ICAR-CICR ANNUAL REPORT 2014-15

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

ICAR-CENTRAL INSTITUTE FOR COTTON RESEARCH

Post Bag No. 2, Shankar Nagar PO, Nagpur - 10 (MS)

Annual Report 2014-15

CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

भाकृअनुप
ICAR

वार्षिक प्रतिवेदन

ANNUAL REPORT

2014-15

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

ICAR-CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

Front Cover : MSH 53 (Vaidehi) Dark Brown Colour Linted culture (Reg. No. INGR 13032)

Back Cover : Suraj Variety (*G. hirsutum*) in HDPS

Published by
Dr. K. R. Kranthi
Director
ICAR-Central Institute for Cotton Research, Nagpur

Editorial Committee
Dr. K. R. Kranthi
Dr. M.V. Venugopalan
Dr. (Mrs) Sandhya Kranthi
Dr. D. Blaise
Dr. (Mrs) S.B. Singh
Dr. S.B. Nandeshwar
Dr. Annie Sheeba

Compilation, Collation and Production
Dr. Mahendra Singh Yadav
Mrs. Vandana Satish

Correct Citation
ICAR-CICR, Annual Report 2014-2015
ICAR-Central Institute for Cotton Research, Nagpur, India
PP. 106

Note

- No part of this report shall be reproduced without permission of ICAR/CICR.
- The reference to some trade names in this report is in no way an endorsement of or discrimination against these products by the Institute.

Printed At : Surya offset, Ramdaspeth, Nagpur

PREFACE

Cotton crop showed its climate resilience once again. Monsoon arrived late by a month this year and rainfall distribution was erratic. Last year, 2013-14, the crop had to face excessive rains. In 2012-13, rains were deficient to the point of drought. Nevertheless cotton continued to perform. Yields in all three years continued to be above 500 kg lint per hectare. Surprisingly, despite the declining market prices over the past two years, farmers still preferred cotton over other crops. Cotton area in 2014 reached a record 12.9 million hectares. Interestingly, the CACP (Commission for Agricultural Costs and Prices, Ministry of Agriculture) concluded in its annual report 'Price policy for *kharif* crops -2014' that out of the 14 major *kharif* crops (Paddy, Maize, Jowar, Bajra, Ragi, Tur, Moong, Urad, Groundnut, Soyabean, Sunflower, Sesamum, Nigerseed and Cotton) cotton gained the maximum net returns at Rs. 31,790/ha, followed by tur at Rs. 19,260/ha and paddy at Rs. 15,679/ha. Certainly, it is the resilience of cotton that makes it the preferred farmers' choice. Though, cotton crop is innately tolerant to several abiotic stresses, what makes it transiently vulnerable to climate, sometimes is the kind of varieties/hybrids that are developed with specific focus on just a few economic attributes and the chemical intensive production practices that tilt the balance away from resilience. This must change.

The institute has been critically examining all factors that influence cotton production and marketing. The yields increased by 60-70%, during the previous decade, but the cost of cultivation increased more than 260% over the period. Fertilizer and insecticide usage also increased about two to three fold over the past five years. These changes are worrisome and need attention.

Efforts are made by the institute to find solutions to several of these intractable problems. New systems were developed to obtain high yields with least chemical inputs using a *Desi* variety 'Phule Dhanwantary'. A new promising variety CSH-3129 was developed for north India by the our Regional Station at Sirsa. CSH 3129 is tolerant to the dreaded leaf curl virus disease and has excellent fibre traits of 29.5 mm length and 23.5 g/tex strength with spinnability of 40s count. Another new promising variety CCH 2623 was identified for cultivation in south India under irrigated conditions. One hundred and ten (110) exotic accessions of *G. hirsutum* were procured from USA during 2014. A new 'Indian cotton varietal garden' was established to conserve varietal diversity. CNA 5, an introgressed line with pigmented plant body was registered as genetic stock with NBPGR New Delhi as INGR 14005. Three new naturally coloured *Desi* cotton (*G. arboreum*) cultures were developed. One hundred and fifty germplasm lines identified as tolerant to water logging for two consecutive years in field were screened under water logging in pot condition, of which 36 were identified as most tolerant.

Two patents were filed for 'CICR Precision Cotton Harvester' and 'Whitefly Suction Trap'. A new method of paper tubes 0.5 x 20 cm was developed for low cost nursery and easy transport. The method was found to be very promising especially when monsoon is delayed. A full length gene coding for gossypol detoxifying protein CYP6AE14 from *Helicoverpa armigera* was isolated and cloned. Cotton fiber strength associated genes expressed during secondary wall synthesis stage such as Sucrose synthase *(SusA1),* Cellulose synthase-7 *(CesA7)* Fasciclin-like arabinogalactan protein *(Ghfla11)* and Fasciclin-like arabinogalactan protein gene *(Ghfla12)* were cloned, sequenced, annotated and submitted to NCBI GenBank.Dual gene construct was developed with indigenous *CICR truncated cry2Ab1Ac* for bollworm

resistance and chitinase A gene from *Serratia marcescens* for disease resistance with chloroplast transit peptide (ctp) of Rubisco small subunit. Microbes that degrade glyphosate were isolated and characterized. Marker assisted breeding techniques are being used to transfer resistance to bacterial blight into the variety 'Suraj'. The introgression is at BC-1 (backcross-1) stage.

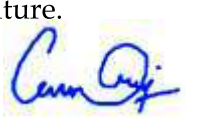
Several high yielding compact plant types with super okra leaf having good fibre quality have been identified which will be amenable for closer planting at a density of 2.5 lakh plants per hectare. Two new genotypes, CSH-3178 and H-1098i were found to be suitable for high density planting. The *Desi* varieties Phule Dhanwantary, MDLABB, CAN 418 and CAN 375 were found to be suitable for HDPS. The variety CISA 614 gave significantly high yield in high density planting in north India. Experiments were conducted to identify allelopathy and cover crops as weed control options. Thornless mimosa, sunnhemp, sorghum and forage cowpea recorded lesser weeds, better ground coverage and identified as suitable cover crops for cotton.

Farmers of Gujarat raised concerns about the incidence of pink bollworm on BGII in early to mid fruiting stage. Surveys conducted by CICR confirmed the concerns. It was found that farmers were extending the crop for 3-4 months beyond the normal harvest period to provide congenial conditions for pink bollworms to survive all through the year and thus accelerating resistance to Bt-cotton.

The recent communication technologies have enabled CICR to launch 'E-KAPAS' voice mail based weekly advisories that became very popular. The programme covered 728516 pre-recorded automatic phone calls to more than 1.0 lakh farmers across 11 cotton growing states involving 18 centres including SAUs working on cotton through mobile- based advisory services with CICR Nagpur as Lead centre. The advisories were provided in local languages as voice messages on a regular basis to registered on cotton production, protection technologies, weather and market information. Weekly advisories issued on the institute's web site in nine languages have become very popular with all stake-holders in the country. The institute disseminated its strategies for IRM on Bt Cotton and HDPS with non Bt varieties across 7376 acres in all the 11 cotton growing states.

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

Research will certainly show the way, but clearly for India to become a global leader in cotton there is more to be done. CICR has been exploring new avenues, new concepts and renewed thinking to develop a roadmap towards high yields at low production costs and least chemical inputs. I earnestly hope that we receive no-holds barred support from all concerned to enable us succeed for India's cotton future.



(K. R. Kranthi)
Director

CONTENTS

Preface

1. Executive Summary 01
2. Introduction 09
3. Research Achievements 11
3.1 : Cotton Genetic Resources 11
3.2 : Hybrid Cotton 15
3.3 : Genetic Improvement 16
3.4 : Genetic Diversity through Introgression 21
3.5 : State Multi-location Varietal Trial (SMVT) 23
3.6 : Molecular Breeding 24
3.7 : Development of Transgenic Cotton 28
3.8 : Seed Production and Technology 30
3.9 : Nutrient Management 33
3.10 : High Density Planting System (HDPS) for Maximizing Productivity 34
3.11 : Weed Management 36
3.12 : Soil Biology and Biochemistry 37
3.13 : Abiotic Stress Management 37
3.14 : Extra Long Staple (ELS) Cotton 38
3.15 : Physiological Manipulation of Extended Cotton Crop 39
3.16 : Cotton Mechanization 40
3.17 : Socio Economic Dimensions of Cotton Farming 40
3.18 : Seasonal Dynamics of Insect Pests and Diseases 43
3.19 : Biological Diversity of Insect Pests and Pathogens 45
3.20 : New Genes and Gene Sources for Pest Management 46
3.21 : Non-Compliance of Regulatory Guidelines 49
3.22 : Development of New Methods, Tools and Protocols 49
3.23 : Natural Enemies and Biological Control 50
3.24 : Integrated Pest Management 54
3.25 : Simulation Model 58
3.26 : Host Plant Resistance 58
4. Technology Assessed and Transferred 60
5. Training and Capacity Building 62
6. Awards and Recognitions 66
7. Linkages and Collaborations 68
8. AICRP on Cotton 69
9. Krishi Vigyan Kendra 72
10. General 77
10.1 : Research Papers Published in refereed Journals 77
10.2 : List of on-going Projects 81
10.3 : Consultancy, Patents, Commercialization of Technology 84
10.4 : Significant Decisions of RAC, IRC, IMC and Other Important Meetings 85
10.5 : Other Important Workshop/Symposia/Meetings 88
10.6 : Results - Framework Document (RFD) Committee 92
10.7 : Participation of Scientists in Seminars/Symposia/Workshops/Meetings 93
10.8 : Distinguished Visitors 97
10.9 : Personnel 98
10.10 : Other Information 99
10.11 : Weather 103
10.12 : Cotton Scenario 104
Annexure-I 105

ICAR-CICR

2014-15 ANNUAL REPORT

1. EXECUTIVE SUMMARY

Crop Improvement

Genetic Resources of *Gossypium*

- Fifty-nine variants of cotton including 42 perennials and 17 landraces belonging to *G. arboreum* and *G. barbadense* were collected from states of Arunachal Pradesh, Madhya Pradesh, Maharashtra and Karnataka, established in pot culture and conserved in the Gene bank for their further utilization in cotton improvement.
- 26 wild species, 15 races of cultivated species and more than 45 synthetic polyploids are maintained in the wild species garden. One new species (EC 669583) established in a pot during 2013-14 was found to be genetically distinct from other wild species based on genotyping data.
- One hundred and forty-two perennials and landraces of cotton were characterized for DUS traits. 96 lines, wild species, races of cultivated species, synthetic polyploids and introgressed derivatives were characterized using 52 polymorphic SSR markers.
- One *G. arboreum* genetic stock CNA 5 (INGR14005; pigmented and long linted (26.7 mm), tolerant to jassids, bollworm, bacterial blight and grey mildew), and two *G. hirsutum* genetic stocks *viz.*, CNH CB-211 (INGR14058; Cluster boll bearing habit), CNH CB -212 (INGR14059; Compact and cluster boll bearing habit) have been registered with NBPGR, New Delhi.
- Seven *G. hirsutum* genetic stocks *viz.*, CNH 1102, GMR 5, IRH 1-4-4, IC 1007, MCU 5 Lintless Mutant, AKH 98-81 Naked Seed Mutant, Pl - 3-1-1, five *G. arboreum* genetic stocks *viz.*, CNA 1052, CNA 1051, CNA 405, CNA 407, CNA 407 and one *G. babadense* genetic stock *viz.*, Suvin restorer have been identified for registration.
- One hundred seventeen (117) exotic accessions (*G. hirsutum*-112 from USA and *Gossypium barbadense* -5 from Israel) were procured through NBPGR, New Delhi for enrichment of Indian Cotton Gene Pool.
- Sixteen long linted accessions with staple length (31.0 – 32.6 mm) and 28 accessions for high fibre strength (25.0 – 26.8 g/tex) were identified upon evaluation of two hundred and fifty two (252) exotic accessions of *G. hirsutum.*
- Upon evaluation of eight hundred and thirty six (836) accessions of *G. arboreum*, twenty long linted accessions having staple length ranging from 26 mm to 28.3 mm and 14 accessions having high fibre strength (22.8 – 26.0 g/tex) were identified.
- Accessions possessing high fibre strength, fibre length, ginning outturn, boll weight and seed cotton yield were identified after evaluating five hundred and fifty (550) *Gossypium herbaceum* germplasm accessions.
- Seeds of 618 accessions (*G. arboreum* -268 and *G.hirsutum*-350) were submitted for conservation in long term storage at NBPGR and medium term storage at CICR, Nagpur.
- Four thousand eight hundred and fifty (4850) germplasm accessions (*G. hirsutum*- 4000, *G. arboreum*-300 and *G. herbaceum*- 550) were grown for rejuvenation and seed multiplication
- Eight thousand three hundred and forty three (8343) germplasm accessions (*G. hirsutum*-8311, *G. barbadense*-1, *G. arboreum*-23 and *G. herbaceum*-8) were distributed to Breeders/ Scientists of State Agricultural Universities for their utilization in research programmes.
- Three thousand eight hundred and eight (3808) accessions of *Gossypium hirsutum* were evaluated at CICR-RS, Sirsa.

- Six single plant selections from germplasm lines *viz.*, IC291590, IC360026, IC356618, IC359978, IC 358085 evaluated during 2013-14 were found to exhibit zero branching habit.
- Among 12 accessions of *Gossypium barbadense* evaluated at CICR-RS, Coimbatore, ICB-194 recorded the highest yield of 130 g/plant followed by ICB-39 (125 g/plant). ICB-194 exhibits high ginning outturn (32%) and boll weight (3.6 g). Upon evaluation of seven dwarf germplasm accessions, ICB-124 is identified for higher seed cotton yield (154 g/plant) and boll weight (3.6 g), EC-16 was found to be earliest in maturity (165 days) compared to Suvin (183 days).Twelve hairy accessions were identified from base collection of *G. barbadense* germplasm and evaluated for yield and sucking pest tolerance.
- Twenty-six *G. hirsutum*, two *G. barbadense* and four *G. arboreum* varieties were established at "Varietal Garden" to conserve them in a perennial form and also assure the continuous supply of genetically pure seeds of cotton varieties for future cotton research. On the basis of genotyping using linked marker CIR 246, selected F_1 plants were backcrossed to the recurrent parent Suraj to develop backcross populations and generation was advanced by taking two crops per year at Nagpur and Coimbatore. Crossing and backcrossing were also attempted to develop cotton varieties resistant to cotton leaf curl virus and nematode resistance using marker assisted breeding.

Genetic Improvement for target traits

- Most promising lines for earliness (Sahana, G-Cot 16, CNHO-12,) compactness (Anjali, Arogya, Pratima), and jassid tolerance (CNH-2024, CNH-409-9, CNHO-7-34) were identified for their utilization to develop early maturing, compact cotton varieties having jassid tolerance.
- A compact, densely hairy and pyramid shaped plant type has been identified in back cross derived culture (Sumangala x ACT SP 16-1) ACT SP 16-1 C-5-1 which showed cleistogamous flower character and cluster boll bearing.
- The drought tolerant cultures DTS 155, DTS 62 and DTS 104 recorded more than 50 per cent increase over the check for seed cotton yield [recorded fibre strength <20 g/tex, fibre length >24 mm, micronaire of 3.5 µg/in and short fibre content of >10 per cent.
- Based on lenticel formation, 23 accessions have been identified as water logging tolerant lines out of 150 accessions screened.
- Field evaluation of thirty one advance genotypes from segregating population and Suvin multiple cross progenies was carried out. Eight high yielding extra long staple (ELS) genotypes of *G. barbadense* yielded more than 1000 kg/ha over the control Suvin (711 kg/ha) apart from having more than 37 mm 2.5% span length and 27-28 g/tex strength with > 3.5 micronaire and 30-31% GOT .
- The *G. arboreum* cultures CISA-6-295, CISA-10, CISA-33-6, CISA-33-7, CISA-33-7, CISA-33-8, CISA-54-1 and CISA-44-1 were found promising for spinning having 2.5% span length >23.0 mm and micronaire between 5-6 and strength >19.0 g/tex.

Heterosis Breeding

- Based on the evaluation of 10 GMS and 23 conventional *G. arboreum* hybrids, GAK-423 x G-135-49 (2944 kg/ha) in GMS hybrids and PA 255 x 30805 (3139 kg/ha) in conventional hybrids have been identified for high yield.
- Heterotic populations developed for superior medium staple (25-27 mm) category from parents selected on the basis of geographic diversity and promising lines were identified.

Introgress Breeding

- F_2 mapping population of *G. herbaceum* x *G. longicalyx*, *G. arboreum race indicum* x *G. davidsonii*, *G. arboreum* x *G. thurberi* and *AKA 8401* x *G. davidsonii* were transplanted in species garden for phenotyping.

- 164 introgressed lines developed from CICR, Nagpur were evaluated at CICR Sirsa, a hot spot area for leaf curl virus. Only seven introgressed lines *viz.*, 11, 49, 51, 54, 145, 149, and 150 showed some tolerance against CLCuV with less than 30% PDI. However, most of the lines showed susceptible reaction against CLCuV.
- The interspecific hybrid of *G. herbaceum* and *G. anomalum* cross having high fibre strength (upto 36.7g/tex) has been conserved as a perennial in the wild species garden for further utilization. Out of the eleven fibre strength specific SSR primers, two of them (BNL 3644 and BNL 1317) were highly polymorphic for a set of 58 F_2 plants of *G. herbaceum* and *G. anomalum.*
- Sixteen (16) naturally coloured cotton introgressed genotypes (*G. hirsutum* and *G. arboreum*) were provided for mass scale seed cotton production in farmers field.

Varietal Development and Multi-location testing

- Two promising cultures CNH 25 (*G. hirsutum)* and CNA 449 (*G. arboreum*) were identified and sponsored in AICCIP for evaluation in 2014-15. *G. arboreum* cultures CNA 2019 and CNA 2043 were evaluated in station trial at CICR, Nagpur.
- *G. arboreum* culture, CISA-6-2 and GMS based *G. arboreum* hybrid CISAA-27 was sponsored in AICCIP Br22a/b and Br25a/b national trials, respectively.
- CCA-2003 and CNA-2023 have been sponsored for the current season in Br 22 a/b.
- Cultures MM 03-39-4-2-3 (Br-02a) and MM03-40-4-3-1 (Br-02b) have been sponsored for multi-location testing in initial evaluation trial of AICRP on cotton during 2014-15 in irrigated and rainfed trials, respectively.
- Five cultures developed from random mating populations have been identified for promotion in AICCIP national trials.
- The proposal for notification of medium staple Central Cotton CCH 2623, for South Zone States under irrigated conditions has been submitted for consideration of Central Sub-Committee on Crop Standards, Notification and Release of Varieties.
- Seventeen promising cultures were sponsored in various National trials of AICCIP during the crop season of 2014-15. Of these, 6 entries were sponsored for National trials of *G. hirsutum* and 4 of *G. arboreum* trial. Seven entries were sponsored for high density planting system trial. CNH 7008 was promoted to Central zone trial Br 03(b) and CNH 1111 was promoted to South zone trial Br 06(b). Three entries (CSH 1110, CNA 1016 and CNH 28I) were retained for central and south zone trials. Fifteen and 6 entries of *hirsutum* and *arboreum* cottons were tested in Common Institute trial. One entry CCB-29 has been entered in AICCIP trial. The genotypes CCB- 44 was identified for high seed cotton yield with high length and other fibre properties.

DUS Characterization

- Two thousand seven hundred nineteen (2719) germplasm lines of *G. hirsutum* were field characterized as per DUS descriptors at CICR-RS, Coimbatore.
- 49 EDVs, 43 VCKs, 63 genotypes under first year testing and 30 under second year testing were subjected to DUS characterization.

Molecular Breeding

- RIL population (EL 958 x UPA 57-17) was developed using single seed descent method for genetic mapping. During 2014-15, 857 SSR markers were screened for parental polymorphism, 157 were found to be polymorphic. So far, 4417 SSR markers were screened for parental polymorphism in *G. hirsutum* and 702 informative SSR markers were identified. Genotyping of 188 RILs using 162 SSR markers and 172 RILs using 2979 SNP

markers (50K SNP chip) has been completed.

- Sixty SSR markers were identified as polymorphic among 48 public sector released cotton varieties of *G. hirsutum* as well as *G. barbadense*. Twelve markers were polymorphic among the 50 SSR screened in *desi* cotton varieties. These markers can effectively identify and distinguish cotton varieties.
- Sixty four polymorphic markers were identified after screening more than 450 genome wide SSR markers among the private sector cotton hybrids and popular cotton varieties. Higher genetic diversity was observed among cotton varieties (47%) as compared to private sector hybrids (32%). SSR markers effectively distinguished varieties (capturing both inter and intra species variation) and hybrids compared to DUS characters.

Development of Transgenics

- Generated *in-vitro* nano complex of VirD2-SS TDNA- VirE2 with cell penetrating peptide (Tat2) for transgene delivery into cotton.
- Transgene delivery using cell penetrating peptide (CPP) through pollen tube pathway was carried out using gossypol biosynthesis gene coding for delta Cadinene synthase.
- *In-planta* transformation using pollen tube pathway was carried out in cv Suraj using agrobacterium containg CICR multigene construct and around 300 seeds were harvested.
- CICR multigene construct was also subjected to transformation and regeneration through somatic embryogenesis.
- Molecular identification of isolated bacterial and fungal strain for glyphosate tolerant / utilization, was done through 16s rDNA and ITS region sequencing.
- Full length coding sequence for *Helicoverpa armigera* chitin synthase B sequence was isolated successfully and characterized for functional motif.
- Members of COBRA gene family was identified as new players in the regulation of the orientation of cell expansion in the plant cell wall and in cotton known to play key role in fibre development.
- Gene expression analysis was carried out through qPCR using mapping population for high fibre strength.

Seed Production and Quality Improvement

- A total of 484.5 q seed including breeder, foundation, certified and truthfully labelled seeds was produced for different crops and about Rs 15-16 lakhs was generated through the sale of these seeds or its by-products.
- The seed cotton yield of 1 month old transplanted crop was found to be superior to 20 days old transplanted and direct sown crop. Bio priming with *Pseudomonas* (2 g/kg) and pulsed magnet treatment at 750 nT 5hr for 15 days have significantly increased the germinability and seedling vigour.
- Higher boll and seed setting was observed with hand pollination over NPK 2%, CICR consortium, Godrej double, DAP 2% and check. Much lower boll and seed setting percentage observed in sterile lines indicated negligible contribution of pollinators in cotton. Studies indicated significant influence of prevailing environment on boll formation percentage and seed setting efficiency.

Crop Production

Phenotyping for drought tolerance

- Eighty seven cotton germplasm accessions were identified as drought tolerant out of 350 germplasm lines screened during rain free hot dry summer days (April-May)
- Among the 87 accessions, Nagpur-9, SGNR-27, F-1226 and DTS-108-09 performed well under drought stress conditions.

Amelioration of Leaf Reddening in Cotton,

CICR, Nagpur

- Based on visual screening, monochrotophos (3 ml/litre), kinetin 20 ppm and CICR nutrient consortia treated plants showed delayed onset of reddening. As the days progressed, monochrotophos (3 ml/litre) sprayed plants remained healthy with relatively higher percentage of green foliage followed by CICR nutrient consortia treated plants.
- Chlorophyll stability index was higher in red leaves of RCH 2Bt (70.5%) than green leaves of RCH 2Bt (64.5) providing evidence for protective role of anthocyanins.
- Seed cotton yield was higher in monochrotophos treated plants (924 kg/ha) followed by CICR consortia treated plants (769 kg/ha) as against control (523 kg/ha).

Weed management

- Among the different concentrations of glyphosate, 5 ml/l and 7.5 ml/l were effective in controlling both the dicot (broad leaved) and monocot (grassy) weeds.
- With enhancers, combination of even a very low concentration of glyphosate (1ml/l) and 100 mM ammonium sulphate was effective in controlling weeds. The activity of glyphosate was also increased by other enhancers such as 100 mM KH_2PO_4, 2% urea and 5% neem oil, however, at a slower rate than ammonium sulphate.
- Among the 48 different combinations of glyphosate, Quizalofop ethyl 5% EC, Propaquizafop 10% EC and Pyrithiobac Sodium tried at low concentrations, combination of Glyphosate 2.5 ml/l and 2.5 ml/l of Quizalofop ethyl 5% EC was found effective in killing both broad leaved and grassy weeds.
- Sorghum and sunhemp were found to be the most effective cover crops for controlling weeds.
- Newspaper as a mulch was found to provide total weed control and was as good as the polythene mulch treatment.

Cotton Mechanization

- Modifications of grid concave, gathering reel and combs were carried out to optimize the CICR Precision Cotton harvester.
- The cotton harvester and modified components were evaluated in RCH-2 at 60 x 60 cm spacing and Suraj at 80 x 10 cm HDPS system.
- 80% harvested seed cotton came off relatively cleaner (25% trash) from the threshing unit and into the pre-cleaner while 20% trashy cotton (40% trash) got discharged from the opening below the grid concave unit.
- Pre-cleaner could clean 20% of overall trash found at the gathering unit.

HDPS

- New genotypes like DSC 99, G. cot 16, H 1098i were found suitable for planting under HDPS at 45 x 10 cm or 60 x 10 cm under rainfed conditions on black soils.
- On the sandy loam soils of north India, CSH-3158, CSH-3132, CSH-3178, RS-2525 and Bhiani 251 were identified as having high yield potential under HDPS.
- Among super okra leaf cultures evaluated at Coimbatore, Surabhi × M_5Z_2 4-2 Bk was identified as high yielding (3492 kg/ha) compared to Suraj (3137kg/ha)
- Surgical cotton varieties with high yield for the black cotton soils were CNA-375, CNA-418, Phule Dhanwantari & MDLABB.
- Inclined plate planter was found to be efficient and cost effective for planting cotton seeds under HDPS.
- Moisture conservation measures such as planting in ridges and furrows or use of bio-mulch resulted in an additional yield of 300 kg seed cotton per hectare over control.

Crop Protection

Pest dynamics

- Seasonal pest population dynamics under protected and pesticide free conditions at Nagpur indicated highest population of thrips, aphids and whitefly during (first fortnight of September). Jassids were above ETL during first week of September to third week of October.
- Seasonal peaks of sap feeders viz., jassids, thrips and whitefly across central zone locations from 2005-06 to 2013-14 (AICCIP data) varied from location to location. Jassids and thrips peaks were recorded between 34-44 standard week and whitefly between 34-54 standard week.
- In North India, whitefly peaks were recorded at 37 standard week and the corresponding populations were recorded as 50.1, 38.9, 33.0 whiteflies/3 leaves on genotypes RCH-134 BGII, HS-6 and Ganganagar Ageti, respectively.
- Pheromone trap catches of American bollworm, Tobacco caterpillar, Pink bollworm and Spotted bollworm were highest during second fortnight of November, between last week of October to first week of November, 10-16 November and 3-9 November, respectively at Nagpur.
- Five mealybug species *viz., Phenacoccus solenopsis, Nipaecoccus viridis, Maconellicoccus hirsutus, Ferrisia virgata* and *Paracoccus marginatus* belonging to Pseudococcidae family of order Hemiptera were recorded in Maharashtra and Madhya Pradesh.

Novel technologies

- CICR Whitefly Adult Suction Trap was designed. The trap is power operated, shoulder mounted, adjustable and sucks whitefly adults available on the underside of the cotton leaves with least harm to the natural enemies flora and cotton crop.
- YST (yellow sticky trap) is an effective scouting mechanism. YST when stuck to the trouser on the outer thigh of the person operating the intercultural machine, trapped maximum number of whitefly when the crop was 45-60 days old.

Biological control

- Fifteen species of spiders belonging to 6 families were recorded in cotton agro-ecosystem. Three species were of orb weavers from family Araneidae, a species of lynx spider from family Oxyopidae, 5 species of crab spider from family Thomisidae, 4 species of jumping spiders from family Salticidae, 2 species of cob web spiders of family Theridiidae. Family Araneidae contributed one third spider population (34.6%) followed by Oxyopidae (27%) and Thomisidae (24.5%).
- Eight natural enemies of mealybugs *viz.*, parasitoids- *Aenasius bambawalei, Metaphycus* sp., *Anagyrus kamali, Acerophagous papayae, Pseudoleptomastix mexicana* hyperparasitoids- *Promuscidea unifasciativentris* and *Prochiloneurus albifuniculus* and predator *Cacoxenus perspicax* were recorded.
- Nineteen insecticidal formulations from 10 groups of insecticides were evaluated for their relative toxicity against cotton mealybug *Phenacoccus solenopsis* Tinsley and its fortuous parasitoid *Aenasius bambawalei* Hayat. Spinosad, Chlorpyriphos and Quinalphos were found to be extremely toxic to *A. bambawalei,* the application of which may be avoided for the control of *P. solenopsis*. Moderately toxic insecticide Thiodicarb was found effective against *P. solenopsis* and relatively less toxic to parasitoid.
- Mortality of pink bollworm from Bharuch district of Gujarat due to the parasitoid *Apanteles sp.*, ranged from 21.2 to 60.9%

Host Plant resistance

- Mealybug induced biochemical changes in cotton indicated increase in total protein,

phenol and total sugar by 50.9 %, 171% and 11.1%, respectively, over control.

- Increased ethylene emission from cotton plants stressed due to jassid infestation was observed with increasing infestation grades under both protected and pesticide free conditions during vegetative and fruiting stage.
- Plants suffering from sudden wilt emitted higher ethylene (2.27 ppm) as compared to healthy plants (1.02 ppm).

Resistance Monitoring

- Resistance development of pink bollworm collected from BG, BG-II and non Bt cotton fields was monitored in 34 districts of India. Incidence of pink bollworm was not observed on Bt cotton in North and South India, but was recorded only in Gujarat. The larval intensity on Bt cotton was more in Amreli and Vadodara as compared to other locations.
- LC_{50} of *Cry1Ac* was lowest against pink bollworm populations of Jalna (0.034 µg /ml of diet) and Mansa (0.049 µg /ml of diet). The highest LC_{50} of *Cry1Ac* was recorded on pink bollworm populations of Khandwa (0.204 µg cry1Ac /ml of diet), Amreli (0.101 µg *cry1Ac* /ml of diet) and Akola (0.11 µg *cry1Ac*/ml of diet).
- Pink bollworm populations of Faridkot (0.05 µg *cry2Ab*/ml of diet) followed by Ahmednagar (0.06 µg/ml of diet), Mansa (0.07 µg/ml of diet) and Sirsa (0.074 µg *cry2Ab*/ml of diet) were most susceptible to Cry2Ab while populations from Khandwa (0.67 µg *cry2Ab* /ml of diet) were most resistant.
- Forty four per cent survival was recorded with 10 ppm *Cry2Ab* in F_1 population of pink bollworm derived from Bollgard-II in Bharuch. Population of pink bollworm collected on NBt from Surat, Anand, Amreli and Junagadh showed poor mortality with 10 ppm *Cry2Ab* as compared to the susceptible strain.

Novel Genes

- The combination of CICR-fusion protein (CICR truncated Cry1Ac and CICR Cry2Ab) with chitinase not only resulted in higher mortality and growth regulation but also caused mortality 48 h earlier than fusion alone. Combination of genes of CICR fusion protein and CICR chitinase is different and effective against *H. armigera*.
- Molecular characterization of four root knot nematode *Meloidogyne incognita* populations using rDNA sequences, the large subunit, small subunit and the internal transcribed spacer regions (ITS) was carried out. Sequence analysis confirmed the identity of *Meloidogyne incognita* species from Nagpur, Wardha, Yavatmal, Chandrapur populations.

Endophytes and endosymbiots

- Based on 16S rRNA amplification and sequencing results, jassids from across India were found to harbor the bacterial endosymbiont, *Delftia acidovorans.*
- Forty seven fungal cultures and seventeen bacterial cultures were isolated as endophytes from cotton. Based on their virulence against *Pectinophora gossypiella, Spodoptera litura, Aphis gossypii*, and *Paracoccus marginatus,* nine bacterial and twelve fungal endophytes were selected for further studies.

Non-compliance of refugia guidelines

- From the commercial seed packets procured from market, non Bt seeds provided as refuge were tested for the presence of Bt. Out of 91 samples tested, 21 packets from 13 companies, carried Bt seeds in refuge packet in addition to non Bt seeds.

Pest and disease management

- Combination of cow urine and calcium nitrate showed significantly lowest CLCuD incidence followed by neem oil, cow urine+whey protein, cow urine alone, all five interventions in combination and kresoxim methyl+ whey protein.

- Maximum per cent reduction in whitefly population was observed with insecticide Diafenthiuron (59.6%) and Triazophos 40EC (49.2%) followed by Flonicamid 50%WG (48.8%) and Neemazal-T/S, 1%EC (44.8%).

Yield modelling

- β version of the ICAR-CICR yield prediction model has been developed using yield responsive factor. The CICR calculator helps determine the cotton crop yield by selecting a set of input parameters. Parameters such as rainfall, temperature, depth of soil, sowing time, solar radiation, sucking pest, bollworm and water logging are the main input factors used by the software.

Dissemination of pest management strategies

- Cotton pest management strategies were disseminated through ICT tools as one of the stakeholders in Crop Pest Surveillance and Advisory Project (CROPSAP) 2014-15 in 28 districts of Maharashtra and through online pest monitoring and advisory services in Sirsa and Fatehabad districts of Haryana.
- NFSM-IRM-HDPS programme was implemented in 11 states covering 5925 ha with involvement of 5568 farmers. The HDPS module was demonstrated on 1096 ha in 131 villages of the 11 cotton growing states with the involvement of 1750 farmers.

Varieties identified for release during 2014-15

CSH 3129

G. hirsutum culture CSH-3129 has been identified for release in irrigated north zone. It has recorded an overall mean seed cotton yield of 2293 kg/ha against 1935 kg/ha and 2068 kg/ha of zonal and local checks respectively. The increase in seed cotton yield of this culture over the Zonal check was 18.5 per cent. The culture has 29.5 mm span fibre length and fibre strength of 23.55 g/tex. CSH-3129 is spinnable at 40s count. The culture is tolerant to cotton leaf curl virus disease.

CCH 2623

The medium staple *G. hirsutum* culture CCH 2623 has been identified for release in southern states under irrigated conditions. The culture recorded a mean seed cotton yield of 1798 kg/ha as against 1589 recorded in the Zonal check variety of Surabhi with 17.0 per cent yield increase. The fibre quality of the culture is characterized by 27.2 mm of 2.5% span length, 4.5 micronaire and 21.3 g/tex of bundle strength.

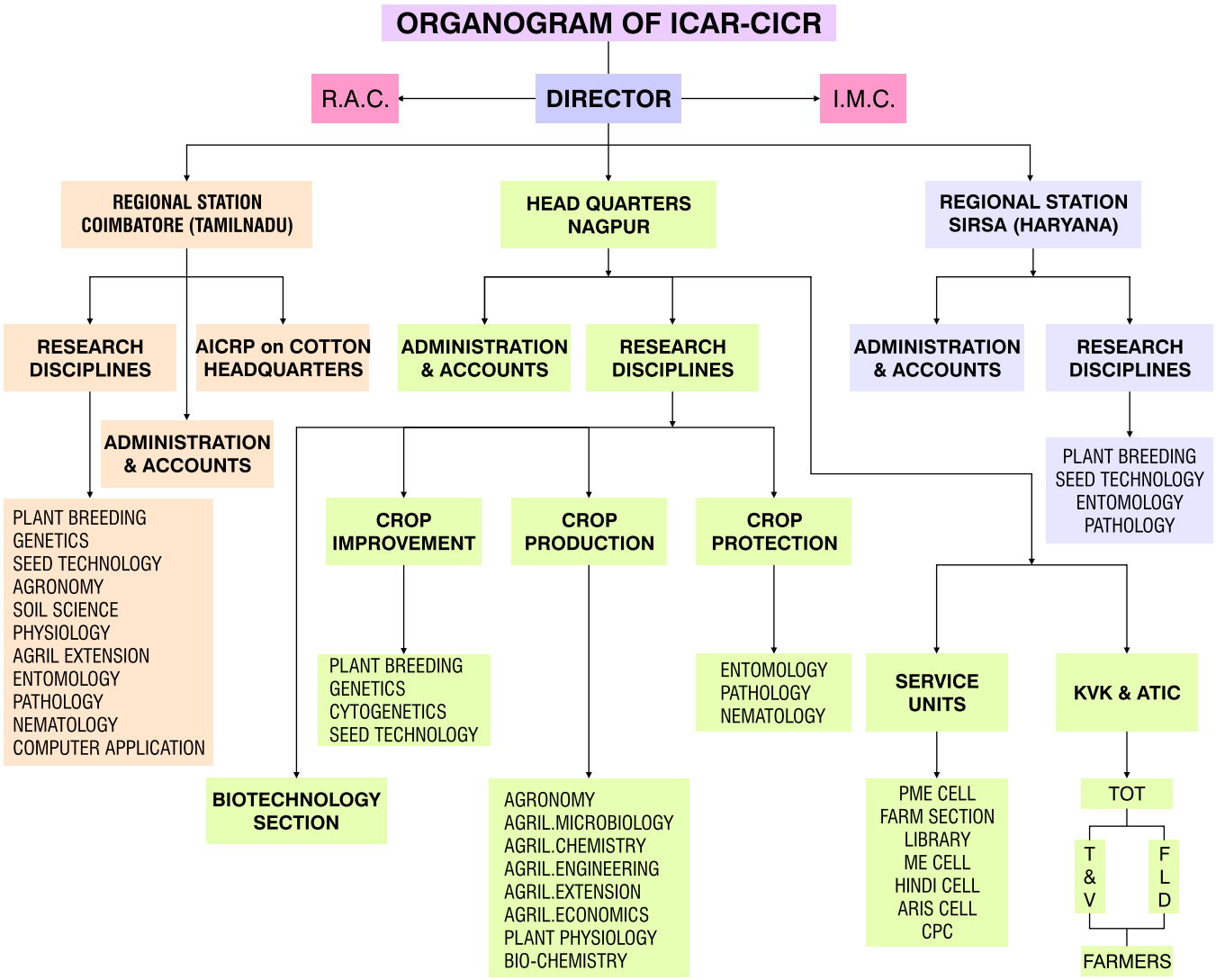
2. INTRODUCTION

2.1 : Brief History

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

2.2 : Mandate

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



2.3 : Staff Position (as on 31st March, 2015)

Name of the Post	Sanctioned Cadre Strength				Post Filled Up			
	Nagpur	Coimbatore	Sirsa	Total	Nagpur	Coimbatore	Sirsa	Total
Director (RMP)	1	--	--	**1**	1	--	--	**1**
Scientific	51	21	8	**80**	32	14	6	**55**
Technical	46	16	10	**72**	37	9	6	**52**
Administrative	34	9	5	**48**	23	6	5	**34**
Supporting	43	17	10	**70**	28	8	8	**44**
Krishi Vigyan Kendra								
Training Organizer	1	--	--	1	1	--	--	1
Technical	11	--	--	11	9	--	--	9
Administrative	2	--	--	2	2	--	--	2
Supporting	2	--	--	2	--	--	--	--

2.4 : Financial Statement

The budget grant and actual expenditure for the year 2014-15 are furnished below : **(Rs. in Lakhs)**

S. No.	Scheme	Sanctioned	Expenditure
ICAR-CICR			
1	Plan	220	219.57
2	Non-Plan	2695	2675.7
Plan Schemes		1703.7	1705.42
Deposit Schemes funded by outside agencies		316.17	302.52

3. RESEARCH ACHIEVEMENTS

3.1: Cotton Genetic Resources

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

Nagpur

Exploration for perennials

Exploration was done in Arunachal Pradesh, Madhya Pradesh, Maharashtra and Karnataka (Table 3.1.1) and 59 variants of cotton including 42 perennials and 17 landraces belonging to *G. arboreum* and *G. barbadense* were collected. These were established in the pot culture and conserved in the Gene bank.

Table 3.1.1: Details of Landraces of *desi* cotton and perennials collected

S. No.	Districts	State	No. of Accessions	Species	Perennial/ Landrace
1.	West Siang, East Siang, Upper Siang and Dibang valley	Arunachal Pradesh	17	*G. arboreum*	Landraces
			14	*G. barbadense*	Perennials
2.	Indore and Khandwa	Madhya Pradesh	1	*G. arboreum*	Perennial
			2	*G. barbadense*	Perennials
3.	Wardha, Hinganghat, Chandrapur, Nandurbar and Dhule	Maharashtra	1	*G. arboreum*	Perennial
			8	*G. barbadense*	Perennials
4.	Raichur, Bijapur, Bagalkot, Gadag, Dharwad, Haveri, Uttarakannada, Davangere, Chitradurga, Bellary	Karnataka	10	*G. arboreum*	Perennials
			6	*G. barbadense*	Perennials
		Total	**59**		

Landraces of *desi* cotton *Gossypium arboreum* from East Siang district, Arunachal Pradesh

Perennial cotton *Gossypium barbadense* from Uttarakannada district, Karnataka

Perennial *desi* cotton *Gossypium arboreum* from Bellari district, Karnataka

Conservation and Exploration of Wild Species

In the wild species garden, 26 wild species, 15 races of cultivated species and more than 45 synthetic polyploids are maintained. One new species (EC 669583) which was established in a pot during 2013-14 was found to be genetically distinct from other wild species as evident from the genotyping data (Fig. 3.1.1).

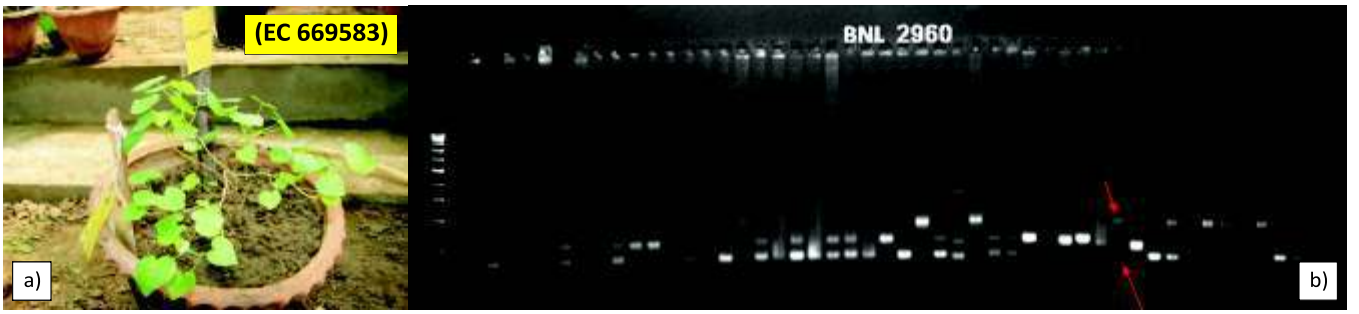


Fig. 3.1.1: a Exotic species EC 669583 established in pot & b - SSR marker BNL 2960 indicating the distinctness as compared to other species conserved in the wild species garden

DUS and Molecular characterization of perennials and wild species

One hundred and forty-two perennials and landraces of cotton were characterized for DUS traits.

96 lines, wild species, races of cultivated species, synthetic polyploids and introgressed derivatives were characterized by SSR markers, 52 of which were confirmed to be polymorphic.

F_2 plants of the mapping population were transplanted in the species garden from pots for their phenotyping:

S.No.	Derivative	Number of F_2 plants transplanted
a.	*G. herbaceum* x *G. longicalyx*	525
b.	*G. arboreum* race indicum x *G. davidsonii*	170
c.	*G. arboreum* x *G. thurberi*	42
d.	*G. arboreum* (AKA 8401) x *G. davidsonii*	31

Genetic stocks registered

Three genetic stocks were registered with NBPGR, New Delhi.

S. No.	Name of the stock	Registration Number	Uniqueness
1	CNA 5	INGR14005	An inter -racial (*Indicum* and *Burmanicum*), pigmented and long linted *G. arboreum* (26.7 mm), tolerant to jassids, bollworm, bacterial blight and grey mildew
2	CNH CB-211	INGR 14058	Cluster boll bearing habit
3	CNH CB -212	INGR 14059	Compact and cluster boll bearing habit

Enrichment of Cotton Gene bank and maintenance of germplasm

One hundred and seventeen (117) exotic accessions (*G. hirsutum* : 112 from USA and *Gossypium barbadense* : 5 from Israel) were procured through ICAR NBPGR, New Delhi for enrichment of the cotton gene pool.

Evaluation of germplasm at Nagpur

Gossypium hirsutum

A set of 252 exotic accessions were evaluated for economic and fibre quality traits. Sixteen long linted accessions with staple length (31.0 – 32.6 mm) and 28 accessions for high fibre strength (25.0 – 26.8 g/tex) were identified and documented.

Long fibre (>31 mm)

EC 697618, EC 700181, EC 700133, EC 700118, EC 676026, EC 700160, EC 700200, EC 700136, EC 700154, EC 700177, EC 700202, EC 700193, EC 700198, EC 697611, EC 700195, EC 700349.

High fibre strength

(>26 g/tex) EC 700133, EC 700181

(25-26 g/tex)

EC 692135, EC 692136, EC 700143, EC 700144, EC 700491, EC 700154, EC 700195, EC 700169, EC 700198 , EC 700156, EC 700202, EC 700217, EC 700513, EC 700164, EC 700200, EC 700225, EC 700159, EC 700187, EC 700224, EC 700158, EC 700160, EC 700177, EC 700193, EC 70017, EC 700125, EC 700128.

Gossypium arboreum

Eight hundred and thirty six (836) accessions were evaluated for fibre quality traits. Twenty long linted accessions having staple length ranging from 26 to 28.3 mm and 14 accessions having high fibre strength (22.8 – 26.0 g/tex) were identified and documented.

Long fibre (mm)

CINA-341 (28.3), IC 440697 (28.1), IC 440484 (27.7), IC 439836 (27.3), CINA 333 (27.2), CINA 333- A-BLL (27.2), IC 564390 (27.1), AKH 4 (26.8), IC 440398 (26.8), PA 235 (26.6), IC 438922 (26.5), IC 440366 (26.5), CINA 349 (26.2), IC 439842 (26.2), IC 439829 (26.1), IC 440814 (26.1), IC 440828 (26.1), IC 440695 (26.0), IC 440473 (26.0), IC 440308 (26.0).

High fibre strength (g/tex)

IC 440695 (26.0), IC 440788 (26.0), IC 440583 (25.4), Comilla-1 (23.9), IC 412567 (23.8), IC 440567 (23.8), IC 440582 (23.7), IC 412342 (23.5), IC 412564 (23.4), IC 440371 (23.2), IC 412310 (22.8), IC 440076 (22.8), IC 440087 (22.8), IC 440554 (22.8).

Gossypium herbaceum

Five hundred and fifty (550) germplasm accessions were evaluated for seed cotton yield, boll weight, ginning outturn and fibre quality traits.

High seed cotton yield (g/plant)

IC 371351 (200.0), IC 371512 (198.3), IC 371353 (197.0), IC 371352 (195.3), IC 371603 (195.0), IC 371511 (192.0), IC 371394 (192.0), IC 371132 (190.0), IC 371395 (191.7).

High boll weight (g)

IC 371413 (2.6), IC 371407 (2.5), IC 371414 (2.5) and IC 371416 (2.5).

High ginning outturn (%)

IC 371425 (39.6), IC 371457 (39.0), IC 371392 (38.9), IC 371419 (38.9) and IC 371376 (38.8).

Fibre length (mm)

IC 371464 (30.6), IC 371406 (27.9), IC 371540 (27.5), Russian-5 (27.1), IC 371348 (26.9), IC 371341 (26.8), IC 371578 (26.8) and IC 371592 (26.8).

High fibre strength (g/tex)

IC 371515 (22.4), IC 371577 (22.0), IC 371578 (21.9) and IC 371364 (21.8).

Evaluation of promising cultures in AICCIP

Two promising cultures CNH -25 (*G. hirsutum)* and CNA 449 (*G. arboreum*) were identified and sponsored in AICCIP and cultures CNA 2019 and CNA 2043 (*G. arboreum*) were evaluated in station trial at CICR, Nagpur.

Conservation of Germplasm in Long Term Storage (LTS) and Medium Term Storage (MTS)

Seeds of 618 accessions (*G. arboreum* -268 and *G. hirsutum*-350) were kept for conservation in LTS at ICAR NBPGR and MTS at ICAR CICR, Nagpur.

Rejuvenation and seed multiplication of germplasm

Four thousand eight hundred and fifty (4850) germplasm accessions (*Hirsutum*-4000, *Arboreum*-300 and *Herbaceum*-550) were grown for rejuvenation and seed multiplication

Distribution of germplasm

Eight thousand three hundred and forty three (8343) germplasm accessions (*G. hirsutum*-8311, *G. barbadense*-1, *G. arboreum*-23 and *G. herbaceum*-8) were distributed to Breeders/Scientists of State Agricultural Universities for research purpose.

Sirsa

Three thousand eight hundred and eight (3808) accessions of *Gossypium hirsutum* were evaluated and the data recorded for different growth and economic characters (Table 3.1.2). Twelve compact germplasm lines were evaluated at 67.5 x 10 cm spacing alongwith checks F 1861, LH 2076 at 67.5 x 30 cm and Bt hybrid Bio Seed 6588 at 67.5 x 60 cm. The number of bolls per plant, boll weight and seed cotton yield/plant were significantly lower in compact lines than the checks. The closer spacing contributed significant increase in per acre yield in

accessions no. 5640 (36.7 q/ha), 5038 (36.5 q/ha), 6109 (36.2 q/ha), and SA 1521 (32.70 q/ha), than the check varieties as well as Bt hybrid Bioseed 6588 (31.4 q /ha).

Table 3.1.2 : Range for various characters in germplasm lines

Character	Minimum	Maximum
Flowering (DAS)	37	99
Plant height (cm)	40	155
Monopodia	1	7
Sympodia	4	13
Boll number/plant	4	38
Plant width (cm)	10	80
Boll weight (g)	2	3.6
Yield/plant (g)	10	100.2

Coimbatore

Germplasm lines of *G. hirsutum* (2719) were field characterized for various morphological parameters. So far, data were recorded on plant type, stem hairiness, stem colour, leaf shape, leaf lobing, leaf colour, leaf surface, leaf glands, leaf nectary, flower bracts, petal colour, pollen colour, boll bearing habit, boll shape and surface, glands on bolls and loculi / boll.

G. hirsutum

Evaluation of zero branching germplasm accessions

Six single plant selections were made from germplasm lines evaluated during 2013-14 *viz.*, IC291590, IC360026, IC356618, IC359978, IC358085 and IC 359992 exhibiting zero branch-ing habit. The single plant progenies were sown in the field and evaluated in 2014.

IC 359992 plants showing zero branching

G. barbadense

Twelve compact accessions of *barbadense* were identified and evaluated with Suvin as control. Among them, ICB-194 recorded the highest yield of 130 g/plant followed by ICB-39 (125 g/plant). ICB-194 exhibits high ginning outturn (32%) and boll weight (3.6 g). Another set comprising seven dwarf germplasm accessions were evaluated for yield potential and economic characters. ICB-124 recorded the highest seed cotton yield (154 g/plant) and boll weight (3.6 g) followed by ICB-174 (125 g seed cotton yield and boll weight 3.5 g) and both were early maturing (169 to 170 days) than Suvin (183 days). EC-16 was also early in maturity (165 days). Twelve hairy accessions were identified from base collection of *G. barbadense* germplasm and evaluated for yield and sucking pest tolerance.

Among the 15 hairy accessions, ICB-264 exhibits highest seed cotton yield of (137 g per plant) and ginning outturn (30.1%) followed by ICB-284 (132 g/plant) and ginning outturn (27%). Both these accessions are tolerant to sucking pests and mature

in 170 and 163 days respectively, as against 184 days by Suvin.

Field evaluation was done with 31 advance genotypes from segregating population and Suvin multiple cross progenies. Eight high yielding, extra long staple genotypes yielded more than 1000 kg/ha while the control Suvin recorded an yield of 711 kg/ha. These genotypes also recorded more than 37 mm 2.5% span length and their strength ranged from 27-28 g/tex with > 3.5 micronaire and GOT that ranged from 30-31% as against 28% in Suvin.

3.2: Hybrid Cotton

Nagpur

Heterosis breeding

G. arboreum

Thirty three *desi* hybrids (10 GMS and 23 conventional) were tested. Among the GMS hybrids GAK-423 x G-135-49 recorded 2944 kg/ha seed cotton yield followed by CICR Hy 2 x 30838 (2515 kg/ha) while PA 255 x 30805 (3139 kg/ha) followed by AKA 8401 x G 135-49 (2528 kg/ha) and AKA-8401 x 30805 (2469 kg/ha) among conventional hybrids were good performers. Boll weight of (> 4.5 g) was recorded in all the F_1 crosses wherever 30838 was a parent.

Development of heterotic pool

G. hirsutum

Heterotic population was developed for superior medium staple (25-27 mm) category from parents selected on the basis of geographic diversity. Of the 37 lines developed, 21 lines were used in crossing programme for developing 132 F_1s. In order to find out percentage of heterosis for seed cotton yield and quality traits, these lines were crossed in two sets in diallel fashion. In the first set, 12 lines were crossed in half diallel to produce 66 F_1s. In second set, 9 lines were used along with three quality parents Suraj, NH 615 and G-21-19-619 for producing 66 F_1s.

Averaged over two seasons, 6 lines *viz.* CNH 20-4-3 (27.6 mm, 24.3 g/tex), CNH 16-3-1 (28.6 mm, 22.9 g/tex), CNH 16-3-5 (30.7 mm, 24.4 g/tex), CNH 10-6-1 (28.7 mm, 25.0 g/tex), CNH 12-4-2 (30.3 mm, 24.5 g/tex) and CNH 18-8-3 (29.4 mm, 24.3 g/tex) were identified for better fibre properties. Line CNH 15-2-1, expressed its superiority as best general combiner for seed cotton yield with positive effects for all the yield contributing traits except sympodial length. Lines CNH 16-3-5 and CNH 12-4-2 exhibited best general combining ability for seed cotton yield and positive GCA (General Combining Ability) effects for all the traits studied. Lines CNH 7-3-3 and CNH 12-2-3 had desirable effects for reduced height while Line CNH 13-1-3 recorded significant GCA effects for number of bolls per plant.

GCA variances were significant for seed cotton yield and most of the yield components indicated importance of additive effects. The estimate of component of variance due to GCA was higher in magnitude than SCA indicating predominance of additive type of gene action for the inheritance of these traits. Both GCA and SCA variances were significant for seed cotton yield and boll number indicating importance of additive and non-additive gene actions in controlling these traits. Promising crosses CNH20-2-4 × CNH 20-4-3, CNH 20-2-4 × CNH 16-3-1, CNH 17-2-2 × CNH 14-1-1, CNH 20-4-3 × CNH 14-6-4 and CNH 12-12-4 × CNH 18-8-3 were identified for significant mid-parent heterosis.

Long staple lines CNH 20-4-3, CNH 16-3-1, CNH 16-3-5, CNH 10-6-1, CNH 12-4-2 and CNH 18-8-3 were identified, based on two years data. These lines can be used as a source for developing improved varieties and hybrids.

Sirsa

Evaluation of GMS based *G. arboreum* hybrids : Six GMS based *G. arboreum* hybrids were evaluated for seed cotton yield with two check hybrids AAH 1 and CICR 2. CISAA-32 (2768 kg/ha) recorded significantly higher seed cotton yield than the check hybrid CICR-2 (2396 kg/ha) followed by CISAA-27 (2632 kg/ha). The GMS based hybrid CISAA-27 was sponsored in AICCIP Br25a/b national trial.

Evaluation of Line x Tester : Fifteen F_1 were produced using 3 lines and 5 testers and evaluated

with check CICR 2. Only one hybrid combination DS 5 x LD 909 (2833 kg/ha) gave higher seed cotton yield than check hybrid CICR 2 (2179 kg/ha). Based on GCA effects, parents DS-5, CISA-2, LD-909 and CISA 6-165 were best combiners and could be used for developing hybrids. Based on SCA estimates, crosses DS 5 x LD 909, CISA 2 x RG 540, CISA 2 x RG 526, CISG 20 x CISA 6-165, CISG 20 x DLSA 17 were adjudged as the best for seed cotton yield involving specific parents. Maximum heterosis was observed for lint (107%) followed by seed cotton yield (96%).

Maintenance of GMS lines : Three GMS lines DS5, CISA 2, GAK 413A4 and 21 newly identified GMS lines were maintained through sibmating. For genetic study of GMS line, CISG-20 having red flower was crossed with DS-5 and CISA-2 GMS lines to develop population and ascertain the gene for male sterility.

3.3 : Genetic Improvement

Sirsa

G. arboreum

Evaluation of spinnable *G. arboreum* cultures : Fourteen cultures were tested in RBD along with two checks CISA-310 and CISA-614. The cultures CISA-6-295, CISA-10, CISA-33-6, CISA-33-7, CISA-33-7, CISA-33-8, CISA-54-1 and CISA-44-1 were found promising for spinning having 2.5% span length (>23.0 mm), micronaire between 5-6 and strength >19.0 g/tex. None of the genotypes record significantly higher seed cotton yield than the check varieties. However, the genotypes CISA 10 and CISA-44-1 were coarse with staple length 24.6 and 24.8 mm, respectively. Coarse genotypes with potential for high yield were CISA 33-6, CISA-6-165, CISA-6-123 and CISA-6.

Evaluation of high yielding *G. arboreum* genotypes : Sixteen high yielding genotypes were evaluated in RBD along with two check varieties CISA-310 and CISA-614. Four genotypes CISA-6-2 (2493 kg/ha), CISA-405 (2540 kg/ha), CISA-8 (2491 kg/ha), CISA-7 (2555 kg/ha) significantly out yielded the check variety CISA-310 (2123 kg/ha). The other two genotypes CISA-33-3 (2391 kg/ha) and CISA-6-187 (2218 kg/ha) showed promising seed cotton yield as they gave numerically higher seed cotton yield than check variety CISA 310 (2123 kg/ha) and CISA 614 (2059 kg/ha). Further, three genotypes CISA 9, CISA -6-209 and CISA-33-1 although not higher yielders, have good spinning quality as they recorded 2.5% span length >24 mm, micronaire 5.4-5.7 and strength >18 g/tex. The genotype CISA-6-2 was sponsored in AICCIP Br22a/b national trial.

Evaluation of Single Plant Progenies: Twenty five single plant progenies were evaluated in 3 replications with check variety CISA 310. SPS 127 (2798 kg/ha) progeny gave highest seed cotton yield followed by SPS 10 (2416 kg/ha). Other promising plant progenies were SPS 37 (2115 kg/ha), SPS 107 (2160 kg/ha) and SPS 103 (2103 kg/ha), respectively.

Nagpur

G. arboreum

One early maturing *G. arboreum* culture *viz*. CNA-2003 was identified amongst 29 cultures. Two cultures *viz*. CNA-2006 and CNA-2009 sponsored earlier in Br 22b were evaluated in the AICCIP trial this year. CNA-2003 and CNA-2023 were sponsored for the current season in Br 22 a/b. Six *G. arboreum* race *cernuum* collections from Mizoram were evaluated for plant height (cm), sympodial length (mm), boll number etc. A couple of very dwarf compact types were identified which could be explored for developing compact *G. arboreum* cultures with plant height (cm) values of less than 50 cm, sympodial length of <2 cm with open bolls ranging from 2 to 10 per cent indicating promise for evolving compact *G. arboreum*.

G. hirsutum

Breeding for compactness, earliness and jassid tolerance

Sixty-one genotypes possessing desirable characters like early maturity, jassid tolerance and compact plant architecture were evaluated in a replicated trial. Upon phenotyping, Sahana, G-Cot 16, CNHO-12, AKH-081, CNH-409-9, KC-3, IC-359691, CNHO7-12, EC-344092, DSC-99, Anjali, SGNR-24, AKH-8828, EC-344804 and CSH-3178

were found to be early maturing as they had more than 85% bolls opened by 150 days after sowing. On the basis of number of monopodia and width of plant canopy, Anjali, Arogya, Pratima, Supriya, Sumangala, CNHTi-1, CSH-3178, IC359478, PI-8-2-BK, Suraj, CNH09-7, CNHO-12, Sikandar Ageti, LRA 5166 and CNHO-7-34 were identified to have compact plant type. Based on jassid grade and nymphs / plant, CNH-2024, CNH-409-9, CNHO-7-34, DSC-99, CNH-2027, CNH-2033, NH-615, AKH-081, AKH-8828, CNH-2026, G-COT16, JK-4, KC-3, CNH-2025 and CNH-2031were identified as promising lines for jassid tolerance.

Coimbatore

A compact, densely hairy and pyramid shaped plant type was identified in back cross derived culture (Sumangala x ACT SP 16-1) ACT SP 16-1 C-5-1 which showed cleistogamous flower character and cluster boll bearing habit. It showed a high degree of tolerance to sucking pests and recorded yield of 52 g/plant.

Compact, densely hairy, pyramid shaped plants showing cleistogamous flower & cluster boll bearing

Evaluation and identification of F_2 segregants plants from three crosses

Individual F_2 plants of three different crosses *viz*. N-170 x IC 356750; N-170 x LRA-5166 (introgressed with *G. thurberi)* and N-170 x IC-358358 were raised and scored for plant architectural traits. Based on different numerical values the plants were classified into groups as dwarf and semi-dwarf compact height, short and closed sympodia, low and medium number of sympodia /plant, small, medium and high boll weight. One hundred and three plant progenies had boll weight >3.0 g.

Breeding for high strength with good fibre length and high yield

Sirsa

Thirteen crosses were attempted between 5 long linted (Coimbatore) cultures with high fibre strength (Sirsa) cultures. Average of three years F_4 (2012-13), F_5 (2013-14) and F_6 (2014-15) progenies of the two crosses *viz*; CSH-3119-10-28-56 (2744 kg/ha), fiber strength 22.9g/tex, fiber length 28.2 mm and MMO3 (39-2-5)-3114-10-64 (2498 kg/ha) were early in maturity and significantly higher yielding than the Check H-1226 (2071.57 kg/ha) and four were at par in seed cotton yield with the check H-1226. There was an improvement in yield in different crosses with advancement in generations. Further, in 2013-14, MMO3 (27-5-1-8)-3047-10-76 recorded 24.1 g/tex fiber strength and 28.7 mm fiber length.

From 13 F_4 populations of crosses of Coimbatore and Sirsa cultures, 72 early plants were selected in

2012-13 and their F_6 progenies were raised during 2014-15. High yielding individual plant progenies were CSH-3119-10-14-28-56 P3, CSH-3119-10-29-58 P2, CSH-3114-10-66 (27-5-1-5) P3, CSH 3047-10-78 22-1-2 P1, CSH 3047-10-78 22-1-2 P3, CSH 39-2-5 3047-10-80-P3.

Coimbatore

Eight superior long staple cultures were evaluated in a replicated trial along with Suraj and Sumangala as check varieties. Analysis of data on seed cotton yield indicated significant differences among the genotypes and the highest seed cotton yield was recorded in the test entry MM 03-12-1-2-3 (1881 kg/ha) as against 995 kg/ha and 837 kg/ha recorded in check varieties. Four test cultures recorded significantly higher yield than both the checks. Cultures MM 03-39-4-2-3 (Br-02a) and MM03-40-4-3-1 (Br-02b) were sponsored for multi-location testing in initial evaluation trial of AICRP on Cotton during 2014-15 in irrigated and rainfed trials, respectively.

Breeding for high GOT % and high yield

Evaluation of 13 F_6 (2013-14) and F_7 (2014-15) progenies of cross SA-977 (HG) x SA-112 (LG) indicated four promising progenies *viz*. P-69, P-86, P139 and P-164 for seed cotton yield and eight progenies *viz*. P-7, P-70, P-84, P-86, P-139, P1-64,P-174 and P-184 for lint yield. These lines also possessed GOT more than 40%. F_3 individual plant progenies were evaluated in which 6 out of 12 of cross (RS-875 x SA-524), 2 out of 85 of cross (CSH-3129 x EC-358002) and 12 out of 68 of cross (F-1861 x SA-668) recorded more or equal to 40% GOT. In two F_2 populations of crosses F-1378 x EC-359044 (20) and LH-2107 x EC-359044 (30), there were 8 and 4 plants with more than 40% GOT. 285 fresh crosses were attempted between 29 females and 13 high GOT F6 lines of the cross SA- 977x SA-112. Five crosses recorded more than 40% GOT.

Breeding for big boll size

Twenty three single plant selections in F_6 generation of a cross Ganganagar ageti x Acala 44 (B2) were evaluated for big boll and other economic characters. The cross had shown continuous reduction in boll weight over the years and during the crop season of 2014-15 it ranged from 3.0 to 5.1 g in different single plant selections (SPS). The selection SPS 131 recorded highest yield of 2112 kg/ha with GOT 37.3%, boll weight 4.5 g, fibre length 27.7 mm, uniformity ratio 53%, micronaire 4.6 µg/in, fibre strength 22.8 g/tex, elongation 5.9% and SFI 7.9%.

Two selections *viz*; SPS 137-2 and SPS 140-1 which recorded good yield (17 q) also had good fibre quality with GOT >40 %, boll weight 5 g, 25-26 mm fibre length, uniformity ratio > 50%, micronaire 4.1 µg/in, fibre strength 21.0 g/tex, elongation 6.0% and SFI 8.3 and 11.1%, respectively were identified for multilocation trial.

Genetic Enhancement

Genetically enhanced lines of advanced generation and cultures were evaluated a spacing of 60 x 45 cm. Thirteen entries of the 55 were found to possess superior fibre quality parameters as compared to the check Suraj which recorded fibre length of 30.4 mm, fibre strength of 24.7 g/tex and micronaire 3.3 µg/in. Some of the lines with good fibre properties were SPS 9-6, SPS 9-7, SPS 9-19, SPS 9-27 and SPS 9-55.

G-21-19-619, a donor of high strength recorded high values for fibre length (32 mm), fibre strength (27.9), and a micronaire (3.3). It contributed to an improvement in fibre properties of the parent PKV-081 which has a fibre length of 27 mm, fibre strength of 20.4 g/tex and micronaire value of 3.2. Three entries SPS9-14, SPS9-15, SPS9-16 were identified as resistant to sucking pests with a grade score of 1 and boll weight of 3.4 g. *G. hirsutum* culture CNH-2015 was tested under HDPS trial and was sponsored for testing in AICCIP trial during 2015-16.

Population Improvement

Nagpur

The GMS based random mating (RM) population of *G. arboreum* and *G. hirsutum* was grown on large plots. All sterile/fertile plants in both the population were tagged at flowering and allowed to open pollinate in the composite population. The out-crossed bolls from each of the sterile plant were harvested separately and will be raised as plant to

row progenies in the subsequent crop season. More than 110 single plants were selected from diploid composite GMS RM population and 230 from *G. hirsutum* GMS RM population based on seed cotton yield, boll number and of fibre quality *viz*. fibre length and strength.

Single plant selections (120 nos.) from random mating population and 750 re-selected plants from the segregating progenies were evaluated in plant to row progeny plots. A few of the progenies were uniform and exhibited good performance for seed cotton yield. Based on fibre quality and other attributes, 60 single plants of *G. arboreum* and 25 of *G. hirsutum* were identified and selected for evaluation in a replicated trial. From the segregating progenies, single plants were reselected for further evaluation as plant to row progenies.

Based on yield performance and fibre quality traits, 79 *G. arboreum* and 198 *G. hirsutum* cultures identified in 2013-14, were evaluated in replicated trial during the crop season 2014-15. Seed cotton yield ranged from 362 kg/ha to 1729 kg/ha in *G. arboreum* cultures while in *G. hirsutum* it ranged from 216 kg/ha to 1928 kg/ha. In all, four trials of *G. arboreum* and 9 of *G. hirsutum* were conducted in 2 replications of 4 row plots following spacing of 60 x 45 cm and 60 x 60 cm, respectively. Based on seed cotton yield, 26 cultures of *G. arboreum* and 68 of *G. hirsutum* were retained for second year replicated trial. Five cultures were identified for promotion in AICCIP national trials. Seed multiplication of the cultures *viz*. CNA 1013, CNA 1016 and 1021 of *G. arboreum*, CNH 1110, CNH 1111, CNH 1118, CNH 1119, CNH 1120 and CNH 1121 of *G. hirsutum* were also done.

Compact plants with big bolls

Sirsa

In GMS based random mating population, the individual plants in the population were monitored and tagged for sterility/fertility at anthesis repeatedly at weekly intervals. All the out-crossed bolls from the sterile plants were bulk harvested and ginned to constitute the next cycle of GMS based random mating population. From the fertile plants, 117 single plants showed tolerance to CLCuV, were selected for evaluation. Seed cotton yield of individual plants ranged from 15 to 190 g.

Breeding for Biotic Stress Tolerance

Nagpur

Jassids

Breeding programme was initiated to develop *G. hirsutum* varieties with improved yield, quality and tolerance to jassid. CNH 2-1 recorded seed cotton yield of 1725 kg/ha followed by CNH 07-16 (1594 kg/ha) and CNH 09-13 (1366 kg/ha) while quality check Suraj recorded seed cotton yield of 864 kg/ha. CNH 2-1 had recorded better fibre properties with bundle strength of 23.4 g/tex and staple length of 28.6 mm.

Eighty-five progenies comprising F_5 and F_6 generations were multiplied for testing in replicated trials. Fifty-one cultures were grown for seed multiplication and further evaluation for performance in replicated trials. From interspecific derivatives, 11 F_6 progenies were selected based on tolerance to jassid and yield potential.

F_1 crosses of high strength germplasm (IC 357608, IC 356751, IC 359292, GISV 267) and cultures (CCH 4474, CCH 7122, CCH LS 2) with Suraj and jassid tolerant variety NH 615 were evaluated for fibre properties.

Three cultures were tested in various AICCIP trials during the year 2014-15. Culture CNH 7008 has

been promoted from initial evaluation trial (IET) of 2013-14 to Br 03 (b) - Preliminary varietal trial (PVT). Culture CNH 7022-4 is being tested in IET of Br 02 (b) and CNH 2007-10 in high density planting system trial Br 06 (b). Early maturing five cultures (145-160 days) CNH 09-7, CNH 09-9 and CNH 2007-16 promoted to AICCIP trials Br 02(b) to be conducted during 2014-15.

CLCuD

Sirsa

Evaluation of advance CLCuD tolerant cultures : Fifteen *G. hirsutum* cultures were evaluated against the check variety RS 2013, LH 2076 and susceptible check HS-6 in RBD with three replications. CSH 2932 recorded minimum 10.5 PDI whereas HS-6, RS-2013 and LH 2076 recorded 40.2, 55.4 and 36.0 PDI, respectively. The highest seed cotton yield was recorded in CSH 2811 (1913 kg/ha) followed by CSH 2836 (1872 kg/ha) as against the check variety LH 2076 (1615 kg/ha). Maximum ginning outturn of 36.0 per cent was recorded in the variety CSH 2924 as compared to local check varieties RS 2013 (34.9%) and LH 2076 (32.7%). The culture CSH 2837 recorded the highest 2.5 % span length of 26.6 mm whereas highest bundle strength of 21.6 g/tex was recorded in CSH 2837. Most of the *G. hirsutum* cultures recorded less than 21 PDI for CLCuV incidence.

Selection of CLCuD tolerant single plants from segregating populations : To develop the segregation populations of *G. hirsutum*, 16 crosses were attempted among CLCuV tolerant germplasm lines in a Line x Tester fashion during 2012-13. Sixteen F_2 populations were grown to select the single plant progenies having high yield potential and tolerant CLCuD. In all, 91 single plants were evaluated in progeny row trials. Some of the single plants recorded more than 100 g yield per plant and were tolerant to CLCuD.

Selection of CLCuD tolerant single plants from progeny to row trials : From the 3rd cycle of random mating 102 single plants were selected and grown in progeny to row trials with 4 rows each. Based on CLCuV tolerance 135 single plants were selected for further evaluation for seed cotton yield and other characters of economic importance.

Evaluation of Introgressed lines against CLCuV resistance: Out of the164 introgressed lines received from CICR, Nagpur seven introgressed lines showed some tolerance to CLCuV (less than 30% PDI).

Abiotic stress

Nagpur

Drought

Seven single and four double crosses were evaluated in a replicated trial. The seed cotton yield ranged from 16.4 to 94.2 g/plant, boll weight 1.7 to 3.5 g, fibre length 24.5 to 31.0 mm, uniformity ratio 45.8 to 54.1%, fibre strength 17.8 to 22.8 g/tex, micronaire values of 2.8 to 4.6 and elongation 4.6 to 5.3%. Cross 28I x Moco recorded the highest seed cotton yield per plant (94.2 g) followed by 28I x HSD (88.7 g), PH 93 x Rajat (79.6 g), PKV 081 x Suraj (59.0 g) and NH 615 x Rex (58.1 g) respectively. 28I x HSD recorded fibre strength of 22.82 g/tex, fibre length of 27.15 mm and strength to length ratio of 0.84. The other single cross PKV 081 x Suraj involving high strength parental line recorded fibre strength of 22.5 g/tex and fibre length of 31.0 mm. In a cross LRA 5166 x N 170, where N 170 is a compact plant type. The F_1 in the second year of testing also showed compactness with bolls very close to the main stem. Among the double cross hybrids, cross (LRA 5166 x N 170) x (PKV 081 x Suraj) and (CCH 510-4 x Moco) x (NH 615 x Rex) recorded seed cotton yield of 50 g/plant.

In F_2 generation, the seed cotton yield ranged from 890 to 2378 kg/ha. The highest seed cotton yield was recorded in cross PKV 081 x CCH 510-4 (2378 kg/ha) with boll weight which ranged from 1.56 to 3.98 g.

In eight drought tolerant lines, fibre length ranged from 22.4 to 30.7 mm, uniformity ratio from 43 to 54%, micronaire from 2.8 to 4.1, fibre strength from 17.6 to 23.5 g/tex, elongation from 4.5 to 6.6% and short fibre content from 17.2 to 22.8%. Three top ranking cultures (DTS 155, DTS 62 and DTS 104) with more than 50 per cent yield increase over the check were identified.

Waterlogging

Nagpur

One hundred and fifty accessions selected during 2012-13 & 2013-14 were screened against waterlogging in pots to further select the most tolerant lines. Among the 36 tolerant lines selected, lenticels were prominent in some tolerant accessions. Based on lenticel formation, 23 accessions (IC 359979, SA 1287, IC 359245, IC 359206, IC 358177, IC 357930, IC 357477, IC 357235, IC 356701, AKH-07-R, IC 359943, IC 359941, IC 359881, IC 359868, IC 359854, IC 359590, IC 359306, IC 359838, IC 359726, 133, 139, 135 and132) were classified as water logging tolerant lines.

Water logging

Waterlogging tolerant accession IC 359979 with lenticels

Waterlogging susceptible accession IC – 359380

G. barbadense Improvement

Coimbatore

Evaluation of Suvin Multiple Cross progenies

Field trials were conducted with 15 (BC_1F_6) genetically advanced Suvin multiple crossed progenies at 60 x 45 cm spacing. Superior single plants with high yield and desirable fibre parameters were identified for further evaluation from the crosses (SN x ICB 75)-1-5-6, (SN x ICB 122) 3-5-6 and (SN x ICB 179)- 3-8-9.

Evaluation of intermated population of Suvin

Five intermated population of Suvin were raised along with the existing Suvin as control for increased yield, ginning outturn and reducing the crop duration. The F_1's of the crosses were raised during the season. The cross SS-2 recorded significantly higher yield (1314 kg/ha) than Suvin. Crosses SS-1(1147 kg/ha), SS-4 (1161) and SS-5 (1005 kg/ha) were on par with each other and had higher yield than Suvin (767 kg/ha). It was observed that except SS-4, all the four crosses were having high 2.5% span length ranging from 37.9-39.4 mm. For strength SS-1 recorded 31.2 g/tex followed by SS-3 (30.5 g/tex) and SS-4 (29.2). Maximum micronaire of 4.1 µg/inch was recorded in SS-2 followed by SS-3 (3.7 µg/inch) while in Suvin it was only 3.3 µg/inch. Cross SS-5 exhibited the highest elongation percentage of 6.7 which is close to control Suvin (6.6). The cross SS-2 was identified for high seed cotton yield with high length and other fibre properties.

Evaluation of Random Mating Populations

From the fourth cycle of random mating populations, 90 single plant selections were made and 28 lines were evaluated for performance during the crop season. RMS-33 (92.7 g) and RMS-49 (92.6 g) recorded high yield and were highly significant than Suvin (38.2 g) followed by the genotypes RMS-12 (87.6 g) and RMS-57 (82 g).

3.4: Genetic Diversity through Introgression

Evaluation of introgressed derivatives

Four hundred and seventy introgressed derivatives were evaluated at Nagpur for fibre and economic traits and those with unique traits were identified. The yield levels were invariably higher in introgressed *arboreum* cultures as compared to that in *hirsutum* cultures (Table 3.4.1 a & b).

Table 3.4.1a : Identified *G. hirsutum* based cultures

S. No	Cultures identified	Seed cotton yield (kg/ha)	25% SL (mm)	Bundle strength (g/tex)	Micronaire (µg/in)	UR %
1.	CNH- Intro14-1 (14005)	83	28.9	21.8	4.2	44
2.	CNH- Intro14-2 (14022)	49	29.2	19.6	2.7	45
3.	CNH- Intro14-3 (14023)	116	27.6	20.2	2.8	45
4.	CNH- Intro14-4 (14007)	524	25.9	19.8	4.2	47
5.	CNH- Intro14-4 (14032)	44	26.7	18.5	3.0	43

Table 3.4.1b: Identified *G. arboreum* based cultures

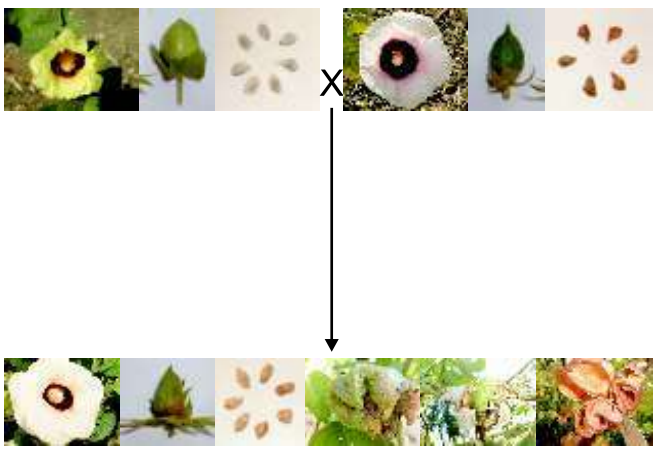
S. No	Cultures identified	Seed cotton yield (kg/ha)	25% SL (mm)	Bundle strength (g/tex)	Micronaire (µg/in)	UR %
1.	CNA-Intro14-1(14336)	908	26.6	19.8	5.5	50
2.	CNA-Intro14-2(14332)	914	22.5	20.1	4.2	51
3.	CNA-Intro14-3(14333)	1074	23.6	21.3	5.4	49
4.	CNA-Intro14-4(14334)	836	24.3	19.8	5.2	50
5.	CNA-Intro14-5(14338)	1540	25.5	22.5	4.0	51

G. herbaceum and *G. anomalum* cross

The F_1 of *G. herbaceum* and *G. anomalum* cross showed only 43% pollen fertility. More than 50% of the bolls were deformed in shape and shed prematurely. However, high fibre strength upto 36.7 g/tex was recorded. This F_1 plant has been conserved as a perennial in the wild species garden alongwith F_2 population of 58 plants and 40 selfed seeds were collected during 2014-15.

Out of the 11 fibre strength specific SSR primers which were screened during 2013-14, two of them (BNL 3644 and BNL 1317) were highly polymorphic for a set of 58 F_2 plants of *G. herbaceum* and *G. anomalum* (Fig. 3.4.1a-b).

Molecular characterization of introgressed derivatives



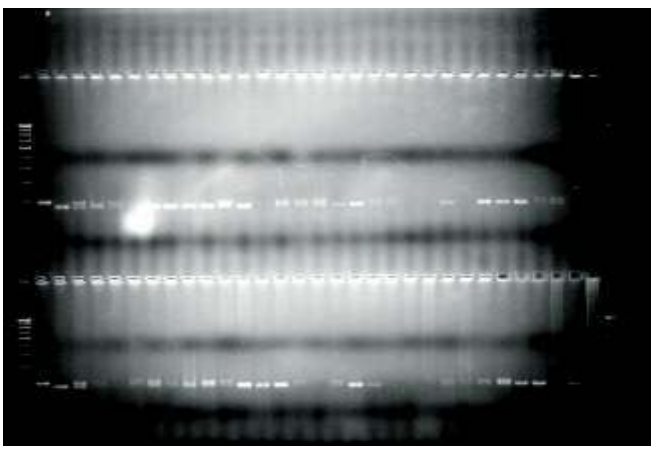


Fig. 3.4.1 a : Morphological observations in parents, F_1 and F_2 of *G. herbaceum* and *G. anomalum* cross ; b: Genotyping of F_2 mapping population with SSR marker BNL 1317

Naturally Coloured Cotton

Nagpur

Sixteen naturally coloured cotton introgressed genotypes (*G. hirsutum* and *G. arboreum*) were evaluated and used for mass scale seed production for evaluation in farmers field. Seeds of ten coloured cotton genotypes supplied by Cotton Research Station, Lam, Guntur were also multiplied.

Dark brown linted MSH-53 (Vaidehi-95), planted in high density at a spacing of 60 x 10 cm yielded 3055 kg/ha.

MSH 53 planted in High Density Planting System

Yarn and cloth made from coloured cotton

From the segregating population, brown colour linted progenies were identified in the cross MCU 13 x VNWH-1-4-1-2. In total, 44 single plants were selected which showed 4 different shades of colour as cream, light brown, brown and dark brown visually. Other characteristics of these progenies are furnished below.

Colour	Cream	Light Brown	Brown	Dark Brown
Number of selected single plants	8	19	3	14
Seed cotton yield (g/plant)	8.4-70.7	7.1-51.8	15.0-40.2	4.9-36.5
Lint Index (g)	4.7-6.6	3.0-5.6	3.1-5.0	1.8-9.1
Seed Index (g)	9.3-11.7	8.2-12.0	8.4-10.5	8.5-19.5
Ginning Outturn (%)	29.5-39.8	22.7-38.2	23.8-37.3	14.0-32.1

Compact colour cotton genotype (MCU 13 X VNWH-1-4-1-2)

From the F_5 generation, single plants were selected which had boll weight (6 to 7 g), lint index (6.5 to 8.5 g) and ginning outturn (39.2 to 47.7%).

3.5: State Multi-location Varietal Trial

Development of Variety

Coimbatore

The proposal for notification of medium staple central cotton CCH 2623 for south zone under irrigated conditions has been submitted for

consideration of Central Sub-Committee on Crop Standards, Notification and Release of Varieties.

Testing of *Hirsutum* cultures in AICRP on cotton

Thirteen high yielding *G. hirsutum* cultures were sponsored for multi-location evaluation in All India Coordinated Research Projects during 2014-15 (Table 3.5.1). Of these, eight were tested in National trials and the remaining five were in advanced stage of testing in zonal trials (Table 3.5.2).

AICRP on Cotton trials

Table 3.5.1: List of entries sponsored for AICRP on cotton trials 2014-15 of CICR, Nagpur

Species	Culture Name	Trial No.
G. hirsutum	CNH 61, CNH 7022, CSH 1, CSH 2, CNH 5, CNH 1118	Br 02 (b)
G. arboreum	CNA 2009, CNA 449, CCA 1022, CCA2006	Br 22a/b
HDPS trials *G. hirsutum*	CNH 29I , CNH 2015, CNH 25 , CNH 1120 ,	Br 06 (a)
HDPS trials *G. hirsutum*	CNH2007-10 , CNH 1121 CNH 1119, CNH 29I	Br06 (b)

Table 3.5.2: Entries promoted/retained for 2014-15

Sl.No.	Culture Name	Zone	Trial No.
1	CNH 7008	Central Zone	Br 03 (b)
2	CSH 1110	South Zone	Br 03 (b)
3	CNA1016	Central Zone	Br 24 (b)
4	CNA1016	South Zone	Br 24 (b)
5	CNH 28I	South Zone	Br 06(b)
6	CNH 1111	South Zone	Br 06(b)

Multilocation Varietal Trial

A State Multilocation Varietal Trial (SMVT) consisting of 16 cultures of *G. arboreum* and 3 control varieties of *G. arboreum* and 16 cultures of *G. hirsutum* and 4 control varieties of *G. hirsutum* was conducted with normal recommended package of practices at CICR, Nagpur. The crop was affected due to drought following the sudden recession of monsoon after mid September 2014.

In *G. arboreum*, the range for seed cotton yield was 472 to 1284 kg/ha. Maximum seed cotton yield (1284 kg/ha) was obtained with JLA-794 followed by AKA 2004-29 (1200 kg/ha) and AKA-2009-6 (1184 kg/ha). The control variety PA-08 recorded seed cotton yield of 940 kg/ha. Compared to the control, only JLA 794 produced significantly higher yield.

In *G. hirsutum*, 16 cultures were compared with four control varieties. Seed cotton yield ranged from 734 to 1198 kg/ha. Three cultures namely; AKH-09-5 (1198 kg/ha), CNH-25 (1073 kg/ha) and CNH 1110 (1070 kg/ha) recorded numerically higher yield than all control varieties. The seed cotton yield of control variety NH 615 was 923 kg/ha.

3.6: Molecular Breeding

A set of recombinant inbred lines (RILs) were developed from a cross between EL 958 and UPA 57-17 following single seed descent method from F_2 individual plants. At the end of F_8 generation, 273 progenies of RILs were obtained; most of them were uniform and are being used for genetic mapping.

During 2014-15, 857 SSR markers were screened for parental polymorphism and, 157 were found to be polymorphic/ informative. So far, 4417 SSR markers were screened for parental polymorphism in *G. hirsutum* and out of that, 702 informative SSR

markers were identified. Genotyping of 188 RILs using 162 SSR markers was completed.

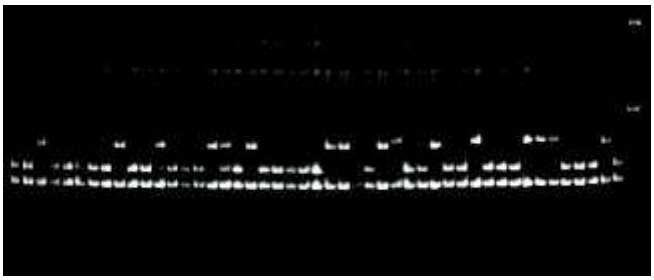


Fig. 3.6.1: Genotyping of RILs with SSR marker Gh0132 in upland cotton

Genotyping of 172 RIL progenies with 2979 SNP markers using 50K SNP chip was done by NBRI under collaborative programme. The same sets of RILs were subjected to SNP genotyping using 70K SNP chip of Illumina through outsourcing. Results indicated that 3589 SNPs are polymorphic with the population.

DNA Fingerprinting

A set of 60 SSR markers were obtained which were polymorphic among 48 public sector released cotton varieties including those of *G. hirsutum* as well as *G. barbadense*. The polymorphic information content of selected 10 best markers ranged from 0.3 to 0.5. These markers were effective in distinguishing each of the 48 tetraploid cotton varieties, stability of which needs to be tested in the next generation selfed progenies. Among the 50 SSR markers studied in 30 cotton varieties (Fig.3.6.2) including those of *G. arboreum* as well as *G. barbadense*, 12 were polymorphic and capable of distinguishing all the 30 genotypes.

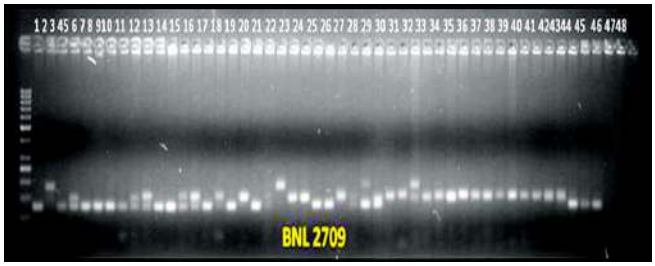
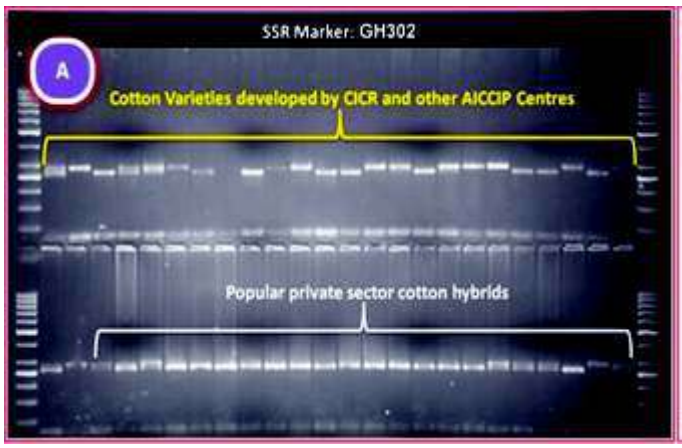
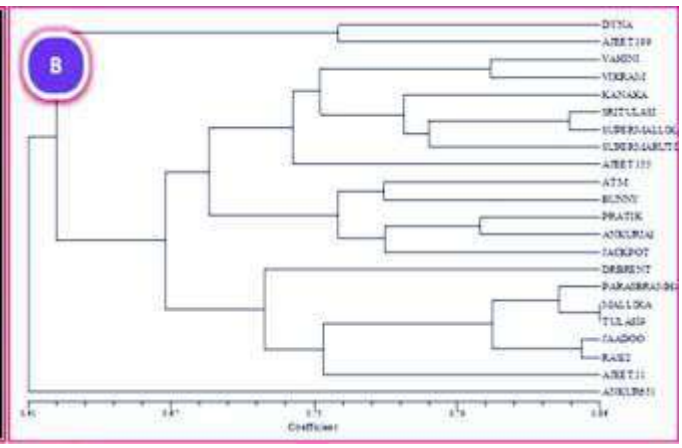


Fig.3.6.2: Fingerprinting of *desi* cotton varieties using SSR markers

Twelve varieties of CICR (Anjali, LRA 5166, MCU 5VT, Pratima, Sujata, Sumangala, Supriya, Surabhi, Suraj, Suvin, CNHO 12 and Arogya), 14 popular cotton varieties (AKH 8828, Khandwa 2, Khandwa 3, MCU 5, PKV Rajat, RS 2013, RS 810, Sahana, G. Ageti, Narsimha, DHY 286, KC 3, Kanchana and PKV 081) along with 22 (Dyna, Ajeet 199, Ankur 651, Vahini, Vikram, Kanaka, AJEET 155, SRI Tulasi, Super Maruti, Super Mallika, ATM, Pratik, Ankur Jai, Jackpot, Bunny, DR. Brent, Paras Bramha, Mallika, Jaadoo, Tulasi 9, Ajeet 11 and Rasi 2) private sector cotton hybrids were profiled for DNA polymorphism using identified 64 polymorphic markers. Utilizing the allelic profiles generated by these distinctly polymorphic markers (Fig. 1A), robust DNA fingerprint was developed which will assist in unambiguous identification of cultivar, its registration and protection under IPR regime. Higher genetic diversity was observed among cotton varieties (47%) as compared to private sector hybrids (32%). SSR markers effectively distinguished varieties (capturing both inter and intra species variation) and hybrids compared to DUS characters (Fig. 3.6.3 A -D).





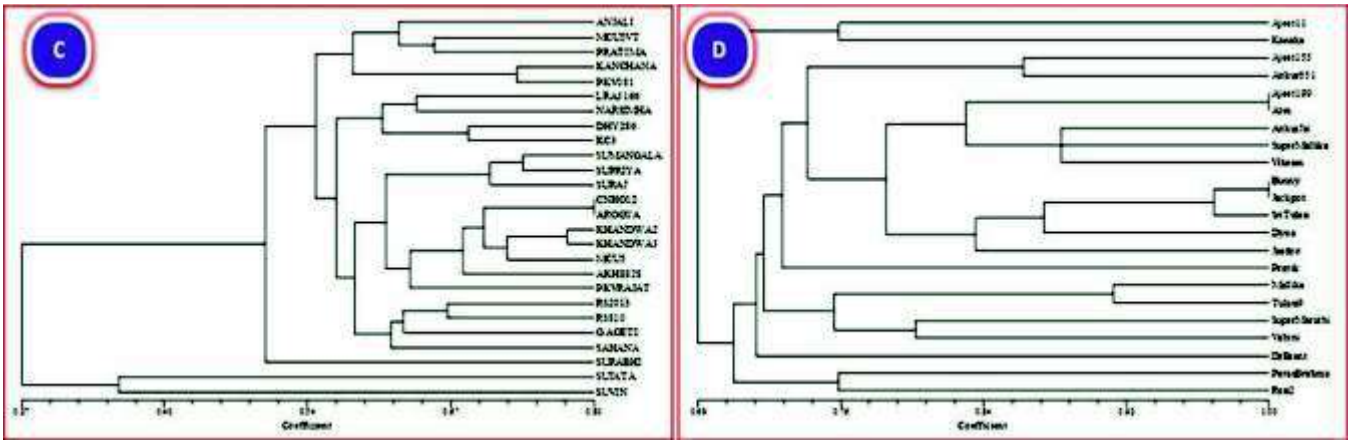


Fig. 3.6.3A - D : Molecular profiling (A) and SSR marker based cluster analysis of private Bt hybrids (B) and CICR varieties (C); DUS trait based cluster analysis of private Bt hybrids (D).

Replicated trial of RILs: During 2014-15, 248 RILs of *G. hirsutum* were grown in 2 row plots in two replications for fibre quality evaluation following incomplete block design. Rajat was the common control variety after every 30 progenies. Observations for boll number, seed cotton yield and GOT was recorded in each RIL progenies.

Phenotyping of RILs : The harvested seed cotton of each RIL progeny is being ginned. The bulk lint of RIL progenies were subjected to fibre quality evaluation using HVI Uster at GTC, CIRCOT, Nagpur. Average seed cotton yield of RIL progenies was 667 kg/ha and is in the range of 186 to 1475 kg/ha.

Maintenance of RILs in diploid and tetraploid cotton: In *G. hirsutum,* 273 progenies were grown in 5 dibble rows for maintenance. Selfed bolls were obtained from each progeny for further maintenance. In *G. arboreum*, a set of 193 progenies were selfed and maintained by single seed descent method. Both the populations were used in genetic mapping.

Marker Assisted Breeding

Cotton Leaf Curl Disease

Sirsa

Screening of new germplasm under field conditions : A total of 3808 lines provided from CICR, Nagpur were sown in the field along with susceptible check variety HS 6 sown at every 10th line at CICR RS Sirsa. The 2128 germinated lines were screened against cotton leaf curl virus disease under field conditions. All the lines showed disease reaction and the PDI ranged between 12.5 to 100. Twenty one lines showed PDI less than 30. The lines with PDI in parenthesis are as follows : BMK-189 (12.50), AKG2/49 (16.67), LD-132 (16.67), N-2944 (16.67), NH-452 (16.67), NH-603 (16.67), NHBBR-2 (16.67), N-148N (18.18), GSH-8 (22.22), LFH-10 (22.22), NHBBR-31 (22.22), IC-356556 (25.00), IC-358353 (25.00), CPH-5728 (25.00), ORS-22 (25.00), NHBBR-5 (26.67), IC-356546 (27.78), IC-356893 (27.78), NAC-1 (27.78), EC-344253 (29.17) and IC-356745 (30.00).

Screening of selected germplasm in nursery : Sixty-one germplasm lines identified as tolerant in 2013-14 were sown in disease screening nursery. Recommended package of practices were followed except plant protection measures against sucking pests. Observations on the incidence and severity of cotton leaf curl virus disease were recorded. All the entries showed symptoms of CLCuD. However based on their disease rating, 6 lines (RS2733: 29.1, F 2276: 28.7, SCS 1061:19.4, RS 2711:27.3, MR 68:28.3 and GISV-251:25.8) showed tolerant reaction.

Confirmation of reaction of parental lines in screening nursery & poly house : Eight lines namely MR 786, Biyani-251, GCH-3, 893, LRA 5166, F 2164, CP 15/2 and RS 2013 and two susceptible varieties HS 6 and F 846 were tested in screening nursery and through artificial inoculation in poly-house for confirmation of their reaction against CLCuD. The PDI of these lines ranged

between12.5- 25.6 in poly house whereas it varied from 16.4 – 46.0 under screening nursery. The two susceptible varieties HS-6 and F 846 showed PDI of 56.7 and 46.2 in poly-house respectively while in screening nursery, it was 54.1 and 49.1, respectively.

Screening for CLCuD. a) Early crop stage under poly-house conditions, b) CLCV free plant, c) Diseased plant under poly-house

Development of F_2 Mapping Population for CLCuD : Six F_1 crosses were advanced to F_2 generation for developing mapping population for CLCuD. The parents (except RS 2013 and F 2164) and F_1 crosses *viz*. Biyani 251 x F-846, F 2164 x HS-6, RS 2013 x HS-6 and F2164 x F-846 had PDI less than 30 indicating CLCuD tolerance.

Fourteen new crosses were attempted for developing mapping population. Seven tolerant parental lines RS-2013, 893, Bhiyani-251, F-2164, GCH-3, MR 786 and LRA 5166 were crossed with two susceptible parents HS-6 and F 846.

Phenotyping of F_2 mapping population: The data on CLCuD reaction was observed on individual plants and the PDI was calculated taking all the plants into consideration. The maximum grade IV was observed only on single plant in the whole population. Majority of plants were in grade of I indicating less disease spread. In parent HS 6, there was 100% disease but the PDI was 28.29 indicating that most of the plants were in Grade I and Grade II.

Coimbatore

The parental lines of CLCuD resistant varieties *viz*., MR 786, GCH 3, F 2164, Bhiyani 251, and GCH 3 were sown in the field and crosses will be affected among these parental lines in diallel mating design. The CLCuD susceptible BG II hybrid RCH 134 BG II and resistant hybrids *viz*., entries 27, 41 and 46 have been sown in the field for effecting crosses.

Bacterial Leaf Blight (BLB)

Nagpur

An elite variety Suraj was used as female parent and 17 F_1 crosses were attempted in 2013-14. F_1 combinations were grown in the field and screened for BLB. One month old plants were sprayed with *Xam* culture (pin pricked plant) and disease incidence was recorded after 7 and 15 days. Based on disease symptoms/reaction F_1 plants were categorized as resistant or susceptible. Molecular screening was also done using an SSR marker CIR 246 for disease resistance. The F_1 plants carrying CIR 246 desired amplicon were selected for crossing with variety Suraj, as a recurrent parent (Table 3.6.1).

On the basis of polymorphic primer screening, individual plants showing resistance to BLB and CIR 246 (146 bp + 156 bp) marker were selected from three F_1 crosses for obtaining BC_1F_1 (Fig. 3.6.4).

Table 3.6.1: F_1 Combination with Suraj (*G. hirsutum*) as female parent

S.No.	F_1 population	S.No.	F_1 population
1	Suraj x CSH 3047	10	Suraj x RKR 4145
2	Suraj x GTHH 032	11	Suraj x IC356719
3	Suraj x CSH 3313	12	Suraj x IC 356901
4	Suraj x IC 356798	13	Suraj x IC359098
5	Suraj x IC 356816	14	Suraj x IC357695
6	Suraj x IC356945	15	Suraj x IC357008
7	Suraj x IC356976	16	Suraj x TXORS80
8	Suraj x IC357392	17	Suraj x EC152280
9	Suraj x IC 358481		

Positive F_1 plants were tagged after molecular screening using marker CIR 246 and backcrossed with Suraj.

Coimbatore

The BC_1F_1 progenies of the crosses Suraj x CSH 3313, Surabhi x SIMA, Surabhi x RKR, MCU 5 VT x SIMA, MCU 5VT X RKR were raised and back crosses were effected with the corresponding recurrent parents. The BC_2F_1 progenies *viz*., Suraj x GTHH 032, Suraj x CSH 3047 and Suraj x CSH 3313 were sown in the field for effecting back crosses with recurrent parent during Summer 2015.

Nematode resistance

Nagpur

Boll to row progeny of F_1 cross each between nematode resistant parents (American Nectariless, G.Cot 10 and Bikaneri Narma) and elite parents (Suraj, Surabhi and NH 615) were raised. F_2 seeds (G.Cot 10, American Nectariless and Bikaneri Narma with Suraj as elite parent) were sent to Regional Station, Coimbatore for phenotyping with respect to reniform and root knot nematode resistance. Markers CIR 316, BNL 3661, BNL 3279, NAU 2152 on chromosome 11 and 14 were found to be polymorphic. Nematode reproduction would be taken as criterion to evaluate reaction of these F_2 populations to nematodes alongwith genotypic characterization.

Coimbatore

The F_1 hybrids of the cross combinations Suraj x BN, Suraj x AN and Suraj x G Cot 10 were sown and back crosses were effected with the recurrent parent.

3.7 : Development of Transgenic Cotton

Cloning of VIRD2 protein in bacterial expression vector: To generate *in-vitro* nano complex of VirD2-ssTDNA-VirE2- with cell penetrating peptide (Tat2) for transgene gene delivery into cotton, VirD2 from *Agrobacterium tumefaciens* LBA4404 was successfully cloned into TA cloning vector. It was further subcloned into a bacterial expression vector (pET28c) using EcoRI and XhoI restriction sites and confirmed through restriction digestion (Fig. 3.7.1 & 3.7.2).

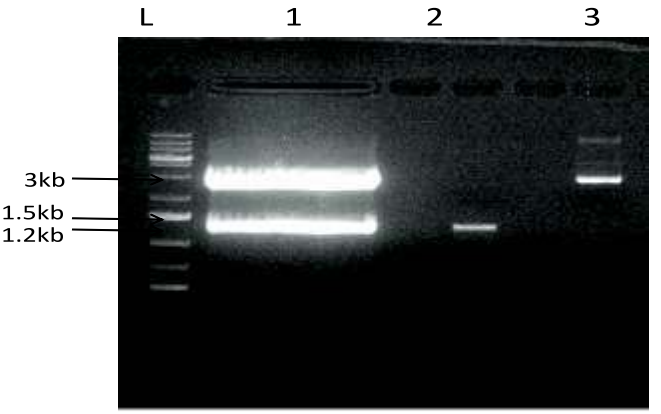


Fig. 3.7.1 : Restriction confirmation of virD2 Clone in TA cloning vector with EcoRI and XhoI

L: 1Kb Molecular ladder ; Lane 1: Restriction Confirmation of virD2 plasmid with EcoRI and XhoI.

Lane 2: virD2 gene product; Lane 3 : pGEMT easy vector with virD2 insert.

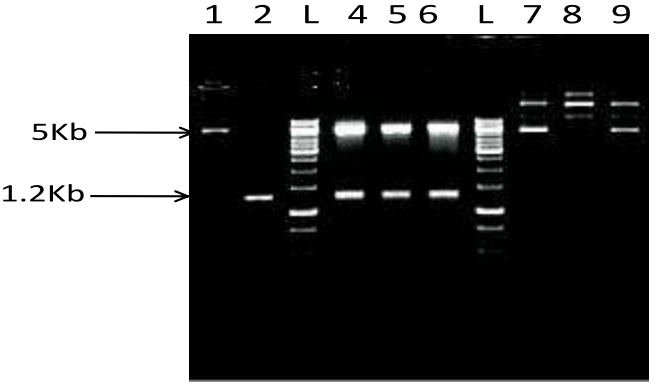


Fig. 3.7.2 : Restriction confirmation VirD2 Clone in pET28c expression vector with EcoRI and XhoI

L: 1Kb Molecular ladder; Lane 1: Linearized pET28c(+) plasmid, Lane 2: virD2 gene fragment,

Lane 4-6 : Restriction digested pET28c(+)VirD2 with EcoRI and XhoI

Lane 7-9: Uncut pET28c(+)virD2 plasmids

Transformation of gene construct - *CICRcry2Ab1Ac:chitinase*

***In-planta* transformation:** Two methods of *in-planta* transformation were adopted to incorporate the gene into var. Suraj (*G. hirsutum*).

1. In the first method half of the portion of style was cut after pollination and *agrobacterium* suspension was injected in to the style of 422 flowers.
2. In the second method, a drop of *Agrobacterium* suspension was added over the stigma gently of 215 flowers. Flowers were covered with paper bag to avoid contamination. Flowers were covered with paper bag after injection of *agrobacterium* suspension.

Seed setting in *in-planta* transformation in var. Suraj (*G. hirsutum*)

Method	Flowers treated	Bolls harvested	Seeds Obtained
1	422	11	230
2	215	06	072

Shoot tip transformation of *CICRcry2Ab1Ac : chitinase gene*

In-vitro germinated seedlings were raised in the laboratory. Shoot tip explants containing meristem cells were isolated aseptically. The shoot tip were treated with *Agrobacterium* suspension for 0.5 h and subjected to co-cultivation and kanamycin selection.

In all 2274 seeds were inoculated, of which 1550 seeds germinated. Explants (1010) were treated with *agrobacterium* and 152 shoots were selected on kanamycin medium. In all, 36 plant-lets were elongated and grown under control condition.

Agrobacterium mediated transformation of CICR-*cry*2Ab1Ac gene construct and regeneration through Somatic embryo-genesis

CICR Bt-multi gene construct (CICR-*cry*2Ab1Ac) was subjected to transformation and regeneration through somatic embryogenesis using Coker as well as Suraj cultivar. Profuse callus was induced initially with Coker 310 and Suraj varieties using MS media with 0.1 mg/l 2, 4-D and 0.5 mg/l kinetin and transformed with multi gene construct by *Agrobacterium* transformation. Putative transformants were induced without antibiotic MS media with B5 vitamins and Maltose 2%. Fortnightly the transformed calli were sub-cultured and somatic embryo formation was observed after 4-5 weeks. Regenerated plants were transferred to H1 medium (Stewart and Hsu) with 1% sucrose. Three year independent putative transformants were regenerated and are under root induction and establishment process.

Transgene delivery using cell penetrating peptide (CPP) through pollen tube pathway

Linearised RNAi gene cassette for gossypol biosynthesis gene, coding for delta *cadinene synthase* driven under Beta Globulin seed specific promoter(BGP) with Tat2 cell penetrating peptide was injected into 40 flowers through pollen tube pathway and six bolls that survived till maturity were harvested.

Validation of fibre strength genes

Gene expression analysis was done with selected genes (*GhcesA1, GhcesA2, GhcesA7, GhcesA8, Ghcobl4, Ghfla3 and GhMT1*) through qPCR using RILs mapping population to establish correlation with high fibre strength. Among them *GhcesA1, GhcesA2, Ghfla3 and Ghcobl4* showed strong association and higher gene expression during

secondary wall synthesis especially at 25 and 30 days post anthesis. Thus all these genes were cloned and characterized for validation through transgenic approach. The promoter region for *GhcesA1* was also cloned and characterized (2.8kb). The other genes of cellulose synthase such as *GhcesA7* and *GhcesA8* were cloned and sequenced. The nucleotide sequence was submitted to NCBI GenBank (GhcesA7: Accession No. KJ777132). Similarly sucrose synthase gene (GhSusA1) is one of only two enzymes which can decompose sucrose into hexoses by catalysing a reversible reaction but preferentially converting sucrose into fructose and UDP-glucose in-planta, was also cloned, sequenced and submitted to GenBank (GhSusA1: KJ777133).

The candidate genes such as GhcesA1, GhcesA2, Ghfla3 and vectors were digested with KpnI and EcoRI restriction enzyme. The fragments were eluted from agarose gel and ligated into pCAMBIA vector with NOS terminator. The vector was transformed into DH5 alpha. The transformants were confirmed by screening with colony PCR, restriction digestion and PCR amplification.

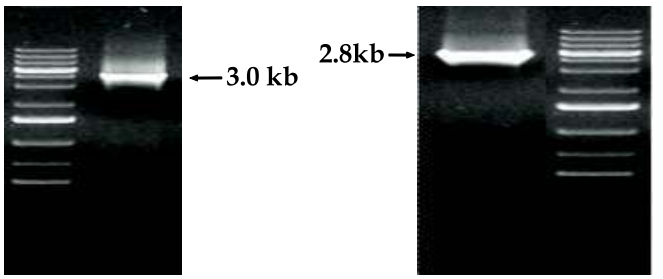


Fig.3.7.3 a. Amplicon of *GhcesA1* gene (3.0kb). b. Amplicon of *GhcesA1* promoter region (2.8kb)

Apart from cellulose synthase, genes encoding other protein genes such as *Fascillin-like-Arabinogalactan-3 (Ghfla3), Ghfla-11 and Ghfla-12* were studied. Among them Ghfla-3 showed higher expression during secondary cell wall synthesis. Hence the *Ghfla-3* gene was cloned for validation. The other fla genes such as *Ghfla-11* and *Ghfla-12* were sequenced and nucleotide sequences were submitted to NCBI GenBank (*Ghfla11: KM457622* and *Ghfla12: KM457623*). The clones were reconfirmed with restriction digestion analysis.

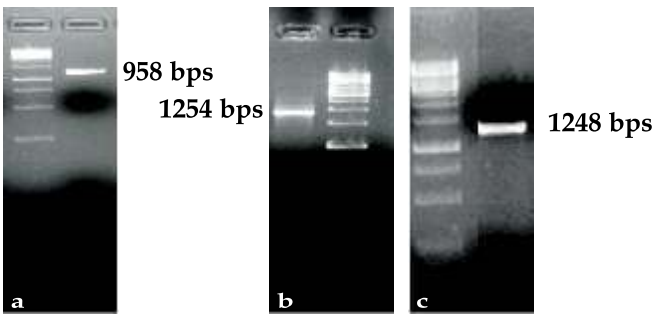


Fig. 3.7.4 a. *Ghfla3* amplicon (958bps) b. *Ghfla11* amplicon (1254bps) c. *Ghfla12* amplicon (1248bps)

3.8 Seed Production and Technology

Nucleus seed production of Anjali and Suraj was undertaken. Breeder seed production was undertaken in respect of Suraj, Anjali, Sumangala and MCU-5VT.

A total of 484.52 q seeds including 194.52 q of cotton seeds of different categories was produced (Table 3.8.1) and resource of around Rs 15-16 lakhs was generated through the sale of these seeds or its by-products.

Table 3.8.1 : Seedproduction achieved during 2014-15

Crop	Stage	Production (Q)
Cotton (8 varieties + parents of CICR -2)	Breeder Seed	4.65
Suraj	Foundation Seed	2.52
Suraj	Certified Seed	161.38
Suraj	Truthfully Labelled Seed	23.85
Barley cv. BH -393	Certified Seed	289.00
Cotton (48 varieties + germplasm lines)	Truthfully Labelled Seed	1.74
G. arboreum race *cernuum*	Truthfully Labelled Seed	0.378
Red Gram BSMR -736	Truthfully Labelled Seed	1.00
Total		**484.518**

Immortalization of cultivar germplasm through 'VARIETAL GARDEN'

Twenty-six *G. hirsutum* varieties (Anjali, Arogya, CNHO-12, Kanchana, LRA-5166, MCU-5, MCU 5VT, Pratima, Sumangala, Supriya, Surabhi, Suraj, PKV-081, AKH-8828, DHY-286, F-846, G. Ageti, HS-6, JK-4, KC-3, Khandwa 2, Khandwa 3, Narasimha, RS-2013, PKV Rajat and Surat Dwarf), two *G. barbadense* varieties (Sujata and Suvin) and four *G. arboreum* varieties (H-1226, HD-123, HD-324 and ABC-5) were established at **"Varietal Garden"** to conserve them in a perennial form and also assure the continuous supply of genetically pure seeds of cotton varieties for future cotton research.

Varietal Garden established at ICAR-CICR, Nagpur

Nagpur

Planting methods and soil/seed treatments to enhance seed production

Seed cotton yield of 1 month old transplanted crop was superior than the 20 day old transplanted and direct sown crop. Boll number and sympodial number were higher in the transplanted crop than the direct sown crop.

Fourteen different soil treatments were given while sowing imidacloprid treated seeds of Jai Bt in the direct sown as well as in transplanted (1 month old seedling) crop. Treatments included, FYM, vermicompost, cotton stalk compost, potassium silicate (Agrisil), potassium silicate (powder), *Bacillus* sp, *Pseudomonas flourescens*, *P. putida* sp, Tricocash, *Caedacea* sp., *Pantoea* sp., humus, *Trichoderma viride* along with control. There was no significant difference for seed cotton yield among the treatments. Single boll weight of the treatments varied from 2-3 g in direct sown crop whereas it was 2.5-3.5 g in transplanted crop. Among the treatments given in direct sown crop, cotton stalk compost gave the highest seed cotton yield (1532 kg/ha) followed by potassium silicate powder (1445 kg/ha) and *Pseudomonas flourescens* (1324 kg/ha). In the transplanted crop, soil treatment with *Pseudomonas flourescens* (1592 kg/ha), gave highest yield followed by *Pseudomonas putida* (1504 kg/ha) and *Bacillus* (1472 kg/ha).

In a study on variety Suraj sown under high density with 60 cm x 10 cm spacing, seed treatment with Thiram @ 2.5 g/kg seed gave the highest seed cotton yield (2193 kg/ha.) followed by Dentop (containing Thiomethoxam) (2150 kg/ha) and imidacloprid combined with Thiram respectively (2013 kg/ha).

In another field trial, seeds were treated with microbial cultures *Pseudomonas fluorescens, Pseudomonas putida,*, Microbial consortia, Tricho cash and untreated control. Among the treatments, *Pseudomonas fluorescens* gave significantly higher yield compared to other treatments.

Coimbatore

Assessment of seed vigour tests for relative storability and field performance

Assessment of seed vigour tests for relative storability and field performance was initiated to standardize the methods of estimating seed vigour in hybrid cotton 153. Seed lots with four vigour levels were evaluated initially and estimation of vigour was done at an alternate month of storage at recommended temperature (25°C) and at an elevated temperature of 35 ± 1°C. The mean data of seed germination, seedling root length, shoot length and dry matter of seedling were computed. The vigour index was computed and compared with seed germination taken at bimonthly intervals. The data on germination revealed that a significant improvement in germination was observed when tested at 35°C (79.9%) than at 25°C (72.3%) over four vigour levels and three intervals of test. Among the vigour levels while V1 (79.5%) and V2 (77.5%) at par with significance over V3 and V4 at 25°C. However, at 35°C V2 was significantly superior (87.7%) than the rest. The period of storage has significant influence on seed germination and a decline was observed with advancement of seed ageing. Across the temperature and interval of test V1 (80.2%) and V2 (82.6%) were on par but maintain its significant superiority over V3 (73.2%) and V4 (68.4%). The interaction of period of test with vigour levels and temperature of test and vigour levels were also significant. The mean data for root length, shoot length, dry matter of seedling and vigour index showed similar trend to that of germination.

Seed treatment for quality enhancement

An experiment conducted with RCH 2 BGII seeds to assess their responses for seed treatments such as priming with botanicals, nutrients, chemicals, growth regulators, bio inoculants and seed coating revealed that treatments of seed coating (15g/kg) with *Pseudomonas*, Turmeric (*Curcuma* sp), rhizome powder @ 20g/kg coating using polymer, polykote (5 ml polymer coating/kg), Molybdenum (sodium molybdate dehydrate) - Dry dressing (0.5 g/kg); seed soaking in Dasakavya (2.5%) KH_2PO_4 (450 ppm), $CaCl_2$ (2%), Panchakavya (10%), KCl (1%), *Prosopis* leaf extract (1.5%), neem leaf extract (1%), KNO_3 (0.5%), Zeatin (20 ppm), H_2O_2 (60 mM), $CuSO_4$ (0.2%), 6BAP (10 ppm); bio priming with *Pseudomonas* (2 g/kg) and pulsed magnetic treatment at 750nT 5h for 15 days significantly increased the germinability and seedling vigour.

Sirsa

Studies to improve the seed and boll setting efficiency in cotton

The effect of growth hormones, pollinator attractant and weather parameters were studied on boll and seed setting efficiency. The higher boll setting (93.7%) was observed with hand pollination. Boll setting in other treatments *viz.* 2%NPK (91.3%), CICR consortium (91.3%), Godrej double (90.7%), 2% DAP (90.2%) were observed significantly higher than control (87.2%). The seed setting efficiency (92.5%) was also significantly higher in hand pollination than other treatments which in turn was at par with respect to seed setting efficiency.

Among pollen attractants, the boll setting (93.0%) with mollases (10%), 92.0% with sugar solution (10%), 90.6% with rose extract (10%) were significantly higher than control (89.0%). The pollen attractants did not increase the seed setting efficiency.

The contribution of pollinators towards the boll setting % and seed setting % was studied using sterile as well as fertile plants of GMS-DS-5 and GMS-16-A with sufficient population of pollinator by keeping one box of honey bee colony in field. The data on boll and seed setting % was recorded at three interval of 15 day each. In sterile plants, the boll setting % was much lower i.e. 2.2 to 4.4% compared to 79.4- 88.3% in fertile plants of DS5 and 2.3-4.6% in sterile plants compared to 77.8-85.6% in fertile plants of GMS 16A. The seed setting percentage was also less in sterile plants i.e. 13.8-24.0 % in sterile plants and 79.5-81.4 % in fertile plants of DS 5 and 14.2-21.4 in sterile plants and 78.2-81.0% in fertile plants of GMS 16A.

The contribution of pollinator on boll and seed

setting efficiency was also estimated by planting the field at 500 m distance with assured availability of pollinator (one box of honey bee) and pollinator's attractant. Another field was purely under natural condition. The significant difference between these treatments were observed only in boll formation till 15th of September but the difference in seed setting efficiency was not significant. In another experiment, the contribution of pollinator was also estimated by keeping the pollinator in covered net in which significant difference was observed only in boll formation (76.1%) compared to open plots (74.5%).

To study the effect of prevailing environment on seed setting efficiency, minimum and maximum temperature, humidity, and rainfall was recorded during flowering and data was correlated with boll and seed setting percentage. Because of similar range of temperature, humidity and rainfall during first and second flowering stages, the boll formation percentage was 85 to 90% and seed setting was 74 to 89%.

DUS Testing

Five different trials were conducted under DUS characterization which included, 49 EDVs, 43 VCKs, 63 genotypes under first year testing and 30 under second year testing. The data on hypocotyls pigmentation, leaf and flower characters, boll and plant growth characters have been completed in three replications of all the above genotypes. Among the observation on EDVs, only thirteen were found to be EDVs with respect to their Initial Varieties and these were subjected to Bt testing by ELISA. Bt test results performed on seeds revealed clear segregation for Bt genes, *Cry 1Ac* and *Cry 2 Ab* in many of the BG II hybrids.

In addition to the regular phenotyping of genotypes as per DUS test guidelines, more traits were studied for suitability in variety characterization. These included variation among genotypes for leaf petiole length and peduncle length. The petiole length of fourth leaf from top on four plants was measured while peduncle length was determined from one boll each selected from upper, middle and lower canopies on three individual plants and mean calculated. A clear genotypic variation could be observed for both leaf petiole length as well as peduncle length with some genotypes showing high and others showing low values. The consistencies in values will be corroborated next year.

3.9: Nutrient Management

(i) Bio enriched compost effects on growth and yield

Bio-enriched compost from cotton plant residues was evaluated for its performance on growth and yield of cotton in a field experiment. Averaged over three years (2012-13, 2013-14, and 2014-15), the present INM practice (PINM), treatment (60:30:30 + 5T FYM) was found to yield significantly higher SCY followed by recommended NPK (90:45:45), and modified INM (60:30:30 + 5T cotton compost). The modified INM (MINM) treatment (Fig. 3.9.1) along with seed treatment with microbial consortia was similar to the RDF without microbial seed treatment. Treating cotton seeds with microbial consortia showed significant yield advantage as compared to the corresponding treatments without microbial seed treatment (Fig. 3.9.1). Boll weight was not affected by any treatment. This study shows that cotton compost can be used as a source of organic manure in the integrated nutrient management for cotton.

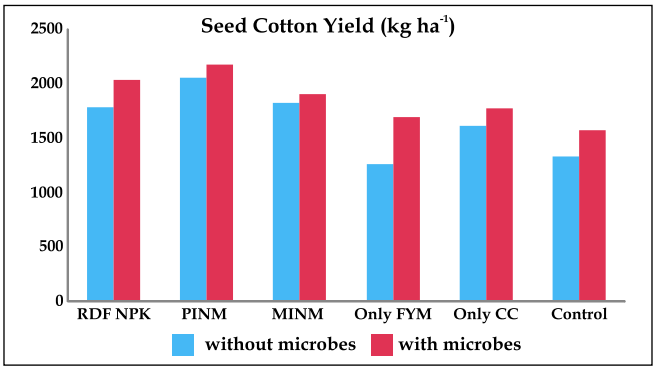


Fig. 3.9.1: Effect of cotton stalk compost on seed cotton yield

(ii) Evaluation of Potassium Silicate formulations on cotton production and protection

The effects of Potassium Silicate formulations

(Agrisil or Potassium Silicate powder) on cotton yield, quality, pest and disease management were evaluated in field under natural and artificial conditions. Under artificial conditions, BLB suspension @ 2 x 10^{10} spores/ml was sprayed at 80 DAS. Suraj (un-treated) seeds were used as test material at a spacing of 45 x 15 cm.

Based on the two year field study (2013-14 and 2014-15), it was found that there was no yield advantage with application of Potassium silicate formulations (Agrisil or Potassium silicate powder) either as seed treatment, soil application or foliar spray. Further, no effect of potassium silicate was observed on disease (20, 40, and 60 DAS) and sucking pests (aphids, whitefly, Jassid, Thrips) incidence. Potassium silicate powder @ 2000 ppm as seed treatment recorded significantly lesser aphid population i.e 1.58 aphids/3 leaves/plant compared to other treatments at 60 DAS.

(iii) Evaluation of nano nutrient formulations for cotton production

Among the commercially available nanofertilizers *viz*., Richfield, Agriklik, Nualgi and Nanomol were evaluated at Coimbatore. Cotton growth and yield was highest with foliar application of Nanomol followed by Nualgi. Unlike combined nutrient nanofertilizers, single micronutrient nanofertilizer *viz*., Nanobor was the best for increasing the cotton yield.

In another trial, application of nano iron oxide recorded more opened bolls, increased boll weight and higher seed cotton yield as compared to magnetite nanoparticles, normal iron oxide and iron sulphate fertilizers. Seed cotton yield was increased by 14% over control, 10% over normal iron oxide, 7.5% over iron sulphate and 6.17% over magnetic iron nanoparticles due to the foliar application of nano iron oxide. 0.5 g/lit of nano iron oxide increased the seed cotton yield which is followed by 1.0 g/lit and 1.5 g/lit of nano iron oxide. Similarly, 60 ppm of nano zinc oxide (50 nm) was much effective in increasing the seed cotton yield as compared to other nano zinc oxide nutrients. The efficacy of nanomagnesium oxide was on par with normal magnesium sulphate. Among the copper sources of nutrients, application of copper oxide nanofertilizers (40 nm) significantly increased the cotton yield as compared to control.

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

On a Vertisol under rainfed conditions at Nagpur, 12 genotypes were evaluated across 3 spacings (45x10, 60x10 and 60x30 cm). The effects of spacing, genotypes and spacing x genotypes interaction effects were significant for seed cotton yield, bursted bolls (per sqm) and boll weight. Across genotypes, yield at 45x10 cm and 60x10 cm were 28.4 and 22.6% higher than that at 60x30 cm (1534 kg/ha). Relative yield of genotypes at different spacings (taking yield at 60x30 cm spacing as 100) is provided in Fig 3.10.1. Top five high yielding genotypes under each spacing were:

45 x 10 cm: H-1098i, DSC-99, G-Cot 16, PKV-081, Kandya

60 x 10 cm: Kandya, H-1098i, CSH-3178, BS-279, NH-615

60 x 30 cm: NDLH-1938, H-1098i, Suraj, PKV-081, G-Cot 16

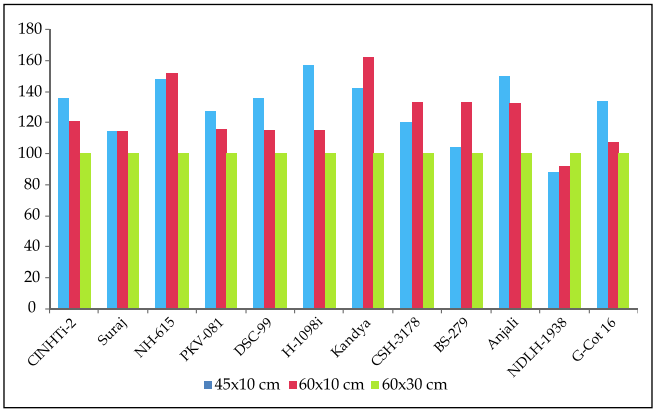


Fig. 3.10.1: Relative seed cotton yield (taking yield at the recommended 60 x 30 cm as 100) of 12 cotton genotypes at 45 x 10 cm, 60 x 10 cm spacing

Averaged over the spacings (45 x 10, 60 x 10 and 60 x 30 cm), CINHTi2 (16.4 PDI) and H 1098i (21.1 PDI) recorded lowest bacterial blight incidence, Anjali (10.4 PDI) and H 1098i (10.9 PDI) recorded

lowest *Myrothecium* leaf spot incidence and NDLH 1938 (11.3PDI) and NH 615 (12.0 PDI) recorded lowest *Alternaria* leaf spot incidence respectively.

Among the genotypes evaluated under HDPS, NH 615 had the lowest incidence of aphids (0.99/3 leaves/plant), CINHTi2 had the lowest incidence of whiteflies (0.8/3 leaves/plant) and both NH-615 (2.32/3 leaves/plant) and G.Cot-16 (2.46 nymphs/3 leaves/plant) had very low incidence of jassids. Row spacing did not differentially influence the square damage due to bollworms.

Among eighty eight new entries evaluated at 60x10 cm spacing, entries -SPS-9, SPS 27-1, SPS 7-1 and AR-27 (a germplasm line) were found superior to check (NH-615) for yield.

Foliar sprays of KNO_3 2 % twice at 14 days interval, 2 sprays of CICR- Nutrient consortia at 14 days interval, 2 sprays of Mepiquat chloride @ 25 g ai/ha and spray of 2% each of urea followed by DAP at 14 days interval were effective in increasing boll weight under HDPS.

In a year of early season drought, post emergence (PE) application of Propquizafop + Pyrithiobac 1.8 ml L^{-1} at 25 DAS, followed by Glyphosate 4 ml L^{-1} 60 DAS PE produced high yield and had high weed control index. It gave highest net returns and proved to be a good weed control option under HDPS.

Under irrigated conditions on sandy loams of north zone, on the basis of mean performance for three years, CSH-3158, CSH-3132, CSH-3178, RS 2525 selection and Bhiani 251 were found promising for HDPS (67.5 x 10 cm). Yield of different genotypes at 67.5 x 10 cm along with that

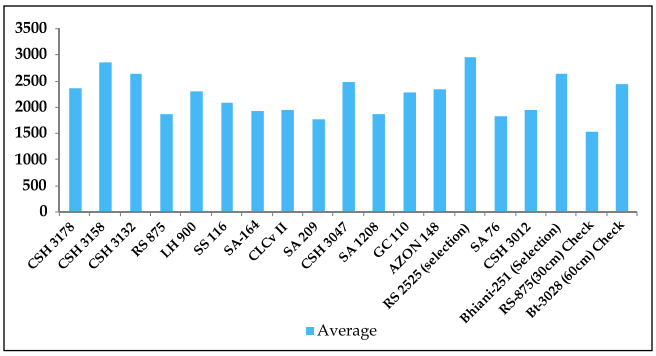


Fig. 3.10.2: Seed cotton yield (kg/ha) of semi-compact genotypes at 67.5x10 cm spacing along with checks Rs. 275 at 67.5x30 cm and Ankur 3028 BGII at 67.5x60 cm spacing.

of checks (RS 875 at 67.5 x 30 cm and Ankur 3028 BGII 67.5 x 60 cm) are provided in Fig 3.10.2.

Under winter irrigated conditions of Coimbatore, seed cotton yield of 3313 and 2804 kg/ha by Anjali and 3164 and 2992 kg/ha by Suraj were harvested respectively with irrigated and protective irrigated condition under HDPS. However, compared to Anjali, the variety Suraj under HDPS gave significantly higher net return under irrigated and protective irrigated condition. Under HDPS, the response to Mepiquat chloride application on yield was not significant in both the varieties.

Amongst different planters evaluated at Coimbatore, inclined plate planter was found to be the most efficient and cost effective.

At Coimbatore, under irrigated conditions with seven compact genotypes having super okra leaf and three check varieties - Suraj, Anjali and Supriya were evaluated at closer spacing of 30 cm x 15 cm. The super okra cultures showed high level of field tolerance to sucking pests and no insecticides were

Super okra leaf culture evaluation in station trial at Coimbatore

sprayed for their control. The highest seed cotton yield of 3492 kg/ha was recorded in Surabhi x M5Z2 4-2 Bk as against 3137 kg/ha recorded in the best check variety Suraj. Fibre quality data indicated the superiority of Surabhi x M5Z2 4-2 Bk for bundle strength recording 24.6 g/tex as compared to 23.9 g/tex in variety Suraj.

Twelve varieties of *G. arboreum* suitable for surgical cotton were evaluated on a Vertisol at Nagpur. CNA-375 was the top yielder followed by CNA-418, MDLABB and Phule Dhanwantary. Phule Dhanwantary was the most compact and accumulated the least dry matter and had the highest harvest Index. It was also amenable to planting at 30 cm row spacing.

Among the *G. arboreums* evaluated for surgical cotton purpose, CNA 2014-2, CNA 2014 -3, CNA 2014-4, CNA 2014-7 and CNA 2014-8 showed good absorbency characteristics and met the IP standard.

3.11: Weed management

(i) Evaluation of herbicides in cotton

Among the different concentrations of glyphosate tested on medium black soils of Nagpur on cotton (Var Suraj) under HDPS (60 x 10 cm spacing), 5 ml/l and 7.5 ml/l dose was effective in killing both the broad leaved and grassy weeds. With enhancers, combination of even a very low concentration of glyphosate (1ml/l) and 100 mM ammonium sulphate was effective in killing the weeds. Glyphosate activity was also increased by other enhancers such as 100 mM KH_2PO_4, 2% urea and 5% neem oil, however at a slower rate compared to ammonium sulphate.

Among the 48 different combinations of doses of glyphosate, Targa super (Quizalofop ethyl), Agil (Propaquizafop) and Hitweed (Pyrithiobac-sodium), combination of glyphosate 2.5 ml/l and 2.5 ml/l of Targa Super was found effective in killing both broad leaved and grassy weeds.

In order to reduce the cost incurred in weed management of cotton, cheaper herbicides were evaluated on black soils of Nagpur. Chlorimuron ethyl was evaluated (as Post- emergence application) in HDPS and BGII -hybrid cotton and it was found effective in killing most of the broad leaved weeds and some grassy weeds. The top application of Cyhalofop butyl, a soybean herbicide and Azimsulfuron a rice herbicide were tolerated by cotton and were effective in controlling grasses besides some broad leafed weeds. After standardizing their doses and stage of application, they can be introduced under herbicide rotation for effective and economical weed management. Bys pyribac Na, a rice herbicide and soybean herbicide Imzethapyr + Imzomax mixture cannot be tolerated by cotton since the cotton plants become stunted and failed to recover.

(ii) Allelopathy as an alternate weed management strategy in cotton

One of the major issues is timely weed control in rainfed cotton grown on Vertisols because the soils become sticky and wet after rains and are very hard when dry conditions prevail. As a result, the window for effective weed control becomes very narrow. A cover crop that has allelopathic effects to weeds is a possible solution for integration with mechanical methods. Field studies were conducted at Nagpur and Coimbatore to evaluate the efficacy of cover crops known to possess allelopathic effects.

At Nagpur, sunnhemp, bajra, sesame, sorghum and marigold had significantly reduced the weed dry matter accumulation. Total weed control was provided by newspaper mulch and polythene mulch. Aromatic cover crops such as fennel, fenugreek, caraway, coriander, bitter cumin were not as effective due to low biomass produced by these crops.

At Coimbatore, thorn-less mimosa, forage cowpea, coriander, fenugreek, sesbania and sunnhemp provided effective weed control. Moreover, the highest (2792 kg/ha) seed cotton yield was obtained with forage cowpea and it was on par with thorn less mimosa (2720 kg/ha), sesbania (2689 kg/ha), sunnhemp (2651 kg/ha), coriander (2598 kg/ha) and fenugreek (2592 kg/ha). Creepers (bitter gourd, ash gourd, and cucumber), horse gram and ajwain were found ineffective for

their weed control efficacy.

Based on the consistent performance of sunnhemp over three seasons at two locations, it can be explored as a technology for weed control. Being a legume sunnhemp also fixes N in the system.

3.12 : Soil Biology and Biochemistry

The uninoculated control with structured water yielded 3135 kg seed cotton/ha as compared to 2695 kg/ha under borewell irrigated water. Among the bio-inoculants, foliar spraying of PPFM @1 % (twice during flowering to boll development) along with seed treatment + soil treatment of azophosmet recorded significantly higher seed cotton yield of 3404 kg/ha under structured water and 3009 kg/ha under bore well water. The uninoculated control recorded significant reduction in seed cotton yield than combined application of seed treatment + soil application and foliar PPFM and was on par with either seed treatment and seed+soil application of azophosmet. The seed cotton yield was enhanced significantly due to structured water (3297 kg/ha as against 2849 kg with bore well) irrigation. The roots of structured water irrigated cotton had higher CEC (20.5 meq/g) than bore well irrigated water (18.12 meq/g). The chlorophyll content was 4.4 mg/g of fresh leaf at 60 DAS in structured water cotton as against 3.3 mg/g recorded with bore well water. The plants were also taller (120.5 cm) as against 116.2 cm under bore well irrigation at harvest.

3.13 : Abiotic Stress Management

(i) Drought Phenotyping

Field phenotyping of 350 cotton germplasm accessions was done for drought tolerance during rain free hot dry summer days (April-May) with high air temperatures between 38 - 43 °C. Eighty seven cotton germplasm accessions were identified as drought tolerant based on percent relative water content, leaf water potential and epicuticular wax content. Among the 87 accessions, Nagpur-9, SGNR-27, F-1226 and DTS-108-09 performed well under drought stress conditions.

***G. hirsutum* germplasm accessions showing few plants with drooping leaves due to lower mid-day water potential and few plants with upright leaves due to high mid-day leaf water potential during hot summer**

(ii) Role of Leaf Phytochemicals in cotton leaf reddening

Reddening in RCH 2Bt plants of the experimental plots at CICR Nagpur was observed during the first week of November. The plants faced declining night temperatures (16 -17^{0}C) during the preceding week and experienced a larger difference between night and day temperature ranging from 13- 20^{0}C during the week. Severity of reddening increased when the night temperature declined followed by longer bright sunshine hours during the day from third week of November. Red pigmentation in majority of plants including monochrotophos treated plots was observed during third week of December when night temperatures fell below 10^0 C. To ascertain the protective role of pigments during the process of leaf reddening, chlorophyll stability index was estimated in red and green foliage of RCH 2Bt. Chorophyll stability index was higher in red leaves of RCH 2Bt (70.5 %) than green leaves (64.5%). Based on visual screening, monochrotophos (3 ml/l), kinetin 20 ppm and CICR Nutrient Consortia treated plants showed a delay in the onset of reddening as compared to the other treatments. However, monochrotophos (3 ml/l) sprayed plants remained healthy with relatively higher percentage of green foliage

followed by CICR Nutrient Consortia treated plants. Percentage of red plants was lower in monochrotophos treated plants.

(iii) Climate change- adaptation and mitigation strategies in cotton

Plants grown under elevated CO_2 atmosphere gave significantly higher yields of 69.8 g/plant compared to 55.4 g/plant under ambient conditions. Pruned crop gave marginally higher yield in both elevated CO_2 and ambient atmosphere. For instance, under elevated CO_2 atmosphere pruned crop gave 75.5 g /plant yield compared to 64.2/plant in seeded crop. Similarly, under ambient atmosphere, pruned crop recorded yield of 61.1 g/plant compared to 49.8 g / plant in seeded crop. Among the hybrids, MRC 6918 recorded the highest yield of 90.1 g/plant irrespective of growing conditions. Total dry matter production was significantly higher in plants grown under elevated CO_2 recording 234.1 g/plant compared to 197.5 g/plant in ambient grown plants. Pruned crop gave higher biomass production in both elevated and ambient condition. Pruned crop on an average produced 250 g/plant compared to normal seeded crop (182 g/plant) irrespective of the hybrids tried. Among the hybrids, MRC 6918 gave highest dry matter of 321.6 g/plant. Plants grown under elevated CO_2 recorded a harvest index of 30.3% compared to 28.5% in plants grown under ambient conditions.

Bunny Bt cotton was raised in open top chamber under elevated CO_2 atmosphere (650 ± 50 ppm) throughout the cropping season. Temperature of 1, 2 and 3°C above ambient was maintained without affecting the Photosynthetic Active Radiation value (PAR). Boll number increased significantly with 1°C rise in temperature above ambient (30 bolls/plant) and decreased to 17 bolls/plant with further increase in temperature of 3°C above ambient atmosphere. Similar trend was observed for boll weight i.e reduction in boll weight with increase in temperature above 2°C from ambient. This reflected on final yield of the crop. With increase in 1°C above ambient, plants produced 143 g/plant seed cotton while further increase of 2 and 3°C reduced the yield to 101 and 81 g/plant respectively. Similarly, the total dry matter production increased marginally with 1°C rise above ambient to 455 g/plant and reduced with further increase in temperature to 408 and 370 g/plant under 2 and 3°C respectively. Harvest Index was maximum in plants grown under temperature 1°C above ambient. However, a drastic reduction was recorded in plants grown under 3°C above ambient. The study revealed that the morphological and productivity attributes were favorable in plant grown at ambient or 1°C above ambient under elevated CO_2 atmosphere of 650 ppm. Further increase in temperature above 1 °C had a deleterious effect on plant growth and development.

On large plots of 500 m^2 each, soil moisture conservation strategies was demonstrated on CSH 3178 genotype of cotton planted in high density planting system (HDPS) at 60 x 10 cm spacing at Nagpur on deep black soils under rainfed conditions. The yield realized in control (without conservation was 1198 kg/ha and the yield gain (over control) was 120 kg/ha with Pusa Hydrogel (single dose)@ 3.25 kg/ha, 300 kg/ha with Ridges & Furrow, 299 kg/ha with bio mulch and 350 kg/ha with Pusa Hydrogel (double dose) @ 6.5 kg/ha.

3.14 : Extra Long Staple (ELS) Cotton in Non-Conventional Regions

Extra long staple cotton production in the southern states declined. Consequently, large amount of ELS cotton is imported to meet textiles industries demand. The kinetic thermal window of cotton crop is 23.5 to 32.0^{0}C. Hence to assess the performance of ELS cotton in central India under slightly harsher climatic variables, the ELS cotton variety SUVIN was sown at weekly intervals (18 July, 25 July, 1 Aug and 8 August). The total rainfall received from first date of sowing (18.7.2014) to first picking (5.2.2014) was 743 mm. The monsoon ceased on 18 September. Thereafter continuous dry spell caused significant moisture stress in crop root zone. During this time, the crop was at boll formation stage and it was highly essential to save

the crop from severe moisture stress for which one protective irrigation was given on 28/29 October, 2014.

Seed cotton yield, yield contributing parameters and water use (ET crop) were affected due to differential dates of sowing. In case of early sown crop (18 July 2014), the seed cotton yield on an average was 1214 kg/ha and comparable to crop sown on 25 July. However, in case of subsequent sown crop (1 August and 8 August), a reduction in seed cotton yield was of the magnitude of 17% and 33% respectively as compared to the crop sown on the first date. Application of Pusa Hydrogel (@ 5 kg/ha) had no additional benefit as compared to normal crop. Water use efficiency, which was calculated based on ET crop was also affected and delayed sown crop had very low water use efficiency as the crop was severely affected due to non availability of soil moisture in crop root zone. Total number of bolls in all sowing dates ranged from 42 to 59 bolls m^{-2}. The effect of sowing dates on boll number was significant with a great reduction under delayed sown crop. The boll weight was not affected due to delayed sowing and it was in the range of 2.99 to 3.36 g.

To assess the performance of 27 germplasm lines of *G. barbadense* with Suvin as check, a field experiment was conducted during *kharif* 2014 in a non-replicated trial. The lines were sown on 16 and 17 July 2014 with a spacing of 90 x 45 cm. On an average, seed cotton yield per plant was 39.6 g with maximum of 63. 2 g in case of ICB 81 and minimum of 19.4 g in case of NDGB 2. In case of standard check i.e. Suvin, the seed cotton yield per plant was 58. 4 g. The highest seed cotton yield recorded in four germplasm lines *viz*., NDGB 86, ICB 28, NDGB 55 and NDGB 9. The first boll opening was recorded between 4 and 11 December in all germplam lines except in case of Suvin, ICB 28, ICB 81, ICB 174 and USAGB 309. Boll opening in the germplasm lines was delayed by 21-26 days.

Fibre quality parameters : The variety Suvin has performed well with respect to staple length (34.16 mm), however the fibre strength and fineness and other relevant fibre qualities were comparable with other germplasm lines. Out of 27 germplasm lines, only seven lines NDGB1, NDGB20, NDGB 26, NDGB 35, ICB-81, ICB-174, EC 22 expressed staple length above 32 mm (32.19 mm to 34.0 mm) These lines also have fibre strength above 26 g/tex.

3.15 : Physiological Manipulation of Extended Cotton Crop

Three BG – II hybrids namely Bunny, RCH -530, and RCH- 20 responded favourably to pruning. Irrespective of the Bt cotton, 116.8 g/plant yield was recorded in normal seeded crop compared to 84.0 g/plant in pruned crop. Among the hybrids, highest yield was recorded in Bunny followed by RCH 530. Total dry matter production was significantly higher in seeded crop registering 408.0 g/plant compared to 317 g/plant in pruned crop irrespective of the hybrids. Bunny and RCH – 530 gave similar value of 390 g/plant. Soon after harvest in the month of July, the normal seeded crop was again subjected to pruning in the month of August 2014 as a winter crop. Adjacent to the pruned plot normal seeded crop was raised for comparison.

Irrespective of the hybrid, significant variation was not discernible between pruned and normal crop. Bunny and RCH – 530 yielded on par with 150.9 and 169.9 g/plant yield respectively, compared to 123.2 g/plant in RCH – 20. Plant growth in terms of total dry matter was almost 40-50% higher in winter than summer crop. Mean dry matter produced to the tune of 580.4 g/plant in pruned crop compared to 417.6 g/plant in normal seeded crop. Maximum dry matter production was recorded for RCH -530 followed by Bunny and RCH -20.

Cry1Ac toxin in leaves of all the Bt BG II version recorded more toxin than the first cycle of fruiting. Almost a similar level of toxin was maintained in the three hybrids studied (2.25 to 2.37 µg/g). Pruned crop almost had double the quantity of toxin (2.55-3.9 µg/g) than the normal seeded crop; (0.891-1.350 µg/g). Leaves had higher level of Cry2Ab toxin (460 µg/g) compared to squares in (406 µg/g) in the initial crop and also the quantity

of toxin in the second crop (pruned crop) decreased. However, regardless of the fruiting cycle (normal and pruned crop) Cry1Ab toxin were at same level. Much variation could not be observed between leaves and squares in Cry1Ab toxin content.

3.16 : Mechanization of Cotton Production

The self-propelled cotton harvester fabricated and tested in 2013 was subjected to several modifications and field trials in order to obtain lesser trash content in harvested cotton. The grid concave inside the threshing unit was replaced with a larger size opening grid from 23x9 mm to 40x20 mm. The earlier grid size was suitable for small grains and it was observed that bigger trash like burs, sticks etc. were unable to pass through the openings, with the result that trash was not getting discharged through the grain outlet (outlet below the concave grid unit). Entire trash after getting separated from seed cotton in the grid concave was being discharged from the threshing unit into the pre-cleaner, where depending on the capacity and nature of pre-cleaner the trash was being separated from seed cotton and both discharged through separate outlets. With larger openings than above, it was observed more seed cotton mixed with trash got discharged through opening below the grid. With 40x20 mm grid size a trade-off between quantities of trashy cotton and cleaner seed cotton could be achieved. In field trials with RCH-2 BG-II hybrid about 80% harvested seed cotton came off relatively cleaner (25% trash) from the threshing unit and into the pre-cleaner while 20% trashy cotton (40% trash) got discharged from the opening below the grid concave unit.

Original Grid Concave

Modified Grid Concave

Clean stripped plants

Improved Reel

Combs with varying teeth spacing were fabricated to take care of different cotton genotypes having varying girth of lower stem and varying angles of branches. The mean stem girth of plants of RCH-2 was 11.3 mm and that of Suraj var. was 9.3 mm. Also, the height of plants dictated the efficiency of harvesting. Stripper harvester was found to give high harvesting efficiency of 95% when average plant height was below 75 cm and height of lower most boll above 10 cm. This was because stripper combs if lowered below this height resulted in digging in.

The gathering reel was found lacking in strength and unable to push the plants into the auger. A new reel was fabricated with strips of flat welded to a central shaft driven by a pulley. This improved reel did not jam and pushed in the stripped bolls positively into the auger.

Of the total trash in harvested cotton, the burs and sticks alone constituted 70-80%. Therefore, it is necessary to incorporate an extensive field/pre-cleaner in the machine itself. Power and space constraints exist in the present harvester to meet a pre-cleaner.

3.17 : Socio Economic Dimensions of Cotton Farming

e-Kapas for technology transfer

'e Kapas' refers to use of electronic technologies especially information and communication technologies (ICTs) for delivering location specific, time sensitive and important alerts based on cotton technologies to farmers, extension workers and other development workers engaged in cotton system. Need based advisories in regional and local language is provided on a regular basis after registration of cotton growers with their mobile number, collecting information on Frequently

Asked Questions (FAQs). Development of content in local languages, develop popular dissemination material on cotton production/protection technologies, weather, market information. Registration of interested farmers as beneficiary of e-Kapas network was made with their names, mobile numbers, villages, tehsil and districts for getting voice messages & advisories free of cost from CICR and participating centres. The farmers were also asked to register directly with short code services 123eworld.com (Mobi Tech Media) system.

During 2014-15, 11766 farmers were registered from CICR Nagpur. Similarly, 986 cotton growers from major cotton growing districts of Tamil Nadu *viz.*, Perambalur, Madurai, Virudhunagar, Salem, Vellore, Erode, Ariyalur, Trichy, Theni, Dharmapuri and Coimbatore were identified and registered. In addition, 3603 farmers was registered at Sirsa (Haryana). The details of the 37432 registered cotton growers so far were developed into a database called e-Kapas farmers' database.

In all, 27 FAQs in cotton were collected through Focus Group Discussions from cotton growers at Nagpur, 29 at Coimbatore and 18 FAQs were compiled at Sirsa.

During the crop season 2014-15, a total of 23.53 lakhs Voice SMS were sent on registered farmers mobile, out of which 16.79 lakhs were attempted successful and delivery percentage was 71%. Among the CICR, voice SMS of 10.09 lakhs (6.83 lakhs CICR Nagpur, 1.87 lakhs CICR RS Sirsa & 1.39 lakhs CICR RS Coimbatore) were sent with delivery percentage of 72%.

The coverage area when the voice message is sent, the system was adopted and the calls were repeated a couple of times to ensure that the farmer does not miss the message.

Feed back

Feedback revealed that voice based mobile services are useful in adoption of practices and farmers like to have voice messages at regular basis during season. The following feedback were recorded with respect to voice message system.

- A better source of timely, relevant and quick information
- Need based and location specific information
- Save time, money and easy to understand available information
- The service is useful to the people who cannot use internet or are not comfortable with text message
- Service is of a great use to illiterate farmers
- Source for strong linkage with research station
- Most farmers preferred mobile service through SMS too
- Farmers like to have toll free call back facility to contact the officers and scientist

Impact of Bt cotton in Maharashtra

This study was conducted to evaluate the impact of Bt cotton in Maharashtra. Data was collected from 2700 cotton farmers belonging to 18 major cotton growing districts of Maharashtra *viz.*, Ahmednagar, Akola, Aurangabad, Amaravati, Beed, Buldhana, Chandrapur, Dhule, Hingoli, Jalgoan, Jalna, Nagpur, Nanded, Nandurbar, Parbahani, Wardha, Washim and Yavatmal. During 2012-14, data collection and analysis for twelve districts was completed. The analyzed results for sample districts indicated that, though Bt cotton was introduced in 2002, most of the producers adopted Bt cotton during 2005-08 and by the end of 2011 almost 90 percent of respondents adopted it. Currently all the respondents are growing Bt cotton. Significant changes took place after introduction of Bt cotton and the important ones are listed in Table 3.17.1.

Nearly 89% respondents reported that sucking pest problem increased year after year. However, they felt that availability of pesticides was not a problem. As per the respondents there are more than 300 Bt hybrids in the market. They mainly depend on the advice of seed dealers/private companies for hybrid selection. Most of the respondents (64%) opined that selected hybrids were not giving expected yield which indicates that they are unable to make good decision regarding the selection of hybrids. Forty per cent of

the respondents said that they were unable to get their preferred hybrid at MRP rate and they had to pay more than the MRP to get it. High yield, big boll size and quality of fibre are the three major traits preferred by the respondents. One-third of respondents were not using non Bt seeds as refugia, 55% of respondents used non Bt seeds as border crop and those who got red gram seed (10% of respondents) as refugia were using it an intercrop. Opinion survey revealed that Bt cotton was not responsible for suicides of cotton farmers (99% of respondents.). Almost all the respondents perceived that there were no incidence of death of animals due to Bt cotton and there were no health hazards due to Bt cotton cultivation. On an average, cotton farmers incurred a total working cost of Rs 19695/- acre and got a gross return of Rs 34428/- acre. Most of the respondents were not satisfied with the current yield and income levels. Hence measures to improve the yield should be taken and also government must ensure the remunerative price for their produce.

Table 3.17.1: Use of inputs before and after introduction of Bt cotton by sample respondents-District wise.

District	Seed rate (kg/acre)		No. of insecticidal sprays		Fertilizers (NPK) (kg/acre)		Respondents used weedicides (%)		Respondents used growth regulators (%)		Yield (q/acre)	
	Before-Bt	After-Bt	Before-Bt	After-Bt	Before-Bt	After-Bt	Before-Bt	After-Bt	Before-Bt	After-Bt	Before-Bt	After-Bt
Ahmednagar	2.8	0.5	7	4	93.4	174.5	1	25	1	8	5	9.4
Akola	2.4	0.8	8	3	66.8	102.7	1	8	1	32	3.6	8.5
Amravati	2.5	0.8	8	3	48.4	93.2	0	39	0	33	3.4	8.8
Aurangabad	3.5	0.6	6	5	90.3	156.7	0	21	0	10	4	8.2
Beed	2.8	0.8	8	4	60.2	110.6	0	10	1	23	4.5	8.0
Buldhana	2.5	0.8	7	4	72.6	143.6	3	35	1	24	4.4	9.8
Chandrapur	1.9	0.8	7	3	59.4	95.3	0	65	1	11	3.0	7.1
Dhule	2.6	0.6	5	3	50.9	92.0	0	28	0	21	4.4	8.2
Hingoli	2.0	0.9	6	4	89.5	174.4	1	55	0	12	3.8	10.7
Jalgaon	2.6	0.5	6	4	61.2	93.5	0	37	0	37	4.4	8.6
Jalna	2.3	0.5	6	4	85.2	135.0	0	27	0	10	4.8	8.2
Nagpur	2.2	0.7	8	4	48.9	95.9	0	39	0	33	4.8	8.1
Nanded	3.1	0.7	8	4	93.7	188.4	0	11	0	2	2.1	6.4
Nandurbar	1.8	0.8	7	4	54.5	93.0	0	29	0	27	4.1	9.7
Parbhani	3.2	0.5	9	5	99.0	130.3	0	19	0	37	2.8	7.1
Wardha	2.6	0.9	8	4	68.7	123.5	0	12	0	39	2.8	6.8
Washim	2.7	0.8	7	4	92.7	145.9	1	47	2	15	4.7	7.4
Yavatmal	2.0	0.8	8	4	66.8	156.5	0	39	0	28	1.5	6.2
All	**2.5**	**0.7**	**7**	**4**	**72.3**	**128.1**	**0.48**	**30**	**0.51**	**21**	**4**	**8.3**

Cotton price forecasting

The ARIMA model of Box-Jenkins analysis showed almost near normal values of actual to the forecasted prices for the cotton markets of Gujarat and Madhya Pradesh. Significant variations in the forecasted prices with that of actual prices were noticed in case of cotton markets at Maharashtra. Forecast accuracy was to the tune of 95% in case of Gujarat and 96% for Madhya Pradesh but slightly wide variation in case of Maharashtra with 88.4%. In case of North Zone, forecast accuracy was to the tune of 91% in case of Punjab, 89% in Haryana and 90% in case of Rajasthan.

Cotton Mechanisation – Tracing the Needs and Gaps for Sustainable Cotton farming in India

The objectives of this project were to compute the intensity of labour shift from cotton to other

sectors; to trace the current mechanisation status and future needs among the different categories of cotton farmers and to suggest viable means for increased productivity in cotton.

Our country lags behind many other large producers of cotton in terms of mechanization. It is reported that the labor availability has dropped from 70% of the population in 1961 to 49% in 2010. Thus, it is expected that we will soon have to mechanize our cotton harvesting operations as it is facing labor shortage and rising farm wages.

Mechanisation gap is found in almost all the stages of the crop except during the land preparation stage. Therefore, top priority of mechanization needs to be given to the cotton farms during sowing, intercultivations mainly weeding and harvesting stages. Cotton harvesting has to be mechanized so as to counter act 50% of the cost of cultivation. It could be seen that human labour cost of weeding and harvesting operations account for 60% of the total labour cost followed by land preparation (16%), plant protection (9.6%), fertiliser application (8.1%) and sowing (4%). Partial budgeting technique was used to find the economic viability of mechanization under selective operations wherein the labour use is high with special reference to sowing, weeding and harvesting operations. The results showed an increased benefit of Rs. 8000 to Rs. 9000 per hectare in all these three operations.

Selective mechanization is the need of the hour. Farm mechanization zone is to be identified in both the rainfed and irrigated cotton farms in all the three cotton zones where labour is scarce. Care should be taken that mechanization should not destabilize the agricultural labour availability. Contract or Co-operative farming in cotton can be encouraged for effective and optimum utilization of the resources to achieve highest yield as targeted for 2020. Increasing irrigation facilities and adoption of scientific innovations and modern technologies like Bollgard II Roundup Ready Flex, mechanised farming and the High Density Planting (HDP) programme are some of the key focus areas which can provide the much needed fillip to increase the productivity level further.

3.18 : Seasonal Dynamics of Insect Pests and Diseases

Nagpur

Sucking pest populations were recorded under protected and pesticide free conditions by taking weekly insect number counts on *G. hirsutum* cv DCH 32. Average highest populations of aphids and whitefly were recorded during the first fortnight of September and thereafter there was a decline. Jassids were above ETL during first week of September to third week of October while thrips were maximum in the first fortnight of September.

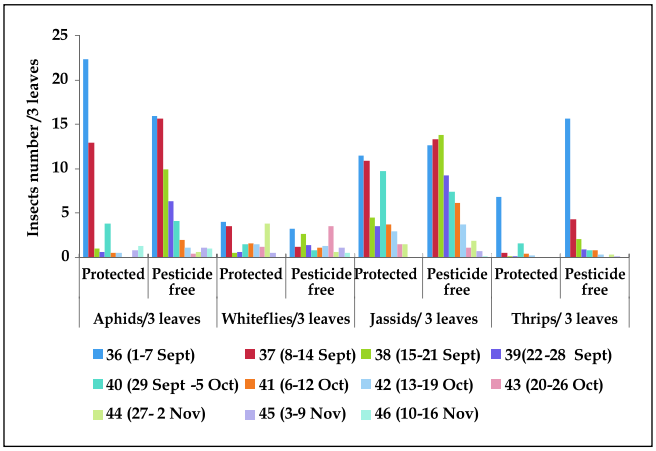


Fig 3.18.1: Seasonal dynamics of sucking pests on DCH 32 during 2014-15

Seasonal peaks of sap feeders across central zone locations during 2005-06 to 2013-14

Seasonal peaks of sap feeders *viz.*, jassids, thrips and whitefly across central zone locations during 2005-06 to 2013-14 (AICCIP data) varied from location to location. Peak infestation of jassids and thrips was recorded between 34 and 44 SW while whitefly infestation was recorded between 34 and 54 SW. Highest population of jassids at peak was recorded at Akola during 2009-10 (36 SW) and during 2011-12 (36 SW) on DCH 32. Highest population of thrips at peak infestation was recorded at Surat during 2005-06 (37 SW) on G.Cot Hy10 and Nanded during 2007-08 (35 SW). Similarly, highest population of whitefly at peak was recorded at Junagarh during 2007-08 (40 SW) on G.Cot Hy10 (Fig. 3.18.2 a-c).

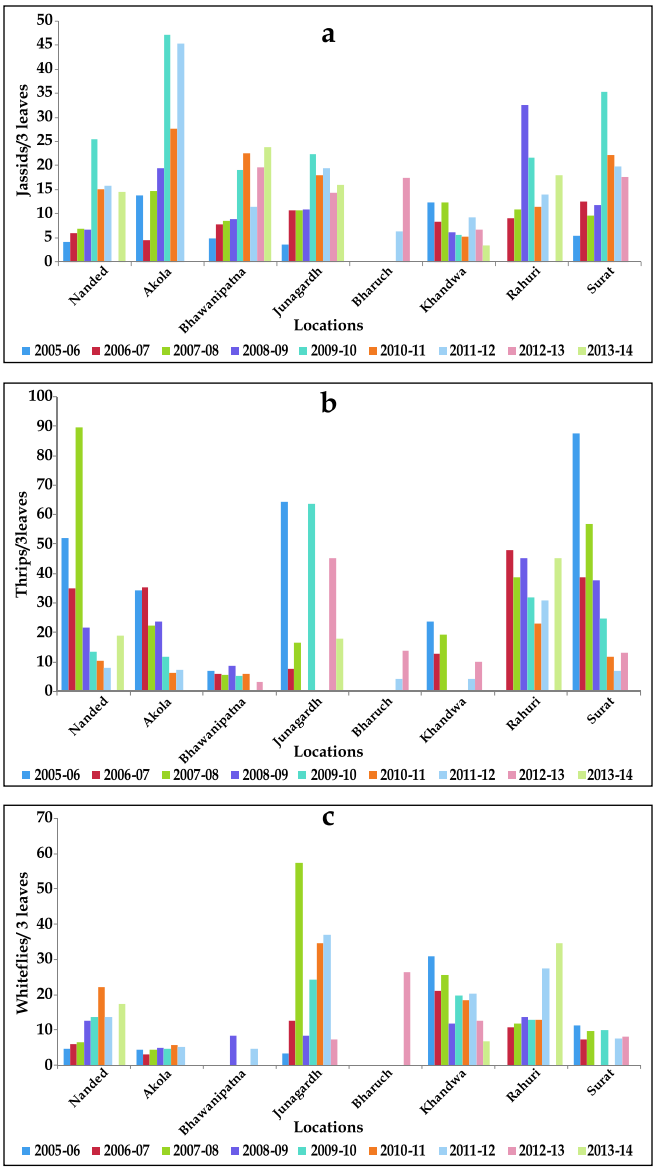


Fig. 3.18.2: Peak population of a) Jassids, b) Thrips and c) Whitefly during 2005-06 to 2013-14

Sirsa

Population of whitefly was initially observed in 24th Standard week and peak activity recorded in 37th Standard week in all the genotypes tested *viz.*, RCH-134 BGII (50.1 whiteflies/3 leaves), HS-6 (38.9 whiteflies/3 leaves) and Ganganagar Ageti (33.0 whiteflies/3 leaves) (Fig. 3.18.3 a).

Jassid population on RCH-134 BGII, RCH-134 Bt, HS-6 and Ganganagar Ageti ranged from 0.0 to 7.7, 0.0 to 8.2, 0.0 to 6.7 and 0.0 to 7.7 jassids/3 leaves, respectively. Peak activity of jassids was observed during 29 to 31 SW in all the genotypes (Fig.3.18.3 b).

RCH 134 BG-II recorded thrips population ranging from 0.0 to 17.7 thrips/3 leaves. In RCH 134 Bt, thrips population ranged from 0.0 to 18.8 thrips/3 leaves. In HS-6, thrips population ranged from 0.0 to 22.2 thrips/3 leaves. In Ganganagar Ageti, thrips population ranged from 0.0 to 20.1 thrips/3 leaves. Initiation of incidence began in the 25 SW while peak activity was observed in 31-32 SW in all the genotypes (Fig. 3.18.3 c).

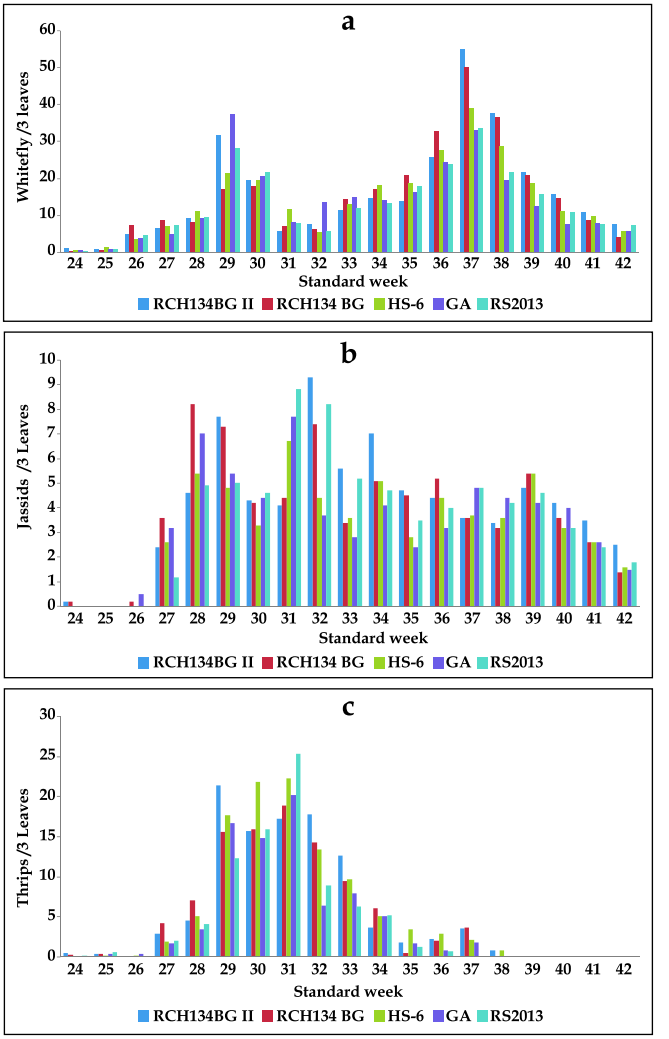


Fig. 3.18.3 a-c : Population dynamics of whitefly-a, Jassids-b and thrips-c under unprotected conditions in North Zone- Sirsa

Bollworm infestation was not observed on RCH-134 BG II & RCH-134 Bt. In NBt varieties i.e. HS-6, GA and RS 2013 first population of bollworm was observed in the 31st week.

Novel scouting method

Scouting of whitefly population with yellow sticky

trap (YST) was done, where the first treatment i.e. YST installed as stationary units at 50 traps/ha being replaced at 15 day intervals accompanied by manual scouting trapped maximum number of whitefly (average 193 whitefly adults based on 6 observations) /trap after 24 hours of installation. The second treatment i.e. YST attached by rod on either side of the wheels of a plough so as to move just above the canopy, the average whitefly recorded 105.6/trap immediately after the operation. The other treatments T3-T6 recorded low population of whitefly, lower than manual scouting, with average of 52.4 whitefly adults /5 plants.

T1-YST installed as stationary unit

T2-YST attached to a rod on either side of wheels of a plough

T3-YST running behind a rope

T4-YST on the pants of the plough operator

T5-YST on mosquito racket

T6-Recommended chemical treatment

A trap named as CICR Whitefly Adult Suction Trap, was designed. The trap is power operated, shoulder mounted, portable, adjustable and suction whitefly adults available on the underside of the cotton leaves without any harm either to natural enemies or crop. Preliminary data on the efficacy of the trap was also collected.

3.19 : Biological Diversity of Insect Pests and Pathogens

Mealybug diversity

Eighteen surveys were conducted covering 134 cotton fields distributed in 14 districts (Nagpur, Wardha, Amravati, Yeotmal, Bhandara, Washim,

Jalna, Aurangabad, Nanded, Parbhani, Chandrapur, Hingoli, Akola and Buldhana) of Maharashtra and one district (Chindwara) of Madhya Pradesh during 2014-15. In these surveys 5 mealybug species *viz.*, *Phenacoccus solenopsis*, *Nipaecoccus viridis, Maconellicoccus hirsutus, Ferrisia virgata* and *Paracoccus marginatus* belonging to Pseudococcidae family of order Hemiptera were recorded in 7 districts. *P. solenopsis* was the dominant species while remaining sp. were observed in traces. In most of the places mealybug infestation was under control. Field infested by *P. solenopsis*, *N. viridis, M. hirsutus, F. virgata* and *P. marginatus* was recorded as 35.8, 6.7, 1.5, 0.7 and 0.7 per cent, respectively out of total fields observed.

Pink bollworm

Resistance development of pink bollworm collected on BG, BG-II and NBt cotton fields was monitored across 8 districts of north India and 3 districts of south India. Incidence of pink bollworm on Bollgard-II was observed in all cotton growing districts of Gujarat *viz.*, Surat, Bharuch, Anand, Bhavnagar, Amreli, Juangadh, Rajkot and Surendranagar. The larval intensity on Bt cotton was more in Amreli and Vadodara as compared to other locations. Pink bollworm was not observed in Bt cotton fields of north and south India.

3.20 : New Genes and Gene Sources for Pest Management

Molecular characterization of root knot nematode population

Molecular characterization of four root knot nematode *Meloidogyne incognita* populations using rDNA sequences, the large subunit, small subunit and the internal transcribed spacer regions (ITS) was done. For PCR amplification of internal transcribed spacer (ITS) of the ribosomal RNA genes, primers forward (5'TTTCACTCGCCGT TACTAAGG3') and reverse (5'TTGATTACGTCC CTGCCCTTT3') were used. Sequence analysis confirmed the identity of *Meloidogyne incognita* species. The ribosomal RNA gene sequences were submitted to NCBI (Nagpur- KC342236; Wardha- KJ913700; Yavatmal- KP233824; Chandrapur- KP233823). Sequences were incorporated into computer program BioEdit Sequence Alignment Editor v.7.2.5 and Phylogenetic analysis was done using MEGA (Molecular Evolutionary Genetic Analysis) computer program 5.05.

Synthesis of primers to amplify root knot nematode parasitism genes and sequencing of amplified regions

Primers were designed for putative parasitism genes available in NCBI database.

List of genes selected for amplification from Root Knot Nematode

Category of genes	Genes
Oesophageal proteins	MSP1, MSP5, MSP6, MSP13, MSP 23, MSP19, MSP29
Regulatory proteins	14-3-3
Other proteins	Cm1, cm2, Cpb1,Cpl1, xyl1,Pel1, pel2,Calc, nod,Eng3, eng4, 16D10

Amplification and cloning of parasitism genes

RNA was extracted from root knot juveniles and females and first strand synthesis was done using Invitrogen kit. Genes MSP 1, MSP6, MSP13, MSP23, MSP19, MSP29 and 14-3-3b protein were amplified and sequenced to confirm identity.

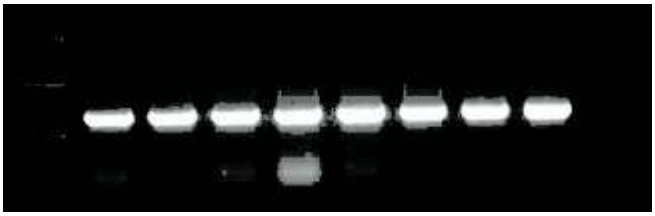
GRADIENT PCR : Lane 1 - 1Kb ladder; 2-5 (msp 6-48^0, 48^0 & 52^0 , -ve); 6-9 (msp 13-48^0, 50^0 & 52^0 , -ve); 10-13 (msp 23-48^0, 50^0 & 52^0, -ve)

GRADIENT PCR : Lane 1 - 1Kb ladder; 14-17 (AY38 as msp-19 -52^0,54^0 & 56^0, -ve

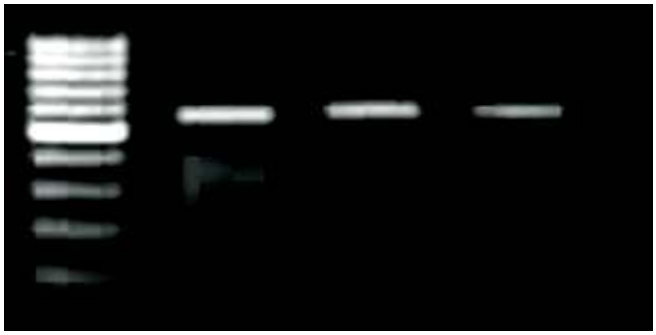
GRADIENT PCR: Lane 1-1Kb ladder; 6-9 (AY40 as msp-1-52^0, 54^0 & 56^0, -ve); 10-13 (AY42 as msp 23- 52^0, 54^0&56^0, -ve)

GRADIENT PCR: Lane 1-1Kb ladder; 2-5 (AY65 as msp-29 -50^0,52^0&54^0, -ve

Lane 1-1Kb ladder; 2-9 (AF64 as msp-5,-ve)



Lane 1-1Kb ladder;2-10 (14-3-3b protein, -ve)



dsRNA for three genes MSP6, MSP13 and MSP 23 was made using Ambion kit as per manufac-turer's protocol
ds-RNA: Lane 1-100bp Ladder; 2-msp6; 3-msp

Synthesis of dsRNA for selected genes and testing dsRNA

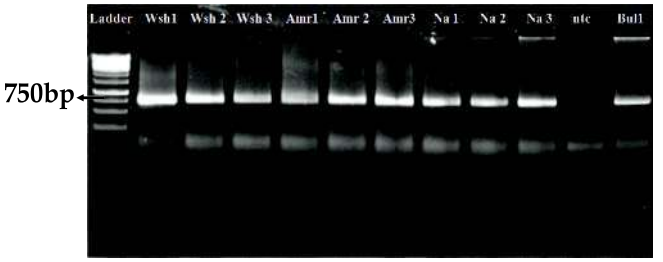
Plant parasitic nematodes have been reported to take up dsRNA on induction with inducers as serotonin, octamine and spermidine. Among the inducers, dopamine was most effective. At 2 hrs of incubation Fluorescein isothiocyanate was observed to reach mid esophageal region.

Efficacy of CICR fusion protein in combination with chitinase

Log dose probit assays were carried out with eleven treatments that included toxins from the clones, CICR fusion gene (without chloroplast transit peptide, ctp), truncated Cry1Ac gene without ctp, CICR Cry2Ab without ctp, CICR Fusion + chitinase, chitinase, CICR truncated Cry1Ac (without ctp) + chitinase, Cry2Ab protein (from corn leaf powder), Cry1Ac protein (sourced from MVPII), Cry1Ac + Cry2Ab, buffer and absolute control. The diet incorporation bioassay was carried out for 13 days using one day old white stage larvae of *H. armigera.* The combination of fusion protein with chitinase not only resulted in higher mortality and growth regulation but also caused this mortality 48 h earlier (i.e 11 days after bioassay) than fusion without ctp alone. Hence the combination of genes of CICR fusion protein and CICR chitinase is not only different but is also an effective strategy against *H. armigera.*

Endosymbionts in jassids

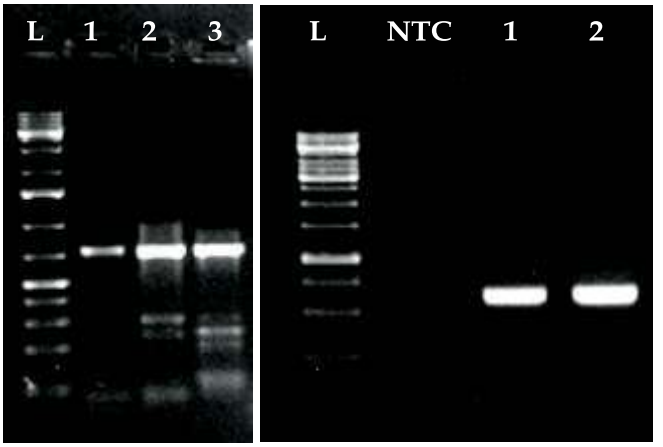
Based on 16S rRNA amplification and sequencing results, jassids from across India were found to harbor the bacterial endosymbiont, *Delftia acidovorans. Delftia acidovorans* (synonym *Comamonas acidovorans*) is a gram negative bacterium belonging to the β- Proteobacteria. It is an aerobic, non-fermentative, rod shaped, classified in the Pseudomonas rRNA homology Group III which is known to be present in the insect's hemolymph. *Delftia* sp. is a known D-amino acid amidase-producing bacterium and might play a key role in insect survival.



(Wsh: Washim Amr: Amravati Na: Nagpur Bul: Buldana and numbers refer to sample)

16S rRNA PCR with Jassids from different locations

Molecular identification of glyphosate tolerant microbes : Molecular identification of isolated bacterial and fungal strain for glyphosate tolerant/ utilization was done through 16S rDNA and ITS region sequencing. The PCR amplification and sequencing of the target region identified the bacterial and fungal strain as *Enterobacter cloacae* subsp. *Cloacae* and *Ganoderma lucidum* respectively.



L= Molecular ladder; 1,2&3 = 733bp PCR amplified product of 16S rDNA from selected samples

NTC= No template control 1,2= 580bp amplified product of ITS region from selected samples

PCR amplified product of 16S rDNA and ITS sequences of glyphosate tolerant bacterial and fungal isolate

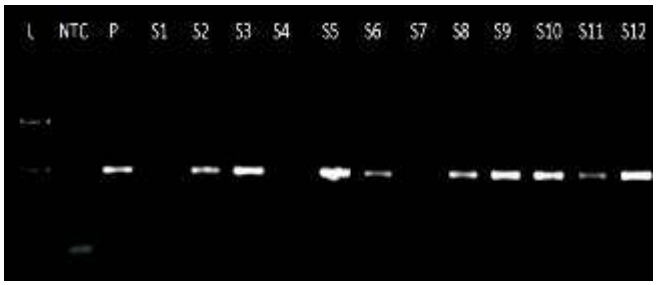
Isolation and characterization of gene coding for *Helicoverpa armigera* chitin synthase B : Full length coding sequence for *Helicoverpa armigera* Chitin synthase B sequence was isolated successfully and characterized for functional motif and enzymes using bioinformatics tools. Alignment of overlapping PCR fragments resulted in open reading frame of *HaCHSB* cDNA consisted of 4584 nucleotides and the encoded protein contains 1528 amino acids. Similar to other chitin synthase family of genes, HaCHSB was predicted to have three domains: an N-terminal domain with nine transmembrane helices; a central catalytic domain which contains catalytically critical sequences, including aspartyl residues, and the 'signature motifs' EDR, QRRRW. It is also predicted that five transmembrane spans (5-TMS) are predicted to appear consecutively after the putative central catalytic domain. C-terminal domain was found to be with additional transmembrane helices and WGTRE near the C-terminus, which are conserved in polymerizing β-glycosyltransferases from many species.

Characterization of *Gossypium arboreum* COBRA gene (GaCOBL) family using bioinformatic tools : Members of the COBRA gene family are involved in the regulation of the orientation of cell expansion in the plant cell wall and in cotton they are known to play important role in fibre development. Hence COBRA gene family of *G arboreum* were characterised through bioinformatics tools. COBRA gene family is known to be GPI anchored protein. GPI anchored cleavage site and N terminal signal peptide cleavage prediction using SignalP programme showed that five isoforms out of 12 *GaCOBL* isoforms analysed, belong to *GaCOBL1* (1), *GaCOBL4* (3) and *GaCOBL* (6) do not possess signal peptide sequence. Multiple alignment of aminoacid sequence of GaCOBL gene family was done using ClustalW program which revealed the presence of CCVS conserved motif in all the GaCOBL isoforms.

Leaf curl virus resistant transgenic cotton

Cotton leaf curl virus resistant transgenic plants were developed in three genotypes *viz.*,H 777, HS 6 and F 846 with three genes sense coat protein (*SCP*), anti-sense coat (*ACP*) protein and antisense-replicase protein (*ARep*). The transgenic seedlings of the three genotypes were raised in the green house contained condition. Molecular confirmation for the presence of the A-Rep gene was done

with the PCR using gene specific primers and full length genes were amplified. Selfed seeds were collected for further analysis.



PCR amplification with *A-Rep* gene specific primers (0.540kb)

3. 21 : Non-Compliance of Regulatory guidelines

Verifying label claim of commercial seed packets

Forty six seed packets were procured from 13 districts of north India representing 22 seed companies. Thirty seed packets representing 17 companies were procured from Maharashtra. All samples collected and tested were found to carry the event claimed on the label. For the first time, NBt seeds provided were tested for the presence of Bt and out of 91 samples 21 packets from 13 companies (Krishidhan, Navbharat, Ankur, Bioseed, JK seeds, Prabhat, Pravardhan, Kribhco, Rasi, Ajeet, Nuziveedu, Paras, Kaveri) contained seed mixtures of Bt and NBt. The practice of providing admixed Bt cotton seed instead of non Bt seed seriously impairs the purpose of refuge.

Field evaluation of existing refuge to determine germination, synchrony, and susceptibility to sucking pests was carried out in *kharif* 2014. BGII hybrid Gajab (Kalash Seeds, Jalna) carried *G. herbaceum* as the refuge. Five non Bt (NBt) refuge of 3 companies, Rasi, Kaveri and Tulasi, recorded less than 5% germination. NBts were susceptible to jassids, despite seeds being treated with imidacloprid. Asynchrony was recorded with Bt hybrids entering the boll formation stage, early, at 65 DAS. BGII hybrids recorded 43-57 bolls per 10 plants while their counterpart NBt refuge carried 0-17 bolls per 10 plants. The difference is also partly due to square shedding by bollworm damage in the latter. This asynchrony between Bt and non Bt refuge would impact the incidence of pink bollworm. Seed cotton from BGII hybrids and corresponding NBt refuge was picked only once between 26 - 29 of November 2014 and 5-9 January 2015, respectively, indicating a delay in maturity of at least 1 month in the picking of NBt refuge. It was inferred that compliance of GEAC guidelines ranged between 'poor to absent' among 17 seed companies.

3.22 : Development of New Methods, Tools and Protocols

Nagpur

Quantification of ethylene emission by normal and stressed plants

Increased ethylene emission under stress by plants infested by jassids was observed with increasing damage grades under both protected and pesticide free conditions during vegetative and fruiting stage. The corresponding ethylene emission in grades I, II, III and IV was observed as 0.94, 1.43, 2.08, 2.82 ppm under protected and 1.02, 1.47, 2.12, 2.72 ppm respectively under pesticide free condition (Fig. 3.22.1). Wilted plants affected by sudden wilt emitted higher ethylene (2.27 ppm) as compared to healthy plants (1.02 ppm) (Fig. 3.22.2). Inhibition of ethylene emission was observed by remedial treatment with cobalt chloride spray and bavistin drenching 48 HAT (hours after treatment) (Fig. 3.22.3).

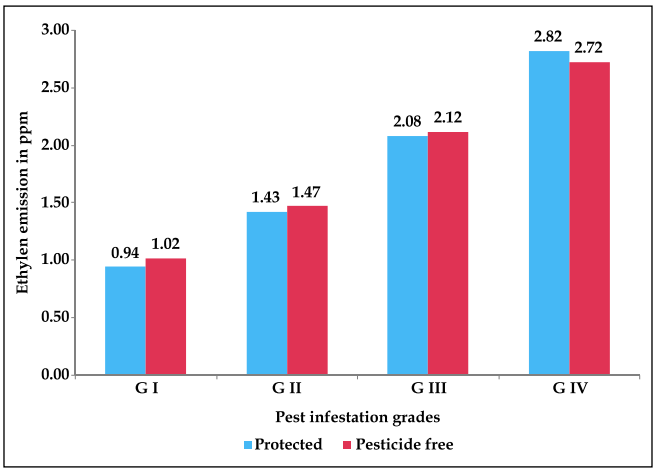


Fig. 3.22.1: Average ethylene emission in different grades by jassids infestation over the season

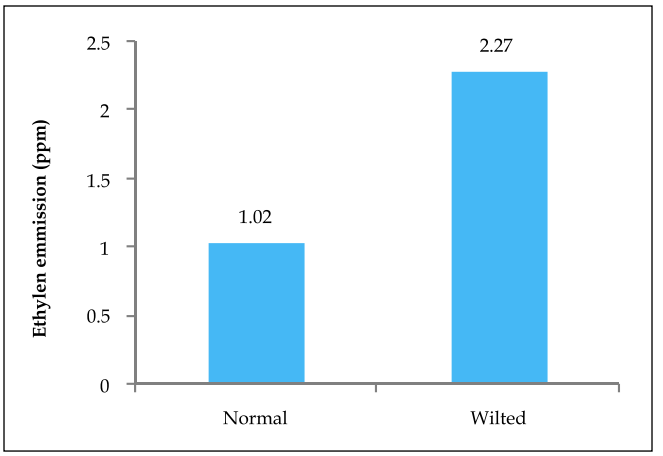


Fig. 3.22.2 : Ethylene emission (mean of 10 plants) by normal and wilted plants

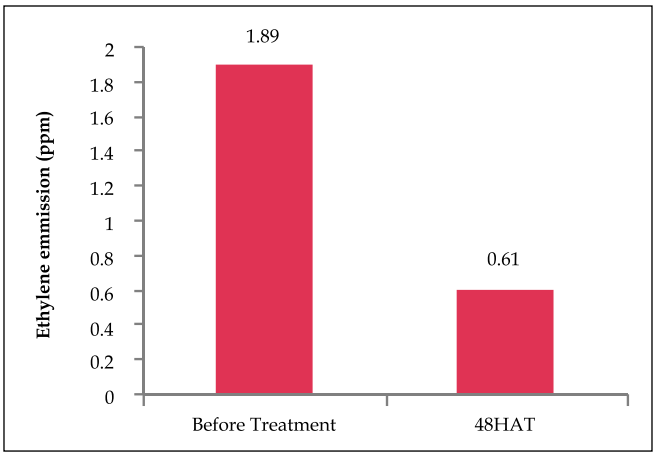


Fig. 3.22.3 : Inhibition of ethylene emission in wilted plants (mean of 10 plants) by cobalt chloride spray and bavistin drenching

Coimbatore

Encapsulation of Bt toxins for the management of bollworms

Microencapsulated *cry1Ac* protoxins were evaluated at different concentrations (0.1 ml, 0.3 ml, 0.5 ml and 0.7 ml / 10 ml of distilled water) against Ist, IInd and IIIrd instars of *H. armigera*. Percentage mortality of all the 3 stages of *H. armigera* was directly proportional to the doses tested. In the leaf bioassays conducted against II instar larvae, the percentage mortality ranged between 25-100% and 60-100% in non encapsulated and encapsulated Bt toxin, respectively.

The percentage of mortality obtained with ultraviolet rays exposed microencapsulated Bt was 100%, 100% and 50% at 24, 48 and 72 hrs after exposure respectively at a dose of 0.7 ml/10 ml of distilled water. Whereas, in non encapsulated Bt toxin, 50%, 50% and 0% of mortality was recorded in 24, 48 and 72 hrs after exposure respectively. Percentage mortality of larvae fed with sunlight exposed microencapsulated Bt was 100% in 24, 48 and 72 hrs after exposure. However, in non encapsulated Bt toxin, only 50%, 50% and 0% larval mortality was recorded at 24, 48 and 72 hrs after exposure, respectively. Equal quantity of encapsulated and non-encapsulated cry1Ac Bt toxin were analysed by 12% SDS-PAGE. Microencapsulated Cry1Ac (135 kDa) showed higher intensity compared to non-encapsulated Cry1Ac, indicating the quality of the protein.

3.23: Natural Enemies and Biological Control

Nagpur

Natural enemies of cotton pests

Three species of parasitoids *Apanteles angaleti Muesebeck, Apanteles glomeratus* (L.), *Palexorista laxa Curran* were recorded on cotton semilooper while one parasitoid *Aphelinus mali* was recorded on aphids. Major general predators of cotton pests recorded were lady bird beetle *Cheilomenes sexmaculata* (Fab.), transverse ladybird beetle *Coccinella transversalis Fab.*, lace wings *Chrysoperla carnea* (Stephans), lady bird beetle *Scymnus coccivora* Ayyar, predatory stink bug, *Eocanthocona furcellata* (Wolff), big eyed bug *Geocoris ochropterus* (Fieber).

Natural enemies of mealybugs

Eight natural enemies of mealybugs were recorded *viz.*, parasitoids- *Aenasius bambawalei, Metaphycus* sp., *Anagyrus kamali, Acerophagous papayae, Pseudoleptomastix mexicana* hyperparasitoids- *Promuscidea unifasciativentris* and *Prochiloneurus albifuniculus* and predator *Cacoxenus perspicax.* Their per cent parasitisation/predation are given in Table 3.23.1.

Table 3.23.1: Natural enemies of mealybugs

Sr. No.	Species Name	Host	Average Parasitisation/ predation (%)
1.	*Aenasius bambawalei* Hayat	*P. solenopsis*	24.9
2.	*Metaphycus* sp.	*P. solenopsis*	4.2
3.	*Anagyrus kamali* Moursi	*P. solenopsis*	2.2
4.	*Acerophagus papayae* Noyes & Schauff	*P. marginatus*	-
5.	*Pseudoleptomastix mexicana* Noyes and Schauff	*P. marginatus*	19.0
6.	*Promuscidea unifasciativentris* Girault	*P. solenopsis*/ *A.bambawalei*	10.0
7.	*Prochiloneurus albifuniculus* (Hayat et al.)	*N. viridis*	54.3
8.	*Cacoxenus perspicax* (Knab)	*N. viridis*	34.6

Spider biodiversity in cotton agro-ecosystem

Fifteen species of spiders belonging to 6 families were recorded in cotton agro-ecosystem during 2013-14 and 2014-15. Three species were of orb weavers from family Araneidae (*Neoscona theisi* (Walckenaer,*1841*), *Eriovixia excelsa* (Simon, 1889), *Leucauge decorata* (Blackwall,1864)), a species of lynx spider from family Oxyopidae (*Oxyopes pankaji* (Gajbe & Gajbe, 2000)), 5 species of crab spider from family Thomisidae (*Thomisus spectabilis* (Doleschall,1859), *Thomisus species* (Walekenaer,1805), *Lysiteles catulus* (Simon, 1895), *Diaea sp.* (Thorell,1869), *Thomisus okinawensis* (Strand, 1907)), *4 species of* jumping spiders from family Salticidae (*Bianor sp.* (Peckham & Peckham, 1886), *Thyene imperialis* (Rossi, 1846), *Phintella vittata* (C.L. Koch, 1846), *Phlegra sp.* (Simon, 1876), *2 species of* cob web spiders of family Theridiidae (*Theridula gonygaster* (Simon,1873), *Romphaea sp.*). Family Araneidae contributed one third spider population (34.6%) followed by Oxyopidae (27%) and Thomisidae (24.5%). The other families *viz.*, Salticidae, Tetragnathidae, Theridiidae had negligible share- 9.2, 3 and 1.84 per cent, respectively.

Pink bollworm parasitisation

Green bolls collected from RCH2 BG-II and Ajeet 155 BG-II hybrids in Waghvan and Katasayan villages, Hansot Taluka of Bharuch, Gujarat during first week of November, 2014 harbored parasitized pink bollworm. Mortality of pink bollworm due to the parasitoid *Apanteles sp.* ranged from 21.18 to 60.86%. This is the second larval parasitoid being reported from field population of pink bollworms collected, since 2013. The parasitoids that emerged from pink bollworms collected on BG-II did not show detectable cry toxins levels when tested using ELISA.

Adult of *Apanteles sp.*

Dead larvae of pink bollworm

Pupa of *Apanteles sp.*

Coimbatore

Entomopathogenic-endophytes

i. Endophytes and entomopathogens

Forty seven fungi were isolated as endophytes from cotton plants. Identification of the fungal organism was carried out by Agarkar Research Institute, Pune based on morphological characters. Based on the virulence studies, 12 isolates. (- *Ulocladium chartarum, Trichoderma pseudokoningi, Fusarium sp., Chaetomium* sp., *Colletotrichum gleosporioides, Cladosporium cladosporioides, Aspergillus terreus, Thielavia icainacearum, Aspergillus flavus, Trichoderma lacteum, Fusarium sporotrichioides, Paecilomyces* sp.) were shortlisted. Out of the 17 bacteria isolated as endophytes from stem and leaf parts of cotton plant, 9 virulant isolates were selected and utilized.

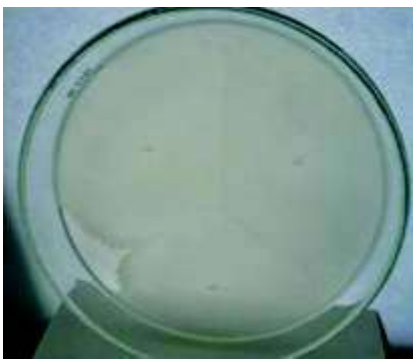
ii. Evaluation of endophytes against major insect pests of cotton

a. Pathogenicity of fungal endophytes : Conidial suspensions for experiments were obtained by scraping conidia from 15-day-old cultures on nutrient agar medium into an aqueous solution of 0.002% Tween 80. They were filtered through cheesecloth to remove mycelium and the concentrations of viable conidia containing $1x10^8$ counts was prepared and utilized for bioassay. Results of bioassay indicated that the highest mortality of 68.9% and 77.8% was recorded due to *Cladosporum cladosporioides* fungi on *P. gossypiella* and *P. marginatus,* respectively. In case of *A. gossypii*, highest mortality of 75.6% occurred due to *Thielavia icainacearum.*

b. Pathogenicity of bacterial endophytes: *In vitro* tests were carried out to test the pathogenicity of bacteria against insects using bacterial cells (500 µl) suspended in sterile distilled water. Results of the bioassay indicated that *Bacillus cereus* isolate HKS1-1 showed highest mortality of 55.6% and 73.3% against *S. litura* and *A. gossypii* respectively. *Bacillus* sp. E13 recorded highest mortality of 71.1% with *P. gossypiella.*

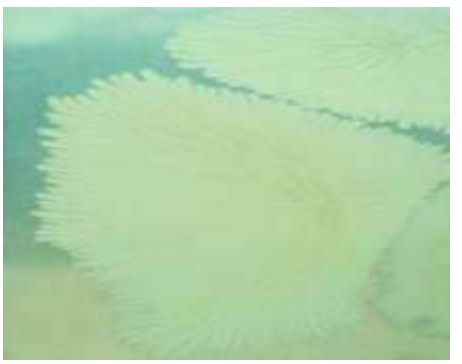
iii. Characterisation of bacterial endophytes and gut bacteria of *H. armigera*

Bacterial isolates were observed for its colour and shape of the colonies, gram staining reaction and endospore production and subjected to biochemical characterization - oxidase test, catalase test, cellulase activity test, motility test, starch hydrolysis test, siderophore production test, biofilm production, surfactin production and chitinase activity. Three types of motility behavior were observed in bacterial isolates. **Swimming motility :** *Bacillus* sp. E13, *Bacillus* sp. GutB2 and *Bacillus subtilis.* **Swarming motility :** *Bacillus* sp. B31, *Bacillus cereus* B1 and *Bacillus cereus* strain Z2. **Twitching motility :** *Bacillus cereus* strain S-1, *Bacillus cereus* strain S-11 and *Bacillus cereus* isolate HKS1-1.



Swimming motility

Swarming motility

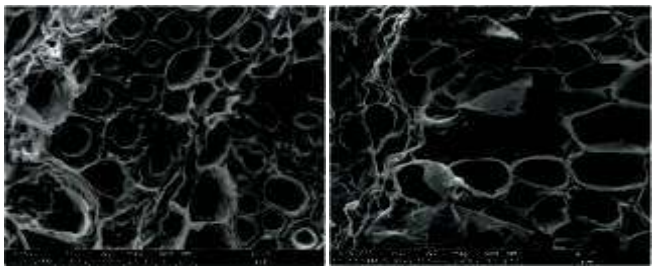


Twitching motility

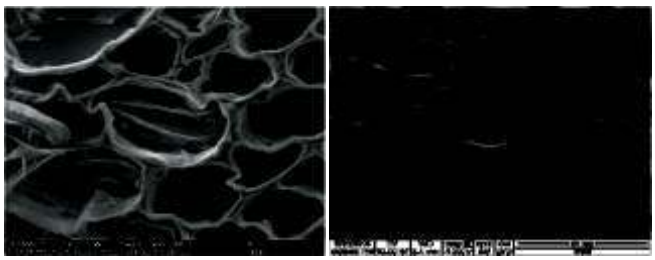
iv. Colonisation of bacterial endophytes on cotton plant

Foliar application on leaves followed by seed coating method yielded higher colonization by the isolate *Bacillus cereus* strain S-1. In stem portion, seed coating followed by soil drenching resulted in high colonization by *Bacillus subtilis.* In root parts of the plant, seed coating, seed immersion and soil

drenching methods showed high colonization with use of isolates *Bacillus cereus* strain S-1 and *Bacillus subtilis*.



Scanning electron microscope photograph on colonization of bacteria on root of cotton plant



Scanning electron microscope photograph on colonization of bacteria on stem of cotton plant

v. Efficacy of colonization of *B. bassiana* on cotton plant

Plant colonization was assessed through re-isolation of *B. bassiana* from the inoculated cotton plant during one month after inoculation. Per cent colonization was calculated as number of samples exhibiting *B. bassiana* outgrowth per total number of samples. Among the four inoculation methods, foliar spray method resulted in colonization efficiency of *B. bassiana* (up to 47%) in cotton leaf parts and 30% in stem. Soil drenching method gave colonization up to 23% in leaf and 20% in stem. Seed coating method gave colonization percentage up to 20 in leaf and 13 in stem. Irrespective of method and isolates, *B. bassiana* colonization was observed in leaf and stem parts of the cotton plant.

Scanning electron microscopy photograph showing *B. bassiana* colonization on cotton leaf

vi. Use of entomopathogenic fungi *Beauveria bassiana* as an endophyte for management of bollworm

Conidial suspensions for experiments were obtained by scraping conidia from 15-day-old cultures on Nutrient Agar medium into an aqueous solution of 0.002% Tween 80. The viable conidia containing $1x10^8$ was prepared and utilized for the bioassay experiment, while distilled water was utilized as control. Pathogenicity was evaluated against major insect pests of cotton under laboratory conditions. Eight isolates of *B. bassiana* showed high mortality of 73.3%,75.6% against *P. gossypiella*, and *A. gossypii* respectively.

Nematode biocontrol

A native isolate of nematophagous fungus, *Purpureocillium lilacinus* isolated from the rhizosphere of cotton recorded cent percent nematode suppression ability against reniform and root-knot nematode under laboratory condition . This isolate was formulated into a talc based product and stored at different temperatures. Formulation stored at refrigerated condition retained maximum spore viability. The formulation was evaluated under lab condition. More than 90 per cent colonisation of eggs of root knot and reniform nematode was recorded in 72 hours. Under liquid fermentation, potato dextrose broth at pH 8.00 and incubated at 25 ± 1 ^{0}C recorded maximum biomass and sporulation. Among solid substrates, rice grain supported maximum of 2.85 x 10^9 spores/g.

Formulation of entomopathogenic fungi

Formulations of four promising native entomopathogenic fungi *viz.*, *Lecanicillium lecanii, Metarhizium anisopliae, Fusarium pallidoroseum* and *Cladosporium cladosporioides* were developed. Talc based formulation and novel formulations with additive were prepared and stored at room temperature and refrigerated condition. Formulation developed with additives recorded maximum spore viability up to six months when stored at room temperature. Two formulations of *L. lecanii* and *M. anisopliae* were sent to 17 AICCIP centres for multi location testing.

3.24 Integrated Pest Management

Nagpur

Ecological selectivity of insecticides

Relative toxicity of insecticides against cotton mealybug *Phenacoccus solenopsis* and its fortuitous parasitoid *Aenasius bambawalei*

Nineteen insecticidal formulations from 10 groups of insecticides were evaluated for their relative toxicity against cotton mealybug *Phenacoccus solenopsis* and its fortuitous parasitoid *Aenasius bambawalei*. The mortality of *P. solenopsis* was higher with Profenophos 50% EC (95.78%) and Chlorpyriphos 20 % EC (91.23 %). Total mortality of *A. bambawalei* was observed with insecticides (Spinosad 45% SC and Acephate 75% SP). The relative baseline toxicity of insecticides aginst *P. solenopsis* was least with Thidicard 75% WP, Quinalphos 25 EC and Thiamethoxam. From the study Spinosad, Chlorpyriphos and Quinalphos were found to be extremely toxic to *A. bambawalei,* the application of which may be avoided for the control of *P. solenopsis*. Moderately toxic insecticide Thiodicarb was found effective against *P. solenopsis* and relatively least toxic to parasitoid.

Evaluation of yellow sticky traps for application in IPM

Whiteflies were (trap density 2 traps /1000 sq m area) trapped in large numbers during first week of September to first week of December. Jassids were trapped in large numbers throughout the season. Highest population of whitefly (158.8/trap/week) and jassids (1548.3/trap/week) was recorded during second week of November.

Pheromone trap catches

Nagpur

Highest number of male moths of American bollworm, tobacco caterpillar, pink bollworm and spotted bollworm were trapped during second fortnight of November, between last week of October to first week of November, 10-16 November and 3-9 November, respectively (Fig. 3.24.1).

Sirsa

The catch for pink bollworm was recorded during

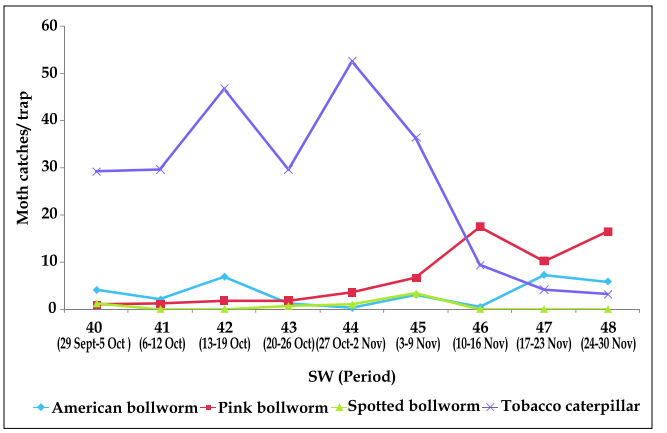


Fig. 3.24.1 : Pheromone trap catches during 2014-15 (Nagpur)

24-42 SMW and peak catch during 41 SMW (15.62/trap/week), for American boll worm peak catch was during 24-42 SMW and highest in 40th SMW (1.86/trap/week), for spotted bollworm peak catch was during 40th SMW (71.62/trap/week) and for tobacco caterpillar, the peak was during 40 SMW (67.67/trap/week) (Fig. 3.24.2).

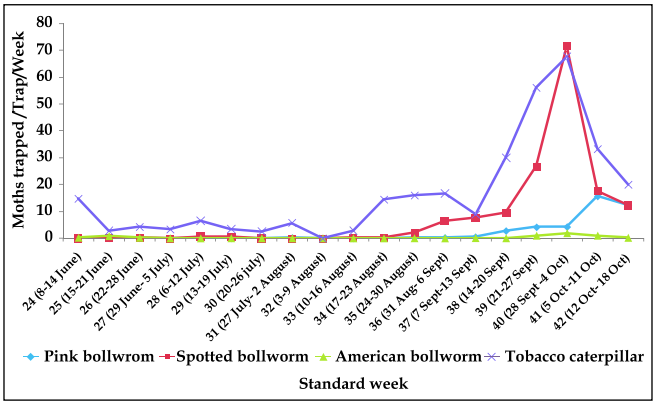


Fig. 3.24.2: Pheromone trap catches during 2014-15 (Sirsa)

Ecological selectivity of insecticides

Five insecticides - Clorantraniliprole 18.5 SC, Flubendiamide 480 SC, Spinosad 45% SC, Indoxacarb 14.5 SC and Emamectin benzoate 5 % SG were sprayed on cotton in a window strategy. Parasitization of mealybugs by *A. bambawalei* was not significantly different among the treatments. Spinosad sprayed plots suffered severe mealybug damage. One spray of spinosad (60 DAS) recorded the least incidence (68.3%) and severity index (1.99) of mealybugs. It increased progressively with 4

consecutive sprays done at 60, 60 and 80, 60, 80 and 60, 80, 100 and 120 DAS and reached 91.7% incidence and 2.95 severity index.

Insecticide Resistance Monitoring

Nagpur

Monitoring of Pink bollworm with Cry toxins

Resistance monitoring of c*ry1Ac* and c*ry2Ab* against pink bollworm populations was carried out. The lowest LC_{50} of c*ry1Ac* on pink bollworm recorded in Jalna @ 0.034 µg *cry1Ac*/ml of diet and Mansa @ 0.049 µg *cry 1Ac*/ml of diet as compared to susceptible population. The highest LC_{50} of *Cry1Ac* on pink bollworm was recorded in Khandwa @ 0.204 µg *cry1Ac*/ml of diet followed by Amreli (0.101 µg *cry1Ac*/ml of diet) and Akola @ 0.11 µg *cry1Ac*/ml of diet. The lowest LC_{50} of *cry2Ab* on pink bollworm was recorded in Faridkot (0.05 µg *cry2Ab*/ml of diet) followed by (Ahmednagar 0.06), Mansa (0.07 and Sirsa (0.074) µg *cry2Ab*/ml of diet. The highest LC_{50} of *cry2Ab* on pink bollworm was recorded in Khandwa (0.67 µg *cry2Ab*/ml of diet).

Pink bollworm bioassay

Pink bollworm larvae were collected from Surat, Bharuch, Vadodara, Bhavnagar, Amreli, Junagadh, Rajkot and Surendranagar district of Gujarat on different Bollgard-II. The collected green bolls from those locations brought into the laboratory and observed per cent larval recovery and locule damage, number of exit holes, number of mines on epicarp and damage and healthy seeds for seed purity with the help of ELISA and GUS test.

F_1 progeny were subjected to diagnostic assays of *Cry1Ac* and *Cry 2Ab* at 10 ppm, 1ppm, 1ppm and control. The highest per cent corrected mortality in 10 ppm of *Cry1Ac* was observed in Vadodara (BtR F2) @ 100.00 and Vadodara (BtS F1) @ 93.00. The lowest per cent corrected mortality was observed in Bharuch (BtS F1) @ 54.00 %. Thirty eight per cent larval survivals was recorded in Bharuch population at 10 ppm of *cry1Ac*.

Pink bollworm populations were collected from NBt from different location of India. The populations were exposed to *Cry1Ac* diagnostic assays. The population collected from Surat and Bhavnagar districts of Gujarat demonstrates 44% and 13 % survival on 10 ppm *Cry1Ac*. Forty four per cent survival was recorded with 10 ppm *Cry2Ab* in F_1 population of pink bollworm of Bharuch that was collected on Bollgard-II. Population of pink bollworm collected on NBt from Surat, Anand, Amreli and Junagadh demonstrated poor mortality on 10 ppm *Cry 2Ab* as compared to the susceptible strain.

Coimbatore

Insecticide resistance monitoring

Insecticide resistance monitoring studies were conducted against Jassids through leaf bioassays with four insecticides namely Flonicamid, Acetamiprid, Thiamethoxam and Imidacloprid at four concentrations such as 0.01 g/l, 0.05 g/l, 0.2 g/l and 1 g/l against the population collected from Coimbatore and Anthiyur of Tamil Nadu and two locations from Dharwad of Karnataka. Jassid populations from 4 locations were tested against Flonicamid. The LD_{50} value against the population from Dharwad location 1 and location 2 was varied from 0.002 to 0.004, however population from Anthiyur (Erode) and Coimbatore recorded slightly higher LC_{50} values of 0.030 and 0.048. Among the four populations tested against Acetamiprid, lowest LD_{50} value was recorded from Dharwad location I (2.0), followed by Coimbatore (0.07), Anthiyur (0.08) and Dharwad location II (0.22). Jassid population tested in 4 locations against thiamethoxam, and the population collected from Dharwad (location 1) recorded minimum LD_{50} value of 0.03. Populations from Coimbatore, Dharwad location II and Anthiyur recorded the LD_{50} value of 0.52, 0.76 and 1.63, respectively. Imidacloprid tested against 4 populations of jassids recorded minimum LD_{50} values in Dharwad location II (0.10), followed by Coimbatore (0.15), Dharwad location I (0.17). Maximum LD_{50} value of 0.42 was recorded in Anthiyur of Tamil Nadu (Fig. 3.24.3).

Bt toxin resistance monitoring

Pink bollworm populations collected from Coimbatore (NBt- Suraj), Srivilliputtur (NBt-DCH

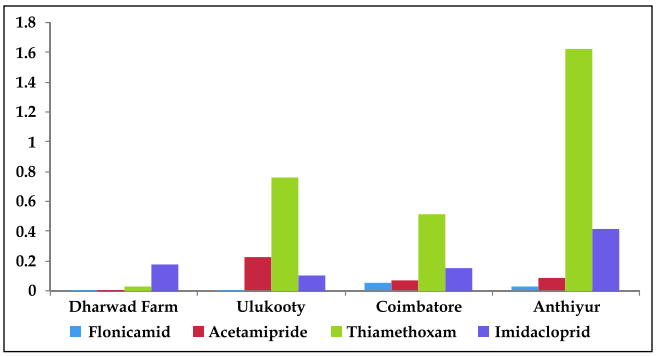


Fig. 3.24.3 : Insecticide resistance against jassids population from Karnataka and Tamil Nadu

32), Surat (Ajit 115 BG I, BG II and NBt G.Cot HY 12) were subjected to the bioassay in the F_1 generation through diet incorporation method. Coimbatore population was treated with *cry1Ac*, Srivilliputtur and Surat populations were treated with *cry2Ab*.

The mean boll damage caused by pink bollworm in NBt varieties (Suraj, DCH 32 and G. cot Hy12) was recorded as 98, 90 and 97 % in population from Coimbatore, Srivilliputtur and Surat, respectively. Whereas, in Bt hybrids, the boll damage was recorded as 88 and 86% in Ajit 115 BG I and Ajit 115 BG II respectively, in Surat. The locule damage caused by pink bollworm in NBt varieties (Suraj, DCH 32 and G. cot Hy12 NBt) was recorded as 65, 80 and 78 % in Coimbatore, Srivilliputtur and Surat, respectively. Whereas, in Bt hybrids the boll damage was recorded as 77 and 59% in Ajit 115 BG I and Ajit 115 BG II, respectively in Surat. The number of pink bollworm larvae per 10 bolls in NBt varieties (Suraj, DCH 32 and G. cot Hy12) were recorded as 28.1, 8.6 and 33.7 in Coimbatore, Srivilliputtur and Surat, respectively. Whereas, in Bt hybrids, the pink bollworm larvae/15 bolls were recorded as 19.2 and 19.8 in Ajit 115 BG I and Ajit 115 BG II respectively, in Surat.

LD_{50} and LD_{90} values for Coimbatore and Srivilliputtur populations were recorded as 0.02 and 0.33, 0.07 and 0.11, respectively. In Surat, populations, Ajit 115 BGI, BG II and G.cot Hy12 the LD_{50} values were recorded as 0.63, 0.20 and 0.07, respectively. However, it was observed that though the larvae from Ajit 115 BGI were treated with *cry2Ab* the LD_{50} recorded was higher (0.627) as compared to the LD_{50} of the population (0.196) collected from BGII (Ajit 115 BGII). Also, the LD_{50} values recorded for BGI was higher than BGII, followed by NBt (G. cot Hy 12) .

Cry1Ac, Cry2Ab resistance monitoring in *H. armigera*

Monitoring of changes in baseline susceptibilities in *H. armigera* were carried out using populations from 19 locations of Maharashtra and Gujarat.

Four populations from Gujarat recorded LC_{50}s ranging from 0.09 µg/ml of diet to 1.71µg/ml of diet with Cry1Ac. The LC_{50} of the same populations to Cry2Ab ranged from 5.47 µg/ml of diet to 12.87 µg/ml of diet. Fifteen populations from 10 locations of Maharashtra were subjected to bioassays with Cry1Ac and the LC_{50s} ranged from 0.0324 µg/ml of diet to 2.613 µg/ml of diet. EC_{50} for 9 populations ranged from 0.035 µg/ml of diet to 0.108 µg/ml of diet to Cry1Ac. Ten populations from 8 locations were tested with Cry2Ab and the LC_{50} ranged from 18.85 µg/ml of diet to 87.89 µg/ml of diet and the EC_{50} to Cry2Ab of 5 populations ranged from 0.347 µg/ml of diet to 4.60 µg/ml of diet.

Sirsa

Role of epicuticular wax on whitefly and CLCuD incidence

Screening of germplasm lines for whitefly, CLCuD was done. The lines were categorized based on whitefly and CLCuD incidence. On the basis of incidence, I category, maximum whitefly (38.2-46.8/3 leaves) and maximum CLCuD (100%), 2nd category low whitefly (19.0-22.6 /3 leaves) and high CLCuD (100%), 3rd category, low whitefly (11.0 to 23.4/3 leaves) and low CLCuD (43.2-61.6%) were made. The quantity of wax among these lines ranged between 38-66 µg/cm^2 in Ist category, 23-101 µg/cm^2 in 2nd category and 291-368 µg/cm^2 in 3rd category.

Innovative interventions for leaf curl management

Based on the experiment conducted during 2014

with 16 treatments and control, five shortlisted interventions i.e. cow urine, kresoxim methyl, calcium nitrate, whey protein and neem oil along with their combinations were tested. Treatment having combination of cow urine and calcium nitrate showed significantly lowest CLCuD incidence followed by neem oil, cow urine + whey protein, cow urine alone, all five interventions in combination and kresoxim methyl + whey protein. In case of PDI, most of the interventions showed numerically lower PDI as compared to control. The lowest PDI was observed in kresoxim methyl+ neemoil followed by calcium nitrate +neem oil and cow urine +neem oil. Maximum seed cotton yield was observed when a combination of cow urine and kresoxim methyl was used followed by cow urine + neem oil and cow urine alone. Based on average of 4 sprays of these interventions, maximum reduction of whitefly was observed in neem oil treatment followed by those combinations where neem oil was one of the components.

Lab and field monitoring of resistance in bollworms against Cry toxins

Isofemale lines (110) from *Earias insulana* population of Sriganganagar were screened for presence of rare resistance allele. Screening of F_2 generation results in 0-40.0 % survival at dose 0.13 µg/ml by 13th day but all the lines died by 19th day after bioassay. LC_{50} of *Cry1Ac* ranged from 0.19 to 1.93 µg/ml of diet for *H. armigera* population. LC_{50} of *Cry1Ac* for *H. armigera* population from Sardulgarh district found to be highest (1.93 µg/ml of diet). LC_{50} of *Cry1c* ranged from 2.25 to 7.28 µg/ml of diet for *H. armigera* population and highest being found for population from Hisar (7.2 µg/ml of diet).

Bollworm adaptability to Bt cotton

Plants expressing only Cry1Ac, Cry2Ab, Cry1Ac and Cry2Ab and non Bt were derived from Bunny BG II through ELISA of single open bolls. Bolls carrying homozygous seeds for each were identified using gene specific primers in PCR.

For determining the allele frequency in Maharashtra, 486 isofemale lines were set up with populations collected on crops other than Bt cotton from 12 districts. The number of isofemale pots (486) were set up as follows: Yavatmal 48, Wardha 30, Washim 46, Hingoli 13, Aurangabad 41, Parbhani 102, Jalna 44, Nanded 53, Buldana 26, Amravati 29, Akola 40 and Nagpur 122. Hatching occurred in 88 pots and a total of 50 bioassays were carried out each with Cry1Ac and 2Ab diagnostic doses in the F_1 generation and 15 bioassays each with Cry1Ac and Cry2ab in the F_2 generation. Seven putatively resistant strains to Cry1Ac: YavA24, JalG37, Amr J27, Akola A3, Nanded H9, Parbhani A12 and A 26 in the F_1 generation were identified of which Akola A3 was tolerant to Cry1Ac and Cry2Ab while Parbhani A26 was susceptible to both Cry1Ac and Cry2Ab.

For determining the allele frequency in Gujarat, 395 isofemale lines were set up with *H. armigera* culture collected on red gram from 9 locations of Gujarat (Vadodara, Anand, Baruch, Ahmedabad, Bhavnagar, Amreli, Rajkot, Junagadh and Surendranagar). Hatching was recorded in 48 pots and bioassays were carried out with the F_1 neonates that were obtained in sufficient numbers in 25 pots and bioassays were continued in the F_2 generation with neonates obtained from 13 pots. While isofemale lines B50 (from Anand), G18 (Rajkot), H30 (Junagadh) and I69 (Surendranagar) showed lower corrected mortality (<50%) with 1.97 ug of Cry1Ac/ml of diet in the F_1 and F_2 generation the rest of the bioassays demonstrated susceptibility. All the lines tested in the F_1 and F_2 generation with Cry2Ab showed poor mortality with the highest concentration of Cry2Ab.

Monitoring of PBW was done in North zone in 4 districts (Faridkot in Punjab; Sriganganagar in Rajasthan; Hisar and Sirsa in Haryana) for recovery of PBW larvae through dissection of green bolls plucked at various stages of crop growth. Green bolls 60-150 each from different varieties (RCH 134 BGII, RCH 134 Bt, GA and HS6) were collected at 120, 140, 160 and 175 DAS as per the availability of bolls. PBW larvae were not recovered in RCH 134 BGII and RCH 134 Bt hybrids at any location. In case of non-Bt varieties at 120 DAS recovery (%) of PBW larvae ranged between 4-16. At 140 DAS, it was between 12.5-19.2. At 160 DAS, however the range was 15.8 – 23.3 and at 175 DAS it was 11.7 – 26.7% respectively (Fig. 3.24.4)

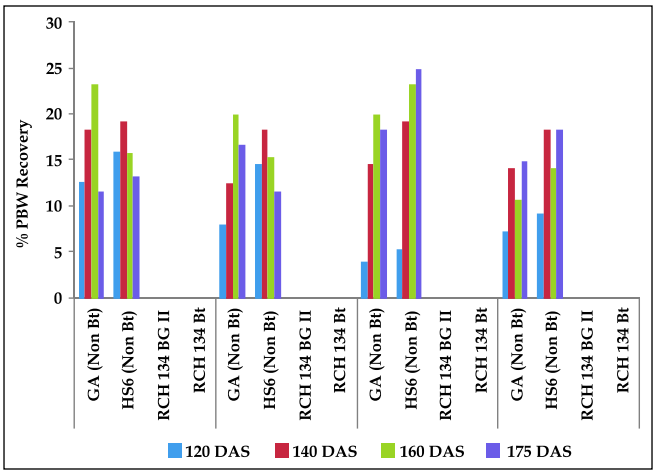


Fig. 3.24.4 : Larval recovery of pink bollworm at different interval

3.25: Simulation Model

Yield influencing parameters includes rainfall, temperature, solar radiation at germination, vegetative growth and reproductive phase, incidence of sucking pest and bollworms, times of sowing (early, normal and late on the onset of monsoon), soil depth and environment (irrigated or rainfed) were scored from 0 to 10 based on degree of influence at different growth periods. The highest score was awarded to optimum points and reduced scores were awarded both for higher and lower sides. Yield and influencing factors of contrasting places *viz.* Coimbatore, Parbhani, Akola, Hisar, Rahuri, Guntur, Dharwad and Faridkot were selected for scoring. The individual score of the different parameters were multiplied and cumulative score was made for different years. The score was correlated with yield data and model was developed by regression approach. The following shifted power model was developed for prediction.

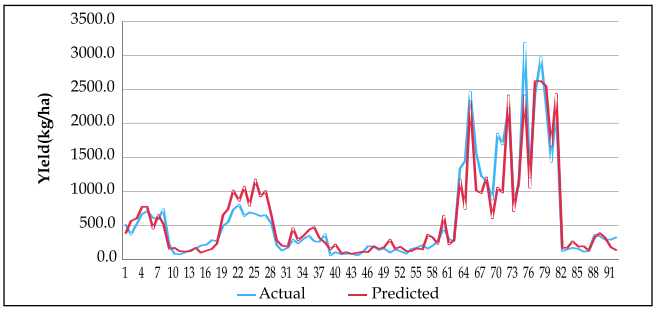


Fig 3.25.1 : Yield prediction model through regression model

β version of the ICAR-CICR yield prediction model has been develop-ed using yield responsive factor. The validation of the model is underway. The CICR calculator helps determine the cotton crop yield by selecting a set of input parameters. Parameters such as rainfall, temperature, depth of soil, sowing time, solar radiation, sucking pest, bollworm and water logging are the main input factors used by the software. The interface provided is user friendly.

3.26: Host Plant Resistance

Volatiles induced in response to leaf hoppers and semiloopers in *G.arboreum*, Phule Dhanawantary.

Ten biotic stress responsive genes were shortlisted- Ethylene responsive factor 1 (ERF 1), ERF 2, ERF 3, Terpene synthase 1 (TPS 1), TPS 2, TPS 3, alpha pinene, Lipoxygenase1 (LOX1), Allene oxide synthase (AOS6), Jasmonate methyl transferase (JHTr). Their expression levels were studied under q PCR, using Ubiquitine 7 (ubq7) as the reference gene. Leaf hoppers and semiloopers were used separately as biotic stress inducers in 60 day old *G. hirsutum* (RCH2) and *G. arboreum* (Phule Dhanawantary) under caged net house conditions. Gene expression was studied 48 h, 72 h, 96 h and 120 h after release of insects. Jasmonate methyl transferase was significantly induced in leaves of Phule Dhanawantary in response to leaf hopper damage upto 120 h after release. Allene oxide synthase, Alpha pinene and LOX1 were induced upto 96 h after release. Up-regulation of all the genes were recorded in response to semiloopers in Phule Dhanawantary upto 72 h. The experiment was concluded at 72 h as all the leaves were eaten by the pest after 72 h. In *G. hirsutum*, RCH 2, alpha pinene and JHTr were the two genes that were induced 72 h after jassid release.

To summarise G. *arboreum* (Phule Dhanawantary) responds differently to biotic stress, in terms of volatile emission as compared to *G. hirsutum*, under caged condition that give us new leads in the area of sucking pest management.

Ethylene emission data of 5 genotypes of cotton

raised from Gaucho treated seed and untreated seed

Five genotypes (RCH 2BGII, Phule Dhanawantary, Suvin, PKV081, and *G. arboreum cernnum* race) representing *G. hirsutum* hybrid, *G. arboreum* variety, *G. hirsutum* variety, *G. barbadense* variety and a *G. arboreum* race were raised using imidacloprid treated and untreated seed. Temporal variation in ethylene emission was recorded from these genotypes using the ethylene detector. Diurnal variation in ethylene emission was recorded with emission being at least 4 fold higher (at 75DAS) in the morning as compared to the evening with differences between varieties also being significant both in the morning and evening.

Ethylene mission was significantly higher in the evening over morning and peaked 75 DAS in all the genotypes, with Phule Dhanawantary, a jassid tolerant *desi* variety recording the highest emission.

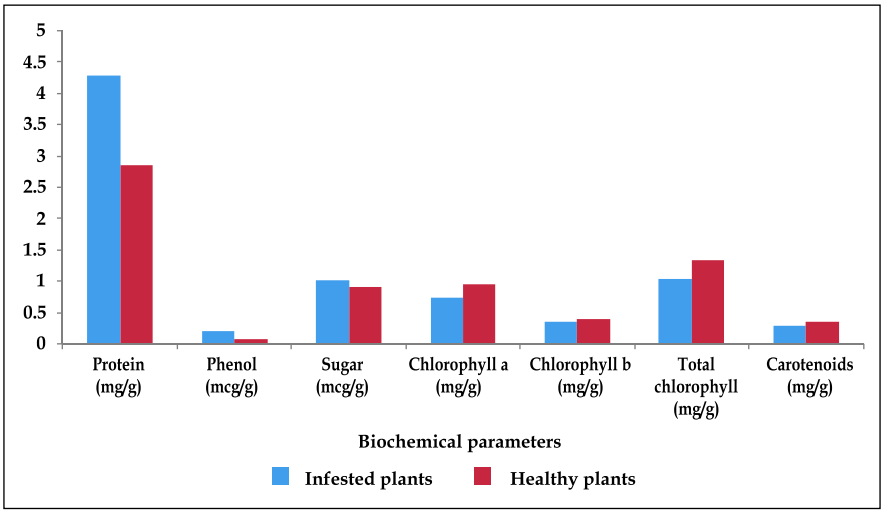
To summarise, *G. arboreum* (Phule Dhanawantary) was unique in its response to biotic stress (leaf hopper damage) by emitting higher ethylene at 75 DAS.

Technology generated based on this finding: Having *G. arboreum* in every alternate row of a *G. hirsutum* field is expected to ward off leaf hoppers from *G. hirsutum*.

Biochemical changes in cotton plant due to infestation by cotton mealybug *Phenacoccus solenopsis* Tinsley

Protien, phenol and sugar were estimated from shoot while chlorophyll and carotenoids were estimated from leaves of mealybug infested and healthy plants.

Total protein contents of the healthy and infested cotton plants shows significant difference. The increase in total protein content was recorded as high as 50.52 % in the mealybug infested cotton plant (4.29±0.24 mg/g) over the healthy cotton plant (2.85 ± 0.43 mg/g). The infestation by *P. solenopsis* resulted increase in the total phenol content in the mealybug infested plants (0.19 ±0.03 mcg/g) over the healthy cotton plants (0.07 ± 0.01 mcg/g). The level of total soluble sugar was increased marginally by 11.11% in the mealybug infested plant (1.00 ± 0.35 mcg/g) but was not statistically different as compared to healthy cotton plant (0.90 ± 0.28 mcg/g). Total photosynthetic pigments were estimated using leaf of the mealybug infested and healthy cotton plant. Though there was depletion in all the photo-synthetic pigments *viz.*, chlorophyll a, chlorophyll b, total chlorophyll and carotenoids due to the mealybug infestation however, values were not statistically different than the values of healthy cotton plants. The decrease in photosynthetic pigments chlorophyll a, chloro-phyll b, total chlorophyll and carotenoids was 21.70%, 11.56 %, 21.42%, 17.54 %, respectively (Fig. 3.26.1).



Fig, 3.26.1: *P. solenopsis* induced biochemical changes

4. TECHNOLOGY ASSESSED AND TRANSFERRED

Technology Transfer

IRM-HDPS

The Insecticide Resistance Management / High Density Planting System module is being implemented by CICR, Nagpur through SAU's, ICAR and recognized agriculture organizations in collaboration with State Department of Agriculture. These strategies were implemented in specific districts of 11 cotton growing states depending on pest situation *viz.* Punjab, Haryana, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Tamil Nadu and West Bengal. The total area covered was 5924.81 hectares with 5568 farmers.

During the year 2014-15 IRM module was implemented in 7 major cotton growing states *viz.* Haryana, Gujarat, Madhya Pradesh, Maharashtra (Nagpur, Wardha, Akola), Andhra Pradesh, Tamil Nadu and West Bengal. The total area covered was 4829.19 hectares under 89 villages involving 3818 farmers.

The average additional profit estimated due to implementation of IRM technologies was Rs. 11773.2 per farmer. The average number of sprays for IRM and Non IRM field were 3.1 as against 5.6 of Non IRM. The yield was 15.63 q/ha in IRM against 14.25 q/ha in case of Non IRM. The average profit per farmer was counted to Rs. 32600 for IRM farmers as compared to Rs. 23250 for Non IRM farmers. The average cost of spray was reduced to Rs.3137.16 per hectare in IRM fields as against Rs. 5395.25 per hectare that was incurred in Non IRM.

HDPS (High Density Planting System) program was dovetailed along with the IRM program this year. In the former, non Bt varieties were promoted for cultivation under shallow soils in the rainfed cotton growing regions. Seeds were procured and distributed by CICR, package of practices were also provided. Bollworm management was crucial under HDPS as the varieties were of non BT. The technology of HDPS elicited great interest across the country. Farmers were convinced about the feasibility of the technology especially under rainfed shallow soil situation.

HDPS module was implemented in 11 major cotton growing states *viz.* Punjab, Haryana, Gujarat, Rajasthan, Madhya Pradesh, Maharashtra, undivided Andhra Pradesh, Odisha, Karnataka, Tamil Nadu and West Bengal. The total area covered was 131 villages under 1095.62 hectares with 1750 farmers. The range of seed cotton yield in each State is given in Table 4.1.

Table 4.1: The range of seed cotton yield (q/acre) in each state across India during 2014-15

Sr. No	State/Centre	Yield of cotton	
		Minimum	Maximum
1	Punjab	5.21	11.61
2	Haryana	5	12.60
3	Rajasthan	4.75	10.25
4	Madhya Pradesh	2.83	6.07
5	Maharashtra, Akola	0.50	8.00
	Maharashtra, Wardha	3.02	7.06
6	Andhra Pradesh	1.1	14.2
7	Odisha	6.9	13.8
8	Karnataka, Dharwad	3	16
9	Tamil Nadu	5.40	7.53

Extension Activities

A total of 136 extension programs were conducted which includes farmer trainings, training of scouts and field days in various IRM villages. Around 489 farmer meetings were conducted. As a part of the project implementation, about 814 field visits were conducted by the District co-ordinators and Field assistants in all the adopted villages to assess the pest load, to train farmers in identification of different pests and diseases and also to promote the advantages involved with IRM strategies.

Table 4.2: Summary of extension activities carried out in IRM/ HDPS villages across India during 2014-15

States/Districts	Extension programme				
	Field visits	Farmer meetings	Field day	Training of scouts	Farmer Training
Punjab	17	16	1	--	1
Haryana	71	12	2	--	1
Rajasthan	11	08	1	--	3
Maharashtra, Akola	38	28	3	--	4
Maharashtra, Wardha	12	41	1	3	6
Maharashtra CICR, Nagpur	27	17	--	--	11
Maharashtra, Parbhani	10	07	--	1	2
Madhya Pradesh	310	282	--	--	19
Andhra Pradesh (including Telangana) Hyderabad	160	29	--	--	45
Odisha	10	5	--	2	--
Karnataka, Raichur	65	26	2	--	14
Karnataka, Dharwad	9	2	--	2	--
Tamil Nadu	44	6	--	1	3
West Bengal	30	10	2	1	5
Total	**814**	**489**	**12**	**10**	**114**

A total number of 15 Technology Chart, 8 Manuals/popular articles, 4287 Pamphlets, 73 Press releases, 43 Radio talk, 27 TV shows and 12 Field Schools were adopted for dissemination of information.

CROPSAP

Disseminated cotton pest management strategies through ICT tools under Crop Pest Surveillance and Advisory Project (CROPSAP) has been executed in 28 districts of Maharashtra. Updated pest management strategies for target cotton pests namely sucking pests were monitored through real time pest data uploaded on website. Made 18 personal visits (in 14 districts of Maharashtra), analyzed pest situation weekly, alerted and issued advisories wherever required during the crop season.

On Farm Demonstrations in Cotton

Five promising cotton technologies were assessed through on farm demonstration in the CICR, Regional Station, Coimbatore. Enhancement of planting quality of seed through seed priming, transplanting technique, foliar nutrition and bio-pesticide formulation against sucking pests were demonstrated in cotton variety Suraj. Additionally, the High Density Planting System technology was demonstrated in cotton varieties Anjali and Suraj.

5. TRAINING AND CAPACITY BUILDING

5.1: Education

Ph.D. study leave

Mr. K. Velmourougane, Scientist (Microbiology) and Mr. A. Sampath Kumar, Scientist (Pathology) have been deputed for Ph.D. programme at IARI, New Delhi and TNAU, Coimbatore respectively.

Joining after study leave

Mr. M. Sabesh, Scientist, Computer Applications joined office on 8th October 2014 after the completion of his Ph.D. study leave.

5.2: Training

5.2.1: Training Received

Name of the officials	Name of the course/training	Place	Period
Mr. Joy Das Mr. Rakesh Kumar	Professional attachment training for ICAR scientists	IIHR, Bangalore	12.05.2014 to 13.08.2014
Dr. A.H. Prakash	MDP on Leadership Development (Pre-RMP Cadre)	NAARM, Hyderabad	01.12.2014 to 12.12.2014
Dr. M. Amutha	Functional Insect Pest Management	Tamil Nadu Agricultural University, Coimbatore	02.12.2014 to 22.12.2014
Dr. A. Manikandan Dr. H. B. Santosh	Cotton Spinning	CIRCOT, Mumbai	05.01.2015 to 09.01., 2015
Dr. D. Kanjana	Nanotechnology tools for crop health and risk assessment techniques	Tamil Nadu Agricultural University, Coimbatore.	04.02.2015 to 13.02. 2015
Dr. A. Manikandan	Role of Scientists in Natural Resources and Environment Management	IIFM, Bhopal	16.02.2015 to 20.02. 2015
Mr. Joy Das	Recent Advances in Statistical Genetics	IASRI, New Delhi	03.02.2015 to 23.02.2015

5.2.1: Training Imparted

International training

C-4 Countries In-country training on Modern Cotton Production technology

An In-country Training program on 'Modern Cotton Production Technology' for C-4 countries (Benin, Burkina Faso, and Chad) was conducted under the Technical Assistance Programme for Africa by Dr. D. Monga, Head, Regional Station CICR, Sirsa and Dr. D. Blaise, Head, Crop Production, ICAR-CICR, Nagpur. The trainings were conducted on 4-5 August in Cotonou, Benin; 8-9 August in Moundou, Chad and 12-13 August 2014 in Ouagadougou, Burkina Faso facilitated by the Nodal Officers of the Cotton TAP in the respective countries. A total of 78 participants were trained during this In-country training programme (26 from Benin, 32 in Chad and 20 in Burkina Faso). The training module comprised country perspectives, modern cotton production practices, pest management and innovative technologies. There was active interaction and participation by the trainees during the two day long training programmes in each country.

Participants at Cotonou, Benin along with Dr. Alice Igue, Nodal Officer, Cotton TAP for Benin

Visit to cotton fields at Mondou, Chad along with Dr. Nomaye, Nodal Officer for Cotton TAP in Chad and Master Trainers Dr. Carrolle and Helene

In county Training for Implementation of Cotton Technical Assistance Programme (TAP) under Indo-Africa Forum Summit-II

Dr. K.R.Kranthi, Director, CICR and Dr. M.V.Venugopalan, Principal Scientist (Agronomy) visited Malawi and Uganda from Dec. 13 to 23, 2014 for implementation of Cotton Technical Assistance Programme (TAP) under Indo-Africa Forum Summit-II. The purpose of visit was to impart training entitled "In country Training Programme on Modern Cotton Production Technology" under TAP. In Malawi the training workshop was held at Machinga Agriculture

Participants of training on Modern cotton Production Technologies from Uganda along with Ms. Jolly Sabune, CEO. Cotton Development Organization, Uganda, Dr. K. R. Kranthi, Director CICR and Dr. M. V. Venugopalan Principal Scientist, CICR, Nagpur

Development Division, Liwonde and was attended by 27 participants. In Uganda training programme was held on Dec. 18 and 19, 2014 at Cotton Development Organization, Kampala, Uganda. Dr. Kranthi shared his knowledge and experience on pest and disease identification and management, technology of GM crops and Bt cotton. Dr. Venugopalan made a presentation on 'Modern Cotton Production Technology' and covered aspects as conservation agriculture, nutrient deficiency diagnosis, soil testing, integrated nutrient management and good agronomic practices.

National Training

Orientation Training Programme on IRM/ HDPS to State Agricultural Officers

One day training programme on Insect Resistant Management under High Density Planting System (IRM/HDPS) was organized by CICR, RS, Coimbatore on 30th of May 2014. The training programme aimed to provide the technical details and guidelines on IRM/HDPS to the Agricultural Officers from the IRM/ HDPS implemented districts of Tamil Nadu. The training programme was conducted by Dr. (Mrs) B. Dhara jothi, Principal Scientist and IRM State Coordinator (Tamil Nadu). Project Co-ordinator and Head, CICR, RS, Coimbatore Dr. A. H. Prakash chaired

the session. The trainees comprised of Deputy Directors of Agriculture, Assistant Directors of Agriculture, Deputy Agricultural Officers, Agricultural Officers of Perambalur, Virudhunagar, Salem and Coimbatore districts of Tamil Nadu state. Dr. A. H. Prakash, Project Coordinator and Head briefed about the importance of public sector varieties and their effective utilization for the sustainable cotton production. He also highlighted the current problems faced in cotton cultivation and the necessity to revive the production system by adopting new techniques such as High Density Planting System for increasing the cotton yield with minimum cost.

Lectures were also delivered by Dr. (Mrs) B. Dhara jothi, IRM State Co-ordinator of Tamil Nadu and Principal Scientist Entomology on "Project implementation and dissemination of IRM strategies under HDPS" and by Dr. K. Sankaranarayanan, Principal Scientist, CICR, RS, Coimbatore on "Agronomical aspects of HDPS". Dr. S. Usha Rani, Senior Scientist delivered a lecture on the novel method of disseminating the useful cotton cultivation tips to the farmers through e-Kapas. The participants were actively involved in the discussions and clarified many of the queries related to HDPS.

Training on HDPS Cotton Cultivation at Pusad

Scientists of CICR Nagpur Dr. A. R. Raju, Dr. Suman Bala Singh and Dr. Vishlesh Nagrare participated in the training on HDPS cotton cultivation jointly organized by Vasantaro Naik Smriti Pratishan and Agriculture Department, Govt of Maharashtra, at Pusad, District Yeotmal on 3rd June 2014. Dr. Raju delivered talk on how to sustain livelihood of farmers with cotton cultivation along with other allied farming activities. Dr. Suman Bala Singh delivered a talk on suitable varieties for HDPS while Dr. Nagrare elaborated pest and disease management strategies under HDPS as well as in Bt cotton. Shri Dipak Asegaonkar, Chairman, Vasantaro Naik Smriti Pratishan,Pusad, presided over the training. Shri Wankhede, Sub Divisional Agriculture Officer, Pusad coordinated the training. About 125 farmers mainly HDPS beneficiaries of ensuing crop season from 4 Talukas *viz.*, Pusad, Mohagoan, Digras and Umarkhed participated in the training.

Training programme for Tribal Cotton Growers

A training programme on "Integrated Cotton Management Practices" for tribal cotton growers was conducted at CICR Regional Station, Coimbatore during July 03-04, 2014 under All India Coordinated Research project on Cotton (AICRP) – Tribal Sub Plan (TSP). Twenty tribal cotton growers from Sadivayal, Thondamuthur villages of Coimbatore District participated in the two days programme. In all 12 lectures by scientists and a field visit was under the arranged programme. The importance of quality cotton seed for higher productivity, physiological disorders of cotton and their management and agro techniques for increasing the yield in cotton were dealt well in the training. In addition information was given on the novel technology – High Density Planting System (HDPS) in cotton. Information on IPM / IRM strategies, emerging pests and their management and nematodes management were also given to the trainees. The trainees visited the trials of pruning techniques in the CICR farm. The trainees were explained about e-Kapas network and all of them joined willingly in the e-Kapas programme. The researchable problems in cotton were identified with the participation of farmers in Best Cotton Cultivation Programme.

An on-campus training programme was also conducted for 20 tribal cotton growers from Senkuttaiyur, Coimbatore on 07.07.14 and 08.07.14 at CICR, Coimbatore under AICRP cotton.

Farmers Training Programme on IRM/HDPS

A training programme on Cotton High Density Planting System was demonstrated for rainfed crop in Tamilnadu by Central Institute for Cotton Research, Regional Station, Coimbatore with collaboration of MYRADA, KVK, Gobichettipalayam at Vellithiruppur and Mathur villages of Andhiyur Block, Gobichettipalayam Taluk, Erode District on 27th August 2014. The farmers were trained by Dr. (Mrs). B. Dharajothi, Principal Scientist and State Co-ordinator of the project and Dr. S. Usha Rani, Senior Scientist, CICR, Regional Station, Coimbatore. The gathering was addressed by the scientists about the method of planting, critical steps to be followed in the crop production and protection, advantage of High Density Planting System and methods for the sustainable cotton production. Officials from MYRADA, KVK Mr. R. D. Srinivasan, Plant Protection specialist, Mr. K Sekar, Soil Science specialist, Mr. N. Shivappa, Manager and Mr. P. Thirumurugan, Helper interacted with farmers and explained about the advantage of cotton cultivation under HDPS.

Later a practical demonstration in the farmers field was conducted wherein the scientists demonstrated the new method of sowing with modified spacing under High Density Planting System. A training handout explaining the technique in detail and other training materials were also provided.

Field Workers Training on IRM/HDPS

Field workers engaged under the project NFSM-IRM/HDPS project were offered training on IRM/IPM and HDPS at CICR, Regional Station Coimbatore on 5th September 2014. The field workers were briefed in detail about identification of pests of cotton, damage symptoms etc., through power point presentations by Dr. B. Dharajothi, Principal Scientist and State Coordinator of the project. Also the methodology of data collection in the project villages was explained in detail. Handouts with the information on the cotton pest management and pest identification were also provided.

Farmers' training on IRM/HDPS under NFSM

A training programme on IRM – HDPS on cotton under NFSM-IRM project was organized at CICR, Regional Station, Sirsa. 95 farmers including farmers who had taken up demonstration trials also attended the training programme. Dr. Monga, Head, CICR, RS, Sirsa discussed in detail about the HDPS in cotton and its production technology.

FOCARS (NAARM Scientist- Training)

The trainees after their study, conducted village seminar and had a public interaction in presence of staff of KVK, CICR, Nagpur. Seminar was held at Institute also, where the trainees shared their experiences of the village. They were taken for industrial visits to Bajaj steel industries, Morarji textiles and other sister institutes such as Ginning Training Center, Central Citrus Research Institute and National Bureau of Soil Survey and Land Use Planning. Dr. V. Santhy, Senior Scientist co-ordinated the complete programme.

6. AWARDS AND RECOGNITIONS

Awards

Young Scientist Award

Dr. S. Usha Rani, Sr. Scientist, CICR, Regional Station, Coimbatore was conferred with **"Young Scientist Award" by** the Society of Extension Education, Agra for the outstanding contribution in the field of Extension Education at 7th National Extension Education Congress held at ICAR Research Complex for NEH Regions, Umiam, Megalaya during 8-11, November 2014.

Achiever Award 2014

Dr J. Gulsar Banu, Principal Scientist (Nematology), CICR, Regional Station, Coimbatore received Achiever Award, 2014 by Society for Advancement of Human and Nature, Dr.Y.S. Parmar University of Horticulture and Forestry, PO Nauni, Solan, Himachal Pradesh.

Best Paper Award

Dr. SESA Khader & Dr A.H. Prakash received ISCI best paper award 2014 for the paper titled "Pruning technique for second fruiting cycle in cotton crop".

ISA Best Poster Award

Dr. P. Nalayini, Principal Scientist (Agronomy), CICR, Regional Station, Coimbatore received Indian Society of Agronomy Best Poster award for the research paper "Cotton based double cropping system for enhancing the production use efficiency under irrigated agro - ecosystem of southern India" presented in the National Symposium on Agricultural Diversification for Sustainable Livelihood and Environmental Security, November 18-20, 2014, PAU, Ludhiana.

Recognitions

ISO 9001-2008

ICAR-CICR was formally awarded the ISO 9001-2008 certificate on 2nd December, 2014 at CICR,

Nagpur. Dr K. R. Kranthi, Director, CICR, received the certificate from Dr. Rajesh Lakhe, Director, Shreyas Quality Management System, Nagpur. Mr. Sachin Agnihotri, Senior Administrative Officer, Dr. Sandhya Kranthi, Head, Crop Protection Division, Dr. D. Blaise, Head, Crop Production Division, Dr. Suman Bala Singh, Head I/c, Crop Improvement Division, Dr. S. B. Nandeshwar, I/c Biotechnology and Dr. S. N. Rokde, I/c FACO and all the Scientists were present.

Fellow of Indian Society of Agronomy - 2014

Dr. M.V. Venugopalan, Principal Scientist (Agronomy) was elected as the Fellow of the Indian Society of Agronomy (ISA), New Delhi during the "National Symposium on Agriculture Diversification for sustainable livelihood and Environmental Security" on 18th Nov. 2014. The award was conferred in recognition of his pioneering research in the kinetics of polypho sphate fertilizers in Indian soils, carbon sequestration in rainfed land use systems, Info-Crop - cotton simulation modelling and its application in forecasting regional cotton production, and the development of High Density Cotton Production Systems for enhancing productivity on marginal soils under rainfed conditions.

7. LINKAGES AND COLLABORATIONS

MoU with IGKV, Raipur

The ICAR- Central Institute for Cotton Research, Nagpur has signed MoU with the Indira Gandhi Krishi Vishwavidyalaya, Raipur on 5th January 2015 for facilitating student's training/ post-graduate research work leading to the award of M. Sc./ Ph. D. degree of the above university.

Linkages

Areas of Linkages	Institution
NATIONAL	
Fibre testing, fibre quality evaluation and nanotechnology	CIRCOT, Mumbai
Multi-location testing of promising cultures, Bt cotton evaluation	AICCIP (21 centres)
Germplasm collection, maintenance and plant quarantine clearance	NBPGR, New Delhi
Seed technological research and breeder seed production	NSP, New Delhi
DNA fingerprinting of cotton	NRC DNA Fingerprinting, 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	CIAE, Bhopal, Precision tools, Nagpur
Decision support system for major insect pests of rice- and cotton-based cropping systems	CRIDA, Hyderabad
Testing of biofilmtechnology in cotton, *G. arboreum* and *G. hirsutum* and evaluation of nano pyridalyl against lepidopteran pests of cotton	Indian Agricultural Research Institute, New Delhi
Vision-based expert system for picking of cotton	IIIT&M, Gwalior; Jamia MiliaIslamia University, Delhi; CMERI-CoEFM, Ludhiana

8. AICRP ON COTTON

Identification of Cotton Genotypes for Release

During the year 2013-14, seventeen cotton cultivars/hybrids were identified by the Central Variety Identification Committee for various agro-climatic zones

Sr. No.	Variety/ Hybrid	Region identified for release
1	**TSH 0250 (*Hirsutum* Culture)**	The genotype has yield advantage of more than 20 per cent over both the check varieties. Genotype is spinnable to 50s to 60s count yarn. It is identified for release in South Zone States under irrigated conditions.
2	**Swadeshi 651 (*Desi* hybrid)**	The hybrid has 14% higher yield over both the check with fibre fineness of 6.4 micronaire and is found suitable for absorbent purpose. It is identified for release in Central Zone States of Maharashtra, Madhya Pradesh, and Gujarat under rainfed condition s.
3	**NACH 18 (*Desi* hybrid)**	The hybrid was superior to both the check hybrids in terms of seed cotton yield. The fibre is coarse with 5.8 micronaire and is suitable for absorbent purpose. It is identified for release in Central Zone States of Maharashtra, Madhya Pradesh and Gujarat under rainfed condition.
4	**NACH 18 (*Desi* hybrid)**	The hybrid was superior to both the check hybrids in terms of seed cotton yield by more than 50 per cent. The fibre is coarse with more than 6.1 micronaire and is found suitable for absorbent purpose. It is identified for release for South Zone States of Tamil Nadu, Andhra Pradesh and Karnataka under rainfed condition.
5	**RHCb 011 (*Barbadense* Culture)**	The genotype has yield advantage over the zonal check variety and it was found to be spinnable to 80s count yarn. Being a *G. barbadense* species, the genotype is susceptible to sucking pests. However, with proper plant protection measures, potential yield can be achieved. It is identified for release in Central Zone States of Maharashtra, Madhya Pradesh, and Gujarat under irrigated condition .
6	**RHC 0717 (*Hirsutum* Culture)**	The genotype has yield advantage over both the check varieties by more than 15 per cent. It was found to be spinnable to 30s-40s count yarn. It is identified for release in Central Zone States of Maharashtra, Madhya Pradesh, and Gujarat under irrigated condition.
7	**CCH 2623 (*Hirsutum* Culture)**	The genotype was superior to both the check varieties in terms of seed cotton yield. The fibre is ideally suitable for spinning to 40s to 50s count yarn. It is identified for release in South Zone States of Tamil Nadu, Andhra Pradesh and Karnataka under irrigated condition.
8	**H 1353 (*Hirsutum* Culture)**	The genotype has yield advantage over both the check varieties by more than 19 per cent. It was found to be spinnable to 40s-50s count yarn. It is tolerant to sucking pest and has better ginning outturn. It is identified for release in Central Zone States of Maharashtra, Madhya Pradesh, and Gujarat under rainfed condition.
9	**H 1316 (*Hirsutum* Culture)**	The genotype has yield advantage over both the check varieties by more than 14 per cent. It was found to be spinnable to 40s-50s count yarn. It was found to be tolerant to sucking pests. It is identified for release in Central Zone States of Maharashtra, Madhya Pradesh, and Gujarat under irriga ted condition.
10	**F 2228 (*Hirsutum* Culture)**	The genotype has yield advantage over both the check varieties by more than 19 per cent. It was spinnable to 30s-40s count yarn from spinning results. It was tolerant to both sucking pests and bollworms. It had less cumulative disease index of 2.6 for CLCuD

		which comes under Moderately Resistant category. It is identified for release in North Zone States of Punjab, Haryana and Rajasthan under irrigated condition for early sowing situation.
11	**FMDH 9 (*Desi* hybrid)**	The hybrid was superior to both the check hybrids in terms of seed cotton yield by more than 24 per cent. The fibre is coarse with more than 6.5 micronaire and is suitable for absorbent purpose. It is identified for release in South Zone States of Tamil Nadu, Andhra Pradesh and Karnataka under rainfed condition.
12	**AKA 2005-3 (*Arboreum* culture)**	The genotype was superior to both the check varieties in terms of seed cotton yield by more than 12 per cent. The fibre is coarse with high micronaire and is suitable for absorbent purpose. It is identified for release in South Zone States of Tamil Nadu, Andhra Pradesh and Karnataka under rainfed condition.
13	**CSH 3129 (*Hirsutum* Culture)**	The genotype has yield advantage over both the check varieties by more than 10 per cent. It was found to be spinnable to 50s-60s count yarn. It was tolerant to CLCuD disease. It is identified for release in North Zone States of Punjab, Haryana and Rajasthan.
14	**GSB 9 (*Barbadense* Culture)**	The genotype has yield advantage over the zonal check variety and it was found to spin 80s count yarn in Central Zone States. In South Zone States, the fibres could not be spun to desired counts because of stickiness. Being *G. barbadense* species, the genotype is susceptible to sucking pests. However, with proper plant protection measures, potential yield can be achieved. Hence, it is identified only for release in Central Zone States of Maharashtra, Madhya Pradesh, and Gujarat under irrigated condition
15	**DHB 1071 (H X B hybrid)**	Under appropriate management condition for sucking pests, the ELS hybrid with yield superiority of over 13 per cent vis-à-vis the check hybrids, is recommended for release in irrigated situations of South Zone States of Tamil Nadu, Andhra Pradesh and Karnataka
16	**LD 949 (*Arboreum* culture)**	The genotype has yield advantage over both the check varieties by more than 18 per cent. It was found to be non-spinnable and have high micronaire and hence suitable for absorbent cotton. Moreover, it is resistant to CLCuD. It is identified for release in North Zone States of Punjab, Haryana and Rajasthan under irrigated condition.
17	**MRDC 233 (*Desi* Hybrid)**	It is found to have good yield potential (18 to 20 q/ha in both the zones) and recorded notable yield superiority over both zonal check as well as local checks. The hybrid is not spinnable and has around 6.0 micronaire and is suitable for Absorbent purpose. The hybrid is identified for release in rainfed tracts of both Central Zone States of Maharashtra, Madhya Pradesh and Gujarat as well as South Zone States of Tamil Nadu, Karnataka and Andhra Pradesh.
18	**SCS 793 (*Hirsutum* Culture)**	The genotype was superior to both the check varieties in terms of seed cotton yield. It is spinnable to 50s to 60s count yarn. It is identified for release in South Zone States of Tamil Nadu, Andhra Pradesh and Karnataka under irrigated condition.

Front Line Demonstrations (FLD) under National Food Security Mission (NFSM) (Commercial Crops)

During the year 2014-15, 205 Front Line Demonstrations on Integrated Crop Management on cotton, 90 Front Line Demonstrations on intercropping with cotton and 160 Front Line Demonstrations on *Desi* / ELS cotton / ELS cotton seed production were conducted by fourteen centres of All India Coordinated Research Project on Cotton.

Evaluation of Cotton Leaf Curl Virus Disease (CLCuD)

A special session on 'Combating Cotton Leaf Curl Virus Disease – CLCuD' was organized during the last annual workshop of the All India Coordinated Research Project on Cotton at the Punjab Agricultural University, Ludhiana. Based on the recommendations and request from Department of Agriculture and Cooperation, New Delhi trials were conducted to screen and recommend the tolerant Bt cotton hybrids for North zone.

Accordingly, during 2014-15, field trials were laid out with 100 released Bt cotton hybrids and 50 pre-release hybrids at five centres of North zone- (Faridkot, Abohar, Hisar, Sirsa and Sriganganagar) with two treatments- Normal date of sowing and late sowing.

Based on the PDI and progress of the disease, the entries were classified as tolerant, moderately tolerant and susceptible.

Recommendations

1. The **'tolerant entries'** may be approved for cultivation in north India for two years (2015 and 2016 *kharif*)
2. The **'moderately tolerant'** entries may be approved for cultivation in north India for one year (2015 *kharif*)
3. The **'susceptible'** entries may be banned for cultivation in Haryana, Punjab and northern Rajasthan (Sriganganagar & Hanumangarh districts).
4. The leaf curl virus disease is not prevalent in southern region (Jodhpur, Pali, Nagaur, Ajmer, Bhilwara, Udaipur, Banswara etc.) of Rajasthan and thus these results are not applicable to the region. Therefore any Bt hybrid approved by the GEAC to be cultivated in north India may be permitted in southern Rajasthan.
5. Early sowing (before 15th May) helps the crop to escape the leaf curl virus (CLCuD) disease. Steps may be taken to release canal water for two to three weeks period before 15th May to enable early sowing.
6. Late sown crop becomes highly vulnerable to the leaf curl virus (CLCuD) disease. Hence late sowing should be strictly avoided.
7. Extension agencies may give wide publicity to encourage the cultivation of hybrids that are tolerant to CLCuD as mentioned in the lists.

Weekly advisory for cotton cultivation

With active participation of scientists of AICRP on Cotton and ICAR-CICR, released periodical (weekly) advisory for cotton farmers for all cotton growing states along with weather report. The advisory include agronomical interventions, nutrient management, irrigation scheduling, pest and disease management. The advisories were uploaded at ICAR-CICR website (www.cicr.org.in).

Tribal Sub-Plan

Under Tribal Sub Plan Programme conducted at UAS Raichur, SAU, Surat and Coimbatore a sum of Rs. 7 lakhs was utilised to conduct training programme and dissemination of cotton production technologies to the tribal cotton farmers to improve their economic status.

9. KRISHI VIGYAN KENDRA

Major Achievements

Implementation of Technology Demonstration on pulses (Pigeonpea) : Krishi Vigyan Kendra, CICR, Nagpur has implemented technology demonstration on pigeonpea (BSMR376) during *kharif* and chick pea (Vijay) during *rabi* 2014-15 on 30 acre of land in Hingna and Saoner taluka. With introduction of improved variety of pigeonpea, the yield was increased by 24.5% over variety ICPL87119. In case of chick pea the yield improvement was 33.3% over local check.

Agronomy : KVK has conducted OFT on High Density Planting System (HDPS) of variety Suraj in Khapri and Sonegaon village of Kalmeshwar block in collaboration with State agriculture department. Three FLDs on Arhar (BSMR-736), Wheat (AKAW-4627) and Linseed (PKV NL-260) were also conducted in village Umred and Bhiwapur of Nagpur districts. In OFT, cv. Suraj recorded 12.34% higher yield over the Bt check. In FLDs, varieties of Linseed (PKV NL-260), Arhar (BSMR-736), Wheat (AKAW-4627) were superior over local checks by 30.8%, 21.8% and 31.3% respectively.

Soil Testing : Soil samples were collected from Umrer, Bhivapur, Katol, Kalmeshwar, Saoner, Ramtek, Narkhed and Kuhi blocks of the Nagpur district through Mobile Soil Testing Van and 540 soil health cards were distributed to the beneficiaries.

Horticultural Fruit Crops: KVK has established an orchard in its farm. The objective was to demonstrate the potential variety of fruit crops suitable for Vidarbha region. The Guava (L-49), Pomegranate (Bhagwa), Orange (Nagpur mandarin) and Sweet Orange (Katol Gold) were demonstrated to large number of farmers, extension functionaries, rural youths and other visitors.

Dairy and Livestock enterprises

- KVK has conducted front line demonstration on 20 cross breed Jersey cows in Wai (Khurd), Kondhasawali, Wai (Buzurg), Metpanjra, Hatla, of Katol tehsil by feeding bypass fat @ 200 g/day/cow in the diet of just calved cows. It was observed that average milk yield increased by 22% and fat content by15%.

- Concentrated feed was fed @ 150 g/doe/day for 3 months to 20 local goats in Metpanjra, Wai (Bujurg) villages of

Katol taluka. It was observed that there was 27.08% increase in average milk yield, whereas, average preweaned body wt. in kids of 5 months old was increased by 19.20%.

- 100 poultry chicks of Swarnadhara and Giriraj breeds in Navegaon Sadhu, Tirkhura and Karhandla villages of Umred taluka were reared under back yard farming system on farmers field. Average body weight of matured hen was more in Swarnadhara by 37.21% and Giriraj by 30.95%. The survivability rate was at par with local chicken.

- **Azolla production unit at KVK :** Azolla production unit has established at KVK technology park during the year 2014-15. KVK is producing about 15 kg. Azolla culture from a pond of size 12'x9' every 15 days and established more than 20 Azolla production unit in Nagpur district on farmers' fields. Front line demonstrations on feeding of Azolla @ 1-2 kg to their cattle in replacement of concentrate feed was conducted on 10 farmers' field. By feeding Azolla 19.85% increase in average milk yield of cows, 10% increase in milk fat and 14.28% increase in conception rate was observed.

Advisory Service/K-MAS

- **Advisory Service provided :** KVK has provided advisory services to the farmer, rural youth and extension workers on agricultural production and protection technology and allied fields through Daily Agrowon, Dr. PDKV, State Agriculture Department, KVK website (weekly weather forecasting) and by personnel guidance, telephonic calls and mobile services. So for 21047 clients in Nagpur district were benefited.
- **Kisan Mobile Advisory Services (K-MAS) :** Through this technology, 636 clients/farmers were registered during 2014-15 and 29 messages were sent to the farmers/rural youth/extension functionaries.

Cotton harvesting bag

KVK-CICR cotton picking bag is gaining popularity due to its advantage of collecting more and clean cotton. This has resulted in increase in efficiency of rural women with higher income. KVK- CICR has received an order of 710 cotton harvesting bags from AFPRO, BAIF-MITTRA, DSAO, Nagpur. These bags were distributed as technical input to the 149 villages covering 9 talukas of Yeotmal and 4 talukas of Nagpur district. KVK has generated revenue of Rs. 1,17,315/- during August 2014 to January 2015 through sale of these bags.

On Farm Trial on Home Science

1. Assessment of charcoal briquettes-An alternative: Assessment of charcoal briquettes cooking fuel was conducted on 20 farm women's field. The traditional coal and bio-briquettes made from cotton stalk was compared in terms of quantity, cost, ash recovered and time required by

each farm women while cooking 250 grams of rice and dal. It was found that food cooked through bio-briquettes is cost effective by 29% as compared to traditional coal and 60% eco-friendly.

2. Assessment of protein rich food provided under SABLA for reducing protein calorie mal nutrition of adolescent girls : This trial was conducted at Butibori circle, Nagpur. Ten adolescent girls were selected for each trial. It was found that consumption of protein rich diet along with local practice helps in increasing weight (by 33%) and Hb% (by 35%).

Training Programme organized

Sr. No.	Training Title	Venue & Date	No. of Participants
1	Protection of Plant Varieties and Farmers' Right Act - 2001	KVK, CICR, Nagpur 26-27th March, 2015	100
2	Goat Rearing	Panchayat Samiti Katol, Katol 27th Jan., .2015	100
3	Integrated courses on 'Bio-diversity of Crops' and 'Rural Goat Production Technology'	KVK, CICR, Nagpur 27-29th Nov. 2014 & 2-4th Dec. 2014.	100
4	Rural goat farming	Seldoh village, Wardha district 22nd May 2014.	30
5	Soil and water management, soil sampling techniques and it's analysis	KVK, CICR, Nagpur 19 to 21th Aug., 2014	72
6	*Sheti Din*	Khapri village of Kalmeshwar taluka, Dist- Nagpur 02nd Sept., 2014	20

Training Programmes conducted

One hundred and twenty four short duration (1 to 3 days) *on-campus* and *off-campus* training courses were conducted in different disciplines for practicing farmers, rural youth and extension functionaries. In all 4924 participants including 1435 SC/ST participants were benefited.

Diagnostic surveys/*Sheti Din* conducted

1. KVK, CICR, Nagpur conducted diagnostic survey at Champa village of Saoner taluka, Dist- Nagpur on 12th Sept., 2014 in collaboration with State Govt. Agril. Dept. Personnel. The experts of KVK diagnosed the problems of parawilt on cotton by visiting farmers field. Thirty farmers were benefited during this programme.

2. Diagnostic field visit was conducted in villages of Chandur Railway taluka of Amravati district on 25.11.2014 alongwith State Agricultural Department personnel. CICR scientists and KVK experts participated in the visit and inspected the HDPS cotton plots (Suraj variety) of 10 different farmers and also explained their queries/complaints.
3. Diagnostic field survey were conducted in villages Ranmangali, Navegaonsadhu and Thana of Bhiwapur and Umred taluka. Experts from CICR and KVK participated in diagnostic survey. The damage caused due to heavy rainfall and general crop conditions were discussed.

Group discussion/Kisan Goshti organized

Kisan Goshti through "*Mann Ki Baat*" in collaboration with Doordarshan, Nagpur

One day Kisan Goshti programme was organized in collaboration with Doordarshan Nagpur at Navegaon (Sadhu) village of Umred taluka on 22nd March, 2015. During this programme the speech of **Hon'ble Prime Minister (*Mann Ki Baat*)** were broadcasted among the farmers through radio and based on the issues of different topics of Hon'ble Prime Minister's speech, the feedback and suggestions from farmers were recorded by Doordarshan, Nagpur.

Group discussion on Horticulture and Livestock production: A group discussion on high density cultivation of fruits and establishment of poultry and goat units was organized in Tarna and Dhandla villages of Umred and Kuhi taluka on 26th June, 2014. The farmers were suggested to start such units on small scale under scientific guidance. Thirty five farmers attended the programme.

***Kisan Goshti* on *kharif* vegetable cultivation:** *Kisan Goshti* on *kharif* vegetable cultivation was organized in Kinhi village of Hingna taluka on 29th May, 2014. Thirty farmers attended the programme.

Shetkarai Charcha

The experts of KVK, conducted group discussion (*Shetkari Charcha*) with 45 farmers of Kinhadmakadi village of Nagpur district on 24 Sept.,2014. During this *charchasatra*, soil sampling techniques, cotton crop production technology and IPM on soybean were thoroughly discussed with 35 farmers and rural youths.

Participation in Exhibitions/Meetings/Workshops/Seminar/Symposia

Sr. No.	Title of Exhibitions/ Meetings/ Workshop/ Seminar/ Symposium	Venue & Date
1	State level Exhibition on eve of "*Dhammachakra Pravartan Din*"	Deekshabhoomi, Nagpur 2- 4th October, 2014.
2	Exhibition on occasion of ICAR Regional Committee meeting zone VII	IGKV, Raipur 17-18th October, 2014
3	Rashtriya Kisan Mela organized by CCRI, Nagpur	CCRI, Nagpur 30-31th October, 2014
4	Agro-Vision (National Level Exhibition)	Reshimbagh, Nagpur 4 – 7th December, 2014
5	Agro-Tech-2014' (State Level Exhibition)	Dr. PDKV, Akola 27-29 December , 2014.
6	102nd Indian Science Congress Exhibition 2015	Mumbai 3-7th January, 2015
7	Agricultural Science Congress (ASC) Expo	NDRI, Karnal 3-6th February, 2015
8	Stakeholders meeting (organized by World Vision India)	BDO's Office, Panchyat Samiti Umred on 1st April, 2014
9	Pre-*Kharif* Review Meeting for Nagpur district	NBSS & LUP, Nagpur 22nd May, 2014
10	National Conference on Management of Bio-degradable waste & nutritional management	RTMNU, Nagpur on 17th January, 2015
11	Workshop on Annual Action Plan 2014-15	Dr. PDKV, Akola 19th May 2014
12	Convergence Workshop	Kadimbag Nagpur 12th June, 2014

Sr. No.	Title of Exhibitions/ Meetings/ Workshop/ Seminar/ Symposium	Venue & Date
13	Guest lecture on "Advance Techniques of IPM and INM in Bt Cotton"	KVK, Kharpudi, Jalna 05th May, 2014
14	Guest lecture on "HDPS Cotton Production Technology	Joga, Saoner taluka 23rd May, 2014
15	Guest lecture on HDPS cotton production technology and soil sampling techniques	Khapri Moreshwar village 24th May, 2014
16	Guest lecture on 'Management of Bt. Cotton on drip irrigation' in 'Agro-Sanvad'	APMC, Katol 20th June, 2014.

Conference paper

- Galkate, U. V. (2014) 'Assessment of production performance of Swarnadhara chicken in Nagpur district' Abstract No.NCM/0 – 02, National Conference on,'Native Chicken Production: Challenges and Opportunities', 4-5th Sept, 2014 at TANUVAS, Chennai, p. 102-103

Popular Article:

- Rokde, S. N. and Galkate, U. V. (2014). '*Krutrim oxytocincha vapar tala* (Avoid use of oxytocin)'. Aadhunik Kisan weekly magazine , Issue 23 (14 to 20th August 2014), pp. 18-19 & 25
- Galkate, U. V. and Rokde, S. N. (2015). '*Dudharu pasuon ko khilaye azolla*' (Azolla as a cattle feed), Krushak Jagat Weekly, Issue - March 16-22th, 2015, pp. 7
- Mrs. Sunita Chauhan (2014). "पपई पासून तयार करा टुटी–फ्रुटी". Agrowon, dated 16th November, 2014 pp.12
- Mrs. Sunita Chauhan "गुलाबापासुन तयार करा गुलकंद". Agrowon, dated 23rd December, 2014 pp.14
- Mrs. Sunita Chauhan "*Banwa Swasthawardhak soybean doodh*". Agrowon, dated 30th March, 2015 pp.14
- Mrs. Sunita Chauhan "*Soybean pasun banwa tofu soybean*". Agrowon, dated 31th March, 2015 pp.14

Radio Talks

- Dr. U.V. Galkate, SMS (Vet. Sci.) delivered a radio talk in live programme on "Answer to farmers' queries on Livestock" in Marathi by All India Radio, Nagpur on 28.10.2015 at 7.30 pm.
- Dr. S. S. Patil, SMS (Extn.) delivered a radio talk in live programme on "Answer to farmers' questions" in Marathi by All India Radio, Nagpur on 15.03.2015 at 1.30 pm.
- Shri H. B. Kumbhalkar, I/c SMS (Agronomy), delivered a radio talk on "*Gahu lagwadiche sudharit tantradhyan/shipharashi*" in Marathi by All India Radio, Nagpur on 27.10.2014 at 3.00 pm.
- Shri P.B.Deulkar, Farm Manager, delivered a radio talk in live programme on "Answer to farmers' queries on *Hello Annadata-Pashuvishayak Shanka samdhan*" in Marathi by All India Radio, Nagpur on 28.10.2014, 4.11.2014 and 11.11.2014 at 7.30 pm.

T.V. Show

- Television show on "महिलाचे कष्ट कमी करण्यासाठी कापूस वेचणी बॅग" in Marathi programme कृषि दर्शन telecasted by Nagpur Doordarshan on 12nd January, 2015.

Resource Generation

- KVK has generated Rs. 2,11,755 through sale of cotton harvesting bags, Osmanabadi goats and horticultural produce.

10. GENERAL

10.1 List of Publications

Research papers published by the Institute's scientists NAAS rating> 6 in 2014-15

1. Babu Santosh, Bidyarani Ngangom, Chopra Preeti , Monga Dilip, Kumar Rishi, Prasanna Radha, Kranthi Sandhya & Saxena Anil Kumar. (2015). Evaluating microbe-plant interactions and varietal differences for enhancing biocontrol efficacy in root rot disease challenged cotton crop. *Eur. J.Plant Pathol.* 142: 345-362; DOI 10.1007/s10658-015-0619-6. (NAAS rating: 7.71)
2. Bhattacharyya T., Sarkar D., Ray S.K., Chandran P., Pal D.K., Mandal D.K., Prasad J., Sidhu G.S., Nair K.M., Sahoo A.K., Das T.H., Velmourougane K. …..2014. Georeferenced soil information system: assessment of Database. (Special Section: Georeferenced Soil Information System) *Current Science*, 107 (9), 1400-1419 (NAAS Rating: 6.91)
3. Bhattacharyya T., Sarkar D.,…..Venugopalan M. V, Velmourougane K.....Soil information system: use and potentials in humid and semi-arid tropics. *Current Science*, 107 (8): 1550-1564. (2014). (NAAS Rating: 6.91)
4. Chandran P., Tiwary P. ,…… Venugopalan M. V., Velmourougane K.....Development of soil and terrain digital database for major food-growing regions of India for resource planning. *Current Science*, 107 (8): 1420-1430. (2014). (NAAS Rating: 6.91)
5. Chatterji S.,…….. Venugopalan M. V., Velmourougane K.....Land evaluation for major crops in the Indo-Gangetic Plains and black soil regions using fuzzy model. Current Science, 107 (8): 1502-1511. (2014). (NAAS Rating: 6.91)
6. Kumar Ashutosh, Srivastava Alok Kumar, Velmourougane K., Bhattacharyya T. 2014. Urease activity and its kinetics in selected bench mark soils of Indo-Gangetic Plains. PNAS, India, Sec. B Biol. Sci. DOI 10.1007/s40011-014-0352-5 (NAAS Rating: 6.40)
7. Kumar Rishi, Tian Jun-Ce, Naranjo Steven E. and Shelton Anthony M. (2014). Effects of Bt cotton on Thrips tabaci Lindemanand its predator, *Orius insidiosus* (Say). *Journal of Economic Entomology* 107(3): 927-932 (2014); DOI: http://dx.doi.org/10.1603/EC13567 (NAAS Rating: 7.61)
8. Mandal C., Mandal D. K.,…….. Venugopalan M. V., Velmourougane K..... Revisiting agro-ecological sub-regions of India – a case study of two major food production zones. *Current Science*, 107 (8): 1519-1536. (2014). (NAAS Rating: 6.91)
9. Patil N. G., Tiwary P.,… Venugopalan, Velmourougane K.....Natural resources of the Indo-Gangetic Plains: a land-use planning perspective. *Current Science*, 107 (8): 1537-1549. (2014).
10. Prasanna Radha, Babu Santosh, Bidyarani Ngangom, Kumar Arun, Triveni Sodimalla, Monga Dilip, Mukherjee Arup Kumar, Kranthi Sandhya, Gokte-Narkhedkar Nandini, Adak Anurup, Yadav Kuldeep, Nain Lata and Saxena Anil Kumar (2014) Prospecting cyanobacteria fortified composts as plant growth promoting and biocontrol agents in cotton. *Experimental Agriculture*, 51(1):42-65. (NAAS Rating: 7.07)
11. Priyadarshani Arun Khambalkar, Sen T. K., Chatterji S. and Venugopalan M. V. Land use changes and their impact on properties of some

soil series of Nagpur district of Maharashtra. *Indian Journal of Agricultural Sciences* 84 (12): 1517–24, December 2014/Article pp 77-84. (NAAS Rating: 6.18)

12. Rao S. S., Sahadevan D. K.,. Wadodkar M. R, Nagaraju M.S.S., Chattaraj S., Joseph W., Rajankar P., Senguptae T., Venugopalan M. V., Das S. N., Joshi A. K., Sharma J. R. a,. Amminedu E. Soil moisture model with multi angle and multi polarisation RISAT-1 data *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences,* Volume II-8, pp. 145-150 (2014). (NAAS Rating: 8.90)
13. Ray S. K.,……. Venugopalan M. V., Velmourougane K.....Soil and land quality indicators of the Indo-Gangetic Plains of India. *Current Science*, 107 (8): 1470-1486. (2014). (NAAS Rating: 6.91)
14. Raychaudhuri Mausumi, Kundu D. K.,…….. Venugopalan M. V., Velmourougane K..... Soil physical quality of the Indo-Gangetic Plains and black soil region. *Current Science,* 107 (8): 1440-1451. (2014). (NAAS Rating: 6.91)
15. Sidhu G. S., Bhattacharyya T.,……. Venugopalan M. V., Velmourougane K..... Impact of management levels and land-use changes on soil properties in rice–wheat cropping system of the Indo-Gangetic Plains. *Current Science*, 107 (8): 1487-1501. (2014). (NAAS Rating: 6.91)
16. Srivastava Alok Kumar, Velmourougane Kulandaivelu, Venugopalan M.V..... Impacts of agro-climates and land use systems on culturable microbial population in soils of the Indo-Gangetic Plains, India. *Current Science*, 107 (8): 1464-1469. (2014). (NAAS Rating: 6.91)
17. Tiwary P., Patil N. G.,…., Venugopalan M. V., Velmourougane K.....Pedotransfer functions: a tool for estimating hydraulic properties of two major soil types of India. *Current Science*, 107 (8): 1431-1439. (2014). (NAAS Rating: 6.91)
18. Velmourougane K., Venugopalan M. V.,..... Impacts of bioclimates, cropping systems, land use and management on the cultural microbial population in black soil regions of India. *Current Science*, 107 (8): 1452-1463. (2014). (NAAS Rating: 6.91)
19. Venugopalan MV, Tiwary P, Ray SK, Chatterji S, Velmourougane K, Bhattacharyya T., ... InfoCrop-cotton simulation model – its application in land quality assessment for cotton cultivation. *Current Science*, 107 (8): 1512-1518. (2014). (NAAS Rating: 6.91)

Research papers published by the Institute's scientists NAAS rating< 6 in 2014-15

20. Reddy A.R., Yelekar Sachitha M. and Agarwal Isabella. (2015). Cotton productivity in the districts of Maharashtra: (TFP) approach. *Journal of Cotton Research and Development*: Vol.29 No.1 pp. 141-146 (NAAS rating 3.41)
21. Bhattiprolu, S. L. Nakkeeran, S. Rao, M. S. L. Chattannavar S. N. Chakrabarty P. K. and Monga D. (2014) Field Evaluation of Systemic Acquired Resistance (SAR) Inducing Chemicals and *Pseudomonas fluorescens* against Foliar Diseases of Cotton. *Cotton Research Journal* 6:41-45. (NAAS rating: 2.27)
22. Young Carla Jo Logan, Yu John Z, Verma Surender K, Percy Rechard G and Alan E Pepper (2015). SNP discovery in complex allotetraploid genomes (*Gossypium* spp., Malvaceae) using Genotyping by Sequencing. *Applications in Plant Sciences- A peer reviewed journal* 2015 3(3): doi:10.3732/app.1400077.
23. Blaise D. and Velmourougane K.. (2014). Dynamics of soil dehydrogenase and alkaline phosphatase activities under organically and conventionally grown cotton on rainfed vertisols of Central India. *Cotton Research Journal*, 6(1), 54-57. (NAAS rating: 2.27)
24. Prasada Rao G.M.V., Kranthi S., Prasad NVVDSD, Gurundipalli ADG, Sujatha S.,

Reddy V. Chenga and Bhosle B.B. (2014). Effect of Imidacloprid 70WS (Gaucho) and Thiamenthoxam 70WS (Cruiser) against leafhopper *Amasca biguttulu biguttula* (Ishida) on susceptible and tolerant Bt and Non-Bt cotton hybrids (2014). *Cotton Research Journal* 5(2): 93-95. (NAAS rating: 2.27)

25. Singh Jagvir, Velmourougane Kulandaivelu, Kranthi Sandhya and Shanty Venoor. (2014). Evaluation of Organic and Inorganic Cultivation Systems of Cotton on Bollworm, Soil Microbial Population and Yield. *Cotton Research Journal* 5(2): 117-119. (NAAS rating: 2.27)

26. Raghavendra K. P., Phanindra M. L. V. and Ananda Kumar P. (2014). Internal Control Gene for Gene Expression Studies Using Real Time Quantitative RT-PCR during Cotton Boll Development. *Cotton Research Journal* 6 (1) 32-36. (NAAS rating: 2.27)

27. Sankaranarayanan K. and Nalayini P. (2014). Performance and behaviour of Bt cotton hybrids under sub-optimal rainfall situation. *Archives of Agronomy and Soil Science*, DOI:10.1080/03650340.2014.986112

28. Sethi Khushboo, Siwach Priyanka and Verma Surender Kumar (2014). Genetic Improvement of *Gossypium arboreum* L. using molecular markers: Status and development needs. *African Journal of Agricultural Sciences*. Vol. 9 (29). Pp. 2238-2249. 17 July, 2014. DOI: 10.5897/AJAR2014.8682. Article Number: B8FB45046128. (NAAS rating: 4.00)

29. Sethi Khushboo, Siwach Priyanka, Verma Surender Kumar (2014). Assessing Genetic Diversity among *Gossypium arboreum* L. genotypes using ISSR markers. *International Journal of Pharma and Biosciences*. Volume 6, Issue 1 (2015), Page 201-208.

30. Sabesh M., Prakash. A. H. and Bhaskaran. G. (2014). Shift in Indian Cotton Scenario due to Shift in Cotton Technology. *Cotton Research Journal*, 6(1): 75-82 (2014) (NAAS Rating 2.27)

32. Sabesh M., Ramesh. M., Prakash. A. H. and Bhaskaran. G. (2014) Is there any shift in cropping pattern in Maharashtra due to introduction of Bt Cotton. *Cotton Research Journal*, 6(1): 63-70 (2014) (NAAS Rating 2.27)

33. Manickam, S. and Prakash, A. H. (2014). Interspecific hybridization between *Gossypium hirsutum* and *G. armourianum*: Morphological and Molecular Characterization of Hybrids. *Cotton Res. J.*, 6(1): 7-12. (NAAS Rating: 2.27)

34. Manickam, S. and Venkata Krishnan, S. (2014). Studies on fibre quality of a long staple cotton variety using high volume instrument and advanced fibre information system for fibre quality improvement. *Electronic Journal of Plant Breeding*, 5(2): 213-219. (NAAS Rating: 4.19)

35. Nagrare V. S., Deshmukh A. J., and Bisane A. K. (2014). Relative performance of Bt-cotton hybrids against sucking pests and leaf reddening under rainfed farming. *Entomol Ornithol Herpetol* 3: 134. doi:10.4172/2161-0983.1000134.

36. Nagrare V. S., Kumar Rishi, Dharajothi B. (2014). A record of five mealybug species as minor pests of cotton in India. *Journal of Entomology and Zoology Studies* 2 (4): 110-114.

37. Nalayini, P., Sankaranarayanan K. and Velmourougane K. (2014). Efficient and economical weed management strategies in winter irrigated Bt cotton. *Cotton Research Journal* 5(2):102-104. (NAAS Rating 2.27)

38. Nalayini, P., Anandham. R., Paul Raj S. and Chidambaram P. (2014). Pink Pigmented facultative Methylotrophic Bacteria(PPFMB) – A potential bioinoculant for cotton nutrition. *Cotton Research Journal* Vol. 6(1):50-53. (NAAS Rating 2.27)

39. Tuteja O.P. (2014) Studies on suitability of

Cytoplasmic Genetic Male Sterility (CGMS) based Heterosis Breeding and its Causes in Upland Cotton (*Gossypium hirsutum* L.). *Cotton Research Journal* 6 (1): 13-17. (NAAS rating: 2.27)

40. Tuteja O.P. (2014). Studies on heterosis for yield and fibre quality traits in GMS hybrids of upland cotton (*Gossypium hirsutum L.*). *Journal of Cotton Research and Development* 28: 1-6. (NAAS rating: 3.41)

41. Prakash A. H., Kranthi K. R., Nagrare V. S., Kranthi S. and Gotmare V. P. (2014). Cotton leaf reddening- Systematic damage caused by use of Methomyl in Cotton. *Cotton Research Journal*, 6(1): 83-88. (NAAS *Rating:*2.27)

42. Saini Priya, Gopal Madhuban, Kumar Rajesh, Verma Sachindra, Srivastava Chitra, Kranthi S. and Kranthi K.R. (2014). Bio-efficacy and Mode of action of Nano Pyridalyl Against *Helicoverpa armigera. Cotton Research Journal* 5(2): 112-115. (NAAS rating: 2.27)

43. Meena R. A., Monga D. and Neha (2014). Studies to enhance cotton plant stand under North Zone *J. Cotton Res. & Dev.* 28(1) 12-17. (NAAS rating: 3.41)

44. Rathinavel K., (2014). Influence of storage temperature and seed treatments on viability of cotton seed (*Gossypium hirsutum* L.). *Cotton Research Journal*.6(1):1-7. (NAAS Rating: 2.27)

45. Usha Rani S., Wasnik S. M. & Sabesh M. (2014) : A Critical Analysis on Issues Faced by Cotton Growers and Labourers in Hybrid Cotton Seed Production. *Cotton Research Journal*, 6(1):71-74. (NAAS rating: 2.27)

46. Khader S.E.S.A and Prakash A.H. (2014) - Photosynthesis and related parameters as influenced by leaf surface wetness of cotton plants growth under irrigated and moisture stress condition – *Cotton Research Journal,* 5 (2): 105-110. (NAAS Rating: 2.27)

47. Khader S.E.S.A and Prakash A.H, (2014) - Pruning technique for second fruiting cycle in cotton crop - *Cotton Research Journal*, 6: (1): 46-49. (NAAS Rating: 2.27)

48. Usha Rani S., and Selvaraj G. (2015). Adoption behavior of *Bt* cotton growers in irrigated and rainfed conditions of Tamil Nadu. *Journal of Cotton Research and Development*. Vol. 29 No.1.pp.132-140. (NAAS rating 3.41)

49. Santhy V., Meshram Mithila, Wakade Renuka, VijayaKumari P.R. (2014). Hydrogen peroxide pre-treatment for seed enhancement in Cotton (*G. hirsutum*). *Afric.J. Agric. Research* 9 (25):1982-89. (NAAS rating: 4.0)

50. Naik Chinna Babu V., DharaJothi, Dabhade P.L. and Kranthi S. (2014). Pink bollworm *Pectinophora gossypiella* (Saunders) Infestation on Bt and Non Bt hybrids in India in 2011-2012. *Cotton Research Journal* Vol.6, No.1 (January-June). (NAAS rating: 2.27)

51. Naik Chinna Babu V., Prasad NVVSD, Rao G. Ramachandra, Raghavaiah G. and Kranthi S. (2013). Survival and Development of American Bollworm, *Helicoverpa armigera* on Bt Cotton Hybrids of Different Bt Events. *Indian Journal of Plant Protection*: 41. (1) 16-24 (NAAS rating: 4.3)

52. Velmourougane, K, Singh Jagvir and Nalayini P. (2014). Field assessment of transgenic cotton expressing Cry1 AC gene on selected soil biological attributes and culturable microbial diversity in deep vertisols. *Cotton Research Journal,* 6(1), 18-27. (NAAS rating: 2.27)

53. Wasnik S. M. and Kranthi K. R. (2014). 'e-Kapas': An ICT enabled tool for dissemination of cotton production technology. *International J. of Exten. Edu.* Vol.10: 136 - 140, 2014. ISSN: 2319-7188. (NAAS rating: 4.15)

54. Nagrare V. S., Bisane K. D., Deshmukh A. J. and Kranthi S. (2012). Studies on life cycle parameters of leafhoppers, *Amrasca biguttula biguttula* (Ishida). *Entomon* 37 (1-4): 93-99.

10.2: List of On-going Projects

S.No.	Project title	Duration
	Crop Improvement	
1.	Improvement of tetraploid and diploid cottons for fibre properties through population improvement approaches. V. N. Waghmare (PI), Vinita Gotmare (PA), O. P. Tuteja (PA), S. K. Verma (PA)	2000-15
2.	Studies on Genetic Enhancement of *G. hirsutum.* T. R. Loknathan (PI)	2002-16
3.	Development of heterotic pool for superior medium staple in tetraploid cotton (*G. hirsutum*). S. M. Palve (PI)	2006-15
4.	Development of drought tolerant genotypes with good fibre quality in *G. hirsutum.* Suman Bala Singh (PL), A. H. Prakash (PA)	2008-17
5.	Breeding of upland cotton for improved fibre quality and resistance to biotic stress (Jassid). S. M. Palve (PI)	2005-16
6.	DNA fingerprinting of private hybrids vis-a vis CICR varieties. H. B. Santosh (PI)	2014-16
7.	Development of long staple *G. hirsutum* variety with improved fibre strength. S. Manickam (PL), V. N. Waghmare (PA), S. L. Ahuja (PA)	2008-17
8.	Development of early maturing, medium staple varieties and hybrids Resistant to CLCuV. O. P. Tuteja (PL), D. Monga (PA), S. K. Verma (PA), Rishi Kumar (PA), S. M. Palve (PA)	2008-17
9.	Development of *G. hirsutum* genotypes with high yield and high GOT. S. L. Ahuja (PL), R. A. Meena (PA), D. Monga (PA), Rishi Kumar (PA)	2012-18
10.	Development of high yielding, early maturing extra long staple *G. barbadense* genotypes with high GOT. K. P. M. Dhamayanthi (PL)	2012-17
11.	MAS/MAB for Water-logging in Cotton. Vinita Gotmare (PL) , S.E.S.A. Khader (PA), M. Saravanan (PA), J. H. Meshram (PA), J.Annie Sheeba (PA)	2012-20
12.	Breeding for early maturity compact plant type and jassid tolerance in cotton. H. B. Santosh (PI)	2014-19
13.	Identification of male sterile plants in genetic male sterility (GMS) using molecular markers. O. P. Tuteja (PL), S. B. Singh (PA), M. Sarvanan (PA)	2012-17
14.	Collection, conservation, evaluation, documentation and maintenance of germplasm of cultivated species of *Gossypium.* Punit Mohan (PL), M. Chakrabarty (PA), S. Manickam (PA), R. A. Meena (PA), K. P. M. Damayanthi (PA)	2006-15
15.	Conservation, characterization and utilization of wild species, races of cultivated species and synthetic polyploids of *Gossypium.* Vinita Gotmare (PL), G. Balasubramani (PA).	2008-15
16.	Exploration, collection and conservation of land races of desi cotton and perennials and from different regions of India. M. Saravanan (PL)	2011-16
17.	DUS characterization and DNA finger printing of public sector cotton varieties. V. Santhy (PL)	2012-17
18.	Studies on Genetic Purity of Public released Cotton Hybrids and its Parents with the help of SDS-PAGE. P. R. Vijayakumari (PL), K. R. Kranthi (PA)	2013-16
19.	Studies to improve the seed and boll setting efficiency in cotton. R. A. Meena (PL), Rishi Kumar (PA), K. Rathinavel (PA)	2012-18

S.No.	Project title	Duration
	Biotechnology	
20.	Deployment of biotechnological tools for enhancing cotton seed by-product utilization: Reduction of gossypol content using CYP6AE14 gene. K. P. Raghavendra (PI), Sandhya Kranthi (PA), G. Balasubramani (PA), K. Velmourougane (PA), M. Chakrabarty (PA)	2014-17
	Crop Production	
21.	Allelopathy as an alternative weed management strategy in cotton. Blaise Desouza (PI), P. Nalayini (PA), A. Manikandan (PA), M. Chakrabarty (PA)	2012-17
22.	Identification of 'crop-cycle' for Extra Long Staple (ELS) cotton in non-conventional regions. R. B. Singandhupe (PI), Blaise Desouza (PA)	2012-15
23.	Evaluation of potassium silicate formulations on cotton production (yield and quality) and protection (pest and disease). K. Velmourougane (PI), J. H. Meshram (PA), A. Manikandan (PA), V. Chinna Babu Naik (PA), Sampath Kumar (PA)	2012-16
24.	Phenotyping of cotton for drought tolerance traits. J. H. Meshram (PI), R. B. Singandhupe (PA), M. Chakrabarty (PA), J. Annie Sheeba (PA)	2013-16
25.	Correlation of leaf colour transmittance with relation to soil/plant nutrient status. J. Annie Sheeba (PI)	2014-17
26.	Evaluation of structured water for cotton production (Ad hoc). P. Nalayini (PI)	2014-15
27.	Role of leaf phytochemicals in cotton leaf reddening and plant responses to management through growth chemicals, nutrients and insecticides. M. Chakrabarty (PI), J. Annie Sheeba (PA), A. Manikandan (PA)	2012-15
28.	MCDA based decision support system for selecting cotton cultivars for different agro climatic conditions. M. Sabesh (PI)	2011-16
29.	Synthesis and characterization of nano-formulated micronutrients foliar spray for yield maximization in different cotton genotypes. D. Kanjana (PI)	2012-17
30.	Cotton Mechanization-Tracing the needs and gaps for sustainable cotton farming in India (Adhoc). Isabella Agarwal (PI), G. Majumdar (PA)	2014-15
31.	Effect of homeopathic medicines on the phytopathological diseases and insects of cotton (Adhoc). S. N. Rokde (PI)	2014-15
	Crop protection	
32.	Gene discovery for useful traits. K. R. Kranthi (PI), Sandhya Kranthi (PA), K. P. Raghavendra (PA), K. Velmourougane (PA), J. Annie Sheeba (PA), A. Sampathkumar (PA)	2014-19
33.	Role of epicuticular wax in reaction of cotton genotypes to whitefly/ CLCuD. Rishi Kumar (PI), D. Monga (PA), Sandhya Kranthi (PA), J. Annie Sheeba (PA)	2014-17
34.	Isolation and characterization of endophytes in cotton and endo-symbionts in bollworms. M. Amutha (PI)	2012-17
35.	Production, stabilisation, formulation and validation of microbial agents and their natural products against insects and nematode pests of cotton. J. Gulsar Banu (PL), M. Amutha (PA)	2012-17
36.	Use of innovative methods for management of cotton leaf curl virus disease. D. Monga (PL), Rishi Kumar (PA)	2011-15

S.No.	Project title	Duration
37.	An accelerated process for preparation of bio enriched compost from cotton plant residues. V. Mageshwaran (PI), D. Monga (PA), P. Nalayini (PA), K. Velmourougane (PA), A. Manikandan (PA)	2011-15
38.	**Technology Mission on Cotton MM I**	2012-17
	TMC MM 1.1: Development of multi-gene constructs and Bt cotton varieties for sustainable pest management. K. R. Kranthi (PI), S. B. Singh (PA), K. P. Raghavendra (PA), S. B. Nandeshwar (PA), G. Balasubramani (PA), M. Chakrabarty (PA), K. Velmourougane (PA), Sandhya Kranthi (PA)	
	TMC MM 1.2: Marker Assisted Breeding for Cotton Leaf Curl Disease (ClCuD), Bacterial Leaf Blight (BLB) and Nematodes Resistance in Cotton. V. N. Waghmare (PI), A. Sampath Kumar (PA), N. Narkhedkar (PA), S. Manickam (PA), J. Gulsar Banu (PA), D. monga (PA), S. K. Verma (PA)	
	TMC MM 1.3: Consolidation of repository of high strength cotton genotypes and evaluation for quality traits and yield in specific agro-eco zones. S. Manickam (PI), T. R. Loknathan (PA), S. M. Palve (PA), P. Nalayini (PA) , Vinita Gotmare (PA) (2013-15)	
	TMC MM 1.4: Evaluation of genotypes and agrotechniques for high density planting system and surgical cotton varieties. M. V. Venugopalan (PI), Blaise DeSouza (PA), V. Chinna Babu Naik (PA), Punit Mohan (PA), T. R. Lokanathan (PA), A. R. Raju (PA), A. Sampath Kumar (PA), K. Shankarnarayanan (PA), S. L. Ahuja (PA), R. A. Meena (PA)	
	TMC MM 1.5: Simulation models/electronic gadgets to predict insect infestation, bollworm resistance to Bt cotton, area, production and price of cotton. Sandhya Kranthi (PI), K. R. Kranthi(PA),V. S. Nagrare (PA), V. Chinna Babu Naik (PA), A. R. Reddy (PA), Anuradha Narala (PA), A. H. Prakash (PA), K. Shankarnarayanan (PA), Isabella Agarwal (PA), B. Dharajothi (PA), Rishi Kumar (PA), M. Chakrabarty (PA), J. Annie Sheeba (PA), M. Amutha (PA)	
	TMC MM 1.6: E-Kapas Network and Technology Documentation. S. M. Wasnik (PI), A. H. Prakash (PA), S. Usha Rani (PA), O. P. Tuteja (PA), M. Chakrabarty (PA), Anuradha Narala (PA)	
	TMC MM I 1.7: Development of cotton picking machinery for small scale cotton production systems. G. Majumdar (PI)	
	Externally funded projects	
39.	DBT: Development of saturated genetic linkage map for *Gossypium hirsutum* L. using SSR and SNP markers. V. N. Waghmare (PI), Punit Mohan (PA)	2012-16
40.	Consortia Research Platform on biodiversity. Punit Mohan (PI), Vinita Gotmare (PA), J. H. Meshram (PA), S. Manickam (PA)	2014-17
41.	UGC: Association mapping of fiber traits in *Gossypium arboreum* L. accessions using SSR, ISSR and AFLP markers. S. K. Verma (PI)	2012-16
42.	NSP: National Seed Project (Crops). K. Rathinavel (PI)	1999-17
43.	DUS: Implementation of PVP legislation 2001 and DUS testing of cotton under ICAR-SAU system. K. Rathinavel (PI)	2003-17
44.	MSP: ICAR project on Seed Production in Agricultural Crops and Fisheries. P.	2007-17

S.No.	Project title	Duration
	R.Vijayakumari (Nd Offi), V. Santhy (PA), K. Rathinavel (PA), R. A. Meena (PA)	
45.	NASF: Molecular characterization and validation of fiber strength genes with fiber specific promoter for improvement in cotton. G. Balasubramani (PI), K. P. Raghvendra (PA), J. Amudha (PA), S. B. Nandeshwar (PA)	2012-17
46.	NPTC: Transgenics in crops. Insect and disease resistant transgenic cotton. G. Balasubramani (PI), J. Amudha (PA), S. B. Nandeshwar (PA), K. P. Raghvendra (PA), Suman Bala Singh (PA)	2012-17
47.	NICRA: Climate change- adaptation and mitigation strategies in cotton. S.E.S.A Khader (PI), A. H. Prakash (CoPI), Blaise Desouza (CoPI), M.V. Venugopalan (CoPI)	2013-17
48.	DST: Design & Development of a cotton picking head. G. Majumdar (PI)	2012-16
49.	DST: Development of vision based expert system for vacuum picking of cotton. G. Majumdar (PI)	2013-15
50.	Maha. Govt: Impact evaluation of Bt cotton in Maharashtra. Anuradha Narala (PI), R. B. Singandhupe (PA), S. N. Rokde (PA)	2012-15
51.	Mahyco: Monitoring changes in baseline susceptibility to Cry toxins in the cotton bollworm, *H. armigera, pink bollworm and Spodoptera litura.* Sandhya Kranthi (PI), K. R. Kranthi (CoPI), V. Chinna Babu Naik (CoPI)	2012-15
52.	GEAC: Event based approval mechanism. Sandhya Kranthi (PI), K. R. Kranthi (CCPI)	2010-15
53.	Consortia research platform (IIHR-Lead centre) - Management of sucking pests in horticultural crops. S. Karnthi (PI)	2014-17
54.	TMC MM II: Dissemination of IRM strategies in India. K. R. Kranthi (PI), Sandhya Kranthi (PA), D. Monga (PA), B. Dharajothi (PA), Rishi Kumar (PA)	2007-15
55.	DST: Entomopathogenic-endophytes mediated plant defense as a novel approach for the management of bollworms in cotton. M. Amutha (PI)	2013-17
56.	Maha. Govt: Crop pest surveillance and advisory project (CROPSAP) in Maharashtra. V. S. Nagrare (PI)	2010-15
57.	NFSM-OPMAS: On line pest monitoring and advisory services (OPMAS) under NFSM –commercial crops. R. K. Tanwar (PI), D. Monga (PA), Rishi Kumar (PA)	2012-17
58.	DST: Engineering root-knot nematode resistance in cotton by RNAi mediated silencing of parasitism genes of *Meloidogyne incognita.* N. G. Narkhedkar (PI), S. B. Nandeshwar (CoPI)	2013-16

10.3 : Consultancy, Patents, Commercialization of Technology

Revenue Generation

The Bt referral lab has generated a revenue of Rs. 52,430/- through sale of Bt Express, Bt Quant, GUS detection Kits during 2014-15.

Patent submitted and published in *IPINDIA* website

A complete patent application was submitted by Er. G. Majumdar *et al* (2014) at Patent Office, Mumbai for the invention of **"Small Cotton Harvester with Precleaner Attachment"** (Filing Application no. 2076/mum/2014, dt. 26/06/2014). The invention was published on 22/8/2014 and request has been made for Examination.

MoU signed by ICAR-CICR

1. Material Transfer agreement (MTA) was signed between ICAR-CICR, Nagpur and National Botanical Research Institute (CSIR-NBRI), Lucknow on 11th June 2014 for validation of the transgenic cotton against whiteflies.

2. MoU signed between ICAR-CICR, Nagpur and Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Krishi Nagar (PDKV), Akola dated 04th July 2014 for production of TFL seeds of PKV 081 for demonstration during 2015-16 seasons.
3. MoU signed between ICAR-CICR, Nagpur and M/s. Bayer BioScience Pvt., Ltd., Hyderabad, Andhra Pradesh dated 22nd Aug 2014 for trials of transgenic crop (Rice).

10.4 : Significant Decisions of RAC, IRC, IMC

Research Advisory Committee Review Meeting

Research Advisory Committee (RAC) review meeting was held at ICAR-Central Institute for Cotton Research (CICR), Nagpur on November 21-22nd, 2014 to review the progress of work and to discuss the technical programme for the year 2014-15. The meeting was chaired by Dr. B. V. Patil, Former Vice Chancellor, UAS, Raichur, Karnataka. The meeting started with welcome address by Dr. K. R. Kranthi, Director, CICR. Dr. Patil, Chairman, RAC in his introductory remarks provided an overview of cotton scenario this year and reiterated that High Density Planting System (HDPS) and mechanical picking of cotton should continue as the two important flagship programmes. Dr. S. K. Mukherjee, Member RAC, stressed on development of drought tolerant cotton varieties. Dr. T. Pradeep, Member, RAC, emphasized on need for prioritization of research efforts benefitting the farmers and other stake holders. Dr. A. K. Dhawan, Member, RAC, discussed about Cotton Leaf Curl Virus (CLCuV) in north India and its management approaches. Dr. A. J. Shaikh, Member, RAC, talked about the challenges for scientific community with respect to availability of cotton in 2050. Dr. N. Gopalakrishnan, ADG (CC) and member, RAC, called for tailoring crop improvement programmes for sustainable cotton production. He also appreciated the E- kapas effort which was included in 100 days achievement of Government of India.

Dr. K. R. Kranthi, Director, CICR, presented ÇICR Vision 2050' before RAC members. The Action Taken Report (ATR) was presented by Dr. M. V. Venugopalan, Member Secretary, RAC. The research achievements of 2013-14 and technical programmes for 2014-15 of various divisions and regional stations were presented by Heads of Divisions and Regional Stations. The RAC members also visited the experimental fields and reviewed the trials laid out. The meeting concluded with vote of thanks proposed by Dr. Sandhya Kranthi, Head, Crop Protection Division, CICR, Nagpur.

The salient recommendations of the RAC include

1. Publication of research results has to be expedited

RAC urged all the scientists to focus their research efforts on basic aspects and called for sincere efforts for the early publication of the findings in the reputed national and international journals.

2. Efforts towards development of cotton *G.*

***hirsutum* and *G. arboreum* genotypes amenable for high density planting system and machine picking**

High density planting system is emerging as an alternate production technology. To sustain the momentum of HDPS system there is need (a) to accelerate efforts for the development of compact genotypes of *G. hirsutum* and *G. arboreum* amenable to closer planting and machine picking. (b) to develop / evaluate planters to obtain satisfactory plant stand in cotton fields.

3. Initiate a long term programme to improve the soil health through appropriate cotton based cropping systems

The decline in soil health and low partial factor productivity of fertilizers in cotton production is affecting the sustainability of cotton production systems. There is a need to initiate a long term research programme with components of both basic and strategic objectives aimed at improving soil health through appropriate cotton based cropping systems.

4. Resistance breeding against whitefly has to be initiated like using Tomato leaf curl virus Ty-2 and Ty-3 virus resistance gene

Cultivated cotton in north India is inherently susceptible to cotton leaf curl virus (CLCuV). In Tomato commercially important alleles like *Ty-1* and *Ty-3*, which were introgressed from the wild tomato relative *Solanum chilense*. These genes were originally mapped to different regions on chromosome 6, but recent findings suggest that they may rather be alleles of the same gene. *Ty-1* and *Ty-3* are alleles that code for an RNA–dependent RNA polymerase of a class for which no function had been described before. Thus, *Ty-1*/*Ty-3* unveils a completely new class of resistance genes. An attempt may be made to utilize the available information about these genes for screening of cotton genotype / germplasm lines for their cross species validation against CLCuV.

5. MicroRNA approach may be explored for the management of cotton leaf curl virus (CLCuV) using the conserved regions

Gemini viruses are plant pathogens that profoundly affect diverse plant crops in tropical and subtropical countries. These are emerging class of viruses with new strains still evolving, thereby making them more virulent with wide host range specificity. Cotton leaf curl virus (CuCLV) is a member of begomoviruses infecting cotton crop causing severe yield losses. Genetic engineering approach through RNAi may be further explored by analysing the sequence information through bio-informatic tools. Conserved region of the target genes in the viral genome may be identified and targeted for management of the Cotton leaf curl virus through RNAi approach.

6. Regular monitoring of PBW incidence on Bt cotton in different ecosystems

There is a concern regarding the incidence of pink bollworm in Bt hybrids in farmers fields and the chances of resistance development cannot be ruled out. Hence, the existing programme on monitoring of pink bollworm population from different agro-eco regions for resistance to Cry1Ac and Cry2Ab needs to be intensified.

Institute Management Committee Meeting

The 52nd Institute Management Committee (IMC) meeting was held on 12th March 2015 under the Chairmanship of Dr. K.R Kranthi, Director, CICR, Nagpur.

At the outset, Shri. Sachin Agnihotri, Sr. Administrative Officer and Member Secretary welcomed the Director, CICR and Chairman, IMC, Dr. R.G. Dani, Vice Chancellor, Dr. PDKV, Akola other members of IMC and special invitees.

Dr. K.R Kranthi, Director CICR & Chairman, IMC in his introductory remark mentioned that non-official members of IMC are yet to be nominated by Council. The major agenda was to seek recommendations of the committee for purchase of equipments, furniture & fixtures and execution of works approved in XII Plan for the year 14-15 and 15-16 to be taken on priority and for processing of the same under B.E. of 2015-16. The chairman stressed that the construction of boundary wall has to be taken at Hqrs. Nagpur on priority basis. Further, Dr. M. V. Venugopalan, I/c PME Cell summarized the research highlights of the institute.

Dr. R.G. Dani, Vice Chancellor, Dr. PDKV, Akola

expressed satisfaction over the research work conducted at CICR and was particularly impressed with the initiatives on high density planting system and screening for CLCuV disease. He emphasized that both CICR, Nagpur and Dr. PDKV, Akola are situated in Vidarbha region of Maharashtra and have a huge responsibility of redressing the problems related to agriculture, with reference to cotton and soybean. He also stressed upon the social distress among the farmers of Vidarbha which is highly vulnerable to climate variability and extremes. Further, he suggested that CICR should implement the recommendations outlined in the QRT report of CICR and AICRP on Cotton submitted under the Chairmanship of Dr. C.D. Mayee, Former Chairman, ASRB, New Delhi.Shri. G.C. Prasad, SFAO, NBSS&LUP, Nagpur expressed satisfaction over the expenditure pattern and the resources generated by the institute. Dr Jagdish Prasad, Principal Scientist, NBSS & LUP, Nagpur stressed the need of purchasing scientific research equipments on priority basis. Dr. A.D Huchhe, Principal Scientist, CCRI, Nagpur recommended planting citrus trees in the Institute farm.

Institute Research Committee (IRC) meeting

Institute Research Committee meeting was held at CICR, Nagpur from March 17 to 19, 2015 under the chairmanship of Dr. K. R. Kranthi, Director, CICR, Nagpur. Dr. K. R. Kranthi, Director, CICR, initiated the meeting with the introductory remarks. Dr. M. V. Venugopalan, Head, PME, presented the RAC recommendations. Dr. Vinita Gotmare, Nodal Officer, RFD, presented the Research Framework Document of 2013-14. Dr. V.S. Nagrare, Secretary, IRC, presented the Action Taken Report of IRC 2013-14. Dr. Sandhya Kranthi, Head, Division of Crop Protection, Dr. D. Blaise, Head, Division of Crop Production, Dr. Suman Bala Singh, Head I/c, Division of Crop Improvement, Dr. D. Monga, Head, Regional Station, Sirsa, Dr. A. H. Prakash, Head, Regional Station, Coimbatore were present. All the Scientists of CICR, Nagpur, CICR, RS, Sirsa and CICR, RS, Coimbatore presented their research findings and the results were discussed. Technical programme for 2015-16 was finalized for each project. Concluding remarks were given by Dr. K. R. Kranthi, Chairman, IRC. Shri. S.P. Muchali, Technical Officer (T5) was felicitated by Chairman, IRC for his services during the IRC meetings conducted over the years as he would be superannuating this year. Dr. J.H. Meshram, Joint Secretary, IRC, proposed the vote of thanks.

Project Monitoring and Evaluation Committee (PMC)

PMC visit to CICR, Sirsa

The Project Monitoring and Evaluation Committee (PMC) from CICR, Nagpur under the chairmanship of Dr. K.R. Kranthi, Director, CICR, Nagpur along with Dr A. H. Prakash, PC & Head, CICR Coimbatore, Dr. Suman Bala Singh, Head Crop Improvement, CICR, Nagpur, Dr. K. Rathinavel, Principal Scientist, CICR, RS, Coimbatore and Dr. M. V. Venugopalan, Principal Scientist & Head PME Unit CICR, Nagpur visited CICR, Regional Station, Sirsa on Sept. 11,2014 and evaluated the performance of the ongoing projects. The team members visited the demonstrations of various hybrids and varieties released/sponsored/ developed by the Station along with large plot of HDPS sown with F-2383 (*G. hirsutum*) and CICR-1 and CICR-3(*G. arboreum*). The visit was followed by discussion and observations about the research programs by Chairman and members.

PMC visit to CICR, Coimbatore

The Chairman and members of Project Monitoring and Evaluation Committee visited CICR Regional Station, Coimbatore during January 19-21, 2015. Under the chairmanship of Dr. K.R. Kranthi, Director, CICR, Nagpur, the committee evaluated the progress of research projects handled by the Scientists in Divisions of Crop Protection, Crop production and Crop Improvement. The committee also visited the experimental field trials and demonstrations in the main as well as new farm. At the end, the Chairman addressed the scientists with his concluding remarks. The program concluded with the vote of thanks proposed by Dr. (Mrs.) S. Usha Rani, Senior Scientist (Agrl. Extension).

10.5 : Other Important Workshop/ Symposia/Meetings

Annual Review Workshops of TMC MMI

A meeting of PI/CCPIs of TMC MM I projects (TMC MM 1.3, TMC MM 1.4, TMC MM 1.5 & TMC MM 1.6) located in southern zone was held at Directorate of Oilseeds Research (DOR), Rajendra Nagar, Hyderabad on 8th May, 2014 to review the progress of work and to discuss the technical programme for the year 2014-15. The meeting started with welcome address by Dr. D. Blaise, Head, Crop Production Division, CICR, Nagpur. In his introductory remarks Dr. K.R. Kranthi, Member Secretary TMC MM-I & Director, CICR explained about purpose of the meeting. Dr. K.S. Varaprasad, Project Director, DOR was present during inaugural function and expressed his desire to be part of TMC 1.6: e-kapas project. He also appreciated the HDPS system of cotton production. The meeting ended with the vote of thanks by Dr. J.H. Meshram, I/c TMC Cell, CICR, Nagpur.

A meeting of PI/CCPIs of three TMC MM I projects (TMC MM 1.4, TMC MM 1.6 & TMC MM 1.7) for central zone was held at Central Institute for Cotton Research, Nagpur on 19th May, 2014 to review the progress of work and to discuss the technical programme for the year 2014-15. The meeting started with welcome of the participants by Dr. M.V. Venugopalan Head, PME Cell, CICR, Nagpur. In his introductory remarks Dr. K.R. Kranthi, Member Secretary TMC MM I & Director, CICR explained about the purpose of the meeting. The action plan for the implementation of IRM-HDPS and HDPS demonstrations at various locations during 2014-15 were discussed and finalized based on the availability of seeds at various centres. The meeting ended with the vote of thanks by Dr. J.H. Meshram, In-charge TMC Cell, CICR, Nagpur

Screening and Evaluation for Cotton Leaf Curl Virus

A Meeting was held on "Screening and Evaluation for Cotton Leaf Curl Virus" under the aegis of the AICCIP on Aug. 5, 2014 at CICR, Nagpur. About 26 participants from public and private sector attended the meeting. Kohinoor seeds, Ankur Seeds, MAHYCO, Ganga Kaveri, Krishidhan seeds, JK seeds, Bayer Crop Sciences, Bioseed, Rasi seeds, Nuziveedu seeds were represented by their officials. Dr. Siwatch (HAU) Dr. Pankaj Rathod (PAU), Dr. A.H. Prakash (PC), Dr. Sandhya Kranthi (CICR), Dr. Chinna Babu (CICR), Dr. Pradeep Kumar (RAU) and Dr. R.K. Arora (PAU) were also present. The meeting was chaired by Dr. C.D. Mayee. While Dr. K.R. Kranthi, Director, CICR, welcomed the gathering, Dr. Mayee gave the introductory remarks, followed by Dr. Rishi Kumar's presentation on the status of leaf curl virus screening procedures. Detailed discussion on the screening methodology followed. A monitoring team under the chairmanship of Dr. K.R. Kranthi was constituted for the year.

Review meeting on TMC MMI-IRM HDPS

Review meeting on TMC MMI-IRM HDPS was conducted at CICR, Nagpur, on 25th August 2014. Dr. K. R. Kranthi, Director, CICR, Dr. D. Blaise, Head, Crop Production, Dr. M.V. Venugopalan, Head, PME, Dr. R.B. Singhandhupe, Shri Atul Sharma from Wardha, Dr. Solanki and Dr. C.K. Patil from Gujarat, Dr. R. K. Patnaik from Orissa, Dr. P. Mewade, Dr. Satish Parsai from Khandwa, Mr. B. Tule and KVK staff attended the meeting. The purpose of the meeting was to review the implementation of IRM – HDPS demonstrations, to take stock of the number of trials/farmers etc in each district and to review the crop condition *viz.*, per cent germination, crop stand and implementation of HDPS package.

Cotton Technology Assistance Programme (TAP) for Africa Review Meet

A review meeting on Cotton TAP was held on 27th August, 2014 at CICR, Nagpur. Dr. K.R. Kranthi, Director, CICR, Dr. D. Blaise, Head, Crop Production Division, Er. Gautam Majumdar, Dr. A.K. Krishna Kumar, Executive Director, IL&FS and Dr. Milan Sharma, Head, Africa Initiatives and Industry Research, IL & FS Cluster Development Initiative Limited attended the meeting. Discussions regarding II phase of the ongoing Technical Assistance program and extension of the programme to five new African countries based on their request were held during the meeting.

Regional Committee Meeting at Raipur

Hon'ble Union Minister for Agriculture, Government of India, Shri Radha Mohan Singh inaugurated the 23rd meeting of ICAR Regional Committee No.VII at Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur on October 17, 2014. The meeting aimed to address the various emerging issues and problems of farming communities of Chhattisgarh, Madhya Pradesh, Maharashtra and Goa. The Inaugural session was chaired by Hon'ble Chief Minister, Government of Chhattisgarh, Dr. Raman Singh. Dr. S. K. Patil, Vice Chancellor, IGKV, Raipur welcomed the dignitaries. Shri Brij Mohan Agrawal, Hon'ble Minister for Agriculture, Veterinary, Fisheries and Water Resources, Government of Chhattisgarh, Sushri. Kusum Mehdele, Hon'ble Minister for Animal Husbandry, Horticulture and Food Processing, Government of Madhya Pradesh, Shri. Ramesh Bais, Hon'ble Member of Parliament, Raipur Lok Sabha, Shri. Devji Bhai Patel, Hon'ble MLA, Dharsiwa, Vidhan Sabha Chhattisgarh, Dr. S. Ayyappan, Secretary, DARE & DG, ICAR, DDGs, Dr. K. R. Kranthi, Director, Central Institute for Cotton Research, Nagpur and Member Secretary of the ICAR Regional Committee, Vice Chancellors of State Agricultural and Veterinary Universities located in the region VII, ADGs, Directors of different ICAR institutions, Agricultural Commissioners and Senior Government Officers from the State Departments, members representing ICAR Society & NGOs, Project Co-ordinators of AICRPs, Heads of Regional Stations, special guests and invitees were present at the occasion. Dr. M.V. Venugopalan, Head, PME Unit, Dr. K. P. Raghavendra, Scientist, Biotechnology, Dr. H.B. Santosh, Scientist, Plant Breeding, Dr. Mahendra Singh Yadav, Chief Technical Officer and Mrs. Vandana Satish, Programme Assistant from CICR attended the meeting. Dr. R. B. Singhandhupe, i/c Head, KVK, Dr. Punit Mohan, Principal Scientist and Shri. S. S. Patil showcased the technologies developed by CICR in the exhibition. Speaking on the occasion, Dr. S. Ayyappan, Chairman of the Regional Committee expressed gratitude to Union Minister of Agriculture, Shri. Radha Mohan Singh for his presence in the ICAR Regional Committee meeting. He also briefed the dignitaries and audience about the major issues to be discussed in the meeting and lauded the contributions of the region towards national agricultural development and prosperity. Dr. Raman Singh, Hon'ble Chief Minister of Chhattisgarh during his presidential address lauded the contributions of farmers, ICAR, SAU's, and KVK's in agricultural development in the region. Hon'ble Union Minister of Agriculture emphasized the role of Regional Committee in agricultural development of region. He appreciated the efforts of National Agricultural Research System in sustaining food grains production through district-wise contingent plans in wake of deficit monsoon. He called for utilization of *desi* cattle breeds in animal breeding programmes to develop climate resilient cattle breeds while exhorting the researchers to be vigilant and realistic towards climate change. He urged all the researchers and administrators to explore the potentiality of inland fisheries and *desi* cattle breeds to achieve higher fish and milk productivity, respectively. Many innovative farmers from the region were felicitated and a number of useful publications in the form of bulletins, CDs, books from ICAR institutes and SAUs were released during the occasion. Dr. K.R. Kranthi, Director, Central Institute for Cotton Research, Nagpur and Member Secretary of the ICAR Regional Committee – VII proposed the vote of thanks.


NAAS Silver Jubilee Symposium

One day NAAS Silver Jubilee Symposium on "25 years of Research on Insect Resistance to toxins – the way forward" was organized at Central Institute for Cotton Research, Nagpur on 27th December, 2014. The symposium was inaugurated by the Chief Guest Dr. S. N. Puri, Former Vice-Chancellor, Central Agricultural University, Imphal, Manipur. Dr. Sandhya Kranthi, Head, Crop Protection Division, welcomed the delegates and participants. Dr. K. R. Kranthi, Director, CICR, gave introductory remarks emphasizing on the specific purpose of technical gathering on Insect Resistance to toxins, especially of young speakers working in this area. Dr. S. N. Puri appreciated the initiative taken by NAAS to discuss upon the burning issues in such scientific forum especially Cotton- Bt Cotton-Pesticides-Resistance-Sustainable Management.

Deliberations were held in two technical sessions. First session was on 'Insecticide Resistance- over 25 years in India' chaired by Dr. S. N. Puri and Co-chaired by Dr. T.V.K. Singh. Speakers and topic of talks were Dr. Rishi Kumar on "Insecticide resistance reports", Dr. G.M.V Prasad Rao on "Management issues in India", Dr. V. Sridhar on "Mitigating resistance with new molecules" and Dr. Sandhya Kranthi on "Mechanisms of insecticide resistance in insects". Second technical session was on 'Resistance to Bt crops across the globe and India'. Speakers and topic of talks were Dr. K. S. Mohan on "Bt Resistance reports including India", Dr. G. T. Behere on "Mechanisms of resistance to Bt crops", Dr. K. P. Raghavendra on "RNAi approaches to break resistance", Dr. P. Srinivas on "Issues with resistance management options".

The house discussed various issues at length and came out with some recommendations *viz.*, 1) Establishing National Referral laboratory for resistance management, 2) Management of refuge along with farmers' awareness, 3) Creating baseline susceptible population for monitoring insecticide resistance and toxins, 4) Standardizing procedures for monitoring and scouting techniques, 5) Promoting new technologies like RNAi and 6) Public- private partnership in research and extension to combat resistance and effective implementable IRM strategies. Certificate of participation and mementos were distributed to all the participants. Rapporteurs were Dr. Vishlesh Nagrare, Mr. Joy Das, Mr. Rakesh Kumar and Miss Suvarna Khadakkar. The symposium concluded with vote of thanks proposed by Dr. K. R. Kranthi.

Review meeting on ClCuD, PBM and HDPS

Review meeting to finalize action plan for Cotton Leaf Curl Virus disease (CLCuD), Pink bollworm management (PBM) and High density planting system (HDPS) was held under the chairmanship of Dr. J. S. Sandhu, Deputy Director General (Crop Science) on Feb. 21, 2015. Dr. Sandhya Kranthi welcomed the dignitaries and introduced Dr. J.S. Sandhu to the audience. Dr. K.R.Kranthi, Director, CICR emphasized on importance of meeting as many issues related to Cotton Leaf Curl Virus disease, Pink bollworm management and High density planting system need to be resolved.

First session on cotton leaf curl disease was chaired by Dr. J. S. Sandhu, DDG (CS). He emphasized on need for sustainability and importance of seed quality. Dr. A. H. Prakash presented evaluation report of released and prerelease Bt hybrids and classified them into tolerant and susceptible based on PDI and progress of the disease.

DDG suggested that the number of entries should be restricted. He stressed that old hybrids should be withdrawn every year and government should be informed as and when seed companies bring new hybrids every 3 years. DDG also pointed out

the need for DNA finger printing of Bt hybrids released by private sector.

Second session on pink bollworm management was chaired by Dr. Raju Barwale, MD, Mahyco. Dr. K. S. Mohan, Consultant, Monsanto India presented talk on "Results of the 'Refuge-In-Bag' trials and Recommendations". To sustain the Bt technology, planting of structured refuge is mandatory. However, farmers are not adopting it. Thus problem of resistance is inevitable in due course of time. He told that Monsanto, on its own and also in collaboration with CICR conducted field trials at various locations for the last three years. The findings of the trials indicated that with 5% refuge in bag (RIB) with isogenic line of counterpart hybrid there was no significant decrease in yield. However, he cautioned and stated that while implementing the RIB seed companies must undertake responsibility of educating farmers, spraying of insecticides and availability of counterpart non Bt hybrid. He told that proposal in dossiers have been submitted to ICAR/ GEAC for approval and gazette notification on the implementation was awaited.

Third session was on High Density Planting Systems and was chaired by DDG (CS) Dr J.S. Sandhu. Dr. Sandhu in his introductory remarks said that HDPs was tested on experimental fields as well as on farmer's participatory mode for the past three years by the Public Sector & Seed Industry and a lot of confidence has been developed.

The first presentation by Dr. M. V. Venugopalan

Dr J.S. Sandhu, DDG (CS), ICAR

provided an insight of the research projects undertaken at CICR and the partners in AICCIP since 2010-11 till date. The second presentation by Dr Blaise Desouza, Head Crop Production Division was on the results of the National Food Security Mission (NFSM). An overview of the on-farm trials undertaken in Vidarbha and other regions in 2012-13 and 2014-5 were also presented. Dr Ramasami, MD Rasi Seed made a presentation of the HDPS trials for Bt hybrids in Maharashtra and South India. Dr Ritesh Mishra, Mahyco and Dr Ashwin Kashikar from Ankur Seeds Pvt Ltd orally briefed the house about the trials conducted by Mahyco and Ankur seeds. Dr Vipin Dagaonkar, Bayer India Ltd informed that response of PGR differs from genotype to genotype and ginning percent needs to be increased for higher productivity.

DDG surmised that the concept of HDPS was good as shown by experimental results from the trials carried out over the past five years and also extensive field trials conducted by CICR and seed companies in farmers fields over the past three years. He suggested a zone-wise analysis on the success or failure of HDPS trials.

Seminar cum workshop on non Bt Cotton seed at CICR, Nagpur

A two day Seminar cum workshop on "Non Bt Cotton Seed" was organized by the Organic and Fair Trade Cotton Secretariat (OFCS) and Central Institute for Cotton Research at CICR, Nagpur on March 24-25, 2015. The workshop was attended by organic cotton stakeholders, organic cotton farmers and scientists of CICR, Nagpur. Dr. K.R. Kranthi, Director, CICR, Nagpur welcomed all the participants. Mrs. Prabha Nagarajan briefed about the agenda of the workshop mainly the issues on availability and production of non Bt cotton seeds. Dr. Kranthi, ascribed the low cotton productivity to cultivation of long duration hybrids and late sowing and suggested that adapting early maturing varieties (150 days duration) and undertaking early sowing can overcome the problems of pests as well as drought. Dr. Sandhya Kranthi, Head, Crop Protection, CICR, Nagpur

presented the information on "Pest management for organic cotton". Dr. Suman Bala Singh, Head, Crop Improvement, CICR, Nagpur gave a talk on "Historical perspective in cotton breeding in India". She mentioned about the archaeological excavations of cloth used during Harappa and Mohenjodaro civilisation that were made from *Desi* cotton. Dr. Blaise Desouza, Head, Crop Production, CICR, Nagpur gave a presentation on "Packages of practices for sustainable organic cotton production". He mentioned that the *Desi* cotton due to its robustness and low input requirements, are more suitable for organic cotton cultivation. Dr. M.V. Venugopalan, Principal Scientist, CICR, Nagpur discussed about the difference between climate variability and climate change and provided an overview of the HDPS on cotton using non Bt varieties. Mr. Arun Ambatipudi (Chetna) discussed the challenges of organic cotton cultivation especially the problem of convincing farmers in taking up non Bt seed compared to the attractively labelled Bt cotton seed packets. Mr. Dharmendra Wele (Arvind – Agri) informed that availability of non Bt seeds as a major problem in organic cotton cultivation. In the session on "Experiences of seed production" Dr. Rajasekhar (CSA), Dr. Subramaniam (Bloom Biotech), Dr. Ramprasad, Mr. Avinash Kamerkar (Pratibha), Mr. Yogender (Bio Re) and Ms. Latabai Madavi (Seed Farmer) shared their views and experiences. Dr. Vinita Gotmare, Principal Scientist, CICR, Nagpur presented "Spectrum of non-Bt varieties/hybrids-quality and biotic /abiotic stress reactions. She discussed the list of varieties released by CICR, State Agricultural Universities for North, Central and South zones. Dr. V. Santhy, Senior Scientist, CICR, Nagpur presented "Seed production-Regulatory aspects" on the first day and "Guidelines on how to start seed production project and seed testing procedures" on the second day. She discussed the legislative aspects of seed quality control including the specific standards for seed production. Miss. Usha, SRF, CICR, Nagpur made a presentation on ways to detect genetic contamination of organic cotton seeds by G M cotton. In the concluding remarks, Mrs. Prabha Nagarajan appreciated all the speakers. She mentioned High Density Plant System (HDPS) as one of the useful systems to increase the cotton yield in the country.

10.6: Results – Framework Document (RFD) Committee

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

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

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

The Institute set a high performance standard and achieved a total composite score of 96% (Ranked in Excellent category) in the Annual Performance Evaluation Report (April 1, 2013 to March 31, 2014). The details are given in Annexure-I.

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

Sr. No.	Seminars/Conferences/Symposia/ Workshops/ Meetings	Place and Date	Participants
1.	Annual Group Meeting of All India Coordinated Cotton Improvement Project	PAU, Ludhiana 6-8 April, 2014	Dr. K.R. Kranthi, Dr. A.H. Prakash, Dr. S. Manickam, Dr. K. Rathinavel, Dr. S. Usha Rani, Dr. K.P.M. Dhamayanthi, Dr. B. Dharajothi, Dr. MV Venugopalan, Dr. S.Kranthi Dr. S.M.Palve Dr. T.R.Loknathan Dr. Punit Mohan Dr. V.N.Waghmare
2.	Meeting on CLCuV in Bt cotton	Krishi Bhawan, New Delhi 17 April, 2014	Dr. K.R. Kranthi
3.	XXIX Annual Group Meeting of NSP (Crops)	S.K. U A & T, Srinagar(J&K) 24-26 April, 2014	Dr. P. R. Vijaya Kumari
4.	Meeting on Performance of HDPS before Hon'ble Agriculture Minister	28 April, 2014	Dr. K.R. Kranthi Dr. MV Venugopalan
5.	XII Plan EFC meeting of DARE/ICAR	30 April, 2014	Dr. K.R. Kranthi
6.	Annual students function	TNAU, Coimbatore 6 May, 2014	Dr. K.R. Kranthi
7.	Annual Review Workshop of TMC MM I	DOR, Hyderabad 8 May, 2014	Dr. S. Manickam Dr. S.M. Wasnik, Dr. MV Venugopalan, Dr. Blaise Desouza, Dr. JH Meshram
8.	Annual Review Workshop of TMC MM II – HDPS – IRM	Department of Agronomy, ANGRAU, Hyderabad 9 May, 2014	Dr. S. Manickam, Dr. B. Dharajothi, Dr.K. Sankaranarayanan, Dr. S.M. Wasnik, Dr. M.V. Venugopalan, Dr. Blaise Desouza, Dr. J.H. Meshram
9.	TMC MM I Annual Review workshop (Central Zone)	CICR, Nagpur 19 May, 2014	Dr. S.Kranthi, Dr. S.M. Wasnik
10.	Resistance Management Workshop	PJTSAU, 27 May, 2014	Dr. S.Kranthi
11.	21st General Body meeting and the Foundation day programme	NAAS, New Delhi 4- 5 June, 2014	Dr. K. R. Kranthi

12.	Essentially Derived Variety Committee meeting at Protection of Plant Varieties and Farmers Rights Authority	New Delhi 5 June, 2014	Dr. A.H. Prakash, Dr. K. Rathinavel
13.	Workshop on 'Impact of Capacity building programme under NAIP"	NASC, Pusa New Delhi 6-7 June, 2014	Dr. K.R. Kranthi Dr. Vinita Gotmare Dr. V. S. Nagrare
14.	Central Insecticide Board meeting at Mantralaya	Mumbai 12 June, 2014	Dr. K.R. Kranthi
15.	HDPS meeting	Main Cotton Research Station ,NAU, Athwa farm, Surat 13 June, 2014	Dr. K. R. Kranthi
16.	Review Meeting of Cotton TAP	Dept. of Commerce, GOI, New Delhi 16 June, 2014	Dr. Blaise Desouza
17.	Sixth Meeting of Asian Cotton Research and Development Network	Dhaka, Bangladesh 18 -20 June, 2014	Dr. K.R. Kranthi, Dr. Loknathan, Dr. M.V. Venugopalan, Dr. Vinita Gotmare, Dr. S.M. Palve, Dr. K. P. Raghavendra, Dr. A.H. Prakash, Dr. S. Usha Rani, Dr. D. Monga, Dr. Rishi Kumar
18.	High Density Planting System meeting	Directorate of Cotton Development Mumbai 1 July, 2014	Dr. K.R. Kranthi
19.	'Current status and experiences with production of Coloured cotton"	New Delhi 21 July, 2014	Dr. K.R. Kranthi
20.	ICAR Foundation Day and Conferences of Directors of ICAR Institutes and Vice Chancellors of SAUs	New Delhi 29 - 30 July, 2014	Dr. K.R. Kranthi
21.	Meeting on promotion of naturally coloured cotton	Office of the Textile Commissioner Mumbai 4 August, 2014	Dr. K.R. Kranthi, Dr. Vinita Gotmare Dr. M.V. Venugopalan
22.	Brain Storming meeting on "Insecticide Resistance Management "	IIHR, Bangalore 30 August, 2014	Dr. K. R. Kranthi
23.	4th meeting to discuss on Collaborative Cotton Mechnization projects of FICCI, Industry Partners M/x Bayer, M/s John Deere and M/s Nuzivedu	Krishi Bhawan, New Delhi 22 Sept., 2014	Dr. K.R. Kranthi
24.	IX Annual Review Meeting of ICAR Seed Project-" Seed Production in Agricultural Crops"	ANGRAU, Hyderabad 22-23 Sept., 2014	Dr. P. R. Vijaya Kumari

25.	IBSC Meeting	MPKV, Parbhani 30 Sept., 2014	Dr. S. Kranthi
26.	Meeting on Naturally coloured cotton	Textile Commissioner at the Office of the Textile Commissioner, Nishtha Bhawan, Mumbai 1 Oct., 2014	Dr. Vinita Gotmare Dr. M.V. Venugopalan
27.	23rd meeting of ICAR Regional Committee No. VII	IGKV, Raipur 17-18 Oct., 2014	Dr. K. R. Kranthi Dr. M.V. Venugopalan Dr. M.S. Yadav Dr. B. Balasubramani Dr. K. P. Raghavendra Dr. H.B. Santhosh Mrs. Vandana Satish
28.	3rd International Conference on Agriculture and Horticulture	Hyderabad International Convention Centre, Hyderabad 27-29 Oct.,2014.	Dr. J. GulsarBanu
29.	National Symposium on "Crop Improvement for Inclusive Sustainable Development"	PAU, Ludhiana 7-9 Nov., 2014	Dr. M. Sarvanan, Dr. S. Manickam, Dr. S. L. Ahuja, Dr. D. Monga, Dr. Neha Saxena, Dr. S. M. Palve, Dr. V. N. Waghmare, Dr. T. R. Loknathan
30.	7th NEEC 2014	ICAR, Research Complex, Umiam, Meghalaya 8-11 Nov., 2014	Dr. Usha Rani
31.	Meeting on Vision 2050 and Institute project prioritization	Krishi Bhawan, New Delhi 10 Nov, 2014	Dr. K.R. Kranthi
32.	National Symposium on Pest Management organised by Entomological society of India	14 - 15 Nov., 2014 IARI, New Delhi	Dr. K.R. Kranthi
33.	National Symposium on Agriculture Diversification, for Sustainable Livelihood and Environmental Security"	PAU, Ludhiana. 18-20 Nov., 2014	Dr. M.V. Venugopalan Dr. P. Nalayini, Dr. K. Sankaranarayanan, Dr. D. Kanjana
34.	International Conference –Cotton India 2014	Mumbai 25 Nov., 2014	Dr. K.R. Kranthi Dr. M.V. Venugopalan
35.	QRT meeting of NSP (Crops)	UAS, Bangalore 11-12 Dec., 2014	Dr. K. Rathinavel

36.	National seminar on Extension Strategies for Sustainable Agriculture – Challenges and Opportunities	AC and RI, Madurai 12 Dec., 2014	Dr. Usha Rani
37.	NAAS Silver Jubilee symposium '25 Years of Research on Insect Resistance to Toxins	Central Institute for Cotton Research (CICR) Nagpur 27 Dec., 2014	Dr. K. R. Kranthi, Dr. S. Kranthi, Dr S.B.Nandeshwar, Dr B. Dharajothi, Dr. Raghavendra, Dr. Nagrare, Dr. N. Gokte Narkredkar, Dr. China Babu
38.	International Symposium	Prof. Jaishankar Telangana Agricultural University, Hyderabad 7 Jan., 2015	Dr. K.R. Kranthi
39.	The Second International Conference on Bio – Resource and Stress Management Hyderabad	PJTSAU, Hyderabad 7-10 Jan., 2015	Dr. P.Nalayini, Dr. K. Sankaranarayanan, Dr. D. Kanjana
40.	Annual Breeder Seed Review Meeting	ICAR, RC, NEH, Shillong 7-8 Jan., 2015	Dr. P. R. Vijaya Kumari, Dr. A.H. Prakash, Dr. S Manickam
41.	National Nematology Symposium on "Nematode Management: A Challenge to Indian Agriculture in the changing climate"	Yashwantrao Chavan Academy of Development Administration (YASHDA), Pune 8-10 Jan., 2015	Dr. Nandini Gokte-Narkhedkar
42.	National Seminar on Sustainable Management of Land Resources for Livelihood Security by ISSLUP, Nagpur	NBSS&LUP Nagpur 28-30 Jan., 2015	Dr. M.V. Venugopalan
43.	12th Agricultural Science Congress (ASC)	NDRI, Karnal 3 Feb., 2015	Dr. K.R. Kranthi
44.	Cotton Advisory Board on coloured cotton	UAS, Dharwad 9 Feb., 2015	Dr. K.R. Kranthi, Dr. S. Kranthi
45.	National Seminar on "Water Management & Climate Smart Agriculture	Junagadh Agri. University, Junagadh Gujarat 13-14 Feb., 2015	Dr. R.B. Singandhupe
46.	Global Social Science Congress 2015 on 'Management of Sustainable Livelihood Systems'	OUAT, Bhubaneswar 14- 17 Feb., 2015	Dr. S.M. Wasnik
47.	Workshop of In-charges of PME cell in ICAR institutes	NASC, New Delhi 23 Feb., 2015	Dr. M.V. Venugopalan
48.	Meeting on GM crop Technology	Delhi University 23 March, 2015	Dr. K. R. Kranthi

10.8: Distinguished Visitors

Name & Designation	Organisation	Date
Nagpur		
Delegates from Afghanistan	Afghanistan	Nov. 17, 2014
Dr. K. P. Wasnik, Addl. Commissioner	Ministry of Agril, Govt. of India	Dec 31 , 2014.
Shri C.K. Bawankule, Minister for Energy, New and Renewable Energy	Maharashtra State and Guardian Minister of Nagpur District	Jan. 17, 2015
Dr. A. K. Singh, DDG (AE)	ICAR, New Delhi	Jan. 18, 2015
Mrs. Roja Sethumadhavan, Dy. Secretary	Division of Extension, ICAR, New Delhi	Jan. 18, 2015
Prof. Chun Xi Zhang	Institute of lifesciences, Zhijiang University, Hangzhou, China	Feb. 7, 2015
Dr. K.P. Arun Kumar, Staff Scientist & Group Leader	Laboratory of Molecular Genetics, Centre for DNA fingerprinting and Diagnostics, Hyderabad	Feb. 7, 2015
Dr. J. S. Sandhu, DDG(CS)	ICAR, NewDelhi	Feb. 21, 2015
Dr. M. S. Swaminathan , Chairman	M. S. Swaminathan Research Foundation (MSSRF)	Feb. 22 and 23, 2015
Sirsa		
Dr . J. S. Sandhu	Agriculture Commissioner, GOI	6th Sept ., 2014
Dr . Gehlawat	Additional Director (Seeds), Govt of Haryana	6th Sept ., 2014

10.9 : Personnel

Director
K R Kranthi, Director, krkranthi@gmail.com

Project Coordinator (Cotton)

Coimbatore
A.H. Prakash, P.C. (Cotton) & Head, prakashcicr@gmail.com

Biotechnology

Nagpur
G Balasubramani, Principal Scientist, bala77bio@gmail.com
Smt. J Amudha, Senior Scientist, jamudhacicr@gmail.com
K P Raghavendra, Scientist, kpraghavendra@gmail.com
Joy Das, Scientist **(Joined on 09.04.2014),** uasjoy@gmail.com
Rakesh Kumar, Scientist **(Joined on 09.04.14)**rakesh.goswami12@gmail.com

Plant Breeding

Nagpur
Smt. S. B. Singh, I/c Head & PS, sumanbalasingh2009@gmail.com
T R Loknathan, Principal Scientist, loknathantr14@gmail.com
S M Palve, Principal Scientist, smpalve2kl@yahoo.com
V N Waghmare, Principal Scientist, vijayvnw@yahoo.com
M Saravanan, Scientist, msaraniari@gmail.com
H B Santosh, Scientist, santoshgpb@gmail.com

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

Sirsa
S L Ahuja, Principal Scientist, slahuja2002@yahoo.com
O P Tuteja, Principal Scientist, optuteja2001@yahoo.co.in
S K Verma, Principal Scientist, surenderkumar64@yahoo.co.in

Genetics & Cytogenetics

Nagpur
S B Nandeshwar, Principal Scientist, sbn3@rediffmail.com
Smt. Vinita Gotmare, Principal Scientist, vinitag22@gmail.com

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

Seed Technology

Nagpur
Smt. P R Vijayakumari, Principal Scientist, rachelvk123@gmail.com
Smt. V Santhy, Senior Scientist, santhy100@gmail.com

Coimbatore
K Rathnivel, Principal Scientist, krathinavelus@gmail.com

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

Economic Botany

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

Agronomy

Nagpur
Blaise Desouza, Head, Crop Production, blaise_123@rediffmail.com
M V Venugopalan, Principal Scientist, mvvenugopalan@gmail.com
A R Raju, Principal Scientist, bumaraju@gmail.com

Coimbatore
K Sankaranarayanan, Principal Scientist, sankaragro@gmail.com
Smt. P Nalayani, Principal Scientist, nalayiniganesh@gmail.com

Soil Science

Nagpur
A Manikandan, Scientist, poonamani223@gmail.com

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

Agricultural Engineering

G Majumdar, Scientist, gama62@rediffmail.com

Plant Pathology

Nagpur
A Sampath Kumar, Scientist, sampath_a@rediffmail.com (on study leave)

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

Entomology

Nagpur
Smt. S. Kranthi, Head, Crop Protection, sandhya.kranthi@gmail.com
V S Nagrare, Senior Scientist, vs.nagrare@gmail.com
Chinna Babu Naik V, Scientist, chinnaenton@gmail.com

Coimbatore
Smt. B Dhara Jothi, Principal Scientist, dhara56@yahoo.co.in
Smt. M Amutha, Scientist, amuento@yahoo.co.in

Sirsa
Rishi Kumar, Senior Scientist, rishipareek70@yahoo. co.in

Nematology

Nagpur
Smt. Nandini Narkhedkar, PS, nnarkhedkar@rediffmail.com

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

Plant Physiology

Nagpur
J H Meshram, Scientist, j.h.meshram@gmail.com
J Annie Sheeba, Scientist, anniephysiology@gmail.com

Coimbatore
S E S A Khader, Principal Scientist, sesakhader@gmail.com

Biochemistry (PS)

Nagpur
Smt. M. Chakrabarty, Scientist, budiya12@yahoo.com (Transferred to IARI New Delhi on 02.08.2014)

Microbiology (PS)

Nagpur
K Velmourougane, Scientist, velicar@gmail.com (on study leave)

Live Stock Management

S N Rokde, Principal Scientist, sunilrokde_2007@rediffmail.com (LMP)

Agriculture Extension

Nagpur
S M Wasnik, Principal Scientist, wasniksm2012@gmail.com

Coimbatore
Usha Rani, Senior Scientist, ushajoshua@rediffmail.com

Agricultural Economics

Nagpur
Smt. Anuradha Narala, Scientist, anuradhanarala@gmail.com

Coimbatore
Smt. Isabella Agarwal, Senior Scientist, is_agarwal@rediffmail.com

Computer Applications

Coimbatore
M Sabesh, Scientist, sabesh23@gmail.com

KVK

Nagpur
R B Singhandhupe, Principal Scientist, rbsingandhupe@gmail.com

PME Cell

M S Yadav, Nodal Officer, cicrrcmunit@yahoo.co.in

Administration

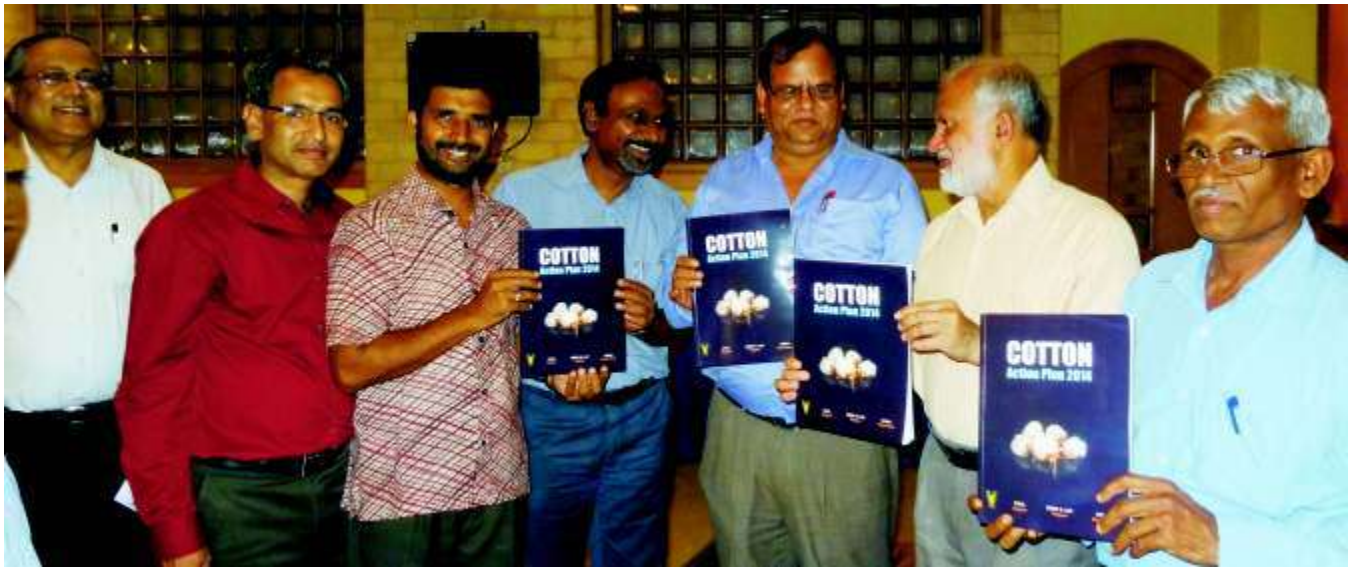
Sachin Agnihotri, Senior Admin Officer, sach_agni123@rediffmail.com
S N Rokde, I/c FACO, finance.cicr@rediffmail.com

10.10 : Other Information

Cotton Action Plan 2014

Dr. S. Ayyappan, Director General, Indian Council of Agricultural Research (ICAR), released contingency plan advisories for cotton titled 'Cotton Action Plan 2014' in a function held on 19th July, 2014 in Nagpur. The action plan was jointly prepared by the Central Institute for Cotton Research (CICR), the National Bureau of Soil Survey & Land Use Planning (NBSS, LUP), Nagpur and the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad. The 'Cotton action plan 2014' bulletin contains advisories for 70 main districts of five major cotton growing states with focus on action plans to ensure healthy crop growth for high yields despite the unforeseen delay in the onset of monsoon across the country. The conditional probabilities of dry spells were calculated by Dr YG Prasad, Principal Scientist, CRIDA, based on 40 year data on seasonal rainfall and weather patterns using Markov Chain probability.

Dr. S. Ayyappan expressed happiness and lauded the contribution of the three ICAR institutions in their efforts to combat the climatic aberrations resulting from delayed monsoon. The cotton contingency action plans contain details of the package of practices to be followed and precautions to be taken especially in fields where cotton sowings were delayed. The contingency advisories are available on the institute website www.cicr.org.in. Dr K.R. Kranthi, Director, CICR, Dr S. K. Singh, Director, NBSSLUP, Dr. M. S. Ladaniya, Director, NRCC, Dr M.V. Venugopalan, Principal Scientist, CICR, Dr R.B. Singandhupe, Dr. Mahendra Singh Yadav and other scientists of the ICAR institutes were also present on the occasion.



ICAR Director General Dr. S. Ayyappan releasing "Cotton Action Plan 2014". Also seen are CICR Director Dr. K.R. Kranthi, NBSS & LUP Director Dr. S.K. Singh, NRCC Director Dr. M.S. Ladaniya and others

Tribal Sub Plan (2014-15)

Imparted training on High Density Planting System (HDPS) of Variety Suraj and cultivation of Surgical Cotton (*G. arboreum*) var. Phule Dhanwantary for Tribal farmers of Jiwati Taluka of Chandrapur District .

An Audio & Video CD was also prepared for the benefit of farmers interested to cultivate a straight

variety in Chandrapur District. The CD depicts the success stories of farmers who have demonstrated cultivation of Suraj on their farm.

Seeds of Suraj, fertilisers and pesticides have been procured for distribution among the Tribal farmers for the next cropping season 2015-16.

CICR Foundation Day Celebration

CICR Foundation Day was celebrated on 1st April, 2014, Dr. G. Balasubramani, gave the introductory remarks and conducted the event "Express your ideas in one minute" under the different topics. The winners under each category were awarded with prizes.

Topic	Winner
New Ideas to develop Institute Facilities	Mr. K. Velmourougane (I Prize), Dr. S.N. Rokde (II prize), Miss Usha Satija (SRF) (III Prize)
Ideas for cotton farmers' prosperity	Dr. Anuradha Narala (I Prize), Mr. K. Velmourougane (II prize), Mr. Raju (SRF) (III Prize)
Wild Idea on cotton 2050	Dr. J. Annie Sheeba (I Prize) , Mr. Sampath Kumar (II prize)
What do you like about CICR	Mr. Izaj Ahmed (I Prize), Dr. Chinna Babu Naik (II prize) and Mr. Muchli (III Prize)
Three steps to end corruption in India	Dr. Anuradha Narala (I Prize), Dr. K.P. Raghavendra (II prize) and Dr. V.S. Nagrare (III Prize)
Do we need a dictator in India	Dr. R. R. Gupta (I Prize)
Advertise a Product to sell Cotton boll	Mr. Sampath Kumar (I Prize)

Swachh Bharat Abhiyan

Swachh Bharat Mission which was launched by Hon'ble Prime Minister on 2nd October, 2014, the birth anniversary of Mahatma Gandhi was also celebrated at CICR, Nagpur and CICR, RS, Coimbatore and Sirsa. Dr. K.R. Kranthi, Director, CICR, initiated the program at CICR, Nagpur with a brief introduction about the program. Mr. Sachin Agnihotri, Senior Administrative Officer, administered oath for maintaining cleanliness as a responsible Indian citizen to all the CICR staff members. It was decided that each person will devote 100 hours in a year towards cleanliness and also motivate hundred persons about the importance of cleanliness. Oath for Swachh Bharat was also administered to staff members at Regional Stations at Sirsa and Coimbatore. Later on, all the staff members carried out cleaning of office premises and office building at Nagpur and its regional stations at Sirsa and Coimbatore.

CICR Participation in Agrovision - 2014

Sixth Agrovision 2014 was held at Reshimbag ground, Nagpur from December 4-9 in which workshops, exhibitions and symposiums on agricultural issues were conducted. Chief Minister of Maharashtra, Shri. Devendra Fadnavis inaugurated the Agrovision-2014 as Dr. C.D. Mayee, Chairman of Advisory Council of Agrovision and other dignitaries looked on. The event hosted free workshops for farmers to create awareness and to inform them about new technologies in the farm sector. The technologies developed at CICR were showcased in a stall as a part of technology dissemination. The event also showcased a wide range of agricultural equipment and products from public and private sectors. Expert Panel Discussion on GM crops was held on 5th December, 2014. Dr. K. R. Kranthi, Director, CICR, Nagpur and Advisory Council Member, Agrovision, participated in the 'Expert Panel Discussion' on "Modern tools for Crop Productivity Improvement and Environment Concern" at 'Agrovision' on 5th December 2014. The issue of Genetically Modified Crops was discussed in the session.

Dr. Kranthi said that every concern about GM crops must be addressed, but let the science not be stopped. He added that experiments and field trials are needed and opined that no country has progressed without science. Dr. C. D. Mayee, Chairman of Advisory Council of Agrovision and Dr. Swapan Kumar Datta, Deputy Director

General, Crop Science, ICAR, were among the expert participants in the discussion. Dr Mayee said 65% of the Indian agriculture is rainfed and Indian scientists have the potential of solving agriculture related problems. He suggested that guidelines should be formed for environmental and health tests. Dr. Datta suggested that there should be clear vision on policy making. He added that agriculture has to progress and it cannot remain in nostalgia. Shri Narayan Suresh, Group editor of BioSpectrum (India and Asia) moderated the session.

ICAR ZONAL Tournament (Central Zone)

Mrs. Sunita Chauhan, Subject Matter Specialist, KVK, Nagpur and Ms. Kalpna Singh, Assistant, CICR, RS, Sirsa won First prize in Javelin throw (women) and Discus throw (women) respectively in ICAR Zonal Tournament (Central Zone) held at NBSS & LUP, Nagpur from September 16 to 20, 2014.

Library

Additions

In the period from 2014-15, the Library purchased 42 new books and 34 Hindi books. The Library subscribed to 11 Foreign Journals and 15 Indian Journals.

Documentation services

Library has developed computerized bibliographic database on Cotton to provide comprehensive and updated information on cotton. About 4675 bibliographic references along with abstracts have been stored in it. Based on this bibliographic database the Library publishes a current awareness bulletin namely "*COTTON RESEARCH ABSTRACTS*". The Bulletin is circulated to all the scientists of the Institute and to all AICCIP Centers in India. In the reported period, four issues of COTTON RESEARCH ABSTRACTS (V28, (No. 1-4), January – December 2014) were published and circulated.

The Library is actively participating in the E-Journal Consortium by responding regularly through e-mails and thus also receiving updates. More than 2000 on-line journals on agriculture and crop science are made available over the network through this consortium.

Four User Terminals installed in the Library have facilitated the library users to access the databases uploaded in the Library Server. Users can also access the Internet on these terminals. Similarly the entire catalog of the library has been downloaded on these terminals for ease of use.

The WebOPAC version of the Library software SLIM21 was updated and by using this Library Application Software, the entire catalogue of holdings of the Library (books and bound volumes) is available on all terminals within the Institute. By its virtue, the entire holdings and the catalogue of the Library are visible on the LAN terminals within the Institute by clicking on the following link. Library Catalogue Web-OPAC Link http://10.0.0.52/ w20/

Progressive Use of Hindi

Hindi Fortnight Celebrations

The Central Institute for Cotton Research Nagpur and Regional Station, Coimbatore celebrated "Hindi Fortnight-2014" with great enthusiasm from 15.9.2014 to 27.9.2014. At CICR, Regional Station, Sirsa, Hindi *Diwas* was celebrated on 26.09.2014.

At the closing ceremony held at CICR, Nagpur on 27th September, Dr Narendra Chaudhary, Director VNIT, Nagpur was the Chief Guest while Dr C. D. Mayee, Ex-Chairman, ASRB was the Guest of Honour. The two-week celebrations included competitions on English News to Hindi translation, Hindi songs to English translation, spot translation of film dialogues, poetry, singing, quiz, logic-connection, elocution, essay writing and

debate. Dr Narendra Chaudhary appreciated the enthusiasm with which the programmes were conducted. He said that there was an imminent need to conduct day-to-day working in Hindi, and also to plan ahead for the Hindi translation of technical terminologies which formed the core of research papers. In his presidential address, Dr. C. D. Mayee narrated his hilarious experiences with the different accents of Hindi in various parts of the country. He said that his experience in Germany as a Humboldt fellow taught him the tremendous importance of mother tongue in the pursuit of science. Dr. K.R. Kranthi, Director and Chairman of the Rajbhasha Committee felicitated the guests. Two publications, Shwet Swarnima and Kapas Samachar were released on the occasion. Prize winners were awarded cash prizes and certificates. Dr. Sandhya Kranthi, Dr. Blaise Desouza, Dr. T. R. Lokanathan, Dr. M. V. Venugopalan, Dr. Suman bala Singh, Dr. S. N. Rokade, Dr. G. Balasubramani, Shri Sachin Agnihotri, Shri Gulbir Singh and Shri Rajnikant Chaturvedi conducted the competitions all through the fortnight and coordinated the Closing ceremony.

Exhibiting CICR technologies

Coimbatore

The technologies, products, inputs and services available at CICR, Regional Station, Coimbatore were exhibited in the exhibition conducted by Tamil Nadu Agricultural University, Coimbatore during the Southern Regional Agricultural Fair and State Level Farmers' day from 6th to 9th January 2015 at TNAU campus. Farmers, Agricultural scientists and those involved in the agricultural business from Kerala, Karnataka, Andhra Pradesh, Telangana and Union Territories visited the stall. Many cotton growers registered their mobile numbers for e-Kapas network. The stall was also visited by the dignitaries, Shri. O. P. Dhahiya, Director, Farm Information, Ministry of Agriculture, Shri. C. Rajendran, Joint Secretary, Department of Agriculture, Tamil Nadu and Dr. K. Ramasamy, Vice Chancellor, Tamil Nadu Agricultural University, Coimbatore.

The technologies available at CICR, Regional Station, Coimbatore were also exhibited in the exhibition in the "FARM TO FINISH EXPO 2015" as a part of the TEXFAIR 2015 during January 9-12, 2015 at the CODISSIA Trade Fair Complex, Avanashi Road, Coimbatore. Thousands of business visitors, including overseas buyers covering Managing Directors/Directors/ Executives and farmers visited the stall displayed by CICR, Coimbatore. The programs were coordinated by the institute exhibition committee (Convener: Dr. (Mrs.) S. Usha Rani, Senior Scientist and Co convener: Dr. (Mrs.) Isabella Agarwal, Senior Scientist).

10.11 : Weather

Nagpur

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
June, 2014	40.05	28.15	65.88	42.29	39.0	5
July, 2014	31.9	23.34	79.50	52.90	454.0	15
August, 2014	32.44	24.56	86.09	69.56	181.0	7
September, 2014	31.44	23.77	91.50	81.70	210.0	9
October, 2014	32.43	20.77	86.63	66.72	0	0
November, 2014	31.52	15.55	79.50	50.04	0	0
December, 2014	27.52	10.65	69.21	48.49	0	0
January, 2015	27.07	11.58	79.95	46.21	0	0
February, 2015	32.07	14.69	73.62	60.28	41.0	3
Total					925	39

Coimbatore

Month	Temperature(°C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
	Max.	Min.	Max. RH	Min. RH		
Aug. 2014	30.6	23.1	81.9	59.3	75.8	7
Sept. 2014	31.8	22.7	85.3	55.0	90.4	5
Oct. 2014	30.1	22.5	93.0	68.0	352.1	15
Nov. 2014	29.5	21.3	90.1	57.8	3.4	0
Dec. 2014	28.8	21.0	88.5	58.7	16.3	3
Jan.2015	30.1	19.2	85.9	47.1	0.0	0
Jan.2015	30.8	19.5	83.2	39.2	0.0	0
Total					538.0	30

Sirsa

Month	Temperature (°C)		Rainfall (mm)	No. of rainy days
	Max.	Min.		
April 2014	35.7	18.2	10.2	1
May 2014	38.8	24.5	36.2	3
June 2014	40.4	27.2	10.7	2
July 2014	37.5	28.2	114.6	3
August 2014	36.1	27.8	2.4	1
September 2014	33.4	24.3	101.7	6
October 2014	25.9	15.6	0	0
November 2014	23.4	8.3	0	0
Total			275.8	16

10.12: Cotton Scenario

State-Wise Cotton Area, Production and Productivity

Zone/State	2013-2014*			2014-2015*		
	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)
Punjab	4.46	21.00	800	4.5	14.00	529
Haryana	5.36	24.00	761	6.39	25.00	665
Rajasthan	3.93	14.00	606	4.54	17.00	637
North Zone	**13.75**	**59.00**	**729**	**15.43**	**56.00**	**617**
Gujarat	25.19	124.00	837	30.08	108.00	610
Maharashtra	41.92	84.00	341	41.92	83.00	337
Madhya Pradesh	5.14	19.00	628	5.78	18.00	529
Central Zone	**72.25**	**227.00**	**534**	**77.78**	**209.00**	**457**
Telangana	-	-	-	16.92	57.00	573
Andhra Pradesh	23.89	78.00	555	7.74	27.00	593
Karnataka	6.62	23.00	591	8.55	30.00	596
Tamil Nadu	1.52	5.00	559	1.73	5.00	491
South Zone	32.03	106.00	563	34.94	119.00	579
Others	**1.57**	**6.00**	**650**	**1.56**	**6.00**	**654**
Grand Total	**119.60**	**398.00**	**566**	**129.71**	**390.00**	**511**

1 bale= 170 kg.

Source: Cotton Advisory Board, Ministry of Textile, Govt. of India.* - As estimated by CAB in its meeting held on 31.03.2015

Annexure- I

Annual (April 1, 2013 to March 31, 2014) Performance Evaluation Report in respect of RFD 2013-2014 of RSCs i.e. Institutes

Name of the Division : Crop Science

Name of the Institution : Central Institute for Cotton Research, Nagpur

RFD Nodal Officer : Dr. M.V. Venugopalan

Objectives	Wt (%)	Actions	Success Indicators	Unit	Wt (%)	Target/ Criteria Value					Achieve-ments	Performance		Percent achieve-ments of 90% column	Reasons for shortfalls or excessive achieve-ments, if applicable
						Excellent	Very Good	Good	Fair	Poor		Raw Score	Weighted Score		
						100%	90%	80%	70%	60%					
1.Genetic enhancement and development of improved cultivars	57	Evaluation of genetic material	Breeding and germplasm lines evaluated	No.	25	120	115	90	80	70	**138**	**100**	**25**	120	
		Develop-ment of improved cultivars / hybrids	Entries contributed for AICRP multiloca-tion trial	No.	24	40	38	34	32	30	**39**	**95**	**22.8**	102.6	
			Varieties identified for release	No.	8	3	2	1	0	0	**2**	**90**	**7.2**	100.0	
2.Technology dissemina-tion and capacity building	20	Demonstra-tions conducted	Front line demonstra-tions and on farm trials conducted	No.	12	100	90	80	70	60	**134**	**100**	**12**	148.9	
		Farmers/ Extension officials training programmes organized	Trainings organized	No.	8	4	3	2	1	0	**7**	**100**	**8**	233.3	Additional unanticipated trainings were warranted to familiarize the concept of HDPS among farmers and field scouts

3. Development and identification of appropriate crop production & protection technologies	12	Development & testing of new technologies	New technologies tested and validated	No.	12	5	4	3	2	1	**5**	**100**	**12**	125.0	
Efficient Functioning of the RFD System	3	Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	01/05/2013	02/05/2013	05/05/2013	06/05/2013	07/05/2013	**27/04/2013**	**100**	**1**		
Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80	0	0	**0**		
		Prepare an action plan for Innovation	On-time submission	Date	2	30/07/2013	10/08/2013	20/08/2013	30/08/2013	10/09/2013	**27/07/2013**	**100**	**2**		
Improving internal efficiency /responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80	**100**	**100**	**2**		
			Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80	**100**	**100**	**2**		
Total													**96**		

Total Composite Score: 96.0

Rating : Excellent

Procedure for computing the Weighted and Composite Score

1. **Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score / 100**
2. **Total Composite Score = Sum of Weighted Scores of all the Success Indicator**