(4):1348-1354.
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7. Kumbhalkar H B, Gawande V.L., Gotmare Vinita and Rathod T.H. (2018) Combining Ability Studies for Yield, its Component Traits and Fibre Properties through Line X Tester Mating Design in Upland Cotton *(Gossypium hirsutum L.) International Journal of Current Microbiology and Applied Sciences* ISSN: 2319-7706 7 10 (NAAS rating: 5.38)
8. Kumbhalkar H. B., Gawande V. L., Gahurkar S. J., Waghmare V. N., Mawle S. R. and Ingle K. P. (2018). Molecular profiling of cotton genotypes for fibre properties using diagnostic set of microsatellite (SSR) markers. *Current Journal of Applied Science &Technology* 29(3): 1-16
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10. Manivannan A., Punit Mohan, Saravanan M. and Waghmare V. N. (2018). Morphological characterization of Asiatic cotton (*G. arboreum*) germplasm of India. *Electronic Journal of Plant Breeding*, 9 (2): 673-81.(NAAS rating:4.97)
11. Md. Farid Uddin, Md. Fkhre Alam Ibne Tabib, Md. Kamrul Islam, Washington Mubvekeri, Sabesh M. and Usha Rani. (2018). Novel ideas to Enhance Cotton Production and value of By-production Africa. ICAC Recorder, September 2018. Vol.34 (3) pp 16-17.
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Chemical Studies; 6(6): 2309-2314. (NAAS rating: 5.31).

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17. Rathinavel K. (2019). Agro-morphological Characterization and Genetic Diversity Analysis of Cotton Germplasm (*Gossypium hirsutum* L.) *International Journal of Current Microbiology and Applied Sciences* 8 (2): ISSN: 2039-2057 (NAAS rating :5.38)
18. Reddy A. R., Blaise D. and Anuradha N. (2018). Cost escalation in cotton cultivation – an analysis. *Economic Affairs*, 63(4): 833-838. (NAAS rating: 4.82)
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21. Sain SK, Monga D and Hanwant D. (2018). First report of downy mildew caused by *Bremia lactucae* on *Sonchus asper* L. (Hill) and *S. tenerrimus* L. in Haryana, India. *Indian Phytopathology*. 71(3): 465–467. (NAAS ratting 5.9)
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23. Sankaranarayanan K., Raju A. R. and Rajendran K. (2018) Weed shift by long term use of dinitroaniline herbicides and glyphosate in cotton. *International journal of chemical studies* 6(5):3082-3085526 (NAAS rating : 5.31)
24. Singh Jyoti Prakash, Verma Pooja, Mahesh Kumar, Tiwari Sachidanand, Ali Ansheef (2018). Heat Stress: An Overview. *Indian Research Journal of Genetics and Biotechnology*. 10(2):202-207.
25. Usha Rani and Prakash A.H . (2018). Front Line Demonstration in Cotton – As a good Transfer of Technology Practice Advocated for Africa from the Experiences of India - Perspectives on Cotton Research and Ideas for Africa- Proceedings & Recommendations of the XIV Meeting of the Southern & Eastern Africa Cotton Forum (SEACF) Ed. Keshav R. Kranthi, Lawrence Malinga & Washington Mubvekeri. ICAC Recorder, 34 (3):4-12.
26. Valarmathi P. (2018). Dynamics of fungicidal resistance in the agro eco-system: A review. *Agricultural reviews* 39(4): 272-281 (NAAS rating: 4.37)
27. Venugopalan M.V. (2019). Avenues to Improve Farm Income from Cotton under Changing Climatic Scenario. *PKV Research Journal* (Accepted). (NAAS rating: 2.74).
28. Verma Pooja., Rao A.R., Priyanka and Singh JP (2018). *In silico* prediction and designing of potential siRNA to control cotton whitefly *Bemisia tabaci* Gennadius vectored cotton leaf curl virus (CLCuV). *Journal of Entomology and Zoology Studies* 6(4): 1055-1060 (NAAS rating: 5.53)

Other Publications

Technical Bulletins:

- Nagrare V.S., Chinna Babu Naik, Fand B.B., Gawande Shailesh P., Nagrale Dipak T. and Narkhedkar Nandini and Waghmare V.N. (2019). Cotton Integrated Pest, Disease and Nematode Management (English) ICAR-Central Institute for cotton Research, Nagpur. Pp: 39
- Nagrare V.S., Chinna Babu Naik V., Fand B.B, Pande Rachna, Gawande S.P., Nagrale D.T., Gokte-Narkhedkar Nandini and Waghmare V. N. (2019). कपास: नाशीजीव, रोग एवं सूत्रकृमि का समेकति प्रबंधन. टेक्नीकल बुलेटनि, ICAR-Central Institute for Cotton Research, Nagpur. Pp.30
- Nagrare V.S., Chinna Babu Naik V., Fand B.B, Rachna Pande, Gawande S.P., Nagrale D.T., Gokte-Narkhedkar Nandini and Waghmare V. N. (2019). कापूस: कडिी, रोग व सूत्रकृमचिे एकात्मकि व्यवस्थापन. टेक्नीकल बुलेटनि, ICAR-Central Institute for Cotton Research, Nagpur. Pp: 39
- Chinna Babu Naik V and Khubhare Sujit (2018). Botanicals for Cotton pests. Cotton Production and Management Technology. ICAR-Central Institute for Cotton Research, Pp: 55.
- Chinna Babu Naik V., Kranthi S., Kumbhare Sujit, Nagrare V. S., , Gokte-Narkhedkar N. Fand B.B., Pande Rachna (2018) Pink bollworm management (Hindi)

10.2: List of on-going projects

Sr. No	Type	Project title, PIs and Co-PIs	Duration
Division of Crop Improvement			
1	Institute	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), D.V. Patil (PA)	2000-2020
2	Institute	Development of Bt cotton varieties using deregulated and non deregulated transgenic events. **V.N.Waghmare (PI)** : **PAs:** Suman Bala Singh (PI), Vinita Gotmare, G. Balasubramani (PI), Amudha J, Raghavendra KP, Saravanan M, Santhosh HB, Chandrashekar N, Rakesh Kumar, MV. Venugopalan, Rachna Pande, Vivek Shah, B.B. Fand, S. Manickam, K. Rameash, A. Sampathkumar, O.P.Tuteja, S.K. Verma, Rishi Kumar, S.K. Sain	2018-2023
3	Institute	Development of compact plant type with improved quality traits through selective mating system. **Suman Bala Singh (PI)**, T.R. Loknathan (PA), J.H. Meshram (PA)	2017-2022
4	Institute	Breeding of upland cotton for improved fibre quality and resistance to biotic stress (Jassid). **S. M. Palve (PI)**, Rachna Pande, Mandhyan	2005-2021
5	Institute	MAS/MAB for Water-logging in Cotton. **Vinita Gotmare (PI)**, M. Saravanan (PA), J.H. Meshram (PA), J.Annie Sheeba (PA)	2012-2020
6	Institute	Harnessing the potential of wild and unadapted germplasm in cotton improvement. **Vinita Gotmare (PI)**, Santosh HB (PA), Chandrashekar N (PA), Madhu T.N (PA), Neelkanth Hiremani (PA), Rakesh Kumar (PA)	2018-2023
7	Institute	Exploration, collection and conservation of land races of desi cotton and perennials and from different regions of India. **M. Saravanan (PI)**	2014-2018
8	Institute	Breeding to improve performance of *Gossypium herbaceum* for adaptation to climate change in central India. **D.V. Patil (PI)**, Punit Mohan (PA)	2015-2020
9	Institute	Breeding for early maturity compact plant type and jassid tolerance in cotton. **H.B. Santosh (PI)**, S. Manickam (PA), K.P. Raghavendra (PA)	2014-2019
10	Institute	Collection, conservation, evaluation, documentation and maintenance of germplasm of cultivated species of Gossypium. **Sunil S. Mahajan (PI)**, M. Saravanan (PA), S. Manickam (PA), KPM. Dhamayanthi (PA), RA. Meena (PA), Anjali Kak (PA)	2018-2023
11	Institute	Strategies to augment quality and storability of cotton seed under different environmental conditions. **Sunil.S Mahajan** (PI), V. Santhy (PA), P.R. Vijayakumari (PA)	2017-2020
12	Institute	Development of high strength cotton genotypes by reducing the short fiber content. **S. Manickam (PI)**, A.H. Prakash (PA), B. Dharajothi (PA), J. Gulsar Banu (PA)	2017-2020
13	Institute	Breeding for high yielding, early maturing sucking pest tolerant extra-long staple G.barbadense genotypes with improved fibre properties. **K.P.M. Dhamayanthi (PI)**, A. Manivannan (PA), K. Rameash (PA)	2017-2020
14	Institute	Development of high yielding, early maturing Asiatic cotton (Gossypium arboreum) genotypes suitable to south Zone. **A. Manivannan (PI)**, V.N. Waghmare (PA), M. Saravanan (PA)	2015-2020
15	Institute	Identification of male sterile plants in genetic male sterility (GMS) using	2012-2019

Sr. No	Type	Project title, PIs and Co-PIs	Duration
		molecular markers. **O.P. Tuteja (PI)** , Suman Bala Singh (PA), M. Saravanan (PA)	
16	Institute	Development of varieties of upland cotton having better fibre traits and tolerance to CLCuD. **O.P. Tuteja (PI)** , V.N. Waghmare (PA), S.K. Verma (PA), D. Monga (PA), Rishi Kumar (PA)	2017-2020
17	Institute	Development of Cotton Leaf Curl Virus resistant genotypes using *G.arboreum/ G.herbaceum* through introgression. **S. K. Verma (PI)**, V.N. Waghmare (PA), S.M. Palve (PA), Rakesh Kumar (PA)	2015-2021
18	Institute	An efficient regeneration system for transformation studies with *CICRcry2Ab1Ac* and fiber strength genes in Cotton (*G. hirsutum*). **G. Balasubramani (PI)**, J. Amudha (PA), K.P Raghavendra (PA), Joy Das (PA), Rakesh Kumar (PA), Chandrashekar N (PA)	2017-2020
19	Institute	Gene discovery for useful traits. **K.P. Raghavendra (PI)** , Sandhya Kranthi (PA), K. Velmourougane (PA), J. Annie Sheeba (PA), A. Sampathkumar (PA), Rakesh Kumar (PA), S.P. Gawande (PA)	2014-2019
20	Institute	Targeted mutagenesis of ghPHYA1 thro ugh CRISPR/Cas9 in Cotton. **Chandrashekar N. (PI)**, Raghavendra, K.P (PA), Joy Das (PA), Rakesh Kumar (PA)	2017-2020
21	Institute	Unveiling the potential of cotton WNT-like gene in somatic embryogenesis through genetic engineering. **Chandrashekar N (PI)**	2018-2021
22	DBT	Development of consensus genetic linkage map for *Gossypium* spp. with SNP markers and QTL analysis for fibre traits. **V.N. Waghmare (PI)** , T.R.Loknathan (PA)	2017-2020
23	ICAR-Extramural	Introgression of genes for whitefly and CLcuD resistance in upland cotton (*G. hirsutum*). **V.N. Waghmare (PI)** , S.M. Palve (PA), Rakesh Kumar (PA), D. Monga (PA), S.K.Verma (PA), Rishi Kumar (PA)	2016-2019
24	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)	2007-2018
25	NSP	National Seed Project (Crops). **K. Rathinavel (PI)**	1999-2018
26	DUS	Implementation of PVP legislation 2001 and DUS testing of cotton under ICAR-SAU system. **K. Rathinavel (PI)**	2003-2018
Division of Crop Production			
27	Institute	Alleviating soil compaction – a production constraint in cotton. **Blaise Desouza (PI)**, Gautam Majumdar (PA), A Manikandan (PA), Savita Santosh (PA)	2017-2020
28	Institute	Identification and characterization of water deficit period under various agro climatic regions with reference to cotton growing states of India. **R. B. Singhandhupe (PI)**, A. Manikandan (PA), S.Chattraj (PA) (NBSS&LUP)	2017-2020
29	Institute	Exploring the productivity potential of long-linted *G. arboreum* cotton. **MV Venugopalan (PI)**, K. Sankarnarayanan (PA), J.H. Meshram (PA), G.I. Ramakrushna (PA), Pooja Verma (PA), S.S. Mahajan (PA), Madhu T.N (PA), Neelakanth Hiremani (PA), M. Sabesh (PA)	2017-2020
30	Institute	Participatory evaluation of technology for improving profitability in calcareous soils. **A.R Raju (PI)**, RB Singandhupe (PA), Anuradha Narala (PA), A. Manikandan (PA)	2016-2020

Sr. No	Type	Project title, PIs and Co-PIs	Duration
31	Institute	Integrated farming system to double income of cotton farmer. **G.I. Ramkrushna (PI)**, R.B. Singandhupe (PA), A. Manikandan (PA), Rachana Pande (PA)	2017-2020
32	Institute	Identifying edaphic & climatic factors influencing fibre quality parameters in cotton and low micronaire management in ELS Cotton. **K. Sankaranarayanan (PI)**, A.H. Prakash (PA), M. Sabesh (PA), A. Manivannan (PA)	2017-2020
33	Institute	Evaluation of Structured water for cotton production. **P. Nalayini (PI)**	2014-2019
34	Institute	Development of remunerative cotton based cropping systems based on conservation agriculture principles. **R. Raja (PI)**, D. Kanjana (PA), K. Sankarganesh (PA), A. Sampathkumar (PA)	2015-2019
35	Institute	Efficient nitrogen fixing legumes for cotton based cropping systems. **A. Manikandan (PI)**, P. Nalayini (PA), V.S. Nagrare (PA)	2015-2020
36	Institute	Evaluation of nano-formulated micronutrients foliar spray for yield maximization in different cotton genotypes. **D. Kanjana (PI)**	2012-2018
37	Institute	Effect of long term application of organic and inorganic sources of nutrients on continuous cultivation of Bt and non Bt cotton with maize cropping system under irrigated conditions. **D. Kanjana (PI)**, K. Sankaranarayanan (PA), Amarpreet Singh (PA)	2017-2022
38	Institute	Phenotyping of root system architecture in cotton (*Gossypium hirsutum* L.) for adaptation to drought tolerance. **J.H. Meshram (PI)**, S.S. Mahajan (PA)	2017-2019
39	Institute	Exploiting the epigenetic transgenerational inheritance of stress responsive traits for imparting abiotic stress tolerance to cotton. **J. Annie Sheeba (PI)**	2016-2021
40	Institute	Metabolite exploration of drought stress in cotton. **Pooja Verma (PI)**, G.I. Ramkrushna (PA)	2017-2019
41	Institute	Development of microbial biofilm formulations for cotton: effects on yield, pests, diseases and soil health. **K. Velmourougane (PI)**, Savitha Santosh (PA), Rachana Pande (PA), Dipak Nagrale (PA)	2017-2019
42	Institute	Microbial interventions for potassium nutrition in cotton. **Savitha Santosh (PI)**, G.I. Ramkrushna (PA), A. Manikandan (PA)	2017-2019
43	Institute	e-Communication: Dissemination of Cotton Technology. **S.M. Wasnik (PI)**, S. Usha Rani (PA), O.P. Tuteja (PA)	2017-2020
44	Institute	Development of transfer of technology innovations for bridging up the yield gap in cotton. **S. Usha Rani (PI)**, S. Manickam (PA), R. Raja (PA), M. Amutha (PA), S.M. Wasnik (PA)	2017-2020
45	Institute	Socio-technological analysis of drip irrigation in cotton cultivation. **C. Karpagam (PI)**, K.Sankaranarayanan (PA), K. Rameash (PA)	2017-2020
46	Institute	Dynamics of cropping pattern in cotton growing districts of Maharashtra. **A.R. Reddy (PI)**	2017-2019
47	Institute	Impact of Institutional Credit on Cotton Farming in Vidarbha Region of Maharashtra. **Anuradha Narala (PI)**, S.M Wasnik (PA), Nandini Gokte (PA), Vinita Gotmare (PA)	2016-2018
48	Institute	Impact analysis of shift in global cotton trade on Indian cotton scenario. **Isabella Agarwal (PI)**	2017-2019

Sr. No	Type	Project title, PIs and Co-PIs	Duration
49	Institute	Development of interactive decision support systems for cotton pest management with prerecorded voice modules. **M. Sabesh(PI)**, C. Karpagam (PA)	2016-2019
50	IFFCO	Validation of impact of input on economics of Bt –hybrid cotton+ pigeon pea strip cropping. **A.R. Raju (PI)**	2017-2020
51	Institute	Development of Cotton based cropping systems under Conservation Agriculture for North-Western Indian conditions. **Amarpreet Singh (PI)**, S.K. Sain (PA), Rishi Kumar (PA), K.Velmourougane (PA)	2018-2023
52	NCP	Quantitative estimation of carbon and moisture fluxes over the cotton based agro-ecosystem: Integrating ground observations, satellite data and modelling. Director, ICAR-CICR, **M.V. Venugopalan (PI),** A. Manikandan (PA)	2017-2020
53	STL	Response of STL mixture grade CNS fertilizer to cotton. **A. Manikandan (PI)**, Blaise Desouza (PA)	2017-2018
Division of Crop Protection			
54	Institute	Standardization and integration of strategies for sustainable nematode management. **Nandini Narkhedkar (PI)**	2017-2020
55	Institute	Elucidating eco-toxicity and resistance development in sucking pests against newer insecticides used in cotton. **V.S. Nagrare (PI)**, V. Chinna Babu Naik (PA), Babasaheb B Fand (PA)	2017-2020
56	Institute	Identification of oviposition deterrent for ethological management of cotton bollworm *Helicoverpa armigera* Hübner. **Rachna Pande (PI)**, Vivek Shah (PA)	2017-2020
57	Institute	Investigations into exacerbation of pest status of cotton pink bollworm *Pectinophora gossypiella* (Saunders) in the context of climate change through development of phenology model. **Babasaheb B Fand (PI)**, V.S. Nagrare (PA), V. Chinna Babu Naik (PA)	2017-2020
58	Institute	Push-pull strategy for management of pink bollworm in cotton. **Vivek Shah (PI)**, Rachna Pande (PA), Pooja Verma (PA)	2016-2019
59	Institute	Diversity analysis of Whitefly (*Bemisia tabaci*), predators and parasitoids. **Prabhulinga T (PI)**, Sandhya Kranthi (PA), Rishi Kumar (PA), M. Amutha (PA), V. Chinna Babu Naik (PA)	2016-2019
60	Institute	Studies on chemical cues mediating sucking pests and natural enemy interactions in cotton eco-system. **Madhu, T.N (PI)**, Rishi Kumar (PA), K. Shankarganesh (PA), K. Rameash (PA)	2016-2020
61	Institute	Identification of resistant genetic sources with mechanism of resistance against cotton leafhopper (*Amrasca biguttula biguttula*) (Ishida) (Hemiptera: Cicadellidae). **B. Dharajothi (PI)**, A. Manivannan (PA), D. Kanjana (PA)	2017-2020
62	Institute	Exploring novel dispensers to enhance the trapping efficacy of gossyplure in managing pink bollworm in cotton. **K. Rameash (PI)**, B. Dharajothi (PA)	2016-2019
63	Institute	Diversity, Ecology and Improvement of eco-compatible management of Thrips in cotton ecosystem. **M. Amutha (PI)**, K. Sankaranarayanan (PA), S.P. Gawande (PA), B.B. Fand (PA), Rishi Kumar (PA)	2017-2020
64	Institute	Studies on prevalence of *Xanthomonas citri* pv. *malvacearum* races of cotton and breeding for BLB resistant varieties. **S.P. Gawande (PI)**, VN	2018-2021

Sr. No	Type	Project title, PIs and Co-PIs	Duration
		Waghmare (PA), Dipak Nagrale (PA), Neelkanth Hiremani (PA), S.K.Sain (PA), Sampathkumar (PA)	
65	Institute	Evaluation of cotton PGPR for broad-spectrum resistance against insect pests and diseases. **Dipak T Nagrale (PI)**, Vivek Shah (PA), T. Prabhulinga (PA)	2016-2019
66	Institute	Identification of endophytes from cotton with special reference to *desi* cotton and evaluation of biocontrol activity against major diseases. **Neelakanth Hiremani (PI)**, S.P. Gawande (PA), S.K. S ain (PA), Pooja Verma (PA)	2017-2020
67	Institute	Role of plant defense activators for management of cotton leaf spot diseases. **Vanita N. Salunkhe (PI)**, S.P. Gawande (PA), J.H. Meshram (PA), Pooja Verma (PA)	2017-2020
68	Institute	Molecular characterization, virulence and genetic diversity analysis of Alternaria leaf spot disease of cotton. **A. Sampath Kumar (PI)**	2017-2020
69	Institute	Studies on symptom expression, host range, transmission and spread of Tobacco Streak Virus infecting Cotton. **P Valarmathi (PI)**, M. Amutha (PA), S.P. Gawande (PA), S.K. Sain (PA)	2017-2020
70	Institute	Studies to identify the most virulent strains of entomopthogenic fungi for whitefly control. **S.K. Sain (PI)**, D. Monga (PA), Sandhya Kranthi (PA), Rishi Kumar (PA), Prabhulinga T (PA), Dipak Nagrale (PA)	2016-2019
71	Institute	Studies to understand, occurrence of parawilt and the effect of rhizosphere microorganism and chemicals on its management in North India. **S.K Sain (PI)**, D. Monga (PA), Pooja Verma (PA), S.K. Bishnoi (PA)	2017-2019
72	Institute	Inventorying potential fungal metabolites for the management of sucking pests and nematodes of cotton. **J. GulsarBanu (PI)**, A.H.Prakash (PA), M. Amutha (PA), P. Valarmathi (PA)	2017-2020
73	Mahyco	Monitoring changes in baseline susceptibility to Cry toxins in the cotton bollworm, *H. armigera*, pink bollworm and *Spodoptera litura*. **Nandini Narkhedkar (Coordination),** V. Chinna Babu Naik (PA), Vivek Shah (PA)	2012-2018
74	CROPSAP	Crop pest surveillance and advisory project (CROPSAP) in Maharashtra. **V.S. Nagrare (PI)**	2010-2018
75	DST-SERB	Pink bollworm, *Pectinophora gossypiella* (Saunders): Resistance Monitoring, Fitness Costs, Inheritance of Resistance to Cry toxins expressed in Bt cotton. **V. Chinna Babu Naik (PI),** Sandhya Kranthi (PA)	2017-2020
76	DST-SERB	Genetic diversity in geographical Population of Pink bollworm *Pectinophora gossypiella* (Saunders) in India. **V. Chinna Babu Naik (PI)**	2017-2021
77	DST-SERB	Evaluation of selectivity of insecticides against different mealy bug species and their major natural enemies associated with cotton, tomato, brinjal and papaya. **K. Shankarganesh (PI)**	2016-2018
78	DST-SEED	Exploration and development of thermal tolerant strain of biocontrol agent, *Acerophagus papaya* for sustainable management of papaya mealybug, *Paracoccus marginatus* in crops. **K. Shankarganesh (PI),** C. Karpagam (PA)	2016-2019
79	DST-SERB	Effect of thermal stress on fitness traits of two mealybug pests, *Phenacoccus solenopsis*, and *Paracoccus marginatus* and their parasitoids *Aenasius bambawalei* and *Acerophagus papaya*. **K. Shankarganesh (PI),**	2016-2019

Sr. No	Type	Project title, PIs and Co-PIs	Duration
		Sandhya Kranthi (PA), K. Rameash (PA)	
80	NICRA	Development of IPM strategies to combat whitefly and other emerging pests of cotton. **Rishi Kumar (PI)**, V.S. Nagrare (PA), Prabhulinga T (PA), D. Monga (PA), M. Sabesh (PA)	2016-2019

Total ongoing projects at CICR Nagpur, Coimbatore & Sirsa (2018-19)

Division	Institute funded	Externally funded	Total ongoing projects
Crop Improvement	21	5	26
Crop Production	24	3	27
Crop Protection	19	8	27
Total	**64**	**16**	**80**

Ongoing projects centre wise (2018-19)

Division	Nagpur	Coimbatore	Sirsa	Total
Crop Improvement	18	5	3	26
Crop Production	16	10	1	27
Crop Protection	15	9	3	27
Total	**49**	**24**	**7**	**80**

10.3: Consultancy, Patents, Commercialization of Technology

Patents

Sr. No.	Name of Institute	Title of Patent	Patent Application Number	Name of Inventor	Present Status of Patent
1	ICAR-CICR, Nagpur	Small Cotton Harvester with Pre-cleaner Attachment	2076/MUM/2014	Er. Gautam Majumdar, Dr.K.R.Kranthi, Dr.Blaise Desouza, Er.K.G.Bhat, Vipin Meshram, Rajesh Jamdal & Amardip V. Kapse	First Examination Report (Application in Amended stage)
2	ICAR-CICR, Nagpur	" CICR Whitefly Adult Suction Trap"	1724/Del/2015	Dr. Rishi kumar, Dr. Dilip Monga, Dr. Sandhya Kranthi, Dr. K.R.Kranthi, Sh. Madan Lal	First Examination Report (Application in Amended stage)

Contract Research / Revenue generation:

Sr. No.	Contract Research/Consultancy/ Revenue generation	Resource / revenue generation (in Rs.)
1	ICAR-CICR has signed MoU with M/s Gharda Chemicals Ltd, Thane, Mumbai on 25 May 2018 for contract research proposal on "Bioefficacy field trials with 3 products in cotton crops during Kharif 2018 and 2019".	10,65,540
2	MoU was signed between ICAR-CICR, Nagpur and International Plant Nutrition Institute (South Asia Program) Gurgaon, Haryana on 2018-19 for contract research proposal on "Validated impact of Nutrient Expert-Cotton Fertilizer Decision Support System in Bt hybrid cotton".	3,75,000
3	Bt testing (AICCIP)	74,69,600
4	Testing fees	34,500

MoUs Signed:

Institution	Date	Area of work	Duration
M/s Gharda Chemicals Ltd, Thane, Mumbai	25 May 2018	Bioefficacy field trials with 3 products in cotton crop during *Kharif*	2018-19 and 2019-20
CSIR- National Botanical Research Institute, Lucknow	06 June 2018	MTA for "Supply/ Exchange/ Transfer of Genetic Resources for Food and Agriculture / Germplasm / Genetic Material / Genetic components for Research".	-
M/s Momentive Performance Material Pvt. Ltd, Delhi	11 July 2018	Contract research proposal on "Evaluation on Bioefficacy improvement from Silwet 408 for effective control of Thrips	-
Rivulis Irrigation India Pvt. Ltd	13 Aug 2018	Collaborative project on "Impact of differential irrigation scheduling based on remote sensing under drip system in cotton".	-
International Plant Nutrition Institute (South Asia Program) Gurgaon, Haryana		contract research proposal on "Validated impact of Nutrient Expert-Cotton Fertilizer Decision Support System in Bt hybrid cotton".	2018-19
St. Vincent Pallotti College of Engineering & Technology, Nagpur, Maharashtra	15-03-2019	Students trainings and post graduate research	2019-2024
Acharya N. G. Ranga Agriculture University, Guntur, Andhra Pradesh	21-01-2019	Students trainings and post graduate research	2019-2024

10.4: RAC, IRC, PMC, QRT meetings

Research Advisory Committee

The second meeting of the current Research Advisory Committee (RAC) of ICAR-Central Institute for Cotton Research (CICR), Nagpur was held on 22nd February 2019 under the Chairmanship of Dr. C.J. Dangaria, Hon'ble Vice Chancellor, Navsari Agricultural University, Navsari. At the outset, Dr. M.V. Venugopalan, Member Secretary, introduced and welcomed the Chairman and members of the RAC. Dr. V.N. Wagmare, Director, ICAR-CICR also extended a formal welcome and underlined the importance the institute attaches for this RAC meeting.

In his opening remarks Dr. C.J. Dangaria, Chairman RAC exhorted that in a highly dynamic global and national cotton scenario characterized by climate change and variability, changing farming situation, input use and pest scenario, the task ahead of cotton scientists is tremendous. He suggested that ICAR-CICR should focus on plant types and management practices for High Density Planting System (HDPS), development of varieties with big bolls and mechanization of cotton harvesting. He added that the RAC is a platform where experienced members provide critical suggestions for improvement of research programmes of the institute and the institute should consider these suggestions in right earnest. Dr R.K. Singh, ADG (Commercial Crops),

ICAR suggested that in the AICRP on Cotton evaluation trials, the Bt cultures must be evaluated both under conventional spacing and HDPS, to assess their potential yield superiority. Dr. S.S. Patil, Member RAC wanted that the task of maintaining the purity and uniformity of germplasm resource should be given priority. Dr. G.R. Chary, Member RAC suggested detailed studies on pink bollworm incidence and severity *vis-a-vis* climate change/ variability. Dr. S.V. Sarode, Member RAC explained the distinction between population diversity due to racial difference and resistance development due to selection pressure. He also urged ICAR-CICR to develop pro-active strategies to delay or prevent resistance development of *H.armigera* to cry toxins.

Dr. M. V. Venugopalan, Member Secretary RAC presented the Action Taken Report on the recommendations of the previous RAC meeting held on 4-5 January, 2018. The Heads of the divisions and regional stations presented the salient achievements of their respective divisions/stations. On the basis of the presentations and interactions, the RAC made certain specific recommendations and some general suggestions for follow up action. The recommendations are summarized below:

Recommendations:

1. Despite inferior performance of CGMS based hybrids over conventional hybrids, due to labour shortage; companies are employing CGMS based systems for hybrid seed production. It is necessary to indentify the reasons for their poor performance and device strategies to overcome it. *Gossypium harknessii* and *Gossypium aridum* may be explored for development of Cytoplasmic Genetic Male Sterility (CGMS) in cotton. Both sterility and restorer genes are to be drawn from same source. Sterile cytoplasm should be used for development of male sterility system so that restoration is manifested. Progenies developed may be evaluated under different temperature regimes to understand the stability of sterility system. Basic research regarding male sterility and hybrid development needs to be initiated and sustained. A net work project involving 2-3 SAUs may be formulated to undertake this work.
2. The early maturing compact lines identified as promising for HDPS must be converted to Bt background on priority. In AICRP on Cotton evaluation trials, the Bt cultures must be evaluated both under conventional spacing and HDPS, to assess their potential yield superiority.
3. Project on the development of Bt varieties using deregulated and non-deregulated events should be pursued more vigorously. All aspects viz., event characterization, bio-safety studies, bio-efficacy and BRL trials should be conducted on priority.
4. Based on the recent recommendations emanated from the meeting of the Group of Secretaries for promoting ELS cotton, a detailed road map clearly identifying the role of different partners and time bound action plan has to be prepared, submitted and executed.
5. ICAR-CICR has developed new *G. barbadense* cultures with high yield potential and fiber properties equal to Suvin. These should be promoted on priority to meet the requirements of ELS cotton.
6. ICAR-CICR should initiate a national programme for developing varieties resistant to Cotton Leaf Curl Virus (CLCuV) with inclusion of interested centre of SAU's. Pooling of genes for resistance from different sources, including *arboreum* cotton through inter mating and pyramiding them is essential for arresting the breakdown of resistance. The material developed should be evaluated in CLCuV hot-pots.
7. ICAR-CICR should have a population improvement programme aimed at developing cultures possessing desirable traits like compact plant type, sucking pest tolerance, CLCuV tolerance, early maturity etc.
8. ICAR-CICR has developed seven Bt varieties, and large scale seed production was taken up during 2018-19 for five Bt varieties. Front line demonstrations may be taken up during 2019-20 to popularize these varieties.
9. ICAR-CICR has developed a prototype of mechanical picker in collaboration with Mahindra & Mahindra. To carry forward this work, a collaborative project involving ICAR-CICR Nagpur, ICAR-CIAE Bhopal, ICAR-CIRCOT Mumbai and other relevant stake-holders must be initiated on priority.
10. ICAR-CICR has successfully implemented the e-kapas programme in collaboration with SAUs. The institute should undertake a study to analyse

the impact of this programme and quantify the economic benefits that the farmer have accrued by adopting the advisories provided. It should be documented as a success story.

11. In the Integrated Farming System (IFS) project, presently there is no off-farm component. On-farm, off-farm and non-farm enterprises need to be properly integrated. Cotton + Soybean in 4:2 rows can be tried and rabi crops like safflower can be evaluated in the harvested rows of soybean to achieve intensification-cum-diversification.
12. Extent of natural infestation of bio-agents (microorganisms/endophytes/endosymbionts) in PBW collected from different locations can be studied to known the geographical distribution of predation/parasites/pathogens of PBW in the natural eco-system.

In his concluding remarks, Dr. Dangaria, Chairman RAC urged that the institute should take note of all the valuable suggestions provided by the members of RAC and should implement them to improve the research outputs. He wanted the scientists of ICAR-CICR to prioritize the demands of farmers (including good hybrids) and work towards finding solutions to the demands.

The meeting concluded with vote of thanks proposed by Dr. D. Blaise, Head I/c, Division of Crop Production, ICAR-CICR, Nagpur.

Institute Research Committee (IRC) meeting

The Annual Institute Research Committee (IRC) meeting of ICAR-CICR was conducted as combined IRC for CICR, Nagpur, CICR, RS, Coimbatore and CICR, RS, Sirsa from 25-27th March and 10th April 2019 at CICR, Nagpur. Dr. V.N.Waghmare, Director chaired the meeting. After a brief welcome by Dr. K. Velmourougane, Secretary, IRC, Dr. M.V. Venugopalan, Incharge PME Cell and Member Secretary, RAC presented the recommendations of RAC meeting held on 22nd Feb 2019. Later, Dr. K. Velmourougane, Secretary, IRC presented the Action Taken Report (ATR) of the previous IRC meeting 2018, which was confirmed and approved by the house. A total of 14 research projects were concluded during the IRC 2018-19, while, 13 projects (2 projects in Crop Improvement, 8 projects in Crop Production and 3 projects in Crop Protection) were newly approved amounting to 82 ongoing research projects excluding 2 NPDF projects from students. Out of 72 Scientists, 61 Scientists attended the Annual IRC 2019.

The Chairman in his concluding remarks praised the remarkable contributions made by the Scientist of CICR in cotton research. The Chairman also congratulated all the Scientists for their commendable job in creating awareness of pink bollworm problem in cotton and their management and also exploration regarding HT cotton in India.

The IRC felicitated Dr. R.A. Meena, Principal Scientist (Seed Technology), CICR, RS, Sirsa who was due for his superannuation in the month of June 2019. In this occasion, Dr. R.A. Meena presented his life time achievement in cotton research before the house. Dr. K. Velmourougane, Secretary, IRC and Dr. Dipak Nagrale, Joint Secretary, IRC coordinated the meeting.

Quinquennial Review Team (QRT)

The Quinquennial Review Team (QRT) to review the work done by ICAR-Central Institute for Cotton Research, Nagpur and All India Coordinated Research Project on Cotton for the period 2013 to 2017 was constituted under the Chairmanship of Dr.S.A.Nimbalkar, Former Vice Chancellor, Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola; Dr. B.M. Khadi, Former Director, ICAR-CICR & Former Director Research, UAS, Dharwad; Dr. K.V. Bhat, Ex-Pr. Scientist and Head Division of Genomic Resources, NBPGR, New Delhi; Dr. M. A. Shankar, Rtd. Director of Research, UAS Banglore; Prof. T.V.K. Singh, Former Emeritus Scientist & Rtd. Dean of Agril. PJTSAU, Hyderabad were the QRT members. Dr.M. V. Venugopalan, Principal Scientist, Agronomy and Incharge PME Cell, ICAR-CICR served as the Member Secretary.

The following QRT meetings held at various locations of Institute and the AICRP during the period.

S.No.	Date	Venue
1.	21st August, 2018	ICAR-CICR, Nagpur
2.	4th September, 2018	CCS HAU, Hisar
3.	5th September, 2018	ARS (SKRAU), Sriganganagar
4.	6th September, 2018	PAU, Faridkot
5.	7th September, 2018	CICR Regional Station, Sirsa
6.	04th October, 2018	ICAR-CICR, Nagpur
7.	5th October, 2018	AICRP on Cotton Centres , Akola
8.	1st November, 2018	Mumbai
9.	2nd November, 2018	Surat
10.	3rd December, 2018	Dharwad
11.	5th December, 2018	AICRP Centres, Coimbatore
12.	6th – 7th December, 2018	ICAR-CICR Regional Station (RS), Coimbatore
13.	18th & 19th January, 2019	Finalisation of recommendation at ICAR-CICR, Nagpur

The committee reviewed the research work. facilites including human resource at ICAR-CICR and Centres of AICRP on Cotton and finalised report alongwith recommndations.

10.5: Other Important Workshop/Symposia/Meetings/Visits

Sr. No.	Seminars/ Symposia/ Workshops/ Meetings/Visits	Place and Date	Organiser
1.	Kisan Kalyan Diwas Awareness and Training Programme in collaboration with ATMA and TAO	Taluka Mauda, Distt. Nagpur on 02.05.2018.	Government of Maharashtra under Gram Swaraj Abhiyan (J.H.Meshram)
4.	AICCIP Monitoring team for South zone	South Zone	AICCIP (Dr. A.R. Reddy)

S.No.	Field Days	Place and Date	Participants
1	Field day of FLD on Integrated Crop Management	Ariyalur District, Tamil Nadu (43 farmers) 07.02.2019	Dr. S. Usha Rani Dr. R. Raja Dr Amutha Dr. A. Sampath Kumar Dr. P. Valarmathi
2	Field day of FLD on intercropping in cotton	Ariyalur District, Tamil Nadu (25 farmers) 08.02.2019	Dr. S. Usha Rani Dr. R. Raja Dr Amutha Dr. A. Sampath Kumar Dr. P. Valarmathi
3	Field day of Karunya Deemed University	Karunya Deemed University, Coimbatore (500 farmers) 27.02.2019	Dr. S. Usha Rani Dr. D. Kanjana Dr. J. Annie Sheeba
4	Field day of FLD on ELS cotton	Namakkal District, Tamil Nadu (50 farmers) 02.03.2019	Dr. S. Usha Rani Dr. R. Raja Dr. M. Amutha Dr. A. Manivannan

IRM-PBW Launch-cum-Orientation workshop

The Launch-cum-Orientation Workshop was held at ICAR-CICR, Nagpur on 14th August, 2018. The workshop was inaugurated by Chief guest Dr. CD Mayee, Ex-Chairman ASRB, who chaired the workshop. Dr. RP Singh, Director, Directorate of Cotton Development, Nagpur was the Guest of honour on this occasion.

Dr. CD Mayee expressed his gratification that the Govt. has taken the issue of PBW in a right perspective and provided timely funding for large scale campaign for effective management of this pest in cotton. He advocated for community based approach for the management of pest like PBW. He congratulated ICAR-CICR for its lead role in this endeavour and conveyed his best wishes for its success.

Dr. RP Singh informed about the inclusion of cotton crop in Central Govt. Scheme of "NFSM: Commercial Crops". He gave brief overview of cotton acreage and production in the current season vis –a- vis previous year.

Dr. VN Waghmare, Director, ICAR-CICR expressed the hopefulness that successful implementation of the project will definitely help in controlling PBW infestation in cotton and will also strengthen the research network of ICAR-CICR on cotton across the region.

Dr. VS Nagrare, Principal Scientist (Ag. Entomology) made a brief presentation of the project covering the important aspects like current status of PBW infestation in the country, initiatives taken by ICAR-CICR to tackle the problem of PBW, the project implementation scheme and budget allocation for various activities under the project.

Elaborative discussion was held on the various activities to be carried out under the project. The guidelines for selection of villages/ cluster of villages in the district, purchase of various inputs for distribution to the cotton farmer beneficiaries, recruitment of manpower and essential educational qualification requirements for the same were discussed. The detailed project documents were also circulated to the participating centres for ease of understanding.

Review Workshop of Insecticide Resistance Management (IRM): Dissemination of Pink Bollworm Management Strategies 2018-19

The REVIEW WORKSHOP of Insecticide Resistance Management (IRM): Dissemination of Pink Bollworm Management Strategies 2018-19 was held on 23rd Feb, 2019 at ICAR-Central Institute for Cotton Research (CICR), Nagpur. Dr R. K. Singh, Assistant Director General (Commercial Crops), Indian Council of Agricultural Research, New Delhi was the Chief guest to chair the Review Workshop. Shri R. P. Singh, Director, Directorate of Cotton Development (DCD), Nagpur (Government of India, Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare)was the guest of honour. Dr S.S. Patil, Principal Scientist and Head, ARS, Dharwad and Dr. Y.P. Singh, Principal Scientist, Crop Science Division, Indian Council of Agricultural Research (ICAR), New Delhi were the special invitees. Dr. V. N. Waghmare, Director, ICAR-CICR, Nagpur, Dr. Blaise Desouza, Head I/C, Crop Production Division, ICAR-CICR, Nagpur, Dr. Nandini Gokte-Narkhedkar, Head I/C Crop Protection Division,ICAR-CICR, Nagpur, Dr. A. H. Prakash, Project Coordinator & Head i/c, ICAR-CICR, RS, Coimbatore, Dr. D. Monga, Head, ICAR-CICR RS Sirsa

Haryana, Dr. M. V. Venugopalan, Head, Project Monitoring and Evaluation cell, ICAR-CICR, Dr. V. S. Nagrare, Principal Scientist and Principal Investigator, IRM-PBW Project, ICAR-CICR, Nagpur were prominently present. Participants from ICAR-CICR, 10 State Agricultural Universities (SAUs) and 3 KVKs, covering a total of 21 districts from seven major cotton growing States from central and south India and new invitees from three Agricultural Universities from North India and one Agricultural University from Gujarat attended the review workshop.

Training for Cotton farmers to appraise them with technologies for higher returns

ICAR-CICR and Directorate of Cotton Development (DCD), Nagpur jointly organized a day long training program for cotton farmers under National Food Security Mission- Commercial Crops at ICAR-CICR, Nagpur. The inaugural session was graced by Dr. V. N. Waghmare, Director, ICAR- CICR, Nagpur, Dr. R. P. Singh, Director, DCD and Smt. Pradnya Godghate, DSAO, Nagpur. Dr. Blaise Desouza, Head(I/c) Division of Crop Production, Dr. Nandini Gokte, Head (I/c) Division of Crop Protection, Dr. S. M. Wasnik (I/c) KVK, CICR, Nagpur shared the dias. The strategies developed by ICAR-CICR in managing Pink bollworm last year were well appreciated and the need to adopt an integrated approach for profitable cotton farming was emphasized. The collective efforts of Central as well as State Government agencies along with cotton ginning mills ensured successful management of Pink bollworm during this season and the necessity to work in similar manner in future was agreed upon. About 60 farmers from Nagpur district attended the training and got benefitted. The farmers were cautioned against unwanted spraying of chemicals on cotton crop. They were also acquainted about CICR Bt varieties, integrated pest, disease and weed management and safe use of pesticides. Dr. Blaise Desouza, Dr. S. M. Wasnik, Dr. V. S. Nagrare, Dr. Ramkrishna, Dr. A.R. Raju, Dr. Dipak Nagrale, Dr. B. B. Fand and Dr. S.P.Gawande delivered lectures. Dr. B.B. Fand conducted the programme.

Collaborative training Program for the Champion farmers

A series of five training program for Champion Farmers adopted by Bayer Crop Science from different Districts and Blocks of Haryana were conducted at ICAR- Central Institute for Cotton Research, Regional Station, Sirsa from 16th to 21st April, 2018 under Public Private Partnership mode. In each training program, 60 progressive farmers designated as Champion farmers from Fatehabad, Sirsa, Ellenabad, Hansi, Jind and Hisar blocks participated. For the benefit of farmers, four important lectures related to cotton production and protection especially, cultural practices, selection of cotton varieties/hybrids (Bt/American/Desi), etc. were delivered on each day by subject experts.

Capacity building workshops on Cotton BMPs for implementing partners of BCI

Based on an MoU signed between ICAR-CICR and Better Cotton Initiative (BCI), resource persons from ICAR-CICR conducted three workshops across the country in Rajkot, Hyderabad and Nagpur during April and May of 2018. Dr. M. V. Venugopalan (Pr. Scientist, Agronomy) and Dr.Vivek Shah (Scientist Entomology) conducted the session in Rajkot on 20th

April 2018 which was attended by 73 participants. Dr. Chinnababu Naik (Scientist Entomology) and Dr. G.I Ramakrushna (Scientist Agronomy) conducted the training sessions in Hyderabad which was attended by 58 participants from Andhra Pradesh, Telangana and Karnataka on 26 April, 2018. The third workshop was conducted in the ICAR- CICR Nagpur premises on 23rd May 2018 and it was attended by 97 participants from Maharashtra and MP. In addition to the interactive and productive knowledge sharing sessions at Nagpur by Dr. M.V Venugopalan, Dr.Chinnababu Naik, Dr. GI Ramkrushna, and Dr.Vivek Shah, there was a special address by Dr.V.N.Waghmare, Director who inspired the participants to take their learnings from these workshops to the grass root level in order to reduce the problems faced by cotton farmers due to increasing cost of cultivation and emerging issues with pink boll worm resistance in the country.

The focus of the workshop was to train the participants on Best Management Practices for cotton through a better insight on soil, water, nutrient and pest interactions. Given the re-emergence of Pink Bollworm in most of the cotton growing states in the country in 2017-18, this issue was given additional focus. A special practical session on sampling procedures and determination of Economic Threshold Level of PBW through dissection of cotton bolls was conducted in all the three trainings. Methodologies to conduct demonstrations on farmers' fields were also finalized during the workshop conducted at ICAR-CICR on 24th May 2018. In all 228 participants including Production Unit managers and representatives from 25 implementing partners of BCI were benefitted through the training. ICAR- CICR envisages this capacity building programme as an essential step to bridge the gap between knowledge available with the researchers and current cotton growing practices and promote sustainability in cotton cultivation in India.

Farmers Fair cum Workshop at Girad (Wardha) under NFSM:IRM -PBW

Farmer's fair cum workshop on Integrated

Management of Pink bollworm was held on 4th December, 2018 at Natural farming development Centre, Magan Sangrahalaya Girad Dist. Wardha. The programme was organised under the project on NFSM-IRM: Dissemination of Pink bollworm Management Strategies. The workshop was inaugurated by Dr. V. N. Waghmare, Director CICR. Dr. Nandini Gokte-Narkhedkar, I/C Head, Division of Crop Protection, welcomed all the participants. Dr V. N. Waghmare pointed out that, different stakeholders including farmers, seed producers, ginners, state agriculture department, social organizations, NGO's, KVKs, State Agriculture Universities etc. need collective efforts in tandem for effective management of Pink bollworm in the ensuing season. He also emphasized on need based application of pesticides on the crop and urged the farmers to avoid indiscriminate use of pesticides. Dr. S. P. Gawande , Scientist (Plant Pathology) and District Coordinator IRM-PBW, Wardha presented the status of Pink bollworm infestation in the selected villages activities conducted under this project during this season.Dr. S. M. Wasnik, Principal Scientist (Extension), acquainted the farmers about the program of e-Kapas and "Mera Gaon Mera Gaurav". Dr. Vinita Gotmare, Principal Scientist (Genetics) in her speech provided information on promising varieties and hybrids of Cotton. Dr. Vishlesh Nagrare, Principal scientist (Entomology) gave detailed information to the stakeholders about integrated management of pink bollworm Dr Babasaheb Fand, Scientist (Entomology) delivered a lecture on 'Safe use of pesticides'. He called farmers attention mainly towards strict adherence to label claims, avoiding mixtures and overuse of pesticides. Dr. Dipak Nagrale, Scientist (Plant Pathology) delivered a lecture on 'Integrated Disease Management in Cotton'. More than 350 farmers from 15 villages of Samudrapur Tahsil of Wardha District participated in this programme. Dr. Sarvanan, Scientist (Plant breeding) proposed the vote of thanks.

Farmers' workshop and Beejmohotsav at Girad, District-Wardha under Mera Gaon Mera Gaurav

One day Farmers' workshop on Integrated Management of Pink bollworm, FLD seed

distribution programme and "Beejmohostav" was organised in collaboration with Magan Sangrahalaya Girad on 5th June, 2018 at Magan Sangrahalaya of Natural Farming Development Center, Girad, Tal. Samudrapur, Dist. Wardha. Dr. Nandini Gokte-Narkhedkar, I/C Head, Division of Crop Protection, ICAR-CICR welcomed all the participants. She pointed out that different stakeholders including farmers, seed producers, ginners, state agriculture department, social organizations, NGO's, KVKs, State Agriculture Universities etc. need to work collectively for effective management of Pink bollworm in the next season. Dr. P. R. Vijayakumari, Principal Scientist (Seed Technology), acquainted the farmers about seed production programme and guided the farmers about Suraj variety. Dr B.B. Fand Scientist (Entomology) gave detailed information about integrated management of pink bollworm. Dr S.P Gawande, Scientist (Plant Pathology) delivered a lecture on 'Safe use of pesticides'. Dr. D.T. Nagrale delivered talk on Identification of Diseases and Integrated Disease Management in cotton. Also distributed seeds under AICCIP FLD consisting of Integrated cotton management and cotton Inter cropping. More than 200 Farmers from 17 villages viz., Arvi, Mohgaon, Faridpur, Shivanphal, Jogingumpha, Girad, Kapsi, Korapna, Tavi, Pimpalgaon,Edlabad, Antargaon, Sawandi, Wadgaon, Hivra, Wagheda and Samudrapur participated. Dr. Sarvanan Scientist (Plant Breeding) proposed vote of thanks.

Workshop on Integrated Management of Pink Bollworm at Girad, Wardha

The one day Farmers workshop on Integrated Management of Pink bollworm was organised by ICAR-CICR, Nagpur at Magan Sangrahalaya , Girad Tal. Samudrapur, Dist. Wardha on 31st July 2018 under TSP and MGMG. In this Dr. Nandini Gokte-Narkhedkar, Head, Division of Crop Protection, welcomed all the participants and urged the farmers to install the pheromone traps for monitoring of pink bollworm. Dr. S.M. Wasnik, Principal Scientist (Extension), acquainted the farmers about the program of e-Kapas and "Mera Gaon Mera Gaurav" and appealed them to register their contact details with the institute so as to get the benefit of mobile based voice messages and agro-advisories issued by the institute from time to time. Dr V. Chinnababu Naik

Scientist (Entomology) gave detailed information to the farmers about integrated management of pink bollworm. He discussed the role of various aspects like termination of crop latest by first fortnight of January, crop rotation, adoption of early maturing varieties, sowing of next season's crop in June, installation of pheromone traps after 45 days of sowing, etc for the management of pink bollworm in the next season. Also demonstrate the installation of Pheromone traps in the cotton field to participants. Dr S.P Gawande, Scientist (Plant Pathology) delivered a lecture on 'Safe use of pesticides'. He called farmers attention mainly towards strict adherence to label claims, avoiding mixtures and overuse of pesticides and need based spray of only recommended chemicals. More than 80 Farmers participated in this workshop. Dr. Dipak Nagrale delivered the lecture on Identification of important cotton diseases and their integrated management. After that Pheromone traps were distributed to the farmers who has taken the demonstrations under TSP and FLD.Also distributed the leaflets consisting of information of Pink bollworm management strategies and safe handling of pesticides published by ICAR-CICR. Dr. Sarvanan Scientist (Plant breeding) proposed the vote of thanks at the end of the programme.

Field Survey for collection of cotton leaf and boll samples from farmers' fields of Buldhana , Jalgaon, Dhule and Nandurbar district of (Maharashtra) for HT testing and assessment of pink bollworm infestation

As a member of committee constituted by Director, ICAR-CICR, Dr. Shailesh P. Gwande , Scientist (Plant Pathology), Dr. A. Manikandan, Scientist (Soil Science), and Mr. Ratnadeep Ramteke, Technical Assistant, ICAR-CICR, Nagpur visited different villages of Khamgaon, and Malkapur tehsil of Buldhan, Bhusaval and Muktainagar of Jalgaon District Erandole, Dhule , Shahada and Nandurbar of Maharashtra for collecting leaf samples for Herbicide Tolerance (HT) testing and for collecting green bolls for assessment of pink bollworm damage on 27th ,28th ,29th and 30th September, 2018 respectively. From each field, one terminal leaf from each of 10 randomly chosen plants and one green boll from each of 20 randomly chosen plants were collected as one sample for HT testing (leaf sample) and pink bollworm damage assessment (boll sample). In total, 40 samples were collected from different locations of four Districts. GPS/locations of the sampling sites were noted and required details about crop history were collected wherever farmers were available in the fields the team interacted with the farmers regarding situation and answered the queries raised by the farmers. The agriculture officials also accompanied the team. Samples were brought in ice boxes and handed over to the concerned laboratory for testing at ICAR-CICR, Nagpur.

10.6: Participation of Scientists in Seminars / Symposia / Workshops

Sr. No.	Seminars/Conferences/Symposia/ Workshops/ Meetings	Place and Date	Participants
1.	Joint Annual Group Meeting of National Seed Project and ICAR Seed Project	CCSHAU, Hisar 7- 9th Apr., 2019	Dr. P. R. Vijayakumari
2.	38th Scientific advisory committee meeting	ICAR-KVK, Coimbatore 9 April, 2018	Dr. K Rathinavel
3.	Annual Group Meeting of ICAR-AICRP on Cotton	CCSHAU, Hisar Haryana 9-10 Apr., 2018.	Dr. V.N.Waghmare Dr. J.H.Meshram, Dr. G.I. Ramkrushna Dr. S. M. Palve Dr. S. Manickam Dr. Sunil Mahajan Dr. Nandini Gokte-Narkhedkar, Dr. V. S. Nagrare Dr. B.B. Fand Dr. D.Monga, Dr. Rishi Kumar, Dr. A.H. Prakash Dr. K. Rathinavel Dr. K.P.M. Dhamayanthi Dr. S. Manickam Dr.K.Sankaranarayanan Dr. S. Usha Rani Dr. M. Sabesh
4.	Meeting held in collaborations with Better Cotton Initiative partners	ICAR-CICR RS, Sirsa 14 Apr., 2018	Dr. D Monga Dr. Rishi Kumar Dr. S.K. Sain Dr Amarpreet Singh
5.	Review meeting of ICAR Regional committee No.VIII	ICAR-Sugarcane breeding Institute, Coimbatore 17 Apr., 2018	Dr. K Rathinavel
6.	Cotton Pink Bollworm management stakeholders meeting	Nagpur 22 Apr., 2018,	Dr. D.V. Patil
7.	Kisan Melava	Dhamna, District Nagpur, 2 May 2018 Pusad, Dist Yavatmal. 5 June 2018	Dr. V. S. Nagrare
8.	Gram Swaraj Abhiyan and Kisan Kalyan Diwas	Umred 02 May, 2018,	Dr. D.V. Patil
9.	Team Leader (Team 1) – Visit of the Inter-ministerial team (IMCT) to Maharashtra for assessment of situation in the wake of Pest Attack on Cotton and Paddy crops and Ockhi	DAC &FW, GOI, New Delhi 14-19 May, 2018	Dr. A.H. Prakash

Sr. No.	Seminars/Conferences/Symposia/ Workshops/ Meetings	Place and Date	Participants
	cyclone during 2017- Committee constitute by DAC, GOI, New Delhi		
10.	Visit of Inter-Ministerial Central Team (IMCT) to Maharashtra for assessment of situation in the wake of pest attack on cotton and paddy crops and Ockhi cyclone.	Aurangabd, Mumbai, 15-18 May 2018	Dr. Nandini Gokte-Narkhedkar, Dr V. S. Nagrare
11.	Finalizing report of visit by Inter Ministerial Central Team.	Krishi Bhavan, New Delhi 28 May 2018	Dr V. S. Nagrare
12.	Interstate Consultative Committee Meeting for whitefly management	Bathinda 30 May 2018 & Abohar 13 Jul., 2018	Dr. D.Monga, Dr. Rishi Kumar
13.	13th review meeting of DUS Test Centres (Kharif crops-2018) by PPV &FRA, New Delhi	NASC, New Delhi 31 May, 2018	Dr. V. Santhy
14.	Meeting of Evaluation committee for evaluating various award application of TNAU Scientists	TNAU, Coimbatore, 31 May 2018	Dr. C. Karpagam
15.	PoCRA – Project on Climate Resilient Agriculture Meeting	ICAR-CICR Nagpur 08 June 2018	Dr. S.M. Wasnik
16.	Meeting of Evaluation committee for evaluating oral presentation of various award of TNAU Scientists	TNAU, Coimbatore, 12 Jun., 2018.	Dr. C. Karpagam
17.	Meeting on conducting M.Sc thesis evaluation and final viva-voce	Annamalai University, Chidambaram, 22 Jun., 2018.	Dr. C. Karpagam
18.	National Seminar on Current challenges and innovative breeding approaches in crop science for agricultural sustenance	APACRI, Kalavai 27 June, 2018	Dr. A.Manivannan
19.	Meeting with Hon'ble Members of the parliament on "Need for alternative cropping pattern in drought affected areas of India"	Coimbatore, 29 Jun., 2018	Dr. MV Venugopalan Dr. V. N. Waghmare Dr. A H Prakash, Dr. K Rathinavel Dr S Manickam, Dr Sankaranarayanan Dr. M. Sabesh
20.	ICAC - 14th meeting of Southern and Eastern African Cotton Forum (SEACF)	Harare, Zimbabwe 4-6 Jul., 2018	Dr. S. Usha Rani
21.	Meetings on Bollworm Management	Kadimbag, Nagpur, 7 Jul., 2018	Dr. N G-Narkhedkar, Dr V. S. Nagrare
22.	Meeting to consider the deferred proposal of Bt cotton hybrid/ varieties.	ICAR-New Delhi 10 Jul., 2018	Dr V. S. Nagrare, Dr. V.Chinna Babu Naik
23.	Member, Institute Management Committee Meeting	ICAR-SBI, Coimbatore 25 Jul., 2018; 20 Sept., 2018; 13 Nov., 2018	Dr A.H. Prakash

Sr. No.	Seminars/Conferences/Symposia/ Workshops/ Meetings	Place and Date	Participants
24.	Assessment Committee meeting for CAS of ICAR-CRIJAF, Barrackpor e	CRIJAF Barrackpore, 7 Aug., 2018	Dr. R. Raja Dr. V. S. Nagrare
25.	Central Sub Committee Meeting for release and notification of crop varieties	ICAR, New Delhi, 10 Aug., 2018	Dr. S. Manickam
26.	Launch -Cum -Orientation Workshop of Project IRM-PBW	ICAR-CICR, Nagpur 14 Aug., 2018 ,	Dr. S.M. Wasnik Dr. V.N.Waghmare, Dr. V. S. Nagrate, Dr. N Gokte-Narkhedkar
27.	Member, Institute Management Committee Meeting	ICAR-CRIJAF, Barrackpore 27 Aug., 2018	Dr. R. Raja
28.	Quarterly Rural advisory programme committee meeting of AIR	Akashwani, AIR, Nagpur 30 Aug., 2018	Dr. S.M. Wasnik
29.	Western Zone Symposium of Indian Phytopathological Society on "Current and Emerging Trends in Plant Health Management"	Colva, Goa 23 -24 Aug., 2018	Dr. Hiremani N.S. Dr. Shailesh P. Gawande Dr. Dipak T. Nagrale
30.	Farmers seminar at Tamil Nadu state "Kisan Sammridhi Mela"	CODISSIA Trade fair complex, Coimbatore, 24 – 26 Aug., 2018.	Dr. B. Dhara jothi
31.	DPC meeting as DG's Nominee & Expert in the discipline of Seed Technology	ICAR-DOGR, Pune 30 Aug., 2018	Dr. V. Santhy
32.	2nd Steering committee meeting of CROPSAP at Pune.	Pune, 7 Sept., 2018	Dr V. S. Nagrare
33.	Meeting on conducting M.Sc thesis evaluation and final viva-voce	Kerala Agricultural University, 14th Sept., 2018.	Dr. C. Karpagam
34.	Workshop on "Preparation of manual and strategy document on Crop Plan"	NASC, New Delhi, 18 Sept., 2018	Dr. M.V. Venugopalan Dr. V. N. Waghmare
35.	Seminar on 'R and STATCRAFT'	PSGR College, Coimbatore 3 Oct., 2018	Dr. D.Kanjana Dr. M. Amutha Dr. P. Valarmathi
36.	International Conference on Multifunctional Advanced Materials - ICMAM-2018	Kamala Nehru Mahavidyalaya, Nagpur. 5-7 Oct., 2018.	Dr. A . Manikandan Dr. Raghavendra, K. P Dr. ChandraShekar N
37.	Meeting on conducting M.Sc thesis evaluation and final viva-voce	TNAU Coimbatore, 15 Oct., 2018.	Dr. C. Karpagam
38.	Workshop on Agri- Startup and Enterprenurship Conclave " Unleashing Potentials in Agriculture fro Young Agriprenueures (UPAYA)	NASC, New Delhi, 16-17 Oct., 2018	Dr .S.K. Sain

Sr. No.	Seminars/Conferences/Symposia/ Workshops/ Meetings	Place and Date	Participants
39.	AFITA/WCCA 2018 conference on Reaserch Frontiers in Precision Agriculture	IIT Powai, Mumbai 24-26 Oct., 2018,	Dr. S.M Wasnik
40.	National Seminar on Abiotic Stress Management: challenges & opportunities (NSASM 2018)	TNAU, Coimbatore October 25-26, 2018	Dr. A.H, Prakash (Convenor) Dr. J. Annie Sheeba
41.	National Conference on Bio-intensive Approaches in Plant Protection and their Socio-economic Impacts	Aligarh Muslim University. 29-30 Oct., 2018	Dr.J.GulsarBanu
42.	International Symposium on Advancements in soil water and plant nutrition research.	VANAMATI, Nagpur. 2 Nov., 2018	Dr. Blaise D Dr. A Manikandan
43.	20th Scientist Adverary committee meeting of KVK-CCSHAU	KVK CCSHAU, Sirsa 14 Nov., 2018	Dr. S.K. Sain
44.	Resource Person & Lecture on "Association mapping and its application in crop improvement" CAFT training on " Application of molecular markers in crop breeding"	CPBG, TNAU, Coimbatore 15 Nov., 2018	Dr. A.Manivannan
45.	Workshop cum training on new BCI criteria for water –organized by BCI, Helvetas and Alliance for Water Stewardship	New Delhi, 21 Nov., 2018	Dr. MV Venugopalan
46.	ISWS Golden Jubilee International Conference on Weeds and Society: Challenges and Opportunities	ICAR - DWR, Jabalpur 21-24 Nov., 2018	Dr. Pooja Verma
47.	AICRP Central zone monitoring	Central Zone 12- 22 Nov., 2018	Dr. C. Karpagam
48.	Lecture on Fibre for the Future Indian Agriculture. CAFTA training on "Frontier Technologies for Future Profitable and Sustainable Agriculture"	TNAU, Coimbatore 28 Nov., to 18 Dec., 2018	Dr. A.H. Prakash Dr. M. Sabesh (Resource Person)
49.	Centre of Advanced Faculty Training (CAFT) on "Facets in Biopesticide and Botanical production",	TNAU, Coimbatore 28 Nov., to 18 Dec., 2018	Dr. P. Valarmathi
50.	Quarterly Rural advisory programme committee meeting of AIR	AIR, Nagpur 29 Nov., 2018,	Dr. S.M. Wasnik
51.	Symposium on Entomology 2018: Advances and Challenges	PJTSAU, Hyderabad, 10-12 Dec., 2018	Dr. V. Chinna Babu Naik
52.	1st National Genetics Congress on Genetics for Sustainable Food, Health and Nutrition Security	ICAR-IARI, Delhi 14-16 Dec., 2018	Dr. V.N.Waghmare Dr. S.B.Singh Dr. S. M. Palve
53.	XVII Shri. Vasantrao Naik Memorial National Seminar on Potential, Prospects & Strategies for Doubling Farmers' Income	Akola, 15-16 Dec., 2018.	Dr. M.V. Venugopalan
54.	Meeting to chalk out a concrete action plan for improvement of productivity, quality and import substitution of natural fibers	ICAR, New Delhi, 18 Dec., 2018	Dr. V.N. Waghmare Dr. A.H.Prakash Dr. S. Manickam
55.	First International conference on Climate	ICAR-NRSS, Ajmer.	Dr. J.Gulsar Banu

Sr. No.	Seminars/Conferences/Symposia/ Workshops/ Meetings	Place and Date	Participants
	change and Adaptive Crop Protection for Sustainable Agri-Horticulture Land Scape	20-22 Dec., 2018	Dr. K. Rameash Dr. M. Amutha Dr. K.Shankarganesh
56.	National symposium on "Cutting edge approaches for sustainable plant disease management and ensuring farmer's profit".	21-23, Dec., 2018,	Dr. P. Valarmathi
57.	Meeting on Proposal for Commercial release of Bt Cotton hybrids/varieties North, Central and South Zone	ICAR- New Delhi, 24 Dec., 2018	Dr. S.K. Sain
58.	Launching of Training Programme on 'Diploma in Agricultural Extension Services for Input Dealers (DAESI)'	Akola, 14 Jan., 2019	Dr. V. S. Nagrare
59.	Extension field survey in Maharashtra state	Jalgon and Jalna 16-24 Jan., 2019.	Dr. C. Karpagam
60.	Meeting of Germplasm Registration Committee	ICAR-NBPGR, New Delhi, 28 Jan., 2019	Dr. S. Manickam
61.	Formulating Price policy for Kharif Crops 2019-20 by Commission for Agricultural Costs and Prices	New Delhi, 01 Feb., 2019	Dr. A.R. Reddy
62.	Strengthening of Seed Systems in the North Eastern and Unreached Regions-Problems, Prospects and Policies" Organised by Indian Society of Seed Technology	ICAR Research Complex for NE Region - Manipur Centre, Imphal. 3-5 Feb., 2019	Dr. Sunil Mahajan
63.	IRAC India Workshop on Insecticide Resistance Management (IRM)	Radisson Blu Plaza New Delhi 4-5 Feb., 2019	Dr Rishi Kumar
64.	Inaugural Address National Conference on Biology and Medicine (NCBM-2019)	Bharathiar University, Coimbatore , 7-8 Feb., 2019	Dr. A.H. Prakash
65.	Golden Jubilee international salinity conference (GJISC-2019).	ICAR-CSSRI, Karnal. 7–9 Feb.,, 2019	Dr. A.Manikandan
66.	Farmers Mela	Adilabad, 7 Feb., 2019.	Dr. V. S. N agrare
67.	XIV Agriculture Science Congress poster presented on "Root phenotyping for drought tolerance in (*G.hirsutum* L)".	NAAS, New Delhi 20-23 Feb., 2019,	Dr. Meshram, J.H,
68.	Quarterly Rural advisory programme committee meeting of AIR	AIR, Nagpur 21 Feb., 2019,	Dr. S.M. Wasnik
69.	Review workshop of insecticide resistance management (IRM): Dissemination of Pink Bollworm Management Strategies.	ICAR-CICR, Nagpur 23 Feb., 2019,	Dr. S.M. Wasnik
70.	XIV Agricultural Science Congress 2019	NASCC, New Delhi 20 – 23 Feb., 2019	Dr. R. Raja, Dr. J. H. Meshram Dr. N. Gokte-Narkhedkar
71.	"Rashtriya Vaigyanik Rajbhasha Parisamvaad" (National Official Language Seminar)	ICAR-CIFE, Mumbai 25-26 Feb., 2019	Dr. Pooja Verma

Sr. No.	Seminars/Conferences/Symposia/ Workshops/ Meetings	Place and Date	Participants
72.	Institute management committee meeting of CICR	ICAR-CICR, Nagpur 26 Feb., 2019,	Dr. S. M. Wasnik
73.	Promotion of ELS Cotton Cultivation in 2019-2020-Evolution of New Strategies	Directorate of Agriculture, Chennai, 28 Feb., 2019	Dr. S. Manickam
74.	Meeting on Promotion of ELS Cotton Cultivation in 2019-2020-Evolution of New Strategies	Directorate of Agriculture, Chennai 28 Feb., 2019	Dr. S. Manickam
75.	VIT Board of studies External member- for BSc (Hons) Agriculture- Annual Meeting	VIT University, Vellore 6 Mar., 2019	Dr A.H. Prakash
76.	Action plan workshop of KVKs of Vidharbha	Dr PDKV, Akola 6-7 Mar., 2019,	Dr. S.M. Wasnik
77.	6th Bio pesticide International Conference (BIOCICON-2019)	Amity University, Raipur, Chhattisgarh 06-08 Mar., 2019	Dr. K. Shankarganesh
78.	Group Meeting of All India Coordinated Cotton Improvement Project for North Zone locations	CCSHAU, Hisar, 11 Mar., 2019	Dr. V.N.Waghmare Dr. S. Manickam Dr. G.Balasubramani Dr. S.S.Mahajan Dr. Nandini Gokte Narkhedkar V. S. Nagrare Dr. RA Meena Dr. OP Tuteja Dr. SK Verma Dr. Rishi Kumar Dr. S.K. Sain Dr. Amarpreet Singh Dr. A.H. Prakash Dr. B. Dharajothi Dr. Manickam Dr. Sankarnarayanan Dr. Sabesh
79.	Action plan workshop of KVKs of Maharashtra & Goa	KVK, Baramati 15-16 Mar., 2019,	Dr. S.M. Wasnik
80.	Meeting on Promotion of ELS Cotton cultivation	Directorate of Agriculture, Chennai 21 Mar., 2019	Dr. S. Manickam
81.	DPC meeting as DG's Nominee & Expert in the discipline of Genetics & Plant Breeding.	ICAR-NRC for Grapes, Pune 29 Mar.,2019	Dr. Vinita Gotmare

10.7: Distinguished Visitors

Name	Organization	Date
Coimbatore		
Dr. R. K. Singh	Assistant Director General (Commercial Crops)	29th June 2018
Dr. S. Bhaskar	Assistant Director General (Agronomy, Agro Forestry and Climatology)	29th June 2018
Shri. Chhabilendra Roul	Special Secretary, DARE and Secretary, ICAR	28th August, 2018
Dr. Trilochan Mohapatra	Secretary DARE & Director General, ICAR	3rd September 2018
Dr. A. K. Singh	Deputy Director General (Crop Sciences)	31st October 2018
Dr. Nimbalkar Dr. B. M. Khadi Dr. M. A. Shankar Dr. T.V.K. Singh	Chairman and members QRT committee	5th and 6th December 2018
Sh Alok Kumar Gupta Shri Naresh Sirohi	ICAR Governing Body Member National Vice President, Kisan Morcha	9th April, 2018



10.8: Personnel

Director
Dr. VN Waghware, Director (Acting)
Project Coordinator (Cotton)
Dr. AH Prakash, PC (Cotton) & Head (Acting)
CROP IMPROVEMENT DIVISION
Genetics & Plant Breeding
Nagpur
Dr. VN Waghware, HOD, Crop Improvement
Dr. (Mrs.) SB Singh, Pr. Scientist
Dr. TR Loknathan, Pr. Scientist
Dr. SM Palve, Pr. Scientist
Dr. (Mrs.) Vinita Gotmare, Pr. Scientist
Dr. DV Patil, Sr. Scientist
Sh. M Saravanan, Scientist
Dr. Santosh HB, Scientist
Coimbatore
Dr. S Manickam, Pr. Scientist
Dr. (Mrs.) KPM Dhamayanthi, Pr. Scientist
Dr. Manivannan A, Scientist
Dr. (Mrs.) K Bhagyalakshmi, Scientist
Sirsa
Dr. OP Tuteja, Pr. Scientist
Dr. SK Verma, Pr. Scientist
Dr. S. L. Ahuja, Pr. Scientist (Retd. on 30.04.18)
Agril. Biotechnology
Dr. (Mrs.) J Amudha, Pr. Scientist
Dr. G Balasubramani, Pr. Scientist
Dr. KP Raghavendra, Scientist
Sh. Joy Das, Scientist (Study Leave w.e.f.28.12.17)
Sh. Rakesh Kumar, Scientist (Study Leave w.e.f.27.12.18)
Dr. Chandrashekar N, Scientist
Seed Science &Technology
Nagpur
Dr. (Mrs.) PR Vijayakumari, Pr. Scientist
Dr. (Mrs.) V Santhy, Pr. Scientist
Dr. SS Mahajan, Pr. Scientist
Coimbatore
Dr. K Rathnivel, Pr. Scientist
Sirsa
Dr. RA Meena, Pr. Scientist
CROP PRODUCTION DIVISION
Agronomy
Nagpur
Dr. Blaise Desouza, HOD, Crop Production (Acting)
Dr. MV Venugopalan, Pr. Scientist
Dr. AR Raju, Pr. Scientist
Dr. Ramkrushna I Gandhiji, Scientist
Dr. B. Bhargavi, Scientist
Coimbatore
Dr. (Mrs.) P Nalayani, Pr. Scientist
Dr. K Shankaranarayanan, Pr. Scientist
Dr. R Raja, Sr. Scientist
Sirsa
Dr. Amar Prit Singh, Scientist
Soil Science
Nagpur
Dr. A Manikandan, Scientist
Coimbatore
Dr. (Mrs.) D Kanjana, Scientist
Farm Machinery & Power
Nagpur
Sh. Er. G Majumdar, Scientist
Plant Physiology
Nagpur
Dr. JH Meshram, Pr. Scientist
Coimbatore
Dr. AH Prakash, Pr. Scientist
Dr.(Mrs.) Annie Sheeba, Scientist
Plant Biochemistry
Dr. (Mrs.) Pooja Verma, Scientist
Agricultural Microbiology
Nagpur
Sh. K Velumourgane, Scientist
Dr. (Mrs.) Savitha Santosh, Scientist
Agricultural Extension
Nagpur
Dr. SM Wasnik, Pr. Scientist
Coimbatore
Dr. (Mrs.) Usha Rani, Pr. Scientist
Dr. C Karpagam, Sr. Scientist
Agricultural Economics
Nagpur
Dr. AR Reddy, Pr. Scientist
Dr. (Mrs.) A Narala, Scientist
Coimbatore
Dr. (Mrs.) Isabela Agarwal, Pr. Scientist
Computer Application in Agriculture
Coimbatore
Sh M Sabesh, Sr.Scientist
CROP PROTECTION DIVISION
Agricultural Entomology
Nagpur
Dr. (Mrs.) Sandhya Kranthi, HOD (Acting)
Dr. VS Nagrare, Pr. Scientist
Dr. Chinna Babu Naik V, Scientist
Sh. Prabhulinga Tenguri, Scientist (Study leave w.e.f.27.08.18)
Sh. Madhu TN, Scientist (Study leave w.e.f.11.09.18)
Dr. Shah Vivek Hanskumar, Scientist
Dr. Babasahed Fand, Scientist
Dr. (Mrs.) Rachna Pande, Scientist
Coimbatore
Dr. (Mrs.) Dhara Jothi, Pr. Scientist
Dr. (Mrs.) M Amutha, Sr. Scientist
Dr. K Shankarganesh, Scientist
Dr. K Rameash, Sr. Scientist
Sirsa
Dr. Rishi Kumar, Pr. Scientist
Plant Pathology
Nagpur
Dr. SP Gawande, Scientist
Dr. DT Nagrale, Scientist
Sh. Neelakanth Hiremani, Scientist
Dr. Vanita Salunkhe, Scientist
Coimbatore
Sh. A Sampath Kumar, Scientist
Dr. P Valarmathi, Scientist
Sirsa
Dr. Dilip Monga, Head of Station (Acting)
Dr. Satish Kumar Sain, Sr. Scientist
Nemotology
Nagpur
Dr. (Mrs.) N Narkedhkar, Pr. Scientist
Coimbatore
Dr. (Mrs.) J Gulsar Banu, Pr. Scientist
KVK
Dr. R. B. Singandhupe, Principal Scientist & I/c Coordinator (Retd. on 31.01.19)
Dr. S. M. Wasnik, Principal Scientist & I/c Coordinator(Joined on 31.01.19)
Dr. S. S. Patil, SMS (Extension)
Dr. U. V. Galkate, SMS (Vet. Science)
Smt. Sunita Chauhan, SMS (Home Science)
Administration
Sh. A. A. Goswami, Sr. Administrative Officer
Ms. Aruna Sharma, Finance & Accounts Officer (Trf. to NBSS&LUP, Nagupr on 16.01.19)

10.9: Other Information

Events

World Soil Day 2018

ICAR-Central Institute for Cotton Research, Nagpur celebrated World Soil Day on 5th December 2018 in order to create awareness on soil health and quality. It was organized at experimental plot of the institute. Dr. V.N. Waghmare (Director), Dr. R.B. Singandhupe (Head i/c),Dr. A. Manikandan(Scientist-Soil Science), Dr. Ramkrushna, G.I. (Scientist- Agronomy), Technical assistants, Supporting Staffs and labour of Division of Crop Production were involved. The theme was "Be the solution for soil pollution".

World soil day celebration at experimental plot

At Mangrul Village, Nagpur Rural (Taluk) collaborated with ICAR-Krishi Vigyan Kendra and Department of Agriculture, Nagpur for celebrations of World Soil Day. On this occasion one day training program was conducted with series of lectures and during the function soil health cards were distributed for the benefit of farmers.

Agro-Vision Exhibition

ICAR-CICR Nagpur coordinated and participated in the "Agro-Vision Exhibition" held at Reshimbagh ground, Nagpur from 23.11.2018 to 26.11.2018 where various research findings of CICR for the benefit of farmers, farm women, students, entrepreneurs, bureaucrats, line department officials were displayed. It was a mega event & more than 700 exhibitors showcase their products and explained the outcomes. Apart from SAUs, KVK's, Government/Private and NGO's exhibited their products. ICAR-CICR displayed the technologies like colored cotton, Bt express kit, e-Kapas, management of cotton reddening and the farm implements developed by the institute. During exhibition large number of visitors interacted with scientists and other staff member of CICR on various issues related to CICR technologies. CICR also coordinated organization of all the stalls by all ICAR institutes located at Nagpur as per instructions of ICAR The team consisting of eight scientists, two subject matter specialists and two technical officer guided the visitors. More than five thousand farmers attended the event. Dr. S.M. Wasnik, Principal Scientist, Extension Coordinated the activities.

Webcasting of PM-Kisan-Samman-Niddhi programme

CICR & ^KVK CICR jointly organised live web telecasting of Pradhan Mantra Kisan Samman Niddhi

Yojna on 24th February 2019 at CICR. Member of Parliament from Ramtek Sh Krupalji Tumane was the Chief guest of the function. He appreciated the research work and other activities of CICR and asked the farmers to take advantage of direct benefit transfer. On the occasion, Web telecasting of man ki baat and live telecasting of PM-Kisan-Samman-Nidhi yojana from Gorakhpur by Hon PM was arranged. The programme was attended by 269 farmers and all the staff of CICR. Dr. S.M. Wasnik, Principal Scientist, Extension Coordinated the activities.

'Kisan Kalyan Diwas' workshop organized

As per the directives of Ministry of Agriculture and Farmers Welfare, 'Gram Swaraj Abhiyan 2018' was organised by State Agriculture Department in collaboration with ICAR-CICR, Nagpur, SAU'S, KVKs and ATMA on 2 May 2018 with the theme 'Doubling of Farmer's Income (DFI)' by 2022. To commemorate the Programme 'Kisan Kalyan Karyashala' was organised at Tehsil levels with the main objective to create awareness among farmers regarding strategy to be adopted for Doubling of Farmers' Income by 2022. Scientist and Subject Matter Specialists teams were constituted for different village blocks of Nagpur district. Accordingly, Dr. R. B. Singandhupe (Agronomy) at Narkhed, Dr. S. M. Palve (Plant Breeding) at Bhiwapur, Dr. S. M. Wasnik (Agrl. Extension) at Parsheoni, Dr. A. R. Raju (Agronomy) at Kalmeshwar, Dr. V. S. Nagrare (Entomology) at Nagpur, Dr. D. V. Patil (Plant Breeding) at Umred, Dr.Sunil Mahajan (Seed Technology) at Kuhi, Dr. Jayant Meshram (Plant Physiology) at Mauda, Dr. Shailesh Gawande (Plant Pathology) at Kamptee, Dr. G. I. Ramakrishna (Agronomy) at Ramtek, Dr. B.B. Fand (Entomology) at Katol, Dr. Deepak Nagrale (Plant Pathology) at Hingna, Dr. S. S. Patil (Entomology) at Saoner, Dr. U.V. Galkate (Animal Science) at Kalmeshwar participated and delivered lectures on various topics related to their respective discipline and related farming system approaches which could be adopted by the farmers for yield enhancement and doubling farmers' income.

Kisan Samriddhi Mela: ICAR-CICR, Regional Station Coimbatore participated in three days' State level Kisan Samriddhi Mela 2018 held during 24-26 August 2018 at CODISSIA, Coimbatore. The event was hosted by ICAR and ICAR-CICR, Regional Station Coimbatore was also one of the organizers. More than 50 exhibitors including ICAR Institutes in the state, KVKs, TNAU, and other private agencies displayed their technologies. ICAR-CICR, Regional Station Coimbatore displayed the technologies including new varieties, multi-tier cropping system, low cast drip irrigation, paper tube nursery management, Cotton pink bollworm, stem weevil and nematode management, Front line demonstrations and e-kapas and mobile apps.

Kisan Samriddhi Mela, Coimbatore

Farmers from across Tamil Nadu state visited the stall. Dr. S Usha Rani and Dr. M. Sabesh coordinated the activities. Two of the farmers from MGMG villages named Shri. M. Selvaraj and Shri. B. Selvaraj were felicitated with "Best Farmer award" in the Mela.

Naturally coloured cotton

Fine quality jackets were made and released in the presence of Hon'ble Union Agriculture Minister Shri Radha Mohan Singh and Union Minister of State for Agriculture and Farmers Welfare Shri. Gajendra Singh Shekhawat.

Naturally Coloured Cotton Jacket being presented to Hon'ble Union Minister of State for Agriculture and Farmers Welfare Shri. Gajendra Singh Shekhawat Ji by Dr. T. Mohapatra, Secretary DARE & DG ICAR.

Three registered genetic stocks viz; CNA-405 (Narrow leaf lobed & brown linted), CNA-407 (Spotted petal blotch & light brown linted) & CNA-407 SPL (Spotless petals & light brown linted) brown coloured linted *desi* cotton sponsored in 2017-18 for evaluation in South Zone Trial were retained for the crop season 2018-19.

4.2 : Kapas Mela-2018

A KAPAS MELA was organized on 30th October at the ICAR-Central Institute for Cotton Research, Nagpur. Dr. C.D. Mayee, Former Chairman, Agricultural Scientists Recruitment Board (ASRB), New Delhi and Dr. Sharad Nimbalkar, QRT Chairman of ICAR-CICR & Former Vice-Chancellor, Dr. P.D.K.V., Akola were the chief guests. The Guests of Honour were Dr. R. P. Singh, Director, Directorate of Cotton Development, Nagpur; Shri Ravindra Thakare, Director, Vanamati Nagpur and Shri. Ravindra Bhosle, JDA Nagpur. Program started with the welcome address by Dr. V. N. Waghmare, Director, CICR, Nagpur, followed by

release of publications- Souvenir Cotton Mela, Integrated Pink Bollworm Management, Safe Handling of Insecticides in cotton farming and Usmanabadi Goat Farming- a profitable ancillary enterprise. Dr C. D. Mayee in his inaugural address emphasized on increasing farmers' income by community farming. Dr. Sharad Nimbalkar stressed upon improving soil fertility and bringing down cost of cultivation. Shri. Ravindra Bhosle highlighted the various agriculture related schemes of Govt of Maharashtra. Five Champion farmers, who successfully implemented CICR technologies shared their experiences and were felicitated. Sh Manikrao Kadam from Wardha shared his experiences on 'High Density Planting System in cotton'; Sh Suresh Haribhau Hiwarkar, Dhapewada, Nagpur shared his experiences on 'Cotton based Intercropping system; Smt Vaishali Sudhakar Kukde, Selu, Ta. Kalmeswar, Nagpur shared her experiences on 'organic cotton production and use of cotton bags while picking of cotton'; Sh Pravin Deshmukh, Telkamathi Nagpur shared his views on 'use of drip irrigation and integrated nutrient management for high yields in calcareous soils'; and Dipak Shankarao Balpande, Aanji Mothi, Wardha shared his views on 'e-kapas voice messages and dissemination of cotton

production information to fellow farmers'. A gallery exhibiting 23 stalls with agricultural and other innovative technologies was put on display.

The function was attended by around 2200 farmers from different parts of Maharashtra. They were provided with information about advanced technology on cotton farming. Farmers were also taken to fields to showcase improved public sector cotton varieties and cotton farming technologies. Experts' talks were arranged to provide guidance on: Improved cotton production practices (Dr AR Raju), cotton varieties (Dr SM Palve & Dr S Mahajan), Integrated management for major cotton insect pests, especially Pink Bollworm (Dr VS Nagrare); 'e-Kapas' (Dr SM Wasnik), Information on Central & State Govt Schemes (M Shende) and Future cotton trading & awareness programme on cotton price risk management (Badruddin Khan). Dr. S.M. Wasnik, Principal Scientist (Extension) and the Organizing Secretary, Kapas Mela-2018 proposed vote of thanks during inaugural session while Dr RB Singandhupe Co-Organizing Secretary proposed the vote of thanks for technical sessions. The Mela was highly appreciated by the farmers.

ICAR-CICR Foundation Day

ICAR-CICR, Nagpur celebrated its 42nd Foundation Day on April 02, 2018. The occasion was graced by Dr. S.P. Kane, Hon'ble Vice Chancellor, Rastrasant Tukadoji Maharaj Nagpur University (RTMNU), Nagpur as a Chief Guest and Dr. C.D. Mayee, Ex. Chairman ASRB as a Guest of Honour. Dr. Blaise Desouza, Head, Division of Crop Production welcomed the guests. Dr. VN Waghmare, Director, ICAR-CICR in his address provided glimpses of salient achievements of the Institute since its establishment. Dr. C.D. Mayee

expressed gratification over the pioneering work being carried out by the Institute and urged to continue dedicated team work for overall development of the cotton farming community. Dr. S.P. Kane expressed his delight at visit to a Research Institute of National importance and extended willingness for starting joint research ventures by RTMNU with proposed formal vote of thanks. The programme was attended by all the staff of the institute.

127th Birth Anniversary of Dr. Babasaheb Ambedkar

ICAR-Central Institute for Cotton Research, Nagpur celebrated Dr Babasaheb Ambedkar Birth Anniversary on 14th April, 2018. Dr. Shankar Khobragade, a renowned cardiologist & MD (Khobragade Multispeciality Hospital, Nagpur) was the Chief Guest. Dr A. K. Basu, Ex-Director, ICAR-CICR, Dr V.N. Waghmare, Director, ICAR-CICR, Dr. S. M. Wasnik (Principal Scientist, Ag. Extension); Dr Ulhas Nandankar (Farm superintendent) and Dr Dipak Nagrale Scientist,

CICR occupied the dias. The Chief Guest highlighted the role played by Dr Ambedkar in several fields through his writings on history, philosophy, law, economics, social equality and justice which are as relevant today as at the time when these were penned. He pointed out that constitutional provisions made by Dr Ambedkar for socially downtrodden, women, labourers and several weaker sections, helped them to lead a dignified life in society. Dr. V. N. Waghmare, Director, ICAR-CICR briefed about thoughts of Dr Ambedkar for welfare of small, marginal farmers, agricultural labourers, industrial labour force and overall up-liftment of countrymen. He pointed out that Dr. Ambedkar incorporated the values of liberty, equality and fraternity in the constitution of free India. Dr. S.M.Wasnik in his introductory remarks urged all to derive inspiration and guidance from thoughts of Dr. Ambedkar for youths in particular and contribute for the social reconstruction of the country. All the staff members including Heads of division, student fellows, administrative, scientific staff, skilled and farm labourers attended the programme. Dr. Deepak Nagrale conducted the proceedings and Dr. Ulhas Nandankar proposed the vote of thanks. The program concluded with the reciting of National Anthem.

International Yoga Day

ICAR-Central Institute for Cotton Research, Nagpur celebrated the "International Yoga Day" on 21st June, 2018 during 10 to 11 am at Institute's training hall. Dr. V.N. Waghmare, Director welcomed the Yogacharya (Trainer) Shri. Prashantji Kale and his team as well as all the staff members. During the hour long activity, Yogacharya Shri Prashantji Kale explained the meaning of "Yoga" and its importance for the harmony of the body, mind and soul of a person. Common Yoga Protocol' provided by the Ministry of AYUSH, Govt. of India was followed.

Superannuation

S. No.	Name of the staff	Designation	Month of retirement
CICR, Nagpur			
1	Shri. Dhondu L Nagose	Skilled Supporting Staff	April 2018
2	Smt. Yashoda Asore	Skilled Supporting Staff	June, 2018
CICR (RS) Coimbatore			
1	Shri. Natarajan Subbakonar	Skilled Supporting Staff	April, 2018
CICR (RS) Sirsa			
1	Dr. S. L. Ahuja	Principal Scientist	April, 2018

Sports

CICR Bagged Medals in ICAR-Western Zone Tournament-2018

Samir S. Chalkhure, Personal Assistant, Shri R. M. Lokhande, ACTO, Dr. S.S Patil, SMS, Dr. U. V Galkate, SMS and Shri Bhausaheb Naikwadi, Technical Assistant, CICR, Nagpur bagged **Silver Medal** in Table Tennis (Team Event) competition in the ICAR-Western Zone Tournaments - 2018 organized at ICAR- IGFRI, Jhansi from October 5-8, 2018.

Sh Sujit Kumbhare, Technical Assistant T1, CICR Nagpur bagged **Bronze Medals** in Athletics Race 200 & 400 mtr during ICAR-Western Zone Tournaments organized at I at ICAR- IGFRI, Jhansi from October 5-8, 2018.

Shri Bhausaheb Naikwadi, Technical Assistant (T-II-3) CICR Nagpur bagged **Bronze Medal** in Athletics (Long Jump) (4.36 m) during ICAR-Western Zone Tournaments organized at I at ICAR- IGFRI, Jhansi from October 5-8, 2018.

Library

Additions

During 2018-19, the Library purchased 122 new books, and 17 Hindi books. The Library subscribed to 14 Indian Journals.

Documentation Services

- Library has developed computerized bibliographic database on Cotton to provide comprehensive and updated information on cotton. About **5063** 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, two issues of *COTTON RESEARCH ABSTRACTS (V32, (No. 1-2), January – December 2018)* were published and circulated.
- The Library is actively participating in the E-Journal Consortium by responding regularly through E-mails and 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 catalogue 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

नागपुर

राजभाषा कार्यान्वयन समिति की त्रैमासिक बैठक का आयोजन

संस्थान में राजभाषा हिंदी के सक्रिय प्रचार–प्रसार के हेतु राजभाषा कार्यान्वयन समिति (वित्तीय वर्ष 2018–19) की त्रैमासिक बैठकों का आयोजन निम्नानुसार किया गया।

राजभाषा कार्यान्वयन समिति की बैठकों की तिथि :

क्र.	दिनांक	विषय
1	12 जून, 2018	वर्ष–2018 राजभाषा कार्यान्वयन समिति की द्वितीय बैठक
2	05 नवम्बर, 2018	वर्ष–2018 राजभाषा कार्यान्वयन समिति की तृतीय बैठक
3	11 फरवरी, 2019	वर्ष–2019 की राजभाषा कार्यान्वयन समिति की प्रथम बैठक

कोयंबटूर

डॉ. विजय वाघमारे, निदेशक, भा.कृ.अनु.प. – केन्द्रीय कपास अनुसंधान संस्थान, नागपुर की अध्यक्षता में क्षेत्रीय केंद्र, कोयंबटूर का हिंदी कार्यनिरीक्षण/मार्गदशन दौरा **1** मई, **2018** संपन्न हुआ। समिति की इस बैठक में राजभाषा हिंदी कार्यनिरीक्षण/मार्गदर्शन समिति, भा.कृ.अनु.प. – केन्द्रीय कपास अनुसंधान संस्थान, नागपुर द्वारा भारत सरकार, राजभाषा विभाग/परिषद की राजभाषा नीति एतत्सम्बन्धी संवैधानिक प्रावधानों का अनुपालन सुनिश्चित करने हेतु क्षेत्रीय केंद्र, कोयंबटूर का हिंदी कार्यनिरीक्षण एवं मार्गदशन किया गया। **डॉ. अ. हि. प्रकाश,** परियोजना

समन्वयक एवं अध्यक्ष, भा.कृ.अनु.प.–के.क.अनु.सं., क्षेत्रीय केंद्र, कोयंबटूर ने समिति की इस बैठक में केंद्र का प्रतिनिधित्व किया तथा केंद्र की राजभाषा कार्यान्वयन समिति के पदाधिकारीगण **श्री अ. अं. गोस्वामी,** वरिष्ठ प्रशासनिक अधिकारी एवं **डॉ. महेंद्र कुमार साहू,** सहायक मुख्य तकनीकी अधिकारी(रा.भा.), भा.कृ.अनु.प.–के.क.अनु. सं. नागपुर भी इस कार्यक्रम में उपस्थित थे। समिति की इस बैठक में केंद्र में राजभाषा हिंदी के सक्रिय कार्यान्वयन एवं **'ग' क्षेत्र** हेतु निर्धारित विभिन्न कार्यक्रमों पर विस्तृत रूप से विचार–विमर्श किया गया, ताकि केंद्र में सही अर्थों में राजभाषा हिंदी का सक्रिय प्रचार–प्रसार हो सके। राजभाषा हिंदी कार्यनिरीक्षण/मार्गदशन समिति द्वारा केंद्राध्यक्ष **डॉ. अ.हि. प्रकाश** को मार्गदर्शन स्वरूप कुछ सुझाव दिये गए, जिस पर केंद्राध्यक्ष ने यथाशीघ्र कार्रवाई किए जाने का आश्वासन समिति को दिया।

सिरसा

डॉ. विजय वाघमारे, निदेशक, भा.कृ.अनु.प. – केन्द्रीय कपास अनुसंधान संस्थान, नागपुर की अध्यक्षता में क्षेत्रीय केंद्र, सिरसा का हिंदी कार्यनिरीक्षण/मार्गदशन दौरा दिनांक 26 सितम्बर, 2018 को संपन्न हुआ। समिति की इस बैठक में राजभाषा हिंदी कार्यनिरीक्षण/मार्गदशन समिति, भा.कृ.अनु.प. – केन्द्रीय कपास अनुसंधान संस्थान, नागपुर द्वारा भारत सरकार, राजभाषा विभाग/परिषद की राजभाषा नीति एतत्सम्बन्धी सांविधिक प्रावधानों का अनुपालन सुनिश्चित करने हेतु क्षेत्रीय केंद्र, सिरसा का हिंदी कार्यनिरीक्षण एवं मार्गदशन किया गया। डॉ. डी. मोंगा, प्रमुख, केन्द्रीय कपास अनुसंधान संस्थान, क्षेत्रीय केंद्र, सिरसा ने समिति की इस बैठक में केंद्र का प्रतिनिधित्व किया और साथ ही इस बैठक में केंद्र की राजभाषा कार्यान्वयन समिति के पदाधिकारीगण भी उपस्थित थे। समिति की इस बैठक में केंद्र में राजभाषा हिंदी के सक्रिय कार्यान्वयन एवं 'क' क्षेत्र हेतु निर्धारित विभिन्न कार्यक्रमों पर विस्तृत रूप से विचार–विमर्श किया गया, ताकि केंद्र में सही अर्थों में राजभाषा हिंदी का सक्रिय प्रचार–प्रसार हो सके। डॉ. महेंद्र कुमार साहू, सहायक मुख्य तकनिकी अधिकारी(रा. भा.) एवं सदस्य, राजभाषा हिंदी कार्यनिरीक्षण/मार्गदशन समिति द्वारा केंद्राध्यक्ष डॉ. डी.मोंगा को मार्गदर्शन स्वरूप कुछ सुझाव उक्त समिति द्वारा दिये गए जिन पर यथाशीघ्र कार्रवाई किए जाने का आश्वासन केंद्राध्यक्ष ने समिति को दिया।

डॉ. विजय वाघमारे, निदेशक(कार्यकारी) भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर हिंदी कार्य निरीक्षण/मार्गदर्शन समिति की बैठक को संबोधित करते हुए।

हिंदी सप्ताह

नागपुर

'हिंदी सप्ताह 06–14 सितंबर, 2018 समारोह' का विधिवत् उद्घाटन **डॉ. विजय वाघमारे,** निदेशक, भा.कृ.अनु.प. –केन्द्रीय कपास अनुसंधान संस्थान, नागपुर के शुभहस्ते दीप प्रज्ज्वलित कर किया गया।

इस कार्यक्रम में विशेष आमंत्रित **डॉ. (श्रीमती) नंदिता साहू ने** हिंदी के महत्व एवं उसकी गरिमा पर प्रकाश डाला तथा इस कार्यक्रम की अध्यक्षता का पदभार संस्थान की राजभाषा कार्यान्वयन समिति के अध्यक्ष **डॉ. विजय वाघमारे,** निदेशक, और साथ ही इस अवसर पर **डॉ. ब्लेज**

डॉ. विजय वाघमारे, निदेशक, भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर के शुभहस्ते दीप प्रज्ज्वलित कर हिंदी सप्ताह समारोह –2018 का उद्दघाटन करते हुए

डिसुजा, विभागप्रमुख, फसल उत्पादन विभाग, **डॉ. नंदिनी गोकटे–नरखेडकर,** विभागप्रमुख, फंसल संरक्षण विभाग, **श्री अ.अ. गोस्वामी,** वरिष्ठ प्रशासनिक अधिकारी, **डॉ. महेंद्र कुमार साहू,** सहायक मुख्य तकनीकी अधिकारी (रा. भा.), भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर उपस्थित थे। 'हिंदी सप्ताह समारोह' के अंतर्गत विभिन्न हिंदी प्रतियोगिताओं (हिंदी भाव–गीत, हिंदी प्रश्न–मंच, हिंदी शुद्ध लेखन, निबंध, चित्र आधारित कहानी, वाद–विवाद, शब्दानुवाद एवं हिंदी काव्य–पाठ प्रतियोगिताओं) का आयोजन किया गया था।

'हिंदी सप्ताह : समापन समारोह' का आयोजन 14 सितम्बर, 2018 को किया गया था। इस अवसर पर "मुख्य अतिथि" महोदय के रूप में **डॉ. प्रमोद रामेश्वर शर्मा,** विभागाध्यक्ष, स्नातकोत्तर हिंदी विभाग एवं उर्दू विभाग, राष्ट्रसंत तुकड़ोजी महाराज, नागपुर विश्वविद्यालय, नागपुर में सादर आमंत्रित थे।

अपने मुख्य सम्बोधन में हिंदी को बहुत ही सशक्त एवं बहुआयामी भाषा बताते हुए उसके साहित्यिक पक्ष को सभा के सामने रखा और हर क्षेत्र में हिंदी भाषा लोकप्रिय है और सही अर्थों में राष्ट्रभाषा पद की अधिकारिणी है यह बताया।

अपने अध्यक्षीय सम्बोधन में **डॉ. विजय वाघमारे,** निदेशक, भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर ने कहा की हिंदी हमारे लिए केवल एक भाषा ही नहीं अपितु राष्ट्रीय अस्मिता का प्रतीक है जिसे राष्ट्र हित में मजबूत करना हम प्रत्येक भारतीय नागरिकों का कर्तव्य है। अतः इस दृष्टिकोण से राष्ट्रीय हित में अपने कार्यालयीन कार्यों में राजभाषा (हिंदी) का अधिक–से–अधिक उपयोग करना हमारा संवैधानिक उत्तरदायित्व है।

हिंदी सप्ताह समारोह –2018 के अंतर्गत आयोजित हिंदी संबंधित विभिन्न प्रतियोगिताओं के विजयी प्रतिस्पर्धी अधिकारियों एवं कर्मचारियों को नकद पुरस्कार वितरित किए गए ।

इस कार्यक्रम का कुशल संचालन **श्री अ.अ. गोस्वामी,** वरिष्ठ प्रशासनिक अधिकारी ने किया और आभार प्रर्दशन **डॉ. महेंद्र कुमार साहू,** सहायक मुख्य तकनीकी अधिकारी (रा.भा.), भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर ने किया।

कोयंबटूर

डॉ. अ. ही. प्रकाश, परियोजना समन्वयक एवं अध्यक्ष, भा. कृ.अनु.प.– केन्द्रीय कपास अनुसंधान संस्थान, क्षेत्रीय केंद्र, कोयंबटूर की अध्यक्षता में बड़े ही उत्साहपूर्ण वातावरण में

डॉ. प्रमोद रामेश्वर शर्मा, विभागाध्यक्ष, स्नातकोत्तर हिंदी विभाग एवं उर्दू विभाग, राष्ट्रसंत तुकड़ोजी महाराज, नागपुर विश्वविद्यालय, नागपुर हिंदी सप्ताह समापन समारोह–2018 के सुअवसर पर सभा का मार्गदर्शन करते हुए।

14–29 सितंबर, 2018 को केंद्र में हिंदी पखवाड़ा–2018 का सफल आयोजन किया गया। केंद्र में आयोजित हिंदी पखवाड़ा–2018 समारोह के दौरान राजभाषा हिंदी संबन्धित विभिन्न प्रतियोगिताओं का आयोजन किया गया। सर्वप्रथम **श्रीमती के. सुभश्री,** प्रभारी अधिकारी (हिंदी) ने इस अवसर पर उपस्थित अधिकारियों एवं कर्मचारियों का स्वागत करते हुए केंद्र में चल रही राजभाषा हिंदी संबन्धित विभिन्न गतिविधियों से अवगत कराया द्य विभिन्न हिंदी प्रतियोगिताओं के विजयी प्रतिस्पर्धी अधिकारियों एवं कर्मचारियों को सम्मानित किया गया। हिंदी पखवाड़ा समापन समारोह–2018 का कार्यक्रम संचालन एवं सभा का आभार श्रीमती के. सुभश्री, वरिष्ठ तकनीकी अधिकारी एवं प्रभारी अधिकारी (हिंदी) ने माना।

हिंदी कार्यशाला 2018–19

सिरसा

डॉ. डी. मोंगा, प्रमुख, भा.कृ.अनु.प.– केन्द्रीय कपास अनुसंधान संस्थान, क्षेत्रीय केंद्र सिरसा की अध्यक्षता में तथा अतिथि वक्ता **डॉ. महेंद्र कुमार साहू,** सहायक मुख्य तकनीकी अधिकारी (रा.भा) एवं **श्री अ. अं. गोस्वामी,** वरिष्ठ प्रशासनिक अधिकारी, केन्द्रीय कपास अनुसंधान संस्थान,नागपुर की मुख्य उपस्थिती में केंद्र में प्रशासनिक, वैज्ञानिक, तकनीकी संवर्ग के कार्मिकों हेतु एक दिवसीय हिंदी कार्यशाला का सफलता पूर्वक आयोजन किया गया। इस हिंदी कार्यशाला का संचालन केंद्र के प्रभारी अधिकारी (हिन्दी) **डॉ. राम चरण मीणा,** प्रधान वैज्ञानिक, भा.कृ.अनु.

डी.मोंगा, प्रमुख, भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, क्षेत्रीय केंद्र, सिरसा हिन्दी कार्यशाला के उद्घाटन सत्र में अपना स्वागत सम्बोधन करते हुए

प.– केन्द्रीय कपास अनुसंधान संस्थान, क्षेत्रीय केंद्र, सिरसा ने किया और इस हिन्दी कार्यशाला में प्रशासनिक, वैज्ञानिक/तकनीकी संवर्ग के लगभग 32 अधिकारियों एवं कर्मचारियों ने सहभागी होकर इस आयोजन को सफल बनाया।

कार्यशाला के अंतिम चरण में सहभागी प्रतिक्रिया स्वरूप अपने विचारों को स्पष्ट करते हुए **डॉ. राम चरण मीणा** ने कहा कि यह कार्यशाला अपने लक्ष्य को हासिल करने मे पूर्णरुपेन सफल रही हैं। साथ ही अतिथि वक्ता के मार्गदर्शन से कार्यशाला में सहभागी अधिकारियों/कर्मचारियों को अच्छी जानकारी मिली है जिससे निसंदेह उन्हें अपना दैनिक कार्यालयीन कार्य हिंदी में करने हेतु बढ़ावा मिलेगा। कार्यक्रम के अंतिम बिन्दु पर इस कार्यशाला में सहभागी समस्त हिन्दी प्रेमी अधिकारियों/कर्मचारियों का आभार केंद्र के प्रभारी अधिकारी (हिन्दी) **डॉ. राम चरण मीणा,** प्रधान वैज्ञानिक, भा.कृ.अनु.प.– केन्द्रीय कपास अनुसंधान संस्थान, क्षेत्रीय केंद्र, सिरसा ने माना ।

नागपुर

भा.कृ.अनु.प.– केन्द्रीय कपास अनुसंधान संस्थान, नागपुर कार्यालय में बड़े ही उत्साहपूर्ण वातावरण में **डॉ. विजय वाघमारे,** निदेशक, भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर की अध्यक्षता में एवं अतिथि वक्ता **श्री मनोज कुमार,** सहायक मुख्य तकनीकी अधिकारी (रा.भा), भारतीय कृषि अनुसंधान परिषद, नई दिल्ली तथा सादर मंचासीन **डॉ.(श्रीमती) नंदिनी गोकटे नरखेडकर,** विभागप्रमुख, फसल संरक्षण विभाग, **श्री अ. अं. गोस्वामी,** वरिष्ठ प्रशासनिक अधिकारी, **श्रीमती शैला कुलकर्णी,** आहरण एवं संवितरण अधिकारी एवं **डॉ. महेंद्र कुमार साहू,** सहायक मुख्य तकनीकी अधिकारी (रा.भा) की गणमान्य उपस्थिति में **'प्रशासनिक/तकनीकी संवर्ग' के कार्मिकों हेतु एक दिवसीय हिंदी कार्यशाला** का सफलता पूर्वक आयोजन **दिनांक 08 मार्च, 2019** किया गया।

हिंदी कार्यशाला के मुख्य अतिथि वक्ता **श्री मनोज कुमार,** सहायक मुख्य तकनीकी अधिकारी (रा.भा), भारतीय कृषि अनुसंधान परिषद, नई दिल्ली ने बड़े ही रोचक एवं मनोरंजक तरीके से संसदीय राजभाषा प्रश्ननवाली भरे जाने के संबंध में उपस्थित अधिकारियों/कर्मचारियों का मार्गदर्शन किया। साथ **ही श्री मनोज कुमार** ने कहा कि हिंदी इस देश के जनसम्पर्क की मुख्य भाषा है और संवैधानिक रूप से इसे राजभाषा का दर्जा प्राप्त है। अतः इस दृष्टिकोण से हमारा यह संवैधानिक उत्तरदायित्व हो जाता है कि इसे हम अपने दैनिक कार्यालयीन कार्यों में अपनाकर राष्ट्र विकास को गति प्रदान करें ।

हिंदी कार्यशाला के सफल आयोजनार्थ **डॉ. विजय वाघमारे** ने संस्थान के हिंदी अनुभाग में कार्यरत **डॉ. महेंद्र**

श्री मनोज कुमार, सहायक मुख्य तकनीकी अधिकारी (रा.भा), भारतीय कृषि अनुसंधान परिषद, नई दिल्ली हिन्दी कार्यशाला को संबोधित करते हुए।

कुमार साहू, सहायक मुख्य तकनीकी अधिकारी (रा.भा) के अथक प्रयासों की सराहना करते हुए कहाँ कि संस्थान में भविष्य में भी विभिन्न संवर्ग के कार्मिकों हेतु विभिन्न विषयों को लेकर नियमित रूप से त्रैमासिक हिंदी कार्यशालों का आयोजन किया जाएंगा, ताकि संस्थान में राजभाषा हिंदी का बहुमुखी विकास हो सके। इस हिंदी कार्यशाला का सफल संचालन एवं सभा का आभार **डॉ. महेंद्र कुमार साहू**, सहायक मुख्य तकनीकी अधिकारी (रा.भा), भा.कृ.अनु.प.– केन्द्रीय कपास अनुसंधान संस्थान, नागपुर ने माना।

पुरस्कार/मान सम्मान

राजर्षि टंडन राजभाषा पुरस्कार : नई दिल्ली स्थित राष्ट्रीय कृषि विज्ञान केन्द्र के ए. पी. शिंदे सभागार में दिनांक : 16 जुलाई, 2018 को भारतीय कृषि अनुसंधान परि द् के 90 वें स्थापना दिवस के सुअवसर पर भा.कृ.अनु.प.– केन्द्रीय कपास अनुसंधान संस्थान, नागपुर को 'ख' क्षेत्र के अंतर्गत व f 2016–17 के दौरान सरकारी कामकाज में हिंदी के प्रयोग में उल्लेखनीय योगदान देने हेतु समारोह के मुख्य अतिथि श्री राधा मोहन सिंह, माननीय केन्द्रीय कृषि एवं किसान कल्याण मंत्री, भारत सरकार के करकमलों द्वारा "राजर्षि टंडन राजभाषा पुरस्कार" (प्रथम पुरस्कार) से सम्मानित किया गया। संस्थान की ओर से यह पुरस्कार डॉ. विजय नामदेव वाघमारे, निदेशक एवं डॉ. महेन्द्र कुमार साहू, सहायक मुख्य तकनीकी अधिकारी (रा.भा.) ने ग्रहण किया। संस्थान को यह पुरस्कार श्री गजेन्द्र सिंह शेखावत, माननीय कृषि एवं किसान कल्याण राज्य मंत्री, भारत सरकार, डॉ. त्रिलोचन महापात्र, सचिव (डेयर) एवं महानिदेशक, भा.कृ. अनु.प., नई दिल्ली, श्री छबिलेन्द्र राऊल, विशेष सचिव(डेयर) एवं सचिव भा.कृ.अनु.प., नई दिल्ली एवं श्री बिम्बाधर प्रधान, अपर सचिव एवं वित्तीय सलाहकार, डेयर/ भा.कृ.अनु.प., नई दिल्ली की गणमान्य उपस्थिति में प्रदान किया गया।

श्री राधा मोहन सिंह, माननीय केन्द्रीय कृषि एवं किसान कल्याण मंत्री से परिषद के 90 वें स्थापना दिवस (दि. 16 जुलाई, 2018) के सुअवसर पर डॉ. विजय नामदेव वाघमारे, निदेशक एवं डॉ. महेन्द्र कुमार साहू, सहायक मुख्य तकनीकी अधिकारी (रा.भा.), भाकृअनुप–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर ने वर्ष 2016–2017 का प्रथम "राजर्षि टंडन राजभाषा पुरस्कार" ग्रहण किया।

10.10: Weather

Nagpur

Month	Temperature (°C)		Relative Humidity (%)		Rain fall (mm)	No. of Rainy Days
	Max	Min	Max	Min		
June, 2018	36.32	25.36	74.95	52.42	217.00	10
July, 2018	30.15	24.37	87.63	75.90	480.00	11
August, 2018	30.05	24.51	84.84	69.75	171.00	8
September, 2018	31.08	23.21	81.80	59.96	74.00	3
October, 2018	33.95	19.28	80.20	44.66	0.00	0
November, 2018	31.72	15.13	77.13	47.61	0.00	0
December, 2018	26.69	10.82	75.63	54.25	0.00	0
January, 2019	27.54	10.06	73.71	36.71	18.00	1
February, 2019	30.73	13.45	60.54	33.22	0.00	0
Total					**960.00**	**33**

Coimbatore

Month	Temperature (°C)		Relative humidity (%)		Rain fall (mm)	Rainy days	Sun shine hours	Solar radiation (cal/cm2/ day)
	Max.	Min.	Morning	Evening				
July 2018	30.0	23.3	84.0	64.3	76.0	9.0	4.1	294.3
August 2018	30.2	23.1	83.8	63.5	58.4	6.0	4.2	301.5
September 2018	32.7	22.3	86.8	53.5	2.0	0.0	4.2	287.3
October 2018	31.6	22.2	86.0	63.3	178.2	9.0	7.1	341.5
November 2018	30.0	21.6	87.5	56.8	30.5	6.0	5.8	297.5
December 2018	30.1	20.8	88.3	53.0	12.0	2.0	4.7	327.8
January 2019	30.2	18.3	86.5	43.8	0.0	0.0	7.3	390.5

Sirsa

Month	Temperature (°C)		Relative Humidity (%)		Rain fall (mm)	No. of Rainy Days
	Maximum	Minimum	Maximum	Minimum		
April, 2018	37.2	20.9	70.4	37.1	0	0
May, 2018	40.6	24.4	55.1	30.8	50.4	2
June, 2018	39.4	24.3	70.7	46.2	42.6	5
July, 2018	36.1	25.9	79.1	61.0	101.5	5
August, 2018	35.4	26.7	76.9	59.0	27.6	3
September, 2018	33.9	24.7	77.8	57.7	64	4
October, 2018	32.9	18.8	74.6	39.2	0	0
November, 2018	28.4	12.4	78.3	38.7	0	0

10.11: Cotton Scenario

Area: in Lakh Hectares
Production: in Lakh bales of 170 kg.
Yield: Kg per hectare

State	Area		Production*		Yield	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Punjab	2.91	2.68	11.76	11.50	687.01	729.48
Haryana	6.65	7.08	21.48	23.00	549.11	552.26
Rajasthan	5.84	6.29	23.26	25.00	677.09	675.68
Total North Zone	**15.40**	**16.05**	**56.50**	**59.50**	**623.70**	**630.22**
Gujarat	26.24	26.59	103.84	87.00	672.74	556.22
Maharashtra	43.51	42.54	83.35	77.00	325.66	307.71
Madhya Pradesh	6.03	6.14	22.14	24.00	624.18	664.50
Total Central Zone	**75.78**	**75.27**	**209.33**	**188.00**	**469.60**	**424.60**
Telangana	18.97	18.27	54.44	47.00	487.87	437.33
Andhra Pradesh	6.46	6.21	21.26	15.00	559.47	410.63
Karnataka	5.47	6.88	17.32	15.00	538.28	370.64
Tamil Nadu	1.83	1.31	5.50	6.00	510.93	778.63
Total South Zone	**32.73**	**32.67**	**98.52**	**83.00**	**511.71**	**431.89**
Odisha	1.45	1.58	3.65	4.50	427.93	484.18
Others	0.50	0.50	2.00	2.00	680.00	680.00
All-India	**125.86**	**126.07**	**370.00**	**337.00**	**499.76**	**454.43**

Source: Cotton Advisory Board, Ministry of Textile, Govt. of India.
* Provisional as estimated by CAB in its meeting held on 18.06.2019