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ICAR

CENTRAL INSTITUTE FOR  
**COTTON**  
RESEARCH

ANNUAL REPORT 2009-10



# CICR

वार्षिक प्रतिवेदन  
ANNUAL REPORT 2009-10



केन्द्रीय कपास अनुसंधान संस्थान, नागपुर  
CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR





**Published by**

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Post Bag No. 2, Shankar Nagar, PO,  
Nagpur - 440010 (MS), India

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**Correct Citation**

CICR, Annual Report 2009-2010  
Central Institute for Cotton Research,  
Nagpur, India  
PP. 100

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**Printed At :**

Surya offset, Ramdashpeth, Nagpur

## PREFACE

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Cotton production in India reached a peak level of 31.5 m bales (5.35 m tonnes) from 9.5 m ha in 2007-08. Since then, the production did not increase further, despite an increase in the area under cotton to 10.1 m ha in 2009-10. Across the globe cotton production did not show any remarkable increase in the last 3 years and it remained around 24 million tonnes. Despite a steady increase in area under Bt cotton, which currently occupies more than 83% of the cotton area in India, the productivity has declined from 560 kg lint/ha in 2007-08 to 488 kg/ha in 2009-10. Amongst the several yield reducing constraints and challenges that have emerged in the recent 3-4 years, problems-erratic rainfall, supra-optimal temperatures, re-emergence of the cotton leaf curl virus in north, emergence of new insect pests such as mealybugs and miridbugs, resurgence of sucking pests, reddening of leaves, jassid resistance to insecticides, emerging bollworm resistance to Bt cotton and parawilt have been significant. Concerns over deterioration in fibre quality and shortage of short and medium staple cotton are also being expressed by the textile industry. CICR is entrusted with a huge responsibility of addressing these challenges and is committed to the cause of cotton and cotton farmers. Importantly, the most immediate challenge is to sustain the productivity gains brought about by transgenic cotton by fine tuning the production and protection technologies.

This report provides a glimpse of the research and developmental activities and the achievements under various programmes undertaken during 2009-10. The highlights include the release of the first public sector Bt variety Bikaneri Narma and the Bt hybrid Bt-NHH44, developed through a collaborative effort of NRCPB New Delhi, UAS Dharwad and commercialization facilitated through CICR Nagpur. In a new exciting development, two new genetically modified events have been developed by the institute for resistance to the cotton leaf curl virus resistance. A novel class I Chitinase gene confirming fungal disease resistance was amplified, cloned from *G. hirsutum* (LRA 5166) and transformed into grey mildew susceptible *G. arboreum* cultivars PA 255, PA 402 and RG 8. The events were found to be promising and are being intensively tested for resistance. From the conventional varietal improvement programme, two high yielding *G. arboreum* varieties viz., CISA 310 and CISA 614 were released for cultivation in the North zone. In addition, an early maturing, high oil yielding compact *G. hirsutum* variety CNHO 12 was released for the Central zone. Agronomy of NHH 44 Bt on rainfed vertisols of Central zone was standardized and 90 x 30 cm spacing was found optimum. Supplementing the recommended NPK with Zn (10 kg/ha) and B (3 kg/ha) was found necessary to sustain rainfed cotton yield on shallow (less than 50 cm) black soils. A prototype of a 2-row fertilizer applicator as an attachment to the bullock drawn blade harrow was developed. Agrotechniques to boost the productivity of ELS cotton fertigation (90:19:37 kg N:P:K) in 6 splits, alternate day drip irrigation at 0.8 Etc, soil moisture conservation through biodegradable mulches were standardized. Lectin genes CFA from *Colocasia esculenta* and AMTC from *Amorphophallus poeniphalus* were effective against aphids and whitefly and in combination with banana lectin form a potent source of gene for the developmental of sucking pest resistant GM cotton. Artificial diets for aphids, jassids and white flies were developed. For eco-friendly (organic) pest management, Mealy Kill was found effective against mealy bugs and synthetic analogues of methyl jasmonate, ocimene and limonene were effective against jassids, aphids and mealy bugs. A talc based formulation of entomopathogen *Lecanicillium leccani* was developed which was effective against mealy bugs (*Phenacoccus solenopsis* and *Paracoccus marginatus*). Insecticide resistance in

jassids was quantified in a networking mode for the first time. Jassids were found to exhibit 5450 fold and 2500 fold resistance to imidacloprid and thiamethaxam as compared to 57 fold resistance to conventional chemicals such as monocrotophos. IRM strategies were further disseminated in 330 villages of 11 districts in North zone, 172 villages in 11 districts of Central zone 150 villages of 10 districts in South zone and 10 villages of South 24 Pargana, district of East zone reaching out to 38,472 cotton farmers.

The research achievements reflect the fruits of the untiring efforts by the entire staff of the institute. The technical support and generous financial assistance from the Indian Council of Agricultural Research and other funding agencies-DBT, DST etc., provides the necessary impetus to accelerate the R&D output. I am highly grateful to Dr. Mangala Rai and Dr. S. Ayyappan Secretary, DARE and Director General, Dr. S.K. Dutta, Deputy Director General (Crop Sciences) and Dr. K.C. Jain, Assistant Director General (CC), ICAR, New Delhi for the guidance and support provided and also for encouraging new research initiatives. The Annual Report (2009-10) is being presented herewith a sense of satisfaction and pride.

K. R. Kranthi  
Director



## Preface

1. कार्यकारी सारांश	1
2. Executive Summary	6
3. Introduction	11
4. Research Achievements	15
4.1 Cotton Genetic Resources	15
4.2 Hybrid Cotton	19
4.3 Genetic Improvement	21
4.4 Genetic Diversity through Introgression	24
4.5 State Multi Varietal Trial (SMVT)	24
4.6 Molecular Breeding	24
4.7 Development of Transgenics	25
4.8 Seed Production and Seed Quality Improvement	30
4.9 Nutrient Management	33
4.10 Irrigation Water Management	34
4.11 Soil Moisture Conservation in Bt Cotton	35
4.12 Cropping Systems	35
4.13 Agronomic Evaluation of Cotton Genotype	37
4.14 Weed Management	38
4.15 Soil Biology and Biochemistry	38
4.16 Cotton Simulation Modelling	40
4.17 Cotton Mechanization	40
4.18 Morpho-frame/Boll Load Management	41
4.19 Studies on Abiotic Stress	42
4.20 Fibre Development	42
4.21 Socio Economic Dimensions of Cotton Farming	42
4.22 Total Factor Productivity Analysis	44
4.23 Cotton Information System	45
4.24 Seasonal Dynamic of Insect Pests and Diseases	46
4.25 Biological Diversity of Insect Pests and Pathogens	50
4.26 Isolation and Identification of New Genes and Gene Sources for Pest Management	52
4.27 Development of New Method, Tools and Protocols	53
4.28 Host-Plant Resistance to Insect Pests Diseases	54
4.29 Identification of Germplasm Sources of Resistance to Insect Pests and Diseases	56
4.30 Biological Control	57
4.31 Integrated Pests Management	60
5. Technologies Assessed and Transferred	65
6. Education and Training	67
7. Awards and Recognitions	71
8. Linkages and Collaborations in India and abroad including externally funded projects	73
9. All India Coordinated Cotton Improvement Project	74
10. Krishi Vigyan Kendra	77
11. General	80
11.1 List of Publications	80
11.2 List of On-going Projects	83
11.3 Consultancy, Patents, Commercialization of Technology	89
11.4 Significant Decision of RAC, IRC and IMC Meetings	90
11.5 Workshops/Seminars/Summer Institutes/Farmer's Day Organised	92
11.6 Distinguished Visitors	92
11.7 Participation of Scientists in Seminars/Symposia/Conferences/Workshops/ Trainings/Meetings	93
11.8 Personnel	95
11.9 Other Information	96
11.10 Weather	98
11.11 National Cotton Scenario	99



## 2.1 Crop Improvement

### Nagpur

- Twelve germ plasm lines including 8 *Gossypium hirsutum*-race *latifolium*, *Gossypium arboreum* race - *cernuum* (3) and one *Gossypium arboreum* race- *bengalense* of unique and novel traits were added to the Gene Bank, CICR, Nagpur.
- Three genetic stocks of *G. arboreum* race *cernuum*, immune to Grey Mildew (*Ramularia areola* Atk) disease viz., 30814 (INGR No. 09117), 30826 (INGR No. 09118) and 30856 (INGR No. 09119) were evaluated and registered with NBPGR, New Delhi.
- Five new interspecific hybrids developed using wild species were added to the existing collection.
- *G. arboreum* culture CNA 1003 having medium staple length and good strength (23 g/tex) with promising yield was promoted in South zone for Agronomy trial.
- Evaluation of 63 breeding lines for drought tolerance in *G. hirsutum* revealed four lines viz. DTS 155-09, DTS 108-09, DTS 100-09 and DTS 104-09 to be drought tolerant with high seed cotton yield.
- *G. hirsutum* variety, CNHO 12 - an early maturing, jassid tolerant cotton with relatively high oil content and synchronous boll bursting habit was released for the central zone under irrigated conditions.
- One new GMS line, ABGMS-developed by induced mutation and one restorer line CIR 1-18 with partial pigmentation and frego bract has been registered with NBPGR.
- Population of Anjali Bt (*G. hirsutum*), PA 255 and RG 8 Bt was advanced for commercialization following characterization of the events.
- A new method of gene transfer through pollen tube pathway was standardized and used for development of transgenic event with cry 1F gene.

- An unique Class I chitinase gene was cloned from LRA, 5166 and transformed in *G. arboreum* variety, PA255.
- Two antisense approach based transgenic events for CLCuV resistance in cultivars HS6 and H777 proved tolerant against the virus when tested in Green house at Sirsa.
- Inverted repeat constructs for five target regions of CLCuV were constructed for development of virus resistant cotton through RNA interference.
- Seed size with respect to seed index significantly influenced field emergence and seed cotton yield.
- Quality seeds of cotton, wheat and redgram were produced and resources to the tune of Rs. 6.72 lakhs were generated under Mega Seed Project.

### Coimbatore

- Three superior *G. barbadense* accessions viz., ICB-167, ICB-274 and ICB-129 had better yield and fibre quality attributes than Suvin.
- The extra long staple interspecific (*G. hirsutum* x *G. barbadense*) hybrids like CCHB-110 (2423 kg/ha), CCHB-215 (2404 kg/ha), CCHB-260 (2400 kg/ha) and CCHB-123 (2391 kg/ha) showed consistent performance during last three years over the check DCH-32 (1997 kg/ha).
- Two years study indicated superiority of CCH 815 and CCH 816 over the check variety Suraj by 25 to 28 per cent.
- Medium Staple culture CCH 2623 tested in the Preliminary Varietal Trial, ranked second and first in the South Zone and Central Zone trials, respectively.
- The compact genotypes viz., HCT 8 and HCT 12 were found superior by over 20 per cent to the best check variety Anjali.
- Extra long staple *G. hirsutum* culture CCH 818 with a mean seed cotton yield of 1957 kg/ha was found superior to Surabhi by 30 per cent.
- Breeder seeds of the varieties viz., LRA 5166, Surabhi,

Suraj,, Supriya and Suvin were produced in sufficient quantities to meet the National Indent..

- Distinctiveness, Uniformity and Stability testing of tetraploid cotton genotypes were taken up in two trials comprising 5 and 23 candidate varieties, respectively. Similar trial was conducted for diploid cotton with one candidate and two reference varieties. For registering cotton varieties under PPV&FR Act, 2001,61 applications comprising new and extant cotton varieties were submitted through NBPGR..
- By coating pre cleaned seeds with polykote @ 3 ml/kg combined with carbendazim @ 2 g lkg, seed deterioration can be prevented up to 18 months retaining the viability to the extent of 77 per cent..

### Sirsa.

- Variety CISA31 0 of *Gossypium arboreum* has been notified for cultivation in entire north zone. The variety CISA 614 was also identified by Variety Identification Committee Meeting (AICCIP) held at ANGRAU, Hyderabad 6-8 April.. 2009 and notified vide Gazette of India NO.608 dated April 1,2010 forthe same zone.
- In theAICCIP North Zone trials, based on three years mean performance (2007-09), GMS based hybrid CSHG 1862 recorded the increase of 13 % for seed cotton yield and 18.1 % for lint yield over the conventional check hybrid CSHH 198 and was identified for agronomy trial in North Zone.
- CSH 3158 and CSH 10 were promoted to Br 03a zonal trial.. The genotype CSH 3129 was promoted to Br 04a zonal trial for further testing. The intra *hirsutum* hybrid CSHH 3008 was promoted to Br 05a zonal trial.. The intra *arboreum* hybrid CISAA 15 was promoted to south zonal trial Br 25a.
- Significantly higher plant stand (up to 98 %) and yield (30.35 q/ha) than normal sown crop on the date of transplanting ( 85% and 25.1 q/ha) was recorded when 25 day old seedlings raised in big containers were transplanted..

## 2.2 Crop Production

### Nagpur

- Under rainfed condition, intercropping of mung in Bt cotton (1:1) was found superior from soil moisture conservation and system productivity point of view.
- Application of 75% N through inorganic + 25% N through organic source and addition of Zn (10 kg/ha) and B (10 kg/ha) with RDF (90: 45: 45) recorded significantly higher seed cotton yield than RDF alone.
- On Vertisols, seed cotton yield of NCS 145 (Bt) was optimized with drip irrigation at 0.8 Etc and application of the recommended Nand K (120 kg Nand 60 kg K<sub>2</sub>O 1 ha) through fertigation and P (60 kg P<sub>2</sub>O<sub>5</sub> lha) as soil application (basal).
- On shallow black soils (Inceptisols), combined application of Zn (10 Kg/ha) and B (3 Kg/ha) alongwith recommended NPK increased the seed cotton yield by 200 Kg/ha over recommended NPK. On medium to deep black soils (vertic Inceptisols and Vertisols) when this was supplemented with 2 irrigations the yield gain was 500 kg/ha over recommended NPK.
- Bt cotton can be profitably intercropped with *Portulaca oleracia* +field bean (*Dolichos lablab*) and fennel..
- The optimum spacing for rainfed BN-Bt cotton on shallow (48 cm) vertic Inceptisols of AESR 10.2 (hot dry sub humid climate) was 60 x 20 cm. Similarly, the optimum spacing for

rainfed NHH 44 Bt hybrid on deep Vertisol was 90 x 30 cm and at this spacing the optimum N dose was 60 kg N/ha. The mean apparent recovery of N decreased with increase in the rates of N application and increased with a decrease in intra row spacing. N use efficiency declined with increase in N application and increased with decline in intra row spacing. Further improvement in N utilization efficiency may be possible at high planting density, only if Harvest Index is improved..

- The Bt hybrids possessed a variable range of Cry protein. With respect to nitrogen treatment, no definite trend was observed. However, there was a perceptible decline in Cry protein content with advancement in the ag~ of the crop and the cry protein content in the leaves were higher than In the squares.
- Land use systems under high management recorded higher microbial counts of general and functional microflora than those under low management system. The mean urease activity across 5 benchmark spots from black soil region was 11.28 (ug NH<sub>4</sub>-N /g) under low management system and 16.63 (ug NH<sub>4</sub>-N /g) under high management system. Similarly the mean dehydrogenase activity was 0.96 (ug TPF/g) under low management system and 1.~4 (ug TPF/g) under high management system. Microbial population was the highest in the top 15 cm layer and declined drastically with depth, irrespective of the management level or land use system or bio-climatic regime. Urease activity declined with soil depth In most of the land use systems.
- Long term studies indicated that on rainfed conditions, vertisols, cotton-soybean rotation compared to cotton - cotton is more suitable from crop productivity and soil health point of view. Similarly nutrient management to cotton through INM imparts sustainability.
- A value chain in cotton fibre, seeds and stalks, long staple cotton production was under taken in 60 acres on 30 farmers' fields in Yavatmal district with integrated cotton production technology developed by CICR.. The results indicated that the yield under this integrated cotton production technology was 2172 kg/ha as compared to 1458 kg/ha with farmers' practice. Tips for clean cotton picking, handling, transporting and storage were also provided to the farmers.
- A solar powered knapsack sprayer was evaluated for the sustenance of pressure under solar spraying cum charging against the normal battery operated operation. This sprayer sustained a pressure of 20+ 10 % psi for a significantly longer time over the battery operated sprayer, thus generating uniform droplet size spectrum over a longer period of time.
- The prototype of 2 row fertilizer applicator for blade harrow as an attachment was developed with a view to save time and labour by combining two operations in one pass especially for the rainfed cotton farmers using bullock power. Rate of application of the fertilizer was found to vary from 70 to 140 kg/ha.
- Growing Bt cotton does not affect selected soil biological properties both in shallow and medium deep soils ?f A~SR 10.2 (hot, dry sub humid climate) under rainfed situations as compared to non Bt cotton and bulk soils. Interestingl~, higher soil biological properties were recorded In soil planted with Bt cotton as compared to Non Bt cotton.
- Majority of cotton farmers from distress areas had high level of alienation from land as compared to non distress area. The perception of farmers studied towards use of pesticide shows that farmers have very fav~rable perceptioin to the positive statements-spraying of pesticides as need based as per the ETL level and also

avoiding frequent sprayings of insecticides. However, majority of farmers in non distress area also expressed positive opinion. The economic viability of cotton farming was slightly lower in distress area compared with that of non distress area.

- Analysis of data from Marathwada and Vidarbha regions of Maharashtra showed that total factor productivity of cotton increased at the rate of 2.78 per cent per annum, whereas total output index increased at the rate of 3.38 per cent per year. During the over all period no district registered negative growth of total factor productivity. Highest total factor productivity growth was observed in Amravati followed by Wardha and Jalna districts.
- The three years experimentation indicated that there was no adverse / deteriorious effect of feeding of Bt cotton leaves on the health of goats. There was no mortality and the survivability of experimental goats was 100 per cent..

### Coimbatore

- Introduction of grain jowar as a sequential crop in cotton fallows enhanced seed cotton yield and total biomass yield. The Production Efficiency and Stability Index were higher under cotton-jowar than cotton-fallow system. Balanced fertilization (RDF) and more appropriately, INM (i.e., NPK+FYM) was helped maintain a steady growth, development and yield. Highest water use efficiency and water productivity were also observed with INM practice. The higher nutrient use efficiency (17.8 kg seed cotton/kg NPK uptake) was recorded under cotton-sorghum in comparison to cotton-fallow.
- Under the existing semi arid condition, 3 splits of N only was needed for desired efficiency and out put (with maximum yield).
- The cuticular absorption of moisture in cotton was more in 4<sup>th</sup> to 7<sup>th</sup> leaf from the top compared to the first 3 leaves from the tip and lower leaf at the bottom. When 1 % potassium was given as foliar spray, maximum potassium was absorption by 4<sup>th</sup> to 8<sup>th</sup> leaf compared to other leaves within one hour of spray.
- The water requirement for ELS cotton was 489, 671 and 832 mm at 0.4 Etc, 0.8 Etc and conventional irrigation. When no mulch was given, the crop responded up to 0.8 Etc while with mulch combinations, the yield level started decreasing beyond 0.4 Etc. The highest water use efficiency was recorded at poly mulch + drip at 0.4 Etc. Poly ethylene mulching was on par with biodegradable poly ethylene mulching.
- Mulching enhanced the seed cotton yield of RCH 20 Bt under rain fed condition. Poly mulching recorded the highest seed cotton yield and was on par with biodegradable mulching, sub soil coir mulching and gunny sheet mulching.
- Drip irrigation scheduled at 0.6 ETc resulted in the highest water expense efficiency, water productivity and the least quantity of water used for production of unit quantity of seed cotton in the ELS Bt cotton (RCHB708Bt). Fertigation of 100% RDF (90:45:45 kg of N, P<sub>2</sub>O<sub>5</sub> & K<sub>2</sub>O/ha) in six splits registered the highest water expense efficiency, water productivity and the least quantity of water required to produce unit quantity of seed cotton.
- Soil moisture conservation by opening of alternate furrow registered higher seed cotton yield and net return than intercropping with soybean (seed cotton yield and *in-situ* green manuring of sunhemp).
- Multi-tier cropping system of cotton + radish + beetroot + coriander with hand weeding thrice at 15, 30 and 60 DAS resulted in the highest net return, seed cotton equivalent

yield, relative production efficiency, relative economic efficiency and per day profitability.

- Bt cotton + coriander inter cropping system resulted in highest gross return, net return and benefit cost ratio. Bt cotton followed by maize recorded the highest seed cotton equivalent yield (4168 kg/ha), gross return, net return and per day productivity.
- The mean weight diameter (MWD) and water stable aggregats (WSA) in cotton-sorghum system were significantly higher than cotton-fallow system. The soil dehydrogenase activity was not significantly influenced by the cropping systems. However, it was maximum with 15t FYM/ha. The effect of cropping systems was not significant on cumulative CO<sub>2</sub> evolution from soil in a period of 30 days. Application of organic sources of nutrient resulted in significantly higher cumulative CO<sub>2</sub> evolution over control..
- To control the late emerging weeds, herbigation (applying herbicide through drip) was found to be more effective method than conventional spraying. Herbigation of herbicide rotation with pendimethalin 1.0 kg on third day followed by 1 hand weeding + metalachlor 1.0 kg on 30DAS recorded significantly less weed dry matter and higher weed control efficiency (WCE) at 60 DAS.
- The validation of the simulation model Infocrop showed that the deviation between the observed and simulated seed cotton yield ranged from 6.0 to 34.2% (mean 20.1 %) for RCH2 Bt cotton whereas the deviation was from -8.0 to 23.1 % (mean 5.8%) for RCH2 Non Bt cotton.
- In Bunny Bt genotype, there was a significantly higher seed cotton yield with foliar application of ethrel @ 5.7 mM (19.1 g/pl), followed by mechanical removal of squares and the least in control. In Bunny NBt genotype the treatment (Ethrel @ 8.56 mM) yielded highest seed cotton yield. Similar results were observed in Mallika Bt, Mallika NBt and JKCH 99 Bt.
- Detopping at 95 DAS followed by nipping of monopodia and sympodia at 105 DAS yielded the highest seed cotton yield (1850 kg/ha) followed by foliar application of maleic hydrazide, while the least in control..
- Modified Hoagland nutrient solution sprayed during the water logging and recovery period brought about a significant change in alleviating the water logging stress.
- Preliminary studies using MCU 5 and its lint less mutant indicated the role of peroxidase enzyme in fibre initiation process. Further, catalaze enzyme might be one of the important enzyme associated with fibre development..
- Impact on yield, the value of output and profit as a per cent of revenue is significantly higher in Bt cotton as compared to non-Bt cotton ranging from 20 % to 34%. The average number of sprays reduced from 9 to 4 with reduction in cost by 48 % and yield enhancement of 14% in Bt cotton as compared to Non-Bt cotton.
- In North Zone, growth rate of Total Factor Productivity (TFP) was higher after the year 2000-01 compared during the year from 1990-91 to 1999-00. The same pattern was observed in Central Zone but in South Zone not significant growth in TFP.
- Cotton + other crops + dairy farming system yield higher economic efficiency as well as ecological efficiency.
- Post Evaluation of Farmers Field Schools (FFS) revealed that the beneficiaries had significantly higher identification; functional; ecological knowledge and decision making ability than Non-FFS.
- Attitude towards cultivating Bt cotton and organic cotton was highly favorable compared to cultivating conventional cotton. The average cost of cultivation for one acre for

organic, Bt, and conventional cotton respectively, Rs.14,338/-, Rs.16,730/- and Rs.17,404/- and average yield under organic, Bt, and conventional cotton cultivation are 8.35, 9.30 and 7.20 q/acre respectively.

- Cotton information repository developed and maintained and Information Retrieval System was also developed and floated at CICR website for public access. Search Engine Optimization (SEO) tools were incorporated in Cotton Portal for clear visibility of CICR website in global cyber network. Two separate sub domains were created for TMC and AICCIP.

### Sirsa

- The performance of Bt hybrid RCH 134 with and without intercrop combinations was evaluated. The yield (3121 kg/ha) and number of bolls/plant (53.9) were significantly higher in sole cotton at spacing 67.5 cm X 75 cm as compared to paired row cotton with and without intercrops.
- The number of opened boll/plant (42.1) were significantly higher in the crop sprayed with lowest concentration i.e. 1500 ppm of defoliant at 145 DAS than control unsprayed crop (37.7) and because of higher number of opened bolls, the yield / ha was significantly higher in crop sprayed with 1500 ppm at 145 DAS (2855 kg/ha) than unsprayed crop.

## 2.3 Crop Protection

### Nagpur

- The safflower caterpillar, *Perigea capensis*, was recorded as an emerging pest on Bt cotton and it was found in cotton fields adjoining soyabean in Amravati and Hingoli districts of Vidarbha.
- Jasmine perfume (2.5 ml/L), ocimene (3 ml/L), limonene (3 ml/L) were effective in reducing jassid populations. Jasmine perfume/ocimene can be used between 45-50 DAS, while limonene may be used at 60 DAS, thereby preventing repeated use of the same molecule.
- A novel non-phytotoxic, botanical bio-emulsifier (soap nut) was identified and evaluated (at 5%) in combination with limonene, ocimene and jasmine perfumes for the control of sucking pests.
- Mealy Kill, a botanical formulation developed by CICR, was found to be as effective @ 10 ml/L as conventional biopesticides in AICCIP trials of Sirsa and Faridkot and superior to conventional biopesticides at Raichur and Coimbatore.
- Native Bt (*Bacillus thuringiensis*) strains from Yavatmal, Jalna and Hingoli caused a mortality of 28%, 64% and 58% respectively of 2 day old *H. armigera* but were less effective than the Ahmedabad Bt strain.
- Jassids, *Empoasca devastans*, collected on cotton, across cotton growing regions of the country demonstrated resistance of 110 fold, 57 fold, 2500 fold and 5450 fold, respectively to acephate, monocrotophos, thiomethoxam and imidacloprid.
- The variability in susceptibility of *H. armigera* to Cry1Ac was 4.71 fold across North India, 152 fold across Maharashtra, 62.8 fold across Gujarat and 1.91 fold in South India.
- The variability in EC<sub>50</sub> of Cry1Ac against *H. armigera* ranged from 0.01 ug/ml of diet in Yavatmal, Maharashtra to 0.593 ug/ml in populations from Bhavnagar, Gujarat.
- Enhanced degradation of Cry1Ac by gut proteases of field tolerant strain of *H. armigera* was observed in populations collected from Bhavnagar (Cry1Ac, LC<sub>50</sub> 0.99 ug/ml of diet).
- Germplasm lines A678, G.Cot 10, GRS 60/15, IC 671 Sel,

K8199, Kekchi Red, Kemp, L-604, L-751, Macha, Meade 9030D, PRS-72, Tamcot SP 21, Tamcot SP 37, 5/44, UA-Bk-4-84, 9-1487 and UPA(57)-1 were resistant to reniform nematode. Application of maleic hydrazide, Hydroxyproline and aminopurine, a kinetin inhibitor was found to impart resistance to root-knot nematode.

- dsRNA for ten parasitism genes was synthesized using Ambion megascript kit. Out of these, dsRNA for two genes viz. protein 40 and Aminopeptidase reduced penetration of the root-knot juveniles by 40 and 53% respectively and reduced the formation of females by 35 and 49%.
- Insecticidal toxin obtained in the fraction collected using 50-100 kDa cut off filter disc was found to have intrahaemocoelic and oral toxicity against *H. armigera*. 50K fraction was characterized further to reveal the presence of a total of 5 subunits of 70 and 48 kDa.
- A biocidal formulation developed from bacteria and plant products, effectively caused mortality of mealy bug crawlers. Bacterial symbionts found effective against insect pests, were characterized biochemically. Optimum conditions for culturing of bacterial symbionts of EPN, were standardized.
- Jassid damage exceeded Grade II, thrips and aphid damage exceeded Grade I throughout the season on Bt and non Bt cotton. Jassid population on Bt cotton was maximum (4 per 3 leaves) in the 40<sup>th</sup> SW while thrips population was maximum in the 37<sup>th</sup> Sw.. Population of mealybug was negligible irrespective of genotype. Pink bollworm population was negligible until crop senescence.
- An increasing mirid population during the 38<sup>th</sup> to 42<sup>nd</sup> SW was observed at different locations and cotton raised adjacent to fallow land recorded minimum mirid incidence.
- Hundred and six host plants of *P. so/enopsis* spreading across 27 families were recorded in cotton + pigeon pea cropping system. The major families of host with severe infestation and wide host range were Asteraceae, Malvaceae, Solanaceae, Fabaceae, Amaranthaceae, Euphorbiaceae, Poaceae, Labiateae and Apiaceae.
- Taxonomic biodiversity of cotton entomofauna was documented through record of eleven species of Hemipterans— one of Lygaeidae, three of Miridae, four of Pentatomidae and four of Pseudococcidae, viz., *Phenacoccus so/enopsis*, *Maconellicoccus hirsutus*, *Nipaecoccus viridis* and *Paracoccus marginatus* were recorded infesting cotton in different cotton growing zones of the India during 2009 crop season.
- *P. so/enopsis* was the sole species that dominated Cotton-wheat and Cotton + Pigeon pea- fallow system of North zone and Central zone respectively while, *P. marginatus* was dominant in cotton+ pulse- maize cropping system of South zone. Mealy bugs *M. hirsutus* and *N. viridis* were observed in negligible number in Central zone.
- Two Hymenopteran parasitoids viz. *Aenasius bambawa/ei* and *Metaphycus* sp. on *P. so/enopsis* and *Promuscidia unfasciiventris* on *N. viridis* were documented in Central zone.
- Coccinellids - *Brumoides sutura/ais* (F.), *Cheilomenes sexmaculata* (F.), *Scymnus coccivora* and *Cryptoaemus montrouzieri* on *P. so/enopsis* were documented as predators while *Gitonides perspicax* Knab was recorded as predator on *N. viridis* 1M, *hirsutus*.
- Simple protocols were developed for lifecycle studies on mealybug and mirids in cotton to assist in insect phenology based simulation modelling.
- Sampling techniques and sample size for mirids *Campyomma livida* was standardized. Top 1/3<sup>d</sup> plant

portion of plant (Bunny Bt) harbored more number of nymphs and adults than the middle and bottom portions. A sample size of 10 plants/acre was found appropriate for sampling nymphs.

- Developmental rates of *P. Solenopsis* at constant temperatures viz. 25, 27, 30 and 32°C were studied in central zone. Fecundity was maximum (434.4 eggs + crawlers) at 25 DC and was found to decrease with increase in temperature. The number of eggs observed per female showed an increasing trend.
- Out of 382 lines, 10 lines were found to be promising with respect of tolerance to sucking pest as well as bollworms, earliness (150-155 days), yield. These are 8 x Suvin (B)-2,6 x 20 (C), 13 x 2 (B) - V, Code 1150 -I, Code 420 (A), Code 426 (A), Code 446 (A), 16 x 74Ax 8,3917 x 74A(B)x 8-B,-L-11 (A)x7xA(B)x8.
- In a trial at farmer's field, the number of bio-agents was high in IPM with dominance of spider population from 38 to 40% SW corresponding to the increasing mirid population. Increased returns of Rs. 3330/- per hectare were obtained in IPM plot over RPP indicating the superiority IPM.
- Six bacterial isolates were found effective in inhibiting the growth of *Fusarium oxysporum* f.sp. *vasinfectum* and *A. alternata* and four bacterial isolates exhibited an inhibition of *M. phaseolina*.
- Fifteen cultures with resistance to bacterial blight / grey mildew have been identified in comparison to local check in seed cotton yield and other yield imparting characters.
- Maximum losses due to diseases were 11.13 - 13.11 per cent in Bt hybrids as compared to 7.53 - 9.37 per cent in non-Bt hybrids H 10 and NHH 44 under unprotected conditions.
- Genetic diversity was observed in 29 isolates of *Fusarium oxysporum* with 9 SSR primers used for characterization and diversity analysis on the basis of virulence, species specificity, growth, pigmentation.
- Distinct cultural variability in sporulation, spore types, growth pattern and pigmentation was observed in the isolates of *A. macrospora*, *A. alternata* and *A. gossypina*.

#### Coimbatore

- Acephate, Chlorpyrifos, Mealy quit and Fish Oil Rosin Soap were found moderately effective in reducing the mealybug (*P. marginatus*) causing a reduction of 39.6,37.3, 36.2 and 30.4 %, respectively. Acephate, Chlorpyrifos, Fish Oil Rosin Soap and Detergent Powder recorded higher yield by 56.5,50.8,46.1 and 45.4kg/ha, over control.
- Six insecticides, namely Confidor, Thiamethoxam, Acephate, Monocrotophos, BYI-2960 and Victor at six doses (0.01,0.05,0.2, 1.0,2.0 and 10 ml/lit.) were tested for jassid resistance. Among the six insecticides, Acephate and Monocrotophos, maximum survival was recorded after 72 hrs at 0.01 and 0.05 ml/lit respectively.
- Repeated application of profenophos increased the jassid population with a resurgence ratio of 0.59-1.05 followed by Acetamidiprid with 0.24-.98 resurgence ratio. No indication of resurgence with four insecticides against aphids, thrips, mealy bugs and mirids was observed. Mealy bug population in all the treatments except Profenophos was on par with the control.
- Six Bt hybrids recorded significantly less mean locule damage by *Pectinophora gossypiella* (0.88-4.85/10bolls) and average larval number (0.15-0.70/10 bolls) as compared to NBt hybrids with 22.04-26.24/10 bolls and 1.80-3.55/10 bolls of locule damage and larval number, respectively. Within Bt and NBt hybrids, no significant

difference was recorded on locule damage and larval population.

The yield loss due to the sucking pests including the emerging pests was 8.6, 12.6, 17.2 and 17.5 q/ha in RCH B708 Bt, Mallika Bt, Bunny Bt and RCH2 Bt respectively.

Among the three hundred and fifty germplasm accessions of *G. hirsutum* screened, six entries (viz., ICGH250, 252, 276,288,341, & 410) and one entry (ICGH 370) were found less susceptible and susceptible to mealy bug respectively. Five (viz., ICGH 474, 480,509,610 and 630) and 1 entry (ICGH 328) recorded minimum and maximum number of mirid bugs, respectively.

Natural predation of *S. epius* was recorded up to 28% on mealy bug *Paracoccus marginatus* on cotton. Among the 3 stages of the predator larvae, 3<sup>d</sup> instar larvae consumed maximum number of crawlers followed by 4<sup>th</sup> instar larvae. Among the 2<sup>d</sup> and 3<sup>d</sup> instar larvae of the predator, 3<sup>rd</sup> instar predated the maximum number of egg masses of 9.6/ day as compared to 2<sup>d</sup> instar (6.3) and this difference was statistically significant.

Two native isolates of *Trichoderma viride* and one isolate of *T. harzianum* were found antagonistic to *Alternaria* leaf spot pathogen.

Survey on entomopathogenic nematodes in cotton ecosystem revealed wide spread distribution of *Steinernema siamkayai* Stock, Somsook, and Reid, 1998.

Out of 43 fungi screened, *Lecanicillium lecanii* (Zim, Zare & Gam) was found to be highly virulent against *Phenacoccus solenopsis* and *Paracoccus marginatus*. Natural occurrence of *L. /ecanii* and *Cladosporium c1adosporoides* was reported for the first time in India.

#### Sirsa

- The reduction in yield of cotton plants was estimated to be 14.87,30.09,34.53 and 51.86 percent for Grade I, II, III and Grade IV mealy bug infestation levels, respectively during 2009.
- The population of *H. armigera* monitored with pheromone trap was observed to be low in North India during 2009.
- ETL of *H. armigera* on Bt cotton was 4.35 and 3.85 larvae /plant, respectively after 120 and 135 DAS release. Resistance monitoring in jassid populations of North India against the commonly used insecticides revealed relatively low resistance problem till date to neonicotinoids.
- Studies on inoculum source and economic damage caused by cotton leaf curl virus disease showed per cent seed cotton yield reduction ranging from 9.85 to 36.31 with 5% to 60% graded POI in case of Bt hybrid Bioseed -6488 BG-I and 8.25 to 59.52% reduction with Bt hybrid 6317.
- *F pallidoroseum* at 1% was effective two weeks after application causing 94% mortality of mealy bug.
- Among various insecticides and biopesticides, acephate (72.86%) and chlorpyrifos (69.13) resulted in maximum reduction of mealy bug after spray followed by *Metarrhizium anisoplae* (41.53 %), *Beauveria bassiana* (37.71 %), new botanical (34.81) and *V. /ecanii*(33.79%).
- The average number of sprays in IRM villages in Sirsa, Hisar and Fatehabad were 2.67, 2.37 and 2.94, respectively where as it was 3.18, 3.88 and 3.32 in case of Non IRM villages. The net profit per ha of IRM farmers over Non IRM was 7125,9483 and 9145 rupees in the respective districts.



### 3.1 Brief history

'Indian Central Cotton Committee used to sponsor cotton research schemes on an adhoc basis till the work of the committee was taken over by the ICAR in 1966. All India Coordinated Cotton Improvement Project (AICCIP) initiated by the Council in the year 1967 with headquarters at Coimbatore gave new fillip and direction in terms of multidisciplinary and multi-centre approaches with the active involvement of State Agricultural Universities. The project has contributed significantly in tackling location-specific problems in terms of varietal improvement and development of appropriate production and protection technologies. However, looking to the low level of productivity since major cotton growing area is under rainfed conditions, a need for expanding the research efforts in the spheres of basic and fundamental research was felt, the **Central Institute for Cotton Research** was established at Nagpur by the ICAR, in 1976. The two regional stations of IARI at Sirsa (Haryana) and Coimbatore (Tamil Nadu) were transferred to CICR to cater to the needs of cotton farming in north and south India, respectively.

The main mission of CICR is to increase the production, productivity and profitability of cotton cultivation in different agro-ecological cotton growing zones through the development of relevant, feasible, economically viable and ecologically sound production and protection technologies including the development of improved varieties and hybrids and promoting basic and strategic research.

### 3.2 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 link with international agencies to accomplish the above mandate.



**CICR RS, Coimbatore**



**CICR RS, Sirsa**

### 3.3 Development and release of cotton varieties and hybrid

#### Release of first public sector Bt cotton hybrid NHH 44

The first public sector Bt hybrid NHH 44-Bt was developed indigenously by using BN Bt as female parent and approved for commercial cultivation by the GEAC, New Delhi on 13<sup>th</sup> May, 2009. The BN Bt is very good combiner for hybrid production and it was developed by incorporating Bt *cry1 Ac* gene. The expression of Cry protein level is high i.e. up to 5.8 ppm. The hybrid was evaluated in all the cotton growing zones and found very promising. It was developed through collaborative efforts of the University of Agricultural Sciences (UAS) Dharwad, National Research Centre for Plant Biotechnology (NRCPB), New Delhi and Central Institute for Cotton Research (CICR), Nagpur.

#### G. hirsutum variety, CNHO 12

CNHO 12 (Saraswati) has been identified for release in the Central zone under irrigated conditions during the year 2009-10. The variety is characterized by dwarf stature, early maturity (160-165 days), medium to high seed oil content (21.8 %) with synchronous boll bursting. It has recorded seed cotton yield of 1501 kg/ha as against 1251 kg/ha of the zonal check LRA 5166.

In the wake of shortage of short staple and medium staple categories of cotton in the country, the new variety CNHO 12, spinnable to 20s counts was recommended for release for its suitability for manufacture of denim. The variety has been assigned with the National Identity Number IC 574486.

#### G. arboreum varieties

##### CISA614

CISA 614 was tested in 32 locations in the North Zone (Punjab, Haryana and Rajasthan) during 2004-2007 and has recorded an over all mean seed cotton yield of 2204 kg/ha as against 1834 kg/ha of HD 123 (zonal check) and 1990 kg/ha of local checks. It was identified by Variety Identification Committee Meeting (AICCIP) held at ANGRAU, Hyderabad 6-8 April, 2009 and notified vide Gazette of India NO.608 dated April 1, 2010.

##### CISA-310

CISA 310 developed by CICR, Regional Station, Sirsa, has been notified vide Gazette of India NO.171 dated January, 2010 for cultivation due to its overall superiority in both seed cotton and lint yield, better fibre quality than the check and less boll damage under irrigated conditions of entire north zone.

### 3.4 Staff Position (as on 31<sup>st</sup> March, 2010)

Name of the Post	Sanctioned Cadre Strength				Post Filled Up			
	NGP	CBE	Sirsa	Total	NGP	CBE	Sirsa	Total
Director (RMP)	1	-	-	1	1	-	-	1
P.C. (Cotton) & Head	-	1	-	1	-	1	-	1
Scientific	50	22	7	79	32	17	6	55
Technical	50	20	7	77	46	12	6	64
Administrative	34	9	5	48	27	6	5	38
Supporting	59	30	10	99	45	18	10	73
<b>Krishi Vigyan Kendra</b>								
Training Organizer	1	-	-	1	1	-	-	1
Technical	11	-	-	11	8	-	-	8
Administrative	2	-	-	2	2	-	-	2
Supporting	2	-	-	2	1	-	-	1

NGP - Nagpur; CBE - Coimbatore



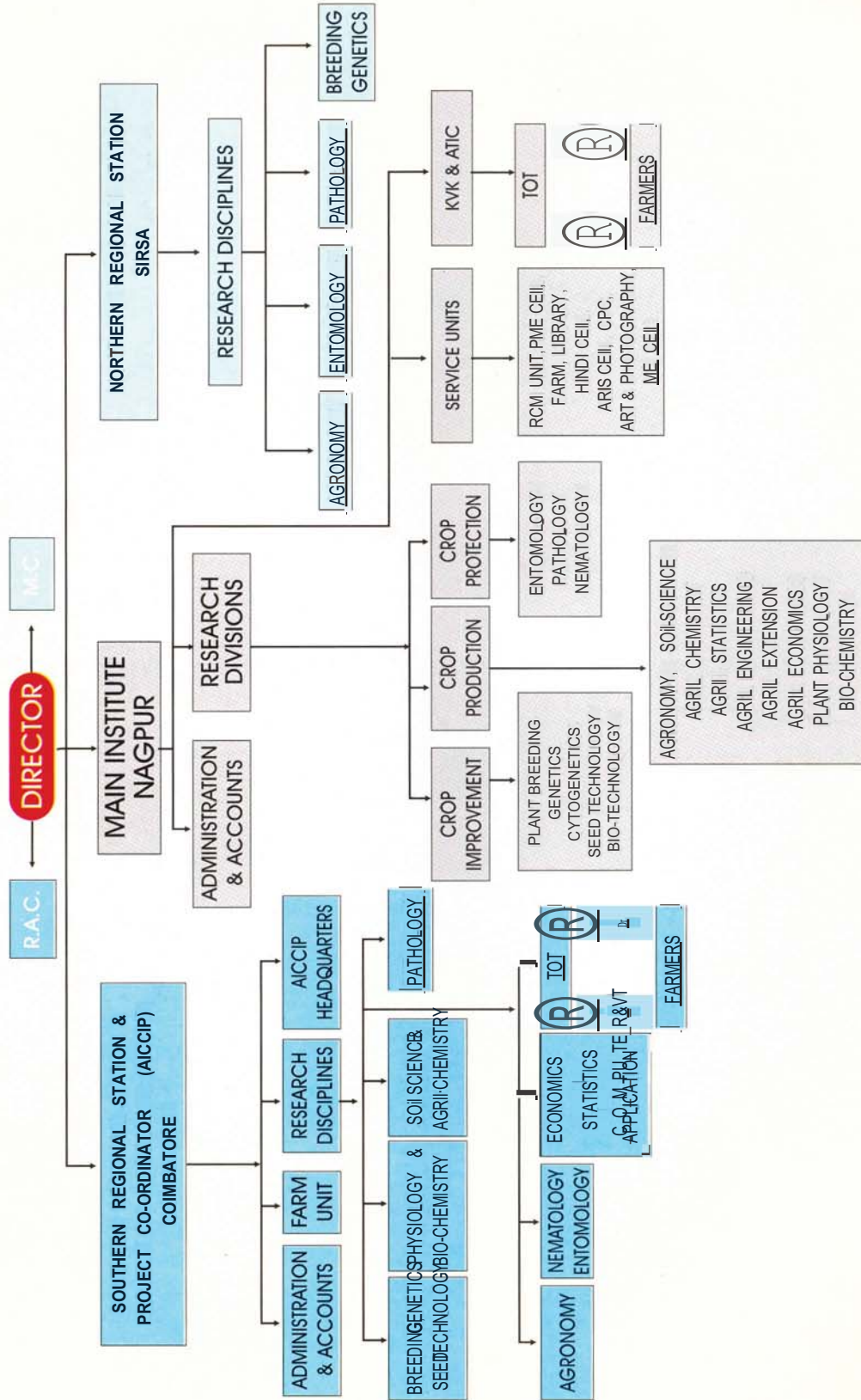
### 3.5 : Financial Statement

The budget grant and actual expenditure for the year 2009-10 are furnished below:

(Rs. in Lakhs)

	Scheme	Sanctioned	Expenditure
1	Plan	325.00	324.06
2	Non-Plan	2030.66	2229.20
<b>PLAN SCHEME</b>			
3	NSP Crop	1.60	7.10
4	AICCIP	630.00	630.00
5	KVK Scheme	110.25	108.96
6	TMC MMI	500.00	512.04
7	MSP	75.50	70.96
8	ITMU	9.50	12.50
<b>AP CESS FUND</b>			
9	ICAR Regional Committee No. VII	0.21	0.10
<b>R DEPOSIT SCHEME</b>			
10	Transgenic Crop	9.75	20.24
11	DBT QTLS	1.33	1.92
12	Bt,Celius	0	0.32
13	MMFRQDBT	9.81	10.88
14	Fast Track	4.00	4.79
15	RNAiDBT	6.44	5.10
16	Gene Stacking	7.86	2.63
17	G.M.O. Project	0	0.008
18	DUS Scheme, Ngp	5.00	4.45
19	DUS Scheme, Cbe	7.50	4.16
20	Dupont Scheme	0	1.03
21	J.K. Toxin	7.43	2.62
22	NMITLI	19.25	16.61
23	DBT Marker	7.16	8.08
24	Indo AUS DBT	10.91	3.85
25	Genetic Eng.(AKI)	11.26	8.35
26	Maint. Of Breeder Seed Scheme.	25.00	24.96
27	TMC Scheme MM-II	180.00	124.92
28	Mahyco I	5.00	3.73
29	Mahyco Bollgard II	10.00	14.48
30	FLD Scheme	56.84	59.55
31	Training	1.79	1.45
32	Testing fee	13.40	22.43
33	FLD KVK	0.34	0.58
34	Bt, Technology	35.05	7.45
35	DUS Mahyco	3.00	0.35
36	SPM	14.59	11.35
37	EBAM Project	11.60	-
38	EPN (BT Cloning)	25.09	3.71
39	DUS Testing	1.41	-
40	I & ISS Project	6.35	-
41	Testing IARI	5.00	-
42	PRT Cotton	18.51	-
43	A Value of Chain for Cotton Fibre	39.63	33.38
44	Development of Decision Support System	13.64	16.82
45	Georeferenced Soil Information System	15.32	8.45
46	Implementing the learning capacity building project	5.38	5.38

# ORGANOGRAM OF CICR





## 4.1: Cotton Genetic Resources

### Nagpur

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

Thirty one exotic accessions of *G. hirsutum* were procured from Uzbekistan and Hazera, Berurim and Israel through NBPGR, New Delhi.

Source Country	Species	No. of Accessions	Characters
Uzbekistan	<i>G. hirsutum</i>	3	Early and highly susceptible to sucking pest, high boll weight
Israel	<i>G. hirsutum</i>	28	Early, high GOT and long capsule

A close wild relative of *Gossypium* viz., *Thespesia lampas* L. was established in existing wild species garden. Twenty wild species, 15 races of cultivated species and 32 synthetic polyploids were maintained in the species garden. Five new interspecific hybrids were added to the existing collection. These included Jawahar Tapi x *G. longicalyx* (F1), AKA7x *G. armourianum* (02-1), AK 8401 x *G. davidsonii* (D3-d), AK8401 x *G. trilobum* (08) and *G. davidsonii* (D3-d) x *G. arboreum* race *indicum* (A 1).

Seeds of one thousand five hundred seventeen *G. hirsutum* including 289 exotics and 350 accessions of *G. arboreum* were sent to NBPGR, New Delhi for long term cold storage, while another set of *G. hirsutum* and *G. arboreum* germ plasm was kept in Medium Term Cold Storage at CICR, Nagpur.

Twelve germ plasm lines (*Gossypium hirsutum*- race-*Latifolium*- 8 and *Gossypium arboreum* race *cernuum*- 3, *Gossypium arboreum* race-*Bengalense* -1) of unique and novel traits were added to the Gene Bank of CICR, Nagpur.



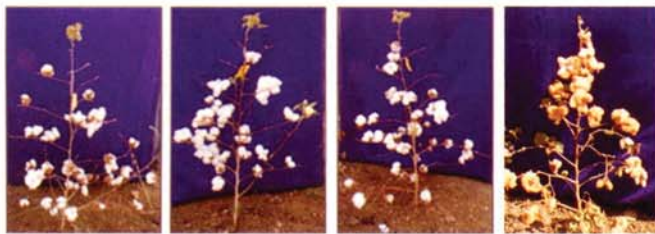
*Thespesia lampas* Linn. wild relative of *Gossypium*

Three genetic stocks of *G. arboreum* race *cernuum* immune to Grey Mildew (*Ramularia areola* Atk) disease viz., 30814 (INGR No. 09117), 30826 (INGR No. 09118) and 30856 (INGR No. 09119) were evaluated and registered with NBPGR, New Delhi.

Eight genetic stocks were approved by Institute Germplasm Registration Committee for registration of the unique morphological traits at NBPGR, New Delhi. These included YPLL-9 (Yellow pigmented leaf lobed) *G. hirsutum*, SLL-3 (Single leaf lobed) *G. hirsutum* race *latifolium*, CINA-333, high seed cotton yielding *G. arboreum* culture, ABGMS (CSHN)-male sterile culture with curved stigma, NISC 40, 43 and 44 Jassid tolerant compact plant type introgressed genotypes suitable for organic cultivation and MSH 53 a dark brown-linted, introgressed derivative.



ABGMS line developed through induced mutation



NISC 40 NISC 43 NISC 44 MSH 53  
Jassid tolerant compact introgressed derivatives of *G.hirsutum*

Two hundred seventeen accessions of *G.hirsutum* and 39 accessions of *G. arboreum* were distributed to various Cotton Research Stations/Centers of SAUs and Government Institutions for research purpose.

Sixty seven newly collected germ plasm lines of Asiatic cotton (*Gossypium arboreum*-30, *G. herbaceum*-35, *G. arboreum* perennials-2) collected from the coastal regions of Andhra Pradesh and were evaluated for yield and yield contributing characters for second consecutive year Table 1.

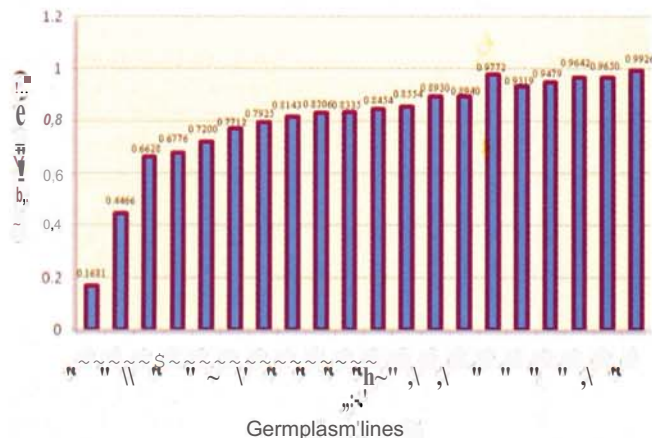
**Table 1 : Evaluation of new Asiatic cottons**

Species	Seed cotton yield/plant (g)	Sollwt. (g)	GOT (%)	MHL (mm)
<i>G. arboreum</i>	15.39-103.0	2.1-3.4	28.6-37.3	17.0-26.3
<i>G. herbaceum</i>	10.23-29.15	0.9-2.8	23.5-30.4	17.0-24.5

### Assessment of Gossypol Content

20 *G. arboreum* germplasm lines were processed. Gossypol was extracted from the seed samples and colorimetric observations were recorded (Fig. 1). Per cent gossypol content was calculated with the help of a standard curve prepared with pure gossypol.

Fig. 1 : Seed Gossypol content(%) in *G.arboreum* germplasm lines



### Molecular Characterization of cotton germplasm (Core Collection) using DNA markers

#### DNA fingerprinting of tetraploid cotton (*G. hirsutum*) using RAPD and ISSR markers

Twenty-four working germplasm of *G. hirsutum* (Boll weight group-4, Boll weight exotic cultivars group-2, GOT group-7, GOT exotic cultivars group-2, Mean hallow length group-4 and okra leaf group-5) were subjected to diversity analysis using RAPD and ISSR markers. Analyzed germplasm were found to form two major clusters A and B. Specificity of markers was

evaluated by using 39 primers including 20 RAPD primers (OPA series) and 19 ISSR primers. Average number of bands produced per loci by RAPD and ISSR were 10-12 and 6-8 respectively. DNA fingerprinting of 24 working collections with one RAPD primer (OPA 11) and one ISSR marker (ISO 2) is presented in Figs. 2 & 3.

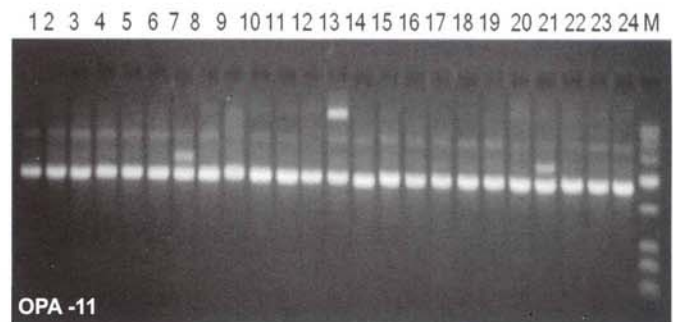


Fig. 2: RAPD profile of 24 cotton germplasm obtained with primer OPA-11, Lane 1-24 corresponds to cultivars taken in analysis. Lane 25, M = 3 kb ladder



Fig. 3: ISSR profile of 24 cotton germplasm obtained with primer IS-02, Lane 1-24 corresponds to cultivars taken in analysis. Lane 25, M = 3 kb ladder.

Robustness of clustering pattern of 24 working germ plasm using RAPD markers was tested using 1000 resampling with 'Freetree software'. The UPGMA clustering pattern of 24 working germplasm using RAPD Markers showed STONEVILLE 213 from France to be the most distinct accession with bootstrap support of 100%. Rest of accessions could be grouped in two broad clusters, A and B. Cluster A consisted of 20 germ plasm with two sub clusters A1 (19 accessions) and A2 (1 accession) with similarity coefficient 0.865. Cluster B consisted of three germplasm i.e BM Cot 167, Miscot 7913-83, RS 513, STONEVILLE 213. GP 187 and Mysore MDH 89 (both from USA) of Cluster A formed one cluster showing highest similarity of 96% (Fig.4).

The UPGMA clustering pattern of 24 working germplasm using ISSR marker showed AC 241 to be the most distinct germ plasm with bootstrap support of 100%. Rest of germ plasm could be grouped in two broad clusters - A and B. Like RAPD marker, cluster A consisted of total of 22 germ plasm with two sub clusters A1 (20 accessions) and A 2 (two accessions) with similarity coefficient 0.848. Cluster B consisted of only single genotype MDH 38 sharing a similarity coefficient of 0.9004 with bootstrap support of 90%. Miscot 7913-83 and RS 513 of Cluster A formed one cluster which showed highest similarity of 97% though they are from different geographical region Sriganganagar (India) and USA, respectively (Fig. 5).

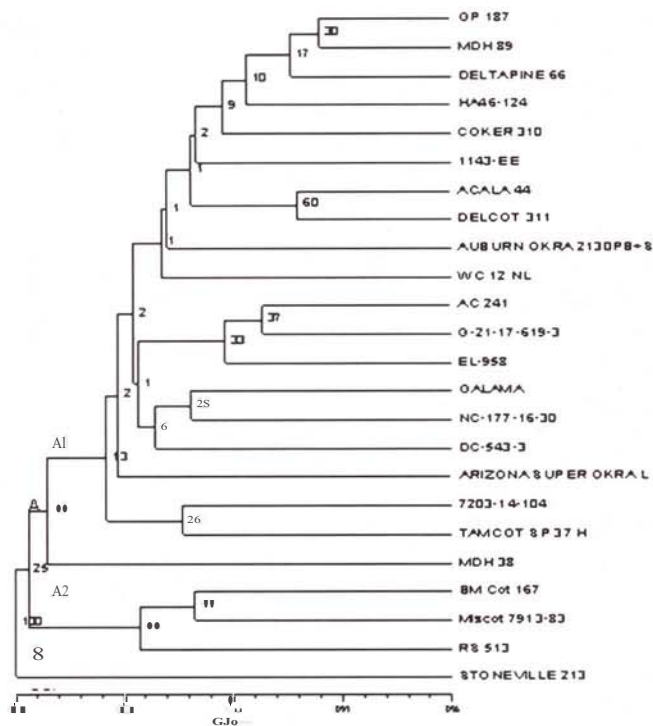


Fig. 4: UPGMA cluster analysis based dendrogram constructed from the RAPD profiles depicting genetic relationships among twenty-four working germ plasm of *G. hirsutum*, per cent bootstrap values depicted inside the figure

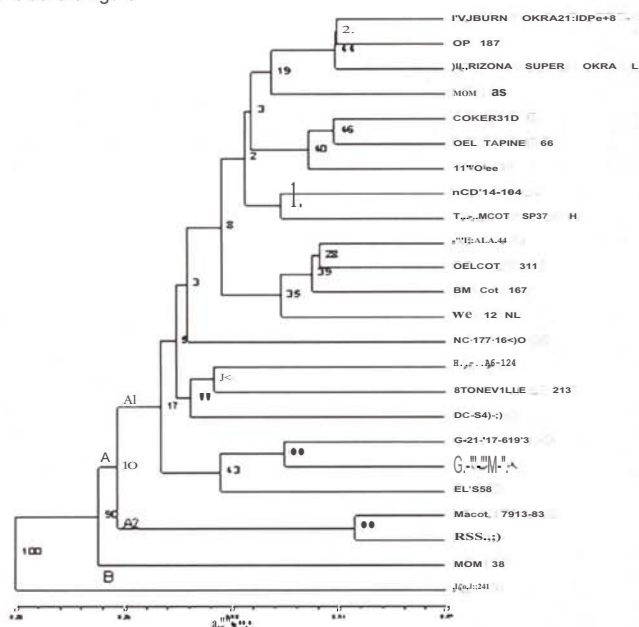


Fig. 5: UPGMA cluster analysis based dendrogram constructed from the ISSR profiles depicting genetic relationships among twenty-four working germ plasm of *G. hirsutum*, per cent bootstrap values depicted inside the figure

#### Molecular Characterization of cotton germplasm using DNA Markers

One hundred working germplasm of *G. hirsutum* (Buti 0394, C 2686-5, Coker 417-68, EL 500, SA 117, UPA(57)-17, XAB-5X TANGUIS, (9-3X1311 C02)-1-3, 21-1-1-4-5, 65-2(5)2-3, SOBHAGYA, REBA PVT 9 (C-V), PEE DEE 0111(A), TAM COT SP37, TAMCOT SP215, TXMAROON 2-78, IRMA-323, BMCOT 95 BLL, BMCOT123(33 MLL), BMCOT 128 (182 MLL YY), DCB 348 CY, B4 EMPIRE, SAJAR 314, LAFRECOBRACT,

Acala 8-1 X TamcotSP-21-1, DUNN 56 C-B, PEE DEE 4548 (A), RS 513, BMCOT 148, ACALA44, STONEVILLE 20, WC 12 NL, A 185, K 3822 (SORT 18819), MZ 561-3, PRS 72, A 72-62, AR 27, EWLS X TIDE WATER.ST, G21-17-619-3, COKER 310, NC 177-16-30, B-58-1290, M-4, MACHA, MEADE 9030 0, S 344, S 4727, X 82,5/44,21,561, ALPPO 40, Tashkent 3, ECV EARLY, SIMA-1, DC1116, DC 118, DC1120, DC1121, DC1122, CNH-36, CNH-151, CNH-152, CNH-154, CNH-1013, CNH-1020, NHBBR-38, CSH-911, ARIZONA SUPER OKRA LEAF (GREEN), AUBURN OKRA213-0PB-SPB1978, GP 187, MDH 90, TXORHU-1-78, TXORS-80, TXORSCE BO-1-79, 79-4303 P1, B56-181, B61-2038, BAR 12 18, COKER 413, GRS 60/15, KEKCHI (RED), SAENZE PENA TOBA, KW-61-276, UPA(62)31, 101-102 B, 150-3-1-1,6288, REBAB-50, BJR-JK-97-16-4, KH-113, JK-258, JK-259, JK-260, JK 344, M-1, M-7, M-15, M-18) were further subjected to molecular characterization by using STMS marker.

Twenty-eight STMS primers produced a total of 139 bands with an average of 4.96 bands per primer. Out of 139 bands 121 were found to be polymorphic, showing 86.12 per cent polymorphism. Average number of polymorphic bands per primer was 4.32. The number of DNA amplified fragment per primer ranged from 3 (JESPR 208) to 7 (MUCS 164 and BNL 2986). The average size of the fragments varied between 100-900bp in 100 germplasm when characterized using STMS marker M-04 (Fig. 6).

#### STMS Cluster analysis

Clustering of 100 working germ plasm lines of cotton with STMS marker M-04 is depicted in Fig. 7. Germplasm showing MZ-561-3 emerged to be the most distinct germplasm with bootstrap support of 100%. Rest of the germplasm could be grouped in two broad clusters-Cluster I and Cluster II with similarity coefficient of 0.652. Cluster I consisted of 93 germplasm whereas Cluster II consisted of six germplasm. Cluster I was further sub-divided into two sub clusters -Ia and Ib with similarity coefficient of 0.659. Subcluster Ia consisted of 86 germplasm of *G. hirsutum* whereas subcluster Ib consisted of seven germplasm. Cluster II was divided into two subclusters -IIa and IIb, with similarity coefficient of 0.662. Subcluster IIa consisted four germplasm i.e., KEKCHI, SENZE-PENA-TOBA, MACHA and S-4727 out of these KEKCHI and SENZE-PENA-TOBA from Bacterial blight resistant group showed highest similarity to each other. They were also known to share similar morphological characteristics i.e seed cotton yield (g), Ginning outturn (%), Mean Halo length (mm) and boll weight (g) etc. subcluster IIb consisted of only two germplasm i.e COKER-413 and M-1. Principal Coordinate analysis (PCA) based on genetic similarity matrices were used to visualize the genetic relationships between *G. hirsutum*.

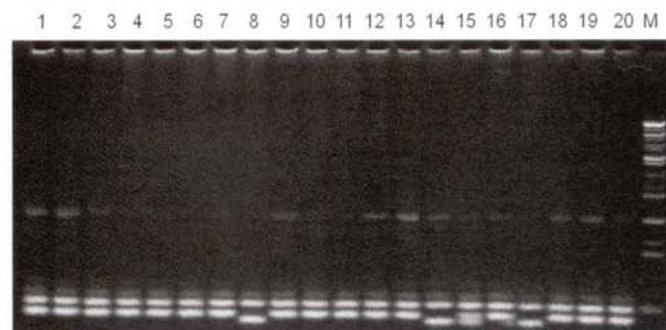


Fig.6:STMS profiling of 20 cotton working germplasm with primer M-04, M-100bp ladder

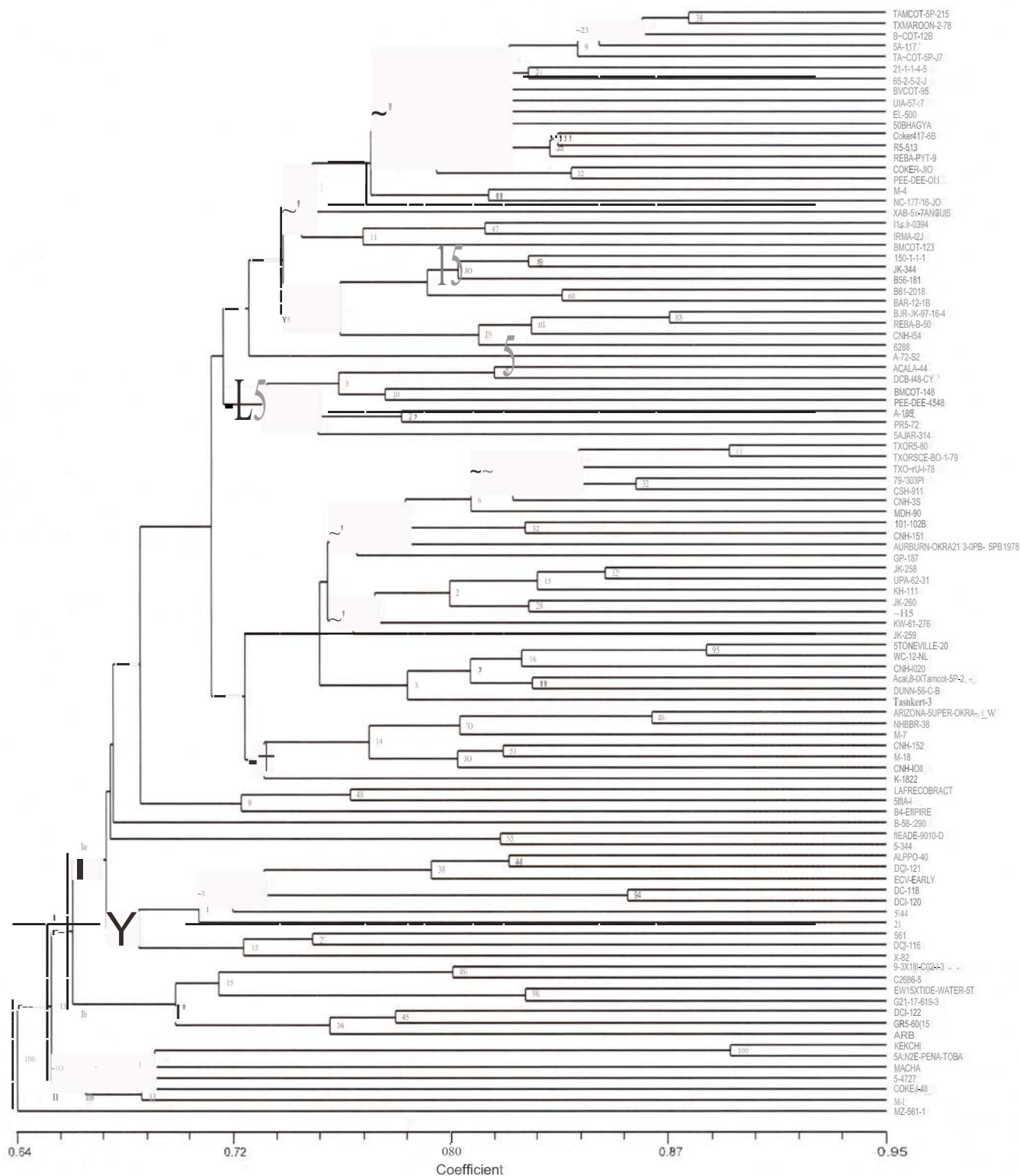


Fig.7 UPGMA cluster analysis based dendrogram constructed from the STMS profiles depicting genetic relationships among 100 working germplasm of *G. hirsutum*, percent bootstrap values depicted inside the figure

A set of 96 core accessions were screened using the informative polymorphic markers. Combination of markers i.e. 14 SSR, 17 SRAP and 15 RAPD markers (a total of 46) were employed to access genetic diversity and develop a marker profile. More informative markers are required to be used for reliably understanding the genetic diversity among the core accessions.

### Coimbatore

Twenty two exotic *G. barbadense* accessions were raised in two row plots and characterized under field conditions. Seed cotton yield and fibre quality parameters of these new accessions are furnished below (Table 2).

**Table 2: Performance of select exotic *G. barbadense* germ plasm accessions**

Accession No.	Seed cotton Yield /Plot (g)	Ginning %	Lint Index (g)	Seed Index (g)	2.5%SI (mm)	Micronaire	Strength (g/tex)
EC 617835	485	34.5	5.7	10.8	35.6	3.7	<b>30.2</b>
EC 617837	614	22.2	2.4	8.4	26.4	4.5	24.8
EC 617838	532	34.9	7.6	<b>14.2</b>	34.5		
EC617852	275	35.5	5.5	10.0	35.3	4.5	29.1
EC 617862	500	35.4	7.0	12.8	<b>37.9</b>		
EC 617864	<b>1380</b>	<b>41.3</b>	7.4	10.5	30.1	<b>5.7</b>	22.7
Mean	601	34.4	5.8	10.9	33.0	4.4	26.4
Maximum	<b>1380</b>	<b>41.3</b>	<b>7.6</b>	<b>14.2</b>	<b>37.9</b>	<b>5.7</b>	<b>30.2</b>
Minimum	122	22.2	2.4	8.4	26.4	3.7	22.7

Note: Bold figures indicate the maximum value recorded among 22 accessions

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

One hundred sixty three *G. barbadense* germplasm lines were evaluated during 2009-2010 and good variability was noticed. There are 5 germplasm lines (ICB-67, ICB-86, ICB-218, ICB-244, ICB-273) expressing the short branching types. Thirteen *G. barbadense* L accessions (ICB-16, ICB-21, ICB-23, ICB-34, ICB-36, ICB-41, ICB-50, ICB-57, ICB-58, ICB-70, ICB-78, ICB-178, ICB-235) were early flowering types. Five accessions (ICB-

41, ICB-212, ICB- 237, ICB-258, ICB- 261) had flowers without petal spot. In boll bearing characters also, variability was observed. All short branching types bearing cluster bolls consisted of 2-6 bolls per cluster.

Seven single plant selection of *G. barbadense* were evaluated in a single row trial to assess their yield performance and fibre properties. Three best superior lines were identified (ICB-167, ICB-274, ICB-129) which possessed better yield potential and high span length than the check Suvin.

**Table 3: Performance of the superior germ plasm lines**

S. No	Accessions	Seed cotton yield /Plot (g)	Ginning (%)	2.5%SI (mm)	Micronaire	Strength (g/tex)
1	ICB-22	131	32	38.4	3.7	29.1
2	ICB-129	179	32	39.4	3.1	27.7
3	ICB-167	191	32	38.6	3.2	25.9
4	ICB-198	124	31	37.7	3.3	24.8
5	ICB-200	129	28	37.5	3.1	26.1
6	ICB-260	112	30	37.2	3.2	26.4
7	ICB-274	186	30	38.3	3.0	27.2
8	Suvin	97	32	36.7	3.5	28.4

### Sirsa

Sixty new exotic germ plasm lines were evaluated and the superior accession for yield/ plant EC 599553 (109 g/plant), boll weight EC 599536 (3.7 g), boll number EC 599553 (33), GOT EC 599569 (37.9%), seed Index EC 599536( 10.4 g) and lint Index EC 599536 (4.9 g) were observed. In addition, 288 accessions of *G. hirsutum* and 326 of *G. arboreum* available at the station were evaluated for yield parameters and reaction to diseases and pest and superior accessions were identified. The required germ plasm lines were supplied to breeders in the Institute as well as Universities of the zone.

Out of 58 *G. hirsutum* genotypes screened for salt tolerance, ten genotypes viz; CSH-612, KH140, RS2525, SCS451, L801, F2168, CNH11 04, RS2524, LH21 08, GISV218 were salt tolerant at Ec around 10. In another experiment at farmer's field out of 76 genotypes screened at 3.1 EC to 3.5 EC, twelve salt tolerant genotypes found were: BS-279, CCH-03-23, BN-TOM-277, CSH-3118, 3119, F-846, RS-875, ANJALI, Pink Filament, BN-Okra, BN-TOM-277. Out of 19 *G. arboreum* genotypes only 4 genotypes viz; CISA 6-214, 5R, RG-18 and cernuum types were found tolerant to salt.

## 4.2: Hybrid Cotton

### Nagpur

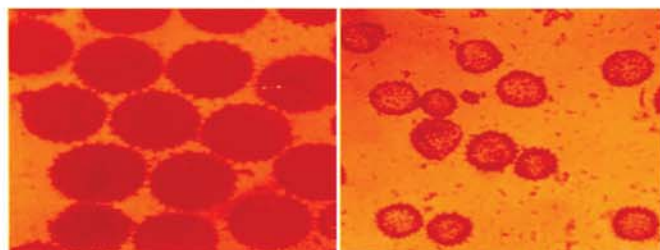
#### Maintenance of Male sterile lines

One hundred thirty seven CMS (*harknessii*), 15 CMS (*aridum*), 19 GMS and 57 restorer lines were maintained through crossing, sibmating and selfing. For improving the CMS and GMS lines, AK 32 CMS (*aridum*), Rajat CMS (*harknessii*) and G 67 (GMS) lines were treated with physical and chemical mutagen (gamma rays and ethyl methane sulphonate). Individual sterile plants were identified and maintained through crossing.

#### TGMS system

Sterility of TGMS lines employed in the development of hybrids were ascertained by pollen staining. Three experimental hybrids of TGMS were evaluated. All the three experimental hybrids showed lower seed cotton yield than the released GMS hybrid of central zone. However the seed cotton yield of one experimental hybrid TGMS 9-1 X PA 255 (1789 kg/ha) was higher compared to the yields of CISA-2 (1647 kg/ha), the popular *desi* hybrid released for north zone and the seed cotton

yields of popular varieties of central zone viz. PA-402 (1597 kg/ha), PA-255 (1434 kg/ha) and AKA8401 (1472 kg/ha)



Pollen sterility of TGMS lines  
(b) ascertained with acetocarmine staining

#### EGMS System

Out of the eight EGMS lines evaluated for stability and seed cotton yield, EGMS-35 recorded the highest seed cotton yield of 2474 kg/ha followed by EGMS 08093-10R (1558 kg/ha) and EGMS 18 (1477 kg/ha). Three EGMS lines namely EGMS 18, EGMS 35 and EGMS 36 were found stable showing sterility in the month of May, 2010 when the temperature was above 40 °C. Out of twenty experimental hybrids evaluated in replicated trial at Agricultural Research Station, Mudhol five hybrids were found promising for seed cotton yield.

#### Apomixis

Boll setting was observed in four lines namely 1060(B), AP1-4, AP 4-15 and AP 5-10 following methods of EMS and RSS. However, the percentage of boll setting was very low ranging from 1.30 % (AP 5-10) to 4.35% (1060 B). Cytological studies of these apomictic lines (IS 244-4-1, IS 244-4-2, IS 181-7-1) revealed the presence of aneuploidy. Cytologically pollen mother cell of these apomictic lines showed abnormalities in pollen development. The triad formation was observed instead of normal tetrad at the end of meiosis. Apomictic lines, when crossed with the dominant marker Bikaneri Narma (Red), their F<sub>1</sub>s showed both normal green and pigmented plants indicating the presence of low percentage of facultative apomixis.

#### Coimbatore

##### Interspecific (*G. hirsutum* x *G. barbadense*) hybrids

In confirmatory trial, yield evaluation was done with forty-nine interspecific hybrids with the best check DCH-32. Hybrids CCHB-110 (2423 kg/ha), CCHB-215 (2404 kg/ha), CCHB-260 (2400 kg/ha) and CCHB-123 (2391 kg/ha) performed well continuously during last three years over the check DCH-32 (1997 kg/ha). The advanced hybrid CCH-110 is having better fibre properties than the other hybrids and DCH-32 (Table 4).

Pooled yield data over past three years revealed that hybrid CCHB-51 with mean yield of 2521 kg/ha was better than the check DCH-32 (1905 kg/ha) with better fibre properties. The hybrid CCHB-51 has been entered in the National trial through AICCIP.

#### Sirsa

##### Diploid Cotton

##### Maintenance and heterosis breeding

Eleven *G. arboreum* GMS lines were maintained through

Table 7: Performance of *intra-hirsutum* hybrid CSHH 3008

Sr. No.	Name of the hybrid	Seed cotton yield (Kg/ha)	Lint yield (kg/ha)	Boll weight (g)	GOT (%)	2.5 % span length (mm)	Tenacity (g/tex)	Mic. value
1.	CSHH 3008	1994 (5)	663	4.0	33.3	27.9	21.8	4.7
2.	Local Checks	1856 (11)	640	3.9	34.7	27.7	23.9	4.7
3.	CSHH 198 (ZC)	1688 (19)	574	4.0	33.8	28.0	24.3	4.6
	CD	317.3	-	-	-	-	-	-
	CV(%)	11.5	-	-	-	-	-	-

sib mating.

Table 4. Performance of identified interspecific hybrids

Hybrids	Seed cotton yield (kg/ha)	Ginning (%)	2.5% SI (mm)	Micro-naire	Strength (g/tex)
CCHB-110	2423	33	37.1	28.5	3.5
CCHB-215	2404	30	36.7	27.4	3.7
CCHB-260	2400	32	37.0	29.0	3.5
CCHB-123	2391	29	37.6	28.6	3.6
DCH-32	1997	30	36.0	29.1	4.3
CD@5%	149	-	-	-	-
CV%	11.9	-	-	-	-

##### Performance of *G. arboreum* hybrid CISAA 14

The GMS based hybrid CISAA 14 recorded seed cotton yield of 2773 kg/ha against local check 2617 kg/ha, ranked 4<sup>th</sup> and was retained in North Zone trial. The hybrid was having 38.0% GOT, 2.5% span length 22.9 mm and bundle strength of 17.7 g/tex.

##### Performance of *G. arboreum* hybrid CISAA 15 and CISAA 16

The GMS based hybrids CISAA 15 and CISAA 16 gave higher seed cotton of 1595 kg/ha and 1373 kg/ha than the local check (1116 kg/ha) (Table 5). In respect of Ginning percent the hybrids were at par with the zonal and local checks. The hybrid CISAA 16 has been promoted to south zone trial for large scale testing.

Table 5: Mean Performance of *G. arboreum* hybrid CISAA 15 & 16 (GMS based)

Entry/Character	Seed cotton yield (kg/ha)	Rank	Ginning (%)
CISAA 15	1595	3	32.3
CISAA 16	1373	6	32.6
LC	1116	14	32.7

##### Tetraploid Cotton

##### Maintenance of CMS lines

Eleven CMS lines were maintained through sib mating. Twenty two cotton restorer lines were maintained through selfing.

##### Performance of GMS based hybrids CSHG 1862

In the AICCIP North Zone trials, based on mean performance of last three years GMS based hybrid CSHG 1862 recorded 13 % increased seed cotton yield and 18 % for lint yield over the conventional check hybrid CSH H 198.

##### Performance of *intra-hirsutum* hybrids CSHH 3008

In the Br 05 (a) CHT AICCIP trial, *intra-hirsutum* hybrid CSHH 3008 recorded mean seed cotton yield of 1994 kg/ha with 33.3 percent ginning outturn and ranked at 5<sup>th</sup> position as compared to 1688 kg/ha of zonal check hybrid CSHH 198. The hybrid also recorded a higher 2.5 % span length of 27.9 mm, and bundle strength of 21.8 g/tex (Table 7).

### 4.3: Genetic Improvement

#### Nagpur

##### *A.G.arboreum* (diploid cotton)

In the Institute trial, CNA 1009 recorded the highest yield of 2128 kg/ha and was marginally superior to the check variety AKA

8401 (Table 7).

In the coordinated (AICCIP) trials, Culture CNA 1003 recorded the highest mean seed cotton yield of 1255 kg/ha and stood first in the South Zone trials (Table 8). Similarly, Culture CNA 1007 recorded the the second highest yield in the south zone trials (Table 9).

Table 7: Institute trial of *G.arboreum*

Sl. No.	Code	Seed cotton yield(kg/ha)	Lint yield (kg/ha)	2.5% span length (mm)	Strength (g/tex)	Micronaire
1	CNA-1008	2065	637	25.7	19.4	5.2
2	CNA-1009	2128	702	26.9	21.3	5.5
3	CNA-1010	2033	668	27.1	19.3	4.5
4	CISA-6-123	1657	543	-	-	-
5	CISA-105	1534	564	25.4	16.9	4.8
Check	AKA 8401	1937	608	25.2	19.3	4.2

Table 8: Performance of culture CNA 1003

Genotype	Dharwad	Nandyal	Mudhol	Kovilpatti	Mean (SZ)	Rank
CNA 1003	1247	2040	1069	666	1255	1
DLSa-17 (SZ)	854	1515	787	672	957	8
CD at 5%	500	134	86	226		
CV	13	23	7	20		

Table 9: Performance of culture CNA 1007

Genotype	Dharwad	Nandyal	Mudhol	Kovilpatti	Mean (SZ)	Rank
CNA 1007	967	2371	1627	617	1395	2
DLSa-17 (SZ)	843	2712	1109	765	1357	3
CD at 5%	206	517	178	280		
CV	12	15	15	13		

In *G. arboreum* station trial, among 10 entries tested, entry CNA 1009 recorded the highest seed cotton yield of 2128 kg/ha followed by CNA 1008 (2065 kg/ha) and CNA 1010 (2033 kg/ha). None of the test entry recorded significantly higher yield than the check variety AKA8401 (1937 kg/ha).

#### Random mating population through conventional crossing:

Gain in seed cotton yield was to the extent of 61.93% after the fifth cycle of random mating as compared to base population.

#### GMS based random mating population

The out-crossed bolls obtained from the second cycle of GMS-RM were bulk harvested, and this composite population was grown. At flowering, the individual plants in the population was checked for sterility / fertility at anthesis at an interval of a week and all sterile plants were tagged. Open pollination was allowed in the population. The out crossed bolls from all the sterile plants were bulk harvested. A fourth cycle of GMS based random mating has been completed.

#### Sirsa

##### Release and Notification of CISA- 310

*Gossypium arboreum* variety CISA 310 was released for commercial cultivation in the North Zone states. The new variety recorded a mean seed cotton yield of 21.7 q/ha as against 19.7 q/ha of RG 8 (Zonal Check) in the various AICCIP trials conducted during 2000-2004. The variety CISA 310

recorded a mean ginning outturn of 36.5 per cent which was higher than that of zonal check varieties. Variety CISA 310 has been notified vide Gazette of India NO.171 dated January, 2010.



*Gossypium arboreum* variety CISA 310

##### Notification of Variety CISA 614

*Gossypium arboreum* variety CISA 614 has recorded an overall mean seed cotton yield of 22.04 q/ha as against 18.34 q/ha of HD 123 (zonal check) and 19.90 q/ha of local checks in the

various AICCIP trials conducted during 2004-2007. The increase in seed cotton yield of the new variety CISA 614 over the common (Zonal check) check was of the order 20.17 per cent. It was identified by Variety Identification Committee Meeting (AICCIP) held at ANGRAU, Hyderabad 6-8 April, 2009 and notified vide Gazette of India NO.608 dated April 1, 2010.



*Gossypium arboreum* variety CISA 614

#### Evaluation of promising varieties

In the station trial CISA 6 (1677 kg/ha) was superior to the common check PA 255 (1235 kg/ha). The genotype CISA 6 has a 2.5% span length 25.1 mm, micronaire of 5.5 and strength of 18.6g/tex.

#### Tetraploid Cotton Improvement

##### Nagpur

#### Drought tolerance

Using Drought Tolerant Efficiency (DTE) based on the performance under rainfed and irrigated condition, the hybrid combinations were evaluated. Pusa 56-4 x 30 I recorded highest DTE of 76.08 per cent., 301 x Pusa 56-4 recorded 67.07 % and Pusa 56-4 x 29 I 66.81 %. Hence prediction based on high DTE will indicate a good measure of tolerance for drought and there is a likelihood of arriving at good drought tolerant genotype. Evaluation of advance generation of sixty nine SPS grown in two separate trials under rainfed condition revealed significant differences between the genotypes for seed cotton yield which ranged from 505.32 to 1534.31 kg/ha as inferred from statistical analysis. DTS 43-09 was the best selection recording 1534.31 kg/ha SCY followed by DTS 83-09, DTS 90-09, DTS 79-09 and DTS 86-09. DTS 83-09 and DTS 69-09 which were among the top ten performers for two years. DTS 76-09 and DTS 77-09 possessed good seed cotton yield, fibre strength and strength to length ratio above 0.80. In another trial, 17 SPS were tested and DTS 31 (32) 13 was identified as the best followed by DTS 31 (32) 07, DTS 1 (12) 11 and DTS 40 (38) 05.

Sixty three breeding lines (SPS) were tested for drought tolerance based on positive chlorophyll value, negative membrane stability value, range of reducing sugar 50-120 mg/g of FW, amino acid content 50-90 mg/g of FW and less of phenols (5.1 to 5.4 mg/g of FW). Twenty nine lines were found to have better adoption to stress in respect to yield compensation during stress. But when compared with check variety LRA5166 only six lines were superior. When the holistic approach viz.,

physiological, biochemical and yield per se was analysed four lines DTS 155-09, DTS 108-09, DTS 100-09 and DTS 104-09 were found to be tolerant and suitable for high yield.

#### Jassid tolerance

Out of the 172 single plant selections made in both  $F_3$  intercross and intra-cross population, based on earliness, tolerance to jassids and yield potential, 45 single plants were identified for further studies. Nine inter-specific derivatives (rai derivatives) were crossed with six cultivated genotypes of *G. hirsutum* resulting in 54  $F_3$ s. 25  $F_3$ s were selected based on earliness and tolerance to jassids and yield potential. Crosses NISC 261 x AKH 081, NUSC 289 x EC 277959, NISC 306 x PKV Rajat and NISC 291 x H 1252 were found promising based on seed cotton yield. The crosses PKV Rajat x MDR 8, AK 32 x FQ 9, DHY 286 x CPT 426, JK 04 x MDR 8 and FQ 9 x MDR 8 were observed tolerant to jassids.

#### Oil Improvement

Fourteen advanced cultures were evaluated for seed cotton yield and oil content. The culture CNHO 21 recorded the highest seed oil content (20.25 %) followed by culture CNHO 675 (19.95 %) and CNHO 5 (19.41 %). 80 single plant selections were made in  $F_3$  progenies based on earliness, yield potential and fibre properties.

*Gossypium hirsutum* variety, CNHO 12 has been identified for release in the central zone under irrigated conditions. The variety is characterized by its dwarf stature, early maturity (160-165 days), medium to high seed oil content of 21.8% with synchronous boll bursting, attributes suitable for central zone. The variety recorded higher strength/length ratio of 0.85 in comparison to zonal check LRK 5166 (0.80).



*Gossypium hirsutum* variety, CNHO 12

#### Genetic Enhancement

In advanced  $F_1$  generation a row bulk populations with a pedigree Reba pvt 91yy x MCU 5 (1958 kg/ha) gave the highest yield as compared to check LRK 516 (720 kg/ha). In advanced BC3F4 of Rajat x (Rajat x Rex) there was an increase of GOT % upto 40%. CIHS 18 has been entered in AICCIP trial (Br 02(b)) trial for 20 10-11.

Twenty nine *G. hirsutum* entries were tested in the institute trial. Entry CISH 18 recorded the highest seed cotton yield of 1954 kg/ha followed by C 1068 (1953 kg/ha) and CNH 1106 (1812 kg/ha). The seed cotton yield of the best check variety LRK 516 was 644 kg/ha.

Random mating population through conventional crossing Gain in seed cotton yield was to the extent of 55.3% after the fifth cycle of random mating when compared to the base population.

#### GMS based random mating population

In the previous year, out-crossed bolls obtained from tagged sterile plants were bulk harvested and a composite population and planted. At flowering, the individual plant in the population was monitored for sterility / fertility at anthesis repeatedly at an interval of a week and tagged all sterile plants. All the out-crossed bolls from the sterile plants in the population were bulk harvested and ginned to constitute the next cycle of GMS based random mating population. A third cycle of GMS based random mating has been completed.

#### Coimbatore

In the station trial of the eleven elite bulks evaluated, the highest seed cotton yield of 1393 kg/ha was recorded in MM 02-11-7 Bk, which was significantly higher than the best check variety Sumangala (1013 kg/ha). Among the eleven stable long staple

cultures were evaluated, the highest seed cotton yield of 1243 kg/ha was recorded in the culture MM 03-27-5-1 as against 817 kg/ha recorded in Surabhi. Among the 18 stable introgression lines evaluated, the highest seed cotton yield was recorded in MM-04-29-515 with 2086 kg/ha as against 1300 kg/ha yield recorded in Sumangala, the best check variety.

Thirteen medium staple cultures were evaluated in a replicated trial with two check varieties for two years. A perusal of two years data indicated that CCH 815 and CCH 816 were superior to the check variety Suraj by 25 to 28 per cent.

Medium Staple culture CCH 2623 was tested in the Preliminary Varietal Trial in both South and Central Zones. As in the previous year, CCH 2623, during the current year also, recorded the second highest yield of 1834 kg/ha in South Zone. By virtue of its higher ginning out turn of 38.1 per cent, it occupied the first rank in lint yield. In the Central Zone, culture CCH 2623 recorded the highest yield for the second year in succession. It recorded a mean seed cotton yield of 1932 kg/ha. A perusal of two years AICCIP data indicated that the culture CCH 2623 was superior to the respective zonal checks in both the zones by 31 to 52 per cent and was also superior to the local checks (Table 10).

Table 10: Combined analysis of culture CCH 2623 in AICCIP trials for seed cotton yield (kg/ha) and fiber quality

Culture	Central Zone			South Zone		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean
CCH 2623	1995 (1)	1932 (1)	1964 (+52%)	1911 (2)	1834 (2)	1873 (+31%)
Zonal Check	1226 (17)	1360 (8)	1293	1537(31)	1333 (8)	1435
Local Check	1610 (16)	1745(6)	1678	1758 (10)	1289 (10)	1524

Culture	Central Zone			South Zone		
	2.5 % SL (mm)	Micronaire	Strength (g/tex)	2.5 % SL (mm)	Strength (g/tex)	Micronaire
CCH 2623	28.0	4.4	23.2	25.6	21.3	4.8
Zonal Check	32.7	4.5	23.9	32.0	24.5	4.3
Local Check	27.4	5.2	21.4	27.9	21.7	4.5

#### Development of early duration, compact genotype

Twelve compact genotypes were evaluated for the third year in succession. Culture HCT 8 recorded the highest yield of 3664 kg/ha followed by HCT 12 with 3355 kg/ha. HCT 7 recorded the

highest ginning out turn of 39.7 per cent. The best check Anjali recorded a mean seed cotton yield of 2692 kg/ha. A perusal of three years data also indicated the superiority of HCT 8 and HCT 12 by over 20 per cent as compared to the best check variety Anjali (Table 11).

Table 11: Combined analysis of promising compact genotypes

Sl.No	Entry	Seed cotton yield (kg/ha)			Mean Seed cotton yield(kg/ha)	% inc. over Anjali
		2007-08	2008-09	2009-10		
1	HCT-8	3751	2292	3664	3236	23
2	HCT-12	-	2066	3355	2711	21
3	HCT-6	4324	1852	2675	2950	12
4	HCT-9	3555	2027	3227	2936	12
5	Anjali©	3392	1788	2692	2624	0
6	MCU7©	3349	1524	2683	2519	-4
	CD@5%		414	570		

#### Development of long and extra long staple *G.hirsutum* cotton

Thirteen long and extra long staple cultures were evaluated in a

replicated trial with Surabhi as check for two years. Culture CCH 818 with a mean seed cotton yield of 1957 kg/ha was superior to Surabhi by 30 percent, followed by CCH 820 with 1935 kg/ha (Table 12).

**Table 12: Performance of promising long staple cultures in Station Trial**

Culture	2008-09	2009-10	Mean seed cotton yield (kg/ha)	% inc. over Surabhi	2.5% SL (mm)	Micronaire	Strength (g/tex)
CCH 818	2329	1586	1957	30	30.2	4.0	25.6
CCH 820	1908	1962	1935	29	31.8	3.8	23.0
CCH 819	2008	1635	1822	21	30.5	3.9	21.7
CCH 822	1870	1699	1784	19	32.2	3.6	25.2
SURABHI©	1540	1460	1500	0	31.6	3.5	22.0
CD@5%	360	280					

**Sirsa**

*G. hirsutum* culture CSH-3158 and CSH 10 were superior to the check varieties in the Initial Evaluation Trials. (Table 13).

**Table 13: Performance of *G. hirsutum* culture CSH 10 in Sr 02(a) PHT Trial**

Sr. No.	Name of the hybrid	Seed cotton yield (kg/ha)	Lint yield (kg/ha)	GOT (%)	2.5 % span length (mm)	Mic. Value	Tenacity (g/tex)
1.	CSH-3158	2616 (6)	893	34.1	27.6	4.7	21.6
2.	CSH10	2585(8)	936	36.1	27.7	4.0	20.9
3.	Local Check	2432 (10)	869	35.0	25.3	4.2	20.0
4.	RS 2013 (ZC)	2307 (12)	767	33.5	27.4	4.0	20.4
	CD at 0.05	292.7	-	-	-	-	-
	CV(%)	10.4	-	-	-	-	-

Similarly, CSH-3129 ranked second(2572 kg/ha) against zonal check(2338 kg/ha) in the North Zone Preliminary varietal Trial (Table 14).

**Table 14: Mean performance of CSH-3129**

Sr. No.	Name of the hybrid	Seed cotton yield (kg/ha)	Lint yield (kg/ha)	GOT (%)	2.5 % span length (mm)	Mic. value	Tenacity (g/tex)
1.	CSH-3129	2572 (2)	914	35.6	30.4	4.5	22.6
2.	Local Checks	2437 (7)	881	36.1	26.4	5.2	19.9
3.	Zonal check	2338 (9)	808	34.93	25.4	4.5	20.6
	RS 2013						
	CD at 0.05	392.1	-	-	-	-	-
	CV(%)	11.3	-	-	-	-	-

**Evaluation of CLCuV resistant cultures**

Forty five CLCuV resistant cultures were evaluated for yield and other parameters. CSH 2838 (2745 kg/ha) and CSH 2827 (2429 kg/ha) as against the check variety RS 2013 (2070 kg/ha) in the first trial and CSH 2912 (2353 kg/ha) and CSH 2907 (1993 kg/ha) as against the conventional check variety RS 2013 (1765 kg/ha) in the second trial were found to be superior in yield.

**4.4: Genetic Diversity through Introgression****Nagpur**

Utilization of wild species, synthetic polyploid.

Established 126 F<sub>2</sub> four BC<sub>1</sub> plants and phenotyping was done for identification of genetic markers and characterization of fibre strength and drought tolerance traits in interspecific cross between *G. herbaceum* and *G. anomalum*. Using cultivated diploid species as female successful crosses were made with *G. anomalum* and *G. davidsonii* species for diversification of male sterility.

**Coimbatore**

Crosses were made between cultivated and wild species (*G. hirsutum* x *G. aridum* and *G. hirsutum* x *G. armourianum*). The seeds of resultant F<sub>1</sub> hybrids were treated with 1% colchicine for 24 hours. In seed treatment, 3 out of 7 seedlings showed successful polyploidisation.

**4.5: State Multi Varietal Trial (SMVT)**

A State Multilocation Varietal Trial (SMVT) consisting of 21 genotypes of *G. arboreum* and 12 of *G. hirsutum* was conducted at CICR, Nagpur. The promising *G. arboreum* genotypes were JLA 705, JLA 794 and CAN 1008 and the promising *G. hirsutum* varieties were AKH 9916 and NH 634.

**4.6: Molecular Breeding****Nagpur**

Diploid Cotton

For developing a framework linkage map in diploid cotton, interspecific F<sub>2</sub> mapping population involving *G. arboreum* (A2) Cv. KWAN-3 and *G. herbaceum* (A 1) Cv. Jaydhar is being used.

Phenotyping of  $F_2$  mapping population and  $F_2$  derived  $F_3$  plant progenies for quality traits have been completed. The data on fibre quality traits and ginning outturn for  $F_2$  population and  $F_2$  derived  $F_3$  progenies showed significant variation for important fibre quality traits. The frequency distribution for ginning outturn, fibre length, maturity ratio and fibre fineness was normal, indicating the traits under consideration are polygenic controlled by QTLs. Extraction of genomic DNA of parental genotypes and individual  $F_2$  plants in the population was done using standard CTAB method.

Polymorphism survey using 408 SSR, 238 pair combinations of SRAP, 283 combinations of TRAP markers was carried out during 2009-10 and identified 53 SSR, 9 SRAP and 40 TRAP

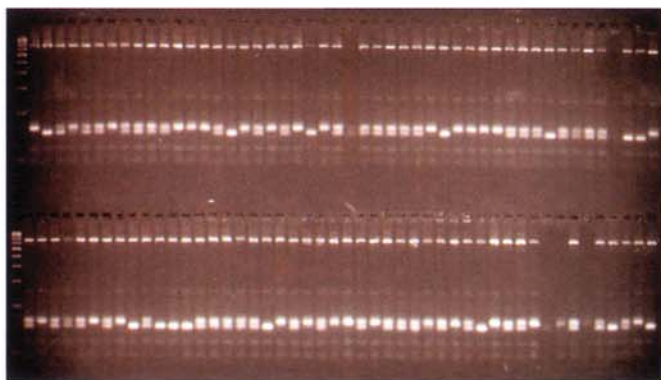


Fig. 8: Genotyping of  $F_2$  (*G. arboreum* x *G. herbaceum*) mapping population using NAU 758 SSR marker

Transgressive segregants with combination of quality characters have been identified in  $F_2$  and  $F_3$  population. Efforts will be made to stabilize the progenies in advanced generation.

#### Upland Cotton (*Gossypium hirsutum* L.)

Development of framework linkage map in tetraploid cotton was carried out under the FAST TRACK Scheme of DST. An intraspecific  $F_2$  mapping population developed involving *G. hirsutum* (AD1) cv. EL 958 and UPA 57-17 was used. Genomic DNA extraction from parental genotypes and individual  $F_2$  plants extracted using CTAB method. Survey for the informative markers has been carried out using 408 SSR, 238 pair combinations of SRAP and 283 pair combinations of TRAP markers. From the total of 921 markers surveyed for parental polymorphism 94 (10.21 %), i.e. 50 SSR, 20 SRAP and 24 TRAP markers, were found to be polymorphic. Survey/ screening for more informative markers is in progress. Genotyping of  $F_2$  mapping population (190 plants) are being used for extensive genotyping. So far we have employed about 50 polymorphic markers to the mapping population. Genotyping with more informative markers is in progress.

#### Development of permanent mapping populations (RILs) for fibre quality traits in diploid and upland cotton

Recombinant inbred lines (RILs), permanent mapping populations for fibre quality are being developed using the  $F_2$  mapping populations developed for construction of a linkage map for diploids and tetraploids cotton. In diploids, 193  $F_3$  plant progenies were raised. One random plant in each progeny was selfed which shall be carried forward to  $F_6$  as boll to row progenies in 2010-11. In *G. hirsutum* a set of 273 progenies were grown in boll to row fashion, single random plants from each progeny was selfed and further those shall be carried forward to  $F_6$  generation in 2010-11.

polymorphic markers. So far, we have identified 101 SSR, 9 SRAP and 40 TRAP and 20 RAPD markers, a total of 170 (12.89%) markers (from a total of 1319 markers screened) were polymorphic. Survey for additional polymorphic markers is in progress. For genotyping, we are using 190  $F_2$  plants and genotyping with 60 informative SSR, 9 SRAP and 1 RAPD (a total of 70 markers) has been completed. Genotyping of  $F_2$  mapping population with identified informative markers is in progress.

Transgressive segregants with combination of quality characters have been identified in  $F_2$  and  $F_3$  population. Efforts will be made to stabilize the progenies in advanced generation.

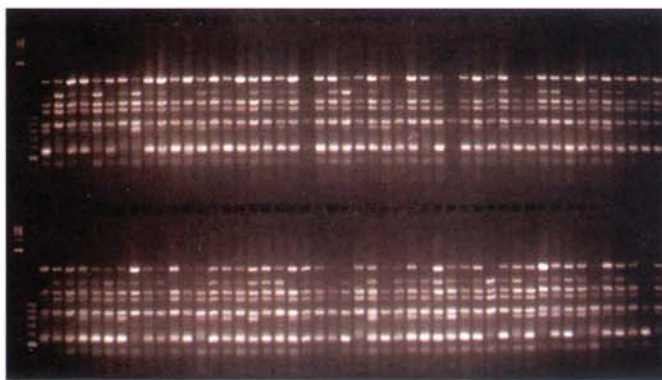


Fig. 9: Genotyping of  $F_2$  (*G. arboreum* x *G. herbaceum*) mapping population using OPE 12 RAPD marker

## 4.7: Development of Trans genes

### Nagpur

#### Targeted Gene integration- Transgenic cotton

#### Bollworm resistant transgenic cotton in tetraploid and diploid cotton

The advanced  $T_4$  generation single event *G. hirsutum* cultivar Anjali (LRK-516) carrying *cry1Ac* was raised under contained condition. Plants showing uniformly high concentrations of Cry protein expression were selfed, rouging out the segregating non-Bt plants. CRY protein expression to the extent of 2.70 ppm was recorded. In case of diploid cotton, 848 plants of *Gossypium arboreum* cv. RG 8 ( $T_6$ ), PA 255 ( $T_4$ ) and PA 402 ( $T_3$ ) containing *cry1Ac* (Fig. 9) and *cry1Aa3* genes, expression of CRY proteins was determined by ELISA. Bt protein in boll to row progeny of 253 plants of RG 8 ranged from 2.54 to 4.6 ppm. Boll to row progeny of PA 255 culture 366 showed protein up to 3 ppm. In other promising cultures viz., 355, 358 and 365, the protein concentration ranged from 2-3 ppm.



*G. hirsutum* cv. Anjali Bt (ILK Bt- 77) carrying Bt *cry1Ac* gene under green house

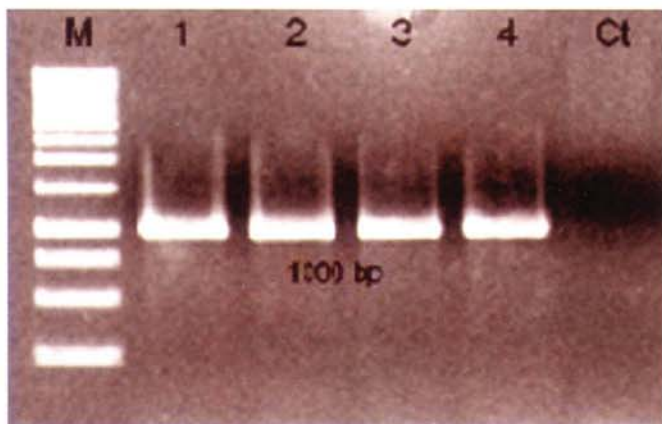


Fig.10: PCR detection of *cry1Ac* in diploid cotton. Lane 1- *cry1Ac* (PA 255, plant no. 43); 2- *cry1Ac* (RG 8 plant no, 306; 3- Bunny Bt, 4- positive control (Agrobacterium containing *cry1Ac* gene); Ct- negative control; M- 1kb ladder

The new transformation events generated during the previous year were characterized. Among 18 putative transformants, one plant (LRK-516) showed single copy gene (*cry1Ac*) integration. Embryonic explants of elite *Gossypium hirsutum* cultivars Anjali and LRA-5166 were also subjected to transformation with *cry1F*. Southern hybridization of 7 transformants (4 Anjali and 3 LRA5166 plants) showed single copy integration of *cry1F* gene in only one Anjali cotton (Fig. 11).

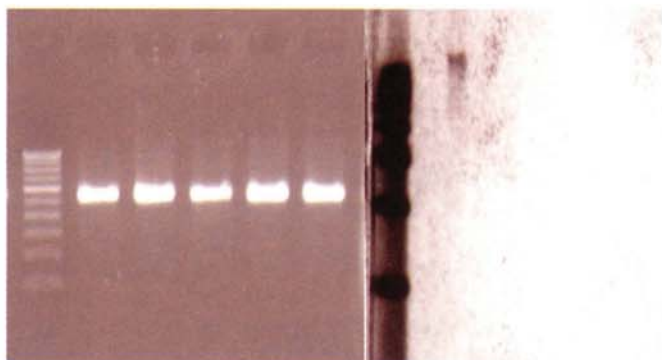


Fig. 11: a. PCR.; *G. hirsutum* cv. LRK-516 carrying Bt *cry1F* ; b. Southern Blot; *G. hirsutum* cv. LRK-516 carrying single copy of *cry1F* gene

*G. hirsutum* variety viz. LRA 5166 were taken for Co-cultivation with indigenously synthesized gene *cry1Aa3*, *cry1Ia5* and *cry1F*. Total 600 explants with gene *cry1Aa3*, 360 explants with *cry1Ia5* and 450 explants with *cry1F* were used for transformation. With *cry1F* construct, 50 putative transformants, in *cry1Ia5*, 25 putative transformants and in *cry1Aa3*, 20 putative transformants were obtained.

#### Characterization of new transformed events

New transformation events were generated with *G. hirsutum* cultivars viz., Anjali and LRA 5166 with *cry1Ac* gene. Total 2076 embryonic explants were subjected to Agrobacterium mediated transformation and 11 primary putative transformants were selected in the kanamycin medium. Five *cry1Ac* transformed plants (3-Anjali and 2 LRA) showed integration of gene when checked by PCR. Southern hybridization of 5 plants showed single copy gene integration in two plants. Southern positive plants were hardened and established in the soilrite. In case of diploid *G. arboreum*, 26 new events (To) containing *cry1Aa3* and *cry1Ac* gene were established in cultivars PA 255

and PA402.

#### Pollen tube pathway transformation

A new method of gene transfer was standardized to overcome limitations associated with recalcitrant, genotype dependent somatic embryogenesis and tissue culture protocols. A number of parameters were standardized. The characteristics of the *cry1F* transformants developed through this novel approach, including transformation frequency, transgene expression, copy number integration, stability of gene integration, etc. were studied. The superiority of the new method will be re-established before filing a patent on the protocol.

#### Genetic Engineering for Abiotic Stress Tolerance in crops and identification of new genes for high water use efficiency

Elite cultivars viz., LRA 5166 and LRK-516 were subjected to genetic transformation with PATRD 29A::AtCBF31 DREB1A+P<sub>o</sub>SMYB02::AtAVP gene construct by *Agrobacterium* mediated transformation. Putative transformants selected in the antibiotic medium were tested for the presence of transgene by PCR confirmation. The transformation frequency of 0.88% in LRA5166 and 0.73 % in LRK 516 was recorded.

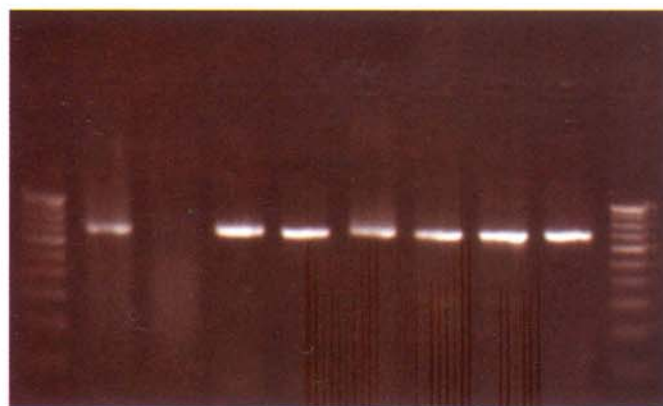


Figure 12: PCR detection of DREB1a positive plants

#### Development of disease resistant transgenic cotton

##### Cloning of Chitinase genes for fungal resistance

Chitinases are known to hydrolyse chitin polymers and are effective against fungi having chitin content in their cell walls. Chitinases belong to group of PR proteins that constitute the second line of plant defense. Using conserved and degenerate primers, a 1.3 kb full length novel class I chitinase gene was amplified and cloned from *Gossypium hirsutum* variety LRA5166. Analysis of sequence revealed the gene to be unique to upland cotton (GenBank # HM 125506). The gene-specific primers failed to amplify the sequence from *G. arboreum* lines including cultivar PA255, PA402 and RG-8 (Fig. 13).

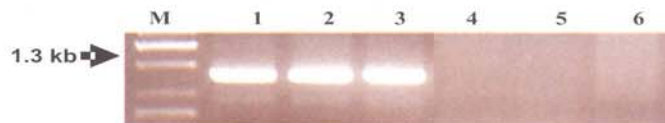


Fig. 13: Amplification of a unique class I chitinase gene from *G. hirsutum* (lanes 1-3) and absent in *G. arboreum* (lanes 4-6)

Diploid cottons *G. arboreum* (4-6) did not possess the same. The forward and reverse primers were engineered with EcoRI sites flanking the initiation and termination codon respectively. Using them the 1.3 kb chitinase gene flanked with EcoRI sites were amplified and cloned in plasmid pGemT (3.0 kb). The

recombinant plasmid was subcloned in the binary vector pBinAR (Fig.14 a&b) and transformed in *Agrobacterium tumefaciens* strain EHA 105, by triparental mating.

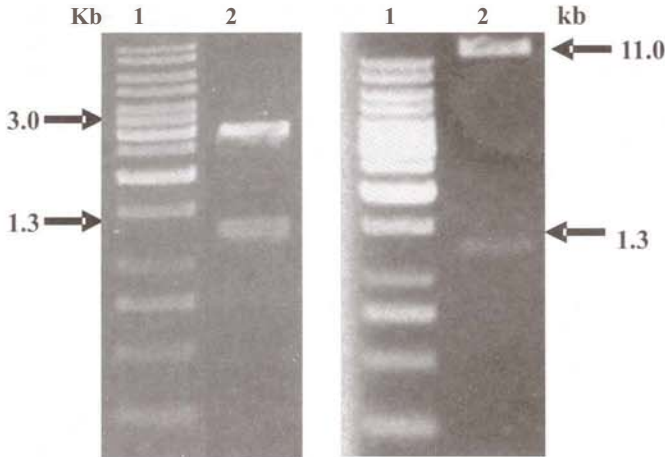


Fig.14: Chitinase gene cloned in pGEM-T (a) and sub cloned in pBinAR19 (b). The resultant plasmids were checked by digestion with AatII and PstI in the former and EcoRI in the latter

### Transformation and characterization of putative transformants

The grey mildew susceptible *G. arboreum* cv. PA255 was transformed with chitinase gene by direct shoot organogenesis. Putative transformants were selected on MS supplemented with 50 µg/ml Kanamycin. Integration of transgene was confirmed by PCR amplification using gene-specific primers (Fig 15). The genomic DNA isolated from the putative transformants (To) showed presence of 1.3 kb gene which was not present in the wild type PA255.

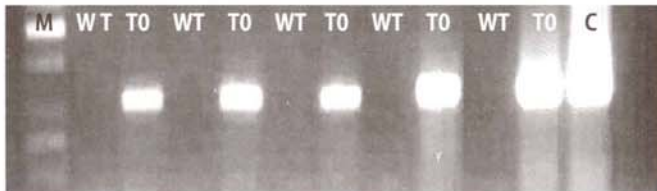


Fig.15: Putative chitinase transformants of *G. arboreum* cv. PA255 were tested for the presence of transgene by PCR. WT, wild type cotton; C, positive control

Southern hybridization of genomic DNA extracted from two putative transformants, with DIG labeled chitinase gene as DNA probe showed insertion of the transgene in both of them (Fig. 16). The transgenic plants are being characterized for the novel gene product.

### Development of transgenic cotton for Cotton Leaf Curl Virus resistance

#### Antisense approach

Southern hybridisation of CLCuV transgenic *G. hirsutum* HS6 (T<sub>1</sub>) plants showed integration of the Sense coat protein, antisense coat protein and antisense Rep gene. Three transgenic events one each involving ACP and ARep in HS6 and SCP in H777 proved tolerant against CLCuV when tested in CICR Regional Station at Sirsa with viruliferous whitefly. Fresh transformation events were generated with each of the three gene constructs. The putative transformants were characterized for the presence of genes using gene specific primers. Further characterization of the T<sub>1</sub> and T<sub>0</sub> plants is in progress.

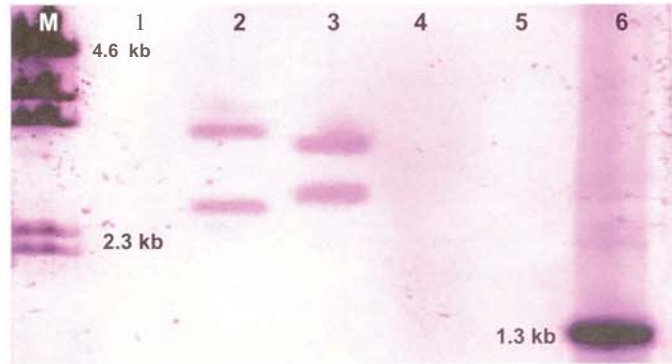


Fig. 16: Southern hybridization of two putative transformants of *G. arboreum* cv PA255 using chitinase gene as DNA probe. Lanes: 2-3, Transformants 1 and 2; lane 6, chitinase gene (positive control); M, Al HindIII



Two (HS 6 ACP and H 777 - SCP) of the three events (T<sub>1</sub>) showing resistance against CLCuVs

#### RNA interference Approach

Based upon the conserved sequences, five sets of primers specific to five different target regions of DNA A and ~DNA components of CLCuV genes were designed. The restriction sites were so designed that each amplified sequence can be cloned in two orientations, on either side of a stuffer fragment in the inverted repeat generating plasmids, pBSK-int (3.1 kb).

#### Construction of inverted repeat constructs of CLCuV target sequences

The sense and antisense strands of DNA-A viz. AC2 (150 bp), CP (185 bp), MP (109 bp) and ~DNA viz., ~C1 (212 bp) and ~V4 (177 bp) were cloned individually on either sides of the intron sequence in plasmid pBSK-int creating inverted repeat constructs pBSK-int-AC2-SA (3.3 kb), pBSK-int-CP-SA (3.4 kb), pBSK-int-MP-SA (3.2 kb), pBSK-int~C1-SA (3.4 kb) and pBSK-int~V4-SA of 3.4 kb (Fig.17 and 18 a-e).

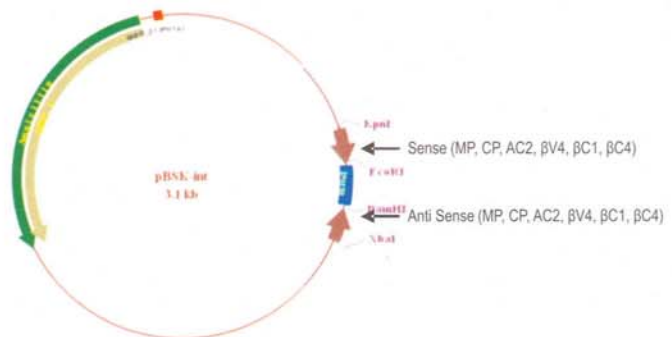


Fig.17: Inverted repeat plasmid pBSK-int (3.1 kb) with sense and antisense strands of 6 viral target sequences

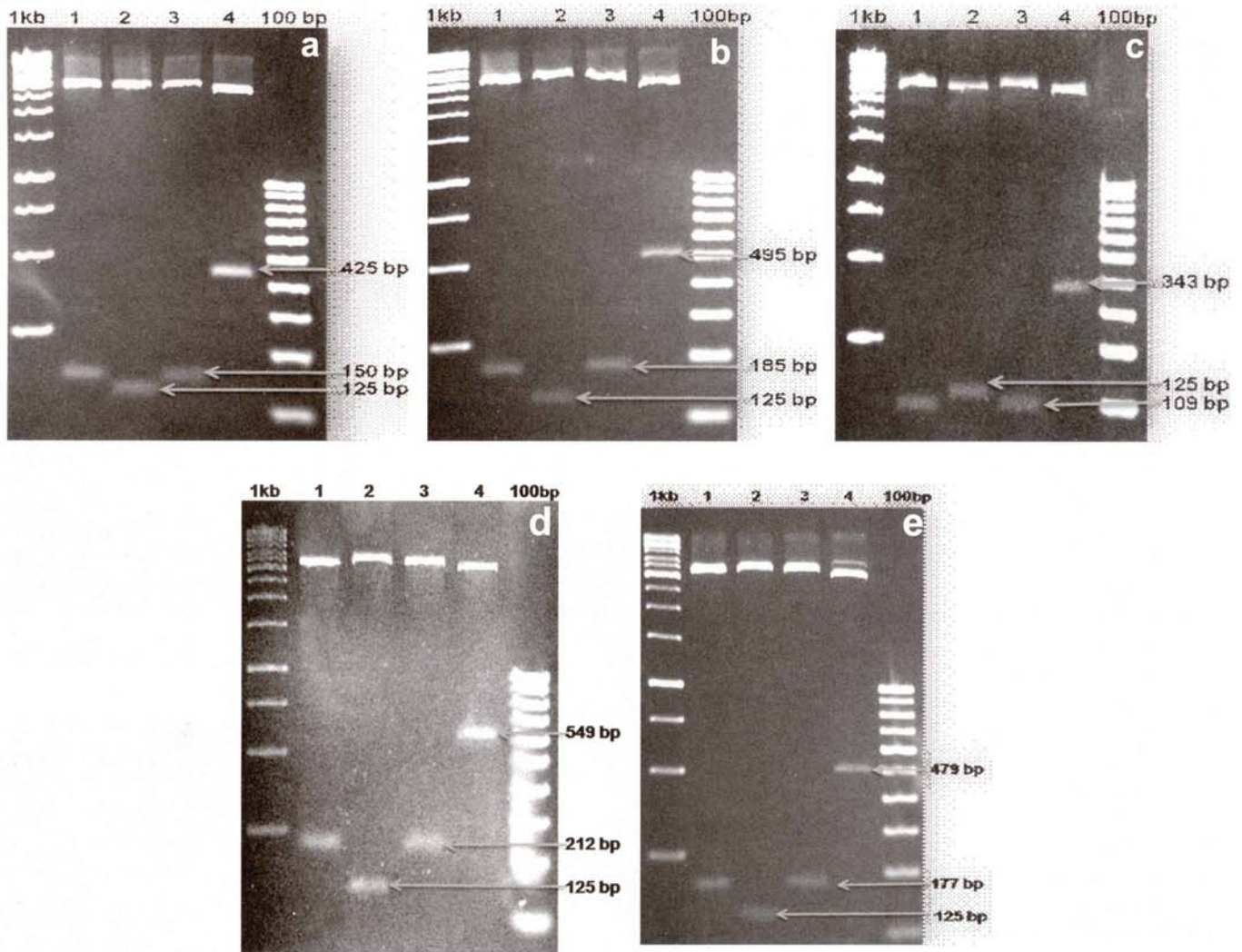


Fig.18 a-e: Inverted repeat construct of a. AC2 gene, b. CP gene, c. MP gene, d. ~C1 gene e. ~V4 gene in pBSK-int (3.1 kb), Lane 1, *KpnI* + *EaeRI* = Sensestrand; 2. *EaeRI* + *BamBI* = Intron sequence; 3. *BamBI* + *XbaI* = Antisense strand; 4. *KpnI* + *XbaI* = Sense+ Int + Antisense fragment

The inverted repeat constructs of target viral sequences in pBSK-Int was sub-cloned into pBinAR and pGreen for transformation in *Agrobacterium tumefaciens* strain EHA 105 and subsequently in cotton. The presence of plasmid with

inverted repeat construct for each target sequence of CLCuV in each binary vector was ascertained by PCR amplification using gene specific primers (Fig. 19 a & b) before initiating plant transformation.

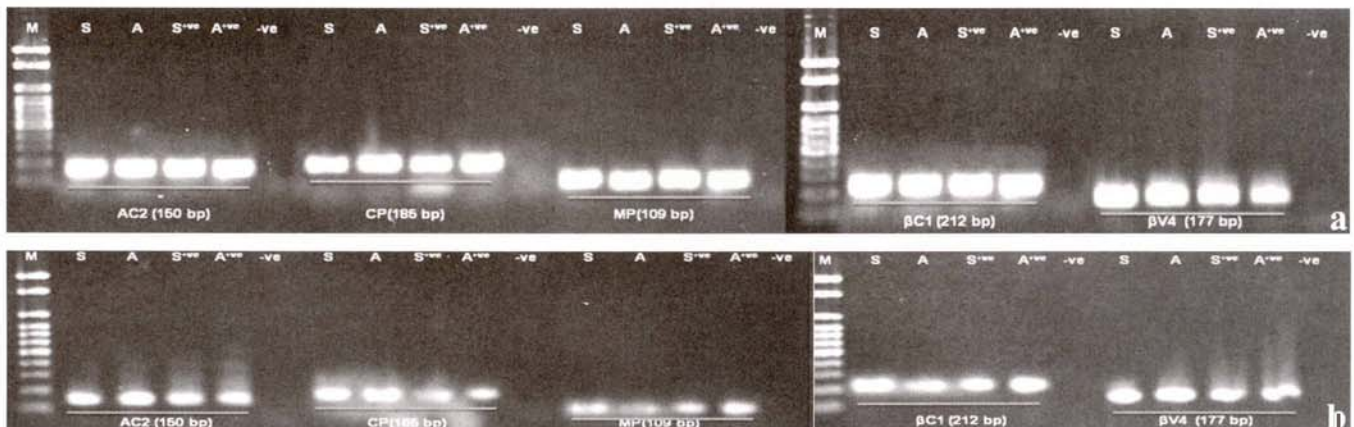


Fig.18 a&b: PCR amplification of sense and antisense strands in *A. tumefaciens* transformed with inverted repeat constructs in pBin-AR (a) and pGreen (b). M, 100 bp ladder; S, Sense; A, Antisense; S +ve and A +ve; positive control (amplified from CLCuV cloned DNA); -ve control

The inverted repeat constructs of target sequences in pBin-AR were transformed in CLCuV susceptible *G. hirsutum* cultivar HS 6. Shoot apex explants containing apical meristem cells were harvested aseptically and inoculated with log phase culture of *Agrobacterium tumefaciens* strain EHA 105 harboring inverted repeat constructs pBin-CP-S-int-A and pBin~C4-S-int-A generated previously. Agro-infection, co-cultivation and regeneration was done as per procedure described by Nandeshwar et al (2009). Putative transformants of pBin-CP-S-int-A (12) and pBin~C4-S-int-A (18) were selected on MS medium containing 50 mg/l Kanamycin.

#### Identification of molecular markers and tagging genes for Bacterial blight resistance

Five cotton lines were screened for resistance against race 18 of *Xanthomonas axonopodis* pv. *malvacearum* by syringe infiltration of bacterial cell. *Gossypium hirsutum* cotton Acala 44 and Ganganagar Agethi were highly susceptible against race 18 of *X. malvacearum*, while *G.hirsutum* cotton IM216, S295 and 101-102 B were completely resistant to race 18. Crosses were effected using two susceptible lines and three resistant lines viz., IM216, S295 and 101-102B. Susceptible lines were employed as female parents while the resistant lines were used as male parents. The F<sub>2</sub>s of each of the four crosses viz. Acala-44 x IM216; Ganganagar Agethi x IM216; Ganganagar Agethi x S295; and Ganganagar Agethi x 101-102B, were completely resistant against race 18 of *X. malvacearum*. The phenotyping of F<sub>2</sub> mapping population of 122 plants of a cross between Acala-44 x IM216 by inoculation with *Xanthomonas axonopodis* pv. *Malvacearum* showed inheritance of resistance and susceptibility at an expected 3:1 ratio indicating single gene dominance of resistance. Chi-Square analysis was performed for testing independent segregation for bacterial blight resistance and susceptible traits.

#### II. Genotyping of parental lines with SSR markers

The bacterial blight resistant and susceptible cotton showing contrasting phenotypes and their crosses were surveyed for genomic polymorphism using SSR and RAPD markers. Polymorphism among the parental lines was surveyed using 280 SSR primers and 60 RAPD primers. Preliminary screening revealed limited polymorphism with SSR primers used. Limited polymorphism ranging from 4.3 to 8.21 percent among the contrasting parents and specific crosses-Acala44xIM216, GAxIM216, GAxS295, GAx101-102B, were observed. The informative markers mostly showed co-dominance while few showed dominant pattern of inheritance (Fig. 20 a&b, Fig. 21 a & b). Twelve out of 280 primers were polymorphic between resistant IM216 and susceptible Acala-44 with only 4.3 per cent of polymorphism (Fig. 16a & b). While 15 SSR markers were informative between IM216 (resistant) and Ganganagar Agethi (susceptible), providing only 5.34 percent polymorphism.

#### Isolation of seed specific promoter sequences for site-specific genetic engineering

Isolation of seed specific promoters for use in RNA interference mediated down-regulation of gossypol in cotton seed was done. Approximately 1100bp seed Alpha globulin promoter sequences from the four *Gossypium* spp viz., *Gossypium hirsutum*, *G. barbadense*, *G. arboreum* and *G. herbaceum* were PCR amplified using degenerate primers and cloned.

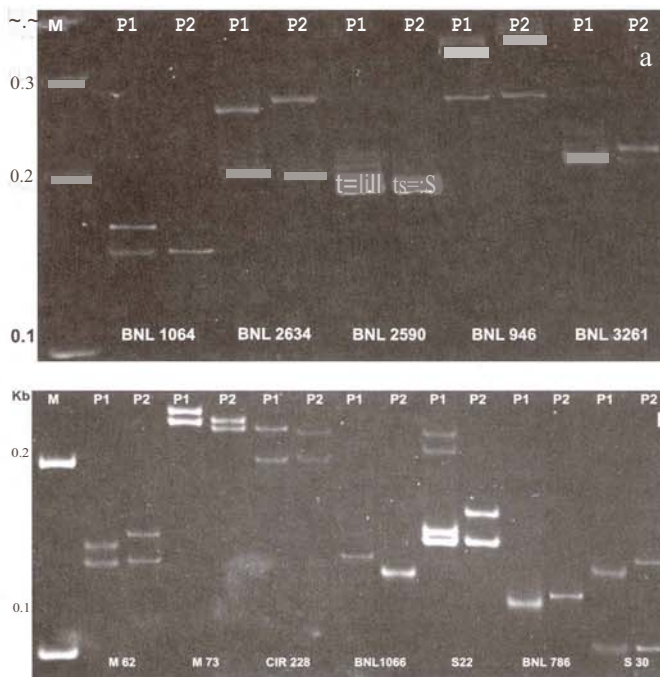


Fig. 20 a & b: Screening of SSR primers to survey polymorphism among bacterial blight resistant and susceptible parents; P1- Acala-44, P2-IM216, M-100 bp Marker

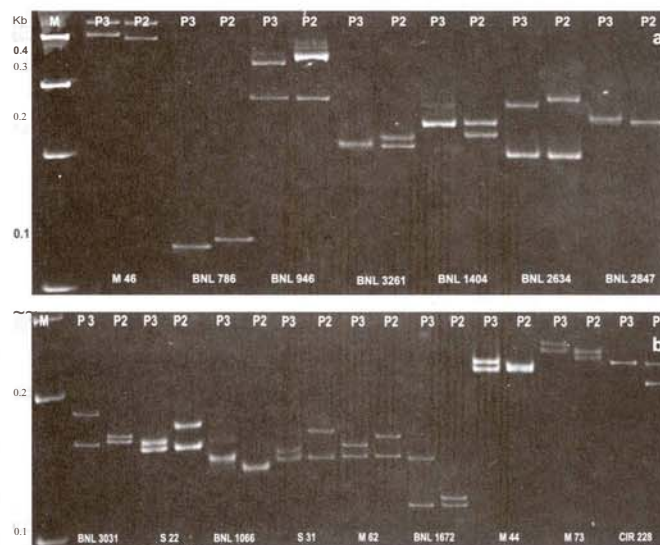


Fig. 21 a & b: Screening of SSR primers to survey polymorphism among bacterial blight resistant and susceptible cotton parents; P3- Ganganagar Agethi (GA), P2-IM216, M-1 00 bp Marker

#### BIOSAFETY OF Bt COTTON

##### Performance of Osmanabadi goats fed with Bt and Non Bt cotton leaves

##### Productive performance

Average milk yield of does (female goats) browsed on Bt cotton leaves was 1600 ml compared to group of that does fed upon non-Bt cotton leaves which yielded 1200 ml milk. The lowest volume of the milk yield of 1000 ml was recorded in the group of that browsed on non cotton crop. However, the percentage of milk fat (MF), solids-not-fat (SNF) and total solids (TS) in milk of does in all the three experimental groups did not differ significantly. No deleterious effect on the quality of milk and milk constituents was documented as a result of feeding on Bt cotton.

#### Nutritional parameters

The dry matter content of Bt and non-Bt cotton leaves was observed to be 20 per cent. The crude protein percentage of leaves in Bt cotton was observed to be 26.19 per cent compared to 20.38 per cent protein in non-Bt cotton.

#### Physiological parameters

Feeding does on the Bt cotton did not have any significant effect on the physiology of the animal. The rectal temperature, heart beat and respiration rate of the does browsed on Bt cotton, non-Bt cotton or non-cotton plant during the end of the year did not show any significant differences.

#### Haemato-biochemical parameters

Haemato-biochemical values of the does browsed on Bt and non-Bt cotton as well as non-cotton plants was characterised. Analysis of hematological values such as haemoglobin (Hb) percentage, packed cell volume (PCV), total erythrocyte count (TEC), total leucocyte count (TLC), MCH, MCV, MCHC, blood albumin, Serum glutamic pyruvate transferase (SGPT), alanine tri phosphate (ALP), calcium, phosphorous and TP etc. in the blood irrespective of their feed, whether Bt, non-Bt cotton or non-cotton plant revealed no significant effect.

#### Health status

The health of all the 12 experimental goats was observed to be good throughout the experimental period. No ailments/gastrointestinal problems &/or any other diseases were observed in case of any of the goats. No adverse/deleterious effect of feeding Bt cotton leaves on the health of goats was observed.

#### Survivability

As there was no mortality in any of the 3 experimental groups of goats during the entire length of experimentation, the survivability of experimental goats was 100 per cent.

#### Coimbatore

#### Development and promotion of Bt transgenic cotton for bollworm resistance

Using BN Bt as the donor parent, the popular cultivars released for South Zone like OS 28, Sahana, MCU 5 & Surabhi are being converted into Bt background through conventional back crossing. The back cross progenies have also been tested for their quantitative expression of Cry protein using ELISA (Table 15).

Table 15: No. of cry 1Ac positive plants identified through ELISA in BC<sub>s</sub> populations

Genotypes	No. of plants Established	No. of cry 1Ac positive plant	Percentage of positive plants
OS28	53	18	34.0
Surabhi	73	27	37.0
MCU 5	58	17	29.3
Sahana	82	23	28.0

## 4.8: Seed Production and Seed Quality Improvement

#### Nagpur

#### Seed production and seed quality improvement

Enhancement of seed germination and vigor

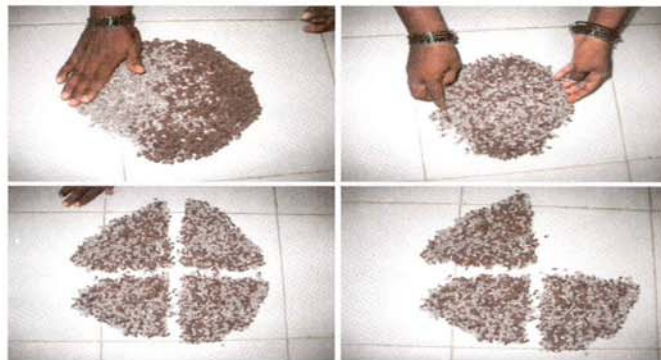
The size graded seeds of six *G. hirsutum* varieties were evaluated to study the effect of seed index on field emergence and seed cotton yield. The seeds with highest index (ranging from 8.5 to 10.0g) gave highest emergence (96%) and seed cotton yield (780 kg/ha) The seed cotton yield from the seeds with lower index (ranging from 7.0 to 8.0 g) followed next (662 kg/ha) The seeds with lowest seed index (less than 7.0 g) gave the least seed cotton yield over varieties (530 kg/ha)

Among the seed hardening treatments the controlled hydration of seeds over night was more effective for early and higher emergence under low soil moisture level (at 40%) compared to the control.

#### Assessment of working seed sample size for Bt testing based on estimation Cry1ac protein

Experiment was conducted to determine the optimum sample size for seed-purity test of commercial Bt-seed lots. Seed lots were prepared artificially by mixing Bt cotton seeds with Non-Bt seeds in different combinations to obtain samples with 50, 60, 70, 80-99% Bt seeds. Seed samples (25 gm) were drawn from commercial Bt seed packet (450 gm) obtained from the market by halving method. The Cry1Ac protein expression was estimated through ELISA. Chi test done on the observed data showed that the hypothesis of testing 10, 20 and 30 seeds as a representative sample to assess seed-purity of the entire seed lot did not hold good, indicating that the present sample size is

probably inadequate.



Preparation of Bt seed samples for analysis using standard method

#### Studies on seed quality parameters of TFL seeds sold in the market

The genetic purity of seed samples collected from Central zone varied from a minimum of 3.33% to a maximum of 100%, compared to the samples from north and south zones where the purity ranged from 80 to 100%.

#### Expression of transgene in seeds of crosses developed from different parental combination with respect to Bt

The leaves from plants obtained from crosses using Bt as female or male parent with homozygous Bt were subjected to ELISA at 45 OAS. The t-test analysis (5%) of Cry-toxin indicated the level to be higher in plants obtained from the cross where Bt was used as female parent (5.54 ppm), compared to the plants obtained from the cross where Bt was used male parent (5.22 ppm). The crossed seeds were studied for Cry protein expression by ELISA in seed parts such as endosperm and

seed coat. Cry toxin levels in the endosperm of seeds obtained from the cross where Bt was used as female parent was significantly higher (6.24 ppm) compared to the seeds obtained from the cross where Bt was used male parent (5.99 ppm).

#### Effect of trans gene on quantity and quality of seed reserves

The total storage protein profile performed on SDS-PAGE revealed no difference in the protein banding pattern of BN Bt as well as its non Bt counter part, BN-1 (Fig.22). Similarly the seed parameters, germination and vigor also showed the properties to be not different between Bt and Non Bt.

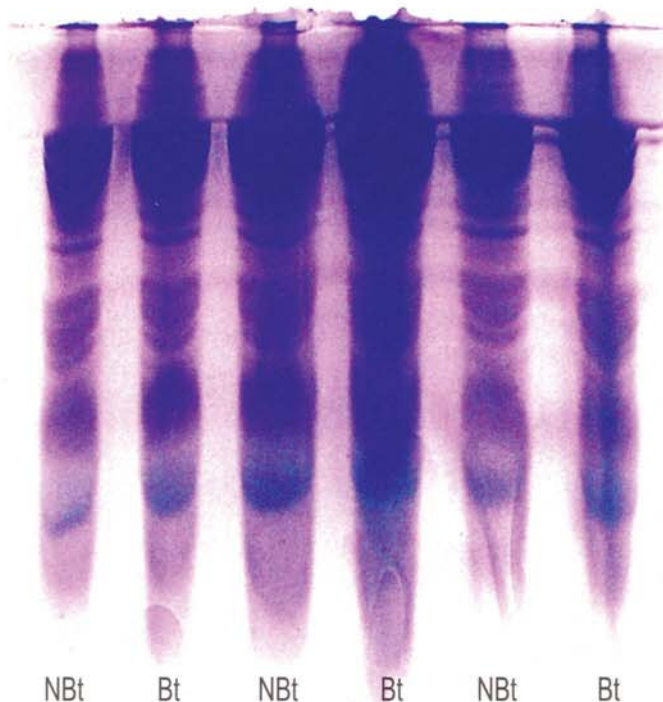


Fig.22: SDS PAGE profile of total seed protein in Bt and Non Bt seeds of BN-1

#### Development of efficient agro-techniques for enhancing productivity and seed quality in cotton

The application of salicylic acid @ 0.25% at 30 days after flowering gave higher seed cotton yield over control in first picking. However, application of lihocin @100 ppm at flower initiation gave higher seed cotton yield in second picking. The results indicated that salicylic acid application hastened the crop maturity compared to control and lihocin application. Seed index and seedling vigor was significantly superior in all treatments over control.

#### Testing and Documentation of extant varieties, hybrids and their Parents for Distinctness, Uniformity and Stability

Twenty five candidate varieties/hybrids from private sector along with twenty two reference varieties of *G. hirsutum* were characterized based on DUS test guidelines.

#### Coimbatore

##### Implementation of PVP legislation

Distinctiveness, Uniformity and Stability testing of tetraploid cotton genotypes were taken up in two trials comprising 5 and 23 candidate varieties, respectively. Similar trial was conducted for diploid cotton with one candidate and two reference varieties. The complete expression of desired morphological characteristics of seedling, leaf, flower, boll and fibre were measured. The characters were recorded from seedling to

maturity adopting the procedure of approved national test guidelines for tetraploid cotton.

Registration of extant and new cotton varieties under PPV&FR Act, 2001 was initiated. In the first phase. Sixty one applications comprising of new and extant cotton varieties were submitted to PPV&FRA through NBPGR. Under the programme of maintenance of reference collection Fifty four *G. hirsutum* and ten *G. barbadense* genotypes were maintained. A database on varieties released by CVRC or State Varietal Release committee and in common knowledge/farmer's varieties, etc., was composed.

#### Film coating of cotton seeds with polymers

Seed deterioration can be prevented up to 18 months of storage and can retain the viability of 77% when pre cleaned seeds were coated with seed polymer polykote @ 3 ml/kg of seed diluted with 5 ml water combined with carbendazim (Bavistin) @ 2 g/kg and the seeds are stored in cloth bag under ambient condition. Viability can also be retained to 76% by coating the seeds with polykote @ 3 ml/kg of seed diluted with 5 ml water combined with carbendazim (Bavistin) @ 2 g/kg and Imidacloprid @ 7g/kg when seeds are stored in polythene bags.

#### Establishment of genetic purity of hybrid seeds through bio molecular profile

Profiling of salt soluble globulins seed protein through SDS PAGE electrophoresis of hybrid G.Cot.MDH 11 and its parent's aid for genetic purity testing of cotton. The presence of additional bands in hybrid will help the seed analysts to identify the % pure hybrid seed as well as admixtures such as parental seed and other variety seeds.

#### Sirsa

##### Technology to enhance the better crop establishment and yield in cotton

Studies on transplanting of raised seedlings indicated that significantly higher plant stand (up to 98 %) and yield (30.35 q/ha) than normal sown crop on the date of transplanting (85% and 25.1 q/ha) was recorded when the raised seedling in big container was transplanted at 25 days seedling stage.

The effect of different levels of seed index showed that the germination percentage (89.5% in CSHH 198 and 87.2% in CICR 2) was significantly higher in seed lot with superior seed index followed by medium seed index (83.3% and 81.6%) and declined in lower seed index lot (72.8% and 72.3%). The yield (32.3 q/ha in CSHH 198 and 32.8 q/ha in hybrid CICR 2) was significantly higher in the plot where seed lot with superior seed index was used than lower seed index seed lot (26.5 q/ha and 26.9 q/ha), respectively. Among the various pre sowing seed treatments, the plant stand was higher in seed lot treated with  $\text{KNO}_3$  100 mM + imidacloprid + vitavax (94.3 %) followed by treatment of DAP 1% + imidacloprid + vitavax (93.1 %) against the control water soaked seed (85 %). Significantly higher yield of 31.04 q/ha was recorded in treatment with  $\text{KNO}_3$  100 mM + imidacloprid + vitavax followed by DAP 1% + imidacloprid + vitavax (30.83 q/ha) and trichoderma (30.41 q/ha) than control (28.55 q/ha).

##### Standardization of seed coating with synthetic polymers and additives

Eight treatments with synthetic polymers and additives were applied on seed and stored in cloth bag as well as polythene under room conditions and observations on moisture content of seed, their germination per cent and vigour index were recorded at bi-monthly interval. Up to 6 month of experiment period, higher germination in cloth bag (88.8%) and polythene bags (90%) was observed in seed lot in which fungicide and

insecticide was used along with polymers as treatment during storage.

### Seed Production

#### Nagpur

Under the Mega Seed production programme, seeds of 13 elite cultivars of cotton along with wheat and pulses were produced. A sizeable resource of 6.72 lakhs approximately was earned through the sale proceeds.

Crop	Stage	Production (Q)
Cotton -13 varieties	TFL	32.89
Wheat cV.HD 2189	Foundation Seed	40.90
Red Gram-BSMR	TFL	73.80
Gram-Vijay	CS	29.80
Wheat-GW-496	CS	55.98

#### Coimbatore

#### Breeder Seed Production

Variety	Breeder seed production (kaps in kg)	Breeder seed distribution (seeds in kg)
LRA 5166	326	111
MCU 5 VT	-	69*
Surabhi	130	111
Suraj	192	54
Supriya	94	6
Suvin	235	33
Total	977	384

\*From Carried over stock

#### Sirsa

#### Maintenance of Nucleus and Breeder Seeds

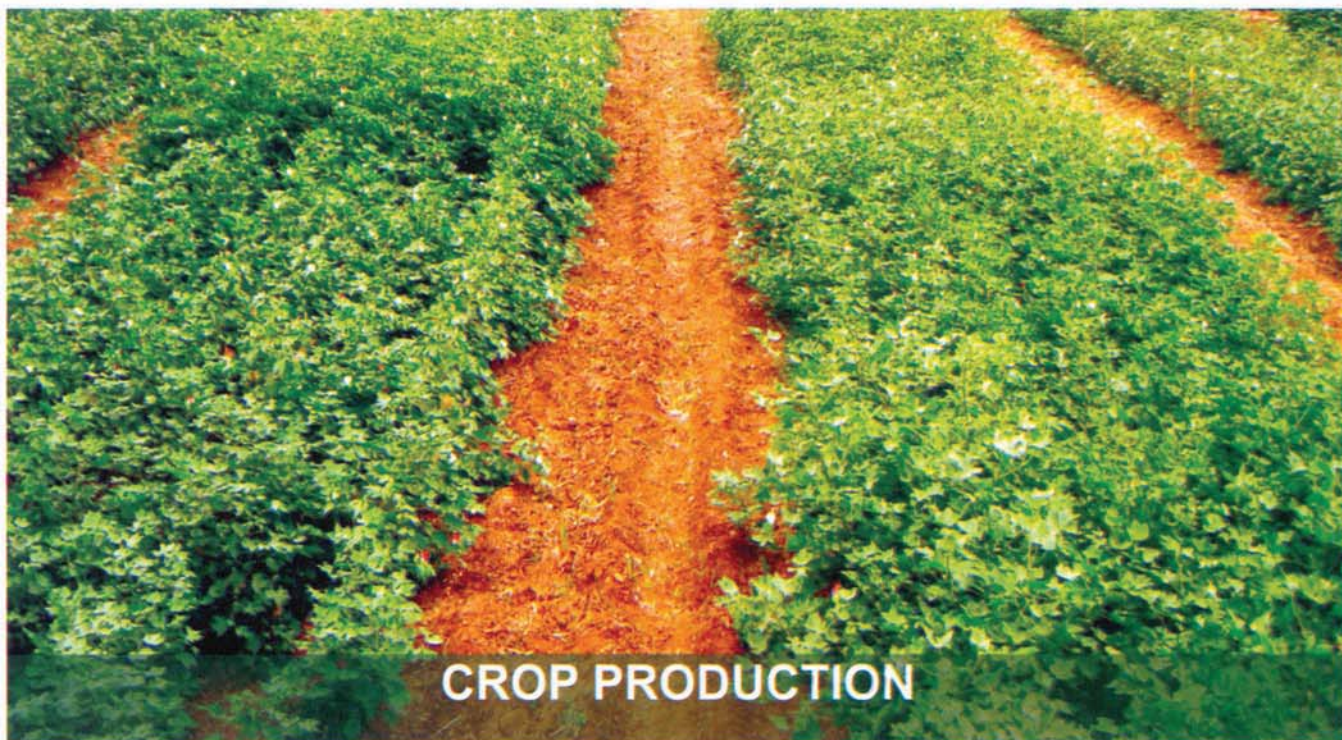
No	Variety/Parents	Quantity (kg)
1	CSHH 198 (F)	45
2	CSHH 198 (M)	38
3	CSHH 243 (F)	25
4	CSHH 243 (M)	10
5	CSHH 238 (F)	35
6	CSHH 238 (M)	30
7	CICR 2 (F)	35
8	CICR 2 (M)	30
9	CISA310	85
10	CISA614	100



Seed production of wheat under MSP programme



Redgram seed production under MSP programme



## 4.9: Nutrient Management

### Nagpur

#### Long term effect of fertilizer and INM on the productivity and soil fertility, under Bt cotton- soybean system

A field trial was continued for the sixth consecutive year on two cropping systems (cotton-cotton and soybean-cotton) with different fertilizer and INM treatments. Higher number of bolls, boll weight and seed cotton (NCS145 Bt) yield were recorded where cotton was grown after soybean. Highest number of bolls, biomass and seed cotton yield (15.96 q/ha) was observed in INM treatment and this was followed by addition of micronutrients with RDF treatment in soybean-cotton system. Higher nutrient apparent recovery was observed with INM treatment as compared to NPK alone (RDF) in both the cropping systems. There was no difference in yields of pigeon pea with the different fertilizer levels except control. There was a higher build up in organic carbon (OC) in INM treatment (0.61 %) and pure organic treatment (15 t FYM/ha) (0.62 %) in 2009-10 as compared to initial value of OC 0.30 % in 2004-05.

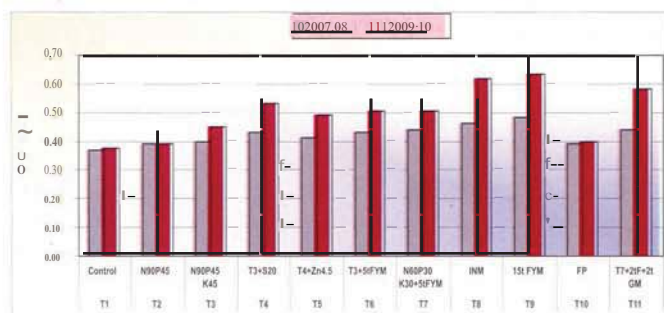


Fig.23: Cumulative effect of different fertilizers and manures alone and in combination on the soil organic carbon percentage

#### Nutrition requirement of Soybean-Bt-hybrid cotton in participatory mode

None of the variable doses of major nutrients tried improved the

seed cotton yields, red leaf numbers and per cent red leaf out of total leaves (from July to September months). About 70% leaves turned red due to sucking pests and 25-30% due to leaf spot diseases. The trials conducted in participatory mode in different villages confirmed that the major reason for leaf reddening was sucking pests as the lower leaves had distorted shapes. Controlling sucking pests early with effective insecticides reduced red leaves and increased yield. In station trials significant improvement in seed cotton yields (by 333 kg ha<sup>-1</sup> overcontrol or 31 %) was observed by the application of Zn, Mg, Band S @ 10, 10.3 and 6 kg ha<sup>-1</sup> y<sup>-1</sup>. In on farm trials in medium to deep soils of Antargaon and Vanoja villages and shallow to medium deep soils of Sukhli and Takli villages (all in Ralegaon Tehsil of Yavatmal district, Maharashtra) indicated that yields could be improved by the application of Zn and B to the extent of 200 kg/ha under rainfed conditions and 400-500 kg/ha with 2 supplemental irrigations.

#### Effect of different nitrogen application levels on Cry-protein in cotton seed oil and gossypol content

Field experiment was carried out with 3 Bt hybrids (Bunny, RCH-2 and NHH-44) and their non-Bt counterparts with 3 levels of NPK (90:45:45, 120:60:60 and 150:75:75). RCH-2 Bt and non Bt showed a stunted growth and the sucking pest incidence was severe. The oil content was in the range 22-24%. Leaf Cry protein estimated at 60, 86 and 110 DAS indicated that the Bt hybrids possessed a variable range of Cry toxin. But with respect to fertilizer treatment, no definite trend could be inferred. At 110 DAS old leaves contained more Cry protein. At 110 DAS total protein (measured by Lowry's method) was found to be more in case of Bt hybrids. Systematic effect of different fertilizer doses was not observed on oil and gossypol content. However, there was considerable variability in seed gossypol content among the Bt and non Bt hybrids.

### Coimbatore

#### Long term effect of continuous application of nutrients in fixed cotton based crop rotation on the productivity,

### nutrient balance and sustainability

Introduction of grain jowar as a sequential crop in cotton follows enhanced seed cotton yield by 21.6% (376 kg/ha) and total biomass yield by 32 % (1446 kg/ha) besides providing an additional yield of 63.4 q/ha of Jowar (5 yrs pooled data). Production Efficiency and Stability Index were higher under Cotton-Jowar system. Soil nutrient depletions were noticed recorded in control and nutrient deficit plots (N and NK) but not in balanced or integrated nutrient supply treatments (NP, NPK, NPK+FYM/CR). NPK levels viz., 60:13:25 kg/ha (RDF) significantly out yielded the control and crop residue treatment (due to partial nutrient immobilization). However, nutrients locked up in crop residues were made available subsequently, and thereby yielding on par with RDF as was evident from pooled data on yield (with similar biomass production, leaf chlorophyll content, microbial biomass and soil O.C.). Although petiole N was highest under 90 kg N/ha, the chlorophyll content was lowest. Application of N alone @ 90 kg prolonged vegetative growth and declined yield over balanced nutrition and INM. FYM alone though maintained soil O.C. at its highest level (0.65 %), could not supply nutrients commensurate with crop demand. Balanced fertilization (RDF) and more appropriately, INM (i.e., NPK+FYM) was optimum for cotton since they maintained a steady growth, development and yield. Highest Water Use Efficiency (WUE, 32.9 kg/ha-cm) along with lower water use (56.5 em) and highest total soil N were also observed with INM practice. Maximum water productivity (Rs.7.35/M<sup>3</sup>) was with the INM practice followed by RDF (Rs.6.98/M<sup>3</sup>). Application of 60:30:30 kg/ha as N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O (RDF) to *hirsutum* cotton (cv. Surabhi) and applying RD-N (90 kg/ha) to succeeding sorghum (Co 428) in rotation was ideal for higher and sustainable yields of both the crops. Based on consumptive use of water, around 4048 and 3257 litres of water were used per kg of seed cotton under cotton-fallow and Cotton-Sorghum, respectively. Highest water productivity (WP, Rs.6.86/M<sup>3</sup>) and highest nutrient use efficiency (NUE, 17.8 kg seed cotton/kg NPK uptake) were calculated under cotton-sorghum in comparison to cotton-fallow (with WP of Rs.5.52/M<sup>3</sup> and NUE of 13.6). Smothering effect of jowar on weed was evident as weed control efficiency increased over the years.

### Synchronizing Nand K supply with crop demand

Under the existing semi arid condition, in the winter irrigated tract of Tamil nadu, 3 splits of N only was optimum for desired efficiency and maximum yield. Weed control efficiency was increased drastically following 3 splits. The highest WUE was observed in 4 splits (55 kg/ha-cm), followed by 5 splits (54.3), 3 splits (52.7) and 2 splits (47.1).

### Studies on cuticular absorption of nutrients and surfactants in cotton

Surfactants- Propanol, Triton-X, Tween 20 and APSA (all purpose spray adjuvant) were found to be effective in facilitating stomatal opening in cotton and these chemicals were sprayed on the foliage at different concentrations (0.5, 1, and 2 mill). The study indicated that 1 ml per litre of water was optimum concentration to induce stomatal opening in all the chemicals tried. Irrespective of the chemical, 50 -60 % of the stomata opened within 30 minutes and extended up to 60 minutes and there after it started closing and by 120 minutes only 18 % if the stomata remained opened. APSA was found to be the best surfactant. When 1 % potassium was applied as foliar spray, maximum potassium absorption was seen in 4<sup>th</sup> to 8<sup>th</sup> leaf (34.5 to 36.6 ppm) compared to 25.3 to 33.8 ppm by other leaves in cotton within one hour of spray.

## 4.10: Irrigation Water Management

### Nagpur

#### Drip Irrigation and N-K fertigation

The seed cotton yield (NCS 145 Bt), water use and water use efficiency indicated that drip irrigation at 0.8 Etc produced optimum seed cotton yield (2164 kg/ha), highest WUE, net returns and B C ratio. The nutrient uptake was also the highest with 0.8 Etc.

Fertigation @ N 120, K 60 at 0.8 Etc led to higher yield, WUE water use and BCR. Fertilizer applied through fertigation in four splits resulted 25 % saving of Nand K.



Bt (NCS 145) cotton under drip irrigation

### Coimbatore

#### Drip Irrigation and Fertigation

Drip irrigation at 0.8 Etc registered the significantly highest seed cotton yield of 2021 kg/ha, which was on par with irrigation scheduling @ 1.0 Etc and 0.6 Etc through drip (Fig 24.). Different levels of fertilizers (75, 100 and 125 % RDF) applied as drip fertigation in six splits at 15, 30, 45, 60, 75, 90 DAS did not have significant influence over soil application of 100 % of RDF in three splits at 0.45 & 90 DAS. Drip irrigation scheduled at 0.6 Etc had the highest water expense efficiency (75.8 kg/ha-cm), water productivity (Rs. 35.2 1m<sup>3</sup>), and the least quantity of water (1325 litre / kg of seed cotton) used for production of unit quantity of seed cotton. Amongst the fertilizer levels, fertigation of 100% RDF (90:45:45 kg of N, P<sub>2</sub>O<sub>5</sub> & K<sub>2</sub>O/ha) in six splits registered the highest water expense efficiency (57.7 kg/ha-cm), water productivity (Rs. 26.81 m<sup>3</sup> of water) and the least quantity of water (1907 l) required to produce single kg of seed cotton.

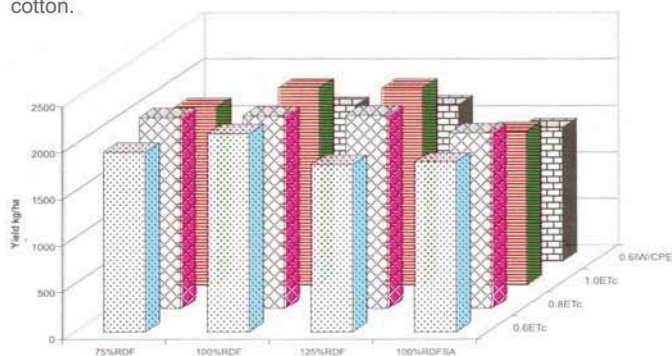


Fig.24: Seed cotton yield as influenced by irrigation schedule and fertilizer levels

### Drip Irrigation and mulching in ELS Bt cotton

Field experiment was conducted to find out the performance of bio mulching and biodegradable polyethylene mulching for moisture conservation, water saving, weed control and enhancing the productivity of ELS Bt cotton, RCHB 708 under drip and conventional irrigation. The total water requirement (including the effective rainfall of 26.8 ha em) at 0.4 Etc, 0.8 Etc and conventional irrigation was 48.9, 67.1 and 83.2 ha em respectively. When no mulch was applied, the crop responded up to 0.8 Etc, while with mulch combinations, the yield did not increase beyond 0.4 Etc. Among the treatment combinations, poly mulching with drip at 0.4 Etc recorded the highest seed cotton yield (5755 kg/ha) and was on par with biodegradable polyethylene mulching at 0.4 Etc (5362 kg/ha) and polyethylene mulching at 0.8 Etc (5526 kg/ha). The water use efficiency ranged from 41.6 kg/ha em under no mulching with conventional irrigation to 117.7 kg/ha em under polyethylene mulching at the lowest moisture regime of 0.4 Etc.



Biodegradable poly mulch

### Irrigation management for ELS Bt hybrid

Amongst surface irrigation methods, application of irrigation @ 0.4 and 0.6 IW / CPE ratio during vegetative and reproductive stage respectively recorded the significantly highest yield (3110 kg lha), which was on par with alternate furrow irrigation (3063 kg lha), protective irrigation (2744 kg lha), skip furrow irrigation (2594 kg lha) and paired row planting (2651 kg lha). The control that received only life irrigation registered the least seed cotton yield (2299 kg lha). The total quantity of water (517.7 mm) and irrigation water (25.6 em) used was maximum with irrigation @ 0.4 and 0.6 IW / CPE respectively for vegetative and reproductive stage and the lowest was recorded with control respectively of 340.5 and 90 mm. Amongst irrigation method, alternate furrow irrigation used the least quantity of irrigation water (18.4 em), recorded the highest water use efficiency of 69.2 kg / ha-cm, water productivity of Rs. 32.2 1m<sup>3</sup> of water and required less amount of water (1444 l / kg) to produce unit kilogram of seed cotton yield.

## 4.11: Soil Moisture Conservation in 8t Cotton

Nagpur

### Development of production technology for Bt cotton

Field experiment on the use of different moisture conservation techniques and nutrient management on Bt cotton was conducted during 2007-2008 to 2009-2010. Pooled data indicated that significantly higher cotton equivalent yield (1790

kg/ha) was obtained with green gram intercropped in Bt cotton (1:1) as compared to other moisture conservation treatments. Further, the yield and fertilizer use efficiency were the highest when 75% inorganic N was supplemented with 25% organic N.



Bt cotton (NCS 145) inter cropped with green gram

### Soil moisture Conservation and integrated nutrient management (INM)

Soil moisture conservation by opening of alternate furrow in cotton registered higher seed cotton yield (1691 kg/ha) and net return (Rs. 19,217/ha) than intercropping of cotton with soybean and *insitu* green manuring of sunhemp. Amongst INM practices, application of recommended dose of nutrients (112.5:45:33.75 kg of N, P<sub>2</sub>O<sub>5</sub> & Kp/ha) through inorganic fertilizer showed higher net return (Rs 22037/ha).

Coimbatore

### Evaluation of organic and inorganic mulches for rainfed Bt cotton

Field experiment was conducted to study the usefulness of various organic and inorganic mulches for efficient moisture conservation for growing Bt cotton under rain fed condition. Eight mulch treatments viz., sub-soil coir pith, maize stover, sugar cane trash, surface coir pith, gunny sheet, biodegradable polyethylene and polyethylene mulching were evaluated against no mulch control with RCH 20 B1. The results revealed that all the mulch treatments enhanced the seed cotton yield. Poly mulching recorded the highest (1985 kg/ha) seed cotton yield and was on par with biodegradable mulching, sub soil coir mulching and gunny sheet mulching. Surface coir pith application recorded significant reduction in yield over other mulches.

## 4.12: Cropping Systems

### Bt cotton based inter cropping systems

Nagpur

Pooled analysis of two years data on shallow and medium deep soils indicated that the reduction in seed cotton yields in both the soils by introducing intercrops in Bt hybrid cotton was not significant compared to respective paired row planted Bt hybrid cotton. Roselle (*Hibiscus sabdariffa*) was most drought resistant and the best leafy vegetable had a better shelf life (dried leaves for lean period). Its yield was 1.3 t ha<sup>-1</sup> on green leaves basis and 0.5 t ha<sup>-1</sup> dry bast fibre (4.6%) basis in very shallow soils. The cotton equivalent yields, cost of cultivation was also significantly increased in paired row planted Bt hybrid cotton intercropping.

On shallow soils, highest net profit was with paired row cotton intercropped with *Rumex* spp. + maize and tomatoes followed spinach + baby corn or *Portulaca oleracea* + field bean and fennel.

In medium to deep black soils, rain water was harvested by opening of furrow after 1<sup>st</sup> interculture within the paired row, but 264 mm post monsoon season rains (in October, 2009) created anaerobic conditions and reduced the seed cotton yields compared to 2008. The most profitable intercropping system with highest profitability was paired row planted Bt hybrid cotton intercropped with field bean and fennel or marigold.



Cotton + Portulaca+ Field bean



Cotton + Marigold

#### Coimbatore

Short duration intercrops viz. clusterbean, coriander, radish, amaranthus, green gram and vegetable cowpea were evaluated against sale crop of Bt cotton. In this novel experiment without altering the cotton crop geometry, short duration intercrops were grown on the other side of ridge. The results indicated that all the intercrops were compatible with Bt cotton, RCH 20. The seed cotton equivalent yield was highest with Bt cotton + coriander system (3795 kg/ha) closely followed by Bt cotton + radish system (3605 kg/ha) as against the lowest (3097 kg/ha) recorded with sale cotton. The economics of Bt cotton based inter cropping system also indicated that cotton + coriander resulted in highest gross return (Rs.121440), net

return (Rs.95215) and benefit cost ratio (3.63) closely followed by cotton + radish system. All the intercropping systems except vegetable cowpea recorded higher net return than sale cotton.

#### Bt cotton based double cropping systems for irrigated condition

Six Bt cotton based double cropping systems viz., two millets, two pulses and two oil seed crops were evaluated to identify the most profitable, productive and sustainable system. Amongst them Bt cotton-maize recorded the highest seed cotton equivalent yield (4168 kg/ha), gross return (Rs.1 0421 O/ha), net return (Rs. 69485/ha) and per day productivity (Rs.257.4/ha).

#### Multi-tier cropping system

Multi-tier systems are labour intensive with respect to weeding because of difficulties in using animal drawn implements. Integrated weed management did not influence seed cotton significantly as compared to hand weeding thrice at 15, 30 and 60 DAS. In multi-tier system of cotton + radish + beetroot + coriander, hand weeding thrice at 15, 30 and 60 DAS helped in realizing the highest net return (Rs.1,37,765), seed cotton equivalent yield (44.4 q /ha), relative production efficiency of 79.9 %, relative economic efficiency of 94.5 % and per day profitability of Rs. 623. Multi-tier system of cotton + radish + beetroot + coriander with pendimethalin @ 0.75 kg /ha + hand weeding at 30 DAS + targa super 50 g /ha gave a net return (Rs.87,269), seed cotton equivalent yield (41.4 q /ha), relative production efficiency of 67.7 %, relative economic efficiency of 81.7 % and per day profitability of Rs. 582. The sale cotton system with hand weeding thrice at 15, 30 and 60 DAS had produced the lowest seed cotton yield (25.6q/ha) , net return (Rs. 49,364 /ha) and per day profitability of Rs.329.



Multi tier cropping

#### Incorporation (*insitu*) of cereals on productivity of succeeding cotton

Sowing of cereals in off season as bulk crop and *in situ* incorporation (45 days period) may provide similar cereal rotation by breaking yield barrier in mono-cropping and makes system sustainable. The second year results indicated that incorporation of *in-situ* grown ragi at 45 DAS produced significantly highest seed cotton yield (2610 kg /ha), Bartlett index (0.89), total rainfall use efficiency of 5.94 kg /mm, effective rainfall use efficiency 10.24 kg /mm and partial factor productivity of 21.75 kg /kg of nutrients, gross return of Rs. 80,900 fha, net return of Rs. 53, 851 /ha and benefit cost ratio of 2.99. In comparison, the control (cotton-fallow system)

produced a seed cotton yield of 1847 kg/ha, Bartlett index of 0.83, total rainfall use efficiency of 4.20 kg/mm, effective rainfall use efficiency of 7.3 kg/mm, partial factor productivity of 15.4 kg/kg of nutrient, least gross return (Rs.57,248/ha) and net return (Rs.38,014/ha).

### Sirsa

#### Intercropping of kharif legumes with Bt cotton under irrigated condition

The performance of Bt hybrid RCH 134 with and without intercrop combinations was evaluated. The yield (3121 kg/ha) and number of bolls/plant (53.9) were significantly higher in sale cotton at spacing 67.5 cm X 75 cm as compared to paired row cotton with and without intercrops. The yield of cotton (2614 kg/ha) and number of bolls/plant (48.7) in sale paired row was statistically at par with paired row with intercrops. As inter crop with in paired row cotton, additional yield of mung bean (297 kg/ha), cluster bean (905 kg/ha) and groundnut (327 kg/ha), was harvested. The net income (Rs. 95197/ha), net return (Rs. 71622/ha) and B: C ratio (4.0) from sale cotton (67.5 cm x 75 cm) was higher than paired row cotton. Among paired row cotton with inter crops, net return (Rs 61604) was observed maximum in cotton + mung bean. The dry matter, N, P and K uptake (kg/ha), nutrient use efficiency (8.4), water use efficiency Rs/ha-cm (1133) and water productivity Rs/M<sup>3</sup> water (11.52) were observed to be higher in normal sale cotton (67.5 cm X 75 cm) than paired row cotton.

#### Evaluation of Bt cotton based double cropping system

The cotton-wheat (Rs.72769/ha) followed by cotton- mustered (Rs 61825/ha) system were observed superior to cotton-barley. Higher plant stand (97.5%) was noticed in transplanted cotton crop, with 21 days tray raised nursery in coco peat (50%) + FYM (35%) + soil (15%) against normal sown cotton 82.5%. Because of higher plant stand, the yield (2667.3 kg) in transplanted cotton was superior than normal sown cotton fields (2437 kg).

## 4.13: Agronomic Evaluation of cotton genotypes

### Nagpur

Separate field experiments were conducted in a Vertisol (> 100 cm depth) for NHH 44 Bt and an Inceptisol (< 50 cm depth) for BN Bt and both under rainfed conditions representing AESR 10.2, with 3 spacings and 4 N levels. In NHH 44 Bt, averaged across spacing, with an incremental increase in N by 30 kg/ha the seed cotton yield increased significantly up to 60 kg/ha and further increase to 90 kg/ha did not provide any additional benefit. However, N x Spacing interaction effect was significant and at reduced intra row spacing (90x20 cm), the response to N was significant up to 90 kg/ha. In BN Bt, averaged across spacing, the seed cotton yield increased significantly only with the first increment of 25 kg/ha. However, spacing x N effect was significant indicating that at a reduced intra-row spacing of 20 cm. (i.e. 60x20), a higher dose of 50 kg N/ha was optimum.

N uptake by BN Bt increased significantly with N application up to 50 kg N/ha, beyond which the increase was not significant. The mean apparent recovery (AR) of N decreased with increase in the rates of N application and increased with a decrease in intra-row spacing. Trend in N use efficiency and its components is presented in Fig. 25. N use efficiency declined with increase in N application but increased with a reduction in intra row spacing from 15.2 at 60 x 45 cm to 22.7 at 60 x 20 cm spacing. It is inferred that the increase in N use efficiency was primarily due to an increase in uptake efficiency at higher N levels, whereas the utilization remains more or less similar at all the spacings. N uptake efficiency declined with increase in N rates, but N

utilization efficiency remained unchanged. N utilization efficiency is a product of N biomass production efficiency (NBPE) and Harvest index (HI). NBPE remained largely unaffected by N rates or spacings but HI was the lowest at 60 x 20 cm spacing (highest population).

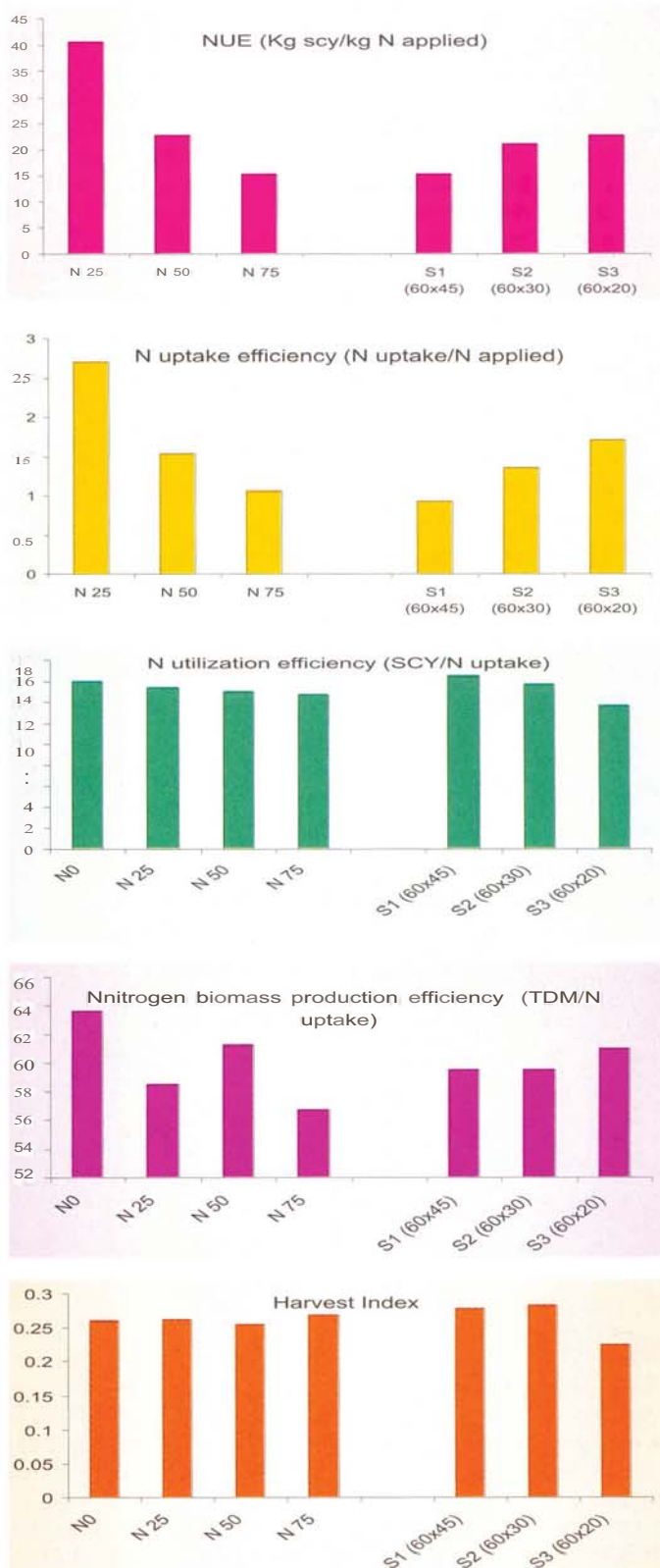


Fig. 25: Effect of N application and intra row spacing on N use efficiency and its components in BN Bt (SCY= Seed Cotton Yields, NUE= Nitrogen Use Efficiency, TDM= Total above ground Dry Matter)

## Coimbatore

### Productivity, profitability and water use efficiency of different genotypes of south zone

Among the fifteen genotypes evaluated significantly highest seed cotton yield (2931 kg/ha) was harvested from RCHB 708 Bt and it was on par with MRC 6918 Bt (2903 kg/ha), Mallika Bt (2903 kg/ha), CCH510-4(2763 kg/ha) and RCH 2 Bt " (2738 kg/ha). The least quantity of water (440.2 mm) had been used by RCH2 Bt, RCH2 " Bt, Bunny Bt, Mallika Bt and Tulasi 9Bt. The highest water use efficiency of 62.6 kg/ha-cm was calculated with Mallika Bt, followed by RCH2Bt II (62.2 kg/ha-cm). In economic terms, RCHB 708Bt registered the highest gross return of Rs.1,36,291 /ha, net return of Rs.1,00,358 /ha and benefit cost ratio of 3.8. The highest partial factor productivity of 23.03 kg /kg of nutrient and economics of nutrient use efficiency of 1.77 kg /Rs invested was with CCH 510-4 whereas the highest water productivity of Rs. 27.55 1m<sup>3</sup> of water were with MCR 6918 Bt.

## 4.14: Weed Management

### Coimbatore

#### Herbigation with herbicidal mixture/herbicide rotation for efficient weed control in cotton and its effects on succeeding pulse crop

Field experiment was conducted to find out efficient, economical

Table 16. Weed control efficiency on 60 DAS and seed cotton yield of cotton (cv.RCHB 708 Bt) as influenced by weed control methods

Weed control treatments	Conventional			Herbigation		
	Weed DMP (g/m <sup>2</sup> )	WCE	SCY (kg/ha)	Weed DMP (g/m <sup>2</sup> )	WCE	SCY (kg/ha)
Pendimethalin 1.5 kg/ha (PRE) + HW (30 DAS, 60 DAS)	41.5	80.2	3502	30.7	83.4	4185
Pendimethalin 1.0 kg + metalachlor 1.0 kg/ha (PRE)+HW (30,60 DAS)	38.4	81.7	3915	24.5	86.8	4407
Pendimethalin 1.0 kg/ha followed by 1 HW + metalachlor 1.0 kg/ha (30 DAS) + HW 60 DAS	18.5	91.2	4460	8.5	95.4	4918
Hand weeding thrice (20,40 ,60 DAS)	36.5	82.6	4512	21.0	88.7	5187
Un weeded check	209.5	-	501	185.0	-	1100
Application method	4.25		417.4			
Weed control treatments	8.96		457.0			
Interaction	12.11		726.4			

\*DMP: Dry matter production, HW: Handweeding, DAS: days after sowing, PRE: Pre-emergence WCE: Weed control efficiency, SCY: Seed cotton yield

## 4.15: Soil Biology and Biochemistry

### Nagpur

Two field experiments were conducted to understand the impact of transgenic cotton on soil microbial population and related soil biological properties under rainfed condition on medium deep and shallow black soils. Soil samples from two Bt cotton genotypes (NHH 44 Bt and BN Bt) and their counterpart, the non-Bt cotton for NHH 44 and bulk soil for BN Bt have been used as test material. Rhizosphere and bulk soil samples were collected from 0-15 and 15-30 cm depth. Samples collected at periodical intervals viz., before sowing, flowering, boll formation and harvest were analyzed for biological properties viz. a) basal respiration, b) urease activity, c) dehydrogenase activity, d)



Evaluation of cotton genotypes

environmentally safe weed control method and to study the efficacy of herbigation technique for cotton crop. Herbicide rotation (pendimethalin followed by metalachlor) with hand weeding recorded significantly lesser dry matter of weeds irrespective of the application method (conventional or herbigation). However, significantly lesser weed dry matter (8.5 g/m<sup>2</sup>) recorded with herbigation technique which suggests that there is scope to use pre-emergence weedicide for post emergence application for killing late emerging weeds without damaging cotton crop (Table 16). Hand weeding thrice and herbicide rotation with hand weeding were on par for seed cotton yield and found superior to other methods. The bio assay crop of green gram grown after the harvest of Bt cotton was not affected due to any of the weed control methods.

Fluorescin diacetate hydrolysis and e) total microbial population (General and functional microflora). Result indicated that there is no adverse effect of Bt cotton on selected soil biological properties, rather higher biological properties were recorded in Bt cotton soil as compared to Non-Bt cotton. Among the soils, medium deep recorded higher biological values as compared to shallow black soil. Samples collected at flowering stage recorded higher values than later stages and values of all the biological properties decreased with increase in soil depth.

#### Developing efficient carrier based microbial delivery system for cotton nutrition and soil health

Three different methods of microbial delivery (seed treatment, soil application and newly identified carrier based delivery) were

taken up to study the survivability and retention of applied bio-inoculants in cotton rhizosphere. To increase the moisture availability for inoculated bio-inoculants, the newly identified carrier material was coated with different moisture retaining materials viz., cotton lint, cow dung, clay, talc and ash. The observation on moisture retention was assessed fortnightly interval. To inhibit the native microflora for better establishment

of inoculated bio-inoculants in cotton rhizosphere, turmeric powder, crude neem seed extract and crude eucalyptus leaf extract were studied. Results indicated that carrier coated with cotton lint retained higher moisture as compared to other materials (Table 17.). Crude neem seed extract gave a higher temporary inhibition of native soil microflora.

Table 17: Moisture retention percentage in carrier coated with different low cost materials

Days after soil inoculation (15 cm)	Cotton lint	Cow dung	Clay	Talc	Ash
15	40.5	32.0	30.0	28.5	19.0
30	32.0	19.0	22.5	19.6	13.0
45	19.5	14.8	16.0	13.5	8.50
60	14.0	8.35	9.65	8.10	5.00

#### Soil Biological properties of soils of Black soil region

The impact of management practices on soil biological properties of representative benchmark soils of Black Soil regions (BSR) of India was studied. Selected soil biological properties viz., soil urease activity, soil dehydrogenase activity and soil microbial population were analyzed in 195 (104- High management and 91- Low management) soil samples from 13 BSR Spots. In general it was found that high management (HM) recorded higher soil biological properties (soil enzyme activities and soil microbial population) as compared to low management/Farmers practice (FM). All the soil biological properties found to be higher at the surface layer and found to decline with depth. Considerable variation was observed with reference to bio-climatic regime and cropping system adopted.

#### Impact of long term fertilization in cotton on soil microbial population

A long term fertilizer experiment was conducted on a vertisol for 5 years (2005 to 2010) with 11 treatments. The microbiological properties of the experimental samples after five years of experimentation are presented in Table 18. The population of

general microflora (Bacteria, Fungi, Yeast and Actinomycetes) varied significantly between the treatments. The bacterial population was found to be more with the Treatment-7 (60:30:30+5tFYM) followed by Treatment-5, the same trend was observed with fungal population. Treatment-5 (90:45:45+S20+Zn20) recorded higher population of actinomycetes followed by treatment-7 and the lowest actinomycetes population recorded in treatment-1 (Control). Yeast population followed a similar trend as bacterial population.

Under physiological/functional groups of microbes, higher *Azotobacter* population ( $9-16 \text{ cfu} \times 10^4/\text{g}$ ) was recorded in treatment-5 (90:45:45+S20+Zn20) followed by treatment-8. Higher Phosphorus solubilising microorganisms (PSM) population ( $9-14 \text{ cfu} \times 10^4/\text{g}$ ) was observed in treatment-4 (90:45:45 + S20) followed by treatment-11. Higher *Beijerinckia* population was recorded in treatment-5 ( $12-18 \text{ cfu} \times 10^4/\text{g}$ ) followed by treatment-7. *Fluorescent pseudomonas* population found to be more in treatment-5 ( $24-36 \text{ cfu} \times 10^4/\text{g}$ ) followed by treatment-9. There are no significant differences in physiological groups of microbes between the treatments.

Table 18: Effect of long term fertilization on soil microbial population ( $\text{Cfu} \times 10^4/\text{g}$ )

Treatments		Bacteria	Fungi	Yeast	Actino
T1	Control	58.67	10.67	19.00	16.33
T2	90:45:0	59.00	8.00	19.67	30.67
T3	90:45:45	65.33	9.33	26.33	19.67
T4	T3+S20	94.33	11.67	31.67	28.00
T5	T4+Zn20	116.00	21.67	52.00	53.00
T6	T3+5t FYM	78.67	13.67	24.67	26.67
T7	60:30:30+5 tFYM	118.67	20.67	41.67	45.67
T8	60:30:30+S20+Zn4.5+5 tFYM+PSB+DAP	104.67	16.00	37.67	38.67
T9	15t FYM	103.33	15.67	33.33	34.33
T10	FP:70:20+2t FYM	85.67	12.33	27.00	27.67
T11	60:30:30+2t FYM+2tGM	90.33	14.67	29.67	28.00
CD @1%		17.71	4.22	8.93	9.17

FP= Farmers practice, GM= Goat manure

#### Long term effect of cotton-fallow and cotton-jowar cropping system on soil aggregation, aggregate associated carbon, soil enzyme activity and CO<sub>2</sub> evolution

Soil samples were analyzed after five years of imposition of integrated nutrient management treatments in a cotton

(*Gossypium hirsutum*)-fallow and cotton-sorghum (*Sorghum bicolor*) system to study the distribution of soil aggregates and aggregate associated carbon as influenced by cropping system and nutrient management in a mixed red and black calcareous clay loam soil (Vertic Ustropept) of Periyanaickanpalayam series at the Central Institute for Cotton Research, Regional

Station, Coimbatore.

Neither the cropping system nor the nutrient management significantly influenced the soil organic carbon (SOC) content. However, the SOC content decreased significantly with depth indicating stratification of SOC. Moreover, neither the cropping system nor the nutrient management significantly influenced the stratification ratio. There was no significant difference in the mean weight diameter (MWD) and percentage of water stable aggregates (WSA) among the nutrient management practices. However, both MWD and WSA in cotton-sorghum system were significantly higher than cotton-fallow system. In the 0-5 cm soil depth, cankers account for 50-59% soil mass. Irrespective of the nutrient management treatments, the maximum soil mass was observed in the micro-aggregate fraction (53-250  $\mu\text{m}$ ) followed by mineral associated fraction ( $<53 \mu\text{m}$ ) and macro-aggregate fraction (250-2000  $\mu\text{m}$ ) and negligible soil mass was observed in large macro-aggregate fraction ( $>2000 \mu\text{m}$ ). In the 0-5 cm soil depth, the maximum SOC concentration was recorded in the macro-aggregate fraction (250-2000  $\mu\text{m}$ ) and the minimum SOC concentration was recorded in the mineral associated fraction ( $<53 \mu\text{m}$ ), which was statistically at par with the micro-aggregate fraction (53-250  $\mu\text{m}$ ). Considering the soil mass as a whole, it was observed that around 54-60% of SOC

could not be accounted in the aggregates. The maximum SOC content was recorded in the micro-aggregate fraction (53-250  $\mu\text{m}$ ) and the minimum content of SOC was found in the mineral associated fraction ( $<53 \mu\text{m}$ ).

Soil dehydrogenase, urease and Fluorescein Diacetate Assay (FDA a measure of the total microbial activity in soil) were estimated in the surface (0-5 cm) soil. The mean soil dehydrogenase activity was maximum 1.69  $\mu\text{gTPF/g soil/24 h}$  with 15t FYM/ha. The dehydrogenase activity was not significantly influenced by the cropping systems. There was no significant difference among the cropping systems and nutrient management practices with respect to the soil urease activity and soil FDA.

Results of a laboratory incubation study revealed that the effect of cropping systems was not significant on cumulative  $\text{CO}_2$  evolution in a period of 30 days. However, nutrient management significantly influenced the cumulative  $\text{CO}_2$  evolution (Fig.26). Application of organic sources of nutrient resulted in significantly higher cumulative  $\text{CO}_2$  evolution over control, whereas the effect of the recommended dose of fertilizer NPK application and control showed a similar pattern of cumulative  $\text{CO}_2$  evolution.

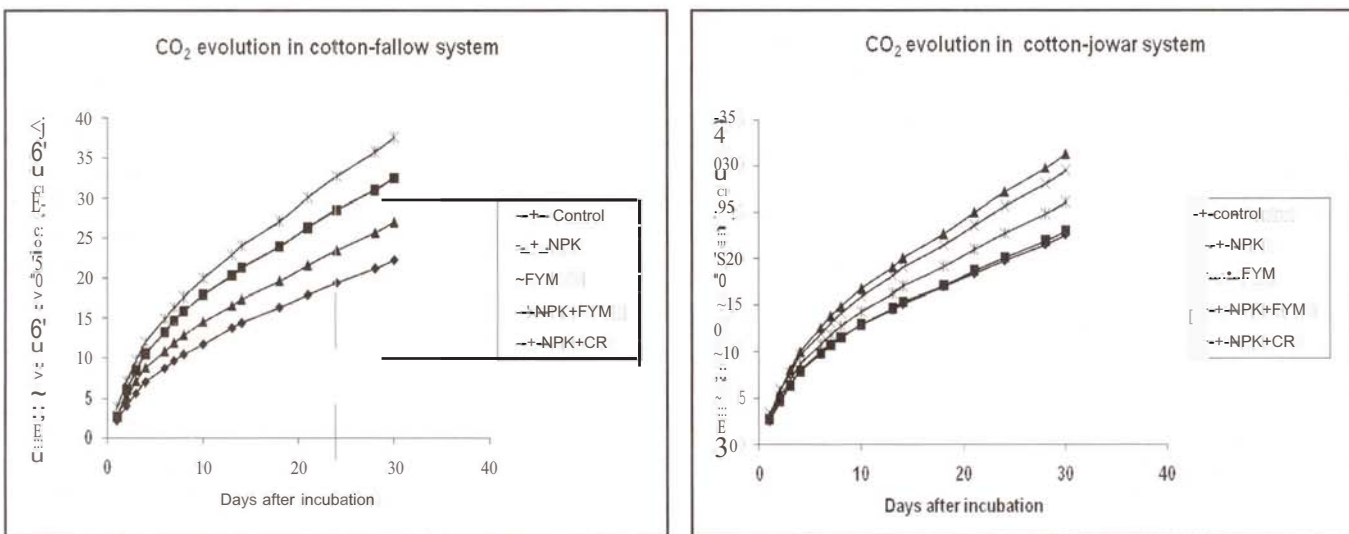


Fig. 26:  $\text{CO}_2$  evolution in cotton-fallow and cotton-sorghum system under different nutrient management practices

#### 4.16: Cotton Simulation Modelling

Simulation of the effect of irrigation and nitrogen on soil water and nitrogen dynamics and productivity and input use efficiency of Bt cotton in a Vertic Ustropept

A generic simulation model INFOCROP was validated using data a field experiments conducted in a mixed red and black calcareous sandy clay loam soil (Vertic Ustropept) of Periyanaickan Palayam series at Coimbatore, for three cropping seasons 2006-07 to 2008-09, to predict the seed cotton yield of RCH2 Bt vs Non Bt cotton. It was observed that the deviation between the observed and simulated seed cotton yield ranged from 6.0 to 34.2% (mean 20.1%) for RCH2 Bt cotton whereas the deviation was from -8.0 to 23.1% (mean 5.8%) for RCH2 Non Bt cotton (Table 19). The root mean square error between the observed and simulated yield for RCH2 Bt was 294.8 kg, which corresponds to 16.1% of the mean observed seed cotton yield. Whereas in case of RCH2 non Bt the root mean square error between the observed and simulated yield for RCH2 Bt was 309.6 kg, which corresponds to 15.3% of the mean observed seed cotton yield.

#### 4.17: Cotton Mechanization

Nagpur

Evaluation of Solar powered knapsack sprayer

In order to overcome the disadvantages of a knapsack sprayer viz., variations in pressure leading to non uniform generation of spray droplet sizes and hence ineffective sprayings and wastage of pesticide and disadvantages of a battery operated sprayer due to long hours of load shedding in rural areas and inability of charging of battery, a novel Solar Operated Knapsack Sprayer has been developed, tested and modified. It has a field capacity of 4 hrs/ha. The weight of the sprayer without pesticide is 9 kg, with a swath of 90 cm giving 10 sprays with a single charge. The sprayer was evaluated for the sustenance of pressure under solar spraying cum charging against the normal battery operated operation. The ANOVA results indicate that the solar operated sprayer sustain a pressure of  $20 \pm 1.0$  psi for a significantly longer time (44%) over the battery operated sprayer, thus generating uniform droplet size spectrum over a longer period of time.

Table 19: Observed and simulated seed cotton yield of RCH2 Bt vs non Bt cotton (pooled over 2006-07 to 2008-09)

Treatment	Observed seed cotton yield (kg/ha)	Simulated seed cotton yield (kg/ha)	Variation (%)
I,N3 Bt	1718	2024	+17.8
I,N3 Bt	1686	1788	+6.0
13N3Bt	1588	1935	+21.9
I,N3 Bt	1736	2330	+34.2
<b>Mean</b>	<b>1682</b>	<b>2019</b>	<b>+20.1</b>
# RMSE = 294.8 (16.1%); O = 0.43; MSEs = 65583; MSEu = 21307			
I,N3 NonBt	1923	1943	+1.0
I,N3 NonBt	1982	1823	-8.0I,N <sub>3</sub>
13NNonBt	1611	1983	+23.1
I,N3 NonBt	1806	2000	+10.7
<b>Mean</b>	<b>1831</b>	<b>1937</b>	<b>+5.8</b>
# RMSE = 309.6 (15.3%); D = 0.32; MSEs = 77773; MSEu = 15587			
# CRMSE =root mean square error; D = index of agreement; MSEs = Mean systematic error; MSEu = Mean unsystematic error			

**Design and Fabrication of prototype of fertilizer applicator as Blade Harrow (bakhar) attachment**

A prototype of fertilizer applicator for blade harrow as an attachment is being developed with a view to save time and labour by combining two operations in one pass especially for the rainfed cotton farmers using bullock power. Rate of application of the fertiliser was found to vary from 70 to 140 kg/ha. Data was collected under laboratory conditions to assess the rate of delivery of the fertiliser and the variation of delivery rates of both the tubes. The ANOVA results indicated that the distribution of fertilizer in the two tynes does not vary significantly when the distribution lever is in the maximum position, discharging an average of 140 kg/ha of fertilizer. However, the distribution is not uniform at minimum and central positions of the lever. Therefore, modification needs to be done in the distributor assembly so that distribution from two tubes is uniform over all the positions of the lever.



**4.18: Morpho-frame/Boll Load Management**

Nagpur

**Bt Morphoframe management using action specific chemicals**

Morphoframes of cotton hybrids viz Bunny Bt & NBt, Mallika Bt & NBt, RCH 2 Bt, MRCH2 Bt, NECH 2RBt, JK CH 99Bt and NCS138Bt were manipulated by spraying 5.7 mM ethylene or 8.56mM at 35-40 DAS(square initiation) or nipping of squares at 35-40 DAS(square initiation). Sudden drop of all the young squares was noticed within 48 hours after foliar spray of ethylene. At the time of spraying itself, all the early formed squares were removed.

Foliar application of ethrel brought about a significant improvement in physiological parameters viz., plant height, leaf area and number of fruiting parts with foliar application of ethylene in the form of ethrel and square removal at 135 DAS. These changes synergistically worked and brought about changes in plant ideotype. There was a positive change in the partitioning of photosynthates to the roots during initial stage and developing bolls in the later stages.

In Bunny Bt, there was a significantly higher seed cotton yield with foliar application of ethrel @ 5.7 mM (19.1 g/pl) followed by T4 (mechanical removal of squares (137.2 g/pl) and the least in control (115.1 g/pl) (Fig. 18). In Bunny NBt the treatment T3 (Ethrel @ 8.56 mM) yielded highest seed cotton yield (138.4 g/pl) followed by T4 (132.5g/pl) and least in T1 & T2 (124.8 g/pl) (Fig 27). Similar results were observed in mallika Bt, Mallika NBt and JKCH Bt.

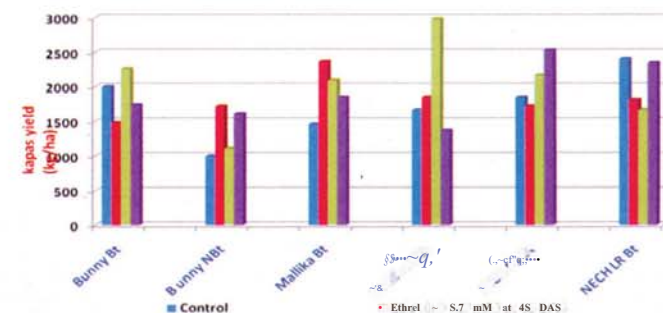


Fig. 27: Response of cotton hybrids to foliar application of ethrel on kapas yield

### Manipulation of morphoframe through nipping at Grand growth stage and mimic the effect using action specific chemicals- Maleic hydrazide

At Coimbatore four genotypes viz., RCH 708 Bt, DCH 32 and Suvin were studied for the effect of maleic hydrazide in comparison to nipping. Detopping at 95 DAS followed by nipping of monopodia and sympodia at 105 DAS yielded the highest seed cotton yield (1850 kg/ha) followed by foliar application of maleic hydrazide (1720 kg/ha). The lowest yield was in control (1253 kg/ha). Application of Maleic hydrazide @ 500 ppm changed the plant morphology with reduced internodal elongation. The LAI improved with better LAD.

At Nagpur averaged across genotypes, detopping at 95 DAS followed by nipping of monopodia sympodia at 105 DAS yielded the highest seed cotton yield (1050 kg/ha) and was on-par with foliar application of maleic hydrazide (1033 kg/ha) and control produced the least (933 kg/ha).

## 4.19: Studies on Abiotic Stress

### Coimbatore

#### Alleviation of water logging stress by foliar application of nutrients in Bunny Bt cotton

In pot culture, water logging was imposed in 30, 60 and 90 day old crop for a period of 5, 10 and 20 days. Modified Hoagland nutrient solution was sprayed during the water logging and recovery period. Water logging for 5 days did not affect the plant height, leaf number and boll weight significantly. However, further increase in water logging duration to 10 or 20 days adversely affected the morphological and yield parameters significantly. The yield was only 40.2 g in plants that suffered water logging continuously for 20 days compared to 60.6 g normal (control) plants which amounts to 34 % yield loss compared to 11 and 23 % in 5 and 10 days of water logging. Nutrient sprays during water logging and recovery period significantly alleviated the water logging stress. About 52.9 g per plant could be harvested in this treatment compared to 47 and 44 g per plant that received nutrient spray during water logging and during recovery period respectively. Water logging during the initial stage of 30 day old crop significantly retarded the morphophysiological characters of cotton. The adverse impact of water logging was reduced with advancement of the crop. For instance, the yield was 36, 48 and 56 and 61 g per plant that were water logged at 30, 60, 90 days after sowing and control respectively, irrespective of water logging duration and nutrient spray treatment.

## 4.20: Fibre Development

### Coimbatore

#### Physiological and molecular elucidation of fibre development process in cotton for enhancing fibre yield

Four enzymes viz., Superoxide dismutase (SOD), Catalase (CAT), Peroxidase (POD) and Ascorbate peroxidase (AOP) were studied from the developing fibre and seeds. The ovules from MCU 5 and its mutant MCU 5 LL were harvested at regular interval (from -10 Days before anthesis to +1.0 DAS) and the assay was conducted.

The SOD activity was maintained around 0.286 units !J.min in both the genotypes from -10 days before anthesis to 6 DM, indicating that SOD activity may not be a rate limiting enzyme in fibre initiation process. The peroxidase enzyme was maintained at around 0.08 to 0.1 throughout the ovule development but the activity was maintained higher (0.004 to 0.01 units!J. min) in lintless mutant in comparison to MCU 5. Catalase activity was maintained relatively high in MCU 5 LL (0.04 to 0.1 units!J. min)

through out the period under study. MCU 5 maintained around (0.02-0.04) till anthesis and drastically reduced with the onset of fertilization. This enzyme might be one of the important enzymes associated with fibre development. Ascorbate peroxidase also maintained similar trend as that of Catalase, indicating a role for this enzyme also.

## 4.21: Socio Economic Dimensions of Cotton Farming

### Nagpur

#### Soil economic assessment of cotton based intercropping system

The data were collected from 150 farmers by proportionate random sampling method from eight villages namely Karanj, Madani, Sevagram and Paonar in Wardha tahsil and Girad, Dhondgaon, Huseinpur and Bhawanipur in Samudrapur tahsil of Wardha district, Maharashtra. The study pointed that there was medium level of awareness of intercropping practices by the farmers while knowledge and adoption of intercropping practices was low level (Fig. 28). Awareness of intercropping of soyabean, mung, urd, cowpea along with cotton among cotton growers was 43.33 %. The values of mean knowledge and adoption scores was 48.02 and 26.06, respectively, while the results of 'z' test indicated non-significant knowledge ( $z = 5.32$ ) and adoption ( $z = 4.37$ ) levels. The major constraints for adoption of cotton intercropping were lack of knowledge and proper understanding in intercropping system. The other bottlenecks were difficulty in intercultural operation, non-availability of seeds of appropriate crop/varieties, farmers mindset, lack of proper understanding on methods of sowing of main and intercrop, fear of more insect attack, labour problem, fear of low yields, stunted plant growth, lack of training and exposure.

The relationship between adoption of cotton intercropping practices and selected farmers socio economic and personal attributes such as education, occupation, land holding, social participation, annual income, awareness and knowledge was examined with Pearson's co-efficient of correlations. The values shows only land holding ( $r = 0.3991$ ) had significant relationship with adoption of intercropping at 1% level while other variables did not contribute towards adoption of intercropping system. Further, adoption of intercropping is more a function of extension and exposure rather than education and income. Multiple linear regression analysis regressing the level of adoption with independent variables indicated that all the selected variables taken together explained 38.4% variation in level of adoption of intercropping practices. It was therefore suggested for taking pro-active sustainable extension intervention by educational activity to train and motivate the growers to adopt cotton based intercropping system.

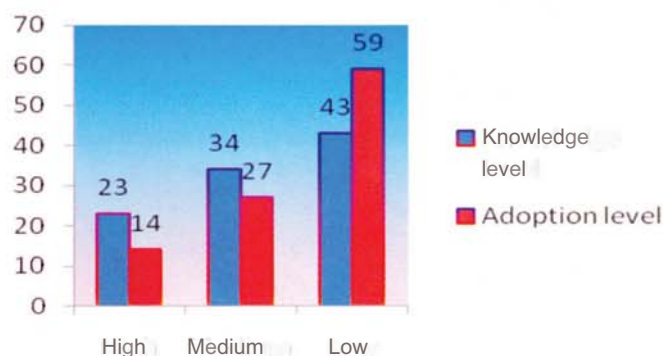


Fig. 28: Knowledge and adoption of inter-cropping practices

### Social dynamics of cotton production in distress areas

The data collected from 200 farmers from eight tahsils of 40 villages in distress district Wardha and non-distress Na-p-r, 20 villages from each district in Vidarbha revealed that m-Jorlt~ of cotton farmers from distress district had high level of alienation from land (73%) as compared to non-distress district (59%), (Fig. 29). The overall alienation was in medium level (Mean score = 59.37). The distress arises due to the feeling among the farmers that the cotton farming has trapped in vicious circle of uncertain rain and drought, repeated cotton crop failures leads to poor financial condition, their work as a farmer is not being rewarded, majority leads stressful life due to unworthy indebtedness and feeling of lost identity in society, no economic/financial support from friends/ relatives during crises and feeling of non involvement in decision making. The study further pointed out that total annual income of farmers is lower than expenditure irrespective of distress or non-distress situation. However, cotton farming is economically viable at growers level as expressed by B: C ratio in distress and non-distress situations, the net returns per hectare was RS.6733/- (B: C ratio 1:34) in non-distress district while Rs.5722/-(B: C ratio 1:1:31) in distress district.. Growing indebtedness (89 & 73% loan) and alcoholism (60 & 50%) among both distress a~d non-distress areas are also seriously increasing. The relationship among the independent variables- annual income, expenditure, income liability gap, family problems, alcoholism, social support with that of alienation found that expenditure (r= 0.3234) and income liability gap (r=0.2816) was positive and significantly correlated with alienation at 1% level in both distress and non-distress districts while alcoholism was significantly correlated at 5% level in distress district.. Annual income (r=-0.2456) and social support (r=-0.2216) was negatively significant at 1% level in distress district while in non-distress districts they were negatively significant at 5% level.. The multiple regression analysis indicated 35.29 and 39.24 per cent variations in the alienation of cotton growers in distress and non-distress district, respectively. Since income from farming was not sufficient to meet their day to day expenditure they expressed dissatisfaction of not being able to increase their income despite their best efforts. Moreover, due to lack of support from development agencies, relatives and friends during crises they are losing interest/enthusiasm in farming resulting in alienation. The study conducted on perception of farmers towards use of pesticide in distress and non-distress shows that farmers have very favorable perception to the positive statements like spraying of pesticide as need based, as per the ETL level and also avoiding frequent sprayings of insecticides. The perception mean index values were 56.64 for distress areas while 68.58 for non distress district

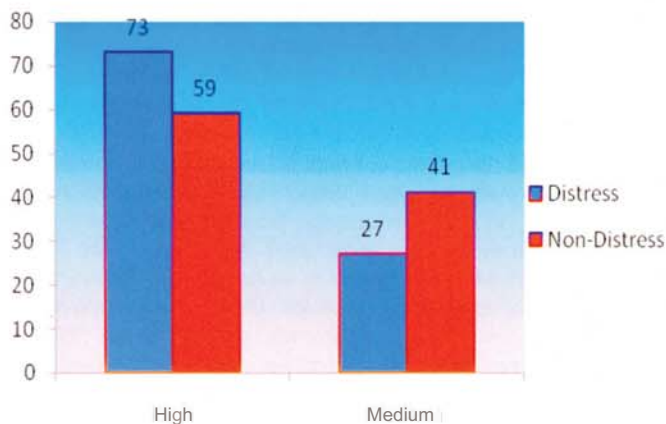


Fig. 29: Farmers alienation from land in distress and Non-distress areas

### Capital requirement for modernization of cotton production on marginal and small farms in Vidarbha

Analysis of the data from 120 small and marginal farmers of Wardha and Nagpur districts of Vidarbha region of Maharashtra indicated that small and marginal farmers of Wardha district are incurring a cost of Rs. 16955 and Rs. 17676/ ha for cultivation of cotton. If they cultivate cotton as per the modern technology they will incur an amount of Rs. 20739 / ha. Small and marginal farmers of Wardha district have only Rs. 5138 and Rs. 6082/ ha owned funds to grow cotton. Thus there is a gap of Rs. 15601 / ha in case of marginal farmers and Rs. 14657 in case of small farmers. In case of Nagpur district small and marginal farmers were using an amount of RS.16344 to Rs. 17583 / ha towards cotton cultivation. As per the survey cotton small and marginal farmers of this district have only Rs. 4599 and Rs 5138 respectively available for cotton cultivation. Thus there is a gap of Rs. 16140/ ha. in case of marginal and Rs. 15601 in case of small farmers towards working expenses.

### Coimbatore

#### Documentation and validation of farmers' indigenous knowledge on farming system approach

To assess the sustainability level of cotton farms under diversified and non diversified conditions, data were collected from one hundred and twenty cotton growers. Comparative analysis between diversified cotton growers (60) and non-diversified cotton growers (60) indicated that the majority of the diversified farmers (66.67 per cent) had high level of economic efficiency than the non diversified farmers (22.33 per cent). Similarly, the diversified farmers (70.00 per cent) had better ecological efficiency than the non diversified farmers (26.67 per cent). Out of the nine economic indicators, the performance of seven indicators was significantly higher in this type of diversified cotton farms than in non-diversified cotton farms. They were production efficiency, employment generation capacity; farm family employment level, net return, technology use level, low cost technology use level and self sufficiency level.. The results showed that the economic efficiency of the system - 'Cotton + other crops + dairy' was the highest. The contribution of dairy activity to the high economic output in diversified farms was significant in terms of milk yielding potential, net return, generation of man days and self sufficiency level.. Similarly, the composite ecological efficiency index of the diversified farms was found to be significantly higher than non diversified cotton farms. The system which had highest ecological efficiency was 'Cotton + other crops + dairy' system. In this system, the dairy activity enabled use of more eco-friendly technologies by the farmers and increased the scope for better organic recycling in the farm.

#### Post evaluation of Farmers Field Schools (FFS) on cotton

Majority of the FFS beneficiaries were more than 45 years in age, middle school level educated, belong to backward class, lived in jointfamily, had 2.7 acres average farm holding, 19 years experience in cotton cultivation, an average annual income of 55,000 INR and highly innovative. The teacher made knowledge test used to compare the changes in knowledge of FFS and non FFS farmers revealed that the beneficiaries had significantly high identification knowledge score (6.97), functional knowledge score (7.11), ecological knowledge score (7.14) and decision making score (8.75) than their counterparts. There were significant changes in their adoption behaviour viz., adoption of more number (5.325) of new varieties and hybrids, weed management (5.83), growth regulators (8.0), number of irrigations (5.9) and marketing behaviour (7.0).. The strong correlation between knowledge level and adoption behaviour proved that a skill-oriented, knowledge intensive and hands-on

education approach was adopted in FFS. High cost, more time consumption, poor involvement of farmers, poor involvement of farm women, inability of the facilitators to provide advanced package of practices in Bt cotton and market intelligence and inconsistency of the farmers in adopting the learnt technologies through FFS are some of the major constraints expressed by the executing agencies.

#### Comparative analysis of conventional, biotech and organic cotton production systems in India

To provide sound information on the environmental sustainability, soil fertility, and safety of organic cotton production system, economic viability, and production increase of biotech cotton production system and about the environmental pollution, high cost of production and low productivity of the conventional cotton production systems, data were collected from 120 Bt cotton growers, 32 conventional growers and 40 organic growers. Survey among the 120 Bt growers indicated that the prevailing major Bt cotton hybrids were RCH 20 Bt, RCH 2 Bt BG II, RCH 708 Bt and Bunny Bt. The average area under Bt cotton area was 1.79 acres and only 23 per cent of the respondents adhered to refuge practice. The attitude towards cultivating Bt cotton was highly favorable and they were willing to continue Bt cotton in next season too. The average cost of cultivation for one acre Bt cotton was Rs.16730/- and average yield was 9.30 q/acre. The major problems faced by them were high seed cost, spurious seeds, less knowledge on location suitability, of hybrids, susceptibility to sucking pests, lack of transgenic in popular varieties and practical difficulties in adopting refuge crop. Survey among the 32 conventional growers revealed that the major cotton varieties hybrids that prevailed in the fields were DCH 32 and Surabhi. The average area under conventional cotton area was 1.02 acres. The attitude towards continuing conventional cotton was highly unfavorable and they were willing to switch over to Bt cotton in next season. The average cost of cultivation for one acre conventional cotton was Rs.17404/- and average yield was 7.20 q/acre. The problems faced by the growers were non availability, and poor quality of seeds, high cost for plant protection, poor adoption of IPM and lack of tolerant varieties and hybrids in the market. Survey among the 40 organic cotton growers revealed that the major cotton varieties prevailed in the fields were MCU 5 and Surabhi. The average area under organic cotton area was 1.62 acres. The attitude towards continuing organic cotton was highly favorable and they were willing to continue organic cotton in next season too. The average cost of cultivation for one acre organic cotton was Rs.14338/- and average yield was 8.35q/acre. The problems faced by the growers were non availability and poor quality of seeds, non availability of organic materials, high cost of inputs, inadequate agencies to guide in getting organic certificates and poor market facilities.

#### An empirical analysis on cultivation of Bt cotton growers with regard to Insect Resistance Management technologies

To have a thorough study on the present status and concerns of end users with regard to Insect Resistance Management technology in Bt cotton, using the constructed attitude scale by Equal Appearing Method, fifty farmers were interviewed. 64.15 per cent of the respondents had highly unfavorable attitude towards cultivating non Bt cotton as refuge crop in Bt cotton fields. The fear of increase in production cost, yield loss, reduction in net gain and troublesome work of spraying separately for non-Bt cotton were the major concerns which compelled them to have unfavorable attitude towards this technology. Majority (68.33%) of the respondents had not adopted the technique as such, some (15.00%) mixed the

seeds and sown, some (8.33%) of them used it for gap filling, few (5.00%) of them cultivated in one or two rows and few (3.34%) persons collected all the non Bt seeds and sown in separate fields. The concerns expressed by them with regard to raising refuge crop were, need of educating all Bt cotton growers to be compliant with all guidelines of insect resistance management technologies through effective modes, justification of time and effort spent for planting the refuge crop in Bt cotton and recommending alternate strategies v;z., natural refuge crop, planting the refuge crop in adjacent fields separately, planting in strips ( in every row one refuge) and planting the Bt cotton without refuge crop.

#### Impact of Bt cotton cultivation on farm economy in India

Two districts namely Guntur and Warangal have been selected for the study pertaining to Andhra Pradesh under South Zone. Data were collected from 60 Bt farmers comprising of three villages v;z., Sakkamuru, Needumukulu and Thullur of Guntur district. 100 per cent of cotton area of sample farms was under Bt cotton. The details about non Bt cultivation was collected from the Bt farmers based on their earlier experience. The average number of sprays got reduced from 9 to 4 with reduction in cost by 48 per cent. The yields of Bt cotton were higher than non Bt cotton by 14 per cent. Human labour was the major input (35 to 40 %) in both the cases with higher share of fertilizers and pesticides in case of non Bt (14%, 36%) when compared with Bt cotton (15%, 24%). Seed cost was higher in Bt cotton (10%) than non Bt cotton (4%). Total cost of production, gross and net returns were higher in large and medium farms when compared with small and marginal farms. Since with the impact on yield, the value of output under Bt cotton is substantially higher, the profit as a per cent of the revenue is also substantially higher in Bt as compared to Non-Bt ( 20 % to 34%). Bt cotton farmers attributed for more profit (72.14 %), less pesticide (52.31 %) and comparatively more bolls (49.15 %) for the choice of Bt cotton.

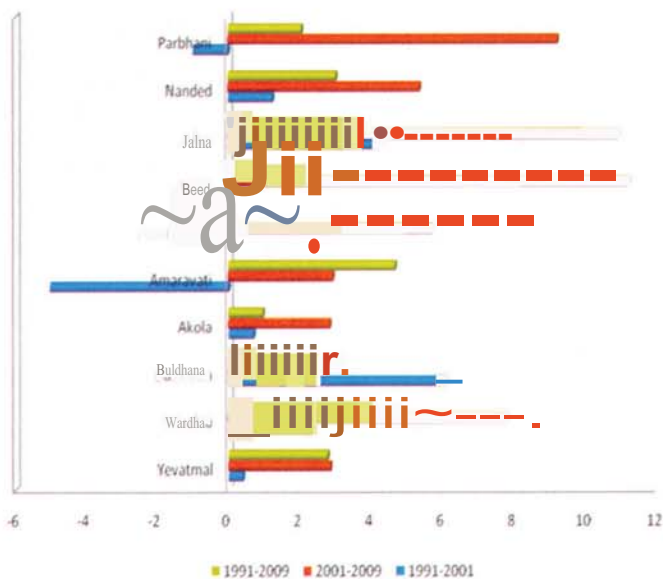
## 4.22: Total factor productivity analysis

### Central Zone:

Data on district level cost of production of cotton, quantities of inputs used in cotton and productivity of cotton were collected from Marathwada Agricultural University, Parbhani and Dr. Panjabrao Deshmukh Krishi Viswavidyalaya, Akola. Data were collected from ten major cotton growing districts belonging to two regions of Maharashtra. The districts for which data have been collected are Yavatmal, Wardha, Buldhana, Akola and Amravati of Vidarbha region and Aurangabad, Beed, Jalna, Nanded and Parbhani district of Marathwada region. Total input, output and productivity indices were worked out for each district using Torniquet-Tehil indexing procedure. Compound growth rates of these indices were worked out and their significance were tested. The analysis was carried out for the period 1991-2001, 2001-2009 and overall period 2001-2009 as per the availability of the data (Fig. 30).

During the first period six districts showed positive total factor productivity growth while four districts showed negative growth. Highest total factor productivity growth was observed in Buldhana followed by Jalna and Wardha. Total factor productivity growth was negative in Amravati, Aurangabad, Beed and Parbhani during this period. During the second period total factor productivity growth was positive in all the ten districts. During this period, total factor productivity growth was highest in Beed followed by Jalna and Parbhani. During the overall period no district registered negative growth of total factor productivity. Highest total factor productivity growth was observed in Amravati followed by Wardha and Jalna.

Fig. 30 :CGR of TFP of cotton in Maharashtra



#### South Zone:

In order to estimate district wise TFP, an attempt is made to collect time-series farm level data from the Government of India sponsored "Cost of Cultivation Scheme. Tamil Nadu is classified into seven agro-climatic zones: north-east, north-west, west, southern, Cauvery delta, high rainfall, high altitude and hilly Zones. Data pertains to the period 1995-96 to 2003-04. The results of TFP of Cauvery Delta zone (Trichy, Karur, Parambalur, Thanjavur, Thiruvarur, Nagapattinam) showed that there exist fluctuations in TII and TOI in most of the years. There exists an inverse relationship between the TII and TOI in the Cauvery Delta zone. Though the inter year fluctuations were seen, the TFP value has increased from 0.87 in 1995-96 to 1.28 in 2003-04. Thus over the years the returns to the cost of cultivation is greater for the cotton crop in the Cauvery Delta zone. Regarding Southern zone (Pudukkottai, Madurai, Theni, Dindigul, Ramanathapuram, Sivaganga, Tirunelveli, Thoothukudi, Virudhunagar), TFP shows a marginal increase from 0.48 in 1995 to 0.55 in 2003. In most of the years, the value of TFP is less than one indicates that the returns in the cotton cultivation is very meager in southern zone. In case of North Eastern Zone (Kancheepuram, Thiruvallur, Vellore, Thiruvannamalai, Villupuram, Cuddalore), TFP over ten years has increased from 1.55 in 1995 to 1.69 in 2003 which shows the better returns to scale for cotton cultivation in the north eastern zone for some of the years. While in the rest of the years TFP value is below one, which indicates that the value of inputs plays a greater role in deciding the output value besides the environment or technological factors. With some fluctuations, the value of output has decreased over the years in case of North Western Zone (Salem, Dharmapuri, Namakkal, Krishnagiri). Though the value of TOI has decreased, the TFP value is more than one in many years which shows higher returns through cotton cultivation. In western zone (Erode, Coimbatore), the value of TII has increased from 0.83 in 1995 to 0.96 in 2003, which explains the increase in the cost of all the inputs over the years. When the value of TOI is concerned it does not change much for 1995-2003. The TFP index has decreased slightly from 0.78 to 0.67 over the years.

#### North Zone:

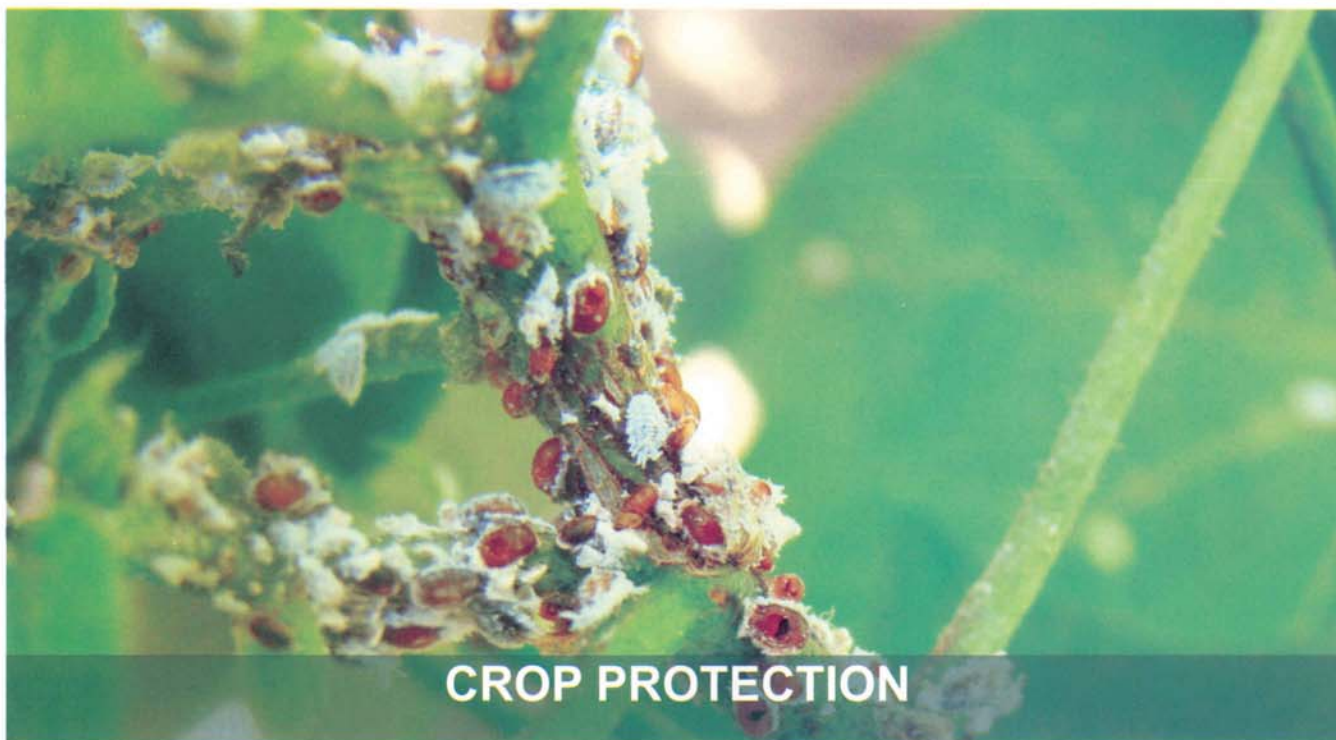
In case of Bhatinda district, based on the input and output data related to cotton crop, the results indicated that growth rates of Total Input Index (TII) showed negative trend during the period 1990-91 to 2007-08. The Total Output Index (TOI) and Total Factor Productivity (TFP) during this period have been showing positive trends as it was indicated by the positive growth rate during this period. The growth rate of TFP during the period 2000-01 onwards increased at higher rate than the period from 1990-91 to 1999-00. In case of Mansa district, the compound growth rate of TII, TOI and TFP decreased during 1990s and increased during 2000s except TII which showed decreasing trend during this period.

## 4.23: Cotton Information System

#### Coimbatore

To strengthen the existing Cotton Information Repository, many new datasets were collected from various sources which are secondary in nature. Appropriate databases were created and also existing datasets were updated. Apart from this, time series data which are quantitative in nature, voluminous abstract datasets were also collected which are lacking in continuity. This abstract information includes both qualitative as well as quantitative information. Beside this, public domain and open access cotton related research as well as popular articles was also obtained. Already some of the articles downloaded from open access and donor articles were uploaded and some were linked to the original source in our portal. With the available datasets in the information repository, web enabled information system on cotton was developed with user friendly tools, which has its own advantage that user has the option to query the information in multi perspective. The software was developed with ASP.NET (2008) for front end and Microsoft Access (2007) as backend. In the back end, the data sets were stored in structured database. ASP.NET framework have been used for forms deployment and ADO data connectivity have been deployed for data transfer from back end to front end and also Crystal Report tools were implemented to generate reports from the queried information also have the option to print the queried data. The software was validated and master copy of the CD version of the above Information retrieval system was developed and replication has to be done for release and distribution to the users.

Two separate sub-domains were created for All India Coordinated Cotton Improvement Project (AICCIP) and Technology Mission on Cotton Mini Mission-I (TMC). The URL for the above projects was [www.aiccip.cicr.org.in](http://www.aiccip.cicr.org.in) and [www.tmc.cicr.org.in](http://www.tmc.cicr.org.in) respectively. The two sub domains were created to have more access to the user and separate indexing were done that user query from the search engine directly fetches the pages of AICCIP and TMC without visiting CICR website. The newly revamped cotton portal developed under web 2.0 technologies and Search Engine Optimization (SEO) tools were introduced. Google Analytics tools in our portal helps in global users to access our site whenever they search any contents related to cotton and also our site will be well highlighted in any search engine. The latest web technologies like content stretch-shrink has been introduced which breaks the monotony of some of the sites. The Farmers' forum was developed and floated on trial basis at CICR portal. The forum was developed using the web tool hypertext preprocessor.



## CROP PROTECTION

### 4.24: Seasonal Dynamics of Insect Pests and Diseases

Nagpur

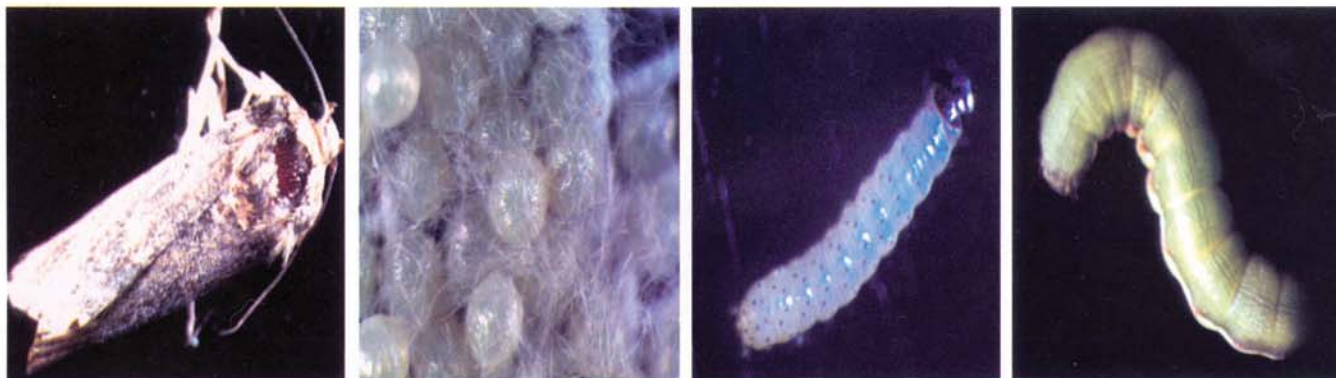
#### Seasonal dynamics of insect pests

Jassid damage exceeded grade II and damage due to thrips, aphids exceeded grade I throughout season on both Bt and non Bt cotton. Mirid population was at a maximum (2.9/plant) during 36<sup>th</sup> Sw. In Bt, maximum jassid population was 4 nymphs per 3 leaves at 40<sup>th</sup> SW and thrips population was maximum at 37<sup>th</sup> SW. Sucking pest incidence was less over the season compared to previous year. Similar trend was observed in case of coccinellids where their presence was dependent on pest population density. Population of mealy bug was negligible irrespective of genotype. Pink bollworm population was negligible till the termination of crop.

Mirid population at different locations during the season showed an increasing trend during 38 to 42<sup>nd</sup> d SW irrespective of the

locations. However, their population was minimum in fields adjacent to fallow land. Spider population also indicated similar trend with increase in population during 38 to 44<sup>th</sup> SW with corresponding increase in mirid population. The spider count was highest in unprotected farm followed by cotton adjacent to road. The corresponding increase in mirid population with respect to decrease in spider population was higher in protected condition due to effect of pesticide application on spider population. Under unprotected condition spider population increased in relation to mirid population. The regression analysis indicated significant increase in spider population with increased mirid population.

The safflower caterpillar *Perigea capensis* was collected as late instar larvae from Hingoli of Marathwada region and Buldana and other areas of Vidarbha, occurring along with *Spodoptera* in Bt cotton fields adjoining soybean in early vegetative stage. Cotton leaves were damaged by larvae in the field. However, larvae did not feed significantly on Bt cotton leaves in the lab as neonates and died at the end of 7 days. Larvae survived on non Bt cotton leaves but neonates gained poor weight.



Adult female moths had a pre-oviposition period of 3 days, egg period of 3-5 days, larval period of 14-17 days and a pupal period of 5 days. Full grown larvae can be confused with the cotton bollworm, *Helicoverpa armigera*.



Beta DNA component of the recombinant strain showed integration of a stretch of 67 bp nucleotide at 738-805 position in f3V4 gene of the previously documented Ganganagar strain AY083590 of CLCuV (Fig.32). Within this stretch of 67 nucleotides, first 22 nucleotides was unique to the new Sri Ganganagar-DC strain while subsequent stretch of 45 nucleotides are conserved in several CLCuV strains. This stretch of 45 nucleotides is also duplicated in the new strain at position 760-805, while in other strains it occur only once within the f3DNA at variable locations. The blast search of the

additional stretch in the database showed 97% identity with Burewala betasatellite, Multan betasatellite and Multan virus CR-recombinant isolates, documented earlier in Pakistan along with other Indian and exotic strains. The integration of this new stretch of nucleotide along with other small stretches within f3DNA has increased the size of this relatively conserved component in CLCuV, from 1350 in (Sri Ganganagar strain, AY083590) to 1436 bp, making the severe Sri Ganganagar-DC strain probably biggest of all documented strains.

**CLCuV Strains**

CLCuV Strains	Difference in the nucleotide sequence in β-DNA
Upward curl	ATTAAAGGGATAAAGTGA-----
Downward curl	AGTAAAGGGATAAAGTGA-----
Enation	ATTAAAGGGATAAAGTGA-----
Sriganganagar	ATTAAAGGGATAAAGTGA-----
Sriganganagar-DC	ATTAAAGGGATAAAGTGA <b>CGATGGAGACGTATTACACGTGGAGTGATTTCTTATTATGTG</b> * *****
Upward curl	-----FGATGGAGACGTATTACACGTGTTGTCA <b>TGTTGGC</b>
Downward curl	-----FGATGGAAACGTATTACACGTGTTGTCA <b>TGTTGGT</b>
Enation	-----FGATGGAGACGTATTACACGTGTTGTCA <b>GGTTGGC</b>
Sriganganagar	-----CGATGGAGACGTATTACACGTGTTGTCA <b>TGTTGGC</b>
Sriganganagar-OC	<b>ATTGTCCATTAAAGGGATAAAGTGA</b> TGATGGAAACGTATTACACGTGTTGTCA <b>TGTTGGC</b> *****

Fig. 32: Additional stretch of nucleotide in β-DNA component of the new recombinant strain of CLCuV

**Coimbatore**

**Occurrence and seasonal dynamics of emerging pests and predators in cotton in Coimbatore district**

Observations on mealybug infestation in 25 farmers' fields of five villages (Meenakshipuram, Elur, Kannamanayakkanur, Vadapudur and Thoppampalayam) revealed that the mean infestation ranged from 23.0 to 42.2 per cent and the intensity of damage ranged from 1.40 to 1.64 grade. The mean infestation of mirid bug ranged from 19.1 to 45.1 per cent and the nymphal population ranged from 9.5 to 22.6 per 50 squares. The predominant predators were coccinellids and spiders. Coccinellids ranged from 22.5 to 39.0 and spiders ranged from 17.5 to 29.8 per 50 plants (Fig. 33).

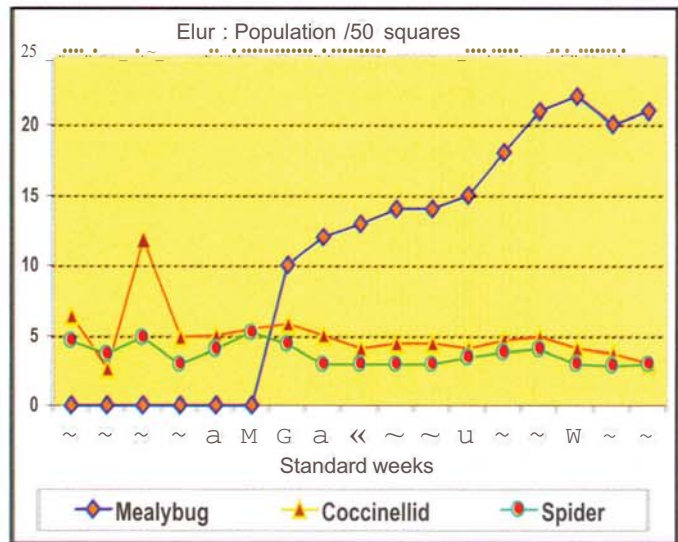
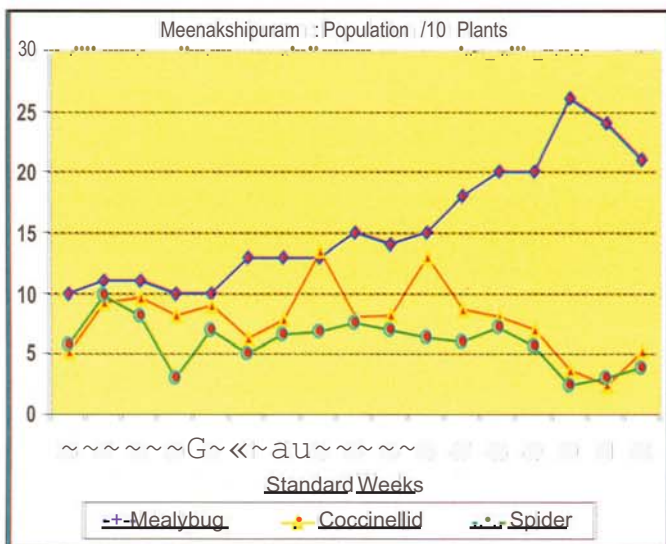


Fig 33: Occurrence and seasonal dynamics of emerging pests and their predators in Meenakshipuram and Elur village

**Population dynamics of cotton pests and their natural enemies**

Jassid population was observed throughout the cropping period in both RCH 2 and Bunny hybrids. A peak incidence of 17.0 per plant was observed on RCH 2 during the first week of December. Mirid bug incidence was recorded during December to January. As compared to Bunny, RCH 2 recorded higher incidence of Mirid bug. Incidence of aphid and whitefly was negligible.

Among the Mealybugs, *Paracoccus marginatus* was the dominant species. The incidence started in both Bt and non Bt Bunny and RCH 2 and the incidence on Bunny was cent per cent as compared to 75% on RCH 2. Well protected crop had a

damage of only 10-15% on Bunny as compared to 100% on unprotected cotton.

#### Population dynamics of Mirids

Adult population of *Creontiades biseratense* appeared during November 1<sup>st</sup> week and continued up to December 3<sup>d</sup> week. Square damage was noticed after adults appeared. Nymphs appeared subsequently on 44<sup>th</sup> standard week (October 2<sup>nd</sup> fortnight) and continued up to 2<sup>nd</sup> week (January 1<sup>st</sup> fortnight). Mean population of adult and nymph varied from 0.05 to 2.15/square and 0.05 to 4.70/square, respectively. Maximum square damage coincided with the peak adult and nymph appearance on 50 and 51<sup>st</sup> standard week. Percentage of square and boll damage varied from 1.31 to 32.38 and 0 to 13.55 respectively. Population of nymphs and adults were in ascending order from 46<sup>th</sup> to 50<sup>th</sup> week (10.04 to 13.85 node stages) and thereafter it declined, same trend was reflected in the percentage of square and boll damage.

#### Determination of sample size for mirid sampling

Field experiment conducted to determine the sample size for sampling mirid bugs showed that top 1/3<sup>d</sup> plant portion harboured more number of nymphs and adults than the middle and bottom portions. When sample size is considered, sample of size of 10 was found appropriate for sampling the nymphs. However, there was no significant difference in the adult population among the sampling size tested.

Population dynamics of cotton mealybug and its natural enemies

Population dynamics of mealybug species viz., *Paracoccus marginatus* and *Phenacoccus solenopsis* were observed under cotton + cowpea intercropping system. *P. marginatus*, alone dominated this season. The Percent Incidence (PI) & Severity Index (SI) of *P. marginatus* ranged from 36 to 96 and 1.109 to

2.375, respectively.

At farmers field, population dynamics of *P. marginatus* and *P. solenopsis* were studied under five cropping systems viz., sole cotton, intercrop with cowpea, surrounded by non-target crop (tomato), cotton field surrounded by weedy road and fallow land with weeds. From 36<sup>th</sup> to 40<sup>th</sup> standard week, there was no mealybug incidence. Less incidence, (SI not crossed 1) of *P. solenopsis* incidence was observed only for few weeks i.e. upto 47<sup>th</sup> week. Regarding *P. marginatus*, among the five systems, cotton field adjacent to weedy road recorded highest mean SI of 2.41, followed by sole cotton and field surrounded by fallow land with weeds.

#### Parasitisation of cotton mealybug

Among the important alternate hosts, *Trianthema portulacastrum* weed recorded high parasitisation (82%) by *Aenasius* sp. Among the different alternate hosts, *Parthenium*, *Abutilon indicum*, *Hibiscus rosa-sinensis* were observed with mealybug incidence throughout the year and served as continuous inoculum. During cropping season (09-10), parasitisation was not observed.

#### Alternate Hosts

Totally 114 alternate hosts including weeds, ornamentals, vegetables and fruit trees were recorded as alternate hosts of the cotton mealybug viz., *P. marginatus* and *P. solenopsis*. Infestation of the mealybug was categorized based on visual observation. Among the host plants, plants belonging to Solanaceae, Malvaceae, Asteraceae and Euphorbiaceae were found to be preferred hosts for cotton mealybug.

#### Growth parameters of mealybug on cotton

Growth parameters of cotton mealybug viz., *P. marginatus* and *P. solenopsis* were observed under laboratory condition.

Table 20: Population growth parameters of mealybug on cotton

Parameter	<i>P. marginatus</i>	<i>P. solenopsis</i>
Gross reproduction rate (GRR)	497	532
Net reproductive rate (Ro)	176.08	157.17
Mean length of generation (Tc)	26.58	30.36
Innate capacity for natural increase ( $r_c$ )	0.1945	0.1665
True intrinsic rate of increase ( $r_m$ )	0.1952	0.1760
True generation time (T)	26.49	28.73
Finite rate of increase (A)	1.2155	1.1924
Doubling time (DT)	3.55	3.94
Annual rate of increase	$9.09 \times 10^{20}$	$7.93 \times 10^{27}$

Where, GRR- Total number of eggs laid per female; Ro- Number of females produced in each generation;  $r_c$  - Capacity of species to increase in number (approximate);  $r_m$  - Capacity of species to increase in number (accurate); Finite rate of increase (A) - number of times a population increases per unit time; T- time taken by species to double its population

The mortality rate was high on first 10 days for *P. solenopsis* and 6 days for *P. marginatus*. *P. solenopsis* adults started laying eggs after 28 days and ceased after 32<sup>nd</sup> day. *P. marginatus*, started laying eggs after 24 days and ceased after 28<sup>th</sup> day. The capacity for increase was slightly less than the intrinsic rate of increase indicating that the population was tending towards overlapping generation.

#### Pest status of IRM village at Coimbatore district of Tamil Nadu

The population of sucking pests, natural enemies and bollworms during the season in IRM project villages was monitored at weekly intervals.

#### (a) Sucking pests

Sucking pests viz. aphids, jassids, thrips and whitefly population were below threshold level and averaged ~.58, 1.75, 0.88 and 0.14 and 2.57, 2.71, 1.47 and 0.02 /3 leaves in IRM and Non IRM villages respectively. The mirid bug population was observed in all the project villages and averaged 0.90 and 1.84/ ten squares in IRM and Non IRM villages respectively. The mealy bug population was recorded in all project villages and averaged 0.19 and 0.41 in IRM and Non IRM villages respectively.

#### (b) Natural enemies

Natural enemies viz coccinellids, spiders and *Chrysopa* averaged 0.32, 0.18 and 0.08 per plant respectively in IRM villages, whereas it was 0.09, 0.03 and 0.02 in non-participatory villages.

#### (c) Bollworm incidence and damage

*H. armigera* larvae ranged from 0.01 to 0.16 and averaged 0.05/plant and the pink bollworm larvae averaged 0.04/plant in IRM project villages. The average percentage of green boll damage, open boll damage and locule damage per plant were 5.13, 8.12 and 15.09 respectively.

#### Sirsa

#### Ecological studies on changing scenario and seasonal dynamics of cotton entomofauna and diseases.

In North, cotton recorded the presence of a single species of mealybug ie, *Psolenopsis* Tinsley. When sampled parallel to the source, infestation level of *P. solenopsis* Tinsley was highest in fields along the water channel (12.50 to 15.50%) followed by fields on the roadside (9.00 to 12.65%) and clean fields (3.90 to 5.50%). When sampled perpendicular to the source, infestations levels recorded was relatively lower: fields along water channel (6.20 to 9.05%) followed by fields along roadside (4.90 to 10.10%) and clean fields (2.40 to 3.47%). For mealybug, a sample size of 25 to 50 plants per acre were sufficient in fields with known source of infestation such as roadside, weeds and water channels. However, a sample size of 100 plants per acre is necessary for clean fields where prior knowledge of mealybug damage is not available. The reduction in yield of cotton plants was estimated to be 14.87, 30.09, 34.53 and 51.86 per cent for Grade I, II, III and Grade IV mealybug damage levels, respectively during 2009. Bioecology of

mealybug was studied. 51 alternate hosts found in cotton-wheat cropping system. *Aenasius bambawalei* a potential parasitoid parasitized mealybugs up to 73.36 % during 38 SWat on-farm trial.

## 4.25: Biological Diversity of Insect Pests and Pathogens

### Nagpur

Taxonomic bio diversity of cotton entomofauna was documented through record of eleven species of Hemipterans - one of Lygaeidae, three of Miridae, four of Pentatomidae and four of Pseudococcidae, viz., *Phenacoccus solenopsis*, *Maconellicoccus hirsutus*, *Nipaeococcus viridis* and *Paracoccus marginatus* were recorded infesting cotton in different cotton growing zones of the India during 2009 crop season. *P. solenopsis* was the sole species that dominated cotton-wheat and cotton + pigeon pea-fallow system of North zone and Central zone respectively while, *P. marginatus* was dominated in cotton+ pulse-maize cropping system of South zone. Mealybugs *M. hirsutus* and *N. viridis* were observed in negligible number in central cotton growing zone. Two species of Hymenopteran parasitoids viz. *Aenasius bambawalei* and *Metaphycus* sp. on *Psolenopsis* and *Promuscidea unifasciiventris* recorded on *N. viridis* were documented in Central zone. Coccinellids - *Brumoides suturalis* (F.), *Cheilomenes sexmaculata* (F.) *Scymnus coccivora* and *Cryptolaemus montrouzieri* on *Psolenopsis* were documented as predators while *Gitonides perspicax* Knab (Drosophilidae: Diptera) was recorded as predator on *N. viridis* / *M. hirsutus*.



*Metaphycus* sp.



*Promuscidea unifasciiventris*



*Gitonides perspicax*

Genetic diversity of the cotton jassid, *Empoasca devastans* - Primers were designed to amplify, the COI, COII and NADH 2 regions of the mitochondrial genome of the Indian cotton jassid.

Primers that amplify COI region of Indian cotton jassid (700bp):  
 Forward primer 5' GCTCAACAAATCATAAAGATATTGG 3' 25bp  
 Reverse primer 5' TAAACTTCAGGGTGACCAAAAAATCA 3' 26bp  
 Primers that amplify COII region of Indian cotton jassid (700 bp):  
 Forward primer 5'TAGTA TGGCA GATTA GTGCAATGAA3'  
 Reverse primer 5' CCNCAAATTT CNGAN CATTG ACCA 3'  
 Primers that amplify NADH1 region of Indian cotton jassid (800 bp)  
 Forward primer 3'CCNTCAGAAAAATCAAANGG 5'  
 Reverse primer 3'GAGTTCAAACCGGCCTAAGCCAGG

An annealing temperature of 50.8°C was used for COI; 60°C was used for COII and NADH2 in PCR reactions. Sequencing data is being subjected to analysis.

#### Host profile of *P. solenopsis* at cotton+pigeon pea cropping system

Though the infestation was not alarming in most of the fields, the host range under rainfed cotton +pigeon pea cropping system was much broader. During current year 2009-10, surveys conducted in cotton field during off season and as well as cotton season, a total 68 hosts were recorded across 26 families out of

which 58 were botanically identified. Cumulatively 106 host plants were recorded spreading across 27 families. Out of total host plants families viz. Asteraceae, Malvaceae, Leguminaceae, and Solanaceae constituted 51% of host plants of *P. solenopsis*. In year 2009-10 these families constituted 47% host range. The major families of host with severe infestation and wide host range were Asteraceae, Malvaceae,

Leguminaceae, Solanaceae, Fabaceae, Amaranthaceae, Euphorbiaceae, Poaceae, Labiateae and Apiaceae. Various biotic and abiotic factors regulated the population of *M. hirsutus* and *N. viridis* in central zone that showed narrow host range compared to *P. solenopsis*.



#### Genetic diversity in *Fusarium* species infecting cotton

Diseased cotton plants showing typical *Fusarium* wilt symptoms were collected from various cotton growing areas of India. A total of 29 different isolates of *Fusarium oxysporum* made from the infected plant samples were categorized on the basis virulence, species specificity, growth, pigmentation etc. SSR primers were designed and synthesized from SSR motifs of nine different loci of *Fusarium* genome. Polymorphism obtained with 9 SSR primers used for characterization and diversity analysis clearly showed the genetic diversity in various isolates of *F. oxysporum*. Based on similarity index, these 29 isolates were grouped in 4 major clusters and cluster A was further sub divided in to A 1 and A2. Isolate No. 16, 17, 22 and 26 were most diverse. Genetic variability among the pathogen populations for discriminating different isolates of *Fusarium* within species was clear. Further, the work on correlation of various characters of the fungus with different SSR alleles is in progress.

#### Diversity and distribution of cotton leaf curl virus (CLCuV)

Leaf samples showing symptoms of virus infection with and without enation were collected from North India and were subjected to PCR diagnosis using coat protein gene specific primer of CLCuV and it was observed that the plants were infected with CLCuV with a new type of symptom (i.e. without enation) which was identified as a new severe strain of the CLCuV (Rajasthan-DC). The new strain is a recombinant with elements of several destructive Pakistan strains, including *Burewala*, *Khokran*, *Multan* strains. The strain knocked down the resistance of hitherto resistant cotton RS810, RS875, RS 2013, F1861, LHH144, LHH2076 including the prominent RCH 134 BG-II cotton. The new strain of the virus predominantly caused downward curling of lamina without prominent enations, unlike earlier strains that showed upward curling and frequent enations on infected plants. Complete genome comprising DNA A and [3-DNA sequences was determined (DNA-A, HM037920; [3-DNA, HM 037921) and prominent variations from previously reported strains were documented.

#### Morphological variation in *Alternaria* leaf spot pathogens:

Leaf spot showing typical symptoms of *Alternaria* were collected from various cotton growing areas. Twenty eight isolates made from these infected leaf samples revealed the presence of three distinct species of *Alternaria*. Out of these 28 isolates, 12 isolates were of *A. macrospora*, 6 isolates of *A. alternata* and 10 isolates of *A. gossypina*. Distinct variability in sporulation, spore

types, growth pattern and pigmentation was observed in the cultured isolates of *A. macrospora*, *A. alternata* and *A. gossypina*.

#### Protocol for lifecycle studies and sampling techniques for mealybug and mirids

Developed simple protocols for lifecycle studies on mealybug and mirids in cotton to develop insect phenology based simulation models. Sampling techniques and sample size for mirids *Campylomma livida* have been devised. Top 1/3rd plant portion of plant (Bunny Bt) harbored more number of nymphs and adults than the middle and bottom portions. Sample of size of 10 per acre was found appropriate for sampling the nymphs (Fig. 34).

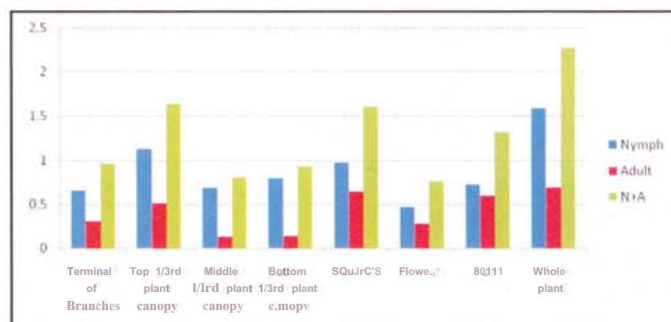


Fig. 34: Mean seasonal counts of *C. livida* nymphs and adults (2009-10)

#### Developmental studies of *P. solenopsis* at 4 constant temperatures

Developmental rates of *Psolenopsis* at constant temperatures viz. 25, 27, 30 and 32°C were studied in central zone. The fecundity was maximum (434.4 eggs + crawlers) at 25°C and found decrease with increase in temperature. The number of eggs observed perfemale showed an increasing trend (Fig. 35).

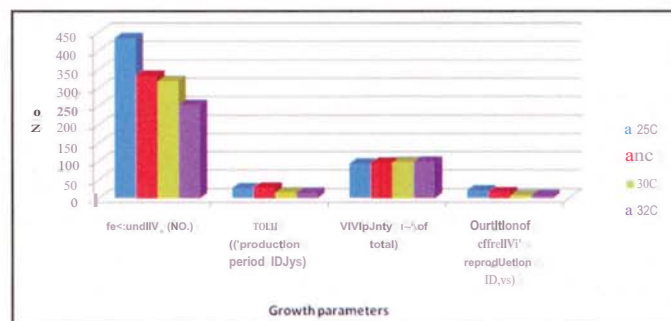


Fig 35: Behavior of Mealybug *P. solenopsis* on some growth parameters

#### Coimbatore

Soil and root samples were collected from the rhizosphere of Bt and non Bt cotton to assess the impact of Bt cotton on soil nematode community at different stages of growth. Based on total number of nematodes in each genera, number of nematodes in different genera and total number of genera richness, different indices viz., Shanon Weiners diversity index, Species richness index, Maturity index and Fungivore to bacterivore ratio were calculated. The results revealed that there were not many differences in indices between Bt and non Bt cotton. But differences were recorded in different stages of growth and depth. In general, flowering recorded maximum population of plant parasitic nematodes. An experiment was conducted to find temporal and spatial distribution of nematodes mainly to standardize the optimum distance and depth to collect

soil samples from farmer's field. Soil sample collected from 15-45 cm near root zone yielded maximum number of nematodes.

An experiment was conducted under micro plot condition to study the pathogenicity of reniform nematode in Bt cotton and to work out Economic Threshold level (ETI) for reniform nematode in Bt cotton. Plant growth parameters were negatively correlated with initial nematode inoculum. Final nematode population increased with increase in initial inoculum to a particular level there after it started decreasing. Based on plant growth and other parameters, ETI for reniform nematode was two nematodes/gm of soil.

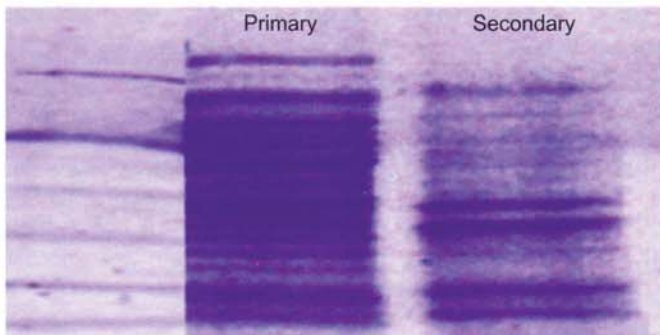
## 4.26: Isolation and Identification of New Genes and Gene Sources for Pest Management

### Nagpur

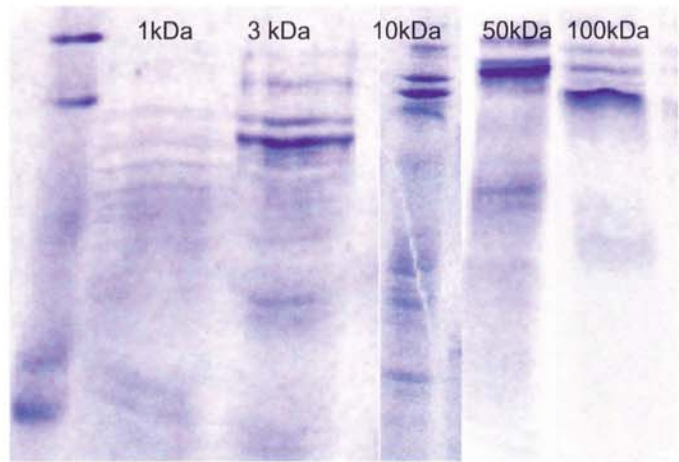
Isolation, identification and characterization of insecticidal toxins in heat tolerant Entomopathogenic nematode-bacterial system with elucidation of factors regulating toxin production

### Toxin isolation

The insect mortality is attributed to potent complex of insecticidal toxins released largely by the bacterial symbiont of entomopathogenic nematode. For isolation of toxins, the bacteria in two phases was cultured on IB broth for 48 hrs on shaker. Extracellular and intracellular fractions were separated by centrifugation and sonication. Protein profile of two phases of the bacterium was resolved on native and SDS PAGE. Comparison of protein profiles of primary and secondary phases revealed several unique bands of proteins that were present in the former but were either missing or expressed in lower concentrations in the latter.



Different fractions from the extracellular and intracellular components of both the phases of bacterium further separated using columns, centrifugal devices and gel filtration were bioassayed against 3<sup>rd</sup> instar larva of *Helicoverpa armigera* for insecticidal activity. Individual fractions at three different concentrations were (5, 10 and 15jJg) were injected into haemocoel of 3<sup>rd</sup> instar *H.armigera* larvae. Control was maintained with *H.armigera* larvae injected with physiological saline solution. Observations on insect mortality after 24 hrs revealed that fraction 50 -100 kDa at 10jJg recorded more than 98% mortality after 24 h while 10K fraction recorded 60% mortality. In other fractions mortality was recorded after 48 hrs only while in control there was nil mortality up to 48 hr, These fractions were also evaluated for oral toxicity with *H.armigera* neonates. 50 -100 kDa fraction was also recorded to have oral toxicity. This fraction was run on native PAGE and individual bands were cut, eluted in buffer (140 mM NaCl, 2,7 mM KCl, 10mM Na<sub>2</sub>HP0<sub>4</sub>, 1.8 mM KH<sub>2</sub>P0<sub>4</sub> pH 7.3) and analysed for insecticidal activity.

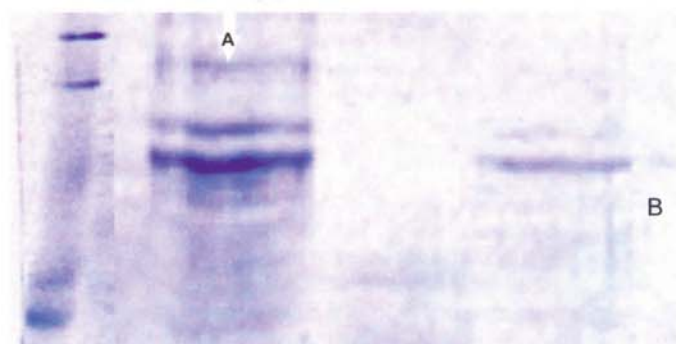


The eluted bands were applied to artificial diet to test for oral toxicity to *Helicoverpa armigera* neonates. These were also injected in intrahaemocoelic for toxicity to *H.armigera*. Results indicate that two bands of approximately 950kDa had insecticidal effect. ID<sub>50</sub> for A band was calculated at 0.1 jJg while ID<sub>50</sub> for B band was 0.12 jJg. At concentration of 0.18 jJg injected in haemocoel mortality ranged between 89-87%. Oral toxicity to neonates of *H. armigera* was also recorded. At 0.05 jJg oral toxicity to neonates was recorded with 78-85% mortality of neonates.

### Intrahaemocoelic toxicity of different fractions of 50-100 kDa



At 0.02 jJg, neonates recorded very slow growth with cessation of further development. Resolution of A protein on 10% SDS PAGE revealed the presence of 3 units with 160,80 and 21 kDa while B protein recorded 70 and, 48 kDa. Amino acid profiling of these indicated following profile.



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

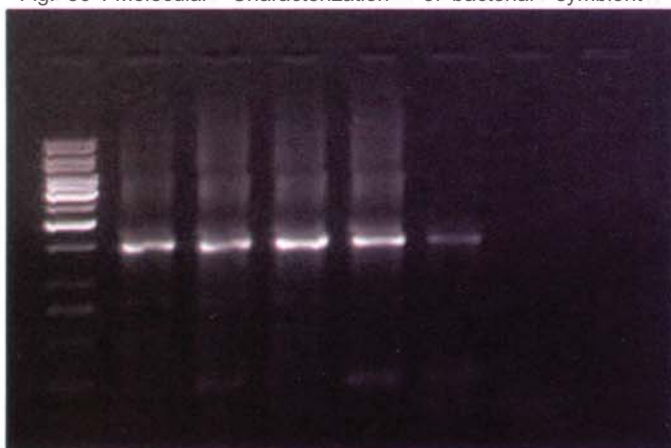
The bacterial symbiont (nonluminescent variant of *Photorhabdus luminescens*) of thermotolerant isolate of EPN *Heterorhabditis indica* developed was taken up for cloning and characterization of potent toxin gene. Toxicity to insects is largely due to toxins produced by bacterial symbiont.

The colony characters on nutrient agar, NBTA and McConkey agar were used for preliminary identification. Primary colonies were generally smaller and more complex. The two forms were distinguished by the following features. On McConkey agar, primary colonies appeared purple blue/ red or bright pink. Secondary colonies were light gray. On NBTA, primary forms were recorded to be green with or without red/ brown/ rust colored center. On nutrient agar, colonies ranged from creamish, yellowish or offwhite acquiring reddish color after 2-3 days.

The bacteria isolated were found to be motile, medium to long rods gram negative anaerobes with peritrichous flagella forming spheroblasts in older cultures.

For molecular characterization of bacterial symbiont, 16s ribosomal RNA was amplified. The sequence amplified was around 1550 bp and it is being cloned for further sequencing (Fig. 36).

Fig. 36 : Molecular Characterization of bacterial symbiont



16s ribosomal RNA sequence of bacterial symbiont was amplified using oligonucleotide primers (5'GGA GAG TTA GAT Cn GGC TC3' sense and 5'AAg GAG GTG ATC CAG CCG CA3'. The sequence amplified was around 1550 bp and it is being cloned for further sequencing.

DNA from primary and secondary phases of *Photorhabdus* has been isolated and quantified for further work.

### Designing of Primers

Five primer pairs were designed by identifying 8-10 amino acid stretch in protein that is rich in amino acid codes by only one or more codons (Met, Trp, Phe, Cys, His, Lys, Asp, Gly, Gin, Tyr) and that has no or few amino acids coded by six codons (Ser, Leu, Arg). Primers were also designed by aligning known toxin sequences from databases.

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

Development and identification of novel bioassays for sucking pests and new lectins for control through transgenic plants.

Fifteen lectins, were tested for their toxicity to whiteflies, aphids and jassids using novel artificial diets and bioassay systems that were developed and validated at the institute. The bioassays, were repeated six times in separate assays for repeatability and reliability of performance for aphids, jassids and whiteflies. Median lethal doses from six sets of bioassays with aphids, were deduced to decide upon the most effective lectins that could be used for the development of transgenic plants. Three sets of jassid and whitefly bioassays were conducted with fixed doses of 10 ppm, and for log dose probit assays using a range of concentrations. Amongst 15 lectins tested, AMTL and CEA were the most toxic on aphids with LC<sub>50</sub> values of 2.2 and 3.9 ppm respectively. CEA, Banana lectin and artocarpin were most toxic to jassids, and AMTL, CEA, Banana lectin and peanut lectins were the most toxic to whiteflies at a range of 1.1-3.3 ppm causing >90% mortality within 72 hours. The genes of the four lectins, were incorporated into plant transformation vectors for the development of sucking pest resistant GM cotton.

### Commercialization of Molecular Diagnostic tools

Five diagnostic primers designed based on specific genetic signatures of *Alternaria macrospora*, *Rhizoctonia bataticola*, *R. solani*, *Ramularia areola* and *Myrothecium roridum* were developed during first phase of the TMC MMI. The pathogens were detected in polymerase chain reaction (PCR) using the genomic DNA as templates. However, for effective development of molecular diagnostic tools in decision support system for sustainable agriculture, the protocols should be robust enough for *in situ* detection of pathogen within the sources viz., infected plant materials, soils etc. The detection of the pathogen within their sources of perpetuation and perennation is highly complicated. The problem is exacerbated by the presence of large number of inhibitors of PCR within these sources. Under such circumstances modification of standard protocols was required to make them amenable to detect pathogen right within the sources. Some of the potential inhibitors present in the soil and plants include SDS, ionic detergents, phenol, ethanol, humic acid, tannic acid etc. These are also the components that are introduced in to the reaction while processing the samples for PCR. The efficacies of some of the chemicals in ameliorating the effect of PCR inhibitors in the reaction or when the source materials were directly used for detection of the pathogens were evaluated.

Substitution of BSA in PCR enhanced the efficacy of amplification and detection of pathogens in the infected plants or in soils. The efficiency of detection of CLCuV within the infected cotton or *Alternaria macrospora* in the infested soil was improved by addition of BSA in the reaction mixture @ 0.2% and or glycerol @2%(Fig.37a&b).

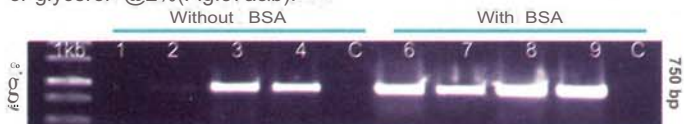


Fig. 37a. PCR Detection of CLCuV in infected cotton through amelioration of PCR inhibitors with BSA. Lanes 1-5: Plant genomic DNA without BSA; Lanes 6-10, with BSA (0.2 %)



Fig. 37b. PCR Detection of CLCuV in infected cotton through amelioration of PCR inhibitors with increasing concentration of Glycerol. Lane1, Marker; lanes 2-9, 0.2 - 2.0% of Glycerol

Combined application of BSA (0.2%) and glycerol (2%) in the PCR reaction enhanced the efficiency of detection of *A. macrospora* in soil by 40% and 80%, respectively (Fig 38, a & b).



Fig.38 a&b: Increase in efficiency of PCR detection of *A. macrospora* with 0.2% BSA- a & 2% glycerol b.

Experiments with PCR inhibitors showed that phenol and humic acids, common contaminants in soil or DNA sample drastically affected the success of PCR causing failure in the amplification and detection of pathogen. Strains of *R. solani* could not be detected at humic acid concentrations above 0.02 % (Fig. 39 a).



Fig. 39 a: Effect of increasing concentrations of Humic Acid in PCR amplification & detection of *R. solani*. Lane 1, Marker; Lanes 2-8, humic acid from 0.004%-0.03%

The problem was however mitigated by substitution of 2 % glycerol in the reaction mixture (Fig. 39b).

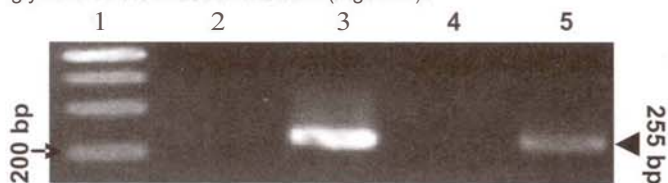


Fig.39 b; Effect of Glycerol on PCR inhibition of *R. solani* caused by humic acid. Lane 1 & 3, 0.02% & 0.04% of humic acid; Lanes 2 & 4, 1.4% & 2.8% of Glycerol substituted in reaction along 0.02% & 0.04% humic acid

Similarly addition of BSA in the range of 0.2% - 0.4 % mitigated the inhibitory effects of humic acid in PCR amplification of strains of *Rhizoctonia solani* (Fig. 40).

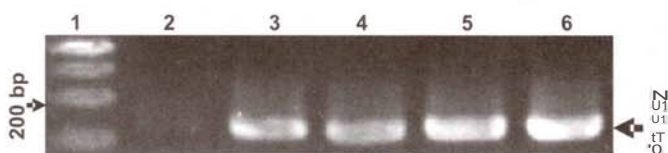


Fig.40: Effect of increasing concentration of BSA on overcoming the effect of 0.02% humic acid in PCR amplification & detection of *R. solani*. Lane 1, Marker; lanes 2-6, 0.2%-0.4% of BSA.

Combined substitution of BSA (0.2%) and glycerol (1.2 %) in a reaction containing 0.02% humic acid greatly improved the efficiency of PCR detection of *R. solani* (Fig. 41).

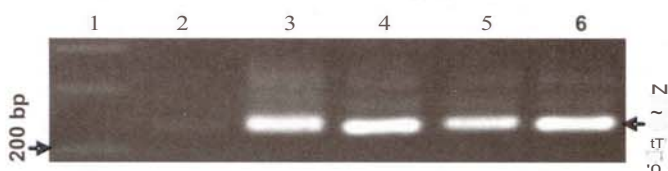


Fig. 41: Effect of combined application of BSA(0.2%) & Glycerol (1.2%) in overcoming the effect of humic acid (0.02%) in PCR amplification of *R. solani*. Lane 1, Marker; lane 2, humic acid alone; lanes 2-5, 0.02% humic acid + 0.2% BSA + 1.2% Glycerol

Contamination of phenol (0.4- 4%) in PCR reaction drastically affected detection of *A. macrospora*. Substitution of 0.2% BSA and 2% glycerol in the reaction mixture containing 2% phenol completely reversed the effects of phenol resulting in detection of the pathogen.

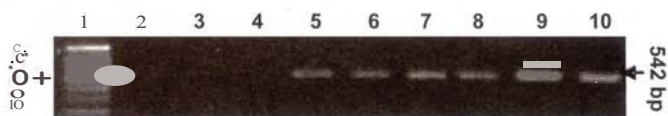
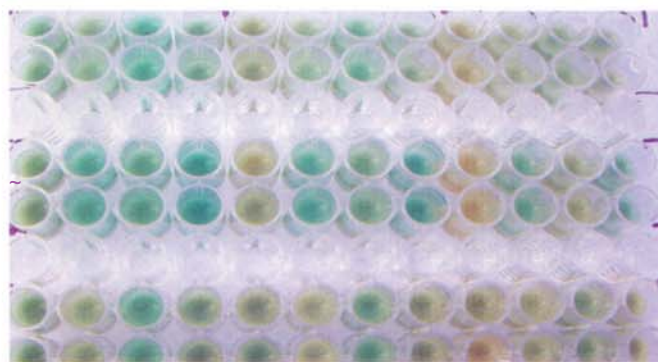


Fig 42: Effect of Phenol on PCR inhibition & its mitigation by BSA & Glycerol. Lane 1, Marker; lanes 2-4, 1.2%, 1.6%, 2% Phenol; lanes 5-7, 0.2% BSA+2% Phenol; lanes 8-10, 2% Glycerol+2% Phenol

#### Development of Immunodiagnostic kits for new Cry toxins and Bt cotton

Cry1C and Cry1B antigens were purified to apparent homogeneity (>99%) using sequential column chromatography and used for the development of polyclonal antisera through immunization and four boosters were administered. The antisera were tested and ELISA kits were developed. The ELISA and Immunochromatographic 'dipstick' kits developed against pat and NPT-II to detect GM crops with kanamycin and bialophos resistance and Cry1F were validated independently at Innovative Bioscience, Nagpur. The sensitivity of the strip was at a minimum detection level of 1ppm for NPTII and 2-3 ppm for PAT. 'Gus detect', a rapid 10 minute colorimetric test developed to detect GUS marker of Cry2Ab in BG II for UID-Awas validated by NBPGR and commercialized. More than 1000 kits have been used by various stakeholders last year. Three different formats of ELISA kits were developed for the detection of Cry 1C and Cry 1B and were validated for their stability.



## 4.28: Host-Plant Resistance to Insect Pests and Diseases

### Nagpur

#### Host plant resistance to insect pests

Out of 382 lines sown during 2009-10, 10 lines (F3-30, F4-10, F5-63, F6-17, F7- 34, Backcross F4-27, Cultures-35, TWC back cross F4- 82, SV lines-42, Germplasm lines-42) were found tolerant to sucking pest, and bollworms with earliness (150-155 days) and good yield viz., 8 x suvin (B) D 2, 6 x 20 (C), 13 x 2 (B) V, Code 1150 I, Code 420 (A), Code 426 (A), Code 446 (A), 16x74A x 8, 3917x74A(B)x8 B,L-11 (A)x7x(A(B))x8.38 lines were found to yield the highest with a moderate duration of 165 days.

#### Evaluation of representative genotypes of released transgene events against Spodoptera

Five rows (comprising of 250 plants of each genotype) were

raised under unprotected condition in the field- Bunny, Bunny Bt, Bunny BG II, Rasi 2, Rasi 2Bt, Rasi 2 BGII, JK Ourga, NCER 3, BN, BN Bt, NHH 44, NHH 44 Bt. While Bollgard II genotypes carrying MaN 531+Mon 15985 events were significantly superior to single gene products in the lab against 2 day old *Spodoptera* larvae, in a 7 day bioassay, it was still insufficient for 100% larval mortality, except in the case of Rasi 2 BG II. BN Bt (variety) was superior to NHH 44 Bt (hybrid) against *H. armigera*, field tolerant strain (Bhavnagar) in lab assays. None of the genotypes with MaN 531 event resulted in 100% mortality of *H. armigera* (field tolerant strain) in the lab. BGII genotypes were slightly superior to BG against *H. armigera* field tolerant strain (FTS). NHH 44 Bt offered about 13% higher mortality over its non Bt counterpart on FTS strain of *H. armigera* while BN Bt offered 70% higher mortality over its non Bt counterpart.



*Spodoptera* adult

*Spodoptera* larva

#### Identification of bacterial blight and grey mildew resistant genotypes in upland cotton

For evaluation of advanced cultures 1 lines of upland cotton for resistance to bacterial blight and grey mildew under field condition, most virulent and predominant race 18 of *X. a. pv. malvacearum* isolated from bacterial blight leaf samples and leaf infusion made from grey mildew infected leaves was used as spray inoculation.

Hundred and five lines with bacterial blight and grey mildew resistance were selected from the population involving resistant lines as donor parents. These lines were also observed to be superior in plant quality parameters. Fifteen bacterial blight and grey mildew resistant cultures have been identified with better plant quality parameters. These cultures were superior in yield as compared to local check LRK 516. The seed cotton yield of 35.7-60.7 g/plant was recorded in these cultures with an average boll weight varied from 2.26 - 3.88 gm/boll and 12.54 21.58 bolls/plant.

Out of 329 lines of *G. hirsutum*, 56 lines were resistant for bacterial blight and 15 lines were resistant to grey mildew under

Table 21: Locule damage (%) in different Bt hybrids

Cultivars	90 DAS	105 DAS	120 DAS	135 DAS	150 DAS	Mean
RCH 2 Bt	0.00 (0.48)	0.00 (0.48)	1.88 (5.74)	0.63 (2.63)	1.88(5.74)	0.88 (4.23)
RCH 530 BG II	1.88 (5.74)	2.50 (6.70)	6.07 (14.10)	4.20 (10.04)	3.44 (10.44)	3.62 (10.75)
RCH NBt	11.19 (18.72)	11.32(18.88)	32.68 (33.68)	16.25 (22.40)	40.72 (39.39)	22.43 (27.50)
MRC 6918 BG II	0.63 (2.63)	7.41 (11.56)	5.51 (13.51)	2.50 (7.90)	3.04 (8.74)	3.82 (10.61)
MRC 7201 BG II	0.63 (2.63)	3.75 (9.81)	3.72 (9.77)	2.19 (6.13)	3.13 (10.05)	2.68(9.11 )
MRC 7201 NBt	15.13 (22.42)	14.32 (21.67)	26.26 (30.56)	22.12 (25.86)	53.36 (47.02)	26.24 (30.19)
Bunny Bt	0.00 (0.48)	0.00 (0.48)	3.69 (9.73)	1.88(6.94)	1.24 (4.76)	1.36 (5.24)
Bunny BG II	2.50 (6.70)	5.00 (10.80)	5.51 (11.60)	6.13 (12.45)	5.09 (11.00)	4.85 (12.59)
Bunny NBt	13.13 (20.74)	15.13 (22.45)	18.75 (25.02)	22.81 (27.79)	40.39 (39.22)	22.04 (27.56)
SEd	3.55	5.12	5.55	5.79	5.85	2.79
CO (0.05 %)	7.33	10.56	11.46	11.95	12.07	5.69

field condition. Seven lines viz. IC 357599, EC 152285, EC 152280, IC 358905, IC 359051, BWR 58 and BWR 28 were resistant against bacterial blight and grey mildew under natural field condition. Two lines viz. 213-1023-1 and 666-56-58-A were resistant to bacterial blight and grey mildew under controlled field condition.

Five lines of *G. hirsutum* viz., Abadhita, Saubhagya, Bikaneri Nerma, NISC 24 and NISC 19 and one line of *G. arboreum* i.e. CINA 348 resistant to *Rhizoctonia* root rot and *Fusarium* wilt have been utilized for development of resistant genotypes.

#### Biochemical, molecular and genetic basis of host plant resistance to cotton nematodes

Germplasm lines A678, G.Cot 10, GRS 60/15, IC 671 Sel, K8199, Kekchi Red, Kemp, L-604, L-751, Macha, Meade 90300, PRS-72, Tamcot SP 21, Tamcot SP 37, 5/44, UA-Bk-4-84, 9-1487 and UPA(57)-1 were resistant to reniform nematode. Acal8-1-X, BM Cot 113, BM Cot 147, G.Cot 16 and MB Cot 142 were tolerant while 150-3-1-1, GP187, MOH 38 was hypersusceptible. Resistance in cotton germ plasm line 116 TLYC Macha reported resistant to root-knot and reniform nematode was confirmed. Bikaneri nerma, Sharda and Paymaster have been found resistant to root knot nematode.

Identification of biochemical parameters that confer resistance to nematodes was carried out. Quinones, peroxidase enzyme and sugars were identified as biochemical parameters conferring resistance against plant parasitic nematodes (root-knot and reniform nematode).

#### Coimbatore

#### Association of emerging pests with Extra Long Stable (ELS) and popular Bt hybrids

Four commercially popular Bt hybrids viz., RCHB708 Bt (ELS cotton), Mallika Bt, Bunny Bt and RCH 2 Bt were studied for their association to emerging pests in unprotected field condition. All the hybrids recorded high population of mealybug *P. marginatus* ranging from 435 to 7831 plant and 2.0 to 3.5 grade intensity of damage. All of them were susceptible to mirid bug and recorded 2.3 to 3.7 nymphs 15 squares (Mean of 15 plants x 5 squares). The yield loss due to the sucking pests including the emerging pests was 8.6,12.6,17.2 and 17.5 q/ha in RCH B708 Bt, Mallika Bt, Bunny Bt and RCH2 Bt respectively.

#### Monitoring the Bt hybrids for the incidence and survival of *P. gossypiella*

Bt hybrids recorded significantly less mean locule damage (0.88-4.85/10 bolls) and average larval number (0.15-0.70/10 bolls) as compared to NBt hybrids with 22.04-26.24/10 bolls and 1.80-3.55/10 bolls of locule damage and larval number, respectively. Within Bt and NBt hybrids, no significant difference was recorded on locule damage and larval population.

Table 22: Larval population in different Bt hybrids

Cultivars	90 DAS	105 DAS	120 DAS	135 DAS	150 DAS	Mean
RCH 2 Bt	0.00 (0.71)	0.00 (0.71)	0.25 (0.84)	0.25 (0.84)	0.25 (0.84)	0.15 (0.80)
RCH 530 BG II	0.50 (0.97)	0.25 (0.84)	0.75 (1.06)	0.50 (0.97)	0.25 (0.84)	0.45 (0.97)
RCH NBt	1.25 (1.22)	1.50 (1.40)	2.00 (1.56)	1.75 (1.49)	2.50 (1.73)	1.80 (1.51)
MRC 6918 BG II	0.25 (0.84)	0.50 (0.97)	1.00 (1.18)	0.50 (0.97)	0.50 (0.97)	0.55 (1.02)
MRC 7201 BG II	0.25 (0.84)	0.50 (0.97)	0.50 (0.97)	0.50 (0.97)	0.50 (0.97)	0.45 (0.97)
MRC 7201 NBt	1.50 (1.36)	3.50 (1.98)	2.75 (1.80)	3.00 (1.78)	7.00 (2.67)	3.55 (1.97)
Bunny Bt	0.00 (0.71)	0.00 (0.71)	0.25 (0.84)	0.50 (0.97)	0.25 (0.84)	0.20 (0.83)
Bunny BG II	0.50 (0.97)	0.50 (0.97)	0.50 (0.97)	0.75 (1.06)	1.25 (1.19)	0.70 (1.09)
Bunny NBt	1.25 (1.27)	3.00 (1.82)	2.00 (1.56)	1.75 (1.44)	3.00 (1.86)	2.20 (1.63)
SEd	0.21	0.21	0.19	0.28	0.26	0.11
CD (0.05 %)	0.43	0.43	0.40	0.58	0.54	0.23

About 50 *G. hirsutum* and 30 *G. barbadense* (breeders materials) were screened against jassids under unprotected condition. All the *barbadense* lines showed an injury grade of IV. No *G. hirsutum* lines were observed to be resistant to jassid and about 22 lines, which were moderately resistant, recorded an injury grade of II. eICR Coimbatore 11 compact *G. hirsutum* type was identified as moderately resistant to jassid.

#### Sirsa

#### ETL of *H. armigera* on Bt cotton

*H. armigera* ETL calculated in Bt cotton was 4.35 and 3.85 larvae/plant, respectively after 120 and 135 DAS release.

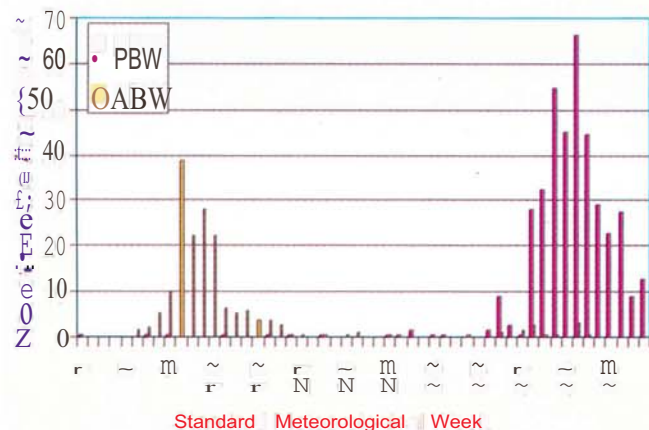
#### Sucking pests' resistance to insecticides

Resistance monitoring in jassid population of North India against the commonly used insecticides revealed relatively low resistance problem till date to neonicotinoids.

#### Determining cultivar association with emerging pests

The infestation of mealy bug started from June. The activity of the parasitoid *Aenasius* was observed at all the locations. A study conducted on 53 Bt cotton hybrids belonging to different events released for North zone revealed that none of the cultivar was found either highly susceptible or resistant to mealybug attack and there were no significant differences in populations of jassids and thrips. Whitefly populations during the later part of season (3<sup>rd</sup> October to 19<sup>th</sup> October) differed significantly among the cultivars.

Fig.43: Pheromone trap catches of American (ABW) and Pink bollworm (PBW)



## 4.29: Identification of Germplasm Sources of Resistance to Insect Pests and Diseases

### Coimbatore

Three hundred and fifty germplasm accessions of *G. hirsutum* were screened under field condition for their reaction to mealybugs and mirid bugs during 2009-10. Six entries (*viz.*, ICGH250, 252, 276, 288, 341, & 410) were found less susceptible to mealybug and recorded less than 10 numbers/plant and grade one damage, while the susceptible entry ICGH 370 recorded 1075 numbers/plant and damage grade of 4.0. The same accessions were screened for mirid bugs and five entries *viz.*, ICGH 474, 480, 509, 610 and 630 were found to have less number of mirid bugs (0 to 0.25/5 squares) as against 4.75 in the susceptible entry ICGH 328.

### Screening of breeding material for multiple disease resistance

A field experiment was conducted under natural disease incidence in order to identify markers for multiple disease resistance. Twelve non Bt cotton varieties were monitored at regular intervals for incidence of diseases. No fungicide was sprayed against any disease. *Alternaria* leaf spot (*Alternaria* sp.) infection first appeared in LRA 5166 and QMR 5 during this period. During January, mild to moderate infections (DPI: 4.5-30.8%) of *alternaria* was noticed in some varieties.

Though the varieties CBR 3, IC 629 and IC 1007 were completely free from *Alternaria* leaf spot infection in the initial stage, these varieties contracted the disease at the maturity stage of the crop. In spite of very severe appearance of grey mildew (*Ramularia areola* Atk.) in the suspected weed host *Euphorbia heterophylla*, the disease was observed only on two varieties, QMR 5 (3.4%) and LRA 5166 (15.4%) during Dec. January; later QMR 5 recovered from grey mildew infection. LRA 5166 and Anjali were found infected with both *Alternaria* and grey mildew. Variety Suvin was found completely free from both *Alternaria* leaf spot as well as grey mildew infection throughout the season.

### Identification of native bioagents by *in vitro* testing

Soil samples from the rhizosphere of all the varieties grown were collected twice for isolation of native biogens. Two native isolates of *Trichoderma viride*, one isolate of *T. harzianum* were found antagonistic to *Alternaria* leaf spot pathogen, and can be exploited for disease management.

## 4.30: Biological Control

Nagpur

Biological control of insect pests

Three parasitoids viz., *A. bambawalei*, *Metaphycus* sp. (Encyrtidae: Hymenoptera) and *Promoscidia unifaciventris* (Aphelinidae: Hymenoptera) have been observed to parasitize mealybug *P. solenopsis* ranging from 7.28 to 100 %. The mealybug species *Nipaecoccus viridis* was found to be predated by *Gitonides perspicox* sp. Knab (Drosophilidae: Diptera). *G. perspicox* predation of *N. viridis* ranged from 33-90%. Mealybug infesting *Triumfetta rhomboidea* showed 100% parasitization by *A. bambawalei* followed by *Lantana camara*. However, cent per cent

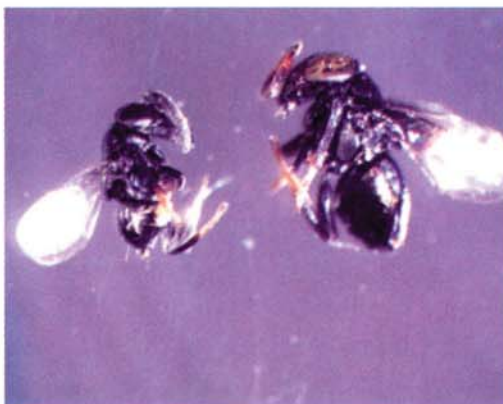
emergence of parasitoid was observed from mummified mealybugs from *Xanthium strumarium*. Duration of adult emergence from date of collection varied with respect to host plants and parasitized mealybugs collected from *Parthenium hysterophorus* emerged in least time period (10 days) with about 71% adult emergence.

Lab multiplication of bio agents

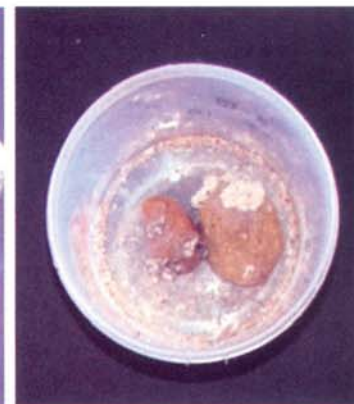
Lab multiplication protocol was standardized for *C. montrouzieri*, *Aenasius bambawalei* and *Scymnus coccivora*. About 500 adults of *A. bambawalei*, 200 adults of *Cryptolaemus montrouzieri* and 1000 beetles of *Scymnus coccivora* have been produced during the year and are being further multiplied on lab host *Psolenopsis*.



Mealybug *P. solenopsis* parasitized by *Aenasius bambawalei*



*Aenasius bambawalei*, male (left), female (right)



Lab multiplication of *A. bambawalei*

Identification of effective bio-control agents for the management of pathogens

Fourteen effective bacterial isolates isolated from the rhizosphere (phylloplane) region of cotton ecosystem were evaluated under *in-vitro* conditions by dual culture method for their antifungal activity. The fast growing strain of Fusarium wilt pathogen *F. o. sp. vasinfectum*, dry root rot pathogen *Macrophomina phaseolina* and fast growing strain of *Alternaria* leaf spot pathogen *Alternaria alternata* were used as test pathogens. Six bacterial isolates were effective and inhibited 62.37 - 76.82 per cent growth of *F. o. f. sp. vasinfectum* with an inhibition zone of 25.0-30.8 mm. The inhibition of 62.65-76.70 per cent was also observed with six bacterial isolates in *A. alternata* with an inhibition zone of 18.0- 22.5 mm. However, four bacterial isolates exhibited an inhibition zone of 30.9- 32.67 mm with an inhibition of 71.03- 74.95 per cent against *M. phaseolina*. The virulent cultures of *F. o. sp. vasinfectum* and *M. phaseolina* were multiplied individually on sorghum seed meal and inoculated separately in a mixture of sterilized soil, sand and FYM. The mixture of soil, sand and FYM having inoculums of respective pathogens was allowed for 10 days to multiply in the earthen pots. Treated seed of susceptible cultivars with effective bacterial isolates was sown in the earthen pots. Seed treatment with effective bacterial isolates suppressed the seedling infection by 61.54- 82.05 and 51.35- 78.38 per cent under pot culture by *F. o. f. sp. vasinfectum* and *M. phaseolina*, respectively. Promising increase in root length and shoot length of seedlings was also observed with seed treatment using these bacterial isolates against *F. o. f. sp. vasinfectum* and *M. phaseolina*.

Role of PGPR bacterial strain and SAR inducing chemicals

in yield improvement and bio-control of diseases

A replicated field trial was conducted in RBD with *Pseudomonas fluorescens* strain CICR H,a to test the efficacy of PGPR strain in enhancing productivity and protection of cotton against Bacterial blight, Myrothecium leaf spot and Grey mildew. Besides, SAR inducing chemicals like salicylic and isonicotinic acid were also evaluated for their efficacy in conferring protection against the diseases.

Application of the bacterial strain enhanced the productivity of cotton besides protecting the plant from disease. Highest yield (1834 kg/ha) was obtained where the seeds were treated with talc formulation of *Pseudomonas fluorescens* containing  $1 \times 10^8$  cfu/ml @ 5 g/kg seeds with three applications as foliar spray. This was followed by the treatment (1815 kg/ha) where the PGPR strain was applied in soil @ 5 g/kg supplemented with three sprays at monthly interval. Treatments where *Pseudomonas fluorescens* strain was applied alone either as seed, soil or foliar application did not result in appreciable increase in productivity. Surprisingly, the SAR inducing chemicals salicylic and isonicotinic acids resulted in appreciable increase in the yield. The treatment effects however were non-significant.

All the treatments resulted in lowering the severity and incidence of Bacterial blight, Myrothecium leaf spot and Grey mildew in cotton. Intensity of Bacterial blight ranged from 0.8% to 1.5% in different treatments compared to 2.5% in Control. Not much variation was observed in incidence of Myrothecium leaf spot disease that ranged from 80-100% in different treatments. Seed treatment or soil application of *Pseudomonas fluorescens* combined with foliar spray or application of salicylic acid or isonicotinic acid were effective in reducing incidence of Grey mildew to 10-20% from 50% observed in control.

**Coimbatore**

**Natural occurrence and predatory potential of *Spalgis epius***

Natural occurrence of 28 % of *S. epius* was recorded on mealy bug *Paracoccus marginatus* on cotton. Second, third and fourth instar larvae of *S. epius* were tested for the predatory potential against mealy bug *Pmarginatus* in the lab. Among the 3 stages of the predator larvae, 3<sup>rd</sup> instar larvae consumed maximum number of crawlers followed by 4<sup>th</sup> instar larvae. Among the 2<sup>nd</sup> and 3<sup>rd</sup> instar larvae of the predator, 3<sup>rd</sup> instar predated significantly maximum number of egg masses of 9.6 / day as compared to 2<sup>nd</sup> instar (6.3).

**Pathogenicity of entomopathogenic fungus**

LD<sub>50</sub> and LT<sub>50</sub> were calculated for fungal pathogens viz., *Metarhizium anisopliae*, *Verticillium lecanii* and *Beauveria bassiana* against all three instars of cotton mealybugs viz., *P marginatus* and *P solenopsis*.

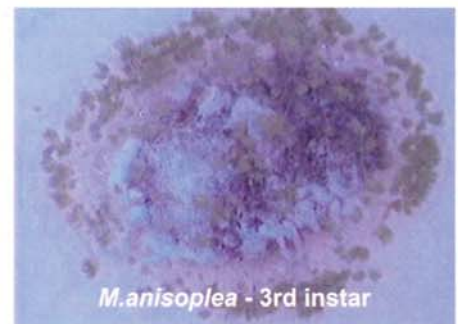
***M. anisopliae*:** LD 50 values for 1<sup>st</sup> instar, 2<sup>nd</sup> instar and adults of *P solenopsis* were 8.7x10<sup>5</sup>, 1.3x10<sup>6</sup> and 5.4x10<sup>6</sup> and the same for *P marginatus* were 5.0x10<sup>5</sup>, 9.8x10<sup>5</sup> and 1.3x10<sup>6</sup> respectively. LT<sub>50</sub> values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P solenopsis* at 10<sup>5</sup> were 4.50, 5.97 and 6.27 days and the same for *P marginatus* were 4.20, 5.03 and 6.00 days respectively. At 10<sup>6</sup> LT<sub>50</sub> values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P solenopsis* were 4.47, 5.67 and

6.24 and the same for *P marginatus* were 3.99, 4.89 and 5.77 respectively. At 10<sup>7</sup>, LT<sub>50</sub> values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P solenopsis* were 3.94, 5.45 and 6.22 and the same for *P marginatus* were 3.56, 4.87 and 5.66 respectively.

***B. bassiana*:** LD 50 values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P solenopsis* were 9x10<sup>5</sup>, 3.9x10<sup>6</sup> and 5.3x10<sup>7</sup> and the same for *P marginatus* were 8.2x10<sup>5</sup>, 2.5x10<sup>6</sup> and 1.4x10<sup>7</sup> respectively. LT<sub>50</sub> values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P solenopsis* at 10<sup>5</sup> were 4.95, 6.10 and 7.17 days and the same for *P marginatus* were 4.68, 6.00 and 7.02 days respectively. At 10<sup>6</sup> LT<sub>50</sub> values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P solenopsis* were 4.60, 5.89 and 6.83 and the same for *P marginatus* were 4.71, 5.37 and 6.80 respectively. At 10<sup>7</sup>, LT<sub>50</sub> values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P solenopsis* were 4.09, 5.60 and 6.71 and the same for *P marginatus* were 3.88, 5.19 and 6.52 respectively.

***V. lecanii*:** LD 50 values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P solenopsis* were 1.5x10<sup>6</sup>, 3.2x10<sup>6</sup> and 1.3x10<sup>7</sup> and the same for *P marginatus* were 1.2x10<sup>7</sup>, 1.7x10<sup>6</sup> and 5.9x10<sup>5</sup> respectively. LT<sub>50</sub> values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P solenopsis* at 10<sup>5</sup> were 5.72, 6.47 and 7.22 days and the same for *P marginatus* were 5.46, 6.21 and 6.93 days respectively. At 10<sup>6</sup> LT<sub>50</sub> values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P solenopsis* were 5.35, 5.99 and 7.05 and the same for *P marginatus* were 4.82, 5.57 and 6.96 respectively. At 10<sup>7</sup>, LT<sub>50</sub> values for 1<sup>st</sup>, 2<sup>nd</sup> instars and adults of *P*

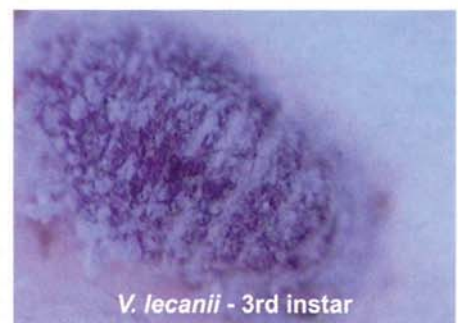
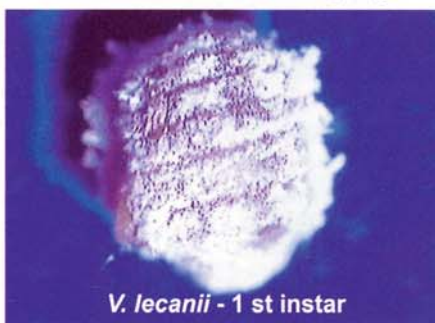
***M. anisopliae* infected mealybug**



***B. bassiana* infected mealybug**



***V. lecanii* infected mealybug**



*solenopsis* were 4.79, 5.65 and 7.07 and the same for *P. marginatus* were 4.55, 5.22 and 6.98 respectively.

#### Histopathological studies on entomopathogenic fungus against cotton mealybug

Histopathological examination was made to understand the pathogenic mechanism of fungal pathogens against cotton mealybug. The fungus infected insect become sluggish and failed to respond to external stimuli within 72 hour of inoculation. Germlings of conidial mass was observed 96 hour after inoculation. Penetration by the germ tubes was randomly located. Areas surrounding the point of entry were darkened indicating lysis presumably due to enzymatic action. Invasion of hyphal bodies into the haemocoel was observed 144 hour after the inoculation. Hyphal penetration of the fat bodies started 156 hour after inoculation. By this time, hyphal invasion occurred in the internal tissues. At this stage, the insect becomes moribund and subsequently dies. At the moribund stage, all the internal organs had extensively disintegrated. The mycelium of the fungus covered the entire body, sometimes making it difficult to identify the insect. There were no signs of infection observed in histological sections of the control insect.

#### Biochemical content changes during pathogenesis

Biochemicals viz., total free sugar, protein and free amino acid content changes on *P. marginatus* and *P. solenopsis* during infection of *M. anisopliae* and *B. bassiana* were analysed during 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup> and 7<sup>th</sup> day after inoculation. Free amino acid and protein content was low in infected insect compared to healthy insect and also decreased with disease development. Total free sugar content of the infected insect was high compared to healthy insect that increased gradually with the advancement of the infection period.

#### Isolation of native entomopathogenic nematodes

Survey on entomopathogenic nematodes in cotton ecosystem revealed the presence of entomopathogenic nematodes in 12 per cent of the soil samples collected. Widespread distribution of *Steinernema siamkayai* Stock, Somsok, and Reid, 1998 was recorded this year.

#### Identification of bacterial symbionts of entomopathogenic nematodes

Bacterial symbiont of *S. siamkayai* was obtained from the infective stage of nematode by hanging drop technique and bacteriological purity was checked by plating on Nutrient Agar supplemented with 0.004% (w/v) triphenyl tetrazolium chloride and 0.0025% (w/v) bromothymol blue (NBTA medium) at room temperature. Growth at various temperatures and enzymatic activities were quantified. Based on nucleotide homology and phylogenetic analysis, bacterial symbiont of *S. siamkayai* was identified as *Xenorhabdus stockiae*. The characteristics of *X. stockiae* are gram negative, rod shaped, highly motile, catalase negative, grow well in MacConkey Agar, produce antibiotics, absorbs dye from Bromothymol Blue, do not bioluminescent at dark, grow well at 15, 25, 28, 37 and 42 °C. *X. stockiae* produces both primary and secondary phase variants. *X. stockiae* also possesses insecticidal and antimicrobial property.

#### Ecological characterization of native entomopathogenic nematode

Ecological characterization of this native isolate of entomopathogenic nematode, *Steinernema siamkayai* was carried out to identify virulent nematode against target pests. The native isolate of *S. siamkayai* has wide thermal activity range with optimum infectivity from 20 to 35 °C. The optimum

temperature for infection and multiplication was 35 and 30 °C respectively. It infects hosts over wide range of soil moisture. The survival and infectivity was reduced with increase in duration and temperature. When stored at 15 and 25 °C, the survival and infectivity of *S. siamkayai* was very high at 15 °C. The maximum infectivity of 100 per cent was recorded for six and four weeks of storage at 15 and 25 °C respectively. At the end of the storage period (20 weeks), 15 and 25 °C recorded 61 and 56.67 per cent survival, respectively. More than 80 per cent infectivity was recorded upto 16 weeks of storage at 15 °C. At the end of storage in sterile distilled water, 68 and 56 per cent infectivity was recorded at 15 and 25 °C respectively. Its ability to tolerate UV radiation was  $LT_{50}$  for revealed by its  $LT_{50}$  of 45.8 minutes. Because of its foraging strategy and adaptation, *S. siamkayai* has potential for the management of pests under tropical condition.

#### Isolation and identification of native entomopathogenic fungi from mealy bug

A survey was conducted to isolate and identify entomopathogenic fungi associated with cotton mealy bug. Out of several fungi screened, 43 isolates were reported to cause mortality under laboratory condition. All the cultures were sent to Agharkhar Research Institute, Pune, IARI, New Delhi and USDA ARS Biological IPM Research, USA, for identification. Out of 43 fungi screened, *Lecanicillium lecanii* (Zim, Zare & Gam) was found to be highly virulent against *Phenacoccus solenopsis* and *Paracoccus marginatus*. Natural occurrence of *L. lecanii* and *Cladosporium cladosporioides* was reported for the first time in India.

#### Lab evaluation of potent isolates against mealy bug and standardization of bio assay method

Preliminary studies to assess the pathogenicity of the entomopathogens were conducted using two different methods viz., spraying and residual film method. Among them spraying method recorded higher mortality of nymphs and adults and it was found to be significantly superior to residual film method.

#### Lab evaluation of isolates against mealy bug (Dose response relationships LD<sub>50</sub>)

To determine dose-mortality response ( $LD_{50}$ ) and time-mortality response ( $LT_{50}$ ) different concentrations viz.,  $10^1$ ,  $10^5$ ,  $10^6$ ,  $10^7$ ,  $10^8$  and  $10^9$  spores  $ml^{-1}$  of test fungi (*M. anisopliae*, *B. bassiana*-1, 2, *C. cladosporioides* and *L. lecanii*) were prepared and tested against nymphs and adults of *Phenacoccus solenopsis* and *Paracoccus marginatus* under laboratory condition by spraying suspension on the leaves which were inoculated with nymphs or adult. Among different fungi tested, *L. lecanii* recorded the lowest  $LD_{50}$  value of  $2.1 \times 10^7$  and  $4.5 \times 10^8$  spores  $ml^{-1}$  against adult and nymph of *P. solenopsis* respectively. The data on dose-mortality of three entomopathogenic fungi against *P. marginatus* revealed that *L. lecanii* recorded lowest  $LD_{50}$  of  $2.2 \times 10^7$  and  $4.7 \times 10^8$  spores  $ml^{-1}$  against adult and nymph respectively.

#### Lab evaluation of isolates against mealy bug (Time response relationships LT<sub>50</sub>)

The time-mortality response of three fungi against *P. solenopsis* and *P. marginatus* nymphs and adults showed significant difference in virulence. The lowest mean lethal time ( $LT_{50}$ ) of 5.54 and 4.80 days respectively was recorded with *L. lecanii* against *P. solenopsis*. The lowest mean lethal time ( $LT_{50}$ ) of 6.40 and 5.23 days respectively was recorded in *L. lecanii* against *P. marginatus*.

#### Effect of temperature on virulence of entomopathogenic fungi against *P. marginatus*

The effect of temperature on virulence of entomopathogenic fungi against two stages viz., nymph and adult of *Pmarginatus* was carried out under laboratory condition. The result revealed that maximum virulence was recorded at 25 -30 DC for all the test fungi.

#### Evaluation of entomopathogenic fungi against mealy bug under pot culture condition - Screening of *Verticillium lecanii* isolates (NBAIL) against *P. marginatus* under pot culture condition

*Verticillium lecanii* isolates supplied by NBAIL, Bangalore were tested against *Paracaccus marginatus* under pot culture condition. There were nine treatments with three replication for each treatment. There was significant difference between treatments. Among nine treatments tested Profenophos (Treated check) was found to be the best. Among *Vlecanii* isolates tested, VI-5 was found to be significantly superior in causing insect mortality at 3 DAS and at 5 DAS.

#### Screening of entomopathogenic fungi against *P. marginatus* under pot culture condition

Three entomopathogenic fungi viz., *M.anisopliae*, *B.bassiana* and *L./ecaniiwere* tested against *Pmarginatus* under pot culture condition. The results revealed that there was significant difference between treatments and *L./ecaniirecorded* maximum of 68 and 76 % mortality at 3 and 5DAS respectively.

#### Development of mass production protocol for *L./ecanii*

Influence of different temperatures on the growth and sporulation of fungal pathogens: The growth and sporulation of the effective fungi, *L./ecanii* was studied at different temperatures viz., 20, 25, 30, 35 and 40° C. The data obtained from this experiment showed that the temperature plays a vital role in the growth and sporulation of *L./ecanii*. The radial growth was significantly higher at 25°C followed by 30°C. The temperature above 30°C significantly reduced the radial growth. A similar trend was noticed in the biomass production also. The maximum biomass was recorded at 25°C and minimum biomass production was recorded at 40°C. When different temperatures were tested on sporulation of *L./ecanii* 25°C supported maximum sporulation. An increase in temperature beyond 30°C was detrimental for sporulation. Low sporulation was also recorded at the lowest temperature.

#### Influence of various culture media on growth and sporulation of *L./ecanii*

Studies were conducted to determine the favourable culture media for the growth and sporulation of *L./ecanii*. Rice, sorghum, pearl millet, finger millet and wheat based media were included in the study. The radial growth, biomass and spore production of *L./ecanii* varied significantly with various culture media tested. The radial growth was maximum in SDAY medium followed by sorghum and PDA. Least radial growth was recorded in pearl millet based media. The biomass production was found to be significantly higher in sorghum followed by SDAY. Sorghum based medium was found to be significantly superior in spore production which was  $4.27 \times 10^{10}$  spores  $m^{-2}$  followed by SDAY medium. Minimum spore production was observed on finger millet based media.

## 4.31: Integrated Pest Management

### Nagpur

Pigeon pea as border and intercrop crop harbors less number of aphids and more number of coccinellids. Mirid population was at par in cowpea and Pigeon pea. Mirid population was maximum in sole cotton as compared to other border crop treatments.

Thus pigeon pea was found to be compatible crop in cotton cropping system as compared to cowpea, jowar and maize as the latter harbor higher sucking pest population. Cowpea, jowar and maize impede intercultural operation for successful.



Cotton+ pigeon pea cropping system most suitable in Central India



Bio formulations Mealy-Quit and Mealy Kill have been developed and supplied for evaluation under field conditions at multiplication trial under AICCIP during current crop season 2009-2010.

Foliar spray of *Verticillium lecanii* (68.61 %), Thiomethoxam (68.35 %), Mealy Quit (65.00%), Neem oil (62.87%), Acephate (59.37%), Acetamiprid (53.33%) were found to significantly reduce the population of jassids.

In a trial at farmer's field, the number of bio-agents was maximum in IPM with dominance of spider population from 38 to 40<sup>th</sup> SW corresponding to the increasing mirid population. An increased returns of Rs. 3330/- per hectare was obtained in IPM plot over RPP indicated the superiority IPM.



**Table 23: Induced host plant resistance for cotton pest management**

Chemical	Structural group	LC <sub>50</sub> * in the lab	Method of testing	Insect against which tested
Limonene	Terpenoid	0.143%	Leaf dip	Jassid nymphs
		0.421%	Diet incorporation	Aphids
		0.342%	Direct spray	Mealy bugs
Ocimene	Terpenoid	0.123%	Leaf dip	Jassid nymphs, Aphids
		0.177%	Diet incorporation	
Jasmine perfume	Terpenoid	0.601%	Leaf dip	Jassid nymphs
		0.191%	Diet incorporation	Aphids

Rasi 2 Bt Gaucho untreated was sprayed 5 times during the season at fortnightly intervals. At 45 DAS confidor was the best treatment (jassid nymph reduction, 41%) and was on par to Limonene 1.5ml/L (jassid nymph reduction 31%) and jasmine perfume 2.5ml/L (25.8% jassid nymph reduction) superior to external control. Ocimene 3ml/L was on par with confidor 50 DAS (41.4% jassid nymph reduction). Sprays at 60 DAS demonstrated that limonene 3ml/L and ocimene 0.5ml/L were on par with confidor causing jassid nymph reduction of 43.9%, 42.6% and 54.2% respectively over external control. Thus experimental evidence is provided to demonstrate that jasmine perfume (2.5ml/L), ocimene (3ml/L), limonene (3ml/L) can effectively be used against jassids in place of neonicotinoid sprays. Jasmine perfume ocimene may be used between 45-50 DAS, while limonene may be used at 60 DAS, thereby preventing repeated use of the same molecule. The choice of placement of these molecules was decided based on their effect on jassid damage grade. These molecules also induced host plant resistance enzymes such as LOX1 and LOX3.

#### Identification of botanical soap products as emulsifiers

A novel non-phytotoxic, botanical bio-emulsifier (soap nut) was identified and evaluated at 5% in combination with limonene, ocimene and jasmine perfume.

#### Multi-location trials with Mealy Kill

Mealy Kill found effective against sucking pests including mealy bugs in laboratory and field trials was submitted to the AICCIP for multilocation testing in the year 2009. Mealy Kill formulation was supplied to 9 AICCIP centres but was tested at 4 centres namely, Raichur, TNAU, Sirsa and Faridkot, essentially against mealy bugs. It was tested at 20 ml/L in North India and 10 ml/L in South India. It offered 34% reduction when sprayed once at Sirsa and was on par with other bio-pesticides such as *V. lecanii*, *M. anisopliae* and *B. bassiana*. It was superior to the bio-pesticides tested at Faridkot. There were no significant differences in yield in the insecticide treated plots and Mealy Kill treated plots in Faridkot. In Raichur and TNAU the reduction in mealy bugs observed due to Mealy Kill was 90% that was on par with the insecticidal check chlorpyrifos both in terms of pest control and yield. Mealy Kill was superior to the other bio-pesticides tested, each, sprayed twice, at these centers in terms of mealy bug control and yield. Mealy Kill is effective against *Phenacoccus* and *Para coccus*.

#### Development and validation of IPM and IRM strategies for conventional and Bt cotton-Sucking pest resistance management

Jassids collected from North South and Central India was tested for their tolerance to both conventional and new chemistries. Imidacloprid, Thiamethoxam belonging to the new class of

chemicals, namely neonicotinoids; acephate, a Class III group of chemical according to WHO category that is ecologically safe; Monocrotophos and Chlorpyrifos conventional OP chemistries were selected for evaluation. Six concentrations ranging from 0.0001 ml/L to 2.0 ml/L, including one control were tested. This study was carried out at Sirsa, Nagpur, Surat and Coimbatore.

The LC<sub>50</sub> for conventional insecticides such as acephate against jassids ranged from 0.0001 mg/L (Rajkot) to 0.011 mg/L (Indore) and the resistance was 110 fold in the latter. The LC<sub>50</sub> for monocrotophos ranged from 0.0001 (Junagarh)mg/L to 0.0113 mg/L with populations from Surendranagar and the resistance ratio was 57 fold. LC<sub>50</sub> for thiamethoxam ranged from 0.0002mg/L (Junagarh) to 0.5mg/L (Indore) and the resistance fold was found to be 2500X. LC<sub>50</sub> for imidacloprid ranged from 0.0002mg/L (Bhatinda) to 0.109 mg/L (Wardha) and the resistance fold was found to be 5450X. Coimbatore, Junagarh and Hisar jassid populations were susceptible to all the insecticides tested. Central India jassid populations were tolerant to neonicotinoids.

#### Stacking of trypsin inhibitor gene into Bikaneri Nerma Bt

F<sub>2</sub> progeny of reciprocal crosses between BN Bt and CINHT11 were raised boll to row from F<sub>1</sub> progeny expressing high Ti and Cry toxin. It was observed that progeny from the cross where female parent CINHT11 were tolerant to sucking pests as compared to progeny that had BN Bt as the female parent. The F<sub>2</sub> progeny was selfed and each selfed boll picked separately to identify homozygous high Ti and high Cry toxin expressing plants in the F<sub>3</sub> generation. Segregating populations of reciprocal crosses of CINHT11 and BNBT had a short duration of 80 days with each plant harboring just 5-6 small bolls with synchronous boll opening thus these populations escaped pink bollworm damage completely. It also gives a scope of manipulating plant population for higher yields.

#### Isolation and characterization of native Bt strains using conventional and molecular methods, for cotton pest management

Soil samples were further collected from Ladakh, Barrackpore and Pasighat in 2009-10. Soil samples of Buldana, Parbhani, Amravati, Aurangabad, Guntur, Hingoli, Abohar Sriganganagar, Mansa, Yavatmal, Wardha, Washim, and Jalna (collected in 2008-09) were subjected to the isolation of Bt strains using the selective sodium acetate method and Bt index was calculated. Toxin was isolated from these strains and subjected to bioassays by the diet incorporation method for both *H. armigera* and *S. litura*. Of these strains, native Bt from Yavatmal, Jalna and Hingoli demonstrated a mortality of 28%, 64% and 58% respectively against *H. armigera* but were less effective than the

Ahmedabad strain. None of the toxins were effective against *Spodoptera litura*. Strains isolated from Ladakh and Pasighat from soil samples collected this year, were ineffective against *H. armigera*.

Till date, the most effective native 8t strain was the Ahmedabad strain that was 14 fold as toxic as *B. thuringiensis var kurstaki HD73*. Primer sets were designed to identify, Cry1 toxins that are specific to Lepidoptera.

5'CTGGATTTACAGGTGGGGATAT3' FP

5TGAGTCGCTTCGCATATTTGACT3' RP

For amplification of Cry1 class

5TTAATCGACAAGTAGATAAYTT3' FP

5'AACTCCATCGTTATTTGTRG3' RP

For Cry2 category have been designed and sent for synthesis.

### Coimbatore

#### Evaluation of Biopesticides and Insecticides to identify the most eco-friendly management strategy

Two insecticides and eight biopesticides were evaluated against mealybug. The results revealed that Acephate, Chlorpyrifos, Mealy Quit and Fish Oil Rosin Soap were moderately effective in reducing the mealybug (*P. marginatus*) and brought out a reduction of 39.6, 37.3, 36.2, and 30.4 % respectively. Acephate, Chlorpyrifos, Fish Oil Rosin Soap and Nirma Powder (detergent) recorded higher yield by 56.5, 50.8, 46.1, and 45.4% over the control.

#### Bio efficacy of a new formulation of Acephate (95 % 5G) in comparison with seven standard insecticides against jassid, mirid bug and predators in cotton

Four rounds of treatment sprays were given on 37, 51, 65 & 97 days after sowing (DAS) in the hybrid RCH2 8t and observations were taken on jassid, mirid bug, predators and influence on seed cotton yield. Imidacloprid, Acetamiprid, Thiomethoxam and Acephate 95 % SG were effective against jassids and brought out a reduction of 45.0, 42.1, 38.2 and 38.2 % over control while Dimethoate and Triazophos recorded 7.7 and 20.0 % higher population. Acephate, Acetamiprid, Fipronil and Dimethoate were significantly superior in reducing the mirid bug population by 20.7 to 30.0 % over control.

Dimethoate was found to be safe to the coccinellid predator while, Triazophos, Acephate 75SP, Acetamiprid and Imidacloprid reduced the predator population by 14.5, 13.7, 12.8 and 11.1% respectively. All the treatments were relatively less toxic to spiders as compared to Coccinellids. Dimethoate and Fipronil recorded 30.0 and 18.3 % higher population of spiders over control. Except Fipronil, all other treatments recorded significantly higher yield ranging from 26.0 to 49.1 % over control.

#### Evolving effective control measure for papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink in cotton

Mean population of papaya mealybug per plant after three rounds of treatment sprays on 37, 51 & 65 days after sowing (DAS) revealed that all the treatments were effective and recorded low population ranging from 1.0 to 3.3 as against 17.3 in control. However, during the late phase of crop growth (158 DAS), cotton plants treated with Acetamiprid 20 S.P. (20 g.a.i. / ha), Dimethoate 30 % EC (250 g.a.i. / ha) and Triazophos 40 % EC (600 g.a.i. / ha) were less preferred for feeding and colony establishment by this mealybug (*P. marginatus*) as against severe infestation observed in plants treated with Thiomethoxam, Fipronil and Acephate 75 SP. Except Fipronil, all other treatments recorded significantly higher yield ranging from 26.0 to 49.1 % over control.

#### Identification of reinfestation level of sucking pests after insecticidal application

Four insecticides namely, Imidacloprid, 0.032%, Acetamiprid, 0.032%, Profenophos, 0.08% and Thiodicarb, 0.09% were sprayed on Bunny Bt at weekly and fortnightly interval after the pest buildup (90 days after sowing). Among the four insecticides, Profenophos increased the jassid population with a resurgence ratio of 0.59-1.05 followed by Acetamiprid with 0.24-.98 resurgence ratio. No indication of resurgence with four insecticides against aphids, thrips, mealy bugs and mirids were recorded, when the insecticides were applied at 7 and 14 days interval. Mealy bug population were on par with the control in all treatments except that of Profenophos.

#### Adult moth catch of *P. gossypiella* in pheromone trap and its correlation with abiotic factors.

Adult moth catch was monitored through pheromone trap catches for *P.gossypiella* and observations were initiated from the month of November and continued upto March. From January onwards, the adults were trapped and gradual increase were recorded during February with a maximum number of 77.5 moths/trap/night.

### Sirsa

Studies on inoculum source and economic thresholds of cotton leaf curl virus disease showed that white fly population/ three leaves (2.80 to 6.13 in Haryana; 3.73 to ~.80 in Punjab and 7.33 to 12.63 in Rajasthan) and CLCuD incidence was high during the season in north zone (15.33 to 20.67% in Haryana; 27.67 to 32.67% in Punjab and 31.67 to 45.67% in Rajasthan). 8hakari (*Tribulus terrestris*), Itsit, Tandala (*Digeria avensis*), Gutpatana (*Xanthium strumarium*), *Abutilon* and *Sida* sps were the main weeds in north zone with white fly population ranged from 0.27-6.87 per three leaves. Eighty seven weeds were collected from north zone and analysed using PCR for detection of cotton leaf curl virus. The studies showed that only *Convolvulus arvensis* (collected from Abohar-Fazilka road side) showed positive reaction towards CLCuD detection. In another experiment to study the effect of Percent Disease Index (PDI) on seed cotton yield, percent seed cotton yield reduction ranging from 9.85 to 36.31 with 5% to 60% graded PDI in case of 8t hybrid Bioseed - 6488 8G-1 and 8.25 to 59.52% was recorded when 8t hybrid 6317 was used. Studies on economic threshold limit of disease based on CLCuD Grades showed percent reduction in seed cotton yield from 7.22 to 58.25 in 8t hybrid 6488, 18.36 to 80.13 in RCH-134 Bt and 19.51 to 72.93% in MRC 6304 in severity grades one to four. There was reduction in quality parameters with increased severity grades in RCH 134 whereas no trend was noted in hybrid MRC 6304.

Off season surveys were conducted continuously for three years i.e. 2007-2008, 2008-09 and 2009-10 with the objective to collect mealybug cadavers from cotton sticks in Haryana and Punjab of North zone wherein seven hot spots were selected. The percent recovery of *F.pallidoroseum* varied from location to location and also in different years. Maximum recovery of entomopathogen from mealy bug cadavers during 2007-08 was observed from village Deon district 8hatinda samples followed but significantly at par from Govindgarh (Dist., Ferozpur) and Malot (Dist., Muktsar). Minimum and significantly less recovery was noted from Pipli in Sirsa district. In 2008-09 season, maximum recovery was made from cadavers collected from Malot in Muktsar district followed by Doda and Govindgarh. Village Doda of Muktsar district showed highest entomopathogen recovery during 2009-10 followed by Fatta Maluka of District Mansa and Govindgarh of District Ferozpur. In general, percentage of cadavers infected with *F.pallidoroseum* was more in villages of Punjab as compared to

that from Haryana. Effect of different doses of *F pallidoroseum* (1%, 2.5%, 5%, 7.5% & 10%) on mealy bug mortality, under *in-vitro* conditions two weeks after application revealed 94% mortality at 1%. No significant increase in mortality with an increase in concentration upto 10% was observed. Under *in-vivo* conditions, however, there was significant increase in mortality with increased concentration. From 1% to 2.5% but thereafter no further significant increase in mortality with increased concentration was noted.

#### Biological control to strengthen IPM

Among various insecticides and biopesticides, acephate (72.86%) and chlorpyrifos (69.13) were resulted into max reduction of mealybug after spray followed by *Metarrhizium anisoplae* (41.53 %), *Beauveria bassiana* (37.71 %), new botanical (34.81%), *V. lecanii* (33.79%). The population of spiders was not affected adversely in any treatment but the lacewings and ladybird beetle were affected adversely by different treatments. Maximum reduction in parasitisation of mealybug by *Aenasius* as compared to control was recorded in Monocrotophos (58.65 %). Under integration of all eco-friendly strategies and validation of IPM packages (use of botanicals/biopesticides/barrier crops and mechanical collection of/arval population and avoid in use of neonicotinoids during the earlier part of the cotton season) sucking pests (Uassids, whitefly and thrips) recorded were 1.13, 5.79 and 9.79 (per 3 leaves) in IPM and 1.27, 5.49 and 11.28 under RPP,

respectively ;0.51 and 0.51 damaged fruiting bodies and 0.11 and 0.14 rosetted flowers were recorded under IPM and RPP , respectively. The Cost: benefit ratio was calculated as 1:3.70 in IPM and 1:3.29 under RPP.

#### Insecticide Resistance Management

##### Nagpur

Insecticide resistance management strategies were implemented in 100918 hectares area in 665 villages of 33 districts in 10 cotton-growing states of India. Forty six thousand five hundred and fifty four farmers were enrolled as IRM farmers during the crop season. A total of 30281 farmers of 330 villages implemented the programme in 72498 hectares in the North Indian states of Punjab, Haryana and Rajasthan. In Central India (Gujarat, Maharashtra and MP) 6723 farmers implemented the programme in an area of 9502 hectares in 170 villages. In West Bengal and South India (Andhra Pradesh, Karnataka, and Tamilnadu) the programme was implemented in 18928 hectares of 9550 farmers in 165 villages. Yields increased by 10-12% and Insecticide usage was reduced by 35-60% in the participating villages. The IRM strategies were refined and a bulletin was published for dissemination in 2010. An algorithm was developed to assess resistance risk with individual genes and in dual gene combination. A stochastic Model Bt Adapt II-A was developed and sent to all the project [partners for evaluation and assessment with real time input



parameters.

#### Monitoring changes in baseline susceptibility (development of tolerance) in *H. armigera* against Cry 1Ac (Mon531)

*H. armigera* eggs/larvae were brought from 31 locations from cotton growing districts of 9 states, raised on semi-synthetic diet till the F-1 generation before evaluation with Cry toxins. All collections made on chickpea and red gram was used for monitoring.

Monitoring changes in baseline susceptibilities were carried out with populations collected from 2 districts in North India (on chickpea), 10 districts of Maharashtra, 7 districts of Gujarat and 2 districts of South India. A total of 31 populations were tested with MVP II for monitoring shifts in baseline susceptibilities.

The highest LC<sub>50</sub> was recorded in Surendranagar of Gujarat and the lowest was recorded from Buldana (0.01 ug/ml of diet) in Central India. The variability was 314 fold across the country. The variability in susceptibility was 4.71 fold across North India, 152 fold across Maharashtra, 62.8 fold across Gujarat and 1.91 fold in South India. The variability in EC<sub>50</sub> ranged from 0.01 ug/ml of diet in Yavatmal to 0.593ug/ml in populations from Bhavnagar. Thus variability in EC<sub>50</sub> across the country was 59.3 fold. Populations from Bhavnagar that survived on MVP II grew well on MVP II containing diet thus demonstrating a high EC<sub>50</sub> value, unlike populations from Surendranagar where higher larval numbers survived on MVP II containing diet; however, the surviving larvae grew poorly on MVP II diet.

#### Validation of LC<sub>50</sub> for populations of *H. armigera* from regions showing unusual LC<sub>50</sub> values

Ten populations were retested at the LC<sub>50</sub> value of cry 1Ac obtained in the first set of bioassays. Of the ten, two populations showing high LC<sub>50</sub> values did not confirm to the results of the first bioassay while the rest did.

#### Mortality of cry 1Ac susceptible and tolerant strains of *H. armigera* on terminal leaves (98 DAS) of MRC6301 (Bollgard) after 120h of release

While the field tolerant strains of Bhavnagar and Buldana did not show significant mortality on MRC 6301 leaves, the field susceptible strains of Aurangabad and Buldana demonstrated full susceptibility.

#### Biochemical mechanism mediating resistance tolerance in field strains of *H. armigera*

Gut enzyme from Bhavnagar *H. armigera* population that demonstrated LC<sub>50</sub> values of 0.99 ug/ml of diet broke down MVP II completely in in vitro bioassays at 30U of gut enzyme as visualized on PAGE while Buldana populations with LC<sub>50</sub> value of 0.01 ug/ml of diet did not break down MVP II with 30U of gut enzyme. This indicated that enhanced degradation of MVP II in the field tolerant strain is responsible for tolerance to MVP II in a field tolerant strain.

#### Monitoring changes in baseline susceptibility (development of tolerance) in *H. armigera* against JK event

Log dose probit assays were carried out on 13 populations of *H. armigera* to determine the LC<sub>50</sub> and EC<sub>50</sub> values. 2008-09 data reveal that the populations of *H. armigera* are also developing tolerance to cry 1Ac (JK event 1).

Monitoring changes in baseline susceptibility (development of tolerance) in *H. armigera* against cry 2Ab + cry 1Ac (MAHYCO event) and cry 2 Ab (MAHYCO). Fifteen populations of *H. armigera* have been subjected to log dose probit assays with cry 2Ab toxin and 17 populations have been tested with cry 1Ac+ cry 2Ab. Data analysis for the combination effect of Cry 1Ac and cry 2Ab is under progress.

#### Sirsa

IRM strategies were disseminated in 75 villages of Sirsa (30 village), Hisar (15 village) and Fatehabad (30 village) to cover a total of 15658 (fifteen thousand six hundred and fifty eight) hectares area with 3870 farmers.

The average number of spays in IRM villages in Sirsa, Hisar and Fatehabad were 2.67, 2.37 and 2.94, respectively where as it was 3.18, 3.88 and 3.32 in case of Non IRM villages. The sprays were mainly given against sucking pests. In Sirsa, Hisar and Fatehabad there were 16.0, 38.9 and 11.4 per cent reduction respectively in insecticides consumption in IRM over non-IRM villages. The cost of spray was rupees 2037.6, 1287.9 and 2251 in IRM and in Non-IRM it was rupees 3661.8, 2319.4 and 3513.1, respectively in Sirsa, Hisar and Fatehabad. By following the IRM strategies there was reduced cost of spray over non IRM villages to the tune of Rs 1624.2, 1031.4 & 1262.1 respectively in the participatory villages at Sirsa, Hisar and Fatehabad districts. The insecticide consumption was 1.98, 1.76 and 1.6911ha in IRM villages at Sirsa, Hisar and Fatehabad as compared to 2.73, 2.68 and 2.54 l/ha in non IRM villages of these districts.

The yield obtained was 22.43, 24.62 and 26.43 q/ ha as compared to 20.60, 21.81 and 23.66 q/ha in IRM and non IRM villages, respectively. Maximum net profit of rupees 45257, 52584 and 56133 and C: B ratio of IRM farmers 1:3.05, 1:3.47 and 1:3.52 as compared to non IRM farmers 1: 2.61, 1: 2.93 and 1:2.99 were observed in Sirsa, Hisar and Fatehabad was observed. The net profit per ha of IRM farmers over Non IRM was 7125, 9483 and 9145 rupees in respective districts.

#### Insecticide Induced Resurgence

In case of whitefly, Cypermethrin, Monocrotophos and Cypermethrin + Monocrotophos were consistently found responsible for resurgence of whitefly being maximum with Cypermethrin+ Monocrotophos in Cypermethrin + Monocrotophos (8.95%). Spinosad (24.69 % resurgence) was consistently found responsible for highest resurgence of mealybug followed by cypermethrin (11.37%) and monocrotophos (3.60 %).





## TECHNOLOGY ASSESSED AND TRANSFERRED

### Nagpur

- Demonstration on promising and newly released Bt hybrid- NHH-44 Bt, Bunny BG II and Rasi-2 Bt
- Cotton based soybean intercropping systems cotton + soybean
- Opening of ridges and furrows for moisture conservation
- Integrated Nutrient Management in cotton
- Foliar spray of MgSO<sub>4</sub> and DAP
- Integrated Pests Management in cotton

### Coimbatore

#### Cotton Value Chain

Successful implementation of the project during last year by adopting integrated cotton production technologies developed at CICR resulted in 25 and 67 per cent of yield and net profit increase, respectively. This led to increase in area of ELS cotton in the village clusters of Kinathukadavu block in Coimbatore district. ELS cotton production was executed in 110 acre in the year of 2009-10. Nearly 955 quintal of ELS Bt hybrid (RCHB 708 Bt) seed cotton was harvested from 110 acre land with uniform quality for value addition research. The mean cost of cultivation is arrived for base year is Rs. 10,903/acre as compared to second year of the project being Rs. 17,237/acre. Mean seed cotton yield of 8.7 q/acre harvested, which is 42.6 per cent higher as compared to base value (6.1 q/acre). The average gross return of Rs. 40,380 and net return of Rs. 23,143 were calculated per acre with benefit cost ratio of 2.34. The base line survey values for gross return is Rs. 18,220 and net return is Rs. 10,903 for acre of land with benefit cost ratio of 1.67.

#### Demonstration of low cost drip irrigation system in cotton

Low cost drip systems (poly tube drip systems) was developed at CICR, Coimbatore and was demonstrated at NAIP village. Polytube drip system, polytubes (150 micron thickness) punctured at regular intervals (60 cm) on single side were placed in planted rows. Poly tubes (Rs 31,252/ha) drip systems is 60 per cent cheaper as compared to the existing drip system (Rs 74080/ha). Water saving to the tune of 40-50 per cent and

yield increase of 25-97 per cent were recorded following the adoption of low cost drip system.



#### Demonstration of Multi-tier cropping system

Multi-tier vegetable intercropping including coriander, radish and cluster bean with cotton was demonstrated at NAIP project village at Vadapudur. RCHB 708 Bt Hybrid cotton was planted at 120 x 60 cm. Two ridges at 60 cm apart are formed making 120 cm. Cotton, radish, cluster bean and corianders are planted on 4 sides of the 2 ridges in sequence. Periodic harvest of intercrops (coriander at 35 DAS, radish at 45 DAS and cluster bean at 75 DAS) resulted in less competition within the component of multi-tier crops leading to yield almost equal to sale cotton. Per hectare gross return of RS.1,32,500, net return of Rs. 77,598, B:C ratio of 3.2 and per day return of Rs 517 were realized with multi-tier system involving radish, cluster bean, coriander with cotton. Sale cotton registered the gross return of Rs 69,000/ha, net return of Rs. 36500/ha and per day return of Rs 243.



### Front line Demonstrations in Cotton

During the year 2009-10, the CICR, Coimbatore centre had conducted seventy five demonstrations on cotton production technology, one unit demonstration on cotton IPM and one unit demonstration on cotton farm implements. The technologies demonstrated under cotton production technology were improved variety Suraj, Bt cotton hybrids RCH 2Bt, RCH 20 Bt and RCH 530 Bt and RCH 708 Bt with improved package of practices, intercropping with cowpea and green gram, application of Bio-fertilizers, pre emergence application of weedicides, management of leaf reddening, management of mealy bugs and stem weevil and soil test based nutrients management. The demonstration resulted in an average seed cotton yield of 1717 kg/ha as compared to the local farmers' practices (1505 kg/ha). One unit demonstration on cotton IPM was demonstrated in 50 hectares using the IPM module developed by the institute. The IPM demonstrated fields gave the average seed cotton yield of 1615 kg/ha as against the non-IPM fields (1426 kg/ha). The implements viz., power weeder, Roto slasher and junior hoe were demonstrated under the component of demonstrations on farm implements.

### Impact analysis of IRM strategies

The impact analysis of the project activities indicated that the implementation of IRM strategies in the project villages resulted in the reduction of number of insecticidal sprays from 2.60 to 1.26, reduction of quantity of insecticides from 562.13 to 232.70 g a.i./ha, reduction of plant protection cost from Rs. 2,182.20 to 800.60/ha and an increase in yield from 10.54 to 11.86 q/ha in IRM villages as compared to non-IRM villages

Increased yield	1.32 q/ha
Increased profit	Rs. 5433/ ha
Saving on plant protection	Rs. 1380/ ha
Increased additional income	Rs. 1928/ ha
Saving from other cultivation cost	Rs. 1118/ha
<b>Total</b>	<b>Rs. 9,859 ha</b>

### Sirsa

#### Demonstration of variety CISA310(*G. arboreum*)

Average yield of 9 demonstrations conducted at 5 locations was 22.3 q/ha, whereas the average yield of check variety was 18.2 q/ha., thus registering an increase of 22.5% over the check variety.

#### Demonstration of GMS based hybrid CICR 2 (*G. arboreum*)

Average yield of 31 demonstrations conducted at 23 locations of CICR 2 hybrid was recorded 27.0 q/ha, in comparison to 22.6 q/ha in case of check hybrid thereby registering an increase of 19.4% over the check hybrid.

#### Hybrid seed production of CICR 2 and CSHH 198 at Farmers' field

The main objective was to educate farmers to produce their own good quality F<sub>1</sub> hybrid seed at a lower price with their limited resources and skill. Training for sowing procedures and desired spacing for successful crossing programme was imparted to the farmers at research station as well as at their fields. Parents of Hybrid CSHH 198 and CICR 2 were sown on farmers' fields under supervision of the scientists and good hybrid seed was obtained by Sh Raja Ram and Sh Rati Ram from Shahpur Begu Distt Sirsa and Sh Trilok Chand from Fatehabad. The farmers were trained for every important step involved in crossing programme for hybrid seed production such as rouging of off types, emasculation, pollination, crop management, etc. In case of CICR 2 the process of hand emasculation of flowers was avoided due to male sterility.

#### Integrated Pest Management (IPM) technology

During the current season five adjoining villages' viz., Bhadra, Jodhkan, Panjawana, Jodhpuria, and Jhopra were selected for disseminating the IPM strategies. In total 12 farmers from these villages covering an area of 50 hectares were adopted under IPM. The emphasis was made in selection of recommended varieties/hybrids viz., MRC-7017 BG-II, MRC-6025, Bioseed-6488-BG-II, RCH-134-BG-II, MRC-6304 and RCH-134.

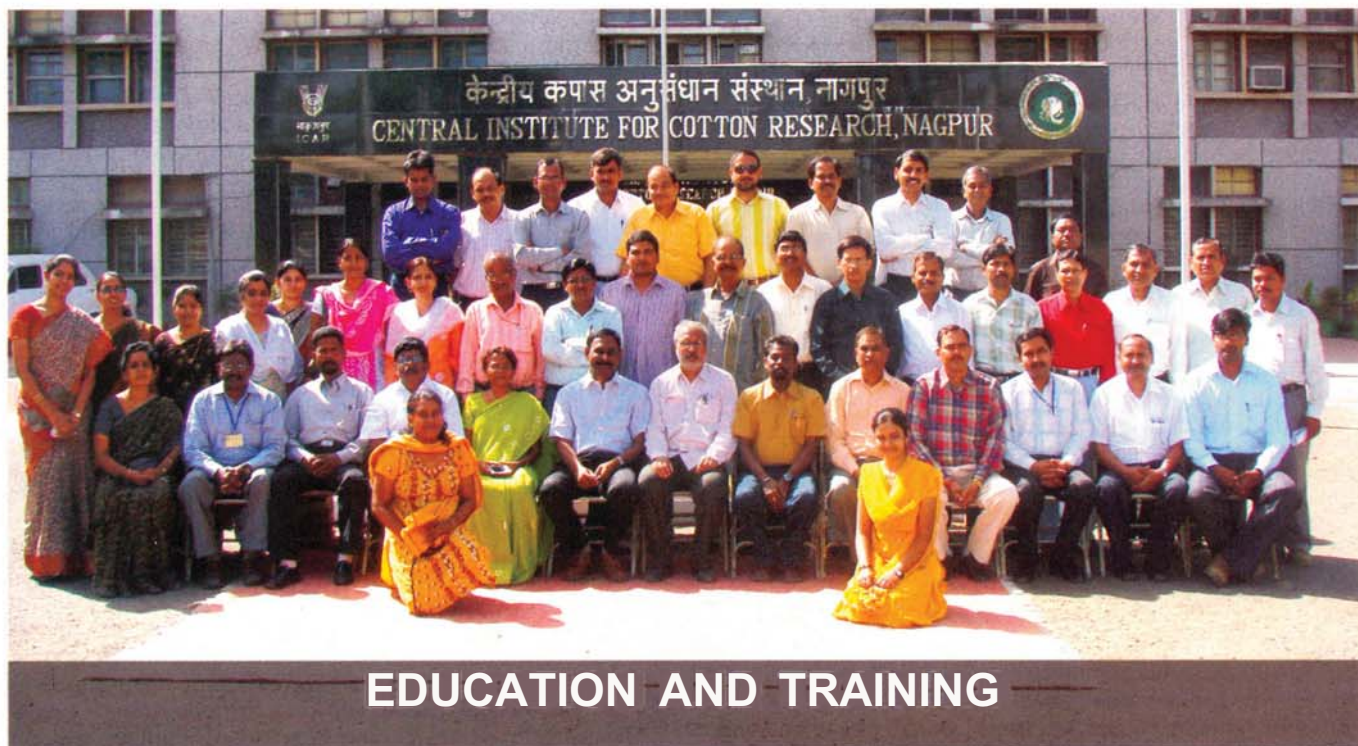
The average population of sucking pests in IPM was comparatively less than Non-IPM practices but the damage to the fruiting bodies like square and bolls is significantly more in non-IPM (1.22 & 0.30) where as the population of natural enemies like spider, *Chrysoperla* and Coccinellids was observed higher in IPM fields.

The maximum pheromone traps catch (39.81/traps/week) was found to be of *Spodoptera litura* followed by *Earias* spp. (30.88/traps), while it was found minimum in Pink bollworm (15.34/traps) and the trap catch of *Helicoverpa* (0.58/traps).

The average yield obtained in IPM and non-IPM plots of Bt cotton hybrids was 22.43q and 20 q/ha. The number of sprays applied both in IPM and Non-IPM are 3 and 5 in Bt hybrids but in non-IPM plots the mixture of insecticides was used. Similarly the spot application of some insecticides for the management of mealy bug infested plants reduced the total insecticide quantity up to 75 % than the non IPM plots where the blanket sprays for the management of mealy bug were applied. The total reduction in cost in IPM plots of Bt cotton/ hybrid was Rs 1970. The net profit gained per hectare was Rs.45165 and RS.35905 in IPM and non-IPM plots of hybrids along with C: B ratio of 1: 3.04 and 1: 2.49.

#### IRM

The IRM strategies were disseminated in 75 villages of Sirsa (30 village), Hisar (15 village) and Fatehabad (30 village) to cover a total of 15658 (fifteen thousand six hundred and fifty eight) hectares area with 3870 farmers. Maximum net profit of rupees 45257, 52584 and 56133 and C: B ratio of IRM farmers were 1:3.05, 1:3.47 and 1:3.52 as compared to non IRM farmers 1: 2.61, 1: 2.93 and 1:2.99 in Sirsa, Hisar and Fatehabad was observed. The net profit per ha of IRM farmers over Non IRM was 7125,9483 and 9145 rupees in respective districts.



## 6.1: Training received

### 6.1.1: International Training

Name of the scientist	Name of the course	Place	Period
Dr. V. Santhy,	Cotton Production and Technology	Egyptian International Centre for Agriculture, Giza, Egypt	1st April, 2009 - 15th June, 2009
Dr K.K. Bandyopadhyay	Carbon Sequestration and Climate Change	Carbon Management and Sequestration Centre, The Ohio State University, Columbus, Ohio, USA	18th January - 17th April, 2010

### 6.1.2: National Training

Name of the Scientist	Name of the course	Place	Period
Dr N Gopalakrishnan Dr. D.Monga Dr K Sankaranarayanan Mr M Sabesh	Team Building organized under NAIP on cotton value chain	YCADA, Pune	13th -15th June, 2009
Er. G. Majumdar	IPR Training on Patentingsystem in India	NIIPM, Nagpur	17th -18th June,2009
Er. G. Majumdar	IPR Training on Patenting inthe field of general engineering/technology	NIIPM, Seminary Hills, Nagpur	13th -17th July, 2009
Dr. Rishi Kumar	Jassid resistance monitoring training	Sirsa	21st July, 2009
Er, G. Majumdar	PERMISNET-II Workshop for nodal officers	NAAS Complex, New Delhi	22nd July, 2009
Dr M. Amutha	Insecticide resistance monitoring on Jassids	CICR, Nagpur	18th August,2009
Er. G. Majumdar	GPS/GIS/PDA training	AMDL, Bangalore	7th-8th Sep,2009
Dr.K,Sankaranarayanan	Short course on cropping system models	ICRISAT, Patancheru, AP, India.	12th -16th October, 2009
Dr. S.L. Ahuja	Genetic enhancement in field crops for use efficiency and tolerance to abiotic stresses	CCS HAU, Hisar	15th Oct- 4th Nov, 2009

Dr S.KVerma	Application of genomics technologies in plant breeding	ICRISAT, Patancheru, A.P.	16th -27th November, 2009
Dr. AR Reddy	Agricultural policy analysis	NCAP, New Delhi	17th -19th November, 2009
Dr. MV Venugopalan	Training programme on cropmodelling under National project on Impact, adaptation and vulnerability of indian agriculture to climate change	IARI, New Delhi	30th Nov -2nd December, 2009
Dr Isabella Aggarwal Dr Usha Rani	Methodological issues in impactanalysis of a agricultural and rural development projects	CARDS, TNAU, Coimbatore	2nd-22nd December,2009
Dr. Rishi Kumar	Intellectual property and its commercialization in agriculture	CCS HAU, Hisar.	15th -24th December, 2009
Er. G. Majumdar	ARIS Incharges sensitization workshop on Uniformity of Website content..	NBPGR, New Delh	18th March,2010
Dr K.P. M Dhamayanthi	Molecular cytogenetics and tissue culture techniques	CSK HP Agriculture University, Palampur, HP	12th -26th April,

## 6.2: Training Imparted

### Nagpur

#### Organization of two weeks multi-skill training programme to Group D staff

As per directions issued by Govt., of India, a two weeks multi-skill training programme was organized during 18.5.2009 to 2.6.2009 for Group D Staff of CICR Nagpur Hqrs. The topics covered were role of ICAR/CICR, cotton & species, research projects, cotton crop improvement, soils, pests/diseases identification, farm implements and maintenance of plant protection equipments, working of administrative section, stores, behavioral values, office procedure, basic knowledge of computers/typing, vigilance & RTI, work in finance section, duties at reception, work in library. The training was planned purely need based as per the requirements of the institute/units keeping in mind the work is supposed to be done by a non-matric/non-ITI staff after training. The inaugural function was chaired by Dr. P R Bharambe, HOD, Crop Production Division on 18.5.2009 and Valedictory function was chaired by Dr. K R Kranthi, Director on 2.6.2009. Dr. S. M. Wasnik, Principal Scientist (Extension) was Coordinator of the Course. The faculty members/experts to train the Group D staff were scientists, technical officers, administrative/finance officials of CICR.. Around 52 Group D staff were benefitted by the training programme.

A similar programme was also held at the CICR Regional Station, Coimbatore from 15.06.09 to 29.06.09. Twenty six lectures were delivered by scientists of CICR and Tamil Nadu Agricultural University on different topics to the supporting staff members.

#### Training on cotton production technology

Two training programme of one day duration were organized on Cotton Production Technology and IPM for FLD beneficiary farmers at villages Dhondgaon (Samudrapur tahsil) and Weni (Hinganghat tahsil) of Wardha district in Vidharbha region of Maharashtra. In all 98 farmers including 84 male farmers and 14 female farmers participated. Also imparted training to 60 extension workers and farmers during the training jointly organized by CICR and State Agri. Dept at Jamb Seed Production Centre under jurisdiction of Hinganghat Taluka Agriculture Officer on 18/3/2010. Further, imparted training to 40 field extension workers of Kisan Call Centre organized at VANAMATI, Nagpur on 16/01/2010.

#### Training on var/eta purity-testing of specified traits

A National Training on "Varietal Purity-Testing of Specified Traits" was organized by CICR, Nagpur during 15-24 February, 2010, wherein 30 candidates participated from Seed Testing, Seed Certification and Seed Production departments. The course was coordinated by Dr. P.R.Vijaya Kumari and Dr. R.K.Deshmukh. Dr.VSanthywas Organizing Secretary.

#### Exposure visit cum training for Master Trainers and SDAO's of state govt. of Maharashtra

In collaboration with 3 SAUs, IPM strategies for cotton were formulated in the beginning of the season and this was disseminated among the farmers through the state agriculture department, Govt. of Maharashtra. On line surveillance was carried out in all 28 districts of Maharashtra throughout the season. Arranged exposure visit of 355 Master Trainers and SDAO's of State Govt. of Maharashtra at CICR Nagpur.. Out of which 242 participated in 2 days duration exposure visit cum trainings in 4 batches -9 & 10,16 & 17,24 & 25 September and 27 & 28 October 2009 at CICR, Nagpur.

### Coimbatore

#### National level trainers training programme



National level trainers training programme on "Nutrient and water management in cotton with special reference to ELS and Desi cotton" had been organised on 18-19'h, March, 2010 to thirty extension officials participated from Tripura, West Bengal, Madhya Pradesh, Orissa, Karnataka, Gujrat, Haryana, and Tamil Nadu. The training programme was sponsored by Directorate of Cotton Development, Government of India, Ministry of Agriculture, Mumbai. Dr N Gopalakrishnan PC &

Head, CICR, Regional Station, Coimbatore, coordinated the training programme with technical support from Dr K Sankaranarayanan, Dr Mrs. Usha Rani and Mr M Sabesh. Extension officials were trained in the aspects of *in-situ* soil moisture conservation, integrated nutrient management, sustainable water management and potential of growing *herbaceum* in coastal region. Field visit was organised to irrigation cafeteria, TNAU, Coimbatore and micro irrigation plots of Jain Irrigation (P) Ltd, Coimbatore.

#### Farmers training programme

Training programme on "Integrated Cotton Production" was organized to NAIP project farmers from 17-22nd March 2010 at Central Institute for Cotton Research, Regional Station, Coimbatore. Field visit was made to farm of M/s Jain Irrigation at Udumulpet and Santhosh Farm (model organic farm), Kottur Malayadipatnam. A visit to textile Mill (Statex mills) was also organised. Farmers were trained on latest technologies of irrigation and e-extension at irrigation cafeteria and technological park of TNAU Coimbatore, respectively. The training also provided an opportunity to Cotton farmers to know newly released varieties, hybrids, Bt hybrids, ELS hybrids, *in situ* soil moisture conservation and nutrient management strategies. Poly mulch techniques, multi tier system and low cost drip system were demonstrated. Advances in management of sucking pests and stem weevil, IPM in Bt cotton hybrids besides clean cotton picking and post harvest handling for effective Value Chain approach were explained. The programme was directed by Dr. N. Gopalakrishnan, PC and Head and coordinated by Dr. K. Sankaranarayanan, Sr. Scientist and M. Sabesh, Scientist, CICR, Coimbatore.

#### Workshop on cotton in Tamil Nadu

Workshop on Cotton in Tamil Nadu: Opportunities and Challenges held on 2:11:2009 at CICR, Regional Station, Coimbatore was jointly organized by Indian Institute of Madras, Chennai and CICR, Regional Station, Coimbatore. The main objective was to find out why the cotton area in Tamil Nadu is less though many innovative technologies developed by public and private agencies available; to find the constraints for cotton

cultivation in Tamil Nadu in Farmers perspective; what is the demand for textile industries in Tamil Nadu; How best the research and academic institutions in enlighten the innovative cotton cultivation practices to the farming community. It was attended by different stake holders including Farmers, Industries, Govt., sector etc. The meeting was chaired by Dr N Gopalakrishnan, PC and Head, and Co-chaired by Dr Mathews, Professor, IIT, Chennai and meeting was coordinated by M. Sabesh, Scientist, and Dr S Usharani, Scientist, CICR, Regional Station, Coimbatore.

#### Workshop between cotton farmers and cotton scientists

An interactive workshop on "Innovations for Higher Economic Return to Cotton Farmers" between cotton farmers and cotton scientists held on 5<sup>th</sup> March, 2010 at CICR, Regional Station, Coimbatore in collaboration with the "Pothigai" Tamil Channel, Doordharshan Kendra, Coimbatore. Cultivators' doubts on Bt cotton, management of emerging pests like Mealy bugs and mirid bugs, intercropping in cotton, drip irrigation in cotton and clean cotton picking were clarified. More than one hundred farmers from Vadapudur, Allapalayam, Kanjapalli, Senthampalayam, Vakkampalayam, Vazhukkuparai in Coimbatore district and other areas participated enthusiastically. This programme was televised on 6<sup>th</sup> and 7<sup>th</sup> June 2010 in DD-Pothigai Tamil Channel between 6.00 AM and 6.30 AM. The programme was coordinated by Dr N Gopalakrishnan, PC & Head, CICR, Regional Station, Coimbatore and Dr (Mrs) S. Usha Rani, Scientist (Sr. scale) (Agricultural Extension).

#### Doordharshan telecast

Telecasting a documentary film about our institute and a series of programme about cotton production technologies in the Tamil DO Channel "Pothigai" in collaboration with the Doordharshan Kendra, Regional Station, Coimbatore was done from 24.01.10 to 16.05.10. The programme was coordinated by Dr (Mrs) S. Usha Rani, Scientist (Sr. scale) (Agricultural Extension). The topics of the programme, concerned resource persons, date and time of telecast are given below

S.No	Topic	Date and Time	Resource person
1	Specialties of the Cotton Varieties/ Hybrids released by CICR	24.01.10,6.00-6.15 AM	Dr. K. N. Gururajan, Principal Scientist
2	Seed Production Technologies in Cotton	31.01.10,6.00-6.15AM	Dr. K. Rathinavel, Principal Scientist
3	Bt Cotton Hybrids	08.02.10,6.00-6.15 AM	Dr. S. Manickam, Senior Scientist
4	Emerging & Key Pests in Cotton & their Management.	15.02.10,6.00-6.15AM	Dr. T. Surulivelu, Principal Scientist
5	Weed Management and Mulching Technologies in Cotton	21.02.10,6.00-6.15AM	Dr. P. Nalayini, Senior Scientist
6	Agro Technologies for Improvement in Cotton Production.	28.02.10,6.00-6.15AM	Dr. K. Shankaranarayanan, Senior Scientist
7	IRM in Cotton	01.03.10,6.00-6.15AM	Dr. B. Dharajothi, Principal Scientist
8	IPM in Cotton	07.03.10,6.00-6.15AM	Dr. M. Amudha, Scientist
9	ELS cotton	22.03.10,6.00-6.15 AM	Dr. K.P.M. Dhamayanthi, Senior Scientist
10	Nematodes Management in Cotton	05.04.10,6.00-6.15 AM	Dr. J. Gulsarbanu, Senior Scientist
11	Diseases Management in Cotton	03.05.10,6.00-6.15AM	Dr. M. Gunasekaran, Senior Scientist
12	Economics of Cotton Cultivation	09.05.10,6.00-6.15AM	Dr. Isabella, Senior Scientist
13	Harvesting and post harvesting technologies in cotton	16.05.10,6.00-6.15AM	Dr. Usha Rani, Scientist
14	Computer Applications in Cotton sectors	16.05.10,6.00-6.15AM	Dr. M. Sabesh, Scientist
14	Documentary film about CICR	07-06-2010	All Scientists
15	Interactive workshop between cotton scientists and cotton farmers	07-06-2010	All Scientists

## Sirsa

### Training Programme on Resistance Monitoring on Jassid To Neonicotinoids

One day training programme on resistance monitoring on Jassid to neonicotinoids was conducted on 17-07-2009. Dr. K.R. Kranthi, Director (Acting) and Head, Crop Protection, CICR, Nagpur demonstrated the methodology of resistance monitoring of jassid to the participants from CICR, RS, Sirsa and Bayer Crop Science.

### Training on Cotton production technology and mealy bug management

A state level training (two days) programme was organized on cotton production technology & Mealy bug Management under implementation of Action Plan of ICDP Mini Mission-II of TMC. One such training programmes was organized on the following

dates:

30 & 31-12-2009, 06 & 07-1-2010, 13 & 14-01-2010, 18 & 19-01-2010, 21 & 22-01-2010, 27 & 28-01-2010, 01 & 02, 03 & 04-02-2010, 08 & 09-02-2010, 10 & 11-02-2010.

The training programme was attended by officials of State Agriculture department of Haryana. State extension officers from eleven cotton growing districts participated. A capsule of ten lectures i.e. five in Crop Improvement, two in Crop Production and three in Crop Protection technologies was provided. Special emphasis was made on emerging pest problems like mealy bug and its management. All the scientists of this Regional Station namely Dr. D.Monga, Dr.S.L.Ahuja, Dr.O.P.Tuteja, Dr.R.A.Meena, Dr.S.KVerma, Dr. Rishi Kumar and agronomist from KVK, CCSHAU, Sirsa/ KVK, Bhatinda were involved.





## AWARDS AND RECOGNITIONS

### International Cotton Researcher of the Year Award- 2009

Dr. K. R. Kranthi, Director, CICR received the coveted ICAC International Cotton Researcher of the Year Award 2009. The Award carries an honorarium of 1000 US dollars and a shield. Dr. Kranthi was selected from 12 candidates in three disciplines of plant breeding, production, protection and biotechnology from 8 countries who had applied for or were nominated for the Award. Dr. Kranthi was awarded for his work on development of diagnostic kits to detect Transgenic cotton, insecticide resistance and quality of insecticides, mechanism of resistance and development of strategies to counter development of insecticide resistance for the benefit of small and medium scale cotton formers.

Dr. K. R. Kranthi received the Award at Cape Town, South Africa on 9<sup>th</sup> September, 2009.

### Best Case study Award

Best Case Study award (Traditional area) by National Council of Indian Institute of Industrial Engineers conferred on Er. Gautam Majumdar for article entitled "Optimum Resource Management in Indian Agricultural for increased efficiency" published in October 2008 issue of Industrial Engineering journal.



### Punjabrao Deshmukh Woman Agricultural Scientist Award 2008

Dr. Sandhya Kranthi, Sr. Scientist (Entomology), Division of Crop Protection, CICR Nagpur was awarded the coveted Punjabrao Deshmukh Woman Agricultural Scientist Award

2008 on the eve of ICAR Foundation Day in a ceremony at NASC, New Delhi on July 16, 2009. Dr. Sandhya Kranthi got the Award for her work on cotton entomology. She was selected for the award from 29 applicants.

Dr. Sandhya Kranthi received the Award consisting of a cash prize of Rs. 50,000/- and a citation from Dr. Farooq Abdullah, Hon. Union Minister of New & Renewable Energy in the presence of Dr. Mangala Rai, Secretary, DARE, and Director General, ICAR.



### Awarded Ph.D degree with Merit Medal



Dr. Raghavendra, Scientist, Biotechnology Awarded Ph.D. degree with JARI Merit medal for outstanding academic performance in Molecular Biology and Biotechnology for thesis entitled as "Transcriptome Analysis of Cotton during Boll Development" from IARI, New Delhi on 13<sup>th</sup> Feb 2010.

#### Fellow of Society of Plant Protection Sciences (SPPS)

Dr J. Gulsar Banu was selected as Fellow of Society of Plant Protection Sciences (SPPS) 2009 by Society of Plant Protection Sciences Indian Agricultural Research Institute, New Delhi from 2009.

#### Dr. (Mrs.) Jagadiswari Rao Woman Scientist Award

Dr J. Gulsar Banu was awarded Dr. (Mrs.) Jagadiswari Rao Woman Scientist Award for the year 2009 by Applied Zoologists Research Association, Central Rice Research Institute, Cuttack, India for outstanding contribution in the field of applied zoological research.

#### Dr. Ambedkar Distinguished National Service Award-2009

Dr. S. M. Wasnik, Principal Scientist (Extension), Division of Crop Production, CICR, Nagpur was awarded 'Dr. Ambedkar Distinguished National Service Award-2009' instituted by Bhartiya Dalit Sahitya Akademy, Delhi on 8<sup>th</sup> December 2009 at a glittering programme organized in Delhi in recognition to his Extension Services. Dr. Wasnik received the Award at the hands of Sh. Jeet Bahadur Darjee, Min. Nepal Govt, Dr. Mata Prasad, Ex-Governor, Sikkim and Dr. Sumanakshar, President, BDSA.

#### First prize for the paper

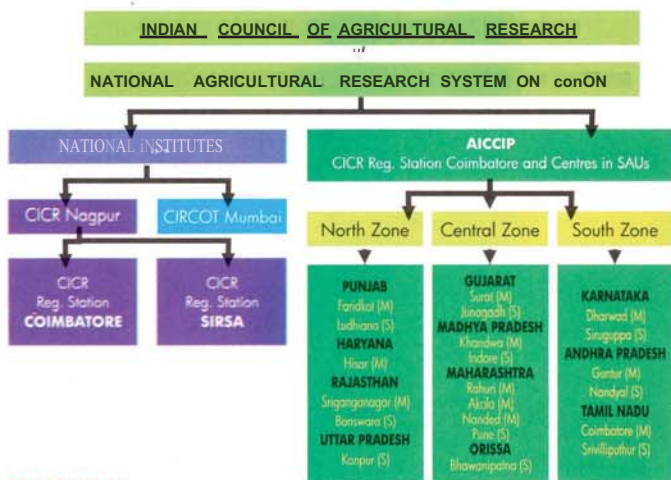
Dr P. Nalayini awarded first prize for the paper "Water Use Efficiency and Production Potential of ELS Bt Cotton Maize System with Hi-tech Moisture Conservation Techniques and ET based Irrigation" at the International Conference on Emerging Trends in Production, Processing and Utilization of Natural Fibres held during 16-18 April organized by Indian Society for Cotton Improvement, Mumbai, Indian Fibre Society, Mumbai in Collaboration with Texas Tech University, USA

#### Best Poster Award

Sr. No.	Name of the Scientist	Title of Paper	Name of Symposium/ Conference	Place and Date
1.	Kuldip Sharma S. Kranthi Manorama K. R. Kranthi	Characterization of gut proteases from <i>cry1</i> Ac susceptible and resistant and restrains of <i>H. armigera</i> (Hub)	7th Asia Pacific Rim Conference on Biotechnology of <i>Bacillus thuringiensis</i> and its environmental impact	New Delhi
2.	S.B Nandeshwar P.K Chakrabarty Keshav Kranthi P. Anandkumar Vidhi Bhatnagar Mithila Meshram	Development of diploid cotton for insect resistance	National Symposium on "Bt Cotton: Opportunities and Prospects"	17-19 Nov. 2009 Nagpur
3.	J. Amudha., G. Balasubramani S. Renuka v.G. Malathi.	Development of cotton transgenic's with antisense rep gene for resistance against leaf curl virus	National Symposium on "Bt-Cotton: Opportunities and Prospects"	17-19, Nov 2009. Nagpur
4.	Nandini Gokte- Narkhedkar N. V. lavhe Anita Shende K.R. Kranthi	Insecticidal toxins from Entomo-pathogenic nematodes for insect pests management- Alternative to Bt toxin	National Symposium on 'Bt Cotton: Opportunities and Prospects'	17-19, Nov. 2009 Nagpur
5.	C.S Praharaaj K.Sankaranarayanan K.K. Bandyopadhyay N. GopaJakrishnan	Optimization of water and NPK in extra long staple Bt cotton through drip-fertigation in semiarid irrigated southern zone	National Symposium on Bt Cotton: Opportunities and Emerging Threats	17-19, Nov. 2009. Nagpur
6.	K.K. Bandyopadhyay A.H. Prakash K.Shankaranarayanan B. Dharajothi N Gopalakrishnan	Assessing trade-off between Bt cotton production and global warming potential using Infocrop-an indigenous generic simulation model	National Symposium on "Bt cotton: Opportunities and Prospects"	17-19 Nov. 2009. Nagpur
7.	M. Sabesh S. Vennila BDharajothi N. Gopalakrishnan	Expert System on Cotton Insect Pest	National Symposium on BtCotton:OpportunWesand Prospects	17-19 Nov.2009. Nagpur
8.	M. Sabesh, N. Gopalakrishnan, G Majumdar	Indian Cotton Portal	National Symposium on Prospects	17-19 Nov. 2009. Nagpur



## LINKAGES AND COLLABORATIONS



### NATIONAL

Areas of Linkages	Institution
Fibre testing and quality evaluation	CIRCOT
Multi-location testing of promising cultures	AICCIP centers
Germplasm collection, maintenance and plant quarantine clearance	NBPGR
Seed technological research and breeder seed production	NSP
Development of Cry 1A(a) gene construct	NBRI
Supply of gene construct and molecular evaluation of transgenic plant.	NRC Plant Biotechnology
DNA finger printing of cotton	NRC DNA Finger Printing
Efficacy of lectins on sucking pests	NIMITLI project with CISR Institutes
Technology for pink bollworm management	State department of Agriculture, Haryana, KVKs, CCS HAU, Hisar, NCIPM etc.

### INTERNATIONAL

Areas of Linkages	Institution
Insect transgene detection kits	Indo- Australian Project with TERI, CEASAR



## CROP IMPROVEMENT

### National Trials

- Nine National Trials, four North Zone trials, eight Central Zone trials and seven South Zone trials were conducted during the year in 221 locations across the country.
- In irrigated national trials, *G. hirsutum* culture viz., F 2228 was found promising in North zone, whereas MR 786 was seen promising in both Central and South zones.
- In the preliminary intra *hirsutum* hybrids trial, the hybrids FHH 200, BHH 624 and RAHH 951 ranked first in North, Central and South Zone, respectively.
- All the twelve *G. barbadense* cultures recorded higher seed cotton yield over the common check variety Suvin in both Central and South zone locations. The entry GSB 40 occupied first rank in Central zone, while GSB 41 occupied first position in South zone.
- In the preliminary interspecific hybrids (*G. hirsutum* x *G. barbadense*) trial, the hybrids GSHB 929 and ARHB 1011 were found promising in Central and South Zone, respectively.
- Promising *G. arboreum* genotypes like RG 585 and JLA505 have been identified for promotion in different zone which was found better than the check varieties in terms of seed-cotton yield. Desi hybrids like Simulai, RAJDH 444 and NACH 18 showed promise in different zones.
- In Central zone locations, the *G. hirsutum* genotype GBHV 164 was promising and occupied the top rank under rainfed situations, whereas in South Zone locations, CPD 168 was the best culture.
- In the preliminary intra *hirsutum* hybrids trial under rainfed conditions, the hybrid NHH 421 was noticed promising in both Central and South Zone locations.
- *G. herbaceum* culture GBhv 288 was found to be superior to the zonal check variety G.Cot 23 in Central Zone.

### Zonal Trials: North Zone

- In the *G. hirsutum* Preliminary Varietal Trial, six cultures

showed promise and F 2164 recorded the highest yield of 2686 kg/ha.

- In the Coordinated hybrid trial, all the five test hybrids performed better than both the check hybrids and RAJHH 743 (3021 kg/ha) was the best hybrid compared to zonal check hybrid (1836 kg/ha).
- *G. arboreum* genotypes viz., CAD 3 and RG 542 were promising.

### Zonal Trials: Central Zone

- In irrigated trial, culture CCH 2623 was the best in the Preliminary Varietal Trial and the genotype BS 279 was found superior in the Coordinated varietal trial with seed cotton yield of 2209 kg/ha as compared to 1635 kg/ha by check variety. In rainfed trials, GISV 218 was promising.
- In the Coordinated hybrid trial, the hybrid RAHH 259 exhibited yield superiority in intra- *hirsutum* category (2176 kg/ha) and RAHB 189 was the best in interspecific (*G. hirsutum* X *G. barbadense*) hybrid category under irrigated conditions.
- In the Coordinated intra *hirsutum* hybrid trial, the hybrid NHH 206 was the best and MRDC 233 was the best in *desi* hybrid group under rainfed situations.
- GAM 141 was the best performing genotype in the coordinated varietal trial of *G. arboreum*.

### Zonal Trials: South Zone

- The *G. hirsutum* genotype, GSHV 155 was the best in Preliminary Varietal Trial and BS 279 was superior in Coordinated Varietal Trial under irrigated situations.
- The hybrid NSPL 423 was the best entry under irrigated conditions in coordinated hybrid trial.
- In interspecific hybrid category, the highest seed cotton yield was recorded in JKCHB 217 (2292 kg/ha) as against 1632 kg/ha in check hybrid DCH 32.
- Under rainfed situation, the NHH 59 was found superior.
- In *desi* category, *G. arboreum* variety CINA 1003 and the hybrid MRDC 233 were the best performing entries.

## CROP PRODUCTION

- Foliar feeding of micronutrients with  $MgSO_4 @ 1.0\% + ZnSO_4 @ 0.5\%$  at Kanpur and Banswara,  $MgSO_4 @ 1.0\%$  at Faridkot and  $FeSO_4 @ 0.5\%$  at Ludhiana gave significantly higher seed cotton yield in North Zone locations. Similarly in Central and South Zone locations, spraying of  $MgSO_4 @ 1.0\% + ZnSO_4 @ 0.5\%$  gave significantly higher seed cotton yield.
- Full dose of MOP at sowing at Sriganaganagar and four sprays of  $2\% KNO_3$  at Kanpur were found effective in North Zone, whereas in Central and South Zones, three sprays of  $3\% KNO_3$  at Nanded and Banswara, four sprays of  $3\% KNO_3$  at Indore, four sprays of  $2\% KNO_3$  at Rahuri and two sprays of  $3\% KNO_3$  at Siruguppa gave significantly higher seed cotton yield.
- Effective management strategies for the mitigation of leaf reddening in Bt cotton has been worked out in both Central and South zones.
- Under crop canopy management studies, narrow spacing of  $60 \times 30$  cm combined with detopping after 55 DAS led to higher seed cotton yield at Khandwa.
- Effective integrated weed management strategies have been standardized for different locations.
- The plant height, stomatal conductance, relative water content, transpiration rate, number of bolls, biomass, boll weight and yield were significantly reduced due to moisture stress in *G. hirsutum*. Genotypes with least susceptibility index have been identified that can withstand stress.
- Per cent defoliation was higher when ethrel was applied at 145 DAS as compared to application at 130 DAS for all concentration.
- Parawilt affected plants recovered with the timely treatment by Cobalt chloride.
- Free amino acid and proline content were higher in the leaf under rainfed condition as compared to irrigated condition, while reducing sugar and protein declined under rainfed condition. The higher amount of free amino acid and proline might have helped in building the osmotic potential fortolerance.
- Different biochemical parameters viz., total chlorophyll content, chl a: chl b ratio, anthocyanin content and nitrate reductase activity were studied at boll developmental stage and all these parameters showed significant variation in response to various leaf reddening management applications.
- *Cry 1Ac* expression was found to be significantly variable among the Bollgard I and Bollgard II hybrids and also between different parts like leaf, squares and boll rinds. The leaves of the Bt cotton hybrids were found to have highest levels of endotoxin protein expressed compared to squares and boll rinds. The *cry 1 AC* expression decreased drastically over the crop growth with endotoxin level falling below the critical level of  $1.91 \mu g/g$  after 110 DAS.
- The high oil containing genotypes 26.01 per cent (CSH-7106), 26.50 per cent (B-58-1290), 25.55 per cent (3HS) and 25.02 per cent (F-1861) has been identified at Dharwad which can be used in breeding programme to increase the oil content keeping the present level of fatty acid composition intact.

## ENTOMOLOGY

### North zone:

- Population dynamics study revealed that jassid population was at higher level (8.5 to 33.0 / 13 leaves) in Ludhiana , at

moderate level (5.8 to 8.8) in Hisar and at below threshold level throughout the season in Faridkot and Sriganaganagar. Whitefly was in higher level only in Sriganaganagar (31.2 to 35.8/3 leaves), while thrips were at below threshold level in all the centres.

- There were no incidences of *H. armigera* and *S. litura* in Sriganaganagar, Faridkot and Ludhiana. Sriganaganagar and Ludhiana had moderate to higher level of Spotted bollworm (5.0 to 9.5 larvae / 5 plants). Pink bollworm was at higher level (2.0 to 6.2/20 green bolls) only in Sriganaganagar and almost no incidence was noticed in Faridkot and Ludhiana.

### Central Zone:

Except Khandwa, in all other centres viz., Akola, Banswara, Junagadh, Bhawanipatna, Nanded and Rahuri, high population of jassid was recorded ranging from 7.8 to 47.1 / 3 leaves. Junagadh recorded higher thrips population (33.2 to 63.6 / 3 leaves), while Banswara had higher whitefly population (32.6 to 35.6 / 3 leaves). Junagadh also had higher aphid population (35.0 to 64.0 / 3 leaves). Very low intensity of mealy bug damage was observed in Junagadh, Surat and Rahuri, while it was absent in other centres.

- *H. armigera* bollworm was at moderate level (3.0 to 8.0 larvae / 5 plants) in Akola, Bhawanipatna, Junagadh, Khandwa, Rahuri and Surat, while Earias bollworm was at higher level (4.0 to 10.0 larvae / 15 Plants) in Bhawanipatna and Rahuri. Pink bollworm was at higher level in Junagadh (6.4 to 5.6 larvae / 20 green bolls), Surat (5 to 9.4), Rahuri (4 to 8) and in Akola (3.4 to 6.4).

### South Zone:

- Jassid population was at higher level in Lam (13.8 to 52.7/3 leaves), Srivilliputtur (10.2 to 18.4), Coimbatore (6.0 to 15.7), Dharwad (6.2 to 13.2) and Raichur (6.9 to 13.2). Aphid was at higher level in Lam (2.6 to 52.7/3 leaves), while thrips were higher in Dharwad (37.0 to 41.0 / 3 leaves).
- The intensity of mealybug infestation was 2.0 to 4.0 grade in Coimbatore and 1.0 grade in Srivilliputtur. Mirid bug was at higher level in Dharwad (10.0 to 29.0 / 25 squares).
- *H. armigera* was at higher level in Dharwad (5.3 to 10.2 larvae / 5 plants) and at moderate level in Raichur (2.2 to 4.6). Earias bollworm was at moderate level in Srivilliputtur (2.0 to 4.0 larvae / 15 plants) and at higher level in Dharwad (4.3 to 8.2). Pink bollworm was at higher level in Dharwad (5.0 to 23.0 larvae / 20 green bolls), Nandyal (6.0 to 9.0), Raichur (2.8 to 4.4) and Srivilliputtur (2.0 to 5.0).

## Chemical Control of Insect Pests

Acephate 75 SP (750 g) and the new formulation of Acephate 95 % SG (562.5 & 750 g) were seen effective against major sucking pests (Jassid, aphid, thrips and whitefly) and helped in higher yield realization ranging from 63.3 to 76.0 %, followed by Imidacloprid (57.3 %) and Acetamiprid (51.1 %) in North zone.

- Acephate 95 % SG and Acephate 75 SP (750 g) were effective against major sucking pests (Jassid, whitefly, thrips and aphid) and gave higher yield by 52.0 to 59.6 % over control in Central zone
- Acephate 75 SP, Thiomethoxam, Acetamiprid and Acephate 95 % SG were effective against major sucking pests (Jassid, aphid, thrips and whitefly) and resulted in higher yield by 35.0 to 38.0 % over control in South zone.
- Profenophos, Chlorpyrifos and Buprofezin were effective against mealybug and resulted in higher yield in North, Central and South zone. Biopesticides viz., Mealy kill, Mealy quit, *M. anisopliae*, *B. bassiana*, *V. lecanii* were

moderately effective.

## PLANT PATHOLOGY

- Cotton leaf curl disease (CLCuO) appeared in epidemic form in Ferozpur district of Punjab on RCH BG II and non descript susceptible genotypes resulting in considerable yield losses. In Rajasthan, out of 6 districts, the disease incidence was seen in two districts only i.e., Sriganganagar and Hanumangarh, which are the traditional cotton growing belts of the State. The remaining four districts viz., Nagour, Jodhpur, Alwar, and Palli were found completely free from leaf curl attack. It was observed that Sriganganagar district was having higher average disease intensity compared to Hanumangarh district. CLCuO was observed in traces at farmer's fields in different *Bt*cotton hybrids in Haryana.
- Low rainfall, high temperature and moderate relative humidity during the vegetative phase of crop favoured high population build up of white fly early in the season with available virus inoculum and some susceptible Bt cotton hybrids, especially in the hot spots, showing higher disease incidence.
- Bacterial blight was reported as important disease in Central zone in Khandwa in Madhya Pradesh (32.3%), Maharashtra (Vidahrbha- 5.5-21.11 %, Rahuri-%, Nanded 2.2-16.2 %) and in South zone in Karnataka (5.0-15.0 %) and Andhra Pradesh (27.0%).
- Alternaria blight was serious in Saurashtra area (2.0-25.0%), Bharuch (5-60%) of Gujarat, Khandwa in Madhya Pradesh (48.2%) and Rahuri (0-29.3 %) and Nanded (3.0-21.5%) in Maharashtra and in South zone in Karnataka (5.0-15.0%) and Tamil Nadu (10.0-26.0%). *Myrothecium* was severe in Madhya Pradesh (39.3%). *Cercospora* was reported to be severe in Tamil Nadu (12.0-50.0%).
- Grey mildew occurred in Maharashtra in the irrigated areas of Vidarbha region (14.6-21.0%). In south zone, it was severe in two states i.e., Karnataka (5.0-30.0%) and Andhra Pradesh (23.3%).
- Tobacco Streak Virus incidence upto 28.06 % was also observed in Andhra Pradesh in January.
- Tetraconazole 11.6% w/w ME @ 900ml/ha, followed by Tetraconazole 11.6% w/w ME @ 800ml/ha and Tetraconazole 11.6%w/w ME @650ml/ha showed the lowest POI of *Alternaria*. Maximum yield increase of 22.97% was observed in Tetraconazole 11.6%w/w ME @ 900ml/ha, followed by 15.14% in Tetraconazole 11.6%w/w ME @ 800ml/ha.
- Seed treatment with *Pseudomonas fluorescens* (TNAU) @ 10 g/kg seed plus foliar spray @ 0.4% on 60 and 90 OAS has given a good per cent disease control of 53.73 followed by SAR inducing chemical (Salicylic acid) @ 50ppm on 60 and 90 OAS with per cent disease control of 50.75 in case of Grey mildew.
- Five sprays of carbendazim at 35, 50, 65, 80 and 95 days after sowing showed reduction of Grey mildew POI from 14.46 to 5.61 and reduction of yield loss upto 27.51 %.
- Five sprays of COC (0.3%) + SS 500 ppm at 35,50,65,80 and 95 days after sowing led to reduction of bacterial blight POI from 28.06 to 14.26 and reduction of yield loss upto 22.85%.
- Five sprays of Propiconazole (@0.1%) at an interval of 35, 50 65 80 and 90 OAS at Khandwa showed reduction of *Myrothecium* leaf spots POI from 22.36% to 7.56% and reduction of yield loss upto 40.66 percent..
- Four sprays of Propiconazole (0.1%) at an interval of 15 days starting from 75 days after sowing has given a good disease control of leaf rust at Oharwad (47.46%) with maximum yield of 3598 kg/ha as compared to 3071 kg/ha in control..
- The number of bolls (40.9% & 31.4%) and seed cotton yield (41.9% & 41.4%) were significantly reduced by CLCuO in RCH 134 in farmers' fields and MRC 6304 Bt at research farm, respectively, when the OI was 100.0 with mixed infection grades in Faridkot district, whereas reduction in seed cotton yield ranging from 8.0 to 77.6% in different severity grades were noted in Bt cotton hybrid RCH 134 at Abohar.





General

## 11.1 List of Publications

### Papers Published in Research Journals

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## 11.2 List of on-going Projects

### Institute Projects

Sl. No.	Name of Project	Name of Project Leader & Associate(s) Dr.	Duration
<b>Crop improvement</b>			
1.	Collection, conservation, evaluation, documentation and maintenance of germ plasm of cultivated species of <i>Gossypium</i>	Punit Mohan (PL), S. Manickam (PA) S. J. Gawande (PA), VS. Nagraire (PA), R. A. Meena (PA), A. B. Dongre (PA), Anjali Kak (PA)	2006-2013
2.	Development of core assembly of <i>Gossypium barbadense</i> , <i>G. arboreum</i> and <i>G. herbaceum</i> germplasm	Punit Mohan (PL), KPM Dhamayanthi (PA)	2008-2012
3.	Development of mapping population for different economically important traits	Head, DCI (PL), V. N. Waghmare (PA) S. M. Palve (PA), S. B. Singh (PA), Vinita Gotmare (PA), T. R. Loknathan (PA) P. R. Vijayakumari (PA), S. Manickam (PA) Punit Mohan (PA)	2008-2012
4.	Improvement of tetraploid and diploid cottons for fibre properties through population improvement approaches	V. N. Waghmare (PL), Vinita Gotmare (PA)	2000-2010
5.	Breeding of upland cotton for improved fibre quality and resistance to biotic stress (bollworms and jassid)	S. M. Palve (PL), M. K. Meshram (PA) S. Venilla (PA), V. Gotmare (PA)	2005-2010
6.	Development of heterotic pool for superior medium staple in tetraploid cotton ( <i>G. hirsutum</i> )	S. M. Palve (PL)	2006-2011
7.	Development of <i>hirsutum</i> genotypes having high oil content coupled with fibre productivity and quality	S. M. Palve (PL)	2008-2013
8.	Studies on genetic enhancement of upland cotton	T. R. Loknathan (PL)	2002-2010
9.	Conservation, characterization and utilization of wild species, races of cultivated species, perennials and synthetic polyploids of <i>Gossypium</i>	Vinita Gotmare (PL), G. Balasubramani (PA)	2008-2013
10.	Identification of genetic markers and characterization of fibre strength and drought tolerance traits in interspecific cross between <i>G. herbaceum</i> and <i>G. anomalum</i>	Vinita Gotmare (PL)	2008-2013
11.	Genetics and development of diploid and tetraploid cottons through inter-racial hybridization for fibre quality, biotic & abiotic stress tolerance	Vinita Gotmare (PL), S. M. Palve (PA)	2008-2013
12.	Diversification of male sterile cytotypes genetic studies and utilization of cleistogamy and protruding stigma in <i>Gossypium</i> spp.	Vinita Gotmare (PL)	2008-2013
13.	Development of drought tolerant genotype with good fibre quality	S. B. Singh (PL), A. H. Prakash (PA)	2008-2013
14.	Development of improved male sterility system through induced mutation	S. B. Singh (PL), O. P. Tuteja (PA)	2008-2011
15.	Development of transgenic diploid cotton for insect Resistance	S. B. Nandeshwar (PI), V. S. Nagraire (PA), S. M. Palve (PA)	2008-2011
16.	<i>In-vitro</i> cell manipulation for induction of somatic embryogenesis and plant regeneration in diploid and tetraploid cotton	S. B. Nandeshwar (PL), A. H. Prakash (PA)	2008-2011
17.	Development of long staple <i>G. hirsutum</i> with improved fibre strength	S. Manickam (PL), V. N. Waghmare (PA) S. L. Ahuja (PA)	2008-2014
18.	Development of extra-long staple high spinning hybrids with wider adaptability	KPM Dhamayanthi (PL), S. Manickam (PA)	1986-2011
19.	Induction of polyploidy and introgression of agronomical traits from diploid wild species to cultivated tetraploids	K. P. M. Damayanti (PL), Vinita Gotmare (PA)	2008-2012
20.	Molecular basis of pathogenicity and race-specificity of <i>Xam</i> and characterization of antagonists of foliar pathogens of cotton for biocontrol	P. K. Chakrabarty (PL)	1994-2009

21.	Development of transgenic cotton resistant against major diseases of cotton.	P. K. Chakrabarty (PL), S. B. Nandeshwar (PA), A. H. Prakash (PA)	2009-2012
22.	Isolation of fibre specific trichome specific promoter from <i>G. hirsutum</i> / <i>A. thaliana</i>	G. Balasubramani (PL), J. Amudha (PA)	2008-2011
23.	Development of drought resistant transgenic cotton and identification of new gene for high water use efficiency	J. Amudha (PL), A. H. Prakash (PA) G. Balasubramani (PA)	2008-2011
24.	Molecular mapping of leaf curl virus resistance gene in the cotton genome	J. Amudha (PL), D. Monga (PA) G. Balasubramani (PA)	2002-2009
25.	Molecular evaluation of cotton germplasm	A. B. Dongre (PL), Punit Mohan (PA)	2000-2011
26.	Development of efficient agro-techniques for enhancing the productivity and seed quality of Bt cotton varieties	R. K. Deshmukh (PL), K. Rathinavel (PA)	2008-2011
27.	Performance of evaluated new Bt hybrids on large size plots (138.24 sq. Mt.)	R. K. Deshmukh (PL), P. R. Vijayakumari (PA), V. Santhy (PA)	2008-2011
28.	Studies on cotton seed with particular reference to germination and dormancy	P. R. Vijayakumari (PL), R. A. Meena (PA) R. K. Deshmukh (PA), V. Shanthi (PA)	2004-2009
29.	Assessment of working seed sample size for Bt seed testing based on estimation of Cry 1Ac protein	P. R. Vijayakumari (PL), K. R. Kranthi (PA)	2008-2010
30.	Studies on seed quality parameters and genetic purity of TFL seed sold in market	P. R. Vijayakumari (PL), K. R. Kranthi (PA) K. Rathinavel (PA), R. A. Meena (PA)	2008-2011
31.	Assessment of seed vigor trait in cotton	V. Santhy (PL), P. R. Vijayakumari (PA), Jagvir Singh (PA)	2003-2010
32.	<b>Phenotyping and genotyping of cotton genotypes</b>	V. Santhy (PL), K. Rathinavel (PA) G. Balasubramani (PA)	2008-2012
33.	Transgene expression and effect of transgene on quantity and quality in seeds of Bt cotton hybrids	V. Santhy (PL), S. B. Nandeshwar (PA), G. Balasubramani (PA)	2008-2011
34.	Utilization of electromagnetic field seed treatment for the enhancement of cotton seed quality and productivity under diversified agro-ecological situations (Ad hoc)	K. Rathinavel (PI), P. R. Vijayakumari (Co-PI), R. A. Meena (Co-PI)	2008-2010
35.	Studies on salt tolerance (Ad hoc)	S. L. Ahuja (PL), R. A. Meena (PA)	2008-2010
36.	Development of varieties and hybrids resistant to CLCuV	a. p. Tuteja (PL), D. Monga (PA), Rishi Kumar (PA)	2008-2013
37.	Technology to enhance the better crop establishment and yield in cotton.	R. A. Meena (PL), D. Monga (PA)	2007-2012
38.	Development of GMS based hybrids and pre-breeding for fibre quality in <i>G. arboreum</i>	S. K. Verma (PL), S. L. Ahuja (PA)	2008-2013
39.	Development of heterotic pools in <i>G. arboreum</i> and <i>G. hirsutum</i>	S. K. Verma (PL), a. p. Tuteja (PA), S. L. Ahuja (PA)	2008-2012
40.	Marker Assisted Selection for developing elite breeding lines in cotton	S. K. Verma (PL), S. L. Ahuja (PA)	2008-2012
41.	Breeding new <i>G. hirsutum</i> varieties with new plant type - Development of medium staple varieties.	K. N. Gururajan (PL), S. Manickam (PA)	1989-2011
42.	Development high yielding and high spinning extra long cotton staple varieties.	K. N. Gururajan (PL), S. Manickam (PA)	1989-2011
<b>Crop production</b>			
43.	Nutrition requirement of soybean-Bt hybrid cotton in participatory mode	A. R. Raju (PL), M. K. Meshram (PA), G. Majumdar (PA)	2008-2012
44.	Agronomic and physiological evaluation of NHH 44 Bt and BN-Bt cotton under rainfed conditions on Vertisols and associated soils	M. V. Venugopalan (PL), M. Chakrabarty (PA), K. K. Bandyopadhyay (PA)	2009-2013
45.	Studies on long term effect of fertilizer and integrated nutrient management on productivity, soil fertility and quality of rainfed hybrid cotton	Jagvir Singh (PL), M. V. Venugopalan (PA), K. Velmourougane (PA)	2004-2025
46.	Studies on impact of transgenic cotton on soil microbial and biological properties under cotton based cropping systems	K. Velmourougane (PL), Jagvir Singh (PA), P. Nalayini (PA)	2008-2011
47.	Developing efficient carrier based microbial delivery system for cotton nutrition and soil health	K. Velmourougane (PL), Jagvir Singh (PA), A. R. Raju (PA)	2008-2011

48.	Effect of different nitrogen levels on oil and protein content in Bt and non-Bt cotton hybrids and effect of Bt gene on cotton seed oil content..	M. Chakrabarty (PL), M. V. Venugopalan (PA)	2007-2010
49.	Assessment of gossypol content in cotton germplasm	M. Chakrabarty (PL)	2004-2012
50.	Economic analysis of cotton based farming system in Vidarbha.	p. R. Deoghare (PL), S. M. Wasnik (PA)	2007-2010
51.	Capital requirement for modernization of cotton production on marginal and small farm in Vidarbha	P. RDeoghare (PL), A. R. Reddy (PA) S. M. Wasnik (PA)	2008-2010
52.	Economic Impact of Bt Cotton cultivation in India	A. R. Reddy (PL), Isabella Agarwal (PA), Rishikumar (PA)	2008-2010
53.	Assessment of cotton based intercropping system and its popularization through farmers to farmers participatory learning approach.	S. M. Wasnik (PL), S. Usha Rani (PA), A. R. Raju (PA)	2008-2012
54.	Performance of Osmanabadi goats under feeding of Bt and Non Bt cotton leaves	S. N. Rokde (PL)	2007-2009
55.	Bio-mulching and biodegradable mulching for Bt cotton based cropping system.	P. Nalayini (PL), K. Sankaranarayanan (PA), K. Velmourougane (PA)	2008-2010
56.	Assessment of productivity potential of genotype vis-a- vis Bt hybrids through agronomic manipulation.	C.S.Praharaj (PL), K.Sankaranarayanan (PA), N.Gopalakrishnan (PA)	2007 -2009
57.	Water management in <i>hirsutum</i> & <i>barbadense</i> cotton	K.Sankaranarayanan (PL), P. Nalayini (PA), C.S.Praharaj (PA), K. K. Bandyopadhyya (PA), P.Nalayini (PL), K.Sankaranarayanan (PA), K.velmourougane (PA)	2004-2010 2008-2010
58.	Herbigating herbicide/ herbicide mixture/ herbicide rotation for efficient and environmentally safe weed control and its effects on succeeding pulses	P. Nalayini (PL), K. Sankaranarayanan (PA), K. Velmourougane (PA)	2008-2010
59.	Simulation of effect of irrigation and nitrogen on soil water and nitrogen dynamics, productivity and input use efficiency of Bt cotton in a vertic Ustropept	K. K. Bandyopadhyya (PL), A. H. Prakash (PA), B. Dharajothi (PA)	2006-2009
60.	Studies on soil aggregation and aggregate associated carbon in cotton based cropping system	K .K .Bandyopadhyya (PL), K. Velmourougane (PA)	2008-2010
61.	Simulation of effect of N management strategies on nitrogen dynamics in soil plant system and nitrogen use efficiency of ELS Bt cotton in a climate change scenario (Ad -hoc)	K.K.Bandyopadhyya (PL),A. H. Prakash (PA), B.Dharajothi (PA), C.S.Praharaj(PA)	2009-2012
62.	Identification and utilization of adaptive responses to abiotic stresses in cotton	S. E. S. A. Khader (PL) N.Gopalakrishnan (PA), K.N.Gururajan (PA)	1995-2009
63.	Studies on the mechanism of cuticular absorption of nutrients and hormones in Bt cotton	S.E.SAKhader (PL)	2008-2012
64.	Economic analysis of contract farming in cotton in TN	Isabella Agarwal (PL)	2005-2009
65.	Adoption, impact and return to research investment in improved cotton cultivars in Tamil Nadu	Isabella Agarwal (PL)	2005-2009
66.	Post evaluation of farmers field schools on cotton	S.Usha Rani (PL), K.Sankaranarayanan (PA)	2007-2010
67.	Documentation and validation of farmers indigenous knowledge on farming system approach in cotton	S. Usha Rani (PL), P. Nalayini (PA)	2007-2010
68.	Comparative analysis of conventional, biotech and organic cotton production systems in India	S. Usha Rani (PL), S. MWasnik (PA) K. Sankaranarayanan (PA)	2008-2011
69.	An empirical analysis on cultivation behaviour of Bt cotton growers with regard to insect resistance management technologies	S.Usha Rani (PL), S.MWasnik (PA)	2008-2011
<b>Crop protection</b>			
70.	Basic studies on bollworm resistance to Bt cotton and development of management strategies	K. R. Kranthi (PL)	2008-2011
71.	Exploitation of induced resistance for cotton pest management	S. Kranthi (PL)	2008-2010
72.	Isolation and characterization of native Bt strains using conventional and molecular methods, for cotton pest management	S. Kranthi (PL), K. R. Kranthi (PA)	2008-2010

73.	Population and community ecology of cotton entomofauna	V. S. Nagrare (PL)	2006-2011
74.	Evaluation and exploitation of compensation as a mechanism for comprehensive insect pest tolerance	V. S. Nagrare (PL), Vinita Gotmare (PA)	2006-2011
75.	Studies on bionomics and management of mealy bug	V. S. Nagrare (PL), K. R. Kranthi (PA)	2008-2011
76.	Ecological - based approaches for sustainable sucking pests management	V. S. Nagrare (PL)	2008-2010
77.	Studies on seed transmitted pathogenic infections and other seed microflora of cotton	P. M. Mukewar (PL)	1989-2009
78.	Screening and Identification of <i>effective</i> bio-control agents for the management of foliar cotton diseases	M. K. Meshram (PL), S. J. Gawande (PA)	2008-2011
79.	Identification of bacterial blight and grey mildew disease resistant genotypes in upland cotton.	M. K. Meshram (PL)	2008-2011
80.	Identification of sources of resistance against Rhizoctonia root rot in tetraploid and fusarium wilt in diploid cotton and their utilization in breeding program	R. C. Ukey (PL), V. N. Waghmare (PA)	2006-2011
81.	Studies on cotton viral diseases (Ad-hoc)	A. K. Mukherjee (PL), M. K. Meshram (PA) V. Jayakumar (PA)	2009-2010
82.	Studies on inoculums source and economic thresholds of cotton leaf curl and virus disease	D. Monga (PL), Rishi Kumar (PA)	2008-2011
83.	Bio-ecology and sampling of mealybug in Bt-cotton.	Rishi Kumar (PL), D. Monga (PA).	2008-2011
84.	Impact of systemic insecticide on sucking pests and non target arthropod communities in Bt and Non Bt cotton	Rishi Kumar (PL)	2008-2011
85.	Studies on the role and effect of insecticides in cotton ecosystem	T. Surulivelu (PL), K. Natarajan (PA)	1989-2011
86.	Studies on the population dynamics of cotton pests and their natural enemies in cotton eco-system	K. Natarajan (PL), B. Dharajothi (PA)	2008-2010
87.	Developing resistant genotypes to jassid	K. Natarajan (PL), KPM Damayanthi (PA)	2008-2012
88.	Standardization of bioassays techniques for resistance monitoring in <i>Pectinophora gossypiella</i> Saunders to transgenic cotton and development of management strategies	B. Dharajothi (PL)	2007-2012
89.	Pesticides, sucking pests and predator interaction on Bt cotton	B. Dharajothi (PL)	2008-2010
90.	Studies on epizootiology, pathogenicity and pathogenic mechanism of Entomopathogenic fungal pathogens against cotton mealybug	M. Amutha (PL)	2008-2011
91.	Establishment of <i>Beauveria bassiana</i> as a symbiotic insecticide against major insect pests and diseases of cotton	M. Amutha (PL), M. Gunasekaran (PA)	2009-2012
92.	Studies on biochemical, molecular and genetic basis of host plant resistance to cotton nematodes	N. G. Narkhedkar (PL)	2006-2010
93.	Potential of rhizobacteria in management of cotton nematodes	N. G. Narkhedkar (PL)	2006-2010
94.	Isolation identification and characterization of insecticidal toxins from heat tolerant isolate of EPN bacterial system	N. G. Narkhedkar (PL)	2008-2011
95.	RNAi mediated crop protection against root-knot nematode	N. G. Narkhedkar (PL), P. K. Charkrabarty (PA)	2009-2012
96.	Identification of hot spots for plant parasitic nematodes in cotton growing zones of India	Gulsar Banu (PL), N. G. Narkhedkar (PA)	2006-2011
97.	Isolation of <i>novel</i> insecticidal proteins from bacterial symbionts of <i>native</i> entomo-pathogenic nematodes	Gulsar Banu (PL), N. G. Narkhedkar (PA), B. Dharajothi (PA)	2006-2011

#### EXTERNALLY FUNDED PROJECTS

##### DST/ DBT

98.	DST; Molecular mapping of fibre quality traits QTLs and marker assisted selection (MAS) in upland cotton ( <i>Gossypium hirsutum</i> L.)	V. N. Waghmare (PI)	2007-2010
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99.	DBT; Molecular mapping of fibre quality and lint yield traits: construction of a framework linkage map in desi cotton ( <i>Gossypium sp.</i> )	VNWaghmare (PI), A.BDongre (PA) Vinita Gotmare (PA), Er Manoj Kumar (PA)	2006-2009
100.	DBT; Engineering virus resistant cotton through dsRNAi-mediated targeting of cotton leaf curl virus	P. K. Chakrabarty (PI), S. B. Nandeshwar (PA), D. Monga (PA), B. M. Khadi (PA)	2007-2010
101.	DBT; Identification of Molecular markers and tagging genes for Bacterial blight resistance	P. K. Chakrabarty (PI), Punit Mohan (PA), V. N. Waghmare (PA), B. M. Khadi (PA)	2008-2011
102.	DBT : "Gene stacking in Bt Cotton"	G. Balasubramani (PI) S. B. Nandeshwar (CCPI), S. B. Singh (CCPI)	2008-2010
103.	DBT; Development of cotton transgenic with improved fibre strength using cellulose synthase gene from <i>Arabidopsis</i>	G. Balasubramani (PI), J. Amudha (CCPI)	2007-2009
104.	DBT; Indo-Australian Project: Enhancing sustainability of transgenic crops through gene stacking	K. R. Kranthi (PI)	2008-2012
<b>NAIP</b>			
105.	Georeferenced soil information system (GeoSIS) for land use planning and monitoring soil and land quality for agriculture	MVVenugopalan (CCPI), K. Velmourougane (CCPI)	2009-2013
106.	A value chain for cotton fibre, seed and stalks: an innovation for Higher Economic Returns to Farmers and Allied Stake holders	N. Gopalakrishnan Consortium partner and CoPI, Sankaranarayanan (Co oPI) P. R. Bharambe (Team Leader, Nagpur) D. Monga, (Team Leader, Sirsa)	2008-2012
107.	Research into development of decision support systems for management of insect pests of major rice and cotton based cropping systems	V. S. Nagrare (CCPI), G. Majumdar (CoPI) Rishi Kumar (CoPI), B. Dharajothi (CoPI) M. Sabesh (CoPI), M. Amutha (CoPI)	2008-2012
<b>OTHER PROJECTS</b>			
108.	Transgenics in Crops (NPTC): Development of bollworm resistance transgenic cotton (ICAR-Network Project)	G. Balasubramani (PI), S. B. Singh (CCPI), J. Amudha (CCPI), S. B. Nandeshwar (CCPI), A. B. Dongre (CCPI), K. R. Kranthi (CCPI), P. K. Chakrabarty (CCPI)	2006-2012
109.	Impact, adaptation and vulnerability of Indian agriculture to climate change. Sub project-- changes in soil carbon reserves as influenced by different ecosystems and land uses in India. (ICAR Network project)	1. Bhattacharyya, NBSS&LUP (PI): M. V Venugopalan, (CCPI), P Chandran, NBSS&LUP (CCPI)	2009-2012
110.	Testing & Documentation of Extant Varieties, hybrids and their Parents for Distinctness, Uniformity & Stability (PVP & FR ACT, 2001). (DUS)	N. Gopalakrishnan (PI), K. Rathinavel (CCPI), VSanthy (CCPI) P.R. Vijayakumari (CCPI) R. K. Deshmukh (CCPI)	2003-2012
111.	Novel approaches for production of hybrid seeds with characteristics of improved insect resistance and higher Yield. Funded by the CSIR, under the New Millennium Initiative project	K. R. Kranthi (PI)	2008-2012
112.	Development of technology for Detecting Presence of GMOs in an Unknown Sample and its Utilization in dealing with Bulk Samples. (Ministry of Agriculture, Government of India GMO Project)	K. R. Kranthi (PI)	2006-2009
113.	Monitoring changes in baseline susceptibilities to cry1Ac in geographic populations of <i>H. armigera</i>	S. Kranthi (PI), K. R. Kranthi (CCPI)	2002-2012
114.	Monitoring changes in baseline susceptibilities to cry2Ab & cry1Ac +cry2Ab in geographic populations of <i>H. armigera</i>	S. Kranthi (PI), K. R. Kranthi (CCPI)	2002-2012
115.	Monitoring changes in baseline susceptibilities to JK toxin (Event 1) in geographic populations of <i>H. armigera</i>	S. Kranthi (PI), K. R. Kranthi (CCPI)	2002-2012
116.	Studies on <i>H. armigera</i> response to Rynaxypyr (DuPont Project) (Funded by Dupont)	K. R. Kranthi (PI)	2006-2009
117.	Implementation of PVP legislation 2001 (Ad hoc)	K. Rathinavel (PI) S.Manickam (Co-PI)	2008-2009
118.	Seed production in agricultural crops and fisheries	K.Rathinavel (PI)	2006-2014
119.	National Seed Project (crops).	K,Rathinavel (PI)	1999-2012

120. Awareness-cum-Surveillance Programme for Management of Major Pests in Soybean-Cotton Based Cropping System in Maharashtra (2009-10) (Funded by Government of Maharashtra)

V. S. Nagrare (PI)

2009-2010

### Technology Mission on Cotton (TMC): Mini Mission I 2007-2012

Project code	Project Title	Name of PI/CCPI Dr.
MM 1.1	Development and promotion of medium and long linted diploid cottons ( <i>G.arboreum</i> and <i>G.herbaseum</i> )	S. K. Verma - PI T. R. Loknathan - CCPI
MM 1.2	Development of extra long staple <i>G.barbadense</i> cotton with improved fibre qualities to meet the requirements of textile industry	K. N. Gururajan - PI
MM 1.3	Identification of <i>G. hirsutum</i> genotypes suitable for machine picking and development of agronomic package	V. Gotmare - CCPI
MM 1.4	Development and promotion of Bt transgenic cotton for bollworm Resistance	S. Manickam - CCPI, Suman Bala Singh, S. B. Nandeshwar, S. M. Palve, O. P. Tuteja, S. K. Verma.
MM 1.5	Molecular characterization of cotton germ plasm using DNA Markers	A. B. Dongre, V. N. Waghmare.
MM 1.6	Exploitation of apomixis and TGMS System in hybrid cotton seed production	S. M. Palve - PI V. Gotmare - CCPI, V. Santhy.
MM 2.1	Development of production technologies for Bt cotton and improvement of water and nutrient use efficiency with precision farming techniques	J. V. Singh - PI C. S. Praharaj - CCPI, P. R. Bharambe, M. V. Venugoplan.
MM 2.2	Identification of <i>innovative</i> Bt cotton based cropping systems improvement of water and nutrient use efficiency with precision farming techniques	P. Nalayini - PI K. K. Bandopadhyay - CCPI, A. R. Raju, P. R. Bharambe, R. A. Meena.
MM 2.3	Mechanization of cotton production	G. Majumdar-PI, A. R. Raju-CCPI
MM 2.4	Physiological manipulation of Bt plant morphoform for enhanced productivity under <i>varied</i> agro-climatic conditions	A. H. Prakash - PI R. K. Deshmukh - CCPI
MM 3.1	Emerging and key pests of Bt cotton- their characterization, taxonomy, genetic diversity and control	K. R. Kranthi - PI, T. Surulivelu - CCPI, Dharajyoti, S. Kranthi, V. S. Nagrare, M. K. Meshram.
MM 3.2	Development and validation of IPM/IRM strategies for Bt cotton under different ecosystems	S. Kranthi - CCPI V. S. Nagrare - CCPI Rishi Kumar - CCPI
MM 3.3	Development, validation, utilization and / or commercialization of bio-pesticides and bio inoculants	P. K. Chakrabarty - PI T. Surulivelu - CCPI J. Gulsar Banu - CCPI N. Narkhedkar - CCPI D. Monga - CCPI
MM 3.4	Development of farmerfriendly diagnostic kits for transgenic <i>event</i> seed	K. R. Kranthi - CCPI
MM 4.1	Quality evaluation of cotton fibres	M. Chakrabarty - CCPI
MM 5.1	Total factor productivity of cotton in India	Isabella Agarwal - PI A. R. Reddy - CCPI
MM 5.3	Indian cotton portal	M. Sabesh - PI N. Gopalakrishnan - CCPI G. Majumdar-CCPI

### Technology Mission on Cotton: Mini Mission II 2007-2012

Project Title	Name of PI/CCPI Dr.
Dissemination of IRM strategies in 500 villages of India	K. R. Kranthi (PI) B. Dharajyoti - CCPI D. Monga - CCPI Rishi Kumar - CCPI

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

Following implements developed have been filed for patents with provisional application

1. Bullock drawn vertical rotor planter for vertisols (Prov. Pat., No.1559/MUM/2009)

2. Cotton Seed Blower (Prov. Pat., No. 1560/ MUM /2009)

3. Solar powered knapsack sprayer (Prov. Pat., No. 1561/MUM/2009)

4. Notification of *G. arboreum* variety CISA 614 for Commercial Cultivation in North Zone

The variety CISA 614 was tested in 32 locations in the North Zone (Punjab, Haryana and Rajasthan) during 2004-2007 and has recorded an overall mean seed cotton yield of 2204 kg/ha as against 1834 kg/ha of HD 123 (zonal check) and 1990 kg/ha of local checks. It was identified by Variety Identification Committee Meeting (AICCIP) held at ANGRAU, Hyderabad 6-8 April, 2009 and notified vide Gazette of India NO.608 dated April 1, 2010.

5. Notification of *G. arboreum* variety CISA 310 for commercial cultivation in north zone

The variety CISA 310 of *Gossypium arboreum* developed at CICR, Regional Station, Sirsa, has been notified vide Gazette of India NO.171 dated January, 2010 for cultivation under irrigated conditions of entire north zone due to its overall superiority in both seed cotton and lint yield, better fibre quality than the check and less boll damage.

6. Notification of *G. hirsutum* variety, CNHO 12 for commercial cultivation in central zone (irrigated condition)

*G. hirsutum* variety, CNHO 12 (Saraswati) has been identified for release in the Central zone under irrigated conditions during the year 2009-10. The variety is characterized by dwarf stature, early maturity (160-165 days), medium to high seed oil content (21.8 %) with synchronous boll bursting. It has recorded seed cotton yield of 1501 kg/ha as against 1251 kg/ha of the zonal check LRA 5166. In the wake of shortage of short staple and medium staple categories of cotton in the country, the new variety CNHO 12, spinnable to 20s counts was recommended for release for its suitability for manufacture of denim. The variety has been assigned with the National Identity Number IC 574486.

7. Release of first public sector Bt cotton hybrid NHH 44-Bt for commercial cultivation

The first public sector Bt hybrid NHH 44-Bt was developed indigenously by using BN Bt as female parent and approved for commercial cultivation by the GEAC, New Delhi on 13<sup>th</sup> May, 2009. The BN Bt is very good combiner for hybrid production and it was developed by incorporating Bt *cry1 Ac* gene. The expression of Cry protein level is high i.e. up to 5.8 ppm. The hybrids were evaluated in all the cotton growing zones and found very promising. It was developed through collaborative efforts of the University of Agricultural Sciences (UAS), Dharwad, National Research Centre for Plant Biotechnology (NRCPB), New Delhi and Central Institute for Cotton Research (CICR), Nagpur.

8. Seed Production

Nagpur

Under the Mega Seed production programme, seeds of 13 elite cultivars of cotton along with wheat and pulses were produced. A sizeable resource of Rs. 6.72 lakhs approximately was earned through the sale proceeds.

Crop	Stage	Production (Q)
Cotton -13 varieties	TFL	32.89
Wheat cV.HD2189	Foundation Seed	40.90
Red Gram-BSMR	TFL	73.80
Gram-Vijay	CS	29.80
Wheat-GW-496	CS	55.98

#### Coimbatore

#### Breeder Seed Production

Variety	Breeder Seed production (kapas in kg)	Breeder seed distribution (seeds in kg)
LRA5166	326	111
MCU 5 VT	-	69*
Surabhi	130	111
Suraj	192	54
Supriya	94	6
Suvin	235	33
Total	977	384

\*From Carried over stock

#### Sirsa

#### Maintenance of Nucleus and Breeder seeds

No	Variety	Quantity (kg)
1	CSHH 198 (F)	45
2	CSHH 198 (M)	38
3	CSHH 243 (F)	25
4	CSHH 243 (M)	10
5	CSHH 238 (F)	35
6	CSHH 238 (M)	30
7	CICR 2 (F)	35
8	CICR 2 (M)	30
9	CISA310	85
10	CISA614	100



## 11.4: Significant Decisions of IRC, IMC and Other Important Meetings

### 1. Research Advisory Committee Meeting

The Research Advisory Committee (RAC) of the Institute held its first meeting at CICR, Nagpur on April 24-25, 2009. Dr. S.S. Beghel, Ex. Vice-Chancellor, Assam Agricultural University, Jorhat, Chairman RAC presided over the meeting and guided the deliberations. Other members of RAC viz. Dr. S.K. Sharma, Ex. Project Director, Project Directorate of Cropping Systems, Modipuram, Dr. V. Shiva Reddy, Group Leader (Transformation) International Centre for Genetic Engineering & Biotechnology (ICGEB), New Delhi and Dr. G.T. Gujar, Head, Division of Entomology, Indian Agricultural Research Institute, New Delhi attended the meeting. Dr. K.R. Kranthi, Acting Director CICR, Nagpur, Dr. P.R. Bharambe, Head Crop Production Division, Dr. V.V. Singh, Head Crop Improvement Division, Dr. N. Gopalakrishnan, Project Coordinator (AICCP) and Head, CICR Regional Station, Coimbatore, Dr. D.Monga, Head CICR, Regional Station Sirsa and Sh. M.K. Meshram, Principal Scientist, Members Secretary were also present.



Dr. K.R. Kranthi, Director, CICR, Nagpur formally welcomed the RAC Chairman and its members. Dr. Kranthi presented an overview of current cotton situation. In his introductory remarks, Dr. Beghel, Chairman RAC appreciated the efforts made in the development of indigenous Bt genotype. Natural resources, especially water, he predicted, would be limiting in the days to come. He advised management of biotic stresses through cultural practices by understanding the life cycle of the pest. Dr. Shiva Reddy congratulated UAS, Dharwad, NRCPB, New Delhi, and CICR, Nagpur for their joint efforts in release of first public sector transgenic variety BN Bt.

The action taken report (ATR) on the recommendations of the previous Research Advisory Committee meeting held on August 3, 2007 was presented and discussed in detail. Dr. Kranthi highlighted the recent research initiatives and major research achievements of CICR, Nagpur and its regional stations. The Project Coordinator, Dr. N. Gopalakrishnan presented the achievements of the Regional Station, Coimbatore wherein the performance of high yielding interspecific hybrid CCHB 110, farming system approach, NAIP project and growing cotton under polymulch were highlighted. Dr. D.Monga, Head Regional Station Sirsa, presented the achievement of the station which includes release of CSHH 243, submission of CISA 614 for varietal identification and registration of 13 genetic stocks. Dr. V.V. Singh, Head Crop Improvement Division, Dr. P.R. Bharambe, Head, Division of Crop Production and Dr. K.R. Kranthi, Director and Head, Division of Crop Protection also presented research achievements of their respective divisions.

During the deliberations, Dr. Shiva Reddy desired that CICR should gear itself with reference to fibre specific genes and must ensure for the partnership in the cotton genome programme. Dr. Gujar expressed satisfaction with work being carried out by the plant protection group. Dr. Sharma desired that yield targets be fixed for rain-fed and irrigated cotton production system.

The Chairman Dr. Baghel, expressed satisfaction at the work being carried out and evinced need for a brain storming session on the challenges for cotton cultivation in North, South and Central India. He suggested for improvement in seed oil from cotton seed as by product, implementation of appropriate strategies for IRM through DOCD, Mumbai and identification of better combiners with agronomic parameters having good yield potential. Dr. Kranthi assured the house that all the valuable suggestions/recommendations will be implemented by improving the research programmes. He also assured the house that the seeds of BN Bt variety and Bt hybrid NHH 44 will be made available to the farmers through the Government agencies. The Director also expressed optimism on obtaining regulatory clearance for the commercialization of hybrid Bt NHH 44. The meeting concluded with a formal vote of thanks by the member secretary.

### 2. Institute Research Council Meeting

Institute Research Council Meeting was held on April 29-30, 2009 at CICR Nagpur under the Chairmanship of Dr. K.R. Kranthi, Director CICR. All the scientists of CICR, Nagpur participated and presented their research findings. The projects were discussed thoroughly and technical programme for the 2009-10 was finalized. The new research proposals were also presented, discussed and finalized to be implemented during 2010-11. IRC also felicitated Dr. VV Singh, Principal Scientist, Plant Breeding and Dr. P.M. Mukewar, Principal Scientist, Plant Pathology who were due for superannuation. The meeting was conducted by Dr. Vishlesh Nagrare, Secretary, IRC and Dr. Velmourougane, Jt. Secretary, IRC.

The annual IRC meeting of CICR, RS, Coimbatore was held on 10<sup>th</sup>-11<sup>th</sup> February 2010 under the Chairmanship of Dr. K. R. Kranthi, Director, CICR Nagpur. Dr. N. Gopalakrishnan, Project Coordinator and Head, CICR, RS Coimbatore made a brief introductory remark introducing the various activities and the overall contributions of scientists from various disciplines.

Dr. K. R. Kranthi, Chairman IRC, in his opening address desired that the research done at this center should fulfill the farmer's need of the region. He also sensitized the scientist regarding the relevance of the institute in the changing scenario of cotton cultivation at national and international level. He told to the house that hybrid era by private companies is at near saturation stage. In the present context of Bt era we need to find innovative avenues to deliver public goods. Leadership is required in solving problems. He congratulated the scientists of CICR RS Coimbatore on good work carried out on production aspects of cotton.

Dr. V. S. Nagrare, Secretary IRC welcomed Dr. K. R. Kranthi, Director, CICR Nagpur and Chairman IRC, Dr. P. R. Bharambe Head Division of Crop Production, Dr. P. K. Chakrabarty, Head Division of Crop Improvement, Dr. N. Gopalakrishnan PC & Head CICR RS Coimbatore and all the scientists. All the Scientists of the station presented the results obtained during 2009-10 and technical programmes for the year 2010-11 were approved by the house.

The annual IRC meeting of the regional station, Sirsa was held on 17<sup>th</sup> July, 2009. The meeting was Chaired by Dr. K. R. Kranthi, Director, CICR, Nagpur. Dr. D.Monga, Head CICR, Regional Station Sirsa welcomed the Director and appraised the house about the on-going research programmes at the station. All the Scientists of the station presented the results obtained during

2009-10 and technical programmes for the year 2010-11 were approved. Dr. P.R. Bharambe, Head Crop Production, Dr. V.V. Singh, Head Crop Improvement and Dr. V.S. Nagrare, Member Secretary, IRC were also present.

### 3. Institute Management Committee Meeting

The 47<sup>th</sup> Institute Management Committee of CICR, Nagpur was held on May 27, 2009 at CICR, Nagpur. Dr. K.R. Kranthi Acting Director CICR, Nagpur; Dr. O.P. Tuteja, Principal Scientist, CICR (RS), Sirsa; Dr. K.N. Gururajan, Principal Scientist, CICR (RS), Coimbatore; Dr. K.B. Hebbar, Principal Scientist, IISS, Bhopal; Dr. (Mrs.) Vinta Gotmade, Sr. Scientist, CICR, Nagpur; Dr. Nandini Gokte-Narkhedkar, J/c. Admn. Officer CICR attended the meeting. Other special invitees were Dr. S.N. Puri, Hon'ble V.C. Central Agricultural University (CAU), Imphal & Chairman, QRT; Dr. N. Gopalakrishnan, PC & Head Regional Station, Coimbatore, Dr. D.Monga Regional Station, Sirsa, Dr. P.R. Bharambe, Head Crop Production Division CICR, Nagpur, Dr. R. K. Deshmukh, J/c HOD, Crop Improvement, CICR Nagpur; Shri M.K. Meshram, Scientist Incharge, KVK, Nagpur and Shri Devesh Nigam, Finance & Account officer.

At the outset Dr. P.R. Bharambe, Head Division of Crop Production welcomed the Director, CICR and Chairman, IMC, Dr. S.N. Puri and other Hon'ble members of IMC. He also mentioned that this session was specially convened to facilitate the presentation of the recommendations of QRT. Director, CICR briefly outlined the recent R & O achievements of the Institute. He highlighted the release of two Bt transgenic cotton from public sector viz., BN Bt *hirsutum* variety and NHH 44 Intra *hirsutum* hybrid as major achievements. Dr. S.N. Puri, Hon'ble VC, CAU, Imphal and Chairman QRT, CICR Nagpur at the outset complimented the research of CICR and AICCIP for the excellent work carried out during the review period. He expressed that the main concern of QRT was regarding the introduction of public sector transgenic into the market. The main recommendations of the QRT pertaining to CICR and AICCIP were also discussed. The meeting ended with thanks to Chair and the members by the Members Secretary.

### 4. Brain storming cotton: facing the new challenges

Brain Storming Cotton on facing the new challenges was held on July 9, 2009 at Central Institute for Cotton Research, Nagpur. The meeting comprised of two sessions. The first session comprised of Background papers and was chaired by Dr. C.D.

Mayee, Chairman, ASRB, New Delhi. The second session was chaired by Dr. Swapan Datta, Deputy Director General (Crop Sciences) and it comprised of views on researchable issues on emerging challenges. These views were compiled from the feedback received from different cotton researchers in India (through e-mail). Dr. C.D. Mayee delivered a talk on 'Cotton- the recent revolution and issues'. He observed that precision farming is the next challenge which should aim at a productivity of 35 q. per hectare. He desired that CICR should take the lead and demonstrate the feasibility of precision farming on a model plot.



Dr. S. Sreenivasan, Director, CIRCOT, Mumbai gave a talk on 'Cotton trade, demand, pricing & quality issues after the introduction of Bt cotton. The recent challenges and ways to tackle them'. Dr. Sreenivasan presented the requirements for cotton of different fibre span lengths based on the feedback from textile industry. He also informed that very few Bt cotton cultivars satisfy the quality norms set by the industry. He also regretted that in 2007 *hirsutum* cotton in 28-32 mm length dominated the production and the production of other three types of cotton obtained from *arborescens*, *herbaceum* and *barbadense* were low. The other issues raised by him related to reduction in micronaire in Bt cotton after second picking only resulting poor quality cotton and mixing of Bt with non-Bt inorganic cotton meant for export. Dr. Sreenivasan presented a futuristic picture of cotton with ideal attributes such as tenacity and extension of polyester, softness of wool, less short fibre content and improvement of GOT.

In the second session on Cotton: Facing the new challenges was chaired by Hon'ble DOG (CS), Dr. Swapan Datta. Dr. P. K. Chakrabarty and Dr. Gopalakrishnan presented some of the issues based on the views received from various cotton workers around the country. Pertinent concerns in cotton biotechnology and breeding were:

Gene construct and future biotech products: How should India deal with IPR?

497 Bt hybrids and more to come, 90% area covered by private Bt cotton hybrids: What are the options left for public sector breeders?

- Bt cotton hybrids: Are they more susceptible?
- Roundup Ready Cotton: Issues on suitability for Indian cropping systems.
- Seed quality, market trade, export and quality issues.

Responding to these issues there was a general observation that there is substantial increase in yield since 2002. An attempt should be made to analyse the Bt hybrids spread in India and quantify the role of Bt gene per se in bringing about of this increase in yield. There is a general observation that only a few hybrids have contributed towards yield growth.

Another issue of concern was whether in addition to Bollgard-I, should we recommend Bollgard-II also since in areas of North zone where diversification is less.

The house arrived at the consensus that public sector institute like CICR must take a lead and concentrate on creation of genetic variability and develop robust parental lines or varieties. There was a need to identify best Bt hybrid for each zone for cultivation. DOG suggested to select only those genotypes with morphological traits that are acceptable to farmers and industry. Roundup Ready issue needs to be discussed cautiously taking the entire cotton based system into account.

Dr. M. V. Venugopalan and Dr. Sandhya Kranthi presented the issues compiled from various emerging problems. Some of the issues raised were:

Melaybugs, Mirid bugs, new emerging pest and diseases: How to prevent resurgences and remedies. Mealy bugs, Mirid bugs, new emerging pests and diseases may best be controlled by good management practices.

Sucking pest resistance to insecticides: The problem and management options.

Bollworm resistance to Cry toxins: Status, trends and management option for India. Refugia option for Bollgard-II.

Leaf reddening and wilt: Causes, consequences and remedies.

Gearing up for Climate change will cotton benefit and how to cope up with it.

Reacting to the deliberations Hon'ble DOG was of the opinion that Bt is a valuable technology and should be nurtured with care.

mismanaged to avoid a breakdown.

Gene pyramiding without disturbing the basic genome should be taken up to tackle multiple problems.

Screening of genotypes/ available material will help in getting the resistant genotypes.

Causes of leaf reddening, its physiological and nutrient interaction were discussed at length. Strategies to overcome leaf reddening and para wilt should be developed and it should be ensured that the susceptible lines are not used in breeding programme.

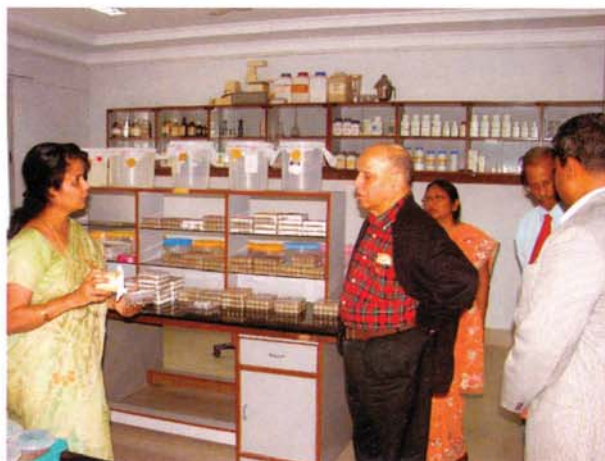
### 11.5: Workshops/Farmer's Day Organized

### 11.6. Distinguished visitors

### Farmers meet

Farmers meet was organized in collaborations with Ramkrishna Bajaj Krishi Mahavidyalaya on 9<sup>th</sup> March 2010 at Rural Institute Hall, Ramkrishna Bajaj Krishi Mahavidyalaya, Pipri, Wardha. The programme was organized in order to disseminate crop production technologies for ensuing season, to discuss with growers all aspects related to appropriate utilization of the technologies to enhance productivity under rainfed conditions and popularize benefits of CICR technologies to reduce cost of cultivation

Name & Designation	Organisation	Date
<b>Nagpur</b>		
Dr. S.S. Baghel <sup>†</sup> , Chairman, RAC & Ex Vice Chancellor	Assam Agricultural University, Jorhat	24 April, 2009
Dr. V. Shiva Reddy, Group Leader (Transformation)	International Centre for Genetic Engineerings Biotechnology (ICGEB), New Delhi	25 April, 2009
Dr. S. N. Puri, Chairman, QRT & Vice-Chancellor	Central Agricultural University, Imphal	27 May, 2009
Dr. Swapan Kumar Datta Deputy Director General (CS)	Indian Council of Agricultural Research, New Delhi	9 July, 2009
Dr. C. D. Mayee, Chairman	ASRB, New Delhi	9 July, 2009
Dr. S. Sreenivasan, Director	CIRCOT, Mumbai	9 July, 2009
Dr. Albertino Jeronimo, Inspector General Cossa LRC Head of Department	Ministry of Agricultural, Mozambique Mozambique Institute of Cotton	12 Nov., 2009 12 Nov., 2009
Hope Ruhindi Mwesigys Hon'ble Minister of Agricultural, Animal Industry of Fisheries	Uganda Government	21Dec., 2009
<b>Coimbatore</b>		
Dr. Mangala Rai Secretary, DARE & Director General	Indian Council of Agricultural Research, New Delhi	6 Nov., 2009
<b>Sirsa</b>		
Dr. Stephen Wambula Muliokela, Executive Director	Golden Valley Agricultural Trust (GART), Zambia	7 Oct., 2009
Mr. Namukototo Mukutu, Chairman, Mr Barry Coxe Member Mr Douglass Moono, Head Prof. G. S. Pandey, Dr, T,P. Rajenderan ADG (PP)	Board of Trustees, GART, Zambia Research & Development, GART Dairy Development, GART ICAR, Krishi Bhawan, New Delhi	8 Oct., 2009



## 11.7 : Participation of scientists in Seminars/ Symposia/ Workshops

Sr. No.	Seminars/Conferences /Symposia/ Workshops/Training	Place and Date	Participants
1.	ICAR Zonal Technology Management and Business Planning and Development	Nagpur 5-6 March, 2009	Dr. P. R. Barambe Dr. MV Venugopalan, Dr. AR Reddy, Er. G. Majumdar
2.	Workshop on formulation of project on Awareness-cum-Surveillance Programme for Management of Major Pests in Soybean-Cotton Based Cropping System in Maharashtra	Nagpur 1 April, 2009	Dr. V.S. Nagrare
3.	Annual Workshop of All India Coordinated Cotton Improvement Project (2008-09)	Hyderabad 6-8 April, 2009	Dr. K.R., Kranthi, Dr A H Prakash Dr. MV Venugopalan Dr. SM Wasnik, Dr. AR Reddy Dr N. Gopalakrishnan Dr. T. Surulivelu, Dr S. Manickam Mr M. Sabesh, Dr S. Ushar Rani
4.	International Conference on Emerging Trends in Production, Processing and Utilization of Natural Fibres	Mumbai 16-18 April, 2009	Dr. K.R., Kranthi, Dr.C.S.Pahraj Dr. N. Gopalakrishnan Dr. P. Nalayani, Dr. D. Monga Dr. K. Shankaranarayanan
5.	Sub committee GEAC meeting	New Delhi, 17 April, 2009	Dr. K.R., Kranthi
6.	Brain Storming Session of development of cotton picker	Noida, 3 June, 2009	Dr. K.R., Kranthi
7.	NAIP (DSS 2046) CMU and CIC meeting	Hyderabad, 6 June, 2009	Dr. V.S. Nagrare
8.	Meeting of ZREAC of Central Vidarbha Region	Yeotmal 19 June, 2009	M.K. Meshram
9.	Workshop on formulation of project on Awareness-cum-Surveillance Programme for Management of Major Pests in Soybean-Cotton Based Cropping System in Maharashtra	Pune 19-20 June, 2009 and 1 August, 2009	Dr. V.S. Nagrare
10.	9th Agricultural Science Congress on technological and Institutional Innovations for Enhancing agricultural Income	Srinagar June 22-24, 2009	Dr P. Nalayani, Dr S. Manickam Dr A.H. Prakash
11.	Director's Conference	New Delhi 16 July, 2009	Dr. K.R., Kranthi
12.	Rural Programme Advisory Committee meeting	Akola, 25 Aug., 2009	M.K. Meshram, Dr. S.M. Wasnik
13.	ICAR Governing Body meeting	New Delhi, 27 Aug., 2009	Dr. K.R., Kranthi
14.	Cotton Advisory Board meeting	New Delhi 29 Aug., 2009	Dr. K.R. Kranthi
15.	Seminar on IPR, PPV&FR and Biological Diversity acts	Coimbatore 4 September, 2009	Dr K. Rathinavel
16.	Workshop on Resistance Management for Bt Cotton	New Delhi 22 September, 2009	Dr. K.R. Kranthi
17.	Workshop on "Role of media in agriculture extension"	Akola, 23 Sep., 2009	M.K. Meshram
18.	Meeting of ZREAC of Central Vidarbha Region	Yeotmal, 8 Oct., 2009.	M.K. Meshram
19.	Meeting on issues relating to WHO Doha negotiations	New Delhi 26 Oct., 2009	Dr. K.R., Kranthi
20.	31st Annual Conference and Symposium on Microbial wealth-Plant health	Siliguri 23-25 October, 2009	Dr. P.K.Chakrabarty
21.	AZRA, 2009 - "National Conference on Biodiversity Conservation and Management of Bio-resources"	Visakhapatnam 28-29 October, 2009	Dr. J.Gulsar Banu
22.	"Cotton Stakeholders' Workshop to Probe Challenges and Opportunities for Cotton in TamilNadu" in collaboration with the Indian Institute of Technology, Chennai	Coimbatore 2 November, 2009	Dr N. Gopalakrishnan Mr M Sabesh Dr K. Shankaranarayanan Dr S. Usha Rani
23.	IV National Conference on Krishi Vigyan KEmdras	Coimbatore, 6-8 Nov., 09	M.K. Meshram
24.	5th International conference on Plant Pathology	New Delhi, 10-13 Nov., 09	Dr. D. Monga Dr. P.K.Chakrabarty
25.	Steering committee meeting.	Rahuri, 11 Nov., 2009	Dr. V.S. Nagrare

26. 7th Pacific Rim Conference on "Biotechnology of Bacillus thuringiensis and its environmental impact"	New Delhi 25-28 Nov. , 2009	Dr. B. Dharajothi Dr S. Manickam Dr. G. Balasubramani Dr. J Amudha, Dr. V. Santhy
27. Rural Programme Advisory Committee Meeting	Amravati, 26 Nov., 2009	M.K. Meshram
28. 2nd Bio-pesticide International Conference.	Palayamkottai 26-28 November,2009	Dr. J.Gulsar Banu
29. Meeting on Mealybug.	Bangalore, 5-6 Dec.,09	Dr. V.S. Nagrare
30. National Symposium on Recent Global Developments in the Management of Plant Genetic Resources	New Delhi 17-18 December, 2009	Dr. R,A Meena Dr. A,B Dongre, DrV Gotmare Dr. Punit Mohan
31. Quarterly Meeting for Agricultural Advisory Committee for finalization of Programmes of All India Radio	Katol 9 February, 2010	Dr. S.M. Wasnik
32. NAIP (DSS 2046) CMU and CIC meeting	Hyderabad, 15 Feb.,10	Dr. V.S. Nagrare
33. National Conference on Plant Protection in Agriculture through Eco-friendly Techniques & Traditional farming Practices	Jaipur 18-20 February ,2010	Dr. Rishi Kumar
34. National Seed Science Congress	New Delhi, 18-20 Jan.10	Dr. V. Santhy
35. National Seminar on Biotechnology for Agriculture, Health, Industry and Environment	Nagpur 20 - 21 February, 2010	Dr. S.B. Nandeshwar
36. Interface on Optimal Land Use and Water Management	Nagpur 22-23 February, 2010	Dr. MV Venugopalan
37. National conference on Innovations in Nematological Research for Agriculture sustainability - Challenges and a road map ahead.	Coimbatore 23-25 February,201 0	Dr.J.Gulsar Banu
38. Network project proposals on Comprehensive Utilization of Natural Fibres: Production, Processing and By-Product Utilization	New Delhi 25 February,2010	Dr. MV Venugopalan
41. Conference on Conservation tillage and Technology Conference	Ada, Ohio, USA 25-26 February, 2010	Dr K.K. Bandyopadhyay
42. Indo-US Bilateral Workshop	Hisar, 25-27 Feb., 2010	Dr. P.K.Chakrabarty
43. National Seminar on Post harvest management of seed for quality assurance and farmers prosperity	Kamal 26-27 February, 2010.	Dr. R,K Deshmukh
44. National Seminar on "Soil security for sustainable Agriculture"	Nagpur 28 Feb., 2010	M.K. Meshram
45. ZTM-BPD meeting cum workshop	Nagpur, 5-6 Mar.,10	Dr. MV Venugopalan
46. NAIP (DSS 2046) Annual review meeting	New Delhi, 5-6 Mar.,10	Dr. V.S. Nagrare
47. Conference on "Carbon Sequestration in Urban Ecosystems Symposium"	Ohio, USA 4 April, 2010	Dr K.K. Bandyopadhyay



## 11.8 Personnel

Name of the Officers/Scientists	Designation	
K R Kranthi (Acting Director upto 14.02.10)	Director (w.e.f. 15.02.2010)	
<b>PROJECT COORDINATOR (Cotton)</b>		
<b>Coimbatore</b>		
N Gopalakrishnan	P.C. (Cotton) & Head	
<b>PLANT BREEDING</b>		
<b>Nagpur</b>		
V V Singh (Retd. 31.08.09)	Principal Scientist	
Smt. S B Singh	Principal Scientist	
T R Loknathan	Principal Scientist	
S M Palve	Principal Scientist	
V N Waghmare	Senior Scientist	
<b>Coimbatore</b>		
K N Gururajan	Principal Scientist	
<b>Sirsa</b>		
S L Ahuja	Principal Scientist	
O PTuteja	Principal Scientist	
S K Verma	Senior Scientist	
<b>GENETICS &amp; CYTOGENETICS</b>		
<b>Nagpur</b>		
S B Nandeshwar	Principal Scientist	
Smt., Vinita Gotmare	Senior Scientist	
<b>Coimbatore</b>		
Smt., K P M Damayanthi	Senior Scientist	
S Manickam	Senior Scientist	
<b>SEED TECHNOLOGY</b>		
<b>Nagpur</b>		
R K Deshmukh	Principal Scientist	
Smt., P R Vijayakumari	Senior Scientist	
Smt., V Santhy	Scientist(ss)	
<b>Coimbatore</b>		
K Rathniveel	Principal Scientist	
<b>Sirsa</b>		
RAMeena	Principal Scientist	
<b>ECONOMIC BOTANY</b>		
<b>Nagpur</b>		
Punit Mohan	Principal Scientist	
<b>AGRONOMY</b>		
<b>Nagpur</b>		
PR Barambe	HOD (Crop Production) Principal Scientist Senior Scientist	
<b>MV Venugopalan</b>		
<b>AR Raju</b>		
<b>Coimbatore</b>		
C S Praharaaj (Trd. to IIPR - 11.2.2010)	Senior Scientist	
K Shankaranarayanan	Senior Scientist	
Smt P Nalayani	Senior Scientist	
<b>SOIL SCIENCE</b>		
<b>Nagpur</b>		
Jagvir Singh	Principal Scientist	
<b>Coimbatore</b>		
K K Bandyopadhyay	Senior Scientist	
Smt., TP Swarnam (Trd. to CARI- 23.9.09)	Scientist (SS)	
<b>AGRICULTURAL ENGINEERING</b>		
G Majumdar	Scientist (SG)	
<b>PLANT PATHOLOGY</b>		
<b>Nagpur</b>		
P M Mukewar (Retd. 30.06.09)	Principal Scientist	
M K Meshram	Principal Scientist	
R C Ukey	Principal Scientist	
AK Mukherjee (Joined on 20.7.09)	Senior Scientist	
SJ Gawande (Trd. to NRCOG 31.12.09)	Scientist (SS)	
<b>Coimbatore</b>		
M Gunasekharan V Jayakumar (Trd. to SSI - 03.06.09)	Senior Scientist	
<b>Sirsa</b>		
Dilip Monga		Head of Station
<b>ENTOMOLOGY</b>		
<b>Nagpur</b>		
K R Kranthi (Director w.e.f. 15.2.10)		HOD (Crop Pro!.)
Smt., S Kranthi		Principal Scientist
Smt., S Vennila (Trd. to NCIPM - 7.5.09)		Senior Scientist
K Rameash (Joined 23.7.09, Trd. NBPGR-RS on 29.12.09)		Scientist (SS)
VS Nagrare		Scientist (SS)
Chinna Babu Naik V (Joined 15.3.10)		Scientist
<b>Coimbatore</b>		
T Surulivelu		Principal Scientist
K Natarajan		Principal Scientist
Smt., B Dhara Jothi		Senior Scientist
Smt M Amutha		Scientist
<b>Sirsa</b>		
Rishi Kumar		Senior Scientist
<b>NEMATODOLOGY</b>		
<b>Nagpur</b>		
Smt., Nandini Narkhedkar		Principal Scientist
<b>Coimbatore</b>		
Smt., J Gulsar Banu		Senior Scientist
<b>PLANT PHYSIOLOGY</b>		
<b>Nagpur</b>		
A H Prakash (joined on 01.02.2010)		Principal Scientist
<b>Coimbatore</b>		
AH Prakash (up to 31.01.2010)		Senior Scientist
S E SA Khader		Principal Scientist
<b>BIOCHEMISTRY (PS)</b>		
<b>Nagpur</b>		
AS Dongre		Principal Scientist
Smt., M. Chakrabarty		Scientist (SG)
<b>BIOTECHNOLOGY</b>		
<b>Nagpur</b>		
P K Chakrabarty (HOD w.e.f. 21.8.09)		HOD, Crop Improvement Senior Scientist
G Balasubramani		Senior Scientist
Smt., J Amudha		Senior Scientist
Smt S. Choudhary (Trd. to NRCSS- 29.01.10)		Scientist
KP Raghavendra (Joined on 19.6.09)		Scientist
<b>MICROBIOLOGY (PS)</b>		
<b>Nagpur</b>		
K Velmourougane		Scientist
<b>AGRICULTURE EXTENSION</b>		
<b>Nagpur</b>		
S M Wasnik		Principal Scientist
<b>Coimbatore</b>		
Usha Rani		Scientist (SS)
<b>AGRICULTURAL ECONOMICS</b>		
<b>Nagpur</b>		
P R Deoghare (Retd. on 31.3.10)		Principal Scientist
AR Reddy		Senior Scientist
<b>Coimbatore</b>		
Smt., Isabella Agarwal		Senior Scientist
<b>COMPUTER APPLICATION</b>		
<b>Coimbatore</b>		
M Sabesh		Scientist (SS)
<b>KVK</b>		
<b>Nagpur</b>		
S N Rokade		Principal Scientist
MS Murthy		Administrative Officer
Devesh Nigam (Relieved on 31.3.2010)		FACO

## 11.9. OTHER INFORMATION

### Foreign delegations Visit to CICR

#### Nagpur

##### Uganda delegation

A high level delegation from Uganda led by Hon'ble Hope Ruhindi Mwesigys, Minister of Agriculture, Animal Industry & Fisheries along with Chairman and Members of Parliament and delegates of Cotton Development Organization visited CICR, Nagpur on Dec.21, 2009. The delegation visited important laboratories and fields at CICR, Nagpur. The delegation also interacted with scientists of CICR at an interactive meeting where views and information regarding cotton production in the two countries were exchanged.

##### Mozambique delegation

A delegation led by Cossa IRC, Head of Department, Mozambique Institute for Cotton and Dr. Albertino Jeronimo, Inspector General, Ministry of Agriculture, Mozambique visited CICR, Nagpur on 12-13 November 2009. The delegation visited important laboratories and fields. The delegation also made a visit to the IRM villages of Wardha and Yavatmal district and interacted with Shri Atul Sharma, District IRM coordinator and farmers regarding implementation of the IRM programme on large scale and farmers' perception regarding IRM.



#### Sirsa

##### Zambian delegation

A Zambian delegation headed by Dr. Stephen Wambula Muliokela, Executive Director, Golden Valley Agricultural Trust (GART), Zambia visited CICR Regional Station, Sirsa on Oct.7, 2009. The delegation comprised of Mr. Namukototo Mukutu, Chairman, Board of Trustees, GART, Mr Barry Coxe Member, Board of Trustees, Mr Douglass Moono, Head Research & Development and Prof. G. S. Pandey, Dairy Development, GART. The delegation had a discussion with the scientists of this station on cotton cultivation and package of practices being followed in North Zone. Dr.D. Monga, Head, made presentation on cotton scenario in India and the delegation showed interest on Bt cotton cultivation and biosafety measures followed in India as Zambia is facing the difficulty in export of lint to European countries. The delegation also visited the Sharada Cotton

Ginning factory and showed keen interest on seed cotton ginning, pressing of bales and oil extraction unit., Dr. H. D. Yadav, Director Extension from CCS HAU, Hisar and Dr. B.S. Sheokand, Senior coordinator, KVK, Sirsa also accompanied the delegation and took part in deliberation along with Scientists of CICR Regional Station, Sirsa.

#### Library

##### Additions

In the period from 2009-10, the Library purchased 173 new books and subscribed to 20 foreign journals and 27 Indian journals. In the said period the Library also purchased 71 Hindi books.

##### Documentation Services Library Networking

- As regards the CD-ROM Workstation, the current version of CROP SCIENCE DATABASE CD was purchased and uploaded in the IAN Server and thereby AGRIS, AGRICOLA, BIOTECHNOLOGY ABSTRACTS, CABABSTRACTS AND CROP CD are visible and accessible in the Institute Network. These CDs range from the period 1970-2010.
- Library has developed computerized bibliographic database on Cotton to provide comprehensive and updated information on cotton. About 3732 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 AICCP Centers in India. In the reported period, four issues of COTTON RESEARCH ABSTRACTS (V23, (No. 1-4), January December 2009) 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.



## Progressive Use of Hindi

### Nagpur

#### OUN Meeting & Quarterly Report

- Official Language Implementation Committee (OLIC) of CICR working under the chairmanship of the Director, CICR met regularly. Proceedings of the meeting were sent to the Council.
- Quarterly progress reports regarding the use of Official Language in Hindi in the institute were sent to the Council regularly.

#### Hindi Day

- CICR celebrated Hindi day as Hindi Chetna Fortnight during 14-29 Sept., 2009 at the institute's headquarter Nagpur. Various programmes and competitions like, hand writing, dictation, words meaning, sandhi-vichched, slogan, idioms, memory, noting & drafting, letter-writing, question-answer, maximum official work in Hindi, maximum published technical & popular articles in agriculture, etc. were organized during this fortnight. The winners were awarded prizes during the prize distribution function held on 29<sup>th</sup> Sept., 2009. Ex-Director of CICR, Dr. M.S. Kairon as Chief Guest and Acting Director CICR Dr. K.R. Kranthi addressed at this occasion.
- Hindi Week was celebrated at institute's regional stations Coimbatore and Sirsa and wherein various programmes and competitions were organized this week and the winners were awarded.
- At Nagpur Dr. S.N. Rokade (Sr. Scientist) awarded 1<sup>st</sup> prize, Dr. U.v., Galkate (S.M.S. of KVK) 2<sup>nd</sup> prize and Dr. M.V. Venugopalan (Principal Scientist) 3<sup>rd</sup> prize for publishing maximum technical articles in agriculture in Hindi.
- For doing maximum official work in Hindi during the year Shri. Ashok Belsare awarded 1<sup>st</sup> prize, Shri. Prakash Mishra 2<sup>nd</sup> prize and Shri. Ramchandra Varchhaye 3<sup>rd</sup> prize.
- Two extension folders Bt cotton variety BN Bt and Bt hybrid NHH-44 Bt were prepared in Hindi.

### Coimbatore

- The Official Language Implementation is being effectively carried out at CICR, Regional Station, Coimbatore. In this Institute, Hindi Workshops are regularly organized as per the Official Language Policies to promote the Hindi usage in official activities for the staff members. The Hindi

Teaching Scheme, Coimbatore, Ministry of Home Affairs, Government of India had organized the Prabodh and Praveen classes for Scientists and Staff members to



acquire Hindi Training. A one day Hindi seminar was organized by Sugar Cane Breeding Institute on 30.7.2009 on "Climate Change". A paper was presented by Project Coordinator and Head on Climate Change in this seminar.

- In the month of September 2009, Hindi day was organized at CICR, Coimbatore. Various Competitions were held for scientists and staff towards Hindi Day celebrations and prizes were distributed on Hindi Day. The Town Official Language Implementation Committee had organized a one day Hindi Singing competitions in view of Hindi Day celebrations. Various staff members from Central Government Offices participated in these competitions and won prizes.
- The Town Official Language Implementation Committee has awarded third prize to CICR, Coimbatore in Hindi Implementation for the year 2008-09. The project Coordinator & Head received the award in the half yearly Meet of Town Official Language Implementation Committee in December 2009. The Official Language Implementation Committee Meeting is being regularly organized at CICR, Coimbatore to discuss various issues on Development and Implementation of Official Language as per the Official Language Policy. The Hindi Cell and the Official Language Implementation Committee of this Institute are working towards achieving the progressive use of Hindi at the Institute.



## 11.10: WEATHER

### Nagpur

Month	Temperature (OC)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
June, 2009	40.7	27.1	53	33	281	15
July, 2009	30.2	24.4	87	72	324	18
August, 2009	31.8	24.9	86	65	228	11
September, 2009	34.2	24.4	85	57	67	4
October, 2009	33.3	20.6	77	40	40	4
November, 2009	29.2	16.6	83	62	27	4
December, 2009	29.3	14.4	80	41	7	1
January, 2010	28.9	11.3	70	28	0	0
February, 2010	33.7	16.8	61	22	0	0
<b>Total</b>					<b>974</b>	<b>57</b>

### Coimbatore

Month	Temperature (OC)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy days (>2.5 mm)
	Max.	Min.	Max.	Min.		
April, 2009	35.6	24.0	83.3	39.2	0	0
May, 2009	34.8	23.8	86.6	46.8	114.6	6
June, 2009	32.1	23.7	79.6	50.7	11.2	1
July, 2009	29.7	22.9	81.9	61.3	87.2	10
August, 2009	31.6	22.9	86.2	54.3	38.8	3
September, 2009	31.5	23.0	88.2	59.1	108.6	7
October, 2009	31.6	21.8	86.7	49.2	115.8	5
November, 2009	29.2	22.3	93.3	65.5	250.6	11
December, 2009	29.0	21.3	88.4	57.4	2.8	0
January, 2010	30.5	20.2	87.6	45.1	0	0
February, 2010	32.9	20.5	85.2	36.0	0	0
March, 2010	35.6	22.2	79.6	25.5	0	0
<b>Total</b>					<b>729.6</b>	<b>43</b>

### Sirsa

Month	Temperature (OC)		Relative Humidity (%)		Rainfall (mm)	Rainy Days
	Max.	Min.	Max.	Min.		
April, 2009	37.1	20.3	44.6	31.6	34.4	2
May, 2009	41.2	26.2	43.5	29.5	0	-
June, 2009	42.4	27.5	42.0	33.0	12.2	2
July, 2009	37.2	28.6	70.4	50.8	1.0	1
August, 2009	36.8	28.0	75.3	54.3	15.4	5
September, 2009	34.2	24.3	81.8	52.8	44.7	3
October, 2009	33.5	17.2	72.0	30.6	-	-
November, 2009	26.2	10.2	80.3	34.3	-	-
December, 2009	23.1	6.7	78.0	33.0	1.0	1
<b>Total</b>					<b>108.7</b>	<b>14</b>

### 11.11: Cotton Scenario

Cotton is one of the principal crops of India and plays a vital role in the country's economic growth by providing substantial employment and making significant contributions to export earnings. The cotton cultivation sector not only engages around 6 million farmers. In 2008, the textile sector contributed about 14% of industrial production, 4% of the GDP and provided direct employment to over 33 million people. The textile sector is the second largest provider of employment after agriculture.

According to USDA, the global cotton output in 2009-10 is expected to be lower at 22.69 million tonnes due to lower acreage in major producing countries. There was a 4.4% decrease in production relative to 2008-09. China is the largest producer of cotton in the world and contributing to one-third of the total global output. India and USA are other major producers and together contribute to 37% of the total global production. The other major cotton producing countries are Pakistan (7%), Brazil (6%), Uzbekistan (4%), and Turkey (3%). India's contribution in export of cotton was 80 lakh bales during 2009-10.

Due to the reduction in cotton production in the world and increase in world cotton consumption have resulted in expectations of an 11.8 million bale production/consumption gap in 2009/10 which represents 11.5% of production, 10.3% of consumption, and 22.7% of ending stocks. The production/consumption gap may impact on prices at the country level this may impact on trade patterns. China's production in 2009-10 was 14.2% lower than in 2008-09 whereas the Chinese consumption is anticipated to increase

3.9%. Hence it is expected that China will import almost 2 million more bales in 2009-10 (9.0 million) than in 2008-09.

Cultivated Bt cotton in 8.381 million hectares in 2009 which is equivalent to 83% of 10.152 million hectares under cotton. In 2009, for the first time, multiple gene Bt cotton occupied more areas (57%) than single gene Bt cotton (43%). Again 2009, was the first year for an indigenous public sector bred Bt cotton variety (*Bikaneri Nerma*) and a Bt hybrid (NHH 44 Bt) were commercially available.

In 2009-10, the highest cotton producing state in India is Gujarat (95 lakh bales with productivity 615 kg/ha), followed by Maharashtra (67 lakh bales with productivity 325 kg/ha). About 70% of total cotton is produced in Gujarat, Maharashtra and Andhra Pradesh from the area of 73%. Area in North zone, Central zone and South zone are 15.00, 67.73 and 18.01 lakh ha, respectively and contributions in production are 13%, 61% and 21% respectively during 2009-10. At a national level, the cotton yields in India have declined to 488 kg/ha during 2009-10 from 524 kg/ha in 2008-09.

India is the only country to grow all four species of cultivated cotton besides different combinations of hybrid. The majority of the cotton in India is grown in nine states which are grouped into three different zones namely, Northern zone (Punjab, Haryana and Rajasthan), Central zone (Maharashtra, Madhya Pradesh and Gujarat) and Southern zone (Andhra Pradesh, Karnataka and Tamil Nadu). Approximately 65% of India's cotton is produced under rainfed condition and 35% on irrigated conditions. Details of cotton scenario (2009-10) are given in Table 1 and 2.

**Table 1: Cotton Growing Zones in India**

Zones	North Zone	Central Zone	South Zone
States	Punjab, Harayana, Rajasthan	Maharashtra, Madhya Pradesh, Gujarat	Andhra Pradesh, Karnataka, Tamil Nadu
Area (million ha )	1.447	6.773	1.850
Production (million bales)	4.00	17.35	6.45
Productivity (kg/ha )	470	435	593
Conditions	100% irrigated	Irrigated and rainfed	Irrigated and rainfed
Soil Type	Alluvial soils	Black cotton soils	Black soils and Red soils
Nature of Genotype	Hybrids and varieties	Hybrids and varieties	Hybrids and varieties
Species Hybrids	<i>G. hirsutum</i> , <i>G. arboreum</i> intra <i>hirsutum</i>	<i>G. hirsutum</i> , <i>G. arboreum</i> , <i>G. herbaceum</i> <i>G. barbadence</i> , Intra <i>hirsutum</i> ,	<i>G. hirsutum</i> , <i>G. arboreum</i> , <i>G. herbaceum</i> , Interspecific tetraploids(HB)
Insect/ Pest	Heliothis, Whitefly, Jassids, Pink bollworm, Mealy bug	Heliothis, Whitefly, Jassids, Aphids, Pink bollworm Mealy bug	Heliothis, Whitefly, Jassids, Aphids, Pink bollworm
Diseases/physiological disorder	Leaf curl virus, Wilt	Wilt, leaf reddening	Wilt, Foliar disease
Sowing Method	Drill Sown	Hand dibbling	Hand dibbling
Time of Sowing	April-June	June-July	July-Sept



**Table 2: State-Wise Cotton Area, Production and Productivity**

Zone/State	2008-2009			2009-2010		
	Area (Lakh ha)	Prod. (Lakh bales)	P (kg/ha)	Area (Lakh ha)	Prod. (Lakh bales)	P (kg/ha)
Punjab	5.27	17.50	565	04.96	14.25	488
Haryana	4.56	14.00	522	05.07	14.75	495
Rajasthan	3.02	7.50	422	04.44	11.00	421
<b>North Zone</b>	<b>12.85</b>	<b>39.00</b>	<b>516</b>	<b>14.47</b>	<b>40.00</b>	<b>470</b>
Gujarat	23.54	90.00	650	26.24	98.00	635
Maharashtra	31.42	62.00	335	35.03	61.00	296
Madhya Pradesh	6.25	18.00	490	06.46	14.50	382
<b>Central Zone</b>	<b>61.21</b>	<b>170.00</b>	<b>472</b>	<b>67.73</b>	<b>173.50</b>	<b>435</b>
Andhra Pradesh	13.99	53.00	644	13.19	50.00	644
Karnataka	04.08	9.00	375	04.27	09.50	378
Tamil Nadu	01.09	5.00	780	01.04	05.00	817
<b>South Zone</b>	<b>19.66</b>	<b>67.00</b>	<b>594</b>	<b>18.50</b>	<b>64.50</b>	<b>593</b>
Others	0.84	2.00	405	1.01	2.00	337
<b>Total</b>	<b>94.06</b>	<b>278.00</b>	<b>502</b>	<b>101.71</b>		
Loose cotton consumed but not counted for in State-wise prod.		12.00			12.00	
<b>Grand Total</b>	<b>94.06</b>	<b>290.00</b>	<b>524</b>	<b>101.71</b>	<b>292.00</b>	<b>488</b>

Prod. = Production

P = Productivity

1 bale= 170 kg.

Source: Office of the Textile Commissioner, Mumbai.







### Training Achievements

Ninety one on campus and off campus short duration (1 to 3 days) trainings were conducted in different disciplines for 1470 farmers, 696 rural youths and 275 extension functionaries. In all 2441 participants benefited from these training courses.

In addition, 14 sponsored training courses were organized for 1 to 3 days duration in different disciplines for farmers and extension functionaries deputed by various agencies viz. State Agriculture Department, ATMA, CIPM, Nagpur, MAFSU, MCED & ICDS Nagpur. In all 513 participants benefitted through these training courses.

### On Farm Trials for Technology Assessment and Refinement

#### Technology Assessed

- Trial on 'Reduction of farm women drudgery through cotton picking bags' was conducted by using improved cotton picking bags developed by MAU, Parbhani and CCS, HAU, Hissar. It was observed that the cotton picking bag designed by HAU is more preferred by the farm women compared to MAU bags and local cotton picking practice. In HAU designed bag, the picking rate was more (5-7 kg h<sup>-1</sup>) and heart rate was lesser (~ HR11.3 beatsm<sup>-1</sup>) and there was no pain in upper arm and knee as compared to MAU (~ HR23.0 beatsm<sup>-1</sup>) and the local bags (~ HR15.2 beatsm<sup>-1</sup>).
- Technology of 'Management of gummosis in Nagpur mandarin' was assessed in village Ranmangli on 10 farmer's field. The recommended practice of a) Double ring system of irrigation, b) application of Bordeaux paste twice before and after monsoon, c) drenching of plant basin twice by matalaxyl MZ-72 @ 2.75 g or fosetyl al @ 2.5 g/lit., alternate foliar application of above fungicides at the same dose twice at 40 days interval was compared against Farmer's practice i.e. a) Conventional Flood irrigation, b) application of Bordeaux paste once in winter season after harvest of the crop (i.e. after rainy season), c) indiscriminate use of chemical fungicides. It was observed that the incidence of gummosis was reduced by 32.40% in

recommended practice as compared to 13.80% in farmer's practice.



#### Technology Refined

OFT Refinement was conducted on 'Fortification of iron in the diet of rural pregnant women with leafy vegetables in the age group of 20-30 years' by selecting 18 samples from ICDS, Nagpur. The recommended daily diet-cereals 415 g, pulses -35 g, soyfortified laddu (soyflour 35 g, Jaggery 50 g, fat 10 g, wheat flour 50 g), green leafy vegetables -150 gm, other vegetables 50 g, fruits 30 g, milk 50 ml, fats 25 g, sugar and jaggery 10 g per pregnant women for 3 months period increased both body weight gain and haemoglobin percentage significantly.

#### Front Line Demonstrations

- Twelve technologies in agriculture, veterinary science and home science discipline were demonstrated under FLD in KVK adopted villages namely Manori, Pipra, Saisar, Dongargaon and Ranmangli Nagpur district. Several extension activities like field days, field visits of farmers to FLD demonstrations, group discussions, scientists-farmers meet, etc. were conducted for effective implementation of FLDs.

## Details of dissemination of technologies through Front Line Demonstrations

### (A) Crop production & protection

Crop Varieties Technology	Area (Ha.)	No. Of Demo.	Yield (Q/Ha.)				Increase In Yield (%) (Rs/Ha.)	Cost of additional inputs	B:C ratio
			Highest	Lowest	Mean	Local Check			
Soybean-INM	10.0	25	14.30	7.90	11.10	8.25	34.54	1510	1.36
Cotton-INM	10.0	25	15.25	8.20	11.70	9.10	28.57	3212	1.57
Cotton-IPM	67.4	59	21.75	15.65	17.45	13.30	31.20	1350	1.92
Pigeonpea-Varietal(Vipula)	10.0	25	11.98	9.46	10.72	8.18	31.05	150	2.46
Chickpea-H.armigera management	6.5	15	17.50	14.50	15.20	12.40	22.56	250	1.85
Brinjal- Shoot & fruit borer Management	3.0	15	183.50	136.50	171.20	126.50	35.33	670	2.05
Chilli-Thrips management	3.0	15	85.00	68.00	78.50	64.00	22.66	250	2.15
Chilli-variety (Jayanti)	5	10	81.25	67.50	72.50	49.20	17.88	560	2.07
Okra	5	11	39.5	33.5	35.13	30.00	17.10	950	2.85

### (B) Livestock production and management

Name of technologies	No. of farmers	No. of animals	Performance of technology on different parameters						Increase in yield (%)
			Average milk yield (Lit/cow/day)		Body wt. Gain(kg)		Body coat		
			Demo.	Local Check	Demo	Local Check	Demo.	Local Check	
Supplementation of Mineral mixture	10	20 cows	8.20	7.30	-	-	-	-	17.14
Endo & ectoparasitic Drugs	10	40 goats	-	-	3.30	2.20	Healthy & shining	Dull, rough & alopecia	50.00

### Drudgery reduction in farm worker

Particulars	Variety/ breed/ other	No. of farm women	No. of Units	Performance parameters / indicators	Data on parameter in relation to technology demonstrated		
					TT	Gujarat Sickle	Tstat
Improved Serrated Sickle	Gujarat sickle	12	12	No. of workers required	1	1	1
				Heart rate during work (beats/min)	15.4	12.5	2.33
				Strokes /min	35.2	45.2	4.44
				Out put	34.0	44.9	3.16

### On Campus Crop Demonstrations

Twenty crop demonstrations on cotton, pigeon pea, soybean, fodder sorghum, fodder maize, berseem, vegetables viz. onion, okra, etc., fruits and flowers were undertaken on KVK's instructional farm. The production and protection technologies of these crops were demonstrated on area ranging from 0.2 ha

to 0.4 ha for each crop. Several farmers, farmwomen and extension functionaries from Nagpur district and other states visited these demonstrations.

### Osmanabadi Goat unit

KVK's Osmanabadi Goat Unit has generated an amount of Rs

8313/- by selling 3 Osmanabadi bucks to 2 beneficiary farmers of Nagpur district on 21/12/2009. These bucks are contributing in genetic improvement of local goats by providing natural service.

### Celebration of Technology Week

Technology Week-2009 was organized during September 14-18, 2009 through public-public and public-private partnership mode. Large number of farm women and extension functionaries participated in this event through officials of Agriculture and allied departments.

### Organized Kisan Melas

KVK, CICR, Nagpur organized Kisan Melas at villages Manori and Pipra, Tq. Umred, Dist. Nagpur on January 12, 2010 and February 11, 2010, respectively. More than 500 farmers including cotton, vegetable growers and livestock owners participated in both the Melas.

### Health Camps for Livestock

Organized 2 livestock Health Camps in Dongargaon and Manori villages of Nagpur district on December 16, 2009 and January 12, 2010, respectively. In both the camps 40 animals including 25 goats, 1 bullock, 10 crossbred cows and 4 calves were treated for their ailment. More than 25 participants benefited by seeking treatment of their livestock. Farmers were advised vaccination, regular deworming and dipping to their livestock.

### Extension Activities

Following extension activities were conducted by KVK, CICR, Nagpur

Nature of Extension Activity	No. of activities	No. of Participants		
		Male	Female	Total
Field Days organized	1	81	30	111
	1	82	33	115
	1	77	30	107
	1	59	18	77
	1	59	28	88
	1	43	26	69
	1	51	32	83
	1	35	8	43
Kisan Mela	2	253	74	327
Kisan Ghosthi	6	366	122	488
Exhibition	3	4321	876	5197
Film Show	16	640	175	815
Method Demonstrations	11	755	251	1006
Radio talks	9	-	-	-
TV talks	2	-	-	-
Extension Literature	1	-	-	-
Advisory Services	-	1893	699	2592
Scientific visit to farmers field	16	375	0	375
Farmers visit to KVK	28	1612	285	1897
Diagnostic visits	28	550	32	582
Ex-trainees Sammelan	2	76	16	92
Celebration of Technology Week	1	712	89	901

### Participation in Exhibitions

- State Agricultural Exhibition held at Dikshabhoomi, Nagpur from Nov. 27-29, 2009.
- State level Agricultural Exhibition at Gondia on the occasion of "Dr. Panjabrao Deshmukh birth anniversary" held from Dec 27 to 29, 2009 organized by Dr. PDKV, Akola.
- Rashtriya Kisan Mela-2010 organized by National Research Centre for Citrus, Nagpur at its campus from February 21-22, 2010.

### Visitors

During the period under report, 924 visitors including practicing farmers, farm women, rural youths and extension functionaries visited the instructional farm, goat unit, fruit cafeteria and vermicompost unit established at KVK farm.

### Diagnostic Survey

Twenty eight diagnostic surveys in adopted villages and other villages of Nagpur district were undertaken to suggest the remedies to overcome specific problems in crops, citrus orchard and animals covering more than 256 ha cropping area and 114 animals in 20 villages of six tahsils of Nagpur district.

### Scientific Advisory Committee Meeting

The 14<sup>th</sup> SAC meeting of KVK, CICR, Nagpur was conducted on September 8, 2009 under the chairmanship of Director, CICR, Nagpur. More than 20 members of agriculture and allied departments participated in the SAC meeting.



General

## 11.1 List of Publications

### Papers Published in Research Journals

Ahuja, S. L., Dhayal, L. S. Monga, D. (2009). Performance of upland coloured cotton germ plasm lines in line 3 tester crosses. *Euphytica*, 169:303-312.

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## 11.2 List of on-going Projects

### Institute Projects

Sl. No.	Name of Project	Name of Project Leader & Associate(s) Dr.	Duration
<b>Crop improvement</b>			
1.	Collection, conservation, evaluation, documentation and maintenance of germ plasm of cultivated species of <i>Gossypium</i>	Punit Mohan (PL), S. Manickam (PA) S. J. Gawande (PA), VS. Nagraire (PA), R. A. Meena (PA), A. B. Dongre (PA), Anjali Kak (PA)	2006-2013
2.	Development of core assembly of <i>Gossypium barbadense</i> , <i>G. arboreum</i> and <i>G. herbaceum</i> germplasm	Punit Mohan (PL), KPM Dhamayanthi (PA)	2008-2012
3.	Development of mapping population for different economically important traits	Head, DCI (PL), V. N. Waghmare (PA) S. M. Palve (PA), S. B. Singh (PA), Vinita Gotmare (PA), T. R. Loknathan (PA) P. R. Vijayakumari (PA), S. Manickam (PA) Punit Mohan (PA)	2008-2012
4.	Improvement of tetraploid and diploid cottons for fibre properties through population improvement approaches	V. N. Waghmare (PL), Vinita Gotmare (PA)	2000-2010
5.	Breeding of upland cotton for improved fibre quality and resistance to biotic stress (bollworms and jassid)	S. M. Palve (PL), M. K. Meshram (PA) S. Venilla (PA), V. Gotmare (PA)	2005-2010
6.	Development of heterotic pool for superior medium staple in tetraploid cotton ( <i>G. hirsutum</i> )	S. M. Palve (PL)	2006-2011
7.	Development of <i>hirsutum</i> genotypes having high oil content coupled with fibre productivity and quality	S. M. Palve (PL)	2008-2013
8.	Studies on genetic enhancement of upland cotton	T. R. Loknathan (PL)	2002-2010
9.	Conservation, characterization and utilization of wild species, races of cultivated species, perennials and synthetic polyploids of <i>Gossypium</i>	Vinita Gotmare (PL), G. Balasubramani (PA)	2008-2013
10.	Identification of genetic markers and characterization of fibre strength and drought tolerance traits in interspecific cross between <i>G. herbaceum</i> and <i>G. anomalum</i>	Vinita Gotmare (PL)	2008-2013
11.	Genetics and development of diploid and tetraploid cottons through inter-racial hybridization for fibre quality, biotic & abiotic stress tolerance	Vinita Gotmare (PL), S. M. Palve (PA)	2008-2013
12.	Diversification of male sterile cytotypes genetic studies and utilization of cleistogamy and protruding stigma in <i>Gossypium</i> spp.	Vinita Gotmare (PL)	2008-2013
13.	Development of drought tolerant genotype with good fibre quality	S. B. Singh (PL), A. H. Prakash (PA)	2008-2013
14.	Development of improved male sterility system through induced mutation	S. B. Singh (PL), O. P. Tuteja (PA)	2008-2011
15.	Development of transgenic diploid cotton for insect Resistance	S. B. Nandeshwar (PI), V. S. Nagraire (PA), S. M. Palve (PA)	2008-2011
16.	<i>In-vitro</i> cell manipulation for induction of somatic embryogenesis and plant regeneration in diploid and tetraploid cotton	S. B. Nandeshwar (PL), A. H. Prakash (PA)	2008-2011
17.	Development of long staple <i>G. hirsutum</i> with improved fibre strength	S. Manickam (PL), V. N. Waghmare (PA) S. L. Ahuja (PA)	2008-2014
18.	Development of extra-long staple high spinning hybrids with wider adaptability	KPM Dhamayanthi (PL), S. Manickam (PA)	1986-2011
19.	Induction of polyploidy and introgression of agronomical traits from diploid wild species to cultivated tetraploids	K. P. M. Damayanti (PL), Vinita Gotmare (PA)	2008-2012
20.	Molecular basis of pathogenicity and race-specificity of <i>Xam</i> and characterization of antagonists of foliar pathogens of cotton for biocontrol	P. K. Chakrabarty (PL)	1994-2009

21.	Development of transgenic cotton resistant against major diseases of cotton.	P. K. Chakrabarty (PL), S. B. Nandeshwar (PA), A. H. Prakash (PA)	2009-2012
22.	Isolation of fibre specific trichome specific promoter from <i>G. hirsutum</i> / <i>A. thaliana</i>	G. Balasubramani (PL), J. Amudha (PA)	2008-2011
23.	Development of drought resistant transgenic cotton and identification of new gene for high water use efficiency	J. Amudha (PL), A. H. Prakash (PA) G. Balasubramani (PA)	2008-2011
24.	Molecular mapping of leaf curl virus resistance gene in the cotton genome	J. Amudha (PL), D. Monga (PA) G. Balasubramani (PA)	2002-2009
25.	Molecular evaluation of cotton germplasm	A. B. Dongre (PL), Punit Mohan (PA)	2000-2011
26.	Development of efficient agro-techniques for enhancing the productivity and seed quality of Bt cotton varieties	R. K. Deshmukh (PL), K. Rathinavel (PA)	2008-2011
27.	Performance of evaluated new Bt hybrids on large size plots (138.24 sq. Mt.)	R. K. Deshmukh (PL), P. R. Vijayakumari (PA), V. Santhy (PA)	2008-2011
28.	Studies on cotton seed with particular reference to germination and dormancy	P. R. Vijayakumari (PL), R. A. Meena (PA) R. K. Deshmukh (PA), V. Shanthi (PA)	2004-2009
29.	Assessment of working seed sample size for Bt seed testing based on estimation of Cry 1Ac protein	P. R. Vijayakumari (PL), K. R. Kranthi (PA)	2008-2010
30.	Studies on seed quality parameters and genetic purity of TFL seed sold in market	P. R. Vijayakumari (PL), K. R. Kranthi (PA) K. Rathinavel (PA), R. A. Meena (PA)	2008-2011
31.	Assessment of seed vigor trait in cotton	V. Santhy (PL), P. R. Vijayakumari (PA), Jagvir Singh (PA)	2003-2010
32.	<b>Phenotyping and genotyping of cotton genotypes</b>	V. Santhy (PL), K. Rathinavel (PA) G. Balasubramani (PA)	2008-2012
33.	Transgene expression and effect of transgene on quantity and quality in seeds of Bt cotton hybrids	V. Santhy (PL), S. B. Nandeshwar (PA), G. Balasubramani (PA)	2008-2011
34.	Utilization of electromagnetic field seed treatment for the enhancement of cotton seed quality and productivity under diversified agro-ecological situations (Ad hoc)	K. Rathinavel (PI), P. R. Vijayakumari (Co-PI), R. A. Meena (Co-PI)	2008-2010
35.	Studies on salt tolerance (Ad hoc)	S. L. Ahuja (PL), R. A. Meena (PA)	2008-2010
36.	Development of varieties and hybrids resistant to CLCuV	a. p. Tuteja (PL), D. Monga (PA), Rishi Kumar (PA)	2008-2013
37.	Technology to enhance the better crop establishment and yield in cotton.	R. A. Meena (PL), D. Monga (PA)	2007-2012
38.	Development of GMS based hybrids and pre-breeding for fibre quality in <i>G. arboreum</i>	S. K. Verma (PL), S. L. Ahuja (PA)	2008-2013
39.	Development of heterotic pools in <i>G. arboreum</i> and <i>G. hirsutum</i>	S. K. Verma (PL), a. p. Tuteja (PA), S. L. Ahuja (PA)	2008-2012
40.	Marker Assisted Selection for developing elite breeding lines in cotton	S. K. Verma (PL), S. L. Ahuja (PA)	2008-2012
41.	Breeding new <i>G. hirsutum</i> varieties with new plant type - Development of medium staple varieties.	K. N. Gururajan (PL), S. Manickam (PA)	1989-2011
42.	Development high yielding and high spinning extra long cotton staple varieties.	K. N. Gururajan (PL), S. Manickam (PA)	1989-2011
<b>Crop production</b>			
43.	Nutrition requirement of soybean-Bt hybrid cotton in participatory mode	A. R. Raju (PL), M. K. Meshram (PA), G. Majumdar (PA)	2008-2012
44.	Agronomic and physiological evaluation of NHH 44 Bt and BN-Bt cotton under rainfed conditions on Vertisols and associated soils	M. V. Venugopalan (PL), M. Chakrabarty (PA), K. K. Bandyopadhyay (PA)	2009-2013
45.	Studies on long term effect of fertilizer and integrated nutrient management on productivity, soil fertility and quality of rainfed hybrid cotton	Jagvir Singh (PL), M. V. Venugopalan (PA), K. Velmourougane (PA)	2004-2025
46.	Studies on impact of transgenic cotton on soil microbial and biological properties under cotton based cropping systems	K. Velmourougane (PL), Jagvir Singh (PA), P. Nalayini (PA)	2008-2011
47.	Developing efficient carrier based microbial delivery system for cotton nutrition and soil health	K. Velmourougane (PL), Jagvir Singh (PA), A. R. Raju (PA)	2008-2011

48.	Effect of different nitrogen levels on oil and protein content in Bt and non-Bt cotton hybrids and effect of Bt gene on cotton seed oil content..	M. Chakrabarty (PL), M. V. Venugopalan (PA)	2007-2010
49.	Assessment of gossypol content in cotton germplasm	M. Chakrabarty (PL)	2004-2012
50.	Economic analysis of cotton based farming system in Vidarbha.	p. R. Deoghare (PL), S. M. Wasnik (PA)	2007-2010
51.	Capital requirement for modernization of cotton production on marginal and small farm in Vidarbha	P. RDeoghare (PL), A. R. Reddy (PA) S. M. Wasnik (PA)	2008-2010
52.	Economic Impact of Bt Cotton cultivation in India	A. R. Reddy (PL), Isabella Agarwal (PA), Rishikumar (PA)	2008-2010
53.	Assessment of cotton based intercropping system and its popularization through farmers to farmers participatory learning approach.	S. M. Wasnik (PL), S. Usha Rani (PA), A. R. Raju (PA)	2008-2012
54.	Performance of Osmanabadi goats under feeding of Bt and Non Bt cotton leaves	S. N. Rokde (PL)	2007-2009
55.	Bio-mulching and biodegradable mulching for Bt cotton based cropping system.	P. Nalayini (PL), K. Sankaranarayanan (PA), K. Velmourougane (PA)	2008-2010
56.	Assessment of productivity potential of genotype vis-a- vis Bt hybrids through agronomic manipulation.	C.S.Praharaj (PL), K.Sankaranarayanan (PA), N.Gopalakrishnan (PA)	2007 -2009
57.	Water management in <i>hirsutum</i> & <i>barbadense</i> cotton	K.Sankaranarayanan (PL), P. Nalayini (PA), C.S.Praharaj (PA), K. K. Bandyopadhyya (PA), P.Nalayini (PL), K.Sankaranarayanan (PA), K.velmourougane (PA)	2004-2010 2008-2010
58.	Herbigating herbicide/ herbicide mixture/ herbicide rotation for efficient and environmentally safe weed control and its effects on succeeding pulses	P. Nalayini (PL), K. Sankaranarayanan (PA), K. Velmourougane (PA)	2008-2010
59.	Simulation of effect of irrigation and nitrogen on soil water and nitrogen dynamics, productivity and input use efficiency of Bt cotton in a vertic Ustropept	K. K. Bandyopadhyya (PL), A. H. Prakash (PA), B. Dharajothi (PA)	2006-2009
60.	Studies on soil aggregation and aggregate associated carbon in cotton based cropping system	K .K .Bandyopadhyya (PL), K. Velmourougane (PA)	2008-2010
61.	Simulation of effect of N management strategies on nitrogen dynamics in soil plant system and nitrogen use efficiency of ELS Bt cotton in a climate change scenario (Ad -hoc)	K.K.Bandyopadhyya (PL),A.. H. Prakash (PA), B.Dharajothi (PA), C.S.Praharaj(PA)	2009-2012
62.	Identification and utilization of adaptive responses to abiotic stresses in cotton	S. E. S. A. Khader (PL) N.Gopalakrishnan (PA), K.N.Gururajan (PA)	1995-2009
63.	Studies on the mechanism of cuticular absorption of nutrients and hormones in Bt cotton	S.E.SAKhader (PL)	2008-2012
64.	Economic analysis of contract farming in cotton in TN	Isabella Agarwal (PL)	2005-2009
65.	Adoption, impact and return to research investment in improved cotton cultivars in Tamil Nadu	Isabella Agarwal (PL)	2005-2009
66.	Post evaluation of farmers field schools on cotton	S.Usha Rani (PL), K.Sankaranarayanan (PA)	2007-2010
67.	Documentation and validation of farmers indigenous knowledge on farming system approach in cotton	S. Usha Rani (PL), P. Nalayini (PA)	2007-2010
68.	Comparative analysis of conventional, biotech and organic cotton production systems in India	S. Usha Rani (PL), S. MWasnik (PA) K. Sankaranarayanan (PA)	2008-2011
69.	An empirical analysis on cultivation behaviour of Bt cotton growers with regard to insect resistance management technologies	S.Usha Rani (PL), S.MWasnik (PA)	2008-2011
<b>Crop protection</b>			
70.	Basic studies on bollworm resistance to Bt cotton and development of management strategies	K. R. Kranthi (PL)	2008-2011
71.	Exploitation of induced resistance for cotton pest management	S. Kranthi (PL)	2008-2010
72.	Isolation and characterization of native Bt strains using conventional and molecular methods, for cotton pest management	S. Kranthi (PL), K. R. Kranthi (PA)	2008-2010

73.	Population and community ecology of cotton entomofauna	V. S. Nagrare (PL)	2006-2011
74.	Evaluation and exploitation of compensation as a mechanism for comprehensive insect pest tolerance	V. S. Nagrare (PL), Vinita Gotmare (PA)	2006-2011
75.	Studies on bionomics and management of mealy bug	V. S. Nagrare (PL), K. R. Kranthi (PA)	2008-2011
76.	Ecological - based approaches for sustainable sucking pests management	V. S. Nagrare (PL)	2008-2010
77.	Studies on seed transmitted pathogenic infections and other seed microflora of cotton	P. M. Mukewar (PL)	1989-2009
78.	Screening and Identification of <i>effective</i> bio-control agents for the management of foliar cotton diseases	M. K. Meshram (PL), S. J. Gawande (PA)	2008-2011
79.	Identification of bacterial blight and grey mildew disease resistant genotypes in upland cotton.	M. K. Meshram (PL)	2008-2011
80.	Identification of sources of resistance against Rhizoctonia root rot in tetraploid and fusarium wilt in diploid cotton and their utilization in breeding program	R. C. Ukey (PL), V. N. Waghmare (PA)	2006-2011
81.	Studies on cotton viral diseases (Ad-hoc)	A. K. Mukherjee (PL), M. K. Meshram (PA) V. Jayakumar (PA)	2009-2010
82.	Studies on inoculums source and economic thresholds of cotton leaf curl and virus disease	D. Monga (PL), Rishi Kumar (PA)	2008-2011
83.	Bio-ecology and sampling of mealybug in Bt-cotton.	Rishi Kumar (PL), D. Monga (PA).	2008-2011
84.	Impact of systemic insecticide on sucking pests and non target arthropod communities in Bt and Non Bt cotton	Rishi Kumar (PL)	2008-2011
85.	Studies on the role and effect of insecticides in cotton ecosystem	T. Surulivelu (PL), K. Natarajan (PA)	1989-2011
86.	Studies on the population dynamics of cotton pests and their natural enemies in cotton eco-system	K. Natarajan (PL), B. Dharajothi (PA)	2008-2010
87.	Developing resistant genotypes to jassid	K. Natarajan (PL), KPM Damayanthi (PA)	2008-2012
88.	Standardization of bioassays techniques for resistance monitoring in <i>Pectinophora gossypiella</i> Saunders to transgenic cotton and development of management strategies	B. Dharajothi (PL)	2007-2012
89.	Pesticides, sucking pests and predator interaction on Bt cotton	B. Dharajothi (PL)	2008-2010
90.	Studies on epizootiology, pathogenicity and pathogenic mechanism of Entomopathogenic fungal pathogens against cotton mealybug	M. Amutha (PL)	2008-2011
91.	Establishment of <i>Beauveria bassiana</i> as a symbiotic insecticide against major insect pests and diseases of cotton	M. Amutha (PL), M. Gunasekaran (PA)	2009-2012
92.	Studies on biochemical, molecular and genetic basis of host plant resistance to cotton nematodes	N. G. Narkhedkar (PL)	2006-2010
93.	Potential of rhizobacteria in management of cotton nematodes	N. G. Narkhedkar (PL)	2006-2010
94.	Isolation identification and characterization of insecticidal toxins from heat tolerant isolate of EPN bacterial system	N. G. Narkhedkar (PL)	2008-2011
95.	RNAi mediated crop protection against root-knot nematode	N. G. Narkhedkar (PL), P. K. Charkrabarty (PA)	2009-2012
96.	Identification of hot spots for plant parasitic nematodes in cotton growing zones of India	Gulsar Banu (PL), N. G. Narkhedkar (PA)	2006-2011
97.	Isolation of <i>novel</i> insecticidal proteins from bacterial symbionts of <i>native</i> entomo-pathogenic nematodes	Gulsar Banu (PL), N. G. Narkhedkar (PA), B. Dharajothi (PA)	2006-2011

#### EXTERNALLY FUNDED PROJECTS

##### DST/ DBT

98.	DST; Molecular mapping of fibre quality traits QTLs and marker assisted selection (MAS) in upland cotton ( <i>Gossypium hirsutum</i> L.)	V. N. Waghmare (PI)	2007-2010
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99.	DBT; Molecular mapping of fibre quality and lint yield traits: construction of a framework linkage map in desi cotton ( <i>Gossypium sp.</i> )	VNWaghmare (PI), A.BDongre (PA) Vinita Gotmare (PA), Er Manoj Kumar (PA)	2006-2009
100.	DBT; Engineering virus resistant cotton through dsRNAi-mediated targeting of cotton leaf curl virus	P. K. Chakrabarty (PI), S. B. Nandeshwar (PA), D. Monga (PA), B. M. Khadi (PA)	2007-2010
101.	DBT; Identification of Molecular markers and tagging genes for Bacterial blight resistance	P. K. Chakrabarty (PI), Punit Mohan (PA), V. N. Waghmare (PA), B. M. Khadi (PA)	2008-2011
102.	DBT : "Gene stacking in Bt Cotton"	G. Balasubramani (PI) S. B. Nandeshwar (CCPI), S. B. Singh (CCPI)	2008-2010
103.	DBT; Development of cotton transgenic with improved fibre strength using cellulose synthase gene from <i>Arabidopsis</i>	G. Balasubramani (PI), J. Amudha (CCPI)	2007-2009
104.	DBT; Indo-Australian Project: Enhancing sustainability of transgenic crops through gene stacking	K. R. Kranthi (PI)	2008-2012
<b>NAIP</b>			
105.	Georeferenced soil information system (GeoSIS) for land use planning and monitoring soil and land quality for agriculture	MVVenugopalan (CCPI), K. Velmourougane (CCPI)	2009-2013
106.	A value chain for cotton fibre, seed and stalks: an innovation for Higher Economic Returns to Farmers and Allied Stake holders	N. Gopalakrishnan Consortium partner and CoPI, Sankaranarayanan (Co oPI) P. R. Bharambe (Team Leader, Nagpur) D. Monga, (Team Leader, Sirsa)	2008-2012
107.	Research into development of decision support systems for management of insect pests of major rice and cotton based cropping systems	V. S. Nagrare (CCPI), G. Majumdar (CoPI) Rishi Kumar (CoPI), B. Dharajothi (CoPI) M. Sabesh (CoPI), M. Amutha (CoPI)	2008-2012
<b>OTHER PROJECTS</b>			
108.	Transgenics in Crops (NPTC): Development of bollworm resistance transgenic cotton (ICAR-Network Project)	G. Balasubramani (PI), S. B. Singh (CCPI), J. Amudha (CCPI), S. B. Nandeshwar (CCPI), A. B. Dongre (CCPI), K. R. Kranthi (CCPI), P. K. Chakrabarty (CCPI)	2006-2012
109.	Impact, adaptation and vulnerability of Indian agriculture to climate change. Sub project-- changes in soil carbon reserves as influenced by different ecosystems and land uses in India. (ICAR Network project)	1. Bhattacharyya, NBSS&LUP (PI): M. V Venugopalan, (CCPI), P Chandran, NBSS&LUP (CCPI)	2009-2012
110.	Testing & Documentation of Extant Varieties, hybrids and their Parents for Distinctness, Uniformity & Stability (PVP & FR ACT, 2001). (DUS)	N. Gopalakrishnan (PI), K. Rathinavel (CCPI), VSanthy (CCPI) P.R. Vijayakumari (CCPI) R. K. Deshmukh (CCPI)	2003-2012
111.	Novel approaches for production of hybrid seeds with characteristics of improved insect resistance and higher Yield. Funded by the CSIR, under the New Millennium Initiative project	K. R. Kranthi (PI)	2008-2012
112.	Development of technology for Detecting Presence of GMOs in an Unknown Sample and its Utilization in dealing with Bulk Samples. (Ministry of Agriculture, Government of India GMO Project)	K. R. Kranthi (PI)	2006-2009
113.	Monitoring changes in baseline susceptibilities to cry1Ac in geographic populations of <i>H. armigera</i>	S. Kranthi (PI), K. R. Kranthi (CCPI)	2002-2012
114.	Monitoring changes in baseline susceptibilities to cry2Ab & cry1Ac +cry2Ab in geographic populations of <i>H. armigera</i>	S. Kranthi (PI), K. R. Kranthi (CCPI)	2002-2012
115.	Monitoring changes in baseline susceptibilities to JK toxin (Event 1) in geographic populations of <i>H. armigera</i>	S. Kranthi (PI), K. R. Kranthi (CCPI)	2002-2012
116.	Studies on <i>H. armigera</i> response to Rynaxypyr (DuPont Project) (Funded by Dupont)	K. R. Kranthi (PI)	2006-2009
117.	Implementation of PVP legislation 2001 (Ad hoc)	K. Rathinavel (PI) S.Manickam (Co-PI)	2008-2009
118.	Seed production in agricultural crops and fisheries	K.Rathinavel (PI)	2006-2014
119.	National Seed Project (crops).	K,Rathinavel (PI)	1999-2012

120. Awareness-cum-Surveillance Programme for Management of Major Pests in Soybean-Cotton Based Cropping System in Maharashtra (2009-10) (Funded by Government of Maharashtra)

V. S. Nagrare (PI)

2009-2010

## Technology Mission on Cotton (TMC): Mini Mission I 2007-2012

Project code	Project Title	Name of PI/CCPI Dr.
MM 1.1	Development and promotion of medium and long linted diploid cottons ( <i>G.arboreum</i> and <i>G.herbaceum</i> )	S. K. Verma - PI T. R. Loknathan - CCPI
MM 1.2	Development of extra long staple <i>G.barbadense</i> cotton with improved fibre qualities to meet the requirements of textile industry	K. N. Gururajan - PI
MM 1.3	Identification of <i>G. hirsutum</i> genotypes suitable for machine picking and development of agronomic package	V. Gotmare - CCPI
MM 1.4	Development and promotion of Bt transgenic cotton for bollworm Resistance	S. Manickam - CCPI, Suman Bala Singh, S. B. Nandeshwar, S. M. Palve, O. P. Tuteja, S. K. Verma.
MM 1.5	Molecular characterization of cotton germ plasm using DNA Markers	A. B. Dongre, V. N. Waghmare.
MM 1.6	Exploitation of apomixis and TGMS System in hybrid cotton seed production	S. M. Palve - PI V. Gotmare - CCPI, V. Santhy.
MM 2.1	Development of production technologies for Bt cotton and improvement of water and nutrient use efficiency with precision farming techniques	J. V. Singh - PI C. S. Praharaj - CCPI, P. R. Bharambe, M. V. Venugoplan.
MM 2.2	Identification of <i>innovative</i> Bt cotton based cropping systems improvement of water and nutrient use efficiency with precision farming techniques	P. Nalayini - PI K. K. Bandopadhyay - CCPI, A. R. Raju, P. R. Bharambe, R. A. Meena.
MM 2.3	Mechanization of cotton production	G. Majumdar-PI, A. R. Raju-CCPI
MM 2.4	Physiological manipulation of Bt plant morphoform for enhanced productivity under <i>varied</i> agro-climatic conditions	A. H. Prakash - PI R. K. Deshmukh - CCPI
MM 3.1	Emerging and key pests of Bt cotton- their characterization, taxonomy, genetic diversity and control	K. R. Kranthi - PI, T. Surulivelu - CCPI, Dharajyoti, S. Kranthi, V. S. Nagrare, M. K. Meshram.
MM 3.2	Development and validation of IPM/IRM strategies for Bt cotton under different ecosystems	S. Kranthi - CCPI V. S. Nagrare - CCPI Rishi Kumar - CCPI
MM 3.3	Development, validation, utilization and / or commercialization of bio-pesticides and bio inoculants	P. K. Chakrabarty - PI T. Surulivelu - CCPI J. Gulsar Banu - CCPI N. Narkhedkar- CCPI D. Monga - CCPI
MM 3.4	Development of farmerfriendly diagnostic kits for transgenic <i>event</i> seed	K. R. Kranthi - CCPI
MM 4.1	Quality evaluation of cotton fibres	M. Chakrabarty - CCPI
MM 5.1	Total factor productivity of cotton in India	Isabella Agarwal- PI A. R. Reddy - CCPI
MM 5.3	Indian cotton portal	M. Sabesh - PI N. Gopalakrishnan - CCPI G. Majumdar-CCPI

## Technology Mission on Cotton: Mini Mission II 2007-2012

Project Title	Name of PI/CCPI Dr.
Dissemination of IRM strategies in 500 villages of India	K. R. Kranthi (PI) B. Dharajyoti - CCPI D. Monga - CCPI Rishi Kumar - CCPI

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

Following implements developed have been filed for patents with provisional application

1. Bullock drawn vertical rotor planter for vertisols (Prov. Pat., No.1559/MUM/2009)

2. Cotton Seed Blower (Prov. Pat., No. 1560/ MUM /2009)

3. Solar powered knapsack sprayer (Prov. Pat., No. 1561/MUM/2009)

4. Notification of *G. arboreum* variety CISA 614 for Commercial Cultivation in North Zone

The variety CISA 614 was tested in 32 locations in the North Zone (Punjab, Haryana and Rajasthan) during 2004-2007 and has recorded an overall mean seed cotton yield of 2204 kg/ha as against 1834 kg/ha of HD 123 (zonal check) and 1990 kg/ha of local checks. It was identified by Variety Identification Committee Meeting (AICCIP) held at ANGRAU, Hyderabad 6-8 April, 2009 and notified vide Gazette of India NO.608 dated April 1, 2010.

5. Notification of *G. arboreum* variety CISA 310 for commercial cultivation in north zone

The variety CISA 310 of *Gossypium arboreum* developed at CICR, Regional Station, Sirsa, has been notified vide Gazette of India NO.171 dated January, 2010 for cultivation under irrigated conditions of entire north zone due to its overall superiority in both seed cotton and lint yield, better fibre quality than the check and less boll damage.

6. Notification of *G. hirsutum* variety, CNHO 12 for commercial cultivation in central zone (irrigated condition)

*G. hirsutum* variety, CNHO 12 (Saraswati) has been identified for release in the Central zone under irrigated conditions during the year 2009-10. The variety is characterized by dwarf stature, early maturity (160-165 days), medium to high seed oil content (21.8 %) with synchronous boll bursting. It has recorded seed cotton yield of 1501 kg/ha as against 1251 kg/ha of the zonal check LRA 5166. In the wake of shortage of short staple and medium staple categories of cotton in the country, the new variety CNHO 12, spinnable to 20s counts was recommended for release for its suitability for manufacture of denim. The variety has been assigned with the National Identity Number IC 574486.

7. Release of first public sector Bt cotton hybrid NHH 44-Bt for commercial cultivation

The first public sector Bt hybrid NHH 44-Bt was developed indigenously by using BN Bt as female parent and approved for commercial cultivation by the GEAC, New Delhi on 13<sup>th</sup> May, 2009. The BN Bt is very good combiner for hybrid production and it was developed by incorporating Bt *cry1 Ac* gene. The expression of Cry protein level is high i.e. up to 5.8 ppm. The hybrids were evaluated in all the cotton growing zones and found very promising. It was developed through collaborative efforts of the University of Agricultural Sciences (UAS), Dharwad, National Research Centre for Plant Biotechnology (NRCPB), New Delhi and Central Institute for Cotton Research (CICR), Nagpur.

8. Seed Production

Nagpur

Under the Mega Seed production programme, seeds of 13 elite cultivars of cotton along with wheat and pulses were produced. A sizeable resource of Rs. 6.72 lakhs approximately was earned through the sale proceeds.

Crop	Stage	Production (Q)
Cotton -13 varieties	TFL	32.89
Wheat cV.HD2189	Foundation Seed	40.90
Red Gram-BSMR	TFL	73.80
Gram-Vijay	CS	29.80
Wheat-GW-496	CS	55.98

#### Coimbatore

#### Breeder Seed Production

Variety	Breeder Seed production (kapas in kg)	Breeder seed distribution (seeds in kg)
LRA5166	326	111
MCU 5 VT	-	69*
Surabhi	130	111
Suraj	192	54
Supriya	94	6
Suvin	235	33
Total	977	384

\*From Carried over stock

#### Sirsa

#### Maintenance of Nucleus and Breeder seeds

No	Variety	Quantity (kg)
1	CSHH 198 (F)	45
2	CSHH 198 (M)	38
3	CSHH 243 (F)	25
4	CSHH 243 (M)	10
5	CSHH 238 (F)	35
6	CSHH 238 (M)	30
7	CICR 2 (F)	35
8	CICR 2 (M)	30
9	CISA310	85
10	CISA614	100



## 11.4: Significant Decisions of IRC, IMC and Other Important Meetings

### 1. Research Advisory Committee Meeting

The Research Advisory Committee (RAC) of the Institute held its first meeting at CICR, Nagpur on April 24-25, 2009. Dr. S.S. Beghel, Ex. Vice-Chancellor, Assam Agricultural University, Jorhat, Chairman RAC presided over the meeting and guided the deliberations. Other members of RAC viz. Dr. S.K. Sharma, Ex. Project Director, Project Directorate of Cropping Systems, Modipuram, Dr. V. Shiva Reddy, Group Leader (Transformation) International Centre for Genetic Engineering & Biotechnology (ICGEB), New Delhi and Dr. G.T. Gujar, Head, Division of Entomology, Indian Agricultural Research Institute, New Delhi attended the meeting. Dr. K.R. Kranthi, Acting Director CICR, Nagpur, Dr. P.R. Bharambe, Head Crop Production Division, Dr. V.V. Singh, Head Crop Improvement Division, Dr. N. Gopalakrishnan, Project Coordinator (AICCP) and Head, CICR Regional Station, Coimbatore, Dr. D.Monga, Head CICR, Regional Station Sirsa and Sh. M.K. Meshram, Principal Scientist, Members Secretary were also present.



Dr. K.R. Kranthi, Director, CICR, Nagpur formally welcomed the RAC Chairman and its members. Dr. Kranthi presented an overview of current cotton situation. In his introductory remarks, Dr. Beghel, Chairman RAC appreciated the efforts made in the development of indigenous Bt genotype. Natural resources, especially water, he predicted, would be limiting in the days to come. He advised management of biotic stresses through cultural practices by understanding the life cycle of the pest. Dr. Shiva Reddy congratulated UAS, Dharwad, NRCPB, New Delhi, and CICR, Nagpur for their joint efforts in release of first public sector transgenic variety BN Bt.

The action taken report (ATR) on the recommendations of the previous Research Advisory Committee meeting held on August 3, 2007 was presented and discussed in detail. Dr. Kranthi highlighted the recent research initiatives and major research achievements of CICR, Nagpur and its regional stations. The Project Coordinator, Dr. N. Gopalakrishnan presented the achievements of the Regional Station, Coimbatore wherein the performance of high yielding interspecific hybrid CCHB 110, farming system approach, NAIP project and growing cotton under polymulch were highlighted. Dr. D.Monga, Head Regional Station Sirsa, presented the achievement of the station which includes release of CSHH 243, submission of CISA 614 for varietal identification and registration of 13 genetic stocks. Dr. V.V. Singh, Head Crop Improvement Division, Dr. P.R. Bharambe, Head, Division of Crop Production and Dr. K.R. Kranthi, Director and Head, Division of Crop Protection also presented research achievements of their respective divisions.

During the deliberations, Dr. Shiva Reddy desired that CICR should gear itself with reference to fibre specific genes and must ensure for the partnership in the cotton genome programme. Dr. Gujar expressed satisfaction with work being carried out by the plant protection group. Dr. Sharma desired that yield targets be fixed for rain-fed and irrigated cotton production system.

The Chairman Dr. Baghel, expressed satisfaction at the work being carried out and evinced need for a brain storming session on the challenges for cotton cultivation in North, South and Central India. He suggested for improvement in seed oil from cotton seed as by product, implementation of appropriate strategies for IRM through DOCD, Mumbai and identification of better combiners with agronomic parameters having good yield potential. Dr. Kranthi assured the house that all the valuable suggestions/recommendations will be implemented by improving the research programmes. He also assured the house that the seeds of BN Bt variety and Bt hybrid NHH 44 will be made available to the farmers through the Government agencies. The Director also expressed optimism on obtaining regulatory clearance for the commercialization of hybrid Bt NHH 44. The meeting concluded with a formal vote of thanks by the member secretary.

### 2. Institute Research Council Meeting

Institute Research Council Meeting was held on April 29-30, 2009 at CICR Nagpur under the Chairmanship of Dr. K.R. Kranthi, Director CICR. All the scientists of CICR, Nagpur participated and presented their research findings. The projects were discussed thoroughly and technical programme for the 2009-10 was finalized. The new research proposals were also presented, discussed and finalized to be implemented during 2010-11. IRC also felicitated Dr. VV Singh, Principal Scientist, Plant Breeding and Dr. P.M. Mukewar, Principal Scientist, Plant Pathology who were due for superannuation. The meeting was conducted by Dr. Vishlesh Nagrare, Secretary, IRC and Dr. Velmourougane, Jt. Secretary, IRC.

The annual IRC meeting of CICR, RS, Coimbatore was held on 10<sup>th</sup>-11<sup>th</sup> February 2010 under the Chairmanship of Dr. K. R. Kranthi, Director, CICR Nagpur. Dr. N. Gopalakrishnan, Project Coordinator and Head, CICR, RS Coimbatore made a brief introductory remark introducing the various activities and the overall contributions of scientists from various disciplines.

Dr. K. R. Kranthi, Chairman IRC, in his opening address desired that the research done at this center should fulfill the farmer's need of the region. He also sensitized the scientist regarding the relevance of the institute in the changing scenario of cotton cultivation at national and international level. He told to the house that hybrid era by private companies is at near saturation stage. In the present context of Bt era we need to find innovative avenues to deliver public goods. Leadership is required in solving problems. He congratulated the scientists of CICR RS Coimbatore on good work carried out on production aspects of cotton.

Dr. V. S. Nagrare, Secretary IRC welcomed Dr. K. R. Kranthi, Director, CICR Nagpur and Chairman IRC, Dr. P. R. Bharambe Head Division of Crop Production, Dr. P. K. Chakrabarty, Head Division of Crop Improvement, Dr. N. Gopalakrishnan PC & Head CICR RS Coimbatore and all the scientists. All the Scientists of the station presented the results obtained during 2009-10 and technical programmes for the year 2010-11 were approved by the house.

The annual IRC meeting of the regional station, Sirsa was held on 17<sup>th</sup> July, 2009. The meeting was Chaired by Dr. K. R. Kranthi, Director, CICR, Nagpur. Dr. D.Monga, Head CICR, Regional Station Sirsa welcomed the Director and appraised the house about the on-going research programmes at the station. All the Scientists of the station presented the results obtained during

2009-10 and technical programmes for the year 2010-11 were approved. Dr. P.R. Bharambe, Head Crop Production, Dr. V.V. Singh, Head Crop Improvement and Dr. V.S. Nagrare, Member Secretary, IRC were also present.

### 3. Institute Management Committee Meeting

The 47<sup>th</sup> Institute Management Committee of CICR, Nagpur was held on May 27, 2009 at CICR, Nagpur. Dr. K.R. Kranthi Acting Director CICR, Nagpur; Dr. O.P. Tuteja, Principal Scientist, CICR (RS), Sirsa; Dr. K.N. Gururajan, Principal Scientist, CICR (RS), Coimbatore; Dr. K.B. Hebbar, Principal Scientist, IISS, Bhopal; Dr. (Mrs.) Vinta Gotmade, Sr. Scientist, CICR, Nagpur; Dr. Nandini Gokte-Narkhedkar, J/c. Admn. Officer CICR attended the meeting. Other special invitees were Dr. S.N. Puri, Hon'ble V.C. Central Agricultural University (CAU), Imphal & Chairman, QRT; Dr. N. Gopalakrishnan, PC & Head Regional Station, Coimbatore, Dr. D.Monga Regional Station, Sirsa, Dr. P.R. Bharambe, Head Crop Production Division CICR, Nagpur, Dr. R. K. Deshmukh, J/c HOD, Crop Improvement, CICR Nagpur; Shri M.K. Meshram, Scientist Incharge, KVK, Nagpur and Shri Devesh Nigam, Finance & Account officer.

At the outset Dr. P.R. Bharambe, Head Division of Crop Production welcomed the Director, CICR and Chairman, IMC, Dr. S.N. Puri and other Hon'ble members of IMC. He also mentioned that this session was specially convened to facilitate the presentation of the recommendations of QRT. Director, CICR briefly outlined the recent R & O achievements of the Institute. He highlighted the release of two Bt transgenic cotton from public sector viz., BN Bt *hirsutum* variety and NHH 44 Intra *hirsutum* hybrid as major achievements. Dr. S.N. Puri, Hon'ble VC, CAU, Imphal and Chairman QRT, CICR Nagpur at the outset complimented the research of CICR and AICCIP for the excellent work carried out during the review period. He expressed that the main concern of QRT was regarding the introduction of public sector transgenic into the market. The main recommendations of the QRT pertaining to CICR and AICCIP were also discussed. The meeting ended with thanks to Chair and the members by the Members Secretary.

### 4. Brain storming cotton: facing the new challenges

Brain Storming Cotton on facing the new challenges was held on July 9, 2009 at Central Institute for Cotton Research, Nagpur. The meeting comprised of two sessions. The first session comprised of Background papers and was chaired by Dr. C.D.

Mayee, Chairman, ASRB, New Delhi. The second session was chaired by Dr. Swapan Datta, Deputy Director General (Crop Sciences) and it comprised of views on researchable issues on emerging challenges. These views were compiled from the feedback received from different cotton researchers in India (through e-mail). Dr. C.D. Mayee delivered a talk on 'Cotton- the recent revolution and issues'. He observed that precision farming is the next challenge which should aim at a productivity of 35 q. per hectare. He desired that CICR should take the lead and demonstrate the feasibility of precision farming on a model plot.



Dr. S. Sreenivasan, Director, CIRCOT, Mumbai gave a talk on 'Cotton trade, demand, pricing & quality issues after the introduction of Bt cotton. The recent challenges and ways to tackle them'. Dr. Sreenivasan presented the requirements for cotton of different fibre span lengths based on the feedback from textile industry. He also informed that very few Bt cotton cultivars satisfy the quality norms set by the industry. He also regretted that in 2007 *hirsutum* cotton in 28-32 mm. length dominated the production and the production of other three types of cotton obtained from *arborescens*, *herbaceum* and *barbadense* were low. The other issues raised by him related to reduction in micronaire in Bt cotton after second picking only resulting poor quality cotton and mixing of Bt with non- Bt inorganic cotton meant for export. Dr. Sreenivasan presented a futuristic picture of cotton with ideal attributes such as tenacity and extension of polyester, softness of wool, less short fibre content and improvement of GOT.

In the second session on Cotton: Facing the new challenges was chaired by Hon'ble DOG (CS), Dr. Swapan Datta. Dr. P. K. Chakrabarty and Dr. Gopalakrishnan presented some of the issues based on the views received from various cotton workers around the country. Pertinent concerns in cotton biotechnology and breeding were:

Gene construct and future biotech products: How should India deal with IPR?

497 Bt hybrids and more to come, 90% area covered by private Bt cotton hybrids: What are the options left for public sector breeders?

- Bt cotton hybrids: Are they more susceptible?
- Roundup Ready Cotton: Issues on suitability for Indian cropping systems.
- Seed quality, market trade, export and quality issues.

Responding to these issues there was a general observation that there is substantial increase in yield since 2002. An attempt should be made to analyse the Bt hybrids spread in India and quantify the role of Bt gene per se in bringing about of this increase in yield. There is a general observation that only a few hybrids have contributed towards yield growth.

Another issue of concern was whether in addition to Bollgard-I, should we recommend Bollgard-II also since in areas of North zone where diversification is less.

The house arrived at the consensus that public sector institute like CICR must take a lead and concentrate on creation of genetic variability and develop robust parental lines or varieties. There was a need to identify best Bt hybrid for each zone for cultivation. DOG suggested to select only those genotypes with morphological traits that are acceptable to farmers and industry. Roundup Ready issue needs to be discussed cautiously taking the entire cotton based system into account.

Dr. M. V. Venugopalan and Dr. Sandhya Kranthi presented the issues compiled from various emerging problems. Some of the issues raised were:

Melaybugs, Mirid bugs, new emerging pest and diseases: How to prevent resurgences and remedies. Mealy bugs, Mirid bugs, new emerging pests and diseases may best be controlled by good management practices.

Sucking pest resistance to insecticides: The problem and management options.

Bollworm resistance to Cry toxins: Status, trends and management option for India. Refugia option for Bollgard-II.

Leaf reddening and wilt: Causes, consequences and remedies.

Gearing up for Climate change will cotton benefit and how to cope up with it.

Reacting to the deliberations Hon'ble DOG was of the opinion that Bt is a valuable technology and should be nurtured with care.

mismanaged to avoid a breakdown.

Gene pyramiding without disturbing the basic genome should be taken up to tackle multiple problems.

Screening of genotypes/ available material will help in getting the resistant genotypes.

Causes of leaf reddening, its physiological and nutrient interaction were discussed at length. Strategies to overcome leaf reddening and para wilt should be developed and it should be ensured that the susceptible lines are not used in breeding programme.

### 11.5: Workshops/Farmer's Day Organized

### 11.6. Distinguished visitors

### Farmers meet

Farmers meet was organized in collaborations with Ramkrishna Bajaj Krishi Mahavidyalaya on 9<sup>th</sup> March 2010 at Rural Institute Hall, Ramkrishna Bajaj Krishi Mahavidyalaya, Pipri, Wardha. The programme was organized in order to disseminate crop production technologies for ensuing season, to discuss with growers all aspects related to appropriate utilization of the technologies to enhance productivity under rainfed conditions and popularize benefits of CICR technologies to reduce cost of cultivation

Name & Designation	Organisation	Date
<b>Nagpur</b>		
Dr. S.S. Baghel <sup>†</sup> , Chairman, RAC & Ex Vice Chancellor	Assam Agricultural University, Jorhat	24 April, 2009
Dr. V. Shiva Reddy, Group Leader (Transformation)	International Centre for Genetic Engineerings Biotechnology (ICGEB), New Delhi	25 April, 2009
Dr. S. N. Puri, Chairman, QRT & Vice-Chancellor	Central Agricultural University, Imphal	27 May, 2009
Dr. Swapan Kumar Datta Deputy Director General (CS)	Indian Council of Agricultural Research, New Delhi	9 July, 2009
Dr. C. D. Mayee, Chairman	ASRB, New Delhi	9 July, 2009
Dr. S. Sreenivasan, Director	CIRCOT, Mumbai	9 July, 2009
Dr. Albertino Jeronimo, Inspector General	Ministry of Agricultural, Mozambique	12 Nov., 2009
Cossa LRC Head of Department	Mozambique Institute of Cotton	12 Nov., 2009
Hope Ruhindi Mwesigys Hon'ble Minister of Agricultural, Animal Industry of Fisheries	Uganda Government	21Dec., 2009
<b>Coimbatore</b>		
Dr. Mangala Rai Secretary, DARE & Director General	Indian Council of Agricultural Research, New Delhi	6 Nov., 2009
<b>Sirsa</b>		
Dr. Stephen Wambula Muliokela, Executive Director	Golden Valley Agricultural Trust (GART), Zambia	7 Oct., 2009
Mr. Namukototo Mukutu, Chairman, Mr Barry Coxe Member	Board of Trustees, GART, Zambia	
Mr Douglass Moono, Head	Research & Development, GART	
Prof. G. S. Pandey,	Dairy Development, GART	
Dr, T,P. Rajenderan ADG (PP)	ICAR, Krishi Bhawan, New Delhi	8 Oct., 2009



## 11.7 : Participation of scientists in Seminars/ Symposia/ Workshops

Sr. No.	Seminars/Conferences /Symposia/ Workshops/Training	Place and Date	Participants
1.	ICAR Zonal Technology Management and Business Planning and Development	Nagpur 5-6 March, 2009	Dr. P. R. Barambe Dr. MV Venugopalan, Dr. AR Reddy, Er. G. Majumdar
2.	Workshop on formulation of project on Awareness-cum-Surveillance Programme for Management of Major Pests in Soybean-Cotton Based Cropping System in Maharashtra	Nagpur 1 April, 2009	Dr. V.S. Nagrare
3.	Annual Workshop of All India Coordinated Cotton Improvement Project (2008-09)	Hyderabad 6-8 April, 2009	Dr. K.R., Kranthi, Dr A H Prakash Dr. MV Venugopalan Dr. SM Wasnik, Dr. AR Reddy Dr N. Gopalakrishnan Dr. T. Surulivelu, Dr S. Manickam Mr M. Sabesh, Dr S. Ushar Rani
4.	International Conference on Emerging Trends in Production, Processing and Utilization of Natural Fibres	Mumbai 16-18 April, 2009	Dr. K.R., Kranthi, Dr.C.S.Pahraj Dr. N. Gopalakrishnan Dr. P. Nalayani, Dr. D. Monga Dr. K. Shankaranarayanan
5.	Sub committee GEAC meeting	New Delhi, 17 April, 2009	Dr. K.R., Kranthi
6.	Brain Storming Session of development of cotton picker	Noida, 3 June, 2009	Dr. K.R., Kranthi
7.	NAIP (DSS 2046) CMU and CIC meeting	Hyderabad, 6 June, 2009	Dr. V.S. Nagrare
8.	Meeting of ZREAC of Central Vidarbha Region	Yeotmal 19 June, 2009	M.K. Meshram
9.	Workshop on formulation of project on Awareness-cum-Surveillance Programme for Management of Major Pests in Soybean-Cotton Based Cropping System in Maharashtra	Pune 19-20 June, 2009 and 1 August, 2009	Dr. V.S. Nagrare
10.	9th Agricultural Science Congress on technological and Institutional Innovations for Enhancing agricultural Income	Srinagar June 22-24, 2009	Dr P. Nalayani, Dr S. Manickam Dr A.H. Prakash
11.	Director's Conference	New Delhi 16 July, 2009	Dr. K.R., Kranthi
12.	Rural Programme Advisory Committee meeting	Akola, 25 Aug., 2009	M.K. Meshram, Dr. S.M. Wasnik
13.	ICAR Governing Body meeting	New Delhi, 27 Aug., 2009	Dr. K.R., Kranthi
14.	Cotton Advisory Board meeting	New Delhi 29 Aug., 2009	Dr. K.R. Kranthi
15.	Seminar on IPR, PPV&FR and Biological Diversity acts	Coimbatore 4 September, 2009	Dr K. Rathinavel
16.	Workshop on Resistance Management for Bt Cotton	New Delhi 22 September, 2009	Dr. K.R. Kranthi
17.	Workshop on "Role of media in agriculture extension"	Akola, 23 Sep., 2009	M.K. Meshram
18.	Meeting of ZREAC of Central Vidarbha Region	Yeotmal, 8 Oct., 2009.	M.K. Meshram
19.	Meeting on issues relating to WHO Doha negotiations	New Delhi 26 Oct., 2009	Dr. K.R., Kranthi
20.	31st Annual Conference and Symposium on Microbial wealth-Plant health	Siliguri 23-25 October, 2009	Dr. P.K.Chakrabarty
21.	AZRA, 2009 - "National Conference on Biodiversity Conservation and Management of Bio-resources"	Visakhapatnam 28-29 October, 2009	Dr. J.Gulsar Banu
22.	"Cotton Stakeholders' Workshop to Probe Challenges and Opportunities for Cotton in TamilNadu" in collaboration with the Indian Institute of Technology, Chennai	Coimbatore 2 November, 2009	Dr N. Gopalakrishnan Mr M Sabesh Dr K. Shankaranarayanan Dr S. Usha Rani
23.	IV National Conference on Krishi Vigyan KEmdras	Coimbatore, 6-8 Nov., 09	M.K. Meshram
24.	5th International conference on Plant Pathology	New Delhi, 10-13 Nov., 09	Dr. D. Monga Dr. P.K.Chakrabarty
25.	Steering committee meeting.	Rahuri, 11 Nov., 2009	Dr. V.S. Nagrare

26. 7th Pacific Rim Conference on "Biotechnology of Bacillus thuringiensis and its environmental impact"	New Delhi 25-28 Nov. , 2009	Dr. B. Dharajothi Dr S. Manickam Dr. G. Balasubramani Dr. J Amudha, Dr. V. Santhy
27. Rural Programme Advisory Committee Meeting	Amravati, 26 Nov., 2009	M.K. Meshram
28. 2nd Bio-pesticide International Conference.	Palayamkottai 26-28 November,2009	Dr. J.Gulsar Banu
29. Meeting on Mealybug.	Bangalore, 5-6 Dec.,09	Dr. V.S. Nagrare
30. National Symposium on Recent Global Developments in the Management of Plant Genetic Resources	New Delhi 17-18 December, 2009	Dr. R,A Meena Dr. A,B Dongre, DrV Gotmare Dr. Punit Mohan
31. Quarterly Meeting for Agricultural Advisory Committee for finalization of Programmes of All India Radio	Katol 9 February, 2010	Dr. S.M. Wasnik
32. NAIP (DSS 2046) CMU and CIC meeting	Hyderabad, 15 Feb.,10	Dr. V.S. Nagrare
33. National Conference on Plant Protection in Agriculture through Eco-friendly Techniques & Traditional farming Practices	Jaipur 18-20 February ,2010	Dr. Rishi Kumar
34. National Seed Science Congress	New Delhi, 18-20 Jan.10	Dr. V. Santhy
35. National Seminar on Biotechnology for Agriculture, Health, Industry and Environment	Nagpur 20 - 21 February, 2010	Dr. S.B. Nandeshwar
36. Interface on Optimal Land Use and Water Management	Nagpur 22-23 February, 2010	Dr. MV Venugopalan
37. National conference on Innovations in Nematological Research for Agriculture sustainability - Challenges and a road map ahead.	Coimbatore 23-25 February,201 0	Dr.J.Gulsar Banu
38. Network project proposals on Comprehensive Utilization of Natural Fibres: Production, Processing and By-Product Utilization	New Delhi 25 February,2010	Dr. MV Venugopalan
41. Conference on Conservation tillage and Technology Conference	Ada, Ohio, USA 25-26 February, 2010	Dr K.K. Bandyopadhyay
42. Indo-US Bilateral Workshop	Hisar, 25-27 Feb., 2010	Dr. P.K.Chakrabarty
43. National Seminar on Post harvest management of seed for quality assurance and farmers prosperity	Kamal 26-27 February, 2010.	Dr. R,K Deshmukh
44. National Seminar on "Soil security for sustainable Agriculture"	Nagpur 28 Feb., 2010	M.K. Meshram
45. ZTM-BPD meeting cum workshop	Nagpur, 5-6 Mar.,10	Dr. MV Venugopalan
46. NAIP (DSS 2046) Annual review meeting	New Delhi, 5-6 Mar.,10	Dr. V.S. Nagrare
47. Conference on "Carbon Sequestration in Urban Ecosystems Symposium"	Ohio, USA 4 April, 2010	Dr K.K. Bandyopadhyay



## 11.8 Personnel

Name of the Officers/Scientists	Designation	
K R Kranthi (Acting Director upto 14.02.10)	Director (w.e.f. 15.02.2010)	
<b>PROJECT COORDINATOR (Cotton)</b>		
<b>Coimbatore</b>		
N Gopalakrishnan	P.C. (Cotton) & Head	
<b>PLANT BREEDING</b>		
<b>Nagpur</b>		
V V Singh (Retd. 31.08.09)	Principal Scientist	
Smt. S B Singh	Principal Scientist	
T R Loknathan	Principal Scientist	
S M Palve	Principal Scientist	
V N Waghmare	Senior Scientist	
<b>Coimbatore</b>		
K N Gururajan	Principal Scientist	
<b>Sirsa</b>		
S L Ahuja	Principal Scientist	
O PTuteja	Principal Scientist	
S K Verma	Senior Scientist	
<b>GENETICS &amp; CYTOGENETICS</b>		
<b>Nagpur</b>		
S B Nandeshwar	Principal Scientist	
Smt., Vinita Gotmare	Senior Scientist	
<b>Coimbatore</b>		
Smt., K P M Damayanthi	Senior Scientist	
S Manickam	Senior Scientist	
<b>SEED TECHNOLOGY</b>		
<b>Nagpur</b>		
R K Deshmukh	Principal Scientist	
Smt., P R Vijayakumari	Senior Scientist	
Smt., V Santhy	Scientist(ss)	
<b>Coimbatore</b>		
K Rathniveel	Principal Scientist	
<b>Sirsa</b>		
RAMeena	Principal Scientist	
<b>ECONOMIC BOTANY</b>		
<b>Nagpur</b>		
Punit Mohan	Principal Scientist	
<b>AGRONOMY</b>		
<b>Nagpur</b>		
PR Barambe	HOD (Crop Production) Principal Scientist Senior Scientist	
<b>MV Venugopalan</b>		
<b>AR Raju</b>		
<b>Coimbatore</b>		
C S Praharaaj (Trd. to IIPR - 11.2.2010)	Senior Scientist	
K Shankaranarayanan	Senior Scientist	
Smt P Nalayani	Senior Scientist	
<b>SOIL SCIENCE</b>		
<b>Nagpur</b>		
Jagvir Singh	Principal Scientist	
<b>Coimbatore</b>		
K K Bandyopadhyay	Senior Scientist	
Smt., TP Swarnam (Trd. to CARI- 23.9.09)	Scientist (SS)	
<b>AGRICULTURAL ENGINEERING</b>		
G Majumdar	Scientist (SG)	
<b>PLANT PATHOLOGY</b>		
<b>Nagpur</b>		
P M Mukewar (Retd. 30.06.09)	Principal Scientist	
M K Meshram	Principal Scientist	
R C Ukey	Principal Scientist	
AK Mukherjee (Joined on 20.7.09)	Senior Scientist	
SJ Gawande (Trd. to NRCOG 31.12.09)	Scientist (SS)	
<b>Coimbatore</b>		
M Gunasekharan V Jayakumar (Trd. to SSI - 03.06.09)	Senior Scientist	
<b>Sirsa</b>		
Dilip Monga		Head of Station
<b>ENTOMOLOGY</b>		
<b>Nagpur</b>		
K R Kranthi (Director w.e.f. 15.2.10)		HOD (Crop Pro!.)
Smt., S Kranthi		Principal Scientist
Smt., S Vennila (Trd. to NCIPM - 7.5.09)		Senior Scientist
K Rameash (Joined 23.7.09, Trd. NBPGR-RS on 29.12.09)		Scientist (SS)
VS Nagrare		Scientist (SS)
Chinna Babu Naik V (Joined 15.3.10)		Scientist
<b>Coimbatore</b>		
T Surulivelu		Principal Scientist
K Natarajan		Principal Scientist
Smt., B Dhara Jothi		Senior Scientist
Smt M Amutha		Scientist
<b>Sirsa</b>		
Rishi Kumar		Senior Scientist
<b>NEMATODOLOGY</b>		
<b>Nagpur</b>		
Smt., Nandini Narkhedkar		Principal Scientist
<b>Coimbatore</b>		
Smt., J Gulsar Banu		Senior Scientist
<b>PLANT PHYSIOLOGY</b>		
<b>Nagpur</b>		
A H Prakash (joined on 01.02.2010)		Principal Scientist
<b>Coimbatore</b>		
AH Prakash (up to 31.01.2010)		Senior Scientist
S E SA Khader		Principal Scientist
<b>BIOCHEMISTRY (PS)</b>		
<b>Nagpur</b>		
AS Dongre		Principal Scientist
Smt., M. Chakrabarty		Scientist (SG)
<b>BIOTECHNOLOGY</b>		
<b>Nagpur</b>		
P K Chakrabarty (HOD w.e.f. 21.8.09)		HOD, Crop Improvement Senior Scientist
G Balasubramani		Senior Scientist
Smt., J Amudha		Senior Scientist
Smt S. Choudhary (Trd. to NRCSS- 29.01.10)		Scientist
KP Raghavendra (Joined on 19.6.09)		Scientist
<b>MICROBIOLOGY (PS)</b>		
<b>Nagpur</b>		
K Velmourougane		Scientist
<b>AGRICULTURE EXTENSION</b>		
<b>Nagpur</b>		
S M Wasnik		Principal Scientist
<b>Coimbatore</b>		
Usha Rani		Scientist (SS)
<b>AGRICULTURAL ECONOMICS</b>		
<b>Nagpur</b>		
P R Deoghare (Retd. on 31.3.10)		Principal Scientist
AR Reddy		Senior Scientist
<b>Coimbatore</b>		
Smt., Isabella Agarwal		Senior Scientist
<b>COMPUTER APPLICATION</b>		
<b>Coimbatore</b>		
M Sabesh		Scientist (SS)
<b>KVK</b>		
<b>Nagpur</b>		
S N Rokade		Principal Scientist
MS Murthy		Administrative Officer
Devesh Nigam (Relieved on 31.3.2010)		FACO

## 11.9. OTHER INFORMATION

### Foreign delegations Visit to CICR

#### Nagpur

##### Uganda delegation

A high level delegation from Uganda led by Hon'ble Hope Ruhindi Mwesigys, Minister of Agriculture, Animal Industry & Fisheries along with Chairman and Members of Parliament and delegates of Cotton Development Organization visited CICR, Nagpur on Dec.21, 2009. The delegation visited important laboratories and fields at CICR, Nagpur. The delegation also interacted with scientists of CICR at an interactive meeting where views and information regarding cotton production in the two countries were exchanged.

##### Mozambique delegation

A delegation led by Cossa IRC, Head of Department, Mozambique Institute for Cotton and Dr. Albertino Jeronimo, Inspector General, Ministry of Agriculture, Mozambique visited CICR, Nagpur on 12-13 November 2009. The delegation visited important laboratories and fields. The delegation also made a visit to the IRM villages of Wardha and Yavatmal district and interacted with Shri Atul Sharma, District IRM coordinator and farmers regarding implementation of the IRM programme on large scale and farmers' perception regarding IRM.



#### Sirsa

##### Zambian delegation

A Zambian delegation headed by Dr. Stephen Wambula Muliokela, Executive Director, Golden Valley Agricultural Trust (GART), Zambia visited CICR Regional Station, Sirsa on Oct.7, 2009. The delegation comprised of Mr. Namukototo Mukutu, Chairman, Board of Trustees, GART, Mr Barry Coxe Member, Board of Trustees, Mr Douglass Moono, Head Research & Development and Prof. G. S. Pandey, Dairy Development, GART. The delegation had a discussion with the scientists of this station on cotton cultivation and package of practices being followed in North Zone. Dr.D. Monga, Head, made presentation on cotton scenario in India and the delegation showed interest on Bt cotton cultivation and biosafety measures followed in India as Zambia is facing the difficulty in export of lint to European countries. The delegation also visited the Sharada Cotton

Ginning factory and showed keen interest on seed cotton ginning, pressing of bales and oil extraction unit., Dr. H. D. Yadav, Director Extension from CCS HAU, Hisar and Dr. B.S. Sheokand, Senior coordinator, KVK, Sirsa also accompanied the delegation and took part in deliberation along with Scientists of CICR Regional Station, Sirsa.

#### Library

##### Additions

In the period from 2009-10, the Library purchased 173 new books and subscribed to 20 foreign journals and 27 Indian journals. In the said period the Library also purchased 71 Hindi books.

##### Documentation Services Library Networking

- As regards the CD-ROM Workstation, the current version of CROP SCIENCE DATABASE CD was purchased and uploaded in the IAN Server and thereby AGRIS, AGRICOLA, BIOTECHNOLOGY ABSTRACTS, CABABSTRACTS AND CROP CD are visible and accessible in the Institute Network. These CDs range from the period 1970-2010.
- Library has developed computerized bibliographic database on Cotton to provide comprehensive and updated information on cotton. About 3732 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 AICCP Centers in India. In the reported period, four issues of COTTON RESEARCH ABSTRACTS (V23, (No. 1-4), January December 2009) 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.



## Progressive Use of Hindi

### Nagpur

#### OUIC Meeting & Quarterly Report

- Official Language Implementation Committee (OLIC) of CICR working under the chairmanship of the Director, CICR met regularly. Proceedings of the meeting were sent to the Council.
- Quarterly progress reports regarding the use of Official Language in Hindi in the institute were sent to the Council regularly.

#### Hindi Day

- CICR celebrated Hindi day as Hindi Chetna Fortnight during 14-29 Sept., 2009 at the institute's headquarter Nagpur. Various programmes and competitions like, hand writing, dictation, words meaning, sandhi-vichched, slogan, idioms, memory, noting & drafting, letter-writing, question-answer, maximum official work in Hindi, maximum published technical & popular articles in agriculture, etc. were organized during this fortnight. The winners were awarded prizes during the prize distribution function held on 29<sup>th</sup> Sept., 2009. Ex-Director of CICR, Dr. M.S. Kairon as Chief Guest and Acting Director CICR Dr. K.R. Kranthi addressed at this occasion.
- Hindi Week was celebrated at institute's regional stations Coimbatore and Sirsa and wherein various programmes and competitions were organized this week and the winners were awarded.
- At Nagpur Dr. S.N. Rokade (Sr. Scientist) awarded 1<sup>st</sup> prize, Dr. U.v., Galkate (S.M.S. of KVK) 2<sup>nd</sup> prize and Dr. M.V. Venugopalan (Principal Scientist) 3<sup>rd</sup> prize for publishing maximum technical articles in agriculture in Hindi.
- For doing maximum official work in Hindi during the year Shri. Ashok Belsare awarded 1<sup>st</sup> prize, Shri. Prakash Mishra 2<sup>nd</sup> prize and Shri. Ramchandra Varchhaye 3<sup>rd</sup> prize.
- Two extension folders Bt cotton variety BN Bt and Bt hybrid NHH-44 Bt were prepared in Hindi.

### Coimbatore

- The Official Language Implementation is being effectively carried out at CICR, Regional Station, Coimbatore. In this Institute, Hindi Workshops are regularly organized as per the Official Language Policies to promote the Hindi usage in official activities for the staff members. The Hindi

Teaching Scheme, Coimbatore, Ministry of Home Affairs, Government of India had organized the Prabodh and Praveen classes for Scientists and Staff members to



acquire Hindi Training. A one day Hindi seminar was organized by Sugar Cane Breeding Institute on 30.7.2009 on "Climate Change". A paper was presented by Project Coordinator and Head on Climate Change in this seminar.

- In the month of September 2009, Hindi day was organized at CICR, Coimbatore. Various Competitions were held for scientists and staff towards Hindi Day celebrations and prizes were distributed on Hindi Day. The Town Official Language Implementation Committee had organized a one day Hindi Singing competitions in view of Hindi Day celebrations. Various staff members from Central Government Offices participated in these competitions and won prizes.
- The Town Official Language Implementation Committee has awarded third prize to CICR, Coimbatore in Hindi Implementation for the year 2008-09. The project Coordinator & Head received the award in the half yearly Meet of Town Official Language Implementation Committee in December 2009. The Official Language Implementation Committee Meeting is being regularly organized at CICR, Coimbatore to discuss various issues on Development and Implementation of Official Language as per the Official Language Policy. The Hindi Cell and the Official Language Implementation Committee of this Institute are working towards achieving the progressive use of Hindi at the Institute.



## 11.10: WEATHER

### Nagpur

Month	Temperature (OC)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
June, 2009	40.7	27.1	53	33	281	15
July, 2009	30.2	24.4	87	72	324	18
August, 2009	31.8	24.9	86	65	228	11
September, 2009	34.2	24.4	85	57	67	4
October, 2009	33.3	20.6	77	40	40	4
November, 2009	29.2	16.6	83	62	27	4
December, 2009	29.3	14.4	80	41	7	1
January, 2010	28.9	11.3	70	28	0	0
February, 2010	33.7	16.8	61	22	0	0
<b>Total</b>					<b>974</b>	<b>57</b>

### Coimbatore

Month	Temperature (OC)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy days (>2.5 mm)
	Max.	Min.	Max.	Min.		
April, 2009	35.6	24.0	83.3	39.2	0	0
May, 2009	34.8	23.8	86.6	46.8	114.6	6
June, 2009	32.1	23.7	79.6	50.7	11.2	1
July, 2009	29.7	22.9	81.9	61.3	87.2	10
August, 2009	31.6	22.9	86.2	54.3	38.8	3
September, 2009	31.5	23.0	88.2	59.1	108.6	7
October, 2009	31.6	21.8	86.7	49.2	115.8	5
November, 2009	29.2	22.3	93.3	65.5	250.6	11
December, 2009	29.0	21.3	88.4	57.4	2.8	0
January, 2010	30.5	20.2	87.6	45.1	0	0
February, 2010	32.9	20.5	85.2	36.0	0	0
March, 2010	35.6	22.2	79.6	25.5	0	0
<b>Total</b>					<b>729.6</b>	<b>43</b>

### Sirsa

Month	Temperature (OC)		Relative Humidity (%)		Rainfall (mm)	Rainy Days
	Max.	Min.	Max.	Min.		
April, 2009	37.1	20.3	44.6	31.6	34.4	2
May, 2009	41.2	26.2	43.5	29.5	0	-
June, 2009	42.4	27.5	42.0	33.0	12.2	2
July, 2009	37.2	28.6	70.4	50.8	1.0	1
August, 2009	36.8	28.0	75.3	54.3	15.4	5
September, 2009	34.2	24.3	81.8	52.8	44.7	3
October, 2009	33.5	17.2	72.0	30.6	-	-
November, 2009	26.2	10.2	80.3	34.3	-	-
December, 2009	23.1	6.7	78.0	33.0	1.0	1
<b>Total</b>					<b>108.7</b>	<b>14</b>

### 11.11: Cotton Scenario

Cotton is one of the principal crops of India and plays a vital role in the country's economic growth by providing substantial employment and making significant contributions to export earnings. The cotton cultivation sector not only engages around 6 million farmers. In 2008, the textile sector contributed about 14% of industrial production, 4% of the GDP and provided direct employment to over 33 million people. The textile sector is the second largest provider of employment after agriculture.

According to USDA, the global cotton output in 2009-10 is expected to be lower at 22.69 million tonnes due to lower acreage in major producing countries. There was a 4.4% decrease in production relative to 2008-09. China is the largest producer of cotton in the world and contributing to one-third of the total global output. India and USA are other major producers and together contribute to 37% of the total global production. The other major cotton producing countries are Pakistan (7%), Brazil (6%), Uzbekistan (4%), and Turkey (3%). India's contribution in export of cotton was 80 lakh bales during 2009-10.

Due to the reduction in cotton production in the world and increase in world cotton consumption have resulted in expectations of an 11.8 million bale production/consumption gap in 2009/10 which represents 11.5% of production, 10.3% of consumption, and 22.7% of ending stocks. The production/consumption gap may impact on prices at the country level this may impact on trade patterns. China's production in 2009-10 was 14.2% lower than in 2008-09 whereas the Chinese consumption is anticipated to increase

3.9%. Hence it is expected that China will import almost 2 million more bales in 2009-10 (9.0 million) than in 2008-09.

Cultivated Bt cotton in 8.381 million hectares in 2009 which is equivalent to 83% of 10.152 million hectares under cotton. In 2009, for the first time, multiple gene Bt cotton occupied more areas (57%) than single gene Bt cotton (43%). Again 2009, was the first year for an indigenous public sector bred Bt cotton variety (*Bikaneri Nerma*) and a Bt hybrid (NHH 44 Bt) were commercially available.

In 2009-10, the highest cotton producing state in India is Gujarat (95 lakh bales with productivity 615 kg/ha), followed by Maharashtra (67 lakh bales with productivity 325 kg/ha). About 70% of total cotton is produced in Gujarat, Maharashtra and Andhra Pradesh from the area of 73%. Area in North zone, Central zone and South zone are 15.00, 67.73 and 18.01 lakh ha, respectively and contributions in production are 13%, 61% and 21% respectively during 2009-10. At a national level, the cotton yields in India have declined to 488 kg/ha during 2009-10 from 524 kg/ha in 2008-09.

India is the only country to grow all four species of cultivated cotton besides different combinations of hybrid. The majority of the cotton in India is grown in nine states which are grouped into three different zones namely, Northern zone (Punjab, Haryana and Rajasthan), Central zone (Maharashtra, Madhya Pradesh and Gujarat) and Southern zone (Andhra Pradesh, Karnataka and Tamil Nadu). Approximately 65% of India's cotton is produced under rainfed condition and 35% on irrigated conditions. Details of cotton scenario (2009-10) are given in Table 1 and 2.

**Table 1: Cotton Growing Zones in India**

Zones	North Zone	Central Zone	South Zone
States	Punjab, Harayana, Rajasthan	Maharashtra, Madhya Pradesh, Gujarat	Andhra Pradesh, Karnataka, Tamil Nadu
Area (million ha )	1.447	6.773	1.850
Production (million bales)	4.00	17.35	6.45
Productivity (kg/ha )	470	435	593
Conditions	100% irrigated	Irrigated and rainfed	Irrigated and rainfed
Soil Type	Alluvial soils	Black cotton soils	Black soils and Red soils
Nature of Genotype	Hybrids and varieties	Hybrids and varieties	Hybrids and varieties
Species Hybrids	<i>G. hirsutum</i> , <i>G. arboreum</i> intra <i>hirsutum</i>	<i>G. hirsutum</i> , <i>G. arboreum</i> , <i>G. herbaceum</i> <i>G. barbadence</i> , Intra <i>hirsutum</i> ,	<i>G. hirsutum</i> , <i>G. arboreum</i> , <i>G. herbaceum</i> , Interspecific tetraploids(HB)
Insect/ Pest	Heliothis, Whitefly, Jassids, Pink bollworm, Mealy bug	Heliothis, Whitefly, Jassids, Aphids, Pink bollworm Mealy bug	Heliothis, Whitefly, Jassids, Aphids, Pink bollworm
Diseases/physiological disorder	Leaf curl virus, Wilt	Wilt, leaf reddening	Wilt, Foliar disease
Sowing Method	Drill Sown	Hand dibbling	Hand dibbling
Time of Sowing	April-June	June-July	July-Sept



**Table 2: State-Wise Cotton Area, Production and Productivity**

Zone/State	2008-2009			2009-2010		
	Area (Lakh ha)	Prod. (Lakh bales)	P (kg/ha)	Area (Lakh ha)	Prod. (Lakh bales)	P (kg/ha)
Punjab	5.27	17.50	565	04.96	14.25	488
Haryana	4.56	14.00	522	05.07	14.75	495
Rajasthan	3.02	7.50	422	04.44	11.00	421
<b>North Zone</b>	<b>12.85</b>	<b>39.00</b>	<b>516</b>	<b>14.47</b>	<b>40.00</b>	<b>470</b>
Gujarat	23.54	90.00	650	26.24	98.00	635
Maharashtra	31.42	62.00	335	35.03	61.00	296
Madhya Pradesh	6.25	18.00	490	06.46	14.50	382
<b>Central Zone</b>	<b>61.21</b>	<b>170.00</b>	<b>472</b>	<b>67.73</b>	<b>173.50</b>	<b>435</b>
Andhra Pradesh	13.99	53.00	644	13.19	50.00	644
Karnataka	04.08	9.00	375	04.27	09.50	378
Tamil Nadu	01.09	5.00	780	01.04	05.00	817
<b>South Zone</b>	<b>19.66</b>	<b>67.00</b>	<b>594</b>	<b>18.50</b>	<b>64.50</b>	<b>593</b>
Others	0.84	2.00	405	1.01	2.00	337
<b>Total</b>	<b>94.06</b>	<b>278.00</b>	<b>502</b>	<b>101.71</b>		
Loose cotton consumed but not counted for in State-wise prod.		12.00			12.00	
<b>Grand Total</b>	<b>94.06</b>	<b>290.00</b>	<b>524</b>	<b>101.71</b>	<b>292.00</b>	<b>488</b>

Prod. = Production

P = Productivity

1 bale= 170 kg.

Source: Office of the Textile Commissioner, Mumbai.





C O T T O N      A      V I S I T      M      M      O      S      U      N      I      V      E      R      S      I      T      Y      O      F      C      O      T      T      O      N      R      E      S      E      A      R      C      H      I      N      S      I      D      I      A      N      A      G      P      U      R  
 M      A      Y      2      0      1      9      W      O      R      K      S      C      O      L      L      E      G      E      O      F      A      G      R      I      C      U      L      T      U      R      E      A      N      D      F      I      S      H      E      R      Y      I      N      S      I      D      I      A      N      A      G      P      U      R  
 C      O      L      L      E      G      E      O      F      A      G      R      I      C      U      L      T      U      R      E      A      N      D      F      I      S      H      E      R      Y      I      N      S      I      D      I      A      N      A      G      P      U      R



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