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

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CICR ANNUAL REPORT 2008-09

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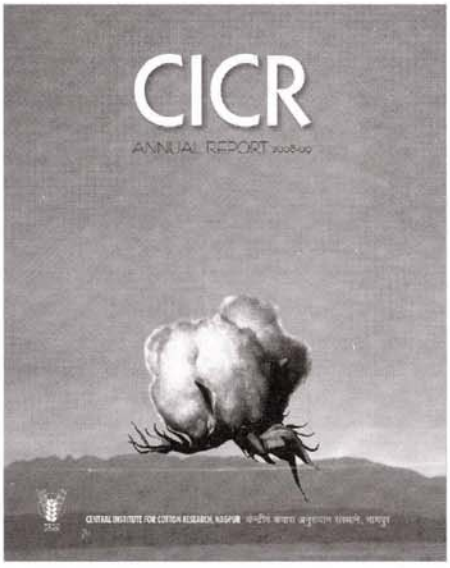


PREFACE

The cropping season 2008-09, with its unpredictable weather patterns all through, was challenging for all crops in the country. But, despite the vagaries, the cotton farmer still managed to produce a good harvest of 290 lakh bales. Amongst several useful technologies that have been playing an important role in enabling farmers to enhance production; 'Bt cotton' clearly appears to have been playing a key role. The area under Bt cotton reached 76 lakh hectares, thus accounting for nearly 80% of the area under cotton in India. Other crop production constraints such as mealybugs, mirid bugs, leaf retldening, wilt, leaf curl virus etc., were effectively dealt, through technologies developed under the leadership of CICR.. With constant support of the technologies developed under the leadership of the CICR, cotton production in India has progressed immensely in the recent 4-5 years. Apart from emerging as a major producer of organic cotton over the past 5 years, India has also emerged as a major cotton exporter with 85 lakh bales export in 2008 and 35 lakh bales in 2009. Nearly half of the global organic cotton is now produced by India. With the current production at 290 lakh bales in 2009, India ranks second in the world in cotton production after China, but, even its best productivity of 560 kg/ha, it ranks 24th rank in the list of 80 cotton producing countries. It is therefore important to address issues related to productivity, especially in the rainfed regions of the country. The Central Institute for Cotton Research has been actively contributing through the technologies developed at the institute for the sustainable progress of cotton production and productivity in the country. The institute continues to provide leadership in nurturing the cotton revolution by providing the much needed technological back up.

This report contains a glimpse of the research and developmental activities undertaken under various programmes during 2008-09. Out of the various research activities carried out during the year, the following achievements have immense potential to contribute towards enhancing cotton production and productivity. The first public sector Bt transgenic cotton variety BN-Bt was developed indigenously and approved for commercial cultivation in the North, Central and South zones on 2nd May 2008 after stringent biosafety studies by RCGM and GEAC, New Delhi.. The 'BN Bt' variety was developed through a collaborative effort. The *Cry1Ac* gene construct was made available by NRCPB, New Delhi to UAS, Dharwad, where the transformation and regeneration was carried out in 'BN', which was developed through pedigree breeding as a reselection from the parent variety 'Bikaneri Narma. The plants were tested and confirmed for the event by NRCPB and biosafety tests were facilitated by the CICR to ensure timely approval by the GEAC. New transgenic events were established with sense and antisense gene constructs in G. *hirsutum* cultivars H 777, F 846 and HS 6 forCICuV resistance. Two bollworm tolerant genotypes 'CINHTi 3' and 'CINHTi 4' were developed by transferring a *trypsin* inhibitor gene (Ti) into two elite genotypes BN and G Cot 10. Immuno-chromatic 'dip stick' kits were developed for Cry1 F and NPT II. The cotton gene bank of the institute was enriched with 732 exotic accessions and 67 national entries. Culture CCH 5-10-4 was released and notified for commercial cultivation in the south zone under the name 'Suraj'. Six unique germ plasm lines possessing novel traits were registered. Technology for Bt cotton + maize intercropping an shallow black soils and Bt

cotton + marigold intercropping and medium black soils were standardized. An eco-friendly solar operated knap sack sprayer with a field capacity of 4 hrs/ha was developed (patent pending) and tested. Nutrient management package to reduce premature resources in Bt cotton in south India was developed. Two new lectin genes were identified as potential sources for use in the development of 'sucking pest resistant' GM cotton. The papaya mealy bug, *Para coccus marginatus* Williams and Granara de Willink, was recorded in a severe form for the first time on cotton and also a Lycanid butterfly *Spalgis epius* (West wood) (Lepidoptera: Lycaenidae) was found to feed on the mealybug P *marginatus* on cotton. A novel technique for rearing mealy bugs on sprouted potatoes was also standardized. IRM (Insecticide Resistance Management strategies were developed and implemented on 79,626 ha area of 44,165 farmers from 827 villages from 10 different states. Yields increased by 12-28% and insecticide use reduced by 22-68% in the participating villages due to the technology.

The research achievements were a reflection of the untiring efforts by the entire staff of the institute. The technical and financial assistance from the Indian Council of Agricultural Research and other funding agencies-DBT, DST etc., provided the necessary momentum to accelerate the R&D output.. I am highly grateful to Dr. Mangala Rai, Secretary, DARE and Director General, Dr. P L Gautam, 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 (2008-09) is being presented herewith a sense of satisfaction and pride.

(K. R. Kranthi)
Acting Director

CONTENTS

2. EXECUTIVE SUMMARY

2.1 Crop Improvement

Nagpur

- Sixty seven new germplasm lines of Asiatic cotton were collected from South India and added to germplasm repository ofCICR. .
- Gene Bank is enriched with 732 exotic cotton acceSSIOns.
- Six unique germplasm lines possessing novel traits were registered with NBPGR while 3 new germplasm with unique characters were identified.
- DNA fingerprinting of 100 germplasm of cotton was done.
- Three hundred forty one G. *hirsutum* germplasm including exotic accessions, 40 G. *barbadense,* 103 G. *arboreum* and 6 introgressed derivatives were distributed to breeders for cotton improvement. .
- GMS based hybrids NGMSH 5-09 and NGMSH 31-09 proved highly promising with superior yield and fibre quality characteristics.
- NHH 44 Bt was submitted for approval for commercial cultivation.
- New Bt hybrid CNH 415 was found highly promising in field trails.
- G. *arboreum* cultures CINA 369 proved highly promising in Nagpur while culture CAN103 excelled in South Zone.
- TGMS trait was found to be monogenic and recessive in nature.
- Culture CNHO 12 identified for high oil content was submitted for release under AICCIP..
- Three new inter-specific F, hybrids developed employing wild species were added to existing collection of hybrids. Besides 26 wild species, 13 races and 32 synthetic polyploid were maintained in the species garden.
- First public sector BN-Bt *G.hirsutum* variety released for commercial cultivation.
- Large number of transgenic events with *cry1Ac, cry1Aa3, cry1F* and *cryIIa5,* Chitinase genes were established in tetraploid and diploid cotton for bollworm tolerance and fungal resistance.
- Fifty two elite cultivars were under Bt-conversion at various stages of back crossing.
- Transgenic events were established with sense and anti-sense gene constructs in G. *hirsutum* cultivars H 777, F 846 and HS 6 for CLCu V resistance.
- For RN Ai mediated resistance against CLCu V were inverted repeat constructs pkSBGus-~C4-SA were cloned in binary plasmids pB inAR and pGreen developed for transformation of cotton.
- Ten new sense and anti-sense strands of CP, MP, AC2, ~C1, ~V4 sequences of CLCuV were created and cloned for generation of 5 inverted repeat constructs for transformation of cotton.
- Genes *AthA* and *RSW* associated with fiber development were cloned from *Arabidopsis* for cotton improvement. .
- 14 out of 40 RAPD and 30 SSR primers used for screening polymorphism among bacterial blight resistance and susceptible lines showed polymorphism among the contrasting parents.
- Out of 330 SSR and 60 RAPD markers screened for analysis polymorphism among diploid and tetraploid parental genotypes with contrasting fiber quality traits 12.72-33.3% showed polymorphism.

Coimbatore

- Culture CCH 510-4 was released and notified for commercial cultivation in South Zone comprising of the states of Tamil Nadu, Kamataka and Andhra Pradesh under the name Suraj. This variety was found tolerant to jassids under both South and Central Zone conditions.
- Culture CCH 801 recorded the highest yield of 2840 kg/ha with high ginning outturn of38 per cent, while CCH 812 recorded the highest

fibre strength of25.6 g/tex.

- In the National Trial under irrigated conditions, Culture CCH 2623 recorded the highest yield of 1995 kg/ha in the Central Zone and the second highest yield of 1911 kg/ha in the South Zone. CCH 4474 was found to possess a higher fibre length and strength.
- Fibre quality evaluation of lint samples of germplasm lines indicated wide variability with 2.5 % span length ranging from 26.4-37.9 mm, micronaire from 3.7-5.7 and bundle strength from 22.7 - 30.2 g/tex.
- The tetraploid interspecific hybrids CCHB-5339 (2662 kg/ha) and CCHB-51074 (2367 kg/ha) were found significantly superior in their yield performance than the best check hybridDCH 32 (1853 kg/ha).
- Seed viability can be retained at 76% by coating the cotton seeds with polykote @ 3ml/kg of seed diluted with 5 ml water combined with carbendazim @ 2 g /kg and imidacloprid @ 7g/kg and stored in polythene bags.

Sirsa

- 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 ofHD 123 (zonal check) and 1990 kg/ha of local checks. It had a mean ginning outturn of36.6 per cent. In lint yield, the variety has recorded an increase of 25.15% over zonal check variety HD 123. It also possessed CISA 614 recorded slightly superior fibre technology characteristics in comparison to zonal, local check varieties and qualifying varieties. This variety, CISA 614, has been identified for commercial cultivation in North Zone.
- In the AICCIP North Zone trials, GMS based hybrid CSHG 1862 in 2nd year testing, recorded a mean seed cotton yield of 3389 kg/ha (3fd rank) with 27.4 mm 2.5% span length, 4.4 micronaire and bundle strength of 22.1 g/tex compared to zonal check CSHH 198 (2806 kg/ha) and was retained in the zonal trial for final testing.
- The GMS hybrid CISAA 14 recorded seed cotton yield of 2292 kg/ha (3'd rank) with 36.5% GOT, 2.5% span length and strength of 18.3 g/tex against zonal check CICR 2 (2100 kg/ha) and was promoted to Br 25a zonal trial for further testing.
- The hybrid CSHH 1907 recorded a mean seed cotton yield of2318 kg/ha (2nd rank) with 34.9 percent ginning outturn, 27.8 mm 2.5 % span length, 4.4 micronaire and bundle strength 21.5 g/tex compared to zonal check CSHH 198 (2062 kg/ha) and was promoted to Br05a1 CHT zonal trial for further testing.
- In the AICCIP National trial, G. *hirsutum* cultures CSH 3129 recorded a mean seed cotton yield of2285 kg/ha (4th rank) with 23.6 g/tex strength, micronaire 4.2 while CSH 612 recorded 2236 kg/ha (5th rank) with 26.5 mm 2.5% span length and bundle strength 20.4 g/tex compared to zonal check RS 2013 (1648 kg/ha) and both the varieties are promoted to Br 03 zonal trial for further testing.
- Mainly fertile plants were obtained while crossing CISA 2 (GMS), DS 5 (GMS) and GAK 413A in combinations indicating that the gene for sterility is different in all the three GMS lines.
- Fifty eight single plants were selected based on yield and fibre quality traits. These single plant selections had 2.5% span length (mm) in the range 21.8-27.8, fibre strength (g/tex) in the range 19.6-21.7 and their micronaire was <5.5.

2.2 Crop Production

Nagpur

- Studies on the long term effect of fertilizers indicated that INM (60: 13:26 kg NPK ha-1 + 20 kg S + Zn4.5 kg/ha + PSB + FYM@5t/ha+ DAP 2 % foliar application) recorded significantly higher seed cotton yield (16.7 q/ha). The mean active forms of organic carbon (very labile and labile forms) in soil ranged from 47-55 % in INM and organic plots as against 42 % under recommended dose of NPK alone. Physiologically important microflora viz. Azotobacter, PSM and

Pseudomonads registered higher population in INM and organic plots.

- Imbalanced nutrition resulted in 30% reddening ofleaves in cotton resulting in yield reduction to the extent of 500 kg ha-1. Magnesium application and rain water conservation techniques considerably checked the leaf reddening on farmers field.
- Microbial population was not significantly different in soils under Bt and non Bt cotton at all stages of crop growth. However at flowering stage it recorded maximum population. The new identified solid carrier based delivery system recorded higher bio inoculants count..
- Bt cotton intercropped with the green gram *1* soybean gave significantly higher yield of cotton and cotton equivalent yields over the opening of furrows in alternate rows. Addition of micronutrients with RDF on soil test basis recorded significantly highest seed cotton yield, nutrient use efficiency and water use efficiency followed by 75 % N through inorganic + 25 % N through organic.
- Irrigation through drip applied at 0.8 ETc followed by 1.00 ETc recorded significantly higher seed cotton yield than that at 0.6 ETc. However, highest water use efficiency was recorded at 0.6 ETc and it was lowest under furrow irrigation.
- For rainfed cotton grown on Vertisols of central zone, entire recommended quantity of K may be applied as basal dose instead of split applications. For higher seed cotton yield and high N utilization efficiency (27 kg seed cotton *1* kg N uptake), N may be applied in 3 equal splits at 10,45 and 75 days after sowing in a normal rainfall year and at 10,30 and 60 days after sowing in a drought year.
- Bt cotton + maize intercropping recorded highest cotton equivalent yield on shallow soil. Bt cotton + marigold was the best combination on medium deep soil under rainfed conditions in central zone.
- A novel solar operated knapsack sprayer has been developed tested and modified which 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 20 sprays with single charge.
- Closer spacing (90 x 20 cm) had an effect on compactness of the cotton plants which is more desirable for mechanical picking. Ethrel spray @ 7000 ppm concentration recorded highest percentage of leaf shedding of 91 % at the wider spacing of 90 x 60 cm, making plants amenable for mechanical picking.
- Ethrel sprayed@ 30 ppm (5.7 m molar SDM) at square initiation stage recorded significantly highest seed cotton yield in Bt cotton hybrid NCS 145.
- Total factor productivity of cotton (1980-2004) increased @ 6.111 per cent per annum in Gujarat, 5.321 per cent per annum in Maharashtra and 5.1776 per cent per annum in Madhya Pradesh.
- The cotton based cropping system cotton + arhar recorded cotton equivalent yield ranging from 15.35 to 17.0 q/ha. However, the system recorded the highest returns of Rs. *122621* ha with B : C ratio 1.57 in medium size group.
- Studies on social dynamics of cotton production in distress areas of Wardha and Yeotmal districts of Vidarbha revealed that majority of cotton farmers had high level of alienation (71.5 %) from land. This alienation arises because of high degree of powerlessness, meaninglessness, isolation and self estrangement. .
- The assessment of cotton based intercropping indicated that common practice of cotton + pigeon-pea strip intercropping is being practiced mostly by the farmers in cotton growing region ofMaharashtra. The adoption of other intercropping systems like cotton + soybean, cotton + mung *1* mid, cotton + cowpea, is negligible.

Coimbatore

- Highest net return (Rs. *1,16,810/ha),* benefit cost ratio (3.51), per day profitability (Rs. 779/day) and relative economic efficiency (221 per cent higher than sole cotton) were calculated with multitier system of cotton intercropped with radish, beet root and coriander with the application of 100 per cent

recommended levels of fertilizer to intercrops.

- Significantly highest seed cotton yield was harvested with cotton, raised after *in situ* incorporation of ragi at 45 days after sowing along with soil application of *Trichoderma viridi.*
- Cotton-sorghum system was superior to cotton-fallow system in this agro-climatic region with respect to improvement in soil health in terms of better aggregation, carbon sequestration besides additional crop yield and income generation.
- Herbicide rotation of pendimethalin 1.0 kg, 1 HW + metalachlor 1.0 kg/ha on 30 DAS recorded lesser weed DMP of12.4 g/m^2 to 16.4 g/m^2 and the WCE was up to 94.7 % on 60 DAS.
- Balanced fertilizer application of 120 : 60 : 60 kgs NPK in either 4,6 or 8 splits with entire P and 50 kg Mg S04+ Boron (as solubor 1 kg) as basal with two foliar spraying ofDAP 1.5 % + K 0.5 % + Mg S04 0.5 % + Boron as Solubor 0.15 % during flowering to boll development stages recorded significantly higher yield and prevented premature.
- Sustainable Yield Index (SYI) calculated on the basis of mean, highest and standard error in yield was maximum and relatively stable (0.42) under Integrated Nutrient Management (NPK: 60:13:25 kg/ha + FYM @ 5 t/ha), followed by NPK + crop residue incorporation @ 2.5 t/ha and organics (FYM @ 15 t/ha) only.
- Hoagland solution of 50% strength as foliar application during water logging stress and recovery period helped the plants maintain better status of chlorophyll, nitrate reductase activity, higher number of bolls all cumulatively resulting in better yield realization.
- Comparative analysis between diversified cotton growers and non-diversified cotton growers revealed that the majority of the diversified farmers had high level of economic efficiency than the non diversified farmers. Experience in cotton farming for many years, big farm size, high annual income, high level of socio-economic status, good contact with extension agency, high level of mass media exposure, high level of risk orientation and economic motivation were the factors that influenced the cotton growers for diversified farming.
- Econometric model suggested that education, irrigation, distance to market centre, distribution of seeds and regional characteristics have significantly determined the probability and degree of adoption. Frontier production function shows that none of the farms in the sample is fully efficient and that there is substantial scope for improving the technical efficiency of cotton production in Tamil Nadu.

Sirs a

- The seedling ofBt. hybrids RCH 134 raised in small, medium and large disposable containers containing mixture of coir pit + FYM + soil (50: 35: 15). The twenty days old seedlings raised in large containers gave significantly higher plant stand (98.6 %) and yield /ha (3035 kg/ha) than normal sown crop (2510 kg/ha).
- The performance of RCH 134 with (sole cotton, paired row sole cotton, groundnut, sesamum, mungbean, moth bean and cluster bean) and without intercrop combinations were evaluated and noticed that the yield (3301 kg/ha) was significantly higher in sole cotton compared to paired row cotton (2771 kg/ha) with and without intercrops.
- Among the cropping sequences (normal sown cotton-wheat, barley and mustard; transplanted cotton-wheat, barley and mustard) evaluated, the highest net income/ha Rs 46935 and 51315 was observed in cotton followed by wheat with normal and transplanted cotton sown, respectively.

2.3 Crop Protection

Nagpur

- Insect pest infestation during the season was minimum during 2008-09. Mealybugs were found to infest several weed plants, apart from cotton. Significant positive association of jassids and thrips; whiteflies and mirids; spiders with predatory mirids was observed

during their temporal occurrence.

- Forty different isolates of *Fusarium oxysporum* were categorized on the basis of virulence, speCIes specificity, growth, pigmentation etc. SSR primers were designed and synthesized from SSR motifs of nine different loci of *Fusarium* genome.
- The presence of Tobacco Streak Virus (TSV) was confirmed on six Bt hybrids (RCH 2 Bt, Bramha Bt, Nirja Bt, Dyana Bt, Sigma Bt, Mallika Bt) and two non-Bt pre-released hybrids (Warangal **HH** 2 and Warangal **HH** 3) samples collected from Andhra Pradesh.
- Eleven species of Hemipterans were recorded in the cotton ecosystem. Three species of Hymenopteran parasitoids and five species of Coccinellid predators were recorded on mealybugs. A new parasitoid, *Aenasius* sp. (Hymenoptera: Encyrtidae) was found to parasitize 57% of mealybug *(P solenopsis)* colonies infesting cotton. A predatory beetle, *Scymnus coccivora* was found to feed on the mealybug *(P solenopsis).* The beetle has been found to occur in the natural ecosystem of cotton in many parts of Central India.
- Amongst five new lectins tested for toxicity to aphids, soybean agglutinin was found to be the most effective with mortality levels exceeding >99% by the end of the 4th day. Banana lectin caused 100% mortality after 6 days. Artocarpin and jacalin were also found to be effective.
- A new diet recipe was developed and was found to sustain aphids for more than 20-30 days without any mortality. A novel bioassay was developed to evaluate the efficacy of lectins on cotton aphids *(Aphis gossypii).*
- Primary and secondary forms of bacterial symbiont of *Heterorhabditis indica* were isolated and protein profile of two phases of the bacterium was resolved on SDS PAGE. Protein fractions were tested against 3rd instar larva of *Helicoverpa armigera* for insecticidal activity. Observations on insect mortality after 24 hrs revealed that fraction >50 KDa recorded more than 98% mortality after 24 h while 10K fraction recorded 60% mortality.
- Low cost insect cages were designed and constructed with PVC pipe and muslin cloth. The cages can be used to conduct laboratory bioassay on insects, especially sucking pests on cotton plants.
- Mealybug reanng was standardized on sprouted potatoes. An initial inoculum of 5-10 gravid mealybug females was adequate. A temperature range of 20 _35^0 C was the most suitable for rapid proliferation.
- PCR amplified fragments of 28s rDNA and 18s rDNA from *Phenacoccus solenopsis* were sequenced and compared with the sequences of *Phenacoccus solani.* At least three unique restriction sites were identified for the two speCIes and used to develop molecular diagnostic tools to distinguish the two species.
- Locus specific tests have been designed for all the approved transgenic events of cotton based on sequences flanking trans gene inserts. The tests are being used under the Event Based Approval Mechanism through a Standing Committee of the GEAC.
- ELISA has been developed for NPT-**II,** VID-A, and *cry1F.* Antiserum has been raised against *cry1C, cry2Ab* and VIP-3A. Immunochromatographic 'dipstick' kits have been developed for crylF and NPT-II. Reaf-Time PCR was standardized for MoN-531 andMoN-15985.
- Thirty five Bt-cotton hybrids from four Bt events of Mon 531 *(cry1Ac),* Event 1 *(cry1Ac),* GFM *(cry1Ac+cry* lAb) and Mon *15985 (cry1Ac+cry* 2Ab) were evaluated in a replicated trial along with five non Bt cultivars to study the association of emerging and key sucking pests under completely unprotected conditions.
- 574 germplasm lines were evaluated for their reaction to sucking pests, effect on natural enemies and response to bollworm damage. Cultures CPT 1068 (B), CPT 1080, CPT 423 (A) and CPT 1094 had higher yield levels in addition to better quality parameters (> 25 mm staple length and >23 g/tex bundle strength) with tolerance to jassids and bollworms.
- Two bollworm tolerant genotypes 'CINHTi 3' and 'CINHTi 4' were developed by transferring a *trypsin inhibitor (Ii)* gene into

two elite genotypes BN and GCot 10, through back-cross breeding. These genotypes can also be used as donor parents for trypsin inhibitors to develop bollworm resistant cultivars.

- A synthetic analogue of jasmonic acid (Jasmine perfume) when sprayed on cotton crop, reduced jassid incidence, significantly increased the incidence of *Chrysopa* eggs while reducing the oviposition by *H. armigera*. Laboratory studies indicated that jasmine perfume has negligible insecticidal activity when applied topically. Spraying jasmine perfume enhanced the levels of LOX 1 (lipoxygenase 1) and LOX 2 (lipoxygenase 2).
- The germplasm line 116 TLYC Macha was found to be resistant to root-knot and reniform nematode. Bikaneri nerma, Sharda and Paymaster were found to be resistant to root knot nematode. Application of ascorbic acid at 0.1 % was found to induce resistance to root-knot nematode in susceptible host by reducing nematode penetration by as much as 48%. This correlates with the role of ascorbate oxidase and ascorbic acid imparting resistance to root-knot nematodes.
- Amongst the 32 genotypes evaluated for resistance to root rot, Bikaneri Nerma, NISC 19, Saubhagya, Abhadita and NISC 24 were found to be moderately resistant..
- From the population of various generations involving resistant lines as donor parents, 158 lines with bacterial blight resistance/grey mildew resistance and plant quality parameters were advanced for next generation. Six lines were identified as resistant to bacterial blight as well as grey mildew diseases. Eleven bacterial blight resistant selections were identified for better fibre quality parameters.
- Incidence of Alternaria leaf spot, Myrothecium leaf spot, bacterial blight and grey mildew was recorded on 43 Bt hybrid entries in three different trials along with NHH 44 as local check.. The incidence of Alternaria leaf spot varied from 8.02-29.4%, while incidence of Myrothecium leafspot was 8.30 29.91 %. The incidence of bacterial blight and grey mildew varied from 9.19-37.31% and 12.42-31.87%, respectively.
- The avoidable quantitative yield losses due to grey mildew disease were higher in susceptible Bt-hybrids as compared to non-Bt hybrid H 10. Early senescence and exposure to favourable weather during that particular stage could be one of the reasons for higher incidence of grey mildew on Bt-hybrids.
- *Bacillus thuringiensis* strains were isolated from soil samples collected from 57 locations of the country. One native Bt strain, from Ahmedabad produced toxin that caused high levels of larval mortality in *H. armigera* with LC_{50} of 0.077 !-lg/ml of diet against *crylAc* tolerant *H. armigera* field strain (Vadodara) and 0.004 !-lg/ml of diet against the field susceptible strain (Nagpur). The toxicity was equivalent to the standard BtK HD 1 and BTK HD73.
- Bioassays were carried out on mealybug *Phenococcus solenosis* (Tinsley) using 28 products comprising of 7 Bio-formulations. Maximum mortality was recorded in treatment Fish Oil Rosin Liquid+ Chlorpyriphos. A newly developed formulation 'Mealy-Quit' showed promising results in controlling mealybug populations and has been promoted for advanced stages oftesting.
- Two *Verticillium lecanii* isolates, VL 5, VL 7 were effective against mealy bug and prevented the development of adults in the treatments.
- Three hundred and twelve isolates of rhizobacteria were isolated from cotton rhizosphere from 47 locations and evaluated against *H. armigera* for efficacy. Out of these 67 isolates were found to have antagonistic properties against bollworm larvae. One *Bacillus cereus* isolate was found to be effective against Mealybug crawlers and can be further used for developing a formulation. A new fungal pathogen, *Fusarium sp.* was isolated from adults of Mealybugs in field epizootic incidence.
- Mortality of H. *armigera* due to *Heterorhabditis indica* was lower on larvae fed on okra as compared to chickpea, pigeon

pea and cotton. Nematode progeny production was highest from larvae fed on pigeon pea and lowest in larvae reared on cotton and weed plants.

- Crop rotation with sorghum and maIZe reduced the population of reniform nematode in cotton. Crop rotation of cotton with tomato drastically reduced root-knot nematode, *Meloidogyne incognita* population in Tomato under farmer's field condition
- Five microbial antagonists *(Streptomyces* spp., Pseudomonas, *Trichoderma* sp., *Penicillium* sp and *Aspergillus niger)* were identified against root rot causing pathogens *Rhizoctonia* and *Fusarium* sp.
- Out of the 100 isolates of rhizobacteria isolated from rhizosphere from different ecosystems, nine bacterial isolates were effective *in vitro* at 0.1 aD against juveniles of root knot and pre-adults of reniform nematodes. Two of the effective bacteria were tentatively identified as *B.subtilis.* and *Bpumilus.*
- *P solenopsis* was recorded on 91 plant species of24 families, whereas the pink mealybug *M hirsutus* was found to occur on 16 host plants spreading across 11 families. *Parthenium hysterophorus* and *Abutilon indicum* were the most common and favourable hosts.
- Foliar application of Acetamiprid, Thiomethoxam, Acephate at recommended doses and stem application ofThiomethoxam Chlorpyriphos and Imidacloprid were found effective in controlling sucking pests-aphid, jassids and thrips.
- The ETL (Economic Threshold Level) for S. *litura* was 2.0 ± 0.7 on non-Bt and 5.3 ± 0.9 larvae per plant on Bollgard-II.
- The enhanced yields from IPM with an increased returns ofRs. 1300 per hectare over RPP indicated the superiority of the symptom based insecticidal interyention in IPM and its feasibility for use in Bt cotton sucking pest management.
- Based on the specific cadherin insensitive resistance mechanism in *crylAc* resistant *Helicoverpa armigera,* primers were designed to amplify region between the exon eight and the retrotransposon in case of resistant insect and exon-eight and exon-nine of susceptible insect..
- Six *cytochrome p450* genes were tested on Real- Time PCR for their relative quantitative expression levels in pyrethroid resistant and susceptible *H armigera.* One of the genes *cyp6b* 7 was found to express selectively in higher quantities in pyrethroid resistant strains.
- Changes in the geographical variability in *H armigera* susceptibility levels to *cry* 1Ac and *cry2Ab* toxins from *Bacillus thuringiensis* were monitored. The LC_{so} values ranged from 0.040 to 3.12 g *cry* 1Ac/ml of diet across the North, Central and South India. LC_{so} values ranged from 2.46 to 34.26 flg *cry* 2Ab/ml of diet with 13.92-fold variability across the strains. The LC_{so} values for the *crylAc* of JK 'event-I', ranged from 0.192 g crylAc/ml of diet to 5.11 g *cry* 1Ac/ml of diet with 4.11- fold, 20.60-fold and 5.89 fold variability III susceptibility across the North, Central and South India.

Coimbatore

- The papaya mealy bug, *Paracoccus marginatus* Williams and Granara de Willink, was recorded in a severe form for the first time on cotton in Coimbatore. Infestation of *Pmarginatus* was observed on G. *arboreum* and G. *hirsutum* species and Bt cotton hybrids under field conditions.
- Hairy varieties were found to be highly susceptible to mealy bug infestation.
- Infestation of mealybug was 100% III unprotected Bunny Bt as compared to 50-60 % in RCH 2 Bt and non Bt. In general the infestation of papaya mealy bug, *Paracoccus marginatus* was high in the farm as well as in farmer's field. In addition to cotton, *P marginatus* infestation was observed on *Parthenium hysterophorum, Tridax procumbens, Acalypha indica, Euphorbia geniculata* and *Crotons sparsiflorus.*
- The observation on mealy bug infestation in 50 farmers' fields of five villages indicated that the mean intensity of damage ranged from

1.0 to 1.22 grade, and the per cent infested plants ranged from 55.0 to 83%. The mean infestation of mirid bugs ranged from 68 to 97% and the population ranged 16 to 85 nymphs per 100 squares.

- Population dynamics of mealybug species *viz., Paracoccus marginatus* and *Phenacoccus solenopsis* were observed under cotton+cowpea intercropping system. During initial period (October) of cropping season, *P solenopsis* incidence was high compared to *P marginatus.* From first fortnight of November onwards, *P. marginatus* populations increased.
- Nineteen weeds were recorded as alternate hosts for cotton mealybug. Initially *Paracoccus marginatus* recorded 100% incidence on *Parthenium hysterophorus* and continued throughout the cropping season and the incidence of *P solenopsis* was found to be 100% on alternate hosts such as *P hysterophorus, A. indicum, P neruri* and *T. procumbense,* at the end of the cropping season.
- Out of 78 Bt cotton hybrids (54 with *cry* 1Ac and 24 with cryIAc+cry2Ab) evaluated for their resistance against major sucking pests, four hybrids (PCH 2270 Bt, PCH 205 Bt, PCH 923 Bt, and ACH 33-1 Bt) recorded low intensity of mealy bug damage. Two Bt hybrids, Rudra Bt and JK Iswar Bt recorded low population of mirid bug (1.38 to 1.44/5 squares) while the check entry RCH 2 Bt had 6.77 mirid bugs per 5 squares.
- A Lycanid butterfly *Spalgis epius* (West wood) (Lepidoptera: Lycaenidae) was found to feed on the mealybug *P marginatus* on cotton, papaya, silk cotton, subabul, *Ixora* sp., *Crotons* sp., *Glyricedia* sp. and *Hibiscus* sp. etc. The larvae were observed as voracious feeders on the egg masses, nymphs, and adults of mealy bugs.
- Two parasitoids, *Torymus* sp. and *Prochiloneurus aegyptiacus* (Mercet) were recorded on the mealybug *P marginatus* with maximum per cent parasitisation of 21% and 7% respectively. The parasitoid, *Aenasius* sp. was found to parasitize *P solenopsis* up to a maximum of 45%.
- Histopathological studies of reniform nematode cotton was studied by inoculating 5000 adult females of *R.reniformis* under pot culture condition. The nematodes gain entry through epidermis and penetrate intercellularly as well as intracellularly through the cortex, endodermis and pericycle and reach the phloem where they feed. A passage slightly wider than the nematode body is formed by destruction of cortical cells.
- Twelve insecticides were evaluated with three entomopathogenic fungal pathogens for compatibility tests. For *B. bassiana,* only Chlorpyriphos was found to be compatible whereas, Spinosad, Econeem, Quinalphos, Acetamprid, Endosulfan and Thiodicarb were slightly toxic.
- Pathogenicity of Bacterial symbiont of EPN *viz., Photorhabdus lumunescens* and *Xenorhabdus* sp. was studied under laboratory condi tion against *Galleria mellonella, Heficoverpa armigera* and *Spodoptera fitura.* Both bacteria were able to cause mortality of test insects at varying levels.
- Antimicrobial property of bacterial symbiont ofEPN *(P lumunescens andXenorhabdus* sp.) was evaluated against plant pathogens *Fusarium* sp. and *Alternaria* sp. and entomopathogenic *(Metarhizium anisopfiae, Beuveria bessiana* and *Verticillium lecanii). P lumunescens* was found to significantly inhibit the growth of both plant pathogenic and entomopathogenic fungi.
- 25 entomogenous fungi associated with mealy bug were screened and *Lecanicillium lecanii* was found to be highly virulent against both *Phenacoccus solenopsis* and *Para coccus marginatus* under laboratory, green house and small scale field studies.
- Among seven isolates, three isolates namely VI 5, VI 9 and V12c were effective in causing mortality of both nymphs and adults of *Paracaccus marginatus,* whereas isolates VII and VI 5 alone were highly effective against *Phenacoccus solenopsis.*
- Acephate and Chlorpyriphos were more effective against the emerging pests (mealy bug and mirid bug) and recorded significantly

higher yield (58.4 % and 51.0 %) over other treatments and control.. Thiodicarb followed by flubendiamide+thiocloprid and thiocloprid treatments were effective against mirid bug and reduced the infestation significantly over other treatments and control..

- Pheromone trap catches of *P gossypiella* recorded throughout the cropping season was correlated with the level of infestation. Infestation was found to start in November with a peak adult moth catch during the month of February also correlated with the maximum larval infestation.
- Implementation of Insecticide Resistance Management (IRM) strategies in the project villages resulted in the reduction of number of sprays by 47% and the plant protection cost from Rs. 2,147 to Rs. 1,021, besides an increase in yield by 21 % over non IRM villages.

Sirsa

- Mealybug infestation in North India was low during 2008-09 and damage to cotton crop was negligible. The mealybug was found to infest at least 47 species of host plants belonging to 24 families. The parasitoids *Aenasius bambawalei* and *Paranathrix tachikawai* were also recorded. The parasitization efficiency of *A. bambawalei* from field collected mealy bugs was 57.0 per cent whereas under laboratory condition it was 60.6 per cent (45-74%).
- Whitefly population remained below ETL throughout the season. Among natural enemies, spiders were the most abundant as compared with natural enemies like Lace wing and Lady bird beetles. Maximum population of spider was recorded in first week of September.
- Anew fungal species *Fusarium pallidoroseum* was isolated from mealy bug cadavers from cotton stalks in Haryana and Punjab. Profenofos showed maximum inhibition of *Fusarium pallidoroseum* after one week of inoculation whereas minimum inhibition was observed in Confidor, Admire and Fipronil.. Fifteen days old crawlers showed lower mortality upto a maximum of 40% in case of *F pallidoroseum.* Formulations of *Verticillium lecanii* controlled 57.8 to 66.1 per cent mealybug after two sprays at weekly interval..
- White fly infestation and cotton leaf curl virus disease incidence was quite low in Haryana, Punjab and Rajasthan.
- DNA isolation from 124 weeds collected from during AprillMay 2008 followed by their amplification using Coat Protein (CP) primer did not show presence of virus in any of the weeds tested.
- A new sampling strategy was devised for mealybug field population assessment based on source of infestation. When sampled parallel to the source, infestation level was highest in fields along with water channel (4.6 to 15.4 %) followed by fields on roadside (5.2-9.8 %) and clean fields (2.07-12.0%). When sampled perpendicular to the source, infestation levels recorded were relatively lower.
- The mealybug *Phenacoccus solenopsis* was found to have 2-4 ovisacs. There are 2 nymphal instars in males and 2 instars in 3 instars in females. Each female produces about 300-500 crawlers. The total life duration extends from 36 to 45 days on cotton. There was a positive correlation between the population increase and temperature where as the relative humidity was negatively correlated.
- Insecticide Resistance Management (IRM) strategies were disseminated in 75 villages of three Districts of Haryana-Sirsa, Hisar and Fatehabad to cover a total of 11254 hectares area with 4511 farmers. There was 24.3% reduction in sprays and 31.2% reduction in consumption of insecticides in IRM over non IRM farmers. There was 10% increase in seed cotton yields and overall net profit of IRM farmers over non-IRM was 7140 per hectare.
- Maximum jassid resurgence was reported in treatment Cypermethrin+Monocrotophos (after the 7th spray). Cypermethrin caused 35.64 % resurgence of whitefly and spinosad alone exhibited moderate resurgence of Mealybugs. Maximum reduction in parasitization by *Aenasius bombawalei* as

compared to control was caused by Monocrotophos.

- Among various insecticides, Acephate and Chlorpyriphos reduced mealybug population by >70%. Among ecofriendly biopesticides, *Metarrhizium anisopliae* was the most effective.
- In a study conducted to integrate all eco-friendly strategies and validation of IPM packages, the average yield in IPM plots obtained was 12.80 q/acre as compared to 12.24 q/acre in RPP (recommended package of practices) plots.
- Foliar application was more effective than stem application. Stem application was found effective only in the initial phase of the cropping season. The predator and parasitoid populations were significantly more in case of stem application as compared to foliar application.
- Grade Percent Disease Index (5, 10,20,40 & 60%) of cotton leaf curl virus disease in Bt cotton hybrid 6488 Bt at village Khippanwali in Ferozepur district of Punjab revealed reduction in seed cotton yield to the extent of 0.08,0.29, 14.5, 17.2 and 40.0% respectively. Similarly 23.8 to 63.1 % seed cotton yield reduction was observed in case of one to four severity grades in case of Bt cotton hybrid Sigma at Chudiwalan village in Ferozepur district of Punjab.

3: INTRODUCTION

3.1 Briefhistory

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 IAR! 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 friendly 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**

3.3 Release of First Public Sector Bt Transgenic Cotton Variety

The first public sector Bt transgenic cotton variety Bikaneri Narma Bt (BN-Bt) was developed indigenously and approved for commercial cultivation in the North, Central and South zones on 2nd 2008 after stringent bio-safety studies by RCGM and GEAC, New Delhi. The work was initiated under NATP program. The BN Bt is a ICAR event set in the varietal background and it is a landmark achievement in the biotech research of the public institute. 'BN Bt Variety' was developed by transferring *cry* 1 Ac gene from the bacterium *Bacillus thuringiensis* (Bt) into the genotype 'BN' which was developed through pedigree breeding a reselection from the parent variety 'Bikaneri Narma'. It was developed through collaborative efforts of the University of Agricultural Sciences (UAS), Dharwad, National Research Centre for Plant Biotechnology (NRCPB), New Delhi and the Central Institute for Cotton Research (CICR), Nagpur.

'BN Bt is a high yielding variety which is medium tall, tolerant to jassids and other sucking pests, tolerant to drought, possesses open plant canopy, medium sized bolls, 2-3 monopodia, fiber length

26-27 mm, superior ginning out-turn (GOT), yellow pollen colour and longer staple length fibre which distinguishes it from the parent variety 'Bikaneri Narma' and the similar variety 'F 414'. It is suitable for rain-fed farming and requires lesser input (water, fertilizer and pesticides) compared to hybrids. It is characterized with high levels (upto 5.2 ppm) of Cry protein expression, and is highly effective in protecting the crop against main target pest, the cotton bollworm, *Helicoverpa armigera*. It showed over-all yield superiority in both seed cotton and lint yield when compared with non-Bt check and local checks.

During the current season 2009, 240 quintal seed has been produced and truthfully labeled, certified seed was made available to farmers at Rs 200 per 2 kg seed bag containing 200 g pigeon-pea refugia seed, through State Seed Corporations of Maharashtra, Gujarat and Andhra Pradesh.

3.4: Staff Position

(As **on 31 March 2009)**

Name of Post	Sanctioned cadre Strength				Post Filled Up			
	NGP	CBE	Sirsa	Total	NGP	CBE	Sirsa	Total
Director (RMP)	1	-	-	1	1	-	-	1
P.c., & Head	-	1	-	1	-	1	-	1
Scientific	50	22	7	79	37	21	6	62
Technical	50	23	8	81	45	16	7	68
Administrative	33	10	6	49	27	7	5	39
Supporting	65	34	12	111	51	25	11	87
Krishi Vigyan Kendra								
Training Organiser	1	-	-	1	1	-	-	1
Technical	8	-	-	8	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 2008-09 are furnished below:

Budget Sanctioned and Expenditure (Rs. in Lakhs)

	Scheme	Sanctioned	Ex penditure
1.	Plan	400.00	400.00
2.	Non-Plan	1605.15	1596.94
PLAN SCHEME			
3.	NSP Crop	18.89	0.67
4.	AICCIP	500.00	500.00
5.	KVK Scheme	78.92	69.74
6.	TMCMMI	629,12	616.69
7.	MSP	26.70	-
APCESSFUND			
8.	Bt, Resistance	5,41	5.36
9.	ICAR Regional Committee No.VII	0,45	0.24
R DEPOSIT SCHEME			
10.	DBT Scheme (DNA)	0.68	0.68
11.	Transgenic Crops	32.78	22.80
12.	DSTQTLS	4.03	3,44
13.	DST FRCCSHP	0.85	0.85
14.	DBT Bt Cellus	4.56	4.20
15.	DBT MMFRQ	18,43	16.79
16.	DST Fast Track	9.04	8.97
17.	DBTRNAi	24.74	24.73
18.	GMO Project	10.58	10.57
20.	DDS Scheme Ngp	4.50	3.78
21.	DDS Scheme Cbe	6.83	6.58
22.	Dupont Scheme	5.02	0.65
23.	Toxicity ofBt (CRY)	0.07	0.07
24.	Indofil Scheme	0.27	0.27
25.	1, K, Toxin	19.24	9.88
26.	NMITLI	52.60	4.32
27.	DBT Marker	14.71	8.51
28.	Indo ADS DBT	16.52	0.13
29.	Genetic Eng. (AKI)	15.54	4.16
30.	Maintenance of Breeder Seed	59.99	48.99
31.	TMC Scheme MM II	233.54	221,04
32.	Bt, Resistance Monitoring (Mahyco) I	14.51	8.61
33.	Bt, Resistance Monitoring (Mahyco) II	27.60	11.25
34.	Ratan Tata SGP 445	2.62	2.62
35.	Ratan Tata SGP 452	2.10	2.10
36.	FLD Scheme	80.00	76.84
37.	TMC MM-I (DAC)	18.37	18,37
38.	Testing Fee Remittance	260.37	133,45
39.	Bt, Tech	81,45	0.62

CICR

ANNUAL REPORT 2008-09

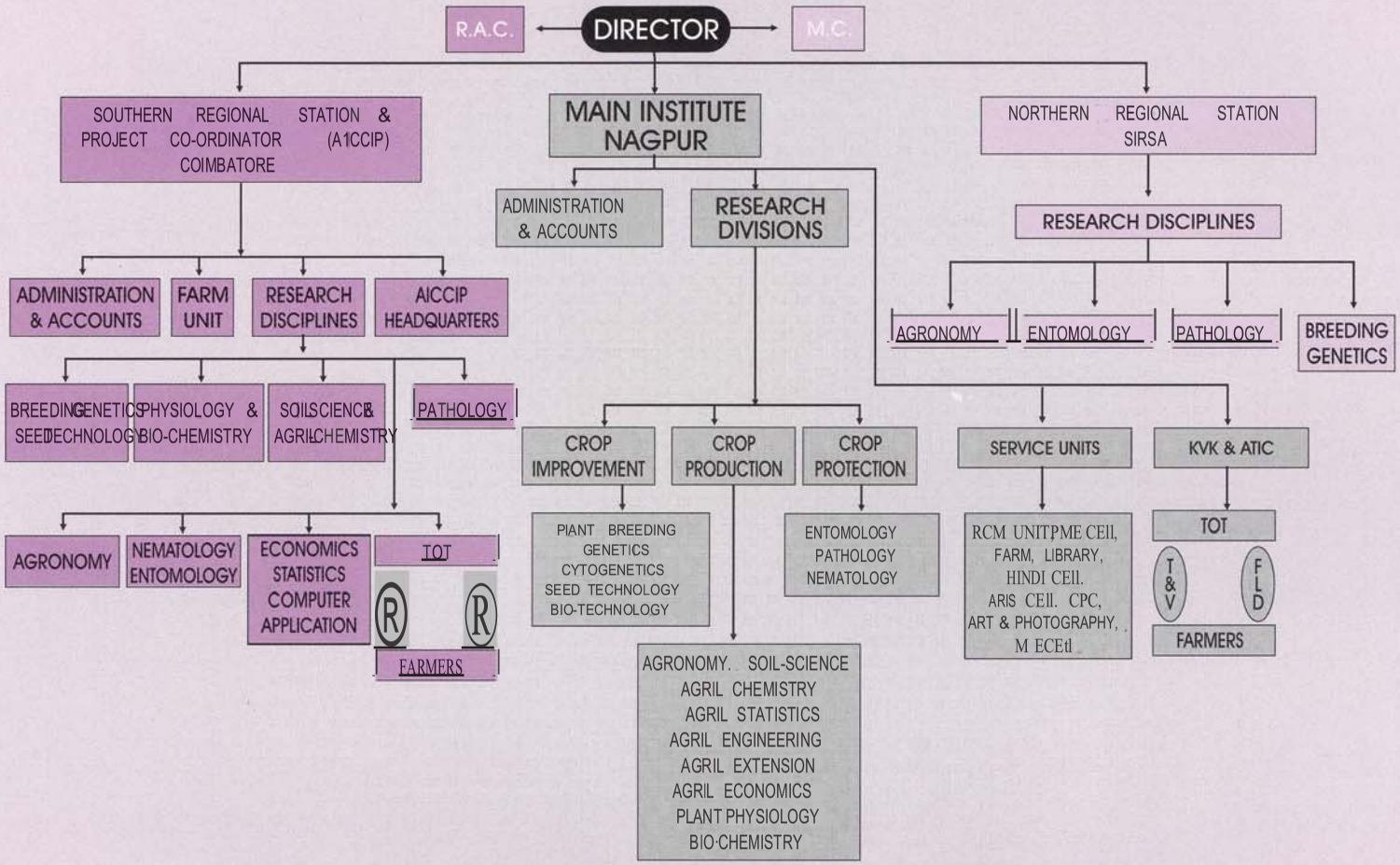
BN Bt - a *G. hirsutum* high yielding variety

Suraj a *G. hirsutum* high yielding variety identified for south zone

CINHTI 3 Trypsin inhibitor mediated *Helicoverpa armigera* tolerant line

CINHTI 4 Trypsin inhibitor mediated *Helicoverpa armigera* tolerant line

ORGANOGRAM OF CICR

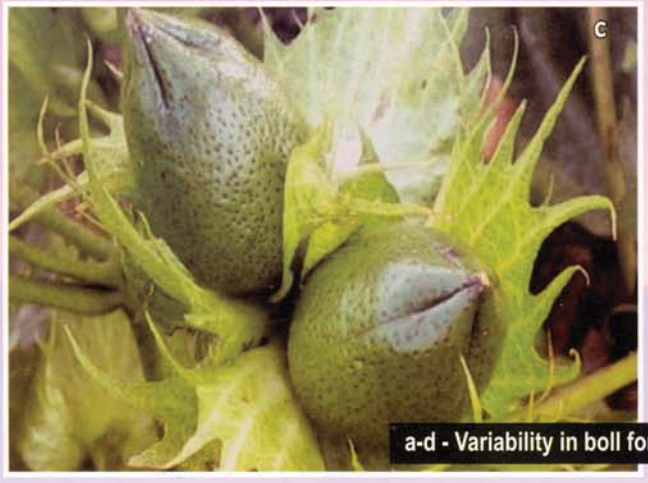


CICR

ANNUAL REPORT 2008-09

YPLL 29 (*Gossypium hirsutum)* Yellow Pigmented Leaf Lobe

SLL-33 (*Gossypium hirsutum)* Single Leaf Lobe



a-d - Variability in boll formation in *G. barbadense*

4. RESEARCH ACHIEVEMENTS

4.1: Cotton Genetic Resources

Nagpur

Exploration and collection of germ plasm

During the year, sixty-seven germplasm lines of Asiatic cotton *(G. arboreum-30,* G. *herbaceum-35* and G. *arboreum* perennials-2) were collected from Rayalseema region of Andhra Pradesh and adjoining areas.

Enrichment of Gene Bank and procurement of quality exotic germplasm

Seven hundred and thirty two accessions were received from USA, Israel and Pakistan through NBPGR, New Delhi.

Source / Country	Species	No. of Accessions	Characters
USA	G. *hirsutum*	683	Long Staple, High Boll Weight.
Israel	G. *hirsutum*	15	Long Staple and Early Maturity.
Pakistan	G. *hirsutum*	4	High GOT and Boll Weight.
USA	G. *barbadense*	30	Extra Long Staple.

Conservation of germplasm

G. hirsutum

Base Collection 1900, Working Collection 400, Core Collection 600

G. arboreum

Base Collection 700, Working Collection 139 were grown for rejuvenation and seed multiplication.

Conservation of germplasm in Long Term Storage and Medium Term Storage

Seeds of one thousand six hundred and forty three (1643) accessions of G. *hirsutum* including exotics, 25 accessions of G. *barbadense* and 700 accessions of G. *arboreum* were sent to NBPGR, New Delhi for Long Term Cold Storage. Another set of G. *hirsutum,* G. *barbadense* and G. *arboreum* germplasm was kept in Medium Term Cold Storage at CICR, Nagpur.

Additions of unique germplasm lines to the Gene Bank

Six germplasm lines with unique and novel traits were registered with NBPGR and added to the Gene Bank ofCICR, Nagpur.

Name of Genetic Stock	Species	Unique & Novel Traits
CINHTi-l (Broad Leaf Lobe)	G. *hirsutum*	Trypsin inhibitor mediated *Helicoverpa armigera* tolerance
CINHTi-2 (Okra Leaf Lobe)	*G. hirsutum*	Trypsin inhibitor mediated *Helicoverpa armigera* tolerance
MSH SP-9l	G. *hirsutum*	Zero monopodium and long pedicel
MSH SP-345	G. *hirsutum*	Cleistogamous flowers
ABC-5	G. *arboreum*	Five loculed bolls
CATS-18	G. *arboreum*	Thermosensitive Genetic Male Sterility

Evaluation and identification of germ plasm lines for unique and novel characters

Three germplasm lines of G. *hirsutum* were identified for their unique traits *viz.,* Yellow Pigmented Leaf Lobe (YPLL-29), Cup Shaped Leaf Lobe (CSLL-59) and Single Leaf Lobe (SLL-33). Unique traits of above germplasm accessions were stable over ~enerations and have been approved by the Institute Germplasm Identification Committee for registration with NBPGR, New Delhi.

One hundred and ten germplasm accessions of G. *barbadense* were evaluated for yield and fibre properties at CICR Regional Station, Coimbatore .

Range of seed cotton yield and fibre properties of *G. barbadense* germplasm lines

Seed cotton yield (gtplant)	2.5% Span length (mm)	Bundle strength (gttex)	Micronaire	Elongation (%)	Uniformity ratio (%)
29.2-135.6	25.8-36.1	21.1-30.0	3.2-5.1	4.5-7.7	43.0-47.0

Assessment of gossypol content in cotton germplasm

Fifteen G. *arboreum* germplasm lines were processed for gossypol estimation. Per cent gossypol content varied from 0.8 to 2.39 per cent.

Distribution of germplasm

Eighty two accessions of G. *hirsutum, 40* accessions ofG. *barbadense* and 58 accessions of G. *arboreum* were distributed to various Cotton Research Stations/Centres of SAUs and Government Institutions for research purpose.

Distribution ofsegregating material (F_2)

F_2 segregating material of 35 crosses of G. *hirsutum* were distributed to different Cotton Research Stations of Central and South Zones. The parents involved in the above crosses had high yielding, big boll, high GOT, high strength and early maturity types.

Germplasm Field Day and distribution of germplasm

Germplasm Field Day was organized. The selection of germplasm accessions was made by the breeders of three zones in the field itself.. The following germplasm accessions were distributed to breeders from Core Collection, Working Collections and Base Collections including exotic accessions for their breeding / crop improvement programme.

Germplasm distributed on field day

Name of Zone	*G. hirsutum*	*G. arboreum*	Introgressed Derivatives
North Zone	74	18	6
Central Zone	91	9	--
South Zone	94	18	--
Total	259	45	6

Utilization of germplasm

Twenty three accessions of G. *hirsutum,* 49 of G. *arboreum* and 8 of G. *herbaceum* were utilized in crossing programme for development of superior genotypes of G. *hirsutum* and G. *arboreum.*

Coimbatore

Field maintenance of 250 G. *hirsutum* accessions was undertaken. Thirty exotic G. *barbadense* germplasm accessions obtained from Nagpurwere sown in pot for seed multiplication. Notable germination was recorded only in 22 accessions, in

which the harvested seed cotton yield ranged from 12.4 g to 70.7 g. The fibre quality evaluation oflint samples indicated wide variability. The 2.5 % span length ranged from 26.4-37.9 mm, micronaire from 3.7-5.7 and bundle strength from 22.7-30.2 g/tex indicating good scope for including select lines in breeding programmes for improving fibre quality especially, micronaire (Table 4.1).

Table 4.1: Seed cotton yield and fibre quality of select *G. barbadense* exotic accessions

Accession No.	*Kapas* weight (g)	2.5 % Span length (mm)	Uniformity Ratio	Micronaire	Bundle strength
EC 617835	32.7	35.6	46.5	3.7	30.2
EC 617837	44.0	26.4	52.2	4.5	24.8
EC 617841	35.1	30.1	47.5	4.7	27.9
EC 617844	12.4	34.4	46.5	--	--
EC 617852	42.7	35.3	47.3	4.5	29.1
EC 617858	32.3	31.7	47.6	4.1	24.3
EC 617861	70.7	31.2	48.5	3.7	25.9
EC 617862	20.2	37.9	40.4	--	--
EC 617864	52.2	30.1	49.4	5.7	22.7
Mean	28.8	33.0	47.3	4.4	26.4
Max.	**70.7**	37.9	52.2	5.7	30.2
Min.	12.4	26.4	40.4	3.7	22.7

One hundred and eight G. *barbadense* germplasm lines were maintained during 2008-09. Seven single plant progenies selected from these germplasm showed superior yield performance. Morphological variability among the germplasm lines in branching pattern, boll formation, petal colour, petal spot, bract number and union of bracts were noticed. The accessions *viz.,* NDGB 11, NDGB 27, NDGB 69, NDGB 82, NDGB 91, NDGB 113, NDGB 142 and NDGB 164 were found to be early in flowering. Five accessions had flowers without petal spot. Short branching types of accessions bearing cluster bolls consisted of2-6 bolls per cluster.

Ninety nine G. *hirsutum* genotypes were evaluated for yield, morphological characters, agronomic characters and fibre quality characters. Seed cotton yield ranged from 30.2 to 142.0 g/plant with the mean seed cotton yield being 71.7 g/plant.. The 2.5 % span length ranged between 24.6 mm and 31.7 mm with the mean being 27.6 mm. The strength ranged from 19.0 to 25.4 g/tex with the mean being 22.3 g/tex.

Sirsa

Two hundred and ninety four lines of G. *hirsutum* and 208 lines of G. *arboreum* were evaluated for yield contributing parameters, fibre properties and morphological parameters. The range for each trait is given in Table 4.2.

Table 4.2: Range for traits in accessions of *G. hirsutum* and *G. arboreum*

Character Name	*G. hirsutum*	*G. arboreum*
Seed cotton yield/ plant (gm)	30-250	16.7-240
Boll weight (g)	2.2-3.6	1.5-2.7
Boll number	10-87	17-72
Ginning Outturn (%)	26.3-35.5	29.4-37.6

Seed Index (g)	5.5-11.1	4.4-7.8
Lint Index (g)	2.51-5.51	2.10-3.79
Number of Monopods	0-8.0	0-6.0
Number of Sympods	3-19	6-18
Plant height (cm)	51-165	80-190
2.5 % span length (mm)	18.0-31.60	15.1-28.8
Uniformity Ratio (%)	43-54	40-55
Fineness micronaire (10-6 glin)	3.3-6.4	3.4-8.1
Fibre strength (g/tex)	15-27.1	11.9-26.0
Boll damage (%)	0.0-62.4	0.0-38.2
Jassid/ leaf	0.0-1.11	0.0-1.33
Whitefly	0.0-10.5	0.0-8.33
CLCuV (%)	0.0-60.0	--

4.2: Hybrid Cotton

Nagpur

Eleven GMS, 93 CMS and 57 restorer lines were maintained through sibmating, crossing and selfing. Sufficient quantity of seeds were also produced.

Forty nine GMS hybrids were evaluated in two separate trials. The seed cotton yield in the first trial ranged from 1239 to 2353 kg/ha. Hybrid NGMSH 5-09 recorded the highest seed cotton yield with 14 and 32 per cent heterosis over the check hybrid NHH 44 and H 8, respectively. It recorded a boll weight of3.9 g, ginning percentage of 38 per cent and mean halo length of 24.1 mm. Hybrids NGMSH 23-09, NGMSH 6-09, NGMSH 8-09, NGMSH 21-09 were the other promising hybrids. In the second trial, 23 hybrids were tested and the seed cotton yield ranged from 1145 to 2246 kg/ha. Hybrid NGMSH 31-09 was the best recording 2246 kg/ha seed cotton yield with 9 and 46 per cent heterosis over NHH 44 and H8. It recorded a boll weight of 4.6 g, Ginning outtum of 38.8% and mean halo length of28.6 mm.

Two hybrids *viz.,* CINHH 128 and CINHH 129 were sponsored for testing in AICCIP trials. CINHH 128 has been promoted for further testing in Central Zone. It ranked fourth with 1759 kg/ha seed cotton yield, 619 kg/ha lint yield, 38.9 per cent GOT, 3.7 g boll weight, 28.7 mm 2.5% span length, 4.2 micronaire and 21.7 g/tex bundle strength.

Common Institute Trial of *intra-hirsutum* hybrids

The common trial was conducted at Nagpur. None of the hybrids tested were significantly superior to the check hybrid NHH 44, eventhough CHH 308 was numerically superior to it (Table 4.3).

Table 4.3 : Common Institute Trial of intra- *hirsutum* hybrids

Sl. No.	Code	Seed cotton yield (kg/ha)	Lint yield (kg/ha)	Boll wt.(g)	Boll No.
1.	CSHH-308	2141	638.13	4.8	22.0
2.	CSHC-196	1577	509.27	3.9	22.1
3.	NGMSH-13	1523	501.16	3.7	21.5
4.	NGMSH-130	1405	445.38	4.2	24.1
5.	LS-3 x LS-13	1003	324.97	3.9	-
6.	NHH 44(LHC)	1989	618.57	4.5	23.2
	CD@5%	**618**	-		
	CV%	**25**	-		

BtHybrids

A prominent hybrid NHH 44 Bt (developed by using BN Bt as female parent) has undergone the Large Scale Trial (LST) in the *Kharif* 2008 and LST reports were submitted to GEAC for the final approval for commercial release in the forth coming *Kharif* season 2009 and these would provide an alternative for the farmers interested for hybrid cultivation.

Sixteen Bt hybrids using BN Bt as male parent were evaluated alongwith two checks RCH 2 and Bunny Bt in replicated trial. Of these, five were GMS based and eleven were conventional hybrids. The hybrids recorded highly significant differences for seed cotton yield. It ranged from 1898 to 3536 kg/ha. Three hybrids were at par to the check Bunny Bt while 15 hybrids were at par to the check RCH 2. CNHH 15 was the best hybrid identified, recording 3536 kg/ha seed cotton yield. It was followed by CNHH 7 (3499 kg/ha), CNHH 18 (3370 kg/ha), CNHH 1 (3317 kg/ha) and CNHH 5 (3220 kg/ha). These hybrids recorded more than 60 per cent heterosis over the check RCH2.

Coimbatore

Evaluation of Bt cotton hybrids released for South Zone

Among the hybrids tested, four *intra-hirsutum* Bt hybrids containing crylAc gene were superior to the best check hybrid RCH 2 BG II (Table 4.4).

Table 4.4: Performance of select Bt cotton hybrids comprising *cry* lAc gene for yield and other characters

Name of the hybrids	Yield (kg/ha)	% Inc over best check	LI (g)	SI (g)	GOT (%)	2.5% SL (mm)	Mic	Bundle strength (~tex)
PRCH 103 Bt	2974	15	6.6	11.4	36.7	28.5	5.0	23.5
OLE Bt	2840	10	6.0	9.9	37.8	28.8	4.8	22.1
Tulasi 117 Bt	2630	2	6.3	12.0	34.3	32.1	4.9	21.4
Tulasi 4 Bt	2592	1	6.3	11.7	35.0	30.3	5.0	21.2
RCH 2 BGII (C)	2577	0	6.7	12.6	34.6	32.2	4.8	20.3
CD@5%	959							
CV%	22							

Among the *intra-hirsutum* Bt hybrids with *cry* 1Ac and *cry* 2Ab genes, only four were superior to the best check hybrid Malliga BG II. However, the differences were not statistically significant (Table 4.5).

Table 4.5: Performance of select Bt cotton hybrids comprising *cry* lAc and *cry* 2Ab genes for yield and other characters

Name of the hybrids	Yield (kg/ha)	% Inc over best check	LI (g)	SI (g)	GOT (%)	2.5% SL(mm)	Mic	BS (g/tex)
ACH-6 BGII	2247	10	5.4	10.6	33.8	29.3	4.7	24.5
Tulasi 9 BGII	2142	5	6.5	11.9	35.1	30.4	4.8	21.8
ABCH 1065 BGII	2051	1	5.2	9.8	34.4	29.8	4.5	24.8
RCH 533 BGII	2051	1	6.7	12.5	34.9	32.2	4.3	21.3
Malliga BGII (C)	2039	0	6.3	11.5	35.3	31.0	4.7	22.7
CD@5%	590							
CV%	21							

Among the ten inter specific *(G. hirsutum* x G. *barbadense)* Bt hybrids evaluated, the highest seed cotton yield of 1922 kg/ha was recorded in NCHB 992 with 25 % yield increase over the best check hybrid DCH 32 (1542 kg/ha).

Evaluation of NHH 44 Bt cotton hybrid in Large Scale Trial in Tamil Nadu

Five Large Scale Trials (LST) were conducted with NHH 44 Bt. Hybrid NHH 44 Bt recorded a higher mean seed cotton yield (1796 kg/ha) as compared to its non Bt version (1300 kg/ha) and RCH2Bt(1541 kg/ha)(Table4.6).

Table 4.6: Mean Performance of NHH 44 Bt in Large Scale Trials in Tamil Nadu

Name of the entry	Seed cotton yield (kg/ha)	Lint yield (kg/ha)	Ginning outturn (%)	Boll weight (g)	2.5% Span length (mm)	Mic	Bundle strength (g/tex)
NHH44 Bt	1796	635	35.4	3.6	26.5	4.5	19.1
NHH44 nonBt	1300	479	36.8	3.4	25.8	4.6	18.6
RCH 2 Bt	1541	530	34.4	4.2	30.7	4.5	21.1
DHH llNonBt	950	348	36.5	3.6	27.6	4.6	18.8

Development of extra long staple interspecific hybrids

Forty nine interspecific hybrids were evaluated with two check hybrids (DCH-32 and TCHB-213). The hybrids CCHB-II0 (2639 kg/ha), CCHB- 215 (2451 kg/ha) and CCHB-260 (2404 kg/ha) were significantly superior in yield as compared to the best check hybrid DCH -32 (2160 kg/ha).

In another trial, the interspecific hybrids *viz.,* CCHB-4 (2662 kg/ha), CCHB-51 (2518 kg/ha) and CCHB-48 (2429 kg/ha) were superior in their yielding ability as compared to other hybrids and the best check DCH-32 (1853 kg/ha). CCHB-4 had the maximum ginning outturn of36 % followed by CCHB-51 (34 %), while the best check DCH-32 had33 %.

In the third yield trial, nine hybrids were evaluated with two check hybrids. CCHB-5339 (2614 kg/ha) and CCHB-5l 074 (2367 kglha) were significantly superior in their yield performance than the best check hybrid DCH-32 (1853 kglha) (Table 4.7).

Table 4.7: Performance of advanced interspecific hybrids

Hybrids	Seed cotton yield (kg/ ha)	2.5 % SL (mm)	Ginning outturn (%)	Bundle strength (g/tex)	Micronaire
CCHB-5339	2614*	38.4	34	31.3	3.7
CCHB-5l074	2367*	37.0	33	30.0	3.6
DCH-32©	1853	36.0	30	29.3	3.3
CD@5%	126				
CV%	14				

Sirsa

Diploid Cotton

New GMS lines identified: 9 GMS lines (CISAG 4, CISAG 7, CISAG 8, CISAG 13, CISAG 14, CISAG 17, CISAG 20, CISAG 27 & CISAG 28) having red flower colour were identified and maintained through sibmating.

PerformanceofG. *arboreum* inAICCIPtrial

The GMS hybrid CISAA 14 recorded a mean seed cotton yield of 2292 kg/ha against 2100 kg/ha of zonal check and was ranked 3'd and has been promoted to the zonal trial.

Development of heterotic pools in *G. arboreum*

Ninety crosses were attempted using 15 testers (LD 327, LD 694, RG 8, CISA31O, CISA614, HD 123, PA 255, HD 324, PA 402, MDL 2617, PAIG *8/1,* DLSA 17, RG 514, CINA 316 & lTapti 007) and 3 *arboreum* GMS lines (GAK 4l3A, DS 5 & CISA 2) to develop heterotic pools.

Tetraploid Cotton

Evaluation of conventional hybrids: The trial was conducted to evaluate the performance of 31 conventional hybrids against check hybrids CSHH 19 and CSHH 238. The highest seed cotton yield was recorded in the conventional hybrid F 505 x SPC 526 P2 (1944 kg/ha) and CSH 2379 x SPC 526 P2 (1736 kg/ha) as against 1250 and 1481 kg/ha of check hybrids CSHH 198 and CSHH 238 respectively. Maximum ginning out turn of 38.5 per cent was recorded in the hybrid CSH 2379 x SPC 97 P3- 4 followed by 38.3 per cent in LRA 5166 x SPC 526 P2.

Evaluation of GMS hybrids: Forty-five GMS hybrids were tested in the station trial. The highest seed cotton yield was recorded in GMS 20 x 005 NAH (1420 kg/ha) followed by GMS 27 x 006 DA (1373 kg/ha). The check hybrid CSHH 243 recorded 1265 kg/ha. Maximum ginning outturn of 38.5 % was recorded by the hybrid GMS 15 x 001 NAH. The highest 2.5 % span length (29.4 nun) and tenacity (22.6 *g/tex)* was recorded by the hybrid GMS 15 x 002 NAH and GMS 20 x 002 NAH, respectively.

Evaluation ofCMS hybrids: Among the 32 CMS based hybrids evaluated, the highest seed cotton yield was recorded by hybrid Jhorar x SPC 920 PI P3 (1574 kg/ha) followed by 1543 kg/ha in CMS 505 x SPC 126 P2-l. The highest ginning out turn of37.8 per cent was recorded by the hybrid CMS 2379 x SPC 97 P3 - P4, followed by 37.5 percent in CMS2379xSPC 1169P2.

Development of heterotic pools in *G. hirsutum*

Fifty crosses were attempted using 10 testers (RS 810, RS 2013, CNH 911, 0231 DA, 00INAH, 002 NAH, 005 NAH, F 1861, LH 2076, BNH 161) and 5 G. *hirsutum* GMS lines (GMS 4, GMS 16, GMS 20, GMS 26 and GMS 27) to develop heterotic pools.

Performance of GMS based hybrids in AICCIP Trial: In the AICCIP North Zone trials, GMS based hybrid CSHG 1862 recorded a mean seed cotton yield of 3389 kg/ha with 32.5 per cent ginning outturn and ranked 3 rd position as compared to 2806 kg/ha of conventional zonal check hybrid CSHH 198. The hybrid also recorded higher 2.5% span length of 27.4 nun, micronaire value 4.4 and bundle strength of 22.1 *g/tex* (Table 4.8).

Table 4.8: Performance of GMS based hybrids in AICCIP trial

Sr. No	Entry	Seed cotton yield (kg/ha)	Lint yield (kg/ha)	Ginning outturn (%)	2.5% Span length (mm)	Mic	Bundle strength (g/tex)
1	CSHG 1862	3389 (3)	1101	32.5	27.4	4.4	22.1
2	ARBHH 51	3188	1102	34.5	29.7	5.1	20.3
3	CSHH 198 (ZC)	2806	933	33.3	26.7	4.9	20.0
	CD@5%	432	160	2.3	-	-	-
	CV (%)	10	11	4	-	-	-

Performance of *intra-hirsutum* hybrids in AICCIP Trial: In the AICCIP National trial, *intra-hirsutum* hybrid CSHH 1907 recorded a mean seed cotton yield of2318 kg/ha with 34.9 per cent ginning outturn and ranked 2nd position as compared to 2062 kg/ha of zonal check hybrid CSHH 198. The hybrid also recorded a higher 2.5 % span length of27.8 nun, micronaire value of 4.4 and bundle strength of2l.5 *g/tex.*

Evaluation ofBt hybrids

Forty two Bt hybrids released for North Zone were evaluated. Only two Bt hybrids, MRC 6029 BG II

(2917 kg/ha) and MRC 7017 BGII (2894 kglha) recorded more seed cotton yield than Bt check hybrid RCH 134 Bt .

4.3: Genetic Improvement

Nagpur

G. arboreum (diploid cotton)

Three strains *viz.,* JLA 505 (1891 kglha) and MDL 2617 (1670 kglha) and PA 528 (1485 kglha) were significantly superior over common check PA 255(1377 kg/ha). Line no.83 (2.5% span length 28.4 mm, fibre strength 22.4 g/tex) and PAIG 63 (2.5% span length 27.8 mm, fibre strength 23.0 g/tex) were found to be superior in fibre quality. Line no.15 (22%) followed by PA 679 (21.7%) were found to be high oil yielding lines. DNSA 08-27 (27.8 mm fibre length and 23.2 g/tex) and PA 702 (27.4 mm fibre length and fibre strength 21.4 g/tex) were found to be superior in fibre quality.

Nineteen cultures of G. *arboreum* were developed, identified and evaluated for yield and fibre properties.The cultures *viz.,* CINA 369 (2260 kglha), CINA 363 (2180 kg/ha), CINA 379 (2050 kg/ha), CINA 370 (2020 kg/ha), CINA 357 (1980 kg/ha) and CINA374 (1950 kg/ha) have registered high seed cotton yield over the check AKA 8401 (1430kglha).

Common Institute Trial of *G. arboreum* cultures

In the common Institute trial also CINA 369 recorded the highest yield of 2269 kg/ha as against 1718 kg/ha of the check variety AKA 8401.

AICCIPtrial ofG. *arboreum* cultures

Culture CAN 1003 with short medium fibre properties performed extremely well in south zone centres and ranked 2nd in Br. 24(b) trial..

Genotype	Dharwad	Nandyal	Kovilpatti	Mean (SZ)	Rank
CAN 1003	1679	1458	1808	1648	2
DLSa-17 (SZ) Check	1588	1139	1890	1539	
CD at 5%	396				

TGMS in diploid *(G. arboreum)*

Two TGMS lines stabilized for two generations by selfing and raising boll to row progenies were crossed with commercial variety of G. *arboreum,* PA 255 (both direct as well as reciprocal) to study the inheritance. The Fls of both crosses rose during summer of2008-09 produced flowers, which were fully fertile indicating the TGMS trait to be recessive. These F ıs were selfed in the off season and F_2s raised during *Kharif,* 2008 to study the segregation. The emergence was 80% in F2s of 9-1 x PA255 F_1 and 13-1 x PA255 Fl' Both the parents as well as Fls were also raised during the season. The segregation was observed for several characters such as anther size, leaf shape, petal colour etc. in addition to male sterility/fertility. Calculated Chi-square values of both the crosses are smaller than the table value at 1% (3.84) indicating best fit of 3: 1 ratio suggesting monogenic inheritance.

Acetocarmine staining prepared in acetic acid revealed pollen grains to be viable in TGMS lines, which turned fertile during low minimum temperatures. The sterile stage of TGMS lines revealed non-stained and deformed pollen.

G. hirsutum (tetraploid cotton)

Apomictic phenomenon in Tetrap10ids

For confirmation of apomictic nature three methods were used: 1) Emasculation and selfing, 2) Removal of style and stigma and 3) Crossing with dominant marker. Boll setting was observed in removal of style and stigma and anther removal methods. Lines IS 244-4-1, IS 244-4-2, IS 181-7-1, AP 2-4 were identified as common lines in which boll set was observed using emasculation and selfing.

Crossing with dominant marker genotype When apomictic lines (244-4-1,244-7-7,244-4-2,

244-4- 3, IS 181-7-1) were crossed with dominant marker genotype (1044 and 1066 pigmented filament) the plants were pigmented and non pigmented indicating presence of low degree of apomictic nature in these lines which showed absence of pigment in F_1 generation.

Cytological studies of these apomictic lines (244-4-1,244-4-2 and IS 181-7-1) showed presence of aneuploidy.

Abiotic stress

One hundred and fifteen single plant selections were evaluated in two sets of experiments. In the first set, 52 SPS were tested and the seed cotton yield ranged from 564 to 2073 kg/ha. DTS 83-09 recorded highest yield of 2073 kg/ha with 55 per cent increase over the best check variety Rajat.. It recorded 39.4 per cent GOT, 27.9 mm mean halo length and 3.2 g boll weight.. DTS 36-09, DTS 75-09, DTS 88-09, DTS 85-09 were other promising genotypes in this trial.

These genotypes were evaluated under stress conditions during peak flowering. Based on chlorophyll and membrane stability values, reducing sugars, amino acid and phenol content four genotypes *viz.,* DTS 39-09, DTS 44-09, DTS 62-09 and DTS 67-09 were found to be drought tolerant.. DTS 67-09 combined good fibre quality and seed cotton yield (1701 kg/ha). Culture DTS 44-09 also possessed good fibre quality and yield (1495 kg/ha).

In the second trial, DTS 119-09 recorded highest yield followed by DTS 102-09, DTS 104-09, DTS 116-09 and DTS 151-09 which recorded more than 50 per cent increase over the check Rajat with more than 38 per cent GOT and 25.0 mm mean halo length.

Biotic stress

Forty five F_2s along with 12 parents were evaluated against resistance to jassid and bollworms. Fifteen crosses were tolerant to jassid and bollworms. For fibre properties crosses PKVR x Deltapine *(Cl),* PKVR x Sireina, NH 545 x Deltapine *(Cl)* and NH 545 x Sireina were selected. 115 single plants were selected from F_2 population based on yield potential, earliness and tolerance to jassid and bollworm. Single plant seed cotton yield varied from 34 to 123 g/plant.. The selected plants are intercrossed to produce a new population in which further selection will be continued.

Oil improvement

For the identification of molecular markers linked to QTLs for fibre strength and oil content in G. *hirsutum* cotton, two genotypes having contrasting values for seed oil content were chosen. The material (F_3 seeds obtained from F_2 progenies) has been obtained for further studies to develop RILs for oil content.. Randomly single plants were selected and tagged. Observations on economic characters besides oil content were recorded on single plant basis.

Based on the performance in AICCIP trials in Central Zone, release proposal of CNHO 12 was submitted to AICCIP in March 2009 for identification in the forthcoming Annual Group Meeting to be held atANGRAU, Hyderabad.

Genetic enhancement of upland cotton

One hundred and eighty plants of BC_3F_3 populations ofPKV 081 x (PKV 081 x PIL) were evaluated. It was found that PKV 081 where initial boll weight was 2.5 g has enhanced upto 4.2 for boll weight and was accompanied by an enhancement of upto 27 mm from an initial halo length of 25 mm. In addition, there has been an increase upto 38% ginning per cent from initial value of 35%. One hundred plants of BC_3F_3 population of H 777 x (H 777 x Rex) were evaluated. There was an increase from an initial boll weight of 2.7 g of H 777 upto 3.6 g in the advance backcross populations. G.Cot 16 x (G.Cot-16 x Suvin) gave highest yield of 1749 kg/ha in BC_3F_3 as compared to LRK-516 (1200 kg/ha) check.. Entry CIHS-16 has been entered in Br 02 (a) trial of AICCIP. Three cultures *viz.,* CIHS-97-1, CIHS-18 and SVLS-97-3 have been entered in common Institute trial..

Common Institute Trial

In the common Institute trial, CPT 511 was the highest yielder with 2530 kg/ha and was significantly superior to the best check variety LRK 516 (Table 4.9).

Table 4.9: Performance of best five entries of *G. hirsutum* trial at CICR

S.No.	Code	Seed cotton yield (kg/ha)	Lint yield (kg/ha)	BoH wt. (g)	Boll No.
1.	CPT 511	2530	756	3.7	19.9
2.	CCH-2623	2491	807	3.5	19.7
3.	CCH-2629	2467	854	3.7	22.7
4.	MM-02-6-4	2413	818	3.3	20.1
5.	CSH -3158	2412	731	3.6	19.5
6.	LRA 5166(NC)	1317	413	3.5	18.7
7.	LRK 516 (LC)	1727	523	3.9	18.2
	C.D.5%	554			
	CV%	17	-		

Coimbatore

Development of medium staple *G. hirsutum* varieties

Seventeen medium staple genotypes were evaluated in a replicated trial. Culture CCH 801 recorded the highest yield of 2840 kg/ha and was statistically superior to the check variety CCH 510-4 (1884 kg/ha). CCH 801 was also characterized by a high ginning outturn of 38 per cent. CCH 812 recorded the highest fibre strength of25.6 g/tex.

In the National Trial of AICCIP under irrigated conditions, culture CCH 2623 recorded the highest yield of 1995 kg/ha in the Central Zone and the second highest yield of 1911 kg/ha in the South Zone (Table 4.10). CCH 4474 was better in quality with a higher fibre length and strength (Table 4.11).

Table 4.10: Performance of CCH 2623 in National Trials of AICCIP

Entry	Central Zone (Mean of 4 locations)			South Zone (Mean of 5 locations)		
	Seed cotton yield (kg/ha)	Rank	Ginning (%)	Seed cotton yield (kg/ha)	Rank	Ginning (%)
CCH 2623	1995	1	35.3	1911	2	37.7
CCH 4474	1344	23	35.4	1649	16	35.1
Zonal Check	1226	31	34.5	1537	31	33.5
Local Check	1610	9	35.0	1758	10	35.3
Zonal Check Variety	LRA 5166			Surabhi		

Table 4.11: Fibre quality performance of CCH 2623

Entry	Central Zone			South Zone		
	2.5% Span length (mm)	Micronaire	BS (g/tex)	2.5% Span length (mm)	Micronaire	BS (g/tex)
CCH 2623	26.7	4.6	21.1	27.3	4.7	21.9
CCH4474	30.2	3.7	25.0	30.4	4.7	24.2
LRA5166 (ZC)	30.2	4.0	23.0	--	--	--
Surabhi (ZC)	--	--	--	31.6	4.1	22.3

Development of early duration, compact genotype

Based upon two-year data, culture HCT 6 (3088 kg/ha) and HCT 8 (3022 kg/ha) were **found** superior to the best check variety Anjali (2590 kg/ha) by 17 to 19 per cent. Culture HCT 8 was found to be consistently superior to the check varieties. With a compact habit and a medium short duration of 145 days, HCT 8 was seen ideally suited for evaluation under rice fallow conditions in Tamil Nadu.

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

Culture CCH 510-4 was released and notifiedfor commercial cultivation in South Zone states of Tamil Nadu, Karnataka and Andhra Pradesh under the name Suraj.

The performance of this variety was also found to be superior to the Zonal check by 27 per cent in Central Zone (Table 4.12). Fibre quality wise also it was found to be superior to the zonal check variety LRA 5166. The variety was found tolerant to jassids under both South and Central Zone conditions. The variety has been identified for release under Central Zone also under irrigated conditions.

Table 4.12: Performance of culture CCH 510-4

Entry	Seed cotton yield (kg/ha)		Ginning (%)	
	South Zone	Central ZJUl~	Sou.th Zone	Central Zone
CCH 510-4	1799	1348	36.3	35.6
Zonal Check	1548	1062	33.9	34.0
% inc. over Zonal Check	16	27		

Fibre Quality of CCH 510-4

Entry	2.5% Span Length (mm)	Micronaire (J1g/inch)	Bundle strength (g/tex)
CCH 510-4	30.1	3.6	22.8
Surabhi (C)	30.6	3.6	20.2
LRA 5166 (C)	27.1	3.6	19.8

In the station trial, seventeen long and extra long staple cultures were evaluated in a replicated trial. Culture CCH 818 recorded the highest yield of 2329 kg/ha and was significantly superior to the check variety Surabhi (1540 kg/ha). The culture also recorded the highest fibre strength of 26.4 g/tex.

Sirsa

Diploid cotton improvement

Submission of proposal of variety CISA 614 for identification: 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 of2204 kg/ha as against 1834 kg/ha of **HD** 123 (zonal check) and 1990 kg/ha of local checks. 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 (Table 4.13). Variety CISA 614 has remained in the group of top five, 25 times out of32 trials as against 15 out of32 ofHD 123 (CC). The proposed variety CISA 614 recorded a mean ginning outtum of 36.6 per cent, which was at par with zonal check. **In** lint yield, the variety has recorded an increase of 25.15% over Zonal check variety **HD** 123. The proposed variety CISA 614 recorded slightly superior fibre technology characteristics in comparison to zonal, local check varieties and qualifying varieties. ***The variety CISA 614 has been identified for commercial cultivation in north zone.***

Table 4.13: Over all performance of variety CISA 614 in AICCIP trials (irrigated) (2004-2007)

Item	Year of testing	No. of Trials	Proposed Variety CISA 614	Zonal Check **HD** 123	Local Check	CD (kg/ha)
Zonal mean yield (kg/ha)	2004-05	6	2286	1652	2024	229
	2005-06	8	2024	1707	2054	217
	2006-07	9	2024	1967	1787	273
	2007-08	9	2481	2007	2097	225
Overall mean		32	2204	1834	1990	236
% Increase or decrease over the check &qual..var.	2004-05	-	-	+38.38	+12.94	-
	2005-06	-	-	+ 18.57	-1.46	-
	2006-07	-	-	+2.90	+13.26	-
	2007-08	-	-	+23.62	+18.31	-
Overall mean	-	-		+20.17	+10.75	-

Evaluation of promlsmg varieties: Eight promising varieties were evaluated. The variety CISA 294 gave significantly higher seed cotton yield (2469 kg/ha) over local check CISA 310 (2243 kg/ha), followed by CISA405 (2346 kg/ha), CISA 614 (2375 kg/ha). Maximum 2.5% span length and strength was recorded by CISA 6 (25.6 mm, 19.7 g/tex). The highest GOT % (38.2) was recorded by CISA 9. The varieties CISA 9 and CISA 10 were having 2.5% span length 25.0 mm and strength of 19.0 and more g/tex.

Evaluation of advance cultures: Eight promising cultures were evaluated with three replications in comparison to local variety CISA 310. None of the cultivar could gave higher yield than check variety, however, CISA-6-214 (2173 kg/ha) gave higher yield but not more than local check followed by CISA-6-187 (1531 kg/ha), CISA-6-209 (1482 kg/ha) and CISA-6-123 (1383 kg/ha). Maximum span length and strength were recorded by CISA-6-214 (25.1 mm, 19.2 g/tex). The highest GOT % (38.0) was recorded by CISA-6-350, CISA-6-214 and CISA-6-256 (37.9%). The highest boll weight was recorded by CISA -6-214 (2.8 gm). Two cultures CISA -6-187 and CISA-6-214 recorded micronaire less than 4.8. The culture CISA -6-214 showed a promise for yield and quality traits and was sponsored inAICCIPNational trial Br22a.

Marker assisted selection for developing elite breeding lines in cotton: A mapping population is being developed by making crosses using parents with extremes for 2.5% span length and strength (g/tex). In Cross I (RG 8 x ARBHA 35), 320 F_2 of cross RG 8 x Arbha 35 were taken. Single plants (320) were ginned and sufficient seed was obtained of each plant for next sowing. The range of mean halo length is 13-30 mm. In Cross II (HD 123xARBHA35),291 FzofcrossHD 123 x Arbha 35 were taken. Single plants (291) were ginned and sufficient seed was obtained of each plant for next sowing. The range of mean halo length is 13-28 mm.

DNA fingerprinting of released cotton cultivars, hybrids and their parents: 21 varieties were taken and RAPD primers were used to screen the varieties for polymorphism. One hundred and thirty three bands were obtained using 20 RAPD primers. The mean band per primer was 6.65. The range of dendrogram is 0.58 to 0.95. The primers were able to distinguish most of the cultivars. However, it could not distinguish CSH 8 and RS 810, RG 268 and AKA 9009, whereas it was able to distinguish RST 9, F1378, RS 2013, AKA 8404, RS 875, F 846, LD 327 etc. Four hybrids (CSHH 198, CSHH 238, CSHH 243 and CICR2) and their parents were taken and RAPD and SSR primers were used to screen them for polymorphism. Two hundred seventy four bands were obtained using 20 RAPD primers. The mean band per primer was 13.7. While in case of SSR, 269 bands were obtained using 27 primers. The mean band per

primer was 9.96. The RAPD primers were not able to distinguish CSHH 198, CSH 24, CISAA 2 and LD 327. All others were distinguished. In case of SSR primers, hybrids as well as parents were distinguished. They were arranged in different groups and showing diversity. The parents of the hybrids are diverse. The primers BNL 1721&3649, MGHES 35, 44, 45, 52, 57 and 21 could identify hybrid CSHH 198 and its parents. The primers MGHES 44 and 21 could identify hybrid CSHH 243 and its parents. The primers BNL 3649 and MGHES 21 could identify hybrid CSHH 238 and its parents.

Two crosses 315 Low GOT x AC 6586 High GOT and 349 Low GOT x 334 High GOT were attempted for developing mapping population for GOT(%).

In replicated evaluation of 17 good fibre quality genotype, only one genotype CISA 158 (2208 kg/ha) gave significantly higher yield than one of the checks LD 694 (1754 kg/ha). Single plant progenies of **11** genotypes *viz;* CISA-156, CISA-101P2, CISA-I01P3, CISA-101PI3, CISA-101PlO, CISA-lOlP7, CISA-lllPl, CISA-llP2, CISA-112P5, CISA-130P1 and CISA-l04 were with fibre length >25 mm and strength >22 g/tex. CISA -112 with good yield and fibre quality was sponsored in Br 22a/b trial of AICCIP.

Tetraploid cotton improvement

Nine new selections from multiple and double crosses in F_5 generation *viz;* CSH 3036, CSH 3158 , CSH 3114, CSH3088 andCSH3047, Jaitpuriya x CISV-24 x 144, CISV-3 x MCU-5-2 x Sikanderpur x CISV-24, CISV 3 x MCU5-2 x S.Sikander x CISV 24, CSH 3088 x CSH 3047, CSH 3088 x CSH 3212, CSH 3149 x AKH 9618 PT Lethari, AKH 0308 xAKH 0308 PT, Br02a40l x CSH 2501and Br 02a 318 x BN ARB 16 out yielded the check variety H-1226 .

Two crosses SA-1425 x SA-977 and SA-977 x SA-112 were attempted for developing mapping population for GOT (%).

In the AICCIP National trial, G. *hirsutum* culture CSH 612 recorded a mean seed cotton yield of 2236 kg/ha with 33.6 per cent ginning outturn and ranked 5th position as compared to 1648 kg/ha of zonal check variety RS 2013. The culture CSH 612 also recorded 2.5 % span length of 26.5 mm, and bundle strength of20.4 g/tex.

Evaluation of CLCu V resistant cultures

In this trial 28 CLCu V resistant cultures were evaluated against the conventional check (RS 2013) and CLCuV susceptible check (RS 921). The highest seed cotton yield was recorded by culture CSH 2842 (2571 kg/ha) followed by CSH 2824 (2723 kg/ha) as against the conventional check variety RS 2013 (2113 kg/ha). Maximum ginning out turn of 36.3 per cent was recorded in CSH 2832 followed by RS 2013 (33.5%), RS 921 (32.8 %). The culture CSH 2831 recorded the highest 2.5 % span length (29.9 mm). In trial-II, 20 CLCu V resistant cultures were evaluated against the normal check (RS 2013) and susceptible check (RS 921). The highest seed cotton yield of 2331 kg/ha was recorded in CSH 2802 followed by CSH 2811 (2244 kg/ha). Culture CSH 2801 recorded 2.5 % span length (27.2 mm), whereas the highest bundle strength of21.8 g/tex was observed in CSH 2808 followed by 21.9 g/tex in conventional check RS 2013 and the highest micronaire value of 5.1 was observed in hybrid CSH 2818.

Twelve genotypes *viz;* CSH-3036, CSH-3158, CSH-3114, CSH-3088, CSH-3118, CSH-2572, CSH-3047, CSH-3089, CSH-3132, CSH-3119, CSH-3127 and CSH-250l identified through single plant selections (F6) were evaluated for their suitability in the cotton, wheat cropping system. At 150 days of sowing six genotypes: CSH 3114, 3118,3036,3088, 3047and 3119 possessed higher yield (>75% boll opening) than check variety H 1226. In final yield by first week of November (170 days) five genotypes out yielded the check H 1226 (1553 kg/ha) *viz.* CSH 3036 (2003 kg/ha), CSH 3158 (2253 kg/ha), CSH 3114 (1773 kg/ha), CSH 3088 (1723 kg/ha) and CSH 3047 (1940 kg/ha). CSH-3119 recorded the highest fibre strength of 26.4 g/tex. CSH 3158 has been sponsored in the AICCIP trial. CSH3129 ranked 4th in the zonal trial with average yield of2285 kg/ha, fibre length 28.9 mm and strength 23. 6 g/tex.

Twenty genotypes evaluated for salt tolerance under salinity test of 4 EC and 10 EC irrigation, five genotypes LRA 5166, Anjali, LH 900, F 846 andAKH 081 indicated tolerance to salinity for the germination and seedling's emergence in laboratory and glass house using solution and soil culture respectively. These genotypes were crossed with high fibre strength genotypes and BN Bt.

Population improvement

Nagpur

Diploid cotton

Random mating population through conventional crossing

Twenty half sibs were grown in 6 row plots and subjected to random crossing. About 400 pollinations were attempted in each half sib. The crossed seeds from each half sib were bulk harvested to constitute the random mating population. The fifth cycle of random mating has been completed in diploids during 2008-09.

GMS based random mating population

The composite population from the second cycle was grown in a large plot The out-crossed bolls from the sterile plants in the population were bulk harvested. A third cycle of GMS based random mating has been completed in G. *arboreum.*

Upland cotton *(G. hirsutum)*

Random mating population

During the crop season 2008-09, twenty half sibs were grown in 6 row plots (10 dibbles/ row) and subjected to random mating. Pollens of all the half-sibs were bulked and composite pollens were used for pollination. About 400-450 female flowers of each half sib were pollinated. The crossed seed from each half-sib family has been bulk harvested and again maintained as half sibs. Thus, the fifth cycle of random mating has been completed in upland cotton.

GMS based random mating population

The composite population from the first cycle was grown in a large plot 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 second cycle of GMS based random mating has been completed in G. *hirsutum.*

4.4: Genetic Diversity through Introgression

Nagpur

Maintenance of wild species, races and perennials

Maintenance of existing 26 wild species, 13 races and 32 synthetic polyploids in the wild species garden.

Three new interspecific F] hybrids were added to the existing collection *viz.* PA183 x G. *aridum* (D4)' AKA 7 x G. *thurberi* (D_9) and G. *davidsonii* (D_{3-d})xG.cot23.

Evaluation of introgressed genetic material for different economic traits

Forty entries were evaluated and three genotypes *viz.,* NISC 43 (1823 kglha) and NISC 44 (2013 kg/ha) in G. *hirsutum* and NISCA1(1620 kg/ha) in G. *arboreum* have been identified for further evaluation and testing.

Using already available F] interspecific hybrid between Digvijay *(G. herbaceum)* and G. *anomalum* a B genome species known for possessing genes for high fibre strength and drought tolerance maintained as perennial in the wild species garden; so far 83 F_2 plants have been established. F] selfed seeds will be collected to obtain minimum of}_00 F_2plants).

Developed four F] crosses *viz.,* DLSA 17 x Soudanense, AK 8401 x Bengalense MCU 10 x Palmeri and MCU 10 x Latifolium.

Stabilization of Cleistogamy in *G. hirsutum* introgressed derivative (MSH 345 white linted genotype)

Crossing with non Cleistogamous type was taken up and harvested 5 bolls.

Attempted crosses with F] hybrids showing protruding stigma namely Sahana x *G.aridum,* Laxmi x G. *aridum,* PKV Hy2 x G. *aridum* and Khandwa2 x G. *aridum* and obtained 3 bolls.

Identified NISC 40 as a high yielding genotype (2050 kg/ha) for Central zone and was sponsored for AICCIPtrial.

Coimbatore

Performance ofintrogressed lines

Twelve stable introgressed lines have been evaluated in a replicated trial along with Sumangala and Surabhi as check varieties. Analysis of data on seed cotton yield indicated significant difference between the genotypes. The highest seed cotton yield of 1846 kg/ha was recorded in MM 02-22-2 with 57 per cent yield increase over Sumangala and 99 per cent yield increase over Surabhi. Nine other cultures were found superior to the best check variety.

Twenty two stable introgressed long staple cultures were evaluated in a station trial along with two long staple check varieties *viz.,* Surabhi and MCU 13. TheultureMM-03-22-1-2Bkrecorded significantly higher seed cotton yield than the best check variety MCU 13 with 114 per cent yield lllcrease.

Identification of stable naked seeded isogenic line

A stable isogenic line with naked seed has been identified in the restorer line AKH 98-81 through mass selection process. The original genotype was fuzzy with the white fuzz throughout the seed surface. The isogenic line is naked and has a small tuft of hair only at the micropylar region.

Naked seeded Isogenic line AKH 98-81

Induction of polyploidy in cotton

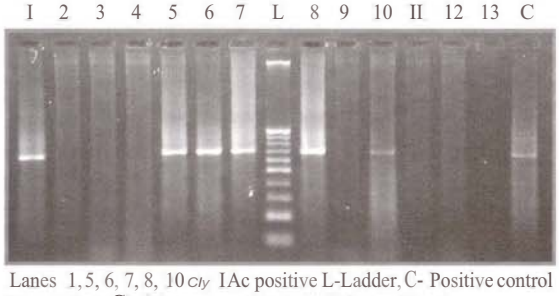
Mitotic studies on the triploids obtained between cultivated and wild species *(G. hirsutum* x G. *aridum* and G. *hirsutum* x G. *armourianum)* confirmed the hybridity and had chromosome number (2n=2x=39). The resultant F) hybrids were treated with colchicine to synthesize polyploids for further exploitation. For doubling chromosomes, seed treatment with 1% colchicine for 24 h or seedling treatment with 0.7 % colchicine for 72 h were found effective. In seed treatment, 3 out of 7 seedlings showed successful chromosome doubling, while in seedling treatment, 2 out of 10 seedlings showed doubling.

4.5: Development of Transgenics

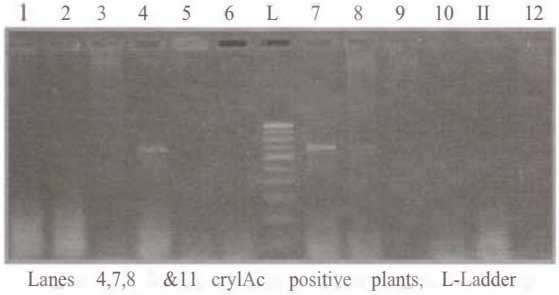
Nagpur

Bollworm resistant transgenic cotton

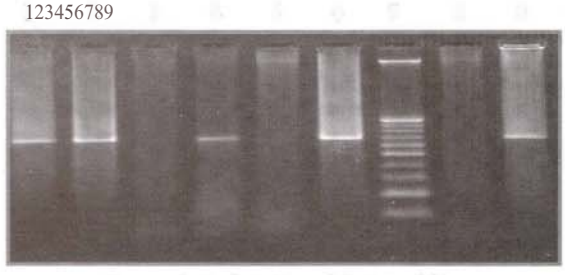
G. *hirsutum* cultivars *viz.,* LRK-516, LRA 5166 and Surabhi and G. *arboreum* cultivars *viz.,* PA255 and PA 402 were transformed with Bt *cry* 1 Ac and crylAa3 genes and generated new primary putative transformants. Eighteen transformants (11 LRK 516, 4 LRA 5166 and 3 Surabhi plants with *cry* 1 Ac and *cry* Aa3 genes were confirmed by PCR analysis (FigA.la-d). Single copy *crylAc* gene intergration was confinned in LRK 516- Bt . In case of G. *arboreum* 6 plants of PA-255 and 4 plants of PA-402 were transformed with *crylAc* gene was established.



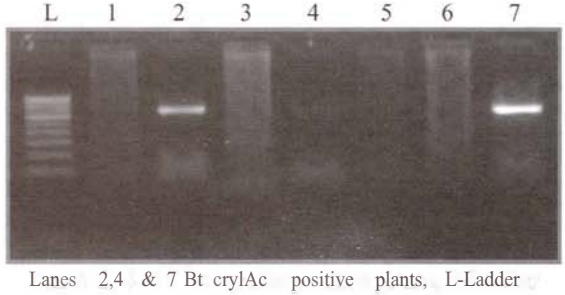
Lanes 1, 5, 6, 7, 8, 10 *Cly* IAc positive L-Ladder, C- Positive control
Fig. 4.1a: G. *hirsutum* Anjali Bt *cry* Ac 1



Lanes 4,7,8 &11 crylAc positive plants, L-Ladder
Fig. 4.1c: G. *hirsutum* LRA 5166 Bt *cry1Ac*



Lanes 1,2,4,6,9 C/ylAa3 positive
Fig. 4.lb: G. *hirsutu111* Anjali Bt cry1Aa3



Lanes 2,4 & 7 Bt crylAc positive plants, L-Ladder
Fig. 4.ld: G. *hirsutum* Surabhi Bt *cry1Ac*

G. *hirsutum* variety *viz.,* LRA 5166 was taken for co-cultivation with indigenously synthesized gene cry1Aa3, *cry1a5* and *crylF.*. With cry1Aa3 construct 40 putative transformant were developed. With *cry 1Aa5* construct 15 putative transformants and with *cry1F* construct 35 putative transformant were developed.

Bt transgenic LRA 5166 with *cry1Ac* (T5 plants) *cry1A3* (T4 plants) and *cry1A5* (T4 plants) were sown in the green house and field.

For confined limited field trial, plants were tested for gene expression and Bt. toxin content.. Total 96 plants with *cry1Ac* were tested with ELISA expression level in only 3 plants found to be optimum level.. Seeds of these plants are collected and stored.

New putative transformation events were established in G. *arboreum* cultivar PA255. Seven days old shoot tips explants were excised aseptically and co-cultivated with *Agrobacterium tumefaciens-EHA* 105 carrying Bt cry genes *(cry* lAc and *cryl* Aa3). In all, seven plants were established out of 20 plants regenerated. The transformation frequency was estimated to be 0.34 toO.62 %.

Somatic. embryogenesis and plant regeneration For regeneration studies seven days old *in vitro* germinated seedlings of cv PA 255 and PA 402 were used as source of explants. Hypocotyl and cotyledonary leaf segments were cultured on MS medium containing different growth regulators such as 2,4-D (0.1 mg/L), zeatin (0.5 mg/L), 2,4-D + kinetin (0.1 mg/L) andIAA + kinetin (2+ 1 mg/L) were used. Callus proliferation was observed within 8-10 days in all the growth regulator combination. The hypocotyls explants showed vigorous callus growth compared to cotyledonary leaf explants. The calli obtained from the above explants were subjected to differentiation in medium containing high nitrogen source.

Protein expression studies: 1080 plants ofBt RG 8, BtPA255 and BtPA402 were tested by ELISA, out of which 103 Bt RG 8 and 146 plants ofBt PA 255 andPA402 plants tested positive.

Conversion of promising genotypes into Bt background

Transferring of approved Bt gene event to elite cotton genotypes and parents of hybrids of the three cotton growing zones is in progress. Fifty two genotypes are under conversion of which twenty genotypes are in BC_4, 5 in BC_3, 12 in BC_2 and 15 inBC_1 generations.

Testing of advance generations of single plants

One hundred and nineteen single plant selections ofBt positive plants in F_4 generation were tested in two trials. Out of the 53 selections tested in the first trial, seed cotton yield ranged from 1077 to 2517 kg/ha. BWT 148 recorded the highest yield (2517 kg/ha) followed by BWT 111 (2415 kg/ha), BWT 141 (2361 kg/ha), BWT 113 (2360 kg/ha) and BWT 137 (2266 kg/ha). The check BN Bt and Rajat recorded 1863 and 1213 kg/ha seed cotton yield respectively. Twenty three selections were at par to the check BN Bt and thirty three selections to the check Rajat..

In the second trial, 66 selections were tested and seed cotton yield ranged from 649 to 1797 kg/ha. Three selections were at par to the check BN Bt (1777 kg/ha) and seventeen selections were at par to the check Rajat (1327 kg/ha). Statistical analysis revealed highly significant differences between the genotypes tested. BWT 246 recorded the highest yield (1797 kg/ha) followed by BWT 210 (1726 kg/ha), BWT 226 (1716 kg/ha) and BWT 247 (1684 kg/ha).

RCGM contained strip trial with Anjali Bt during *Kharij*

As per the approval of RCGM, contained green house trial was conducted with new events of G. *hirsutum* cv. *viz.,* Anjali Bt carrying *cry1* Ac gene in the Poly house. Anjali Bt recorded a seed cotton yield of 1240 kg/ha with an increase of 16 per cent over Non-Bt check.. The CRY protein expression was estimated by ELISA test and the protein concentration ranged from 1.95 -2.70 ppm. Other morpho economic attributes like plant height, number of boll per plant, boll weight, number of monopodia and sympodia and ginning outtum were also recorded.

Commercial release of public sector transgenic cotton BN Bt variety

The first public sector Bt transgenic cotton variety BN-Bt was developed indigenously and approved for commercial cultivation in the north, central and south zones on May 5'" 2008 after stringent biosafety regulation by RCGM and GEAC, New Delhi. The variety is characterized by

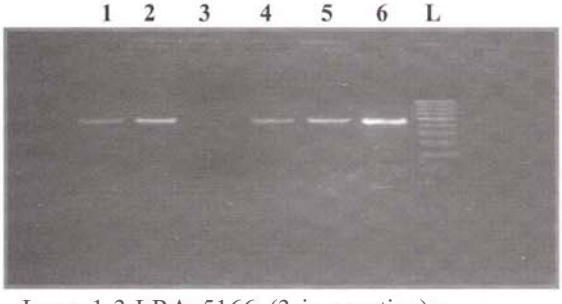
compact plant habit with high yielding and good fiber traits. The expression of Cry protein was recorded up to 5.2 ppm, and highly effective against the main target pest bollworm *(Helicoverpa armigera)*. The work was initiated under NATP program in collaboration with National Research Centre for Plant Biotechnology, New Delhi, Central Institute for Cotton Research, Nagpur and University of Agricultural Science, Dharwad. The BN Bt is an ICAR event set in the varietal background and it is a landmark achievement in the biotech research of the public sector. The advantage of this variety is that the farmers can reuse the seeds year after year, thus it created an economical option for the farmers in India.

Gene stacking in Bt cotton

Gossypium hirsutum cultivars *viz.,* LRA 5166 and LRK 516 and G. *arboreum* cultivars *viz.,* PA 255 and PA402 were transformed with Bt *cry1F* gene. With Bt *cry1F* gene construct 8007 embryonic explants were subjected for transformation and selection. Forty six primary putative transformants were selected in the kanamycin medium. After repeated subculturing, the putative transfomants were successfully eatablished in poly house. Four transformants (2 LRA 5166 and 2 LRK 516) with crylF plants were confirmed by PCR analysis (Fig. 4.2a-b). Five plants ofPA 255 and 4-plants of PA 402 were established. Southern blot was carried out with LRK 516 primary putative transformant event carrying Bt crylF plant and confirmed the single copy gene integration.

Gossypium arboreum cultivar PA 255 and PA 402 were subjected to *Agrobacterium* inoculation with *cry1F* gene. The explants after co-cultivation for three days on MS medium containing kinetin (0.1 mg/L) were screened on kanamycin containing medium. Ninety seven shoot tips were selected, out of which 15 plants were regenerated and seven were established in the soil. The transformation frequency was estimated from 0.66 to 1.0 in different events.

Plants established in the soilrite: varieties LRA 5166 and LRK 516 carrying *cry* IF



Lane 1-3 LRA 5166 (3 is negative);
Lane 4-5 LRK 516; C: Positive control,
L: Ladder

Fig. 4.2a: *G. hirsutum* cultivar Anjali carrying Bt *cry* IF

L: 100 bp ladder, 2 &4 LRK 516

Fig. 4.2b: Southern Blot analysis to analylse copy no. of *crylAc*

Transgenic cotton development

Long staple *G.arboreum* cultivars PA 255 and PA 402 were utilized in transformation. Four indigenously synthesized genes namely *cry* IAa3, *cry* IF, *cry* lAc, and chitinase were used. Surface sterilized seeds of these cultivars were germinated under *in vitro* condition by providing 16:8 hours photoperiod. The seven days old *in vitro* germinated seedlings were used as source of explants.

The shoot tip explants were isolated in such a way that both the cotyledonary leaves were removed and a sharp cut below the cotyledonary node was provided. The explants were collected in the Petri plate and were infected with log phase culture of *Agrobacterium.* Four indigenously synthesized genes viz. crylAa3, crylF, *crylAc* and chitinase genes were used. The shoot tip explants were infected by *Agrobacterium* for 30 minutes and later co-cultivated for four days on MS medium containing myoinositol (100 mg/l), thiamine (10 mg/l) and Kinetin (0.1 mg/l). After co- cultivation, the shoot tip explants were subjected to Kanamycin selection. To control the growth of *Agrobacterium,* Carbeniciilin (500 mg/I) was also added along with Kanamycin in the medium

Transformation with *cry1Aa3, cry1F,* and chitinase genes

Data on transformation of shoot tip explants with different genes is provided in Table 4.14.

Table 4.14: Transformation of shoot tip of *G. arboreum* cv PA 255

Gene	Genotype	Explants co-cultivated	Explants survived after passage of Kanamycin medium	Plant regeneration	Plants established in soil	Transformation frequency
cryIAa3	PA255	400	22	04	03	1.0
		400	18	04	03	1.0
cry IF	PA 255	480	15	04	04	0.83
		350	10	-	-	-
Chitinase	PA255	532	18	-	-	-
		430	07	-	-	-
		421	19	05	02	1.18
		550	20	03	02	0.54
		360	18	02	-	0.55
		642	12	-	-	-

a) b) c)

Transformation of *G. arboreum* (PA 255) with chitinase gene

a.Selection of shoot tip explants on Kanamycin (50 mg/ml) medium.

b.Regeneration of complete plant *in vitro.*

c.Establishment of plant containing chitinase gene.

Leaf curl virus resistant transgenic cotton

Gene constructs

Three genes constructs containing Anti-sense Rep (A-Rep), anti-sense coat protein (ACP) and sense coat protein (SCP) under the control of35S CaMV promoter and *npt-II* as a plant selection marker in binary vector pBIN AR was used for transformation. The number of explants used, primary new putative transformants selections and their transformation frequency are presented in the following Table 4. 15 .

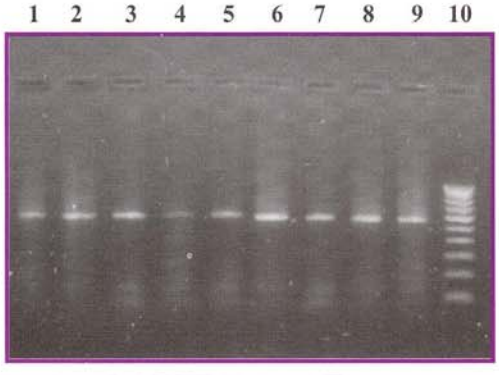
Table 4.15: New putative transformation events for CLCuV resistance *G. hirsutum* genotypes and transformation frequency

Genotypes	Gene construct	No. of explants used	Putative transformants	PCR positive	Transformation frequency (%)
H 777	*SCP*	815	8	3	0.37%
	ACP	760	9	2	0.26%
	A-Rep	934	15	4	0,42%
F 846	*SCP*	755	6	3	0.39%
	ACP	710	4	2	0,28%
	A- Rep	685	5	2	0,29%
HS-6	*SCP*	879	6	4	0,45%
	ACP	770	6	3	0.39%
	Anti- Rep	825	5	2	0.24%

Southern analysis

DNA of the PCR positive transgenic lines were digested with EcoRI and HindIII and then run in 0.8% agarose gel electrophoresis. Later the restricted DNA was transferred to nitrocellulose membrane and they were fixed by baking at 80° centigrade in the oven.

The blots were hybridized with non-radioactive labeled Antisense Coat Protein (ACP), Sense Coat Protein (SCP) and Anti-sense Rep (A-Rep) gene probe. The single copy gene integration was found in H777 putative transformant (Fig. 4.3 a-b).



Lane 1-3: H 777, Lane 4-6: HS 6,
Lane 7-9: F 846, Lane 10: 100 bp ladder

Fig. 4.3 a : PCR analysis of TO Putative transformants with the antisense Rep gene

Lane 1; Un-transformed control.
2: Transformed plant

Fig.4.3 b : Southern analysis of H777 transgenic with antisense coat protein

Engineering virus resistant cotton through dsRNAi-mediated targeting ofCLCuV

With the aim to develop cotton leaf curl virus (CLCuV) resistant transgenic cotton through RNAi-mediated targeting, seven sets of primers with engineered restriction sites, were designed to amplify seven conserved target sequences within DNA-A and ~DNA components of the virus. This included CP gene (761 and 185 bp), Movement Protein (109 bp) and AC2 (150 bp) on DNA A component and ~C4 (367 bp), ~C1 (212 bp) and ~V4 (177 bp) on ~DNA component of CLCuV.. The PCR amplified sense and antisense strands of each of these gene fragments, flanked with *KpnI* and *EcoRI andBamHI* andXbaI sites, respectively, were cloned in pGemT (Fig.4.4 a & b).

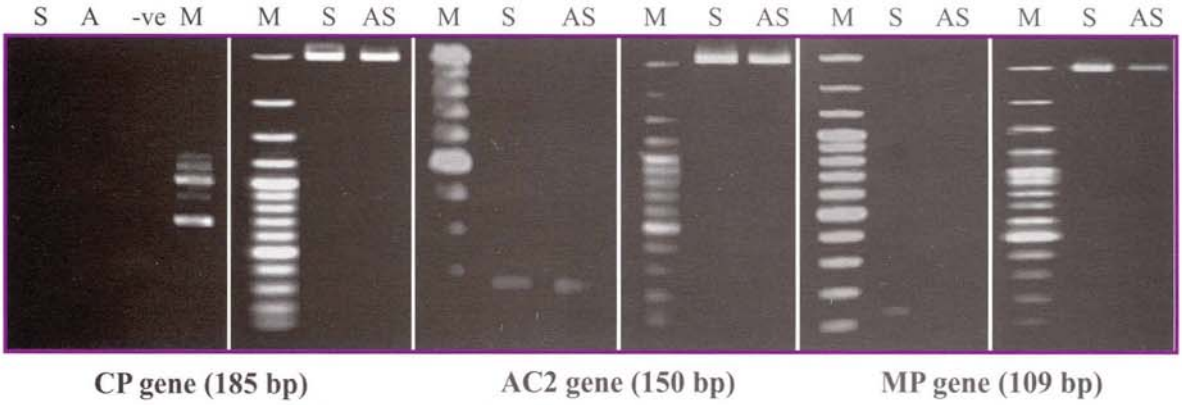


Fig. 4.4 a : PCR Amplification (a) and cloning (b) of sense (S) and antisense (AS) strands of different genes/ sequences on DNA-A component of CLCuV. Plasmids were confirmed by digestion with *EcoRI* & *KpnI* for sense and *XbaI* & *BamHI* for anti sense constructs. CP, Coat protein; AC2, replication associated factors; MP, Movement protein; M, 100 bp ladder

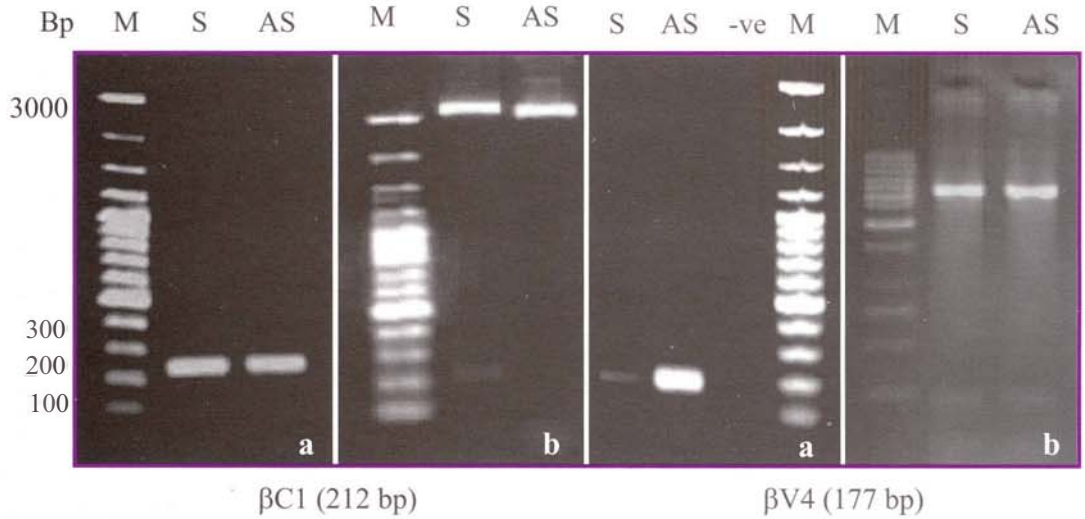


Fig. 4.4 b: PCR Amplification (a) and cloning (b) of sense (S) and antisense (AS) strands of different sequences on ~ DNA component of CLCuV. Plasmids were confirmed by digestion with *EcoRI* & *KpnI* for sense and *XbaI* & *BamHI* for anti sense constructs. M, 100 bp ladder

Sense and antisense strands of each PCR amplified and cloned components were sequenced and compared with the original sequences ofCLCu V.

Two inverted repeat constructs pKSBGus-CP-SA(5.4 kb) and pKSBGus- ~C4-SA (4.6 kb) were previously generated by cloning the sense and antisense strands of CP and ~C4 gene fragments in plasmid pKSBGus2 (3.9 kb). One of them pKSBGus- ~C4-SA, was cloned in each of the two binary plasmids, pBinAR and pGreen (Fig. 4.5 a & b). The plasmid construct was transformed in *A. tumefaciens* strain ERA 10 1 by tri-parental mating and is ready for transformation in cotton (Fig. 4.5c). Remaining sequences of DNA-A and ~DNA are in the process of cloning in plasmid pKSB-Int (3.1 kb).

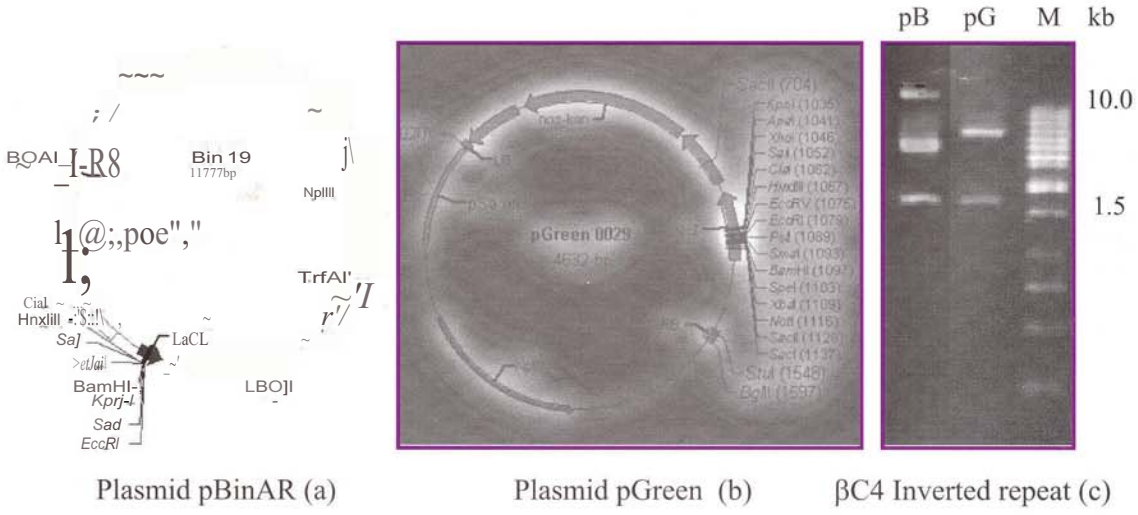


Fig. 4.5. **Binary plasmids** (a), **pBinAR (pB) (b), pGreen (pG) and the gel picture showing the inverted repeat fragment of PC4 cloned in each vector (c). M, lkb DNA ladder**

Development of transgenic cotton with high fiber strength using cellulose synthase gene from *Arabidopsis*

AthA and *Rsw-l* genes were amplified from *Arabidopsis thaliana* using concerned primers. The amplified product of 5.0kb and 6.kb for *AthA* and *Rsw-l* respectively were cloned into pJET 1.2lblunt vector and transformed in *E.coli.* (Fig. 4.6). The clones were confirmed by restriction analysis and PCR and sequenced. The nucleotide sequence of *AthA* (FJ687279) was BLAST analysed and results showed homology with CesA2 *(AthA)* gene. Full length sequence of *Rsw-l* gene was also analyzed and sequence was submitted to GenBank (Bankit No. 1178577). Incase of promoter gene isolation from cotton genome, inverse primers were designed with FastPCR software. For cotton fiber specific promoter isolation, total genomic DNA was isolated and digested with restriction endonuclease and then allowed for circularization with ligase enzyme. PCR was carried out with Pfu polymerase. The expected length of amplicon ~1.8kb was amplified with specific primers. The amplicon was cloned into pJET vector and transformed into host bacteria. The positive clone was reconfirmed the gene presence and subjected to sequence analysis.

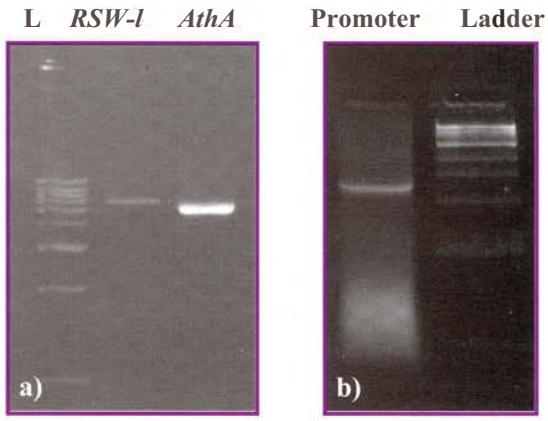


Fig. 4.6: PCR amplification of *AthA* and *RSW* (a) and it promoter (b)

Coimbatore

Induction of somatic embryos

Five to seven day old hypocotyls and cotyledons of cotton genotypes *viz.,* Suvin, Sumangala, LRA 5166, Bunny and Mallika were utilized for callus induction in MS basal medium with various combinations of hormones. The hormones used were Auxin (Indole Acetic acid, NAA, 2,4 D) and Cytokinin (Kinetin, BA and BAP). Among the combinations tested, good callusing was observed with 2,4-D and BA. They were sub cultured and being maintained.

Bio-safety of Bt cotton

Nagpur

Performance of Osmanabadi goat under browzing on Bt and non-Bt cotton leaves

Bt and non-Bt variety NCS 145 was cultivated on 2 acres of land each. These experimental groups each comprising of four does were formed. Members of group I were allowed to browze on Bt cotton leaves while those of group II browzed on non-Bt counterpart of the variety while members of group III browzed on vegetation other than cotton. All the goats were fed on cotton for three months when sufficient foliage was established on plants. Observations revealed no difference on reproductive performance as well as on birth weight of kids born to the to the does fed on Bt cotton. Besides no significant difference was observed on account of feeding on Bt cotton in any of the physiological parameters like rectal temperature, respiration rate and heart beats. Haematobiochemical test conducted on does fed on Bt and non-Bt cotton too revealed no significant difference indicating bio-safety of the genetically modified cotton on goat.

4.6: Molecular Breeding

Nagpur

Molecular characterization of cotton germplasm using DNA markers

One hundred germplasm lines were subjected to DNA fnger printing using 28 STMS markers (Fig. 4.7 a-e).

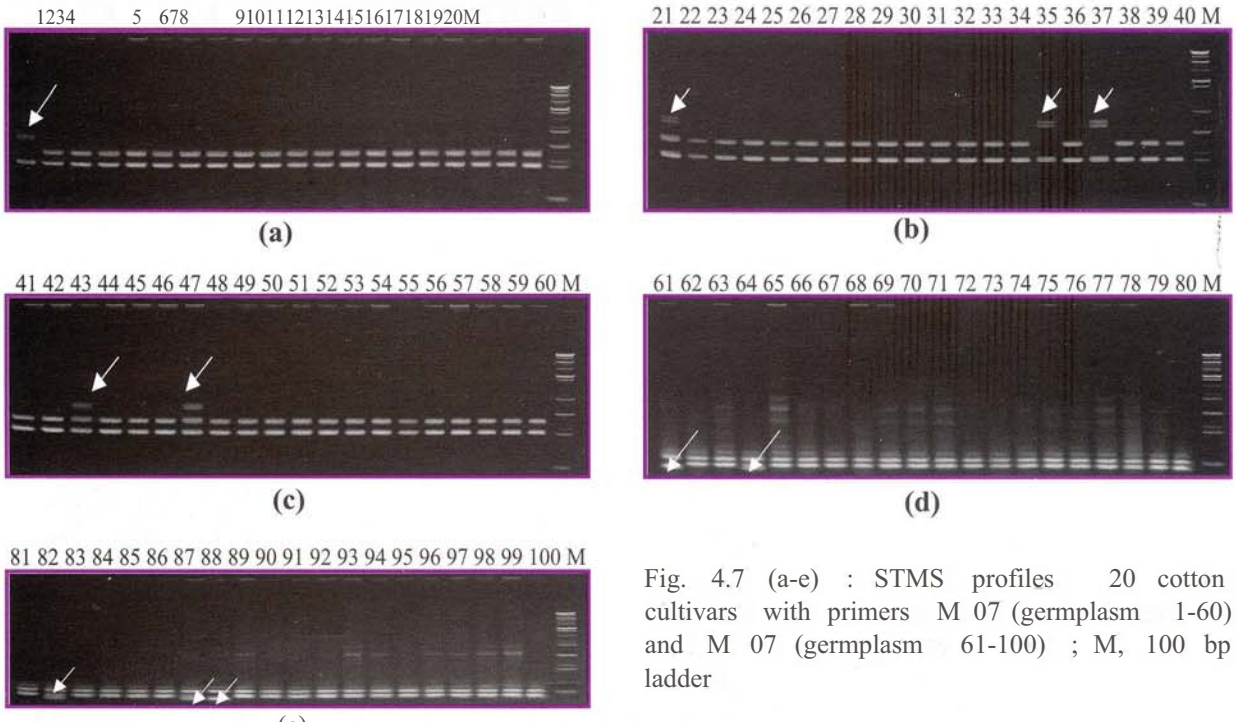


Fig. 4.7 (a-e) : STMS profiles 20 cotton cultivars with primers M 07 (germplasm 1-60) and M 07 (germplasm 61-100) ; M, 100 bp ladder

Twenty four working germplasm collections of G. *hirsutum* (fourteen of yield group, two of yield group exotic cultivators and eight of boll weight group) were subjected to RAPD and ISSR profiling (Fig. 8 & 9).

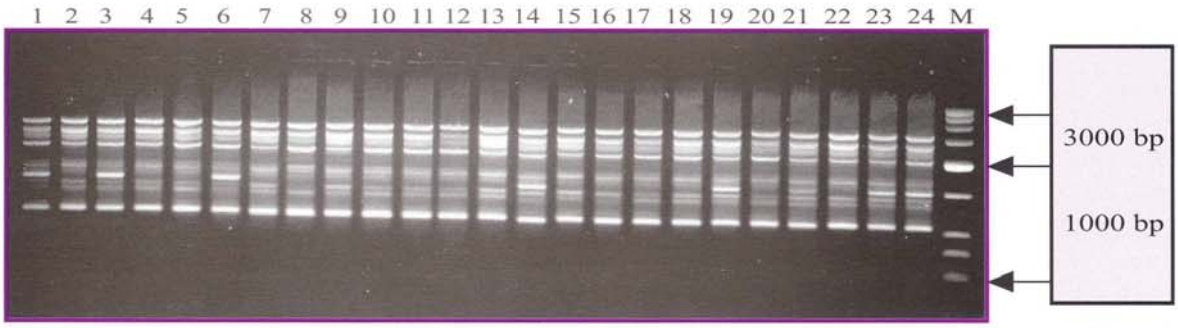


Fig. 4.8 : RAPD profiles of 24 cotton germplasm generated with primer OPA-17; M, 3 kb ladder

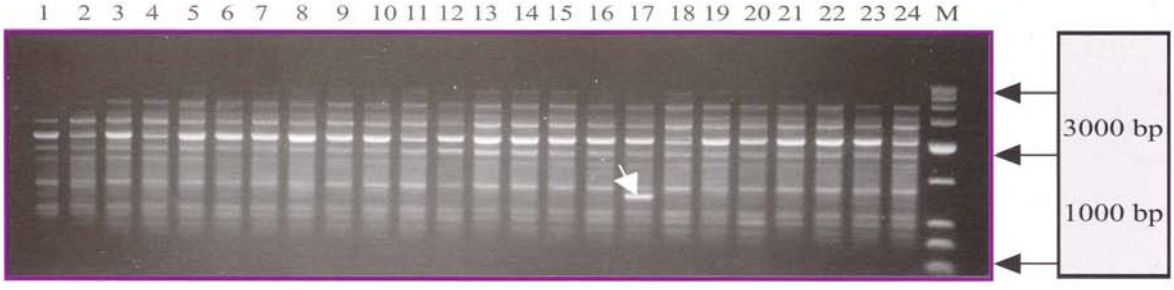


Fig. 4.9 : ISSR profile of cotton cultivars generated with primer IS-7; M, 3 kb ladder

PCA and UPGMA cluster base dendrograms were constructed from the STMS, RAPD and ISSR profiles depicting their genetic relationships as well as genetic polymorphism. Some of the germplasms with unique molecular markers were identified.

Molecular mapping ofleaf curl virus resistance gene in the cotton genome

SSR primers (51) were screened with the parents RS 875 x F 846 and CNH 123 x CNH 1020.sSR primers *viz.,* JESPR 230, 231, 232, 242, 246, 310 generated polymorphic bands. F_2 populations were screened with the 6 SSR primers. JESPR 242,230, 231, 234 could produce 290bp, 90bp, 250 bp, 350 bp alleles respectively in the resistant parent and segregated in the F_2 population (Fig. 4.10 a, b & c).

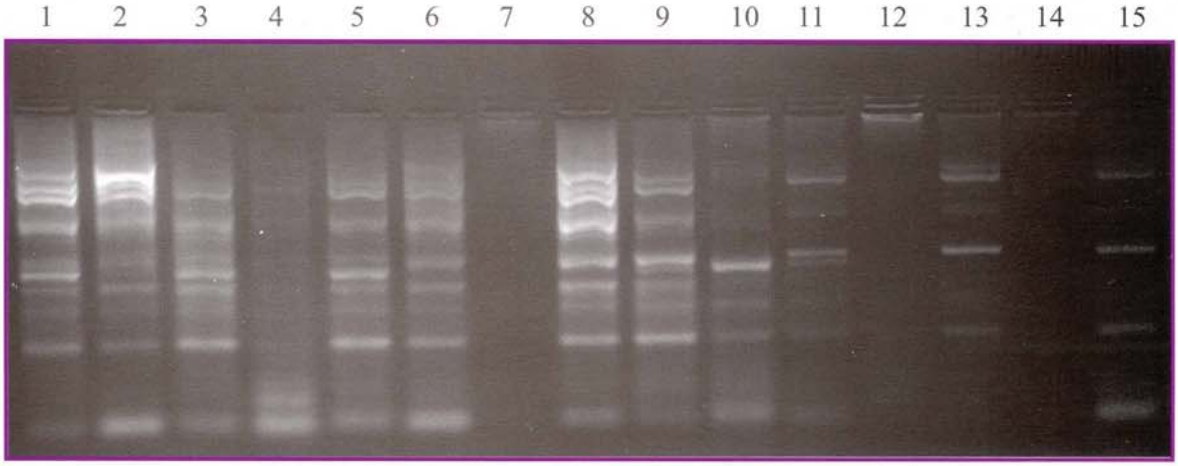


Fig. 4.10 a : Lane 1& 2: CNH 123, CNH 1020,Lane 3 -15: F_2 Population

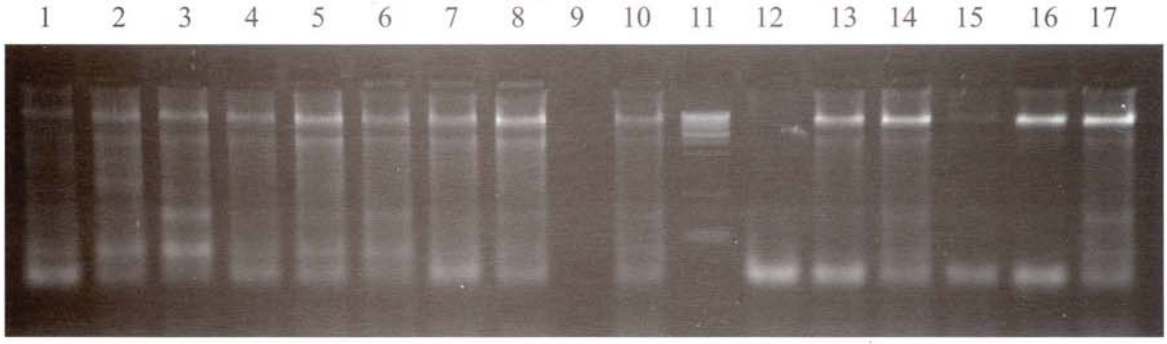


Fig. 4.10 b: Lane 1& 2: CNH 123, CNH 1020, Lane 3 -17: F_2 Population

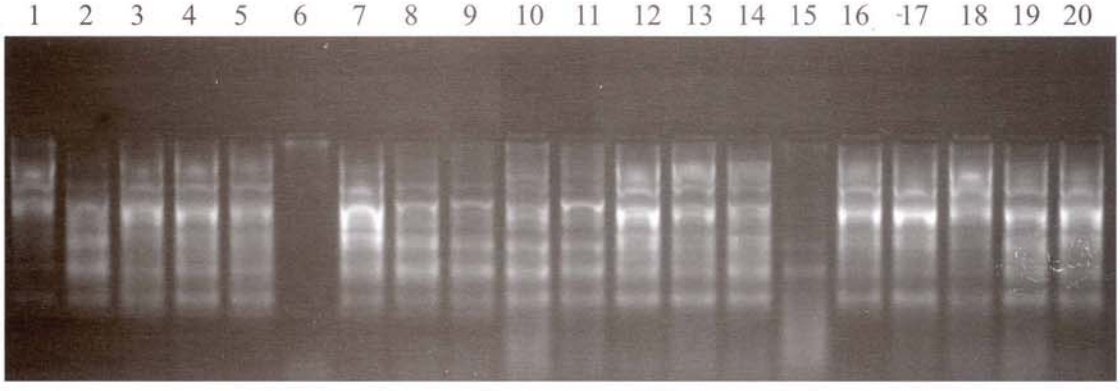


Fig. 4.10 c: Lane 1: CNH 123,Lane 2 :CNH 1020,Lane;3-20:F_2 population

Fig. 4.10: Genotyping of parental genotyeps and F_2 population using SSR primers JESPR 242 (a), 230 (b) and 231 (c)

Identification of Molecular markers and tagging genes for Bacterial blight resistance

Screening of parental lines for resistance against bacterial blight

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 1M 216, S 295 and 101-102 B were completely resistant to race 18. The susceptible and resistant cotton with contrasting phenotypes were further employed in crossing and development of hybrids. Genetic crosses were affected involving Acala-44 (Susceptible) x 1M 216 (Resistant) with contrasting phenotypes.

For validation of markers, additional crosses were also effected using two susceptible lines and three resistant lines *viz.,* 1M 216, S 295 and 101-102B. Susceptible lines were employed as female parents while the resistant lines were used as male parents. The F, plants of the cross involving Acala-44 and x IM216 were screened against race 18 of *X malvacearum* and were found to be completely resistant.. F] plants were selfed and F_1 seeds were harvested. F_2 mapping population of nearly 250 plants of cross involving Acala-44 and x IM216 will be grown in the field during of2009-10 crop season and advanced for further screening against the pathogen race and linkage analysis.

DNA finger printing of parental genotypes with SSRmarkers

The bacterial blight resistant and susceptible cotton showing contrasting phenotypes and their crosses were surveyed for genomic polymorphism using SSR and RAPD markers. Genomic DNA was extracted from cotton leaves using commercial kits (Zymo, USA), following manufacturer's protocol and quantified. A set of 144 SSR primers from Cotton Marker Database (CMD) were synthesized for initial survey of

polymorphism. This included 127 pair of EST-SSR primers from STY and MGHES group in CMD and 17 whole genome SSR primers from BNL, CIR and CM databases. Polymorphism among the parental lines, if any, was surveyed using 30 SSR primers and 40 RAPD primers.

Preliminary screening revealed limited polymorphism with SSR primers (Fig. 4.11a). Limited number of markers used however was not significantly informative to qualify as a polymorphic marker between the contrasting parents. However, 14 out of 40 RAPD primers exhibited polymorphism between resistant and susceptible lines (Fig. 4.11b). Acala 44 lacked SSR amplicons of 125 bp when amplified using STY02 and STY03 whereas the resistant cotton IM216 and the hybrid possessed the specified amplicon.

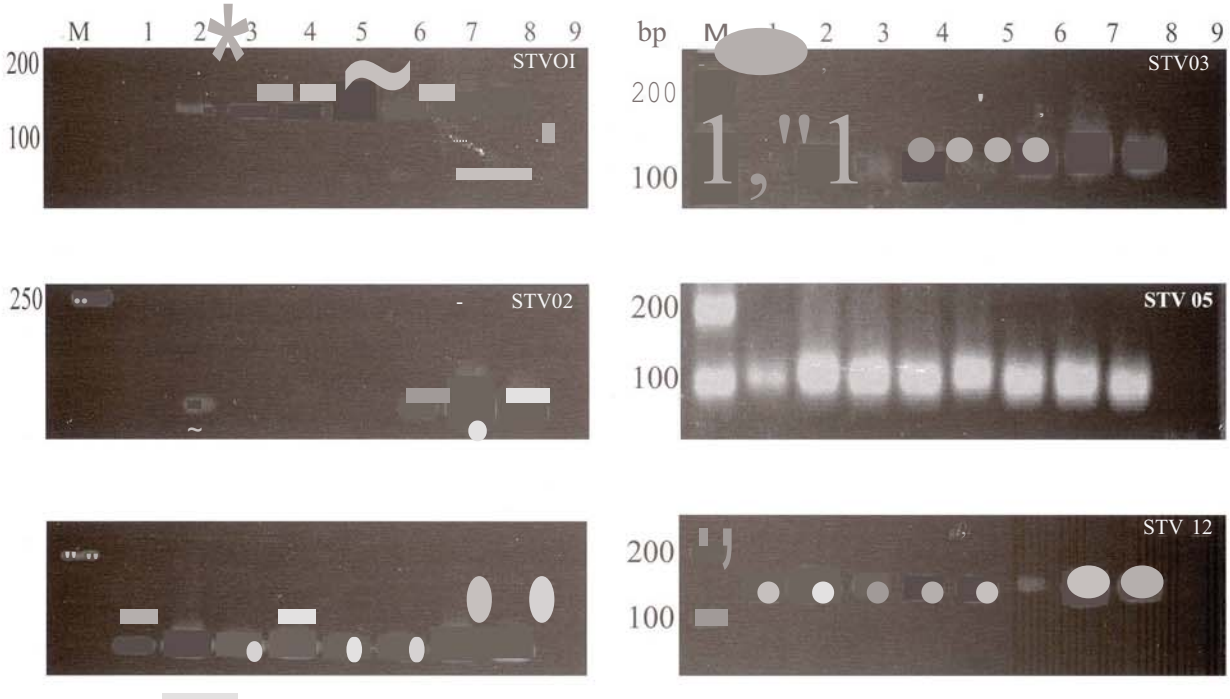


Fig. 4.11 a : Screening of EST SSR primers to survey polymorphism among bacterial blight resistance and susceptible cotton and their inheritance. 1-Acala 44, 2-IM216, 3-Ganganagar Agethi, 4 -Acala - B2, 5-Acala 44 x IM216,6- Ganganagar Agethi x Acala - B2,7-101-102 B,8-S295, M- Marker

Diploid cotton

An interspecific F_2 mapping population involving G. *arboreum* (A2) Cv. KWAN-3 and G. *herbaceum* (AI) Cv. Jayadhar was developed. Parental genotypes and each plant in a F_2 mapping population were extensively phenotyped for the morphological variation. The data on fibre quality traits and ginning outturn was analyzed that showed significant variation in the F_2 population. 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.

Of the 330 SSR and 60 RAPD markers screened, 42 SSR markers (12.72%) and 20 RAPD markers (33.3%) were polymorphic with the parental genotypes. The informative SSR and RAPD markers have been employed for genotyping ofF_2 mapping population. In general the polymorphism in cotton genotypes is very less may be because of narrow genetic base of the cultivated cotton genotypes (Fig. 4.12 a& b).

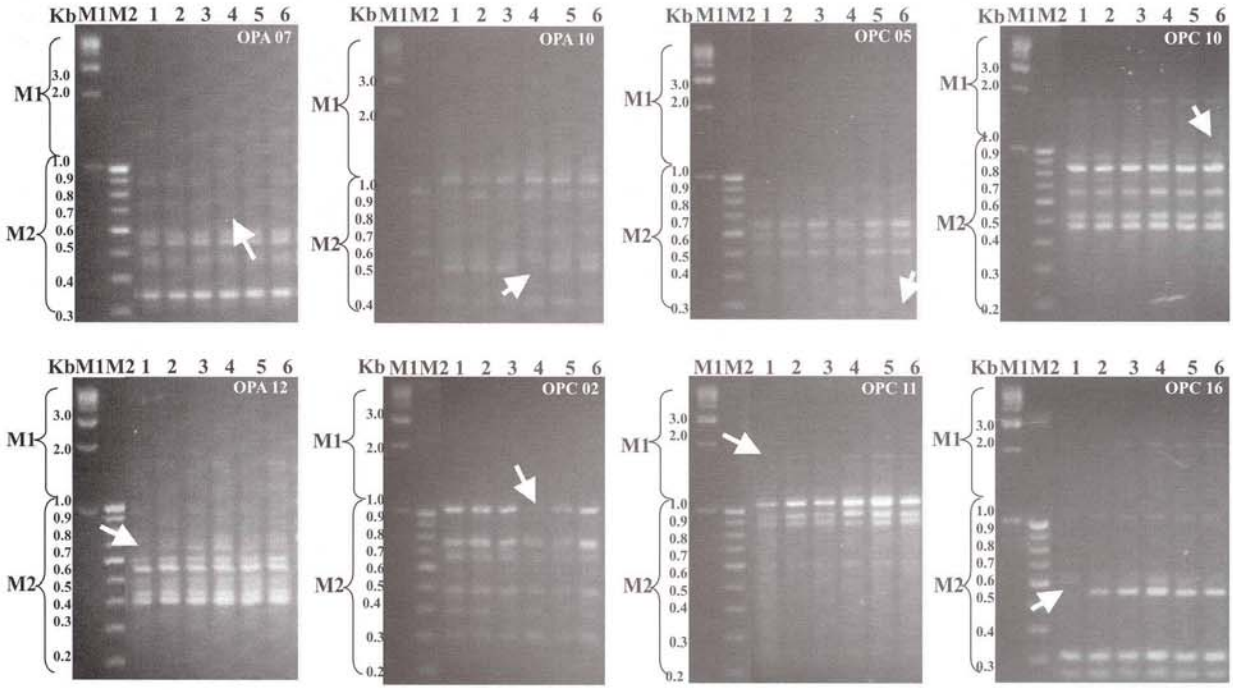


Fig 4.11b: Screening of Arbitrary primers to survey polymorphism among bacterial blight resistance and susceptible cotton and their inheritance in crosses. l-IM216, 2-Acala 44 x IM216, 3-Acala 44, 4-Ganganagar Agethi, 5-Ganganagar Agethi x B2, 6-B2, Ml-l Kb ladder, M2-100 bp ladder

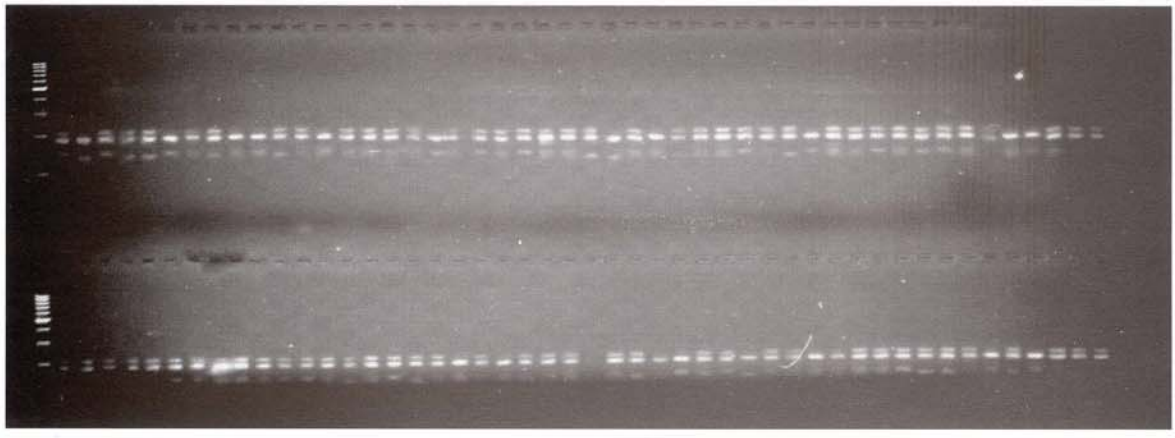


Fig. 4.12 a-b: Genotyping of F_2 mapping population using CIR218 SSR marker

Upland cotton *(Gossypiuin. hirsutum* L.)

An intraspecific F_2 mapping population involving G. *hirsutum* (AD_1) cv. EL 958 and UPA 57-17 was developed. Survey for the informative markers has been carried out using SSR and RAPD markers. A total of 330 SSR and 60 RAPD markers were screened of which 50 SSR (15.15%) and 18 RAPD (30.0%) markers were polymorphic with the parental genotypes. Genotyping of F_2 mapping population with identified informative markers is in progress (Fig. 4.13).

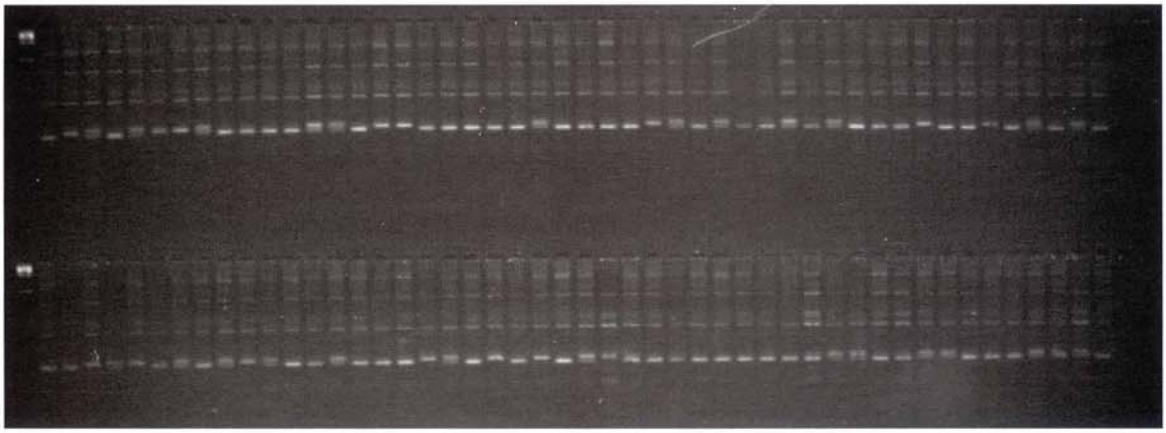


Fig. 4. 13: Genotyping of *G.hirsutum* F_2 mapping population with CIR 203 SSR marker

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

Permanent mapping populations for fibre quality in diploid and tetraploid cotton are being developed. F_2 mapping populations developed for construction of a linkage map for diploids and tetraploids were used as base populations for development of RILs. In diploids, 205 F_4 plant progenies were raised. Of this, one random plant in each of 193 progenies was selfed to carry forward to F_5 generation. In G. *hirsutum,* 297 progenies selfed bolls were obtained which shall be carried forward to F_5 generation.

Genotyping with RAPD markers

Blight susceptible Ganganagar Agethi failed to generate amplicons of 1.0, 0.68 and 0.53 kb, respectively with primers OPC02, OPA07 and OPAIO while the blight resistant isogenic line ACB2 and its cross with Ganganagar Agethi generated respective amplicons. The blight resistant IM216 lacked amplicons of sizes 0.68 kb, 1.8 kb and 0.58 kb respectively while the susceptible Acala 44 and its cross with IM216 generated the specific amplicons when amplified using arbitrary primers OPAI2, OPC11 and OPC16. Similarly OPC05 and OPC10 failed to generate the amplicon of 0.3 kb and 1.2 kb in resistant AcB2 but amplified the fragment in the susceptible Ganagnagar Agethi and its cross with AcB2.

4.7: Seed Production and Seed Quality Improvement

Nagpur

Seed vigor traits studies in cotton

Assessment of seed vigor traits

Seedling emergence is significantly influenced by the seed grade giving higher values in seeds with highest grade (Grade Awith seed index 8.5 g 7.5 g and GradeB with seed index 7.56.5 g). No. of bolls per plant as well as seed cotton yield percentage were also significantly higher in A and B grades compared to C (lowest grade with seed index 6.5 5.5 g) and D (non graded with wide range of seed index,7.5g-4.5g). Varietal differences were non significant..

Seed treatment with mannitol and Disodium hydrogen phosphate @ 2% overnight soaking followed by drying were found effective in superior seedling emergence compared to control in both the moisture levels.

Transgene expression and its effect of quality of reserves in Bt cotton hybrid

Studies on seeds obtained from Bt cotton hybrids indicated that the level of protein expression (in ppm) was negligible in seed coat (0.02 to 0.15) as compared to the whole seed (2.43 to 6.66).

Seed quality improvement

Dormancy (physiological) ranged from 23-39% in the crosses between G-67 and BW-3718, maximum being in the parent G-67 followed by

B1((G-67x BW-3718)x G-67) at 37%. In another set, the dormancy was 26-40% maximum being in both the parents (G-67 and EG-l20) and B2 (G-67xEG-120)x EG-120) by 36%. This proves the existetnce of dormancy in the cotton seeds just after picking. The dormancy levels reduced after 45 days.

Boll load **management and yield**

NHH 44 hybrid seed was produced at varying crossing period (between 1st September to 15th November 2008 and number of days, 30, 45 and 75 days crossing period). Crossing period as well as number of crossing days did not influence the seed yield. Boll setting percentage was significantly higher (45.7%) when crossing was done from 1st October to 1st November 2008 compared to control (26.2%). Germination percentage was significantly higher (87%) when crossing was done from 1st October to 15th November 2008 compared to control (82%). Vigour index was higher (2662) when crossing was done from 1st September to 15th October 2008 compared to when crossing was done from 1st September to 30th September 2008 (2295).

Soil depths, low input management

Cotton in deep soil gave the highest yield (1651 kg/ha) compared to shallow (1410 kg/ha) and medium (1362 kg/ha) soils. Among the species, G. *arboreum* (PA 255) gave the highest yield (1534 kglha) as compared to G. *hirsutum* (NCS 145 Bt) (1415 kg/ha). 25% RDF with foliar sprays (3) of macro and micro nutrients gave highest yield (1528 kg/ha) compared to 100% RDF (1445 kg/ha). Significantly highest germination percentage was observed in seed produced from medium soil type (89%) compared to shallow (88%) and deep (82%) soil. 25% RDF + 0.5 ton of organic matter + foliar sprays of macro and micro nutrients had significantly higher germination percentage (88%) compared to 100% RDF (86%). Seed produced from shallow (2391 kg/ha) and medium (2396 kg/ha) soils had higher seedling vigour index compared to deep soil (2157 kg/ha).

Agro-techniques to increase seed cotton yield in Bt hybrids

a. Foliar application of salicylic acid (0.25%) at 95 days after sowing (DAS) gave higher yield (1201 kg/ha) compared to control (870 kg/ha).

b. Organic compost application (2 ton / ha) at pre flowering stage gave higher yield (1372 kglha) compared to control (1143 kg/ha).

c. Foliar application of lime (0.75%) at flower initiation stage gave highest yield (1325 kg/ha) compared to control (1008 kglha).

d. Foliar application of GAl' 100 ppm at flower initiation stage gave highest seed cotton yield of 1700kg/haascompared to control(1398 kg/ha).

Coimbatore

Implementation ofPVP legislation

DDS trials of new cotton varieties were conducted with three *Gossypium hirsutum* (C 5196, C 5009 and C 5193) and two G. *barbadense* (C 5118 and C 5171) candidate varieties along with 15 reference varieties. The seedling, leaf, flower, boll and fibre characters were recorded from seedling to maturity stage adopting the approved national test guidelines for tetraploid cotton. Cotton seeds of 194 reference varieties (137 G. *hirsutum,* 12 G. *barbadense,* 36 G. *arboreum* and 10 G. *herbaceum)* including parental lines and hybrids were maintained underreference collection.

Registration of 25 genotypes of extant and new cotton varieties under PPV &FR Act, 2001 was initiated.

Film coating of cotton seeds with polymers

The seed deterioration can be prevented up to 18 months of storage and the viability of 77% can be retained when pre cleaned seeds were coated with seed polymer polykote @ 3mllkg + carbendazim (Bavistin) @ 2 g /kg of seed and the seeds stored in cloth bag under ambient conditions. Viability can also be retained upto 76% by coating the seeds with polykote @ 3mllkg + carbendazim @ 2 g /kg + imidacloprid @ 7g /kg, when seeds were stored in polythene bags.

Genetic purity testing of hybrid seeds through bio molecular profile

Genetic purity testing of cotton hybrids Sruthi and Savita and their parental lines using seed protein profile through SDS PAGE electrophoresis indicated the presence of additional bands in hybrid Sruthi and the presence of similar bands in male parent and hybrid in Savita. This will help to ascertain the level of genetic purity of hybrid.

Breeder Seed Production

The following quantities of Breeder Seeds were produced and distributed during the year.

Variety	Production (q)	Distribution (q)
LRA 5166	2.50	0.90
MCU 5 VT	3.00	1.20
Surabhi	3.00	2.40
Suvin	1.50	0.45
Suraj	0.50	0.10

Sirsa

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

Significantly higher plant stand (98.6 %) and yield (3035 kg/ha) than normal sown crop (2510 kg/ha) was recorded when the seedlings raised in big containers were transplanted at 20 days seedling stage. In G. *hirsutum* (hy. CSHH 198) the lab germination percentage was significantly higher in seed lot with superior seed index (89.5%) than lower seed index seed lot (62.8%) and ungraded seed (70.6%). Similar was the case in G. *arboreum* (hy. CICR 2). The seed cotton yield in higher seed indexlot ofCSHHI98(3230kg/ha)and CICR2 (3280 kg/ha) was significantly higher than lower seed index seed lot with 2650 kg/ha and 2580 kg/ha, respectively. Among the various pre sowing seed treatments, the plant stand was higher in seed lot treated with KNO_3 100 mM + imidacloprid+ vitavax (89.1 %) followed by treatment ofDAP 1% + imidacloprid + vitavax (88.1%) against the control (water soaked seed) which was 80 %. The significantly higher yieldlha 31.04 q was recorded in treatment with KNO_3 100 mM+imidacloprid + vitavax followed by DAP 1% + imidacloprid + vitavax (3083 kg/ha) and trichoderma (3042 kglha) than control (2856 kg/ha).

Maintenance ofN ucleus and Breeder seeds

Breeder seed produced during this year were distributed between various Govt., and Private seed producing agencies as well as to the interested farmers of the zone under FLD and other institute schemes.

Maintenance of Nucleus and Breeder seeds

SN	Variety /hybrid	Breeder seed produced (q)
1	CSHH 198 (F)	0.25
	(M)	0.50
2	CSHH 243 (F)	0.25
	(M)	0.25
3	CSHH 238 (F)	0.25
	(M)	0.25
4	CISAA2 (F)	0.25
	(M)	0.25
5	CISA 310	1.00

Standardization of seed coating with synthetic polymers and additives

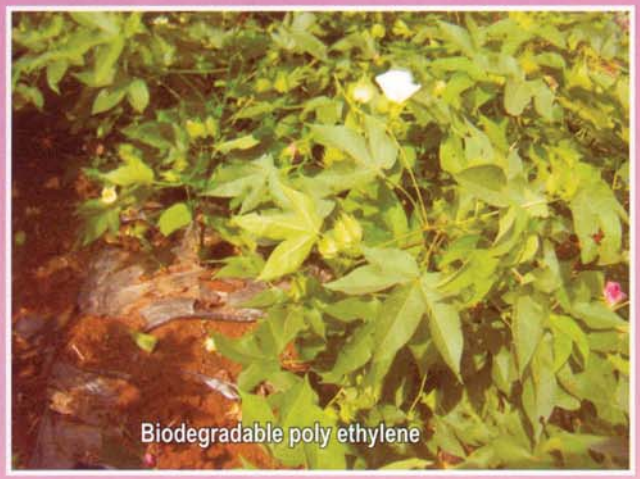
Eight seed treatments with synthetic polymers and additives applied on seed (packed in cloth bag & polythene bag) evaluated for moisture content of seed, germination per cent and vigour index (bi-monthly). The germination per cent in treated seeds with polymer and additives ranged from 64.3 to 76.3% in case of cloth bag and 68.0% to 74.5% in polythene bag. At six month of storage the moisture content of the seed was higher in seeds packed in cloth bag (10.71-11.19%) than polythene bag (9.13-9.46%) in all the treatments.

CICR

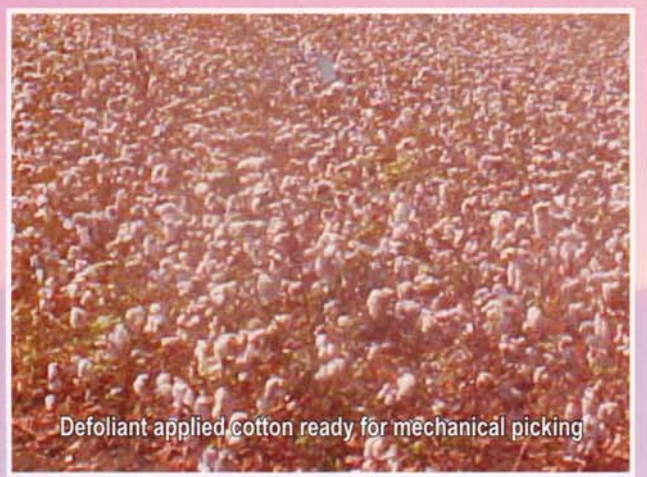
ANNUAL REPORT 2008-09

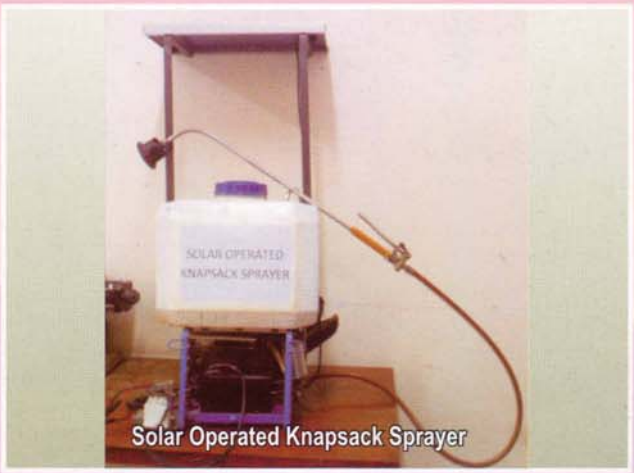

Multi-tier cropping system in cotton


Cotton + Maize intercropping


Biodegradable poly ethylene


Gunny mulch


Defoliant applied cotton ready for mechanical picking



Solar Operated Knapsack Sprayer

4.8: Nutrient Management

Nagpur

For Bunny Bt application of 100% RDF (120:60:60) and 125% RDF through drip were at par and superior to 75% of the fertilizer dose applied through drip.

Under rainfed conditions addition of limiting micronutrients through soil alongwith RDF on soil test basis increased seed cotton yield of Bunny-Bt over RDF alone by 12%.

Long term effect offertilizer and INM

Under long term trials higher yield of seed cotton (16.7 q/ha) was recorded under INM (N_{60} P_{13} K_{26} +Szo+Zn_{45} +PSB +FYM @5t/ha +DAP 2 % foliar) followed by N_{90} P_{20} K_{39} +5t FYM (16.1q/ha) as compared to fertilizer N_{90} P_{20} K_{39} without FYM (Fig. 4.14). Marginal improvement in staple length with the application of N_{90} P_{20} K_{39} + 5t FYM (applied in alternate years) was also observed. Higher yield of strip intercropped pigeon pea was recorded in FYM treated plots.

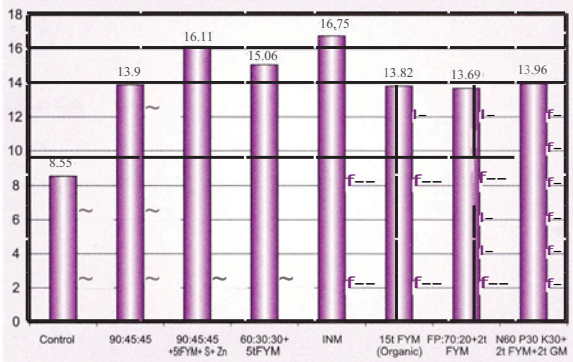


Fig. 4.14: Seed cotton yield(q/ha) as influenced by different fertilizers

Organic carbon build-up was noticed in organic manure plots. Fractionation of soil organic carbon pools under different nutrient management indicated that the mean active forms (very labile + labile forms) in the soil ranged from 47-55% in INM plots and organic plots as against 42% in recommended NPK (alone) plots and 42.5 % in absolute control. Physiologically important microflora viz., Azotobacter, PSM and Pseudomonads registered higher population in INM and organic plots compared to other treatments.

There was general decline in microbial population in 2009 as compared to 2008 in both rhizosphere and non-rhizosphere (Bulk) samples at 0-9" depth. The highest total microbial population was recorded in Treatment-5 (90: 45: 45: 20: 20: 0) followed by Treatment-7 (60: 30: 30: 0: 0: 5 tFYM in alternate year) (Fig. 4.15).

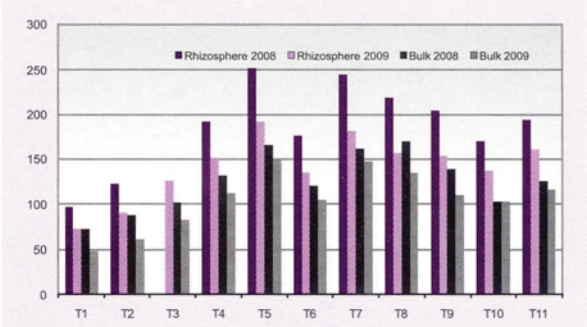


Fig. 4.15 : Impact of long term fertilization on total soil microbial population in cotton

Nutrient requirement of Soybean-Bt hybrid cotton rotation

The data from farmers participatory trials in three villages showed significant correlation between N fertilizer applied and seed cotton yields. The results also indicated that 1.5 times recommended dose of fertilizers improved the yields. With 1.5 times recommended dose of fertilizers in shallow soils without rain water conservation seed cotton yield was 15 q ha^{-1} and in medium deep and deep soils it was 20 q ha^{-1}. Shallow soils with imbalanced fertilization are more vulnerable to reddening of leaves with 30% red leaves which in turn reduced yields by 5 q ha^{-1}.

The red leaves were significantly reduced to 25% by soil application of $MgSO_4$ @ 20 kg ha^{-1}. Magnesium application and rain water conservation delayed the appearance of red leaves until late October/November. The plant analysis showed no deficiency of N, K or Mg whereas P was extremely low in red leaves.

Synchronizing Nand K supply with crop demand

For Bt hybrid (Bunny) grown under rainfed conditions on Vertisols of Agro-eco sub-region 10.2, split application of K along with N did not offer any yield advantage over splitting ofN alone and hence the entire recommended quantity of K

may be applied as basal dose. For high yield and high N utilization efficiency (27 kg seed cotton/kg N uptake), N may be applied in 3 equal splits at 10, 45 and 75 days after sowing in a year of normal rainfall and at 10,30 and 60 days after sowing in a drought year.

Effect of different nitrogen levels on oil and protein content in Bt cotton

Field experiment was laid out with 3 Bt hybrids (Bunny, NCEH 2R)) and their non- Bt counterparts in a split plot design with 3 levels of NPK (90:45:45,120:60:60 & 150:75:75). Crop growth was satisfactory except for NCEH 2R NBt.. No definite trend for total protein content at 110 DAS) was observed in the leaves with increase in nitrogen level beyond 120:60:60. There was difference in protein content between Bt and non-Bt hybrids. Seed oil content was in the range 15 - 25%. Bunny Bt and non-Bt hybrids were found to contain relatively higher oil content in the range 24-26%. There was no significant difference in seed cotton yield among the treatments. Among the cultivars, both Bunny Bt and non-Bt hybrids performed well..

Coimbatore

Long term sustain ability

In an upland cotton *(Gossypium hirsutum* L. cv. Surabhi) grown under irrigated condition on a medium fertile black clay loam soil the Sustainable Yield Index (SYI) (based on 5 years pooled yields) calculated on the basis of mean, highest and standard error in yield was maximum and relatively stable (0.42) under INM (NPK: 60:13:25 kg/ha + FYM@5t/ha)followedbyNPK + crop residue incorporation @ 2.5 t/ha (0.40) and organics (FYM @ 15 t/ha) only (0.39) (Table-4.16). Soil nutrient status after 5 years continuous cropping showed application of NPK or INM or organics slightly enhanced soil OC and decreased available K status in the root zone over the initial levels. Yet, significant enhancement in soil NaHCO) extractable P was observed under NPK, INM and FYM supplemented treatments over control (Table 4.16).

Table 4.16 : Sustainable Yield Index (SYI) and final soil nutrient status after 5 years of cropping

NPK (kg/ha)			FYM (t/ha)	SYI Cotton	OC (%)	P(ppm)	K(ppm)
0	0	0	0	0.37	0.61	8.4	352
60	13	25	0	0.38	0.65	12.8	384
90	0	0	0	0.36	0.61	9.0	366
90	19	0	0	0.37	0.63	10.6	374
90	19	37	0	0.37	0.65	11.6	396
0	0	0	15	0.39	0.66	13.6	403
60	13	25	5	0.42	0.68	14.4	408
60	13	25	2.5#	0.40	0.67	11.1	390
C.D.(0.05)				-	NS	3.9	NS
Initial status				-	0.60	7.7	410

<0.3 unstable, 0.3-0.7 relatively stable and >0.7 stable, #crop residues in t/ha)

Fertigation through drip

Trials for two consecutive years in large plots with RCHB 708 Bt indicated that fertigation @ 90:19:37 kg NPK/ha with 6 splits ofN andK (at 15 days intervals from 30 days after planting) through drip led to significantly higher seed cotton yield (3058 kg/ha) over that in both 75 % NPK applied in 6 splits (2842 kg/ha) and soil application through 3 splits (2784 kg/ha). Thus this dose and schedule was optimum resulting in a saving of

25% NPK by fertilizers, besides providing highest net return (Rs. 54,934/-) and B:C ratio (2.93).

Synchronization in Nand K supply with crop demand

Synchrony in N or N + K supply through multiple splits commensurating with crop growth stages was not apparent under irrigated conditions existing semiarid situation at Coimbatore especially for long duration cotton (RCH 708 Bt). Yet, averaged over 2 years, maximum seed cotton yield (3133 kg/ha), net return (Rs 68,195/- and B:C ratio (3.60) were obtained under 3 equal splits ofN only applied at 45,75 and 105 DAS (P & K as basal with NPK dose of 90: 19:37 kg/ha). It is concluded that under the existing condition, 3 splits of N only @ 30 kg/split at 45, 90 and 105 DAS is optimum.

Nutrient management to reduce the premature senescence (PS) in Bt cotton

Premature senescence in Bt cotton could be managed by balanced fertilization and split (4 times) Nand K application. RCH 20 Bt responded to split NK up to eight splits but the response was not significant beyond four splits. The balanced fertilization includes application of 120 : 60 : 60 kgs NPK in either 4 splits with entire P and 50 kg Mg S04+ Boron (as solubor 1 kg) as basal with two foliar spraying ofDAP 1.5 % + K 0.5 % + Mg S04 0.5 % + Boron as Solubor 0.15 % during flowering to boll development stages. This combination recorded significantly higher yield and PS symptom was not observed.

Studies on mechanism of cuticular absorption of nutrients and hormones in Bt cotton

Foliar sprays of nutrients and hormones were tried on Bunny Bt cotton at 70th day after sowing followed by another two sprays at 10 days interval under both irrigated and moisture stress condition. Plants grown under irrigated condition gave significantly higher yield than plants grown under moisture stressed condition irrespective of the treatments with a mean increase of 25%. The effect of treatments was distinct only in plants grown under irrigated condition. Among the treatments, Hoagland 50%, Hoagland 100% and DAP 2% spray retained significantly more number of bolls at harvest.. Irrigation favoured a significant increase in boll weight by 9%, irrespective of the treatments effected. Under irrigated conditions, there was a significant increase in boll weight where 2% DAP and Hoagland solutions were sprayed.

Basic studies on nutrient uptake through foliar application indicated that the uptake of potassium in the leaf did not increase with increase in concentration of potassium applied. The amount of potassium absorbed by the foliage in 0.5 and 2% KCl spray was almost to the same level of 43 and 45 ppm respectively. Time of application was found to be an important factor in favoring the absorption of nutrients. Spraying during the early hours was not conducive for foliar uptake and sprays imposed during the evening hours helped in penetration of more nutrients. For instance, uptake of potassium was only 31ppm when sprayed at 8.00 am while spray at 4.00 pm gave a concentration of 49 ppm in the leaf.

4.9 : Irrigation Water Management

Nagpur

Development of production technology for Bt cotton and improvement of WUE and NUE with precision farming techniques

Results on different irrigation schedules and fertilizer levels in Bt cotton (Bunny) indicated that irrigation at 0.8 ETc was more economic in obtaining higher seed cotton yield, water use efficiency and fertilizer use efficiency in Bt cotton than irrigating at 1.0 ETc.

Coimbatore

Drip fertigation in cotton

Based on last 2 years trial, alternate day based irrigation at 0.8 ETc through drip was optimum for a long duration hybrid RCHB 708 Bt (Table 4.17). An average of 25.2 % lower water use and 31 % higher WUE was obtained with 0.8 ETc over surface irrigation at 0.6 IW/CPE.. Thus, an average 1564 litres of water were consumed per kg of seed cotton under 0.8 ETc drip (2057 litres/kg in IW/CPE of 0.6). In addition, drip fertigation with 90: 19:37 kg NPK/ha was optimum for realization of higher seed cotton yield and fertilizers beyond the above dose had little influence on the quantum of water use, WUE water productivity or yield. The results showed drip-fertigation at 0.8 ETc with 90:19:37 kg NPK/ha was optimum under the existing semi arid condition at Coimbatore where

the crop received a total rainfall of 57.3 cm out of which 17.4 cm (30.3%) was effective and the evaporation was 80 cm.

Irrigation scheduling under poly/biol biodegradable mulching for 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 ofELS Bt cotton, (RCHB 708) under drip and conventional irrigation. The design used was split plot with eight mulch treatments in the main plot and three moisture regimes in the sub plot (Table 4.18). The results indicated that the total water requirement was 438,589 and 767 mm at O.4ETc (drip), 0.8 ETc (drip) and conventional irrigation. When no mulch was applied, the crop responded up to 0.8 ETc while with mulch combinations, the yield declined beyond 0.4 ETc. The highest water use efficiency of 126.2 kglha cm was recorded at poly mulch + drip at 0.4 ETc. Poly-mulching was on par with biodegradable mulching for seed cotton yield and closely followed by other mulches except surface coir and no mulch. The interaction between mulches and moisture regimes was significant. . Among the treatment combinations, poly mulching with drip at 0.4 Etc

Table 4.17: Mean effects of drip-fertigation on yield and water use parameters (pooled for 2 yrs)

Drip fertigation	Seed cotton yield (kg/ha)	Water use (em)	WUE (kg/ha-cm)	WP (Rs/M^3)
DripO.6ETc	2606	37.9	68.7	20.6
Drip 0.8 ETc	3017	47.2	63.7	19.1
Drip 1,0ETc	3008	56,4	53.3	16.0
Surface 0.6	3067	63.1	48.6	14.6
C,D.(0.05)	360	3.3	8.4	2.6

Table 4.18 : Seed cotton yield in extra long staple Bt cotton (cv. RCHB 708) as influenced by moisture regimes and mulches

Mulches	Drip (0,4 ETc)	Moisture regimes		
		Drip (0.8 ETc)	Conventional Irrigation	Mean
No mulch control	3046	3957	3262	3421
Sub soil coir pith (2kg/m^2)	4199	3957	4121	4092
Maize stover (5 kg / m^2)	4141	4086	3712	3979
S.Cane trash (5 kg / m^2)	4109	3967	3931	4002
Surface coir pith (5 kg 1m^2)	3798	3460	3069	3442
Gunny sheet	4255	4142	3585	3994
Biodegradable poly mulching	5105	4442	4489	4679
Poly mulching	5526	5310	5235	5357
Mean	4272	4165	3926	
CD (p=0.05) for mulches	683.7			
CD (p=0.05) for moisture regimes	296.2			
CD (p=0.05) for mulches x moisture regimes	1018			

recorded the highest seed cotton yield as against the lowest yield recorded under no mulch with drip at 0.4 Etc.

Optimization of irrigation and nitrogen requirement for Bt cotton

Field experiments were conducted in a split plot design during 2006-07 to 2008-09 to study the interaction effect of irrigation and N on yield, input use efficiency and water and nitrogen dynamics in Bt cotton (RCH2 Bt) on a mixed red and black calcareous sandy clay loam soil (Vertic Ustropept) of Periyanaickan Palayam series. Treatment details are presented in Table 4.19. Protective irrigation treatment refers to one irrigation at sowing, one life saving irrigation within one week after sowing and one irrigation after earthing up operation at 45-50 days after sowing in the absence of rainfall.. It was observed that all the irrigation treatments were statistically at par with respect to seed cotton and lint yield whereas N application up to 60 kg N/ha significantly improved the yield. There was no further significant difference in the seed cotton or lint yield at 90 and 120 kg N/ha. There was significant reduction in the earliness index at higher irrigation and nitrogen levels. There was significant reduction in water use efficiency and water productivity with the increase in the level of irrigation whereas there was increase in the water use efficiency and water productivity due to N application @ 60 kg N/ha over no nitrogen control. . The nitrogen utilization efficiency of cotton (i.e. kg seed cotton yield per kg of N uptake) decreased significantly with the increase in the level of irrigation whereas the N levels did not influence the nitrogen utilization efficiency significantly. However, partial factor productivity of nitrogen (PFPN) decreased significantly with the increase in irrigation and N levels. Thus, RCH2Bt cotton hybrid may be grown with protective irrigation and 60 kg N/ha to achieve higher water and nitrogen use efficiency without significant yield reduction in winter irrigated situation in the Southern zone of the country.

Table 4.19 : Water use efficiency/ Nitrogen use efficiency of RCH2 Bt cotton under varied irrigation and nitrogen levels (Pooled over 2006-07 and 2008-09)

Treatment	Water use efficiency (kg/ha-cm)	Water productivity (Rs/m^3)	N utilization efficiency (kg SCY /kg N uptake)	Partial factor productivity of N (kgSCY/kg N applied)
Irrigation				
Control (Protective irrigation)	48	10.96	32.7	24.7
0.6 IW/CPE	36	9.11	22.9	22.7
0.8 IW/CPE	30	7.45	22.1	22.6
1.0 IW/CPE	29	7.19	19.2	24.1
Nitrogen				
Control	31	7.84	24.1	
60 kgN/ha	36	8.85	24.2	32.1
90 kgN/ha	37	9.01	22.4	21.4
120 kg N/ha	38	9.02	26.2	17.1
LSD 0.05 (1)	2.5**	0.60**	2.61 **	1.39*
LSD 0.05 (N)	2.3**	0.55**	NS	1.21**

Water use efficiency on cotton based cropping systems

Higher water use in cotton genotype (Surabhi) to the extent of 8.2 % was recorded under cotton-

fallow over cotton-sorghum system. Similarly, significantly higher water productivity (by Rs.1.62/M^3) was recorded under INM (NPK @60: 13:25+FYM 5 t/ha) over control.. There was a significant increase in WUE and a decrease in water use to the tune of7.26 kg/ha-cm and 8.7 cm respectively under INM over control.. Thus, integrated nutrient management and efficient cropping system use less water for unit /crop productivity.

Comparative performance of Bt and non-Bt cotton under scanty rainfall situation

Bt cotton recorded the mean seed cotton yield of 1433 kg/ha as compared to 855/kg with non-Bt hybrids (rainfall 436.8 mm and effective rainfall 264.2 mm). Bt hybrid yielded 3.5 and 5.4 kg seed cotton/mm of total rainfall and effective rainfall use efficiency respectively as compared to non Bt hybrids which recorded respectively the least mean average of 2.0, and 3.2 kg/mm. Bartlett earliness index ofBt was 0.73 as compared to 0.62 with non Bt. Bt hybrids registered the mean gross return ofRs. 41,300/ha, net return ofRs. 24, 136/ha and benefit cost ratio of2.40. In non-Bt hybrids the average gross return was of Rs. 24,553/ha, net return was Rs. 10,180/ha and benefit cost ratio was 1.72. Bt hybrids registered the mean highest partial factor productivity of 11.94 kg of *kapas* /kg of added nutrients and economical nutrient use efficiency of 0.9 kg/rupee investment made on nutrients. The corresponding values for non-Bt hybrid were 7.1 kg/kg of nutrients and 0.55 kg/ rupee respectively.

4.10: Soil Moisture Conservation in BtCotton

Nagpur

Field experiment on different moisture conservation techniques on Bt cotton indicated significantly higher seed cotton yield and economic return with intercropping system *viz.,* cotton + green gram (1: 1) over the treatments of mulching with sunhemp or opening of alternate furrows.

Coimbatore

A field experiment was conducted in RBD with 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 using RCH 20 Bt.. The results indicated that all the mulch treatments enhanced the seed cotton yield under rain fed condition. The yield increase ranged from 11.3 % to 83 %. Poly mulching recorded the highest (1646 kg/ha) seed cotton yield and was on par with all other mulch treatments except surface coir pith and no mulch control.. Surface application of coir pith recorded significant reduction in yield over other mulches.

4.11: Cropping Systems

Nagpur

Identification of innovative Bt cotton based cropping system for rainfed cotton

A large plot demonstration on Bt cotton hybrid indicated that intercropping with legumes like green gram and black gram, vegetable cluster bean and flowers like marigold was profitable. An innovative design for both bullock drawn and tractor drawn paired row planting system for Bt hybrid (67.5x45 cm) was developed and tested.

On shallow soils, the seed cotton yields were not significantly influenced by the different of cropping systems. However, cotton equivalent yields (4396 kg ha'i) and net returns (Rs. 98,425 ha'i) were highest in Bt hybrid cotton intercropped with maize + tomato followed by Bt hybrid cotton intercropped with Portuluca + Dolichus lab lab + fennel (3177 kg ha'l, Rs. 65, 117 ha'l) and Bt hybrid cotton intercropped with sweet com (baby com) +cowpea (2805 kg ha'l, Rs. 45, 412 ha'l). On the medium deep soils the highest cotton equivalent yields (CEE) 2933 kg ha'l, net returns Rs. 61, 870 ha'i was with cotton +maize (green cobs) intercropping followed by marigold intercropping (2850 kg ha'i Rs. 53, 223 ha'i) and spinach intercropping followed by relay cropping of green peas (2507 kg ha'i Rs. 52,675 ha'l). Soil moisture was a limitation for grain filling of majority of the relay crops such as safflower, gram and lentil..

Bt hybrid cotton was relay planted with green leafy vegetables, winter oil seeds, pulses and cereal grain crops. The most successful relay cropping system in a year with 50% less rainfall during crop growth period was Bt hybrid cotton paired row planted at 67.5 x 45 cm relay planted with castor at

the end of September. The relay crop harvested by January, produced 3 q ha^{-1} castor beans.

Coimbatore

Identification of Innovative Bt Cotton Based Cropping Systems for irrigated cotton

Short duration intercrops like clusterbean, coriander, radish, amaranthus, greengram and vegetable cowpea were evaluated against sale crop of Bt cotton. Normally, cotton crop is grown in one side of the ridge and the other side is kept vacant and in this novel experiment without altering the cotton crop geometry, short duration inter-crops were grown on the other side of ridge. The results indicated that all the intercrops evaluated were found suitable to grow with Bt cotton, RCH 20. The seed cotton equivalent yield from intercrops varied from 4.44 q to 10.12 q/ha and the cotton + coriander inter cropping recorded the highest seed cotton equivalent yield, gross return, net return and B/C ratio closely followed by cotton + radish system.

Incorporation (in situ) of cereals on productivity of succeeding cotton

The assumption is that sowing of cereals as bulk crop in the off-season by using available moisture and in-situ incorporation (45 days period) may provide similar cereal rotation effect to the succeeding cotton which help to break yield barrier and make the system sustainable was tested. The first years result revealed that significantly highest seed cotton yield (1598 kg/ha) was harvested with cotton, raised after *in situ* incorporation of ragi at 45 days after sowing (DAS) along with soil application of *Trichoderma viridi*. The results were on par with *in-situ* incorporation of sunnhemp + *Trichoderma viridi* (1449 kg/ha) and *in situ* incorporation ragi alone at 45 DAS (1402 kg/ha). The control (fallow-cotton) recorded seed cotton yield 1192 kg/ha. The highest gross return (Rs. 41,539/ha), net return (Rs. 21,551/ha), benefit cost ratio (2.08) were obtained with incorporation of ragi at 45 days after sowing with soil application of *Trichoderma viridi*.

Multi -tier cropping system

The highest net return (Rs. 1,16,81 O/ha), benefit cost ratio (3.51), per day profitability (Rs. 779) and relative economic efficiency (221 per cent higher than sale cotton) were obtained with multi tier system of cotton intercropped with radish, beetroot and coriander with application of 100 per cent recommended levels of fertilizer to intercrops. Sale cotton system had a with net return of Rs. 34,300/ha, benefit cost ratio of 2.20 and per day profitability ofRs. 243.

Sirsa

Intensification of cotton based cropping system for maximizing the use of natural resources under irrigated conditions

Three cropping sequences *viz* cotton-wheat, cotton-barley and cotton-mustard were evaluated (Table 4.20). Based on the system as a whole, the highest net income/ha of Rs 46935 and 51315 respectively was obtained in cotton followed by wheat with normal as well as transplanted cotton. The maximum (87.1 %) land use efficiency was recorded in normal sown cotton-wheat as well as normal sown cotton-barley cropping system. The production efficiency (kg/ha/day) was recorded higher in transplanted cotton-wheat (16.24) followed by nonnal sown cotton-wheat (14.69) cropping system.

Table 4.20 : Comparative evaluation of *rabi* crops after cotton

System	Cotton planting system	Performance of Rabi crops	
		Yield (q/ha)	Gross Income (Rs./ha)
Cotton-wheat	Nornlal	38.13	41943
	Transplanted	38.00	41800
Cotton-barely	Normal	38.63	25110
	Transplanted	39.41	25616
Cotton	Normal	13.50	24300
Mustard	Transplanted	12.90	23220

Soil plant narrations in intercropped *kharif* legumes with Bt cotton under irrigated condition

The performance ofBt. hybrid RCH 134 with and without intercrop combinations (Cotton + Mungbean, Cotton + Mothbean, Cotton + Cluster bean, Cotton + Groundnut) was evaluated. The yield (3301kg per ha) was significantly higher in sale cotton at spacing 67.5cm x 75 cmcompared to

paired row cotton (2771 kg per ha) with and without intercrops. The dry matter, N, P and K uptake (kg/ha), nutrient use efficiency, water use efficiency and water productivity was also higher in sole cotton (67.5 cm x 75 cm) than paired row cotton. The water use efficiency and water productivity was higher in sole and paired row cotton without intercrops than paired row cotton with inter crops.

4.12: Agronomic Evaluation of Cotton Genotypes

Nagpur

Effect of closer spacing on plant characters suitable for mechanical picking for Bt cotton

The effect of closer spacing on plant characters suitable for mechanical picking and was studied in replicated trials using Bunny Bt. Closer spacing of90 x 20 cm recorded highest yield (2286 kg ha!), followed by 90 x 30 cm (1942 kg ha!) whereas, wider spacing of 90 x 60 cm recorded less yield (1048 kg ha!). The closer spacing had an effect on compactness of the plants which is more desirable for mechanical picking.

Coimbatore

High density planting with genotypes

High density planting (HDP) of cotton varieties *viz.,* CCH 510-4 and CCH 724 at 90 x 10 cm resulted in realizing higher seed cotton yield, net return and B:C ratio at par with Bt hybrid (RCH-2 Bt) planted at recommended 90x60 cm. Thus, comparable yields and profits could be realized through agronomic manipulation of existing improved straight varieties . The additional benefits from HDP include early harvest in 2 pickings, escape from pests, weeds, and scope for rotational crops due to early pickings.

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

The trial was conducted to identify high potential and resource efficient genotypes to realize high productivity, profitability, and effective ~tilization of resources. The results (Table 4.21) indicated that significantly highest seed cotton yield (3975 kg/ha) was recorded with RCHB 708 Bt, which was followed by CCH 510-4 (3336 kg/ha), Narashima (3176 kg/ha) and Surabhi (3126 kg/ha). The Bartlett earliness index was high for Bunny Bt (0.81), MallikaBt (0.81) and Tulasi 9 Bt (0.76) higher value. The total quantity of water used was lower for Bunny Bt, Mallika Bt and Tulasi 9 Bt. The water use efficiency (kg/ha-mm) was observed higher with RCHB 708 Bt (6.5), Mallika (6.4), Tulasi (6.2) and CCH 510-4 (5.9). RCHB 708 Bt , Mallika Bt, and Tulasi Bt had higher water productivity of 22.0,18.0 and 17.5 rupees per cubic meter of water. Data on partial factor productivity for fertilizer and economic parameters are also presented in Table 4.21 .

4.13: Weed Management

Coimbatore

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

Field experiment was conducted during 2008-09 cropping season to find out efficient, economical and environmentally safe weed control method and to find out the efficacy of herbigation technique. The design used was split plot with two methods of application (Herbigation and conventional spraying) and six weed control treatments like (Flucholoralin 1.5 kg/ha (PRE)+HW (30 DAS), Pendimethalin 1.5 kg/ha (PRE) + HW (30 DAS), Pendimethalin + metalachlor 1.0 kg/ha (PRE) + HW (30 DAS), Pendimethalin 1.0 kg/ha fb 1 + HW + metalachor 1.0 kg/ha (30 DAS), hand weeding thrice (20,40,60 DAS), Un weeded check). Herbicide rotation of pendimethalin 1.0 kg/ha fb 1 HW + metalachlor 1.0 kg/ha on 30 DAS recorded lesser weedDMPofl2.4 . g/$m^2$to 16.4 g/m^2 and the WCE was up to 94.7 % on 60 DAS. The seed cotton yield was significantly enhanced under drip system with the yield level from 4015 to 5155 kg/ha as against 3569 to 4430 kg/ha under conventional method. Hand weeding thrice recorded the highest (4793 kg/ha) seed cotton yield and was on par with herbicide rotation + HW and herbicide mixture +HW.

4.14: Soil Microbiology

Nagpur

Impact of transgenic cotton on soil microbial population

Two field experiments one each in shallow and

Table 4.21: Productivity, water use efficiency and profitability of different genotypes of south zone

Genotypes	Seed cotton yield (kg/ha)	Bartlett index	Water productivity (Rs/m^3)	WUE (kg/ha-mm)	ENUE (kglRs)	PFp (kg / kg)	Gross Return (Rs/ha~	Net Return (Rs/ha)	B:C ratio
RCH2Bt	2884	0.71	14.6	5.6	1.2	16.0	74979	45213	2.52
RCH 2Bt11	2931	0.67	14.8	5.7	1.2	16.3	76211	46208	2.54
RCH 20Bt	3039	0.59	14.0	5.4	1.3	16.9	79004	48464	2.59
RCHB 708 Bt	3975	0.53	22.0	6.5	1.7	22.1	135163	99939	3.84
MRC 6918Bt	2670	0.75	16.1	4.7	1.1	14.8	90781	62084	3.16
BUNNYBT	1962	0.81	11.8	4.2	0.8	10.9	54925	29770	2.18
MALLIKABt	2982	0.81	18.0	6.4	1.3	16.6	83487	53231	2.76
THULASI 9 Bt	2895	0.76	17.5	6.2	1.2	16.1	81061	51239	2.72
DCH32	3039	0.53	16.8	4.9	1.3	16.9	103324	66433	2.80
SURABHI	3126	0.42	15.5	5.5	2.0	26.0	87516	50888	2.39
MCU5VT	2248	0.47	11.2	4.0	1.4	18.7	62957	31591	2.01
SVPR2	2271	0.43	9.7	4.0	1.5	18.9	54496	22997	1.73
NARASIMMA	3176	0.50	14.6	5.6	2.0	26.5	82585	45652	2.24
LRA 5166	3085	0.45	13.1	5.5	2.0	25.7	74043	37657	2.03
CCH 510-4	3336	0.49	15.4	5.9	2.1	27.8	86743	48851	2.29
CD 5%	443								

medium soil have were conducted to assess the impact ofBt cotton on soil microbial community at different stages (sowing, flowering, boll formation, harvest). It was observed that there are no much population changes in general (bacteria, fungi, actinomycetes and yeast) and physiological (azotobacter, PSM, fluoroscent pseudomonads and *Beijerinkia)* groups between Bt and Non-Bt cotton in all the stages (Fig. 4.16 & 4.17). The flowering stage recoded maximum population compared to other stages. Their population was found to increase with flowering with a decline towards harvest.. Medium deep soil recorded higher population count as

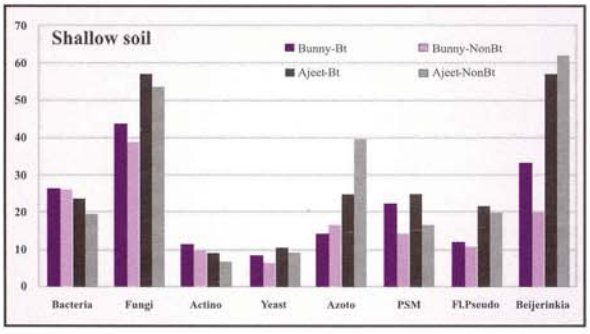


Fig. 4.16 : Per cent microbial changes in Bt and Non-Bt cotton - shallow soil (mean over stages)

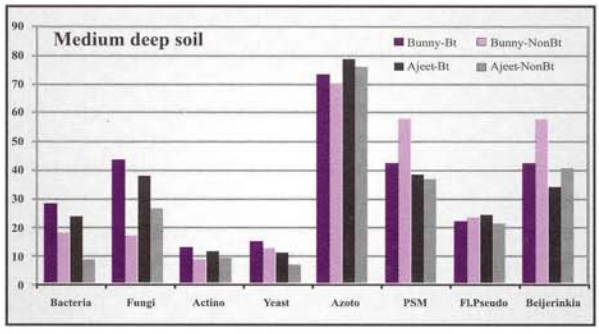


Fig. 4.17: Per cent microbial changes in Bt and Non-Bt cotton-Medium deep soil (mean over stages)

compared to shallow soil.. Among cotton hybrids, Bunny Bt recorded slightly higher microbial population as compared to BG-II cotton (Ajeet).

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

Three different methods of microbial delivery were taken up to study the survival and retention of applied bio-inoculants in cotton rhizosphere. Under the seed treatment, the bio-inoculants were applied as microbial suspension @ 10^8 cells/ml, while in the soil application method the treatment was simulated with FYM as carrier material with the cell load of 10^8 cells/g following standard procedure. The third treatment i.e. the newly identified solid carrier was impregnated with bio-inoculants *viz., Azospirillum* spp., *Bacillus polymyxa* and *Azotobacter* spp. and applied at the cotton rhizosphere. Results indicated that till 3 DAS, seed treatment retained maximum bio-inoculants population followed by soil application, but at later stage i.e. 60 DAS, the new identified solid carrier based delivery system recorded higher bio-inoculants count (Fig. 4.18).

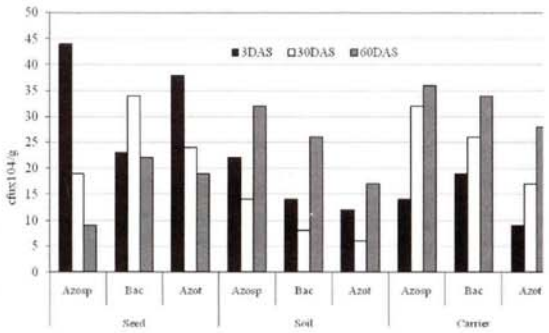


Fig. 4.18 : Effect of delivery system on survivability of bioinoculants in the cotton rhizosphere

4.15: Cotton Simulation Modelling

Coimbatore

The validation of the generic simulation model INFOCROP using the daily weather data and the data on biomass partitioning, leaf area index, incidence of insect pests, collected from 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, Results indicated that the root mean square error between the observed and simulated seed cotton yield was 333, which corresponds to 17.5% of the mean observed seed cotton yield. The index of agreement (D index) between the observed and simulated seed cotton yield was 0.52. The mean systematic error (MSEs) and the mean unsystematic error (MSEu) were 63720 and 111208, respectively.

INFOCROP can serve as a useful tool in taking critical decisions with respect to optimization of input use and assessing the global warming potential (emission of green house gases expressed as CO_2 equivalent = CO_2 + 21 x CH_4 + 310 x N_2O). It was observed that there was significant reduction in water use efficiency of cotton but significant increase in global warming potential and carbon efficiency (g CO_2 equivalent green house gas emission/ kg seed cotton yield) with the increase in the level of irrigation (Table 4.22). There was a trade-off between the cotton production and global warming potential estimated by the model.. This calls for efficient use of water to reduce the global warming potential..

4.16: Cotton Mechanization

Nagpur

Development of a novel 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 was 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 em giving 20 sprays with a single charge.

Defoliation of cotton plant for mechanical picking:

Nagpur

Since defoliation of cotton plant is a pre-requisite

Table 4.22 : Trade-off between cotton production and green house gas emissions (Pooled over 2006-07 to 2008-09).

Treatment	Seed cotton yield (kglha)	Water use efficiency (kglha-cm)	Global warming potential (kg CO/ha)	Carbon efficiency (g CO/kg SCY)
Irrigation				
Control (Protective irrigation)	1974	48	4572	2374
0.6 IW/CPE	1873	36	5862	3137
0.8 IW/CPE	1746	30	6210	3456
1.0IW/CPE	1947	29	6492	3521
Nitrogen				
Control	1662	31	5554	3406
60 kg N/ha	1926	36	5756	3040
90 kg N/ha	2005	37	5850	2980
120 kg N/ha	2046	38	5976	2963

for clean machine picking, defoliants Ethrel and Dropp alone and in combination with Roundup to suppress re-growth, at 3000,5000 and 7000 ppm concentrations were evaluated on Bunny Bt at three different spacings of 90x60, 90x30 and 90x20 em. Ethrel at 7000 ppm concentration gave the highest percentage of leaf shedding of 91% at the widest spacing of90x60 em.

Sirsa

The effect of foliar spray of 1500 ppm, 2000 ppm and 2500 ppm concentration of defoliant (ethrel) at 145 days after sowing and 160 DAS was evaluated. Compared to unsprayed crop, the crop sprayed with ethrel @ 1500 ppm at 145 DAS had a lower number of green leaves at harvest, a significantly higher boll number plant (42.1) and a significantly higher seed cotton yield (2855 kg/ha).

4.17: Morpho-frame/Boll Load Management

Nagpur

Bt morphoframe manipulation using action specific chemicals

Five Bt hybrids namely RCH 2 Bt, JKCH 99 Bt, NECH 2R Bt, NCS 138 Bt and NCS 145 Bt were tested. Chemical and mechanical treatments included (i) 5.7 millimolar ethrel foliar spray, (ii) 8.5 millimolar, (iii) mechanical removal of square (once) at 30-35 days days after sowing alongwith control.. Amongst hybrids, NCS 138 had given the highest yield of 1446 kg/ha which was significantly superior over RCH 2 Bt and JKCH 99 Bt. Foliar application of both doses as well as mechanical removal of square gave significantly higher seed cotton yield over control..

In another experiment, four Bt hybrids namely NCS 145 Bt, NCS 145 non-Bt, NCS 145 BG II and XL 708 Bt were tested under four morpho frame manipulating techniques *viz.*, detopping of main stem at different intervals and spray of foliar application of maleic hybdrazide @ 500 ppm at 95 DAS. The results indicated that de-topping treatments as well as maleic hydrazide application did not affect the yield.

Coimbatore

Manipulation of morpho-frame using action specific chemicals

Five entries viz Bunny Bt, RCH2 Bt, NECH 2R Bt, JK CH 99 Bt and NCS 138 Bt and four treatments (foliar application of ethrel @ 5.7 & 8.56 mM control and nipping of squares) was done at 35-40

DAS (square initiation). Sudden drop of all the young squares was noticed within 48 hours after foliar spray of ethylene.

There was 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 75 DAS. These effects synergistically worked and brought about changes in plant ideotype through out the crop growth. Higher plant height, square number, boll number and even the leaf area was maintained at 120 DAS. The effect offoliar application of ethylene @ 8.56 mM (T_3) yielded significantly higher seed cotton yield followed by T_2 (5.7 mM ethylene), T4 (mechanical removal of squares). All these treatments were significantly superior over the control (T J

Manipulation of morpho frame though nipping at grand growth stage and mimic the effect using using action specific chemicals- Maleic hydrazide in cotton.

The cotton genotypes - DCH 32 and RCH 708 XL (Bt) out yielded Suvin (Table 4.23). Application of Maleic hydrazide @ 500 ppm changed the plant morphology with reduced internodal elongation. Improved LAI with better LAD and there was a significant improvement in seed cotton yield (Table 4.23) De-topping (T2 & T3) and control (Tl) were on par with one another.

Table 4.23: Effect of morpho frame manipulation techniques on seed cotton yield in different cotton genotypes

Genotypes	Yield (kg/ha)
Vl:DCH32	2185
V2: RCH 708 XL	2055
V3: Suvin	935
CD5%	291
Morphoframe manipulating techniques	
Tl: Control	1691
T2: De-topping of main stem at 85 DAS followed by nipping of sympodia and monopodia at 95 DAS	1728
T3: De-topping of main stem at 95 DAS followed by nipping of monopodia and sympodia at 105 DAS	1420
T4:F oliar application of Maleic hydrazide @ 500 ppm at 85 DAS	2061
CD5%	404

4.18: Studies on Abiotic Stress

Coimbatore

Effect of water logging on morphological, biochemical and yield attributes:

Four Bt cotton hybrids namely Bunny, RCH 20, RCH 2 and Mallika were subjected to prolonged water logging for 20 days in 55 days old crop. Plant height was significantly retarded upto 70 days after sowing, irrespective of the Bt hybrids, recording 45 cm in water logged plants compared to 60 cm in control plants. Similarly, reduction of 31 % in leaf production was observed consequent to water logging as observed on 70th day. Water logged plants could produce only 10 squares compared to 17 in control plants regardless of the hybrids studied. At harvest, only 22 bolls were produced by plants subjected to water logging treatment compared to 25 in normal plants. Among the hybrids, Mallika cotton produced more number of bolls. Boll weight was not affected due to water logging. A reduction of 6-12 % in total yield was recorded in plants subjected to water logging. Among the hybrids, RCH 2 and Bunny Bt

were less affected than Malika and RCH 20 due to water logging in terms of total yield with a loss of 6-8 %. Total chlorophyll content started declining from 7 t4 day after logging and the increase was at a faster rate after 14th day of water logging (Table 4.24). Similar trend was observed for nitrate reductase activity.

When water logging was withdrawn, chlorophyll content recovered at a faster rate after 14 days. Interestingly, nitrate reductase activity appeared to be more in water logged plants to compared to control plants during recovery period after withdrawal of water logging treatment in Bunny cotton.

Table 4.24: Effect of water logging on Chlorophyll and NR activity

Bt cotton	Treatment	Days after water-logging			Days after recovery		
		7	14	21	7	14	21
		Chlorophyll content (mg/g)					
Bunny	control	3.32	3.30	3.28	3.32	3.37	3.40
	water log	3.00	3.15	2.53	2.75	3.18	3.28
RCH 20	control	3.42	3.46	3.41	4.34	3.34	3.36
	water log	3.40	2.96	2.81	2.76	3.02	3.30
CD 5%		0.08			0.15		
		Nitrate reductase activity (u mol NO_2 g fr wt)					
Bunny	control	4.99	5.04	4.98	4.48	4.44	4.45
	water log	5.34	4.03	2.75	4.80	4.81	4.77
RCH 20	control	4.51	3.81	2.36	4.34	4.37	4.37
	water log	4.46	3.79	2.29	4.74	4.84	4.68
CD 5%		0.22			0.14		

Alleviation of water logging stress by nutrient application:

Among other treatments, Hoagland solution of 50% strength as foliar application during water logging stress maintained better status of chlorophyll in the foliage. Similarly, during recovery stage after water logging, chlorophyll status was more under this treatment. Better activity of nitrate reductase activity could be maintained by spray of nutrient solution under water logging situation and among the treatments Hoagland 50 % appeared to be better. These favorable changes reflected on the productivity attributes at harvest with plants producing 24 bolls compared to 21 bolls per plant in control. Similarly, the yield per plant was significantly higher where Hoagland 50% nutrient solution was sprayed recording a yield of 147 g per plant compared to 127 g per plant in unsprayed.

Development of drought tolerant genotypes with good fibre quality

Fifty advanced culture lines of cotton *(G. hirsutum)* was raised in field and evaluated for drought tolerance during peak flowering stage. Biochemical parameters *viz.,* reducing sugars, amino acid, phenol and physiological parameters like chlorophyll content and membrane stability were analysed in both control and stress plants. The yield per plant and fibre quality was also quantified. Finally, the lines have been separated based on the differential expression of each biochemical factors in control and stress plants.

The difference is expressed as percent increase/ decrease over the control.. Based on these values 50 breeding lines have been rated for drought tolerance. The genotype was rated as tolerant if there was a positive cholorophyll value, negative membrane stability value, higher reducing sugars and amino acid content and less of phenols. These are rated with LRA 5166 which is known as moderately tolerant to moisture stress as a standard. Based on these values the lines DTS 39-08, DTS-44-08, DTS 62-08 and DTS -67-08 were found to be tolerant lines.

4.19: Fibre Development

Coimbatore

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

Two lines of cotton *(Gossypium hirsutum* L.)- MCU 5 and its lint less mutant MCU 5 LL was grown under controlled conditions with optimum agronomical inputs. The flowers were tagged on the day of anthesis and samples were collected only from the tagged plants from anthesis till harvest at regular intervals. Biochemical constituent's *viz.,* reducing sugars, amino-acids, phenols and total soluble protein was estimated in developing ovules at 5 days interval from anthesis to boll bursting. The quantum of total soluble proteins is half of that of normal ovules.

RAPD PCR analysis among the MCU 5 and its mutant MCU 5LL was done with synthetic oligonucleotides of 20 base {5'- CAC AGA ATA TGA TCA CTC GC-3'}. Ovules at -2,0,2,4 and 6 DAA was utilized for the work.. The amiplfied product gave three extra bands of 700, 900 and 1000 kb in MCU 5 LL which was completely absent in lintless mutants. Similarly, there were two extra bands in MCU 5 at 300 and 250 kb.

For the first time isozye banding patterns for important rate limiting enzymes *viz.,* Peroxidases and SOD was attempted (Fig. 4.19).

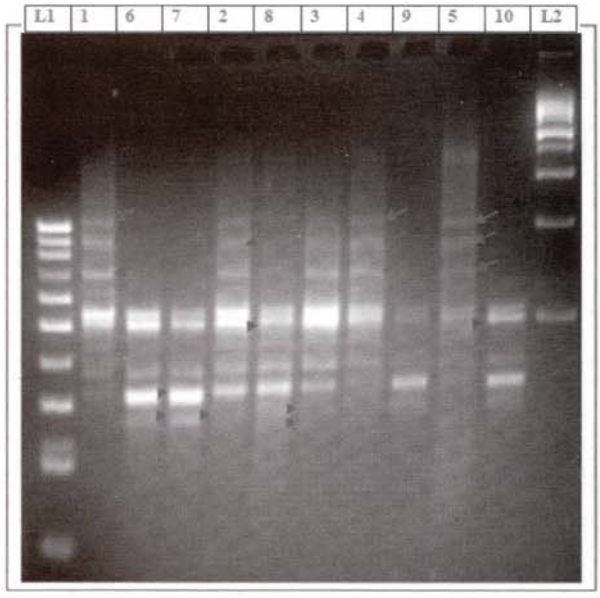


Fig. 4.19: Lane Description:
Ll: 100bp ladder (Chromous cat no. LAD 01)
L2: 500bp Ladder (Chromous Cat No. LAD 02)
1-5 no. is -2, 0, 2, 4 & 6 DAS MCV 5 ovules
6-10 no. is -2, 0, 2, 4 & 6 DAS MCV 5LL ovules

4.20: Socio Economic Dimensions of Cotton Farming

Nagpur

Economic Impact of Bt Cotton Cultivation

Analysis of data ofYavatmal and Wardha district of Maharashtra indicated that 100 per cent of cotton area of sample farms was under Bt cotton. The cost of cultivation of Bt cotton was Rs 13483/ha. The cost of human labour accounted for 38.75% of the total cost.. Cost of seed, bullock labour and fetilizers accounted for 19%, 18% and 11% of total cost respectively. Cost of plant protection chemicals accounted for only 3%. Total cost of production gross and net returns were higher in large and medium farms when compared with small and marginal farms. Human labour consumption was 23%more in Bt cotton when compared with non Bt cotton. Seed cost was 86% more and cost of fertilizers was 83% more in Bt cotton than in non Bt cotton production. Plant protection costs reduced by 81% after adoption of Bt cotton. Seed cotton yield ofBt cotton was 13.16 q/ha where as it was 9.69 q/ha in non Bt cotton. Net returns was 51% more in Bt cotton production when compared with non Bt cotton production.

Economic analysis of cotton based farming system in Vidarbha

The expenditure incurred on hired labour component contributed a major share, ranging from 18.9 to 21.6 per cent, in the total cost of cultivation of Bt cotton and pigeon pea system. This was the highest (Rs. 23164.80/ha) under

medium size group of farm. On an average, the total cost of Bt cotton and pigeon pea was Rs. 22727.55/ ha. The cotton equivalent yield ranged from 15.4 to 17.0 q/ha. This system recorded the highest net return ofRs. 12262/ ha and benefit cost ratio 1.57 in case of medium size group offarm.

Modernization of cotton production on marginal and small farmers in Vidarbha

The data ofNagpur district indicated that in case of marginal size group of farmer, the average land holding per household was 0.79/ha. The male and female family labour available per household was 1.06 and 1.0 respectively. Similarly, in case of small size group of farmers, the average land holding per household was 1.67 ha. The male and female family labour available per household was 1.36 each. Under existing practices the total cost of cultivation of cotton and pigeon pea/ha on marginal and small farm was Rs. 16344 and Rs. 17583 respectively. Whereas, under improved practices it increases to Rs. 20739/ ha. The surplus capital available for working expenses of cotton production was 9.2% higher with small farmers than marginal farmers.

Accessibility to mass media and information Technology

The data was collected from 100 extension workers and 300 farmers (100 each of progressive, less progressive and backward villages) from Wardha and Nagpur districts ofVidharbha region of Maharashtra state. The study indicated a very significant contributions of print as well as electronic media, since majority of extension workers and farmers realized better access to newspapers, farm magazines, radio, TV, Cable TV in cotton related information (Fig. 4.20) . Use of latest media/information technologies like Kisan call centre, mobile/cellular phones, web information/internet is increasing among extension workers as around 40% were occasionally utilizing these for updating their knowledge.

Overall, the utilization of mass media and information technology was medium to high levels by the farmers of progressive and less progressive villages whereas it was medium to low levels in case of backward villages (Fig. 4.21). The farmers were not very satisfied with the coverage, content and time as many times they observed that information not related to their situation, incomplete, complex, costly and not timely.

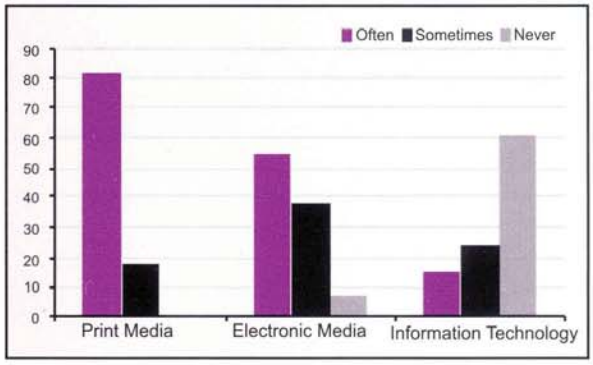


Fig.4.20: Utilization of mass media and information technology (Extension Workers)

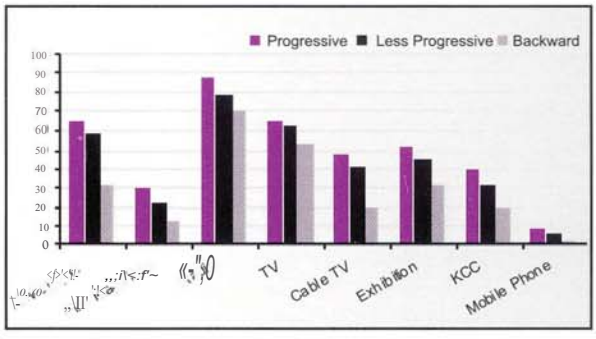


Fig.4.21: Utilization of mass media and information technology (Farmers)

The farmers as well as extension workers suggested that in newspaper, sufficient space may be devoted for cotton related information, the articles be simple, timely and should cover regular tips of cotton IPM. Similarly, the electronic media TV and radio programmes should be timely and attractive, duration of broadcast/telecast be enhanced with stress on success stories of farmers and coverage on market related information. There was a highly significant relationships of variables i.e., education, caste, socio-economic status, innovativeness and availability of mass media and mass media utilization.

Social dynamics of cotton production in distress areas

Analysis of the data collected from 200 sample farmers from 40 villages in distress district Wardha and Yavatmal in Vidarbha indicated that majority of cotton farmers from region had high

level of alienation (71.5 %). This alienation arises because of high degree of powerlessness, meaninglessness, isolations and self estrangement. They felt high powerlessness because of non-availability of capital/credit and lack of economic support from friends/relatives. Cotton farming becomes meaningless due to non availability of guaranteed remunerative price of the produce. They also feel that cotton farming is trapped in the vicious circle of uncertain rains and drought. The feeling of isolation is because majority of them lead a stressful life and they fail to obtain moral support during crises. The repeated cotton crop failures leading to poor financial condition and the cotton grower's feeling of high self estrangement that their work as a farmer is not rewarding compelled them to make serious reduction in the area under cotton farming and opt to some other crop which requires low input costs.

The social dynamics indicated that large proportion belongs to rainfed land holding (70.5%), around 40% percent were under low annual income category (Rs.25,000/- only). Expenditure on events per annum was observed to more by Rs.15274/- over net income and three-forth respondents (76.5%) have single cropping patterns. It was found that the income of the farmers is declining and falling short of expenditure to the tune of39%. The majority of the farmers (88%) in the study area were indebted and most of them had taken loan from various credit agencies for agriculture purpose and to meet family expenditure but could not repay the loan because they are incurring more on expenditure for household activities than income realized from agriculture.

Coimbatore

Documentation and validation of farmers' indigenous knowledge on farming system approaches in cotton

Eight types of integration with nine components were documented among 60 farms in western zone of Tamil Nadu (Salem, Erode and Coimbatore district). Traditionally majority of them. (43.33 per cent) had been adopting "cotton + other crops + Dairy" farming system approach. Due to the introduction of contract farming in poultry industries, 10 per cent of them were adopting cotton + Maize + poultry farming system. Due to the interventions by development departments, the components *viz.,* biogas, sericulture, vermiculture and farm machineries were introduced in some of the farms (46.67 per cent). 43.33 per cent of the respondents who adopt integration of cotton (1 acre) followed by sorghum with dairy (2 cows) had an average annual net return. of Rs.31562/- and employment generation of977 man days per year. Among the various integration types observed, integrating cotton (1.0 acre) with dairy (3 jersey cross bred), biogas (4m^3 capacity), vermicompost (800 square feet), sericulture (1000 square feet) and farm machinery (one tractor running for 150 days) resulted in the highest productivity of Rs. 2,05,500 (net return) and 1265 man days (employment generation). 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). Experience in cotton farming for many years, big farm size, high annual income, high level of socio-economic status, good contact with extension agencies, high level of mass media exposure, high level of risk orientation and economic motivation were the factors that influenced the cotton growers for diversified farming.

Post evaluation of Farmers Field Schools (FFS) on cotton

During the year, using semi- structured interview schedules data on changes introduced by FFS on knowledge and decision making of cotton growers were collected from one hundred farmers from ten FFS (ten farmers in each FFS) in Coimbatore and Salem districts of Tamil Nadu and fifty farmers in five FFS of Dharwad district of Karnataka were collected. To find the changes in knowledge after attending FFS, teacher made knoweldge test was used. Three scores were derived from the farmers' ability to identify (identification score), define (functional score) and to describe (ecological score). Separate set of questions were asked to find out the changes in their decision making behaviour. To find out the changes in their adoption behavior, adoption quotient was used. The study indicated that after attending the FFS,

the beneficiaries had high identification knowledge score (5.5), functional knowledge score (5.4), ecological knowledge score (4.4) and decision making score (4.5). There were significant changes in their adoption behaviour *viz.,* adoption of more number (5.6) of new varieties and hybrids, reduction in number of irrigations (4.3), weeding operations (2.6) and pesticidal sprays (1.5). 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.

Comparative analysis of conventional, biotech and organic cotton production systems

Data collected from 120 Bt cotton fanners in Salem and Coimbatore districts of Tamil Nadu indicated that nearly half of the Bt cotton growers had high level of awareness about the cultivation aspects. More than one third of them (35.83 %) had known the how-to-do aspect of the various practices. 29.16 % of them had known the principle behind each practice recommended. Majority of them (52.50) fell under the category of low level with regard to extent of adoption of cultivation practices in Bt cotton. Majority (87.00 %) of them perceived that Bt cotton technology was efficient, economically feasible, physically compatible with other technologies existing in the farm, with visible results, with continuity and complexity. High cost of the seed, inadequate knowledge on Bt cotton's control over all pests, inadequate knowledge on ETL of different cotton pests, inadequate training in cultivation of Bt cotton, inadequate technical guidance from extension workers, no special price for kapas ofBt cotton, propaganda of NGO against Bt cotton varieties were the constraints expressed by the Bt cotton growers in Bt cotton cultivation.

An empirical analysis on cultivation ofbt cotton by growers with regard to insect resistance management (IRM) technologies

To find out the Bt cotton farmers' attitude towards IRM technologies in Bt cotton, a scale was constructed following the Equal Appearing Interval (EAI) method. Attitude was operationalised as the mental disposition of the respondents about IRM technologies in Bt cotton in varying degrees of favourableness and unfavourableness.

A total of 48 statements concerning the psychological o]jject were collected and edited. These were subjected to 30 judges and the scale and Q values were computed. Considering the time limitation from farmers' point of view, ten statements were finally selected based on scale and Q values. Along with the attitude scale based on the literature, other independent and dependent variables were operationalised. Using the scales and the variables the interview schedule was constructed. Pre-survey was conducted among 30 farmers and accordingly the schedule was modified.

Economic analysis of contract farming **in** cotton **in** Tamil Nadu

In Tamil Nadu, Super Spinning Mills is taking up contract farming of organic cotton in the form of centralized model at Vazhukkuparai of Madukkarai block in Coimbatore district.. This is the second year of the project on organic farming. Around 35 cotton farmers are part of this programme. The gross returns were Rs.22484/- per ha in organic cotton as against Rs.33359/- per ha in Bt cotton in the same area. With regard to cost of production, it was almost at par with each other to the tune of Rs.2450/- per quintal.. The organic cotton field is yet to reap its economies of scale.

Adoption, impact and returns to research investment on improved cotton cultivars **in** Tamil Nadu

Six districts *viz.,* Coimbatore, Dharmapuri, Salem, Madurai, Theni and Villupuram were taken up for the study. Average and percentage analysis, Disaggregate analysis, Cost and returns, Multiple regression analysis and Tobit analysis were the tools of study used to analyse the objectives. Education, non- farm income, farm size, irrigation, market distance, presence of private seed sector and district dummies were the independent variables considered for the study. The results indicated that adoption of hybrids from private sector was on an increase. Econometric model suggested that education, irrigation, distance to market centre, distribution of seeds and regional characteristics have significantly determined the probability and degree of adoption. Frontier production function shows that none of the farms in the sample is fully efficient and that there is substantial scope for improving the technical

efficiency of cotton production in Tamil Nadu. The results emphasize the need for strengthening rural education, extension service and provision of modem inputs and credit to the cotton farmers.

Impact of Bt cotton cultivation on farm economy in India

Two districts from Tamil Nadu *viz.,* Coimbatore and Salem were selected for the study. Sixty farmers from each district have been selected for the study. There is a skeweness towards Bt cotton over non-Bt cotton in regard to the number of sprays, thus escalating the cost of pesticide application in non-Bt cotton. This in turn results in a higher total cost of cultivation to the tune of Rs.4OOO/-per ha. in non-Bt cotton. Though there is just three per cent increase in yield, the gross returns is high in case of Bt cotton to the tune of 18.5 per cent.. The cost of production in case ofBt cotton is Rs.1324/q as against Rs. 1713/q in case of non Bt cotton.

4.21: Total factor productivity analysis

Nagpur

During the period of analysis (1980-2004) TFP index in Gujarat ranged from 43.59 in 1987-88 to 362.10 in 1997-98. TFP increased at the rate of 6.11 % per annum. In this state TII decreased at a rate of 1.13 %. Though input use showed a negative growth output increased at the rate of 4.6186 % per annum. This growth in output was mainly due to the growth of TFP. Contribution of TFP to output growth was worked out to be 110 %. TFP of cotton in Maharashtra and it increased at an annual rate of5.32 % during the period of analysis. T01 increase at the rate oD.49 % per annum where as TII increased by 0.52 % only, which is not significant.. The share of TFP in output growth is 86.63 %. In Madhya Pradesh all the three indices showed significant positive growth during the period of analysis. TII increased at the rate of 5.066 % per annum while the output index increased at the rate of 7.92 % per annum. TFP showed a compound growth rate of 5.177 % per annum. During this period TII increased at the rate of3.246 % per annum. Contribution of productivity increase in total output growth was 65.36 %.

Total input, output and productivity indices were worked out for five important cotton growing districts of Marathwada region ofMaharashtra for the period 1990-2008. During the overall period, input index as well as output index showed positive significant growth in almost all districts. Total factor productivity growth was also positiv~ and significant in all the districts except Beed. Contribution of productivity growth to total output growth ranged from 45.22 % to 76.35 %. It was highest (76.35 %) in Nanded followed by Jalna and Parbhani. After the introduction ofBt cotton i.e., after 2002-03 growth rates ofTFP were high when compared with previous period. Similarly total input, output and productivity indices were worked out for five important cotton growing districts ofVidarbha region of Maharashtra for the period 1990-2002. Of the five districts only two districts, Yavatmal and Buldhana registered positive growth in input use. Growth of output index was positive in Yavatmal, Wardha and Buldhana districts while it was negative in Akola and Amaravati districts. Growth of total factor productivity was positive in all the districts except Amaravati. Contribution of productivity growth to output growth ranged from 30.99 % to 121.08 % in this region.

Coimbatore

The growth rate of Total Factor Productivity indices was negative in case of Andhra Pradesh and Tamil Nadu over the years 1980-81 to 2003-04. The TFP Growth was negative and the Total Input Index and Total Output Index has shown positive trend in Andhra Pradesh. In case of Kamataka, the TFP Growth rate was positive whereas the Total Input Index and Total Output Index were negative. In case of Tamil Nadu, Total Input Index, Total Output Index and Total Factor Productivity Growth were negative. Data on household cost of cultivation for Tamil Nadu has been initiated by decoding the CCPC data obtained from TNAU, Coimbatore.

A Value chain for cotton fibre, seed and stalks: an innovation for higher economic returns to farmers and allied stakeholders

Nearly 600 quintal of ELS Bt hybrid (RCHB 708 Bt) *kapas* was produced with uniform quality for value addition research. Impact ofthe project (first year) was assessed and it was found that excess use of seed materials (0.8 kg/ acre) were found in base

line year was reduced to 0.5 kg / acre by following the optimum seed rate and spacing. Fertilizer application was followed as per the soil test; which in-turn. minimized the fertilizer quantity from 256 kg/acre to 216 kg/acre. Labour saving implements and machines were demonstrated which helped to reduce labour requirement. . Family labour utilized is reduced from 39.4 to 23.5, and hired labour is reduced from 50 to 36/ acre of cotton cultivation. The total cost of cultivation computed for base year is Rs. 10,903/acre as compared to first year of the project is Rs. 10,020/acre. Seed cotton yield (7.6 q/acre) is increased at the rate of25 per cent as compared to base value of 6.1 q/acre. The average gross return of Rs. 24,938 and net return of Rs. 14,918 were calculated per acre with benefit cost ratio of2.49. The base-line survey values for gross return is Rs. 18,220 and net return is Rs. 10,903 for acre ofland with benefit cost ratio of 1.67.

4.22: Cotton Information System

Coimbatore

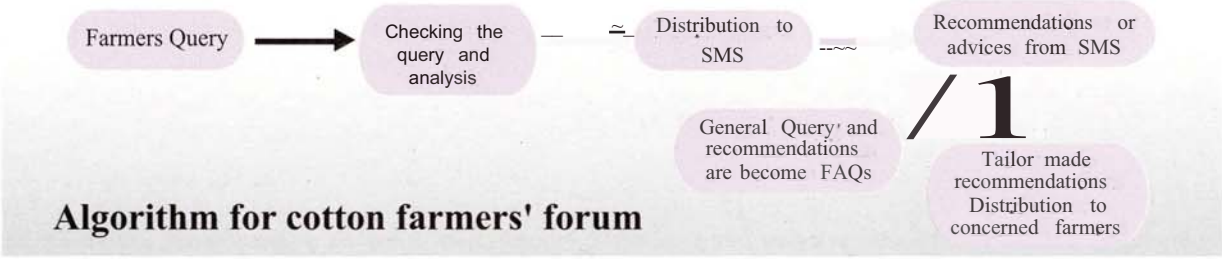
Indian Cotton Portal

Cotton portal (www.cicr.org.in) was periodically updated with latest information from different sources for different stakeholders. Integrated hit counter has been incorporated in our portal, an average of 100 users were visiting our cotton portal every day globally. Many cotton related queries were received from users after visiting our cotton portal.. Cotton portal was indexed in many of the leading search engines like google, yahoo, excite, lycos, dogpile, altavista, ask.com, mamma, webcrawler, etc. Keyword Search tool was integrated in our Cotton Portal to enable the user fetch the specified information from CICR website by invoking keyword search.

A module for Cotton Farmers' forum to be incorporated in our portal has been developed. The algorithm, for the farmers' forum was prepared (below diagram). The user/farmers can raise the cotton cultivation related queries in the forum and will be redistributed to the concerned subject matter specialist (SMS), after getting the recommendations or advices from the SMS the solution will be transmitted to the concerned farmer who raised the query. All the raised queries with appropriate recommendation would be placed under FAQs in the portal for the benefit of other farmers. The user/farmer can have the option to present their query along with any photograph of the symptom of the damage as an attachment so that SMS can have clear vision of the problem. There should be a check after farmers submitting the query and also should impose some condition attachment file to avoid vandalism to the portal..

Information Retrieval System

To strengthen the existing Cotton Information Repository, we have collated many new data sets from various sources which are secondary in nature. Around 25 datasets related to cotton identified for the information system and the Information Retrieval System software were developed with latest version of visual Basic. NET (2008) and for front end and Microsoft Access (2007) as backend. **In** the back end the data sets were stored in structured database. Visual basic. NET framework 3.5 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. Interactive Cotton insect pest CD was developed. The CD was prepared in HTML codes with pictorial representation and information include life history, host plant, dynamics, symptom of damage, control measures, ETL levels etc, the same will be incorporated in cotton portal.. The CD for Package of Practice for cotton cultivation was also prepared for nine cotton growing states.



Algorithm for cotton farmers' forum

CICR

ANNUAL REPORT 2008-09

Parasized mealybug by Aenasius sp

Aenasius sp.

Hardened ovisacs of *M.hirsutus* after predation by *G.perspicax*

Maggot of *G.perspicax* feeding on eggs of *M.hirsutus*

Adult flies of *G.perspicax*

Heavily parasitised colonies of M.hirsutus

4.23: Seasonal Dynamics of Insect Pests and Diseases

Nagpur

Seasonal dynamics of insect pests

Jassids attained pest status during first and last weeks of August and September. Incidence of thrips was restricted to vegetative phase of crop growth with a single peak during first week of August.. Whiteflies and mirid bugs occurred throughout the season with peaks during third and last weeks August and September, respectively. Spiders and predatory mirid bug infestation was higher during September to November.

The American bollworm, *Helicoverpa armigera* oviposition started during last week of July and declined by mid October. There were three peaks of *H armigera* larval incidence at fortnightly intervals between mid August and last week of September. The pink bollworm, *P gossypiella* had its onset during last week of September with its rapid raise from mid November. *Spodoptera ldura* male moth catches were more than five per day per trap between August and October months. December-January months had shown considerable *Harmigera* catches in pheromone traps indicating the onset of infestation on the *rabi* crops.

Mealybug infestation was less severe during the year 2008-09 and did not cause significant damage to the crop in any part of the country. Mealybugs were noticed initially on *Hibiscus rosasinensis* Linn. in the first week of July in Yavatmal District but did not proliferate to infestive stages. Mealybugs were also found to infest weeds such as *Hibiscus sabdarifJa* L., *Abutilon indicum, Parthenium hysterophorus, Xanthium sp., Tribulus terrestris., Sida sp., Trianthema monogyna,* etc., in various parts ofthe country.

Multispecies associations of entomofauna

Significant positive association of jassids and thrips; whiteflies and mirids; spiders with predatory mirids was observed during their temporal occurrence. Whiteflies and thrips had simultaneous occurrence with chrysopids. Temporal association between spiders and mirids was altered upon insecticidal sprays thereby indicating significant effect of insecticides on spiders. The parasitoid *Anaesius bambawalei* (Encyrtidae) infested 58% colonies of the mealybug, *P solenopsis* in cotton-wheat cropping system.

Bollworm damage to Bt and non-Bt cotton

Square and open boll damage ranged between 0 to 5 and 0 to 10% on Bt hybrids as against 3-5 and 11-14% on Non Bt hybrids, respectively. Bollworm damage to squares on Bt-cotton did not exceed 2% on Bt Bunny whereas the boll damage due to *E. vittella* reached 20% and *P gossypiella* damage was less tha5% onNonBtBunny. LRA5166 (non-Bt) suffered greater than 10% square damage due to *H armigera* between mid August to mid October, upto 20% boll damage due to *E. vittella* between mid October and mid November and up to 100% damage due to *P gossypiella* at final picking.

Incidence of diseases

Economic damage to the cotton crop due to diseases was negligible. Disease infection was examined on cotyledonary leaves and bolls of 50 genotypes including Bt cotton. The following pathogens were recorded: *Alternaria macrospore, Cercospora gossypina, Colletotrichum indicum, Helminthosporium gossypii, Macrophomina phaseolina, Myrothecium roridum, Phompsis malvacearum* and *Pestalotiopsis gossypii.* Cotton pathogens *Alternaria macrospora, Colletotrichum indicum, Macrophomina phaseolina, Myrothecium roridum,Phoma exigua and X a. pv. malvacearum* were found in 1-6% seed samples tested.

Coimbatore

Population dynamics of cotton pests and their natural enemies

Aphid population was negligible and a maximum incidence of 510 per leaf was observed during the first week ofJanuary both in Bt and Non Bt RCH 2. Jassids were observed throughout the cropping season and an incidence of 68 jassids per plant were observed during December in RCH 2 Bt and Non Bt. Bunny cotton recorded less incidence (4.5/plant) as compared to RCH 2. Mirid bug incidence was observed during December and a population of 46 per 20 squares was recorded during December. Infestation of mealybug was 100% in unprotected Bunny Bt as compared to 50-60 % in RCH2 Bt and non Bt. In general the infestation of papaya mealy bug, *Para coccus*

marginatus was high in the faml as well as in farmer's field. In addition to cotton, *P marginatus* infestation was observed on *Parthenium hysterophorus, Tridax procumbens, Acalypha indica, Euphorbia geniculata* and *Crotons sparsiflorus.*

Bt cotton was free from bollworm infestation, whereas non-Bt RCH2 and Bunny had heavy incidence of *Helicoverpa armigera* and the incidence was 60-70 % on reproductive parts during mid-December, with a maximum larval population of 4.6 per plant.. Amongst natural enemies only the predatory spiders were recorded throughout the cropping period.

Occurrence and Seasonal dynamics of Emerging pests and Predators

The observation on mealy bug infestation in 50 farmers' fields of five villages revealed that the mean intensity of damage ranged from 1.0 to 1.22 grade, and the per cent infested plants ranged from 55.0 to 83%. The mean infestation of mirid bugs ranged from 68 to 97% and the population ranged 16 to 85 nymphs per 100 squares. In general, the predators' activity (Coccinellids and Spiders) was at higher level in all the villages from first week of September to mid October and later during November - December months (Table 4.25).

Table 4.25: Occurrence and Seasonal dynamics of Emerging pests and Predators in cotton coimbatore District. . Hybrid: RCHB 708 Bt

Villages	Mealybug*			Mirid bug*		Predators *1100* plants*	
	Infested plants o/o	Intensity of infested (Grade)	No.ofgradt 4 plants plants	Infested squares o/o	Nymphsl 100 squares	C.B	Spiders
Kanna-manaya-kkanor	67.50	1.02	0	97.00	85.14	85.88	45.11
Chokkanoor	59.05	1.00	0	81.05	40.02	62.11	16.76
Appachigo-undanoor	55.00	1.00	0	68.70	16.01	58.17	22.23
Thoppam-palayam	65.82	1.15	0	80.76	28.70	45.70	42.64
Nachipala-yam	83.11	1.22	0.06	81.70	77.36	46.11	2.17

C.B: Coccinellid Beetles; * Mean ofl7 weeks observations

Population Dynamics ofmirid bug, *Crenotiades biseratense* under different cropping systems

Occurrence of mirid bug C. *biseratense* was recorded from mid-December onwards up to February. The nymphal population was higher than the adult population during late December and mid-January (ranging from 0.85-2.45 nymphsl 10 squares) and maximum adult population was recorded during 2nd week of January (3.55 nymphs). Low population of spiders was recorded throughout the period except during late February. The percentage of square and boll damage were increasing from mid-January till the period of observation and the percentage of damage varied from 22-34% and 14-50%, respectively.

Population dynamics of cotton mealybug

Population dynamics of mealybug species *viz., Paracoccus marginatus* and *Phenacoccus solenopsis* were observed under cotton + cowpea intercropping system. During initial period (October) of cropping season, *P solenopsis* incidence was high compared to *P marginatus.* From first fortnight of November onwards, *P marginatus* populations increased. The Per cent

Incidence (PI) and Severity Index (SI) was higher in *P marginatus* with a range from 12-100.00% and 1.09-3.05 respectively. Whereas the PI and SI of *P solenopsis* was 17-43% and 1.00 to 1.25 respectively) (Table 4.26).

The population dynamics of *P solenopsis* was recorded under three cropping systems *viz.,* sole cotton, intercropping with cowpea and surrounded by non target crop (Tomato) in farmer fields. Maximum mealybug incidence of 85% was

Table 4.26: Incidence and Severity Index of *Paracoccus marginatus* and *Phenacoccus solenopsis*

Standard Weeks	*Paracoccus marginatus*		*Phenacoccus solenopsis*	
	Per cent Incidence	Severity Index	Per cent Incidence	Severity Index
44	12.00	1.67	24.00	1.25
46	88.00	1.09	17.00	1.18
47	94.00	2.06	33.00	1.00
49	97.00	2.41	30.00	1.00
50	100.00	2.74	36.00	1.00
52	99.00	2.55	43.00	1.00
1	100.00	2.63	41.00	1.00
3	98.00	2.98	36.00	1.00
5	100.00	3.01	34.0	1.00
7	100.00	3.05	38.00	1.00
8	100.00	2.91	40.00	1.00

recorded in both sole cotton and non target cropping system. However, the severity index was higher (1.47) on sole cotton compared to non target system (1.33). Intercrop receiving less PI (75%) and SI (1.42) respectively (Table 4.27). Mealybug incidence was less during the period of September to first fortnight of November. From second fortnight of November onwards mealybug incidence increased in all three cropping system.

Prevalence and distribution of nematodes in Cotton ecosystem

Trophic diversity of nematode in cotton ecosystem was studied. Among different trophic groups present in the rhizosphere of Bt cotton, plant parasitic nematodes contributed maximum (77.15 %) to trophic diversity followed by bacteria feeders (22.25 %). Predator and omnivorous nematode populations were found to be very low. Plant parasitic nematodes consists of six genera, of which reniform nematode, *Rotylenchulus reniformis* recorded the highest absolute frequency of 77.80%. Reniform nematode alone was recorded from the soil and root.

Seasonal dynamics of reniform nematode

Seasonal dynamics of reniform nematode under field condition was studied for three years. Nematode population in the rhizosphere of Bt cotton was found to fluctuate during the cropping season with minimum population during sowing and harvest time and maximum population during mid season. Bioclimatics of reniform nematode in Bt cotton revealed that the nematode population in the rhizosphere is mostly influenced by soil temperature and moisture. Other weather parameters like maximum and minimum temperature, relative humidity and rainfall does not influence the nematode population in soil. Temporal and spatial distribution of reniform nematode in rhizosphere of cotton revealed that the population was more in 0-30 cm depth, which is the optimum depth for the collection of soil samples from cotton. Young feeder roots always supported maximum nematode population.

Table 4.27: Population dynamics of *P. solenopsis* at three cropping systems

Standard Weeks	Sole cotton		Intercrop (Cow pea)		Surrounded by Non target crop (Tomato)	
	Per cent Incidence	Severity Index	Per cent Incidence	Severity Index	Per cent Incidence	Severity Index
39	20.00	1.00	15.00	1.00	15.00	1.00
41	15.00	1.00	15.00	1.00	15.00	1.00
42	5.00	1.00	0.00	0.00	0.00	0.00
43	0.00	0.00	0.00	0.00	0.00	0.00
45	25.00	1.00	25.00	1.00	20.00	1.00
46	85.00	1.47	65.00	1.08	85.00	1.06
48	75.00	1.27	60.00	1.17	75.00	1.13
49	70.00	1.36	70.00	1.21	75.00	1.20
51	70.00	1.29	75.00	1.27	75.00	1.27
1	65.00	1.38	60.00	1.42	60.00	1.33
3	50.00	1.20	40.00	1.38	45.00	1.22

Histopathology of reniform nematode

Histopathological studies of reniform nematode cotton (Bunny Bt) was studied by inoculating 5000 adult females of *R. reniformis* under pot culture condition. The nematodes gain entry through epidermis and penetrate intercellularly as well as intracellularly through the cortex, endodermis and pericycle and reach the phloem where they feed. A passage slightly wider than the nematode body is formed by destruction of cortical cells.

Pathogenicity of reniform nematode on cotton

Pathogenicity of reniform nematode on cotton (Bunny Bt) was studied under pot culture condition for second year. The initial nematode inoculum consists of 0, 10, 100, 500, 1000, 2000,3000,4000,5000 and 10,000 nematodes. At the end of the experiment, plant growth parameters and nematode multiplication was studied. Plant growth parameters were found to decrease with increase in initial inoculum. Economic threshold level for *R. reniformis* in cotton was recorded as 2 nematodes/gm soil. Soil samples collected from the rhizosphere of cotton resulted in the presence of entomopathogenic nematodes in 10 % of the samples.

Sirsa

Occurrence and seasonal dynamics of insect pests

Mealybug infestation in North India was low during 2008-09 and damage to cotton crop was negligible. The mealybug was found to infest at least 47 species of host plants belonging to 24 families. Parasitoids *Aenasius bambawalei* and *Paranathrix tachikawai* were also recorded. The parasitization efficiency of *A. bambawalei* from field collected mealy bugs was 57.0 per cent whereas under laboratory condition it was 60.6 per cent (45-74%).

Survey was carried out in five locations that were previously infested with mealybugs. The weed flora of these location were also examined for the infestation and intensity of mealybug. The infestation of mealy bug started in the month of June-July and reached 32-42% in the month of Aug.-Sept at the five locations. Maximum number of grade-4 (severely infested) plants were recorded in month of September. The surrounding weed flora, *Parthenium* sp., *Abutilon indicum, Sida* sp.and *Helianthus* sp. play an important role in initial infestation as well as the intensity of infested plants

4.24:Biological diversity of insect pests and pathogens

Nagpur

Taxonomic diversity of cotton entomofauna

Eleven species of Hemipterans were recorded in the cotton ecosystem. Of these, one was of Lygaeidae *Geocoris ochropterus* (Fieber), three of Miridae *(Campylomma livida* Reuter, *Creontiades biseratense* Dist. *Hyalopeplus lineifer* Walker), four ofPentatomidae *(Nezara viridula* (Linnaeus) var. *torquata* (Fabricius), *Nezara viridula* (Linnaeus) var. *smargdula* (Fabricius), Plautia *frimbriata* (Fabricius) and *Piezodorus rubrofasciatus* (Fabricius) and four of Pseudococcidae, *Phenacoccus solenopsis* Tinsley, *Maconellicoccus hirsutus* (Green), *Nipaecoccus viridis* Newstead and *Paracoccus marginatus* Williams and Granara de Willink.

Three species of Hymenopteran parasitoids *Aenasius bambawalei* Hayat (Encyrtidae), *Promuscidea unfasciativentris* Girault (Aphelinidae) and *Aprostocetus bangaloricus* Narendran (Eulophidae) on *P solenopsis,* five encyrtids *viz., Encyrtus aurantii* (Geoffroy), *Prochiloneurus pulchellus* Silvestri, *Anagyrus dactylopii* (Howard), *Anagyrus mirzai* Agarwal & Alam and *Homalotylus albiclavatus* (Agarwal) and one each of Aphelinidae *Promuscidea unfasciativentris* Girault), Signiphoridae *(Chartocents kerrichi* (Agarwal), Pteromalidae *(Pachyneuron leucopiscida* Mani) and Eulophidae *(Aprostocetus bangaloricus* Narendran) on *M. hirsutus* in cotton +pigeon pea cropping system was documented. Coccinellids (Coccinellidae: Coleoptera) *viz., Brumoides suturalais* (F.), *Cheilomenes sexmaculata* (F.), *Scymnus castaneus* Sicaid and *Cryptolaemus montrouzieri on P solenopsis* and *Gitonides perspicax* Knab (Drosophilidae;Diptera) on *M hirsutus* were found as predators.

Microsatellite DNA fingerprinting studies on Fusarium

Forty different isolates of *Fusarium oxysporum* were categorized on the basis of virulence, species-specificity, growth, pigmentation etc. SSR primers were designed and synthesized from SSR motifs of nine different loci of *Fusarium* genome. Further, different isolates were subjected to SSR-PCR.. The polymorphism obtained revealed that these primers are sufficient for studies on genetic diversity inF *oxysporum.*

Diversity and distribution of Tobacco Steak Virus in Cotton

Leaf samples showing symptoms of virus infection, were collected from different locations in Punjab (Abohar, Bhatinda), Haryana (Sirsa, Hissar, Fatehabad), Rajasthan (Hanumangarh, Shriganaganagar), Maharashtra (Nagpur), Andhra Pradesh (Warangal, Karimnagar, Hanamkonda) and Tamil Nadu (Coimbatore, Erode). RNA was extracted and RT-PCR was carried out using TSV specific primers: TSV1F-5'GCC ATG TCT TCC CGT ACC GAC AA3, TSV1R-5'TTC TGG TGG CAT CAA GGG AGC TG3, TSV2F-5'GCT TCT CGG ACT TAC CTG AGA T3, TSV2R -5'CCA CAT CGCACACAAGTATTA C3'. The presence of Tobacco streak virus (TSV) was confirmed on six Bt hybrids (RCH2 Bt, Brahma Bt, Nirja Bt, Dyana Bt, Sigma Bt, Mallika Bt) and two non-Bt pre-released hybrids (Waranga1 HH2 and Warangal HH3) in samples collected from Andhra Pradesh.

Coimbatore

First record of a new mealy bug species infesting on cotton

The papaya mealy bug, *Paracoccus marginatus* Williams and Granara de Willink, was recorded in a severe form for the first time on cotton in Coimbatore. Infestation of *P marginatus* was observed on G. *arboreum* and G. *hirsutum* species and Bt cotton under field conditions. It was observed that severe infestation lead to stunted growth and drying of the sympodial branches .The mealy bug infestation was observed as clusters of cotton-like masses on the leaf, squares and bolls. The adult female is yellow, covered with a white waxy coating and measures approximately 2.2 mm long and 1.4 mm wide. A series of short waxy caudal filaments less than one-fourth the length of the body exist around the margin. Eggs are greenish yellow and are laid in an ovisac that is three to four times the body length and entirely covered with white wax .The ovisac is developed beneath the adult female.

4.25: Isolation and identification of new genes and gene sources for pest management

Nagpur

Novel genes for control of sucking pests

Amongst five new lectins tested for toxicity to aphids, soybean agglutinin was found to be the most effective with mortality levels exceeding >99% by the end of the 4th day. Banana lectin caused 100% mortality after 6 days. Artocarpin andjacalin were also found to be effective. After 6 days of feeding on the lectins, mortality levels exceeded 60% with jacalin and 88% with artocarpin. A novel bioassay was developed to evaluate the efficacy of lectins on cotton aphids *(Aphis gossypii)*. Eight diet recipes (four published diets and four new recipes) were formulated and tested on *Aphis gossypii* and *Myzus persicae*. A new diet recipe was found superior to all the diets tested and was found to sustain aphids for more than 20-30 days without any mortality.

Isolation and characterization of insecticidal toxins from heat tolerant Entomopathogenic nematode-bacterial system

Entomopathogenic nematodes owe their efficacy to a great extent to associated bacterial symbiont. The toxin was found to be heat labile and lost its insecticidal activity at 60°C. The bacteria exists in two phases, primary phase is toxin producing while secondary phase is less effective in toxin production. Primary and secondary forms of bacterial symbiont of *Heterorhabditis indica* were isolated on differential media as NBTA and McCone Agar. Protein profile of two phases of the bacterium was resolved on 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.

The extracellular and intracellular fractions of both the phases of bacterium were separated into fractions using Pall (lK, 3K,IOK,50K and lOOK) and Biorad columns. Protein content of different fractions was estimated and found to range between 1,32 -1,68 mg/ml. The fractions were tested against 3'd instar larva of *Helicoverpa armigera* for insecticidal activity. Observations on insect mortality after 24 hrs revealed that fraction >50 KDa recorded more than 98% mortality after 24 h while 10K fraction recorded 60% morality. 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. The 50K was also recorded to have oral toxicity.

4.26: Development ~f new methods, tools and protocols

Nagpur

Low cost insect cages designed to conduct laboratory bioassay

Low cost insect cages were designed and constructed with PVC pipe and muslin cloth. The cages can be used to conduct laboratory bioassay on insects, especially sucking pests on cotton plants. The length and breadth can be interchangeable according to the requirement. These cages are light in weight (Approx. 500 gm), easy to assemble and dis-assemble, easy to pack and transport and can be stored in a packed condition when not in use. The raw material for making one cage costs about Rs. 180.

Laboratory rearing of the mealybug *Phenacoccus solenopsis*

Mealybug rearing was standardized on sprouted potatoes. Medium sized sprouted potatoes (Approx 5-10 cm length and 5-8 cm breadth) are ideally suited for rearing. The potatoes are placed on 2-3 cm layer of black cotton soil mixed with vermicompost in a plastic container (8-10" diameter and 12" height). An initial inoculum of5-10 gravid mealybug females is adequate. A temperature range of20 _35°C is the most suitable for rapid proliferation. During summer months temperature can be maintained with help of air coolers or air conditioners. Potato sprouting was done in BOD incubators at 20°C for 10 days and thereafter at room temperature.

Lab multiplication of mealybugs was tested on 10 locally available media. Material used were Newspaper, dried cotton stalks, potato sprouts, honey, agar tablets, parthenium stalks, fresh cotton leaves and fresh hibiscus leaves. Results showed that sprouted potatoes are good source of nutrients for mealybug multiplication.

Development and validation of PCR- RFLP tools for the identification of *Phenacoccus solenopsis*

PCR amplified fragments of 28s rDNA and 18s rDNA from *Phenacoccus solenopsis* were sequenced and compared with the sequences of *Phenacoccus solani.* At least three unique restriction sites were identified for the two species. BSR GI was found to selectively restrict the PCR-RFLPproductobtained with the 28s rDNAprimers using the DNA of *P. solenopsis* at the 135bp position resulting in the appearance of two bands on the gel, while did not have a restriction site in the amplicon of *P solani.* BsiWI selective restricts the 28s rDNA PCR product of *P solani* at the 170bp position giving rise to two bands and does not have restriction site in the amplicon of *P solenopsis.* Tat 1 digests both *P solani* and *P. solenopsis* at different positions- giving 3 bands with *P solenopsis* cutting the 700bp PCR-RFLP fragment at 135 and 534bp positions while restricting *P solani* at only 1 site at 544bp position resulting in 2 bands on the gel.

Planococcus ficus primers designed to amplify the CoI region were effective in deriving the nucleotide information of a 200bp fragment for studying the CO 1 region of *P. solenopsis* from 14 locations. Two haplotypes with reference to the CO 1 mitochondrial genome were identified (Fig.4.22).

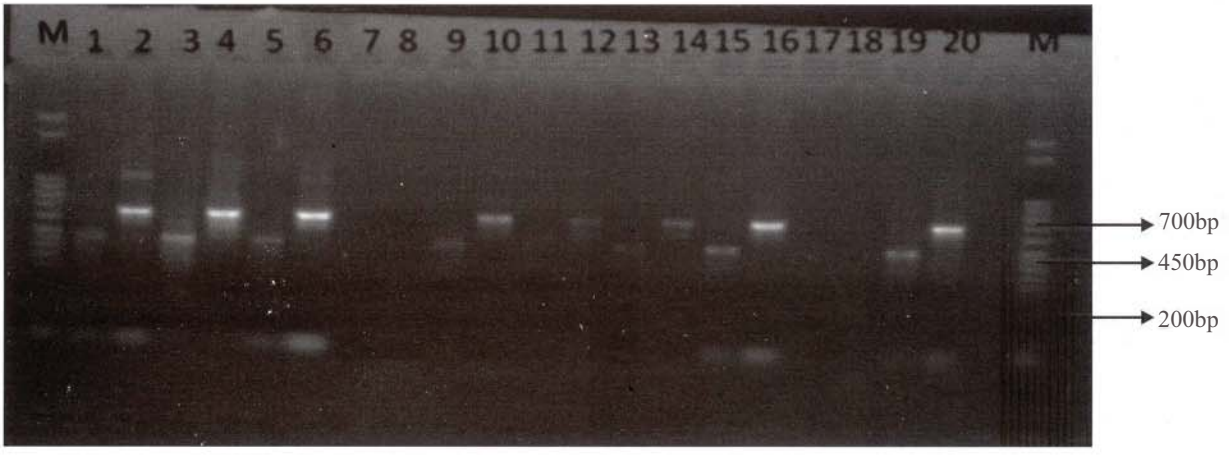


Fig.4.22: Molecular tools for the identification of *P. solenopsis*
PCR RFLP with BSR GI restriction enzyme on PCR production obtained with 28s rDNA
It can identify *P solenopsis.*
It can putatively differentiate *P solenopsis*
Even numbered lanes are undigested PCR products, using 28 srDNA primers with the genomic DNA from mealy bugs collected on cotton across the country (10 locations) as control, for the odd numbered lanes that are the enzyme digested products.

Development of kits to detect GM crops

A database has been developed to enlist all genes, markers, promoters, traits and crops that have been released for commercial cultivation in India and elsewhere in the world. The database includes genes, markers, promoters, traits and crops. Locus specific tests have been designed for all the approved transgenic events of cotton based on sequences flanking trans gene inserts. The tests are being used under the Event Based Approval Mechanism through a standing committee of the GEAC. ELISA has been developed for NPT-II, UID-A, and *cry1F.*. Antiserum has been raised against *crylC,cry2Ab* and VIP-3A. Immunochromatographic 'dipstick' kits have been developed for *cry1F* and NPT-II. A colorimetric GUS test has been developed for UID-A. Kits are being developed using two different polyclonal antisera against pat and NPT- II to detect GM crops with kanamycin and bialophos resistance. Real-Time PCR was standardized for MoN-531 and MoN-15985.

4.27: Host-Plant resistance to insect Pests and Diseases

Nagpur

Cotton cultivar association with emerging pests

Thirty five Bt-cotton hybrids from four Bt events ofMon 531 *(cry* 1Ac), Event 1 *(cry* 1Ac), GFM *(cry* 1Ac+cry 1Ab) and Mon 15985 *(cry* 1Ac+cry 2Ab) were evaluated in a replicated trial along with five non Bt cultivars to study the association of emerging and key sucking pests under completely unprotected conditions. Six Bt-cotton hybrids, ACH 33, Brahma, Mallika, RCH 386, VICH 111 and NECH 2R were found to be susceptible to jassids, while 19 were moderately tolerant and the rest, ACH 155, MRC 6301, MRC 7301 and JKCH 226 were tolerant.. All the cultivars harboured mirid bugs between 60 and 80 DAS. While the Bt-cotton hybrids ACH 155, GK 205, Mallika, PCH 155, VICH 5, KDCH 441, MRC 7301 and MRC 7326 and non-Bt cotton hybrids, Ankur 651 and JKCH 226 did not have early season incidence. The hybrids MRC 6301 Bt and Ankur 651 (non Bt) did not support late season mirid development.. Occurrence of *Spodoptera litura* laIvae was seen at least on one occasion in some of the Bt-cotton hybrids (Ankur 09, Bramha, GK 205, Jai, Mallika, RCH 118 andRCH377) between 45 and lOODAS.

Infestation of pink bollworm *Pectinophora gossypiella* on Bt-cotton hybrids

Infestation of *Pectinophora gossypiella* was recorded on 10 Bt hybrids and 7 non-Bt hybrids (RCH 2 Bt, RCH 2BG II Bt, RCH 530BG II Bt, RCH 533 BG II Bt, MRC nOIBG II Bt, MRC 7347 BG II Bt, MRC 7351BG II Bt, Bunny BG II Bt, ACH 11 -2 BG II Bt, ACH 33-2 BG II Bt and RCH 2 NBt, RCH 530 NBt, MRC nO 1NBt, MRC 7347 NBt, MRC 7351 NBt, Bunny NBt). In general, pink bollworm infestation was low during the the season. Infestation started during November on non-Bt hybrids only and continued upto Feburary. The locule damage ranged from 0,40-2.36 and 3.84-7.08 in Bt and non-Bt hybrids respectively.

Coimbatore

Alternate Hosts of cotton mealybug

Nineteen weeds were recorded as alternate hosts for cotton mealybug. Initially *Para coccus marginatus* recorded 100% incidence on *Parthenium hysterophorus* and continued throughout the cropping season with an average SI of2.95 followed by *A. indicum* with an average SI of 1.63. On the other hosts, *Abutilon indicum, Phyllanthus niruri, Tridax procumbense* and *Commenelina bengalensis* the intensity was severe at the end of the cropping season. The incidence of *P solenopsis* was found to be 100% on alternate hosts such as *P hysterophorus, A. indicum, P neruri* and *T. procumbense,* at the end of the cropping season. However, maximum average SI (1.56) and PI (69%) were recorded *onA. indicum.*

Cultivar association with insect pest resistance / susceptibility

Out of78 Bt-cotton hybrids (54 with crylAc and 24 with crylAc+ *cry* 2Ab) evaluated for their resistance against major sucking pests, four hybrids (PCH 2270 Bt, PCH 205 Bt, PCH 923 Bt, andACH 33 1Bt) recorded low intensity of mealy bug damage. Two Bt hybrids, Rudra Bt and JK Iswar Bt recorded low population of mirid bug (1.38 to 1.44 / 5 squares) while the check entry RCH 2 Bt had 6.77 mirid bugs per 5 squares. Four Bt hybrids, ACH 33 1 Bt, ACH 33 2 BG II, ACH 155 1 Bt and ACH 155 2 BG II) were tolerant to jassid infestation and recorded 0.1 to 1.0 grade of Jassid injury. Out of 24 Bt-cotton dual-gene (*cry* 1Ac+ *cry2Ab)* hybrids evaluated for their resistance against mealy bug damage, two Bt hybrids, NCS 854 BG II (0.7) and RCH 530 BG II (0.8) recorded less than one grade infestation as compared to the check entry RCH 2 Bt which had 1.66 grade of infestation. Based on injury grade, three BG II Bt hybrids (ACH 6 BG II, ACH 177 BG II and ACH-Ill-ll BG II) were found to be tolerant to Jassid infestation and recorded less than one grade injury due to Jassids as compared to the check entries NCS 207 Bt (Mallika) and non-Bt DCH 32. Four Bt hybrids, MRC nOI BG II (1498 kg Iha), MRC 7347 BG II (1365), ACH-Ill-ll BG 11(1358), ACH-6 BG II (1358) with low level damage of mealy bug and mirid bug recorded significantly higher yield over rest of the entries.

Sirs a

Determining cultivar association with emerging pests

Cotton crop harboured maximum infestation of mealybugs in the month of October. The mean maximum plants infested with mealybug were

recorded in RCH-308 (48 per cent) where as the minimum were in JKCH-1947 (27 per cent). The mean incidence ofjassid / 3 leaves on the basis of9 weekly observations varied between 2.14 (Ankur-2534) to 3.16 (Jassid-II). The peak of jassid incidence was recorded in the 2nd and 3rd week of August.. Ankur-2226 and MRCH- 6025 exhibited second grade symptoms of damage due to jassid infestation. Whitefly population remained below ETL throughout the season. Among natural enemies, spiders were the most abundant as compared with natural enemies like lacewing and lady bird beetles. Maximum population of spider was recorded in first week of September. The mean spider population per plant ranged between 0.29 (MRC-7045) to 0.54 (KDCHH-98I 0). The *Chrysoperla* population ranged between 0.21 (ACH-33) to 0.67 (VBCH-I006) and ladybird beetle population per plant ranged between 0.18 (KDCHH-441) to 0.30 (JKCH-I050).

4.28: Identification of germplasm sources of resistance to Insect Pests and Diseases

Nagpur

Evaluation of resistance to insect pests

Five hundred and seventy four germplasm lines were evaluated for their reaction to sucking pests, effect on natural enemies and response to bollworm damage. Two sets of experiments each consisting 20 promising cultures were field evaluated for their tolerance to jassids and bollworms under unprotected conditions. Cultures CPT 1068 (B), CPT 1080, CPT 423 (A) and CPT 1094 had higher yield levels in addition to better quality parameters (> 25 mm staple length and >23 g/tex bundle strength) with tolerance to jassids and bollworms. CPT 8 was a high yielder and jassid tolerant but with poor fibre strength (17.3g/tex). CPT 119 (B) and CPMT5 (B) were identi fied as long staple (>31mm) with good strength (>25 g/tex). CPT 511 was identified through the station trial formultilocational testing under ofAICCIP

Bollworm tolerance through Trypsin inhibitors

During a screening program for bollworm tolerance, germplasm lines EC345771, EC314435, EC 140834, EC 314451, EC 345760, EC 345767, and EC 345768 were found to be tolerant to *H armigera.* An attempt was made to transfer the trait of bollworm tolerance into good yielding Indian genotypes with sucking pest tolerance using EC 140834 (okra leaved bollworm tolerant but jassid susceptible poor yielding line). Promising lines were isolated from segregating progeny and selfed for five generations to obtain stable genotypes with high levels of tolerance to bollworms and jassids. Stable genotypes isolated from boll to row progeny of the most tolerant lines were subjected to biochemical analysis to identify the factors responsible for tolerance to bollworms. The presence of trypsin inhibitor (Ti) in the bollworm tolerant genotypes (CINHTi 3 and CINHTi 4) was found to be responsible in conferring tolerance to *H armigera. In vitro* trypsin inhibitory assays and bioassays with semi-synthetic diet were conducted. Mortality and growth regulatory effects were found correlated to the Ti levels in the plant part tested. Trypsin inhibitory property was detected in the boll rind that was highest in lO-day old bolls of the F, progeny derived from high bollworm tolerant lines of the previous generation. Trypsin inhibitor assays were carried out using BApNA (a trypsin specific substrate) in *in vitro* gut enzyme assays using ammonium sulfate precipitated and dialyzed total protein from boll rind of 10-day-old bolls of CINHTi 3 and CINHTi 4. The two genotypes can also be used as donor parents for trypsin inhibitors to develop bollworm resistant cultivars.

Induced Resistance to Insect Pests

A synthetic analogue of jasmonic acid was tested as spray, and at two doses dispensed through cotton swabs or sponge pieces placed in Eppendorfvials. These treatments were compared with acetone sprayed control for sprayed plots and unsprayed plots for the other treatments. Jasmine perfume, reduced jassid incidence when dispensed through Eppendorfvials during the early season (36 DAS) while sprays were effective in the mid vegetative phase, The Eppendorf method and sprays were equally effective in the early reproductive phase (60 DAS) and mid reproductive phase (75 DAS) offering protection up to 10 days after application. The early season application did not cause significant impact on the damage grade, while in the mid-vegetative, early-reproductive and mid-reproductive phases, the sponge and spray methods demonstrated lower jassid damage. Jasmine perfume sprays significantly increased

the incidence of *Chrysopa* eggs while reducing the oviposition by *H. armigera.* Laboratory studies indicated that jasmine perfume has negligible insecticidal activity when applied topically.

Spraying jasmine perfume at two doses 2ml/L and at 8ml/L caused LOX1 (lipoxygenase 1) to increase by 21.8 fold (at 2ml/L) in sprayed plant and 34-61 % in unsprayed neighbor at 72h after spray. At 8ml/L jasmine perfume spray the treated plant exhibited 350 fold increases in LOX1 and between 244-343 fold increases in the untreated neighbor over control.. Similarly, LOX 2 (lipoxygenase 2) was also induced in both sprayed and unsprayed plants demonstrating the role of jasmine perfume sprays in stepping up LOX activity through interplant communication and consequently impacting host plant resistance in the plant.. Field application of jasmine perfume, (depending on its method of application) significantly increased yields between 7.8-43.65 per cent over unsprayed control.. Even when used at 40 mM jasmine perfume exhibited no phytotoxicity on cotton.

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

Reconfirmation of resistance in working collection (300) against reniform and root-knot nematode was taken up. 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. Acala 8-1-X, BM Cot 113, BM Cot 147, G.Cot 16 and MB Cot 142 were tolerant, while 150-3-1-1, GP187, MDH 38 were susceptible. The germplasm line 116 TLYC Macha was found to be resistant to root-knot and reniform nematode. Bikaneri nerma, Sharda and Paymaster were found to be resistant to root knot nematode. Ten accessions found resistant to reniform nematode were analyzed for total proteins and reducing/nonreducing sugars. In susceptible cultivars both the sugars were enhanced, while there was no difference in total protein content..

Application of ascorbic acid at 0.1% was found to induce resistance to root-knot nematode in susceptible host by reducing nematode penetration by as much as 48%. This correlates with the role of acsorbate oxidase and ascorbic acid imparting resistance to root-knot nematodes.

Screening for resistance to root rot

Amongst the 32 genotypes evaluated for resistance to root rot, Bikaneri Nerma, NISC 19, Saubhagya, Abhadita and NISC 24 were found to be moderately resistant..

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

From the population of various generations involving resistant lines as donor parents, 158 lines with bacterial blight resistance/grey mildew resistance and plant quality parameters were advanced for next generation. Six lines were identified as resistant to bacterial blight as well as grey mildew diseases. Eleven bacterial blight resistant selections were identified for better fibre quality parameters. The seed cotton yield of these selections varied from 1229-1732 kg/ha with an average plant yield of 52.5-87.8 gm/plant.. The average boll weight varied from 3.21-3.89 gm/boll and 17.50-25. 10 boll/plant..

Evaluation of Bt-cotton hybrids for foliar diseases

Incidence of Alternaria leaf spot, Myrothecium leaf spot, bacterial blight and grey mildew was recorded on 43 Bt hybrid entries in three different trials along with NHH 44 as local check.. The incidence of Alternaria leaf spot varied from 8.02-29.4 per cent, while incidence of Myrothecium leafspotwas 8.30- 29.91 per cent.. The incidence of bacterial blight and grey mildew varied from 9.19-37.31 per cent and 12.42-31.87 per cent, respectively.

Coimbatore

Evaluation for resistance to insect pests

Screening of promising cultures against Jassids

Seven cultures (VRS 19 X LSC 3) 362 332, (VRS X 115) 6341 543, L (L X PIG) 52 11 BK, L (L X IBM) 26 231, L (L X IBM) 26 294, HCT 7, HCT 8 showed resistance to Jassid damage. In general, h~iry varieties were found to be highly susceptible to mealy bug infestation.

Sirs a

Evaluation for resistance to insect pest and diseases

Out of 37 entries screened, almost all the entries were found tolerant to jassids. The population of whitefly was between 1.74 to 4.78 adults and all the entries were recorded moderately tolerant..

Maximum and minimum population was 7.80 and 1.60 adult/ 3 leaves, respectively. However, the mealy bug appeared on almost all the entries and its population ranged from 0.37 to 4.66 as observed on 5 cm portion of stem. Twenty three genotypes were found to be resistant to cotton leaf curl virus. None of the entries crossed ETL of jassid and whitefly and thrips out of the 38 entries of G *arboreum* screened.

4.29: Biological Control

Nagpur

Isolation of new Bt *(Bacillus tlmringiensis)* strains

Soil samples were collected from 57 locations of the country. Samples were from 8 districts representing 36 locations of North India, 11 districts representing 13 locations of Gujarat, 3 districts, representing 6 locations of South India and 10 districts representing 12 locations of Maharashtra. Soil samples were also obtained from Ladakh and Pasighat.. Using the standard 'sodium acetate selection method' Bt strains were isolated from 16 soil samples. Toxin isolation, protein estimation and bioassay using undiluted toxin was carried out for 16 toxins. One native Bt strain, from Ahmedabad produced toxin that caused high levels of la rval mortality in *H. armigera* with LC_{50} of 0.077 *~g/ml* of diet against *crylAc* tolerant *H. armigera* field strain (Vadodara) and 0.004 *~g/ml* of diet against the field susceptible strain (Nagpur). The toxicity was equivalent to the standard BtK HD 1 and BTK HD 73.

Natural parasitization and predation on mealybug

A new parasitoid, *Aenasius* sp. (Hymenoptera: Encyrtidae) was found to parasitize 57% of mealybug *P solenopsis* colonies infesting cotton. *Aenasius* sp. is an endoparasite that has immense potential to be used as biological control agent to control mealybug populations. A predatory beetle, *Scymnus coccivora* was found to feed on the mealybug *P solenopsis.* The beetle has been found to occur in the natural ecosystem of cotton in many parts of Central India.

Evaluation of biopesticides for mealybug control

Bioassays were carried out on mealybug *Phenococcus solenosis* (Tinsley) using 28 products comprising of 7 Bio-formulations [Fish Oil Rosin Liquid (FORL), Neem oil, Mycojaal *(Beavaria bassiana), Verticillium lecanii, Metarrhizium anisoplae,* Derisom (karanj oil) and Mealy-Quit], 2 Insecticides [Chlorpyriphos and Acephate] and 1 Insect Growth Regulator [Applaud] and their combinations with different doses on sprouted potatoes. Mortality observations were recorded four days after treatment (DAT). Maximum mortality (64.84%) was recorded in treatment FORL 2 mlll + Chlorpyriphos 1.5 mlll while remaining treatments were relatively less effective in controlling mealybug populations. FORL 2 mlll + Chlorpyriphos 1.5 mlll also caused maximum mortality (87.13%) at 8 DAT and was comparable with higher doses of Mealy- Quit 25 mlll (66.06%), Mealy-Quit 20 mlll (66.19%) and Mealy-Quit 15 mill (63.85%). Treatment comprising ofFORL 2 mill + Acephate 1*g/l,* FORL 2 mill + Acephate 0.5 *g/l,* Derisom 2 mlll, Derisom 2 mlll + FORL 2 mill, Mealy-Quit 10 mlll and Neem oil 10 mlll showed moderate mortality 55.48, 55.47, 53.81, 51.99, 49.97 and 49.90% respectively and were statistically at par while remaining treatments were less effective. Even at higher doses FORL alone was ineffective in controlling mealybug populations. A newly developed formulation 'Mealy-Quit' showed promising results in controlling mealybug populations up to 63.85% at 15 mlll and has been promoted for advanced stages of testing. The formulation was supplied to different locations for testing its performance.

Evaluation ofbiopesticides against insect pests

Two *Verticillium lecanii* isolates, VL-5, VL 7 were effective against mealy bug and prevented the development of adults in the treatments. Streptomyces isolates at O.D 0.5 were tested and found to be ineffective against mealy bug. Three hundred and twelve isolates of rhizobacteria were isolated from cotton rhizosphere from 47 locations and evaluated against *H. armigera* for efficacy. Out of these 67 isolates were found to have antagonistic properties against bollworm larvae. Twenty of these isolates were found to cause mortality of bollworm larvae when incorporated into semisynthetic diets. The isolates were also

evaluated for their possible efficacy against Mealybug of cotton and one *Bacillus cereus* isolate was found to be effective against Mealybug crawlers and can be further used for developing a formulation. Anew fungal pathogen, *Fusarium sp.* was isolated from adults of mealybugs in field epizootic incidence. Fungal spore suspension 50 spores/l 00 III was tested for its efficacy and was found to be effective not as immediate measure but was able to reduce mealy bug population over a period of2-3 generations.

Effect of host plants on infectivity of entomopathogenic nematodes to insect pests.

Infectivity of EPN *Heterorhabditis indica* was evaluated on *H. armigera* larvae reared for one full generation on different host plants cotton chickpea, pigeon pea, okra, com and two weed plants. Mortality of *H. armigera* due to *H indica* was lower on larvae fed on okra as compared to chickpea, pigeon pea and cotton. Nematode progeny production was highest from larvae fed on pigeon pea and lowest in larvae reared on cotton and weed plants. Host plant background of target pest is thus important information in determining the dosage ofEPN for field application.

Biological control of Diseases and nematodes

Five microbial antagonists *(Streptomyces* spp., Pseudomonas, *Trichoderma* sp., *Penicillium* sp and *Aspergillus niger)* were identified against root rot causing pathogens *Rhizoctonia* and *Fusarium* sp. A total of 57 purified single colony bacterial isolates were isolated from the cotton eco-system and tested under *in-vitro* conditions by dual culture method for their anti-bacterial and antifungal activity against the predominant and virulent race 18 of *Xanthomonas axanopodis* pv *malvacearum* and fast growing strain of Fusarium wilt pathogen *Fusarium oxysporum fsp. vasinfectum.* Seven bacterial isolates were found to effectively inhibit the bacterial growth of *Xam* with an inhibition zone ranged from 13-19 mm. However, five bacterial isolates exhibited antifungal activity inhibiting the growth of *F.* o. f. sp. *vas infectum* with an inhibition zone ranging from 26.5-29.0 mm. The inhibition of *Fusarium* varied from 61.24- 76,25 per cent.

At least 100 isolates of rhizobacteria were isolated from rhizosphere from different ecosystems and evaluated against root-knot and reniform nematodes at different concentration. Nine bacterial isolates were effective *in vitro* at 0.1 OD against juveniles of root-knot and preadults of reniform nematodes. The mortality of nematodes due to these bacteria ranged between 58-81 % after 48 hrs. These isolates were taken up for use as root dip in tomato seedlings against root-knot nematode. Three isolates were effective in preventing penetration of nematodes when used as root dip. Per cent penetration of root knot juveniles in treated seedlings ranged between 8-19% as compared to control (26-38%). Two of the effective bacteria were tentatively identified as *B. subtilis* and *B. pumilus.* The colony morphology, pigment production, spore staining, oxygen requirement, thermal death point, fermentation of carbohydrates, gelatin liquefaction etc. were characterized.

Coimbatore

Record of a promising predator of mealybug

A Lycanid butterfly *Spalgis epius* (West wood) (Lepidoptera: Lycaenidae) was found to feed on the mealybug *P marginatus* on cotton, papaya, silk cotton, subabul, *Ixora* sp., *Crotons* sp., *Glyricedia* sp. and *Hibiscus* sp. etc. The larvae were observed as voracious feeders on the egg masses, nymphs, and adults of mealy bugs.

Natural parasitisation of Mealy bug

Two parasitoids, *Torymus* sp. and *Prochiloneurus aegyptiacus* (Mercet) were recorded on the mealybug *P marginatus* with maximum per cent parasitisation of 21% and 7% respectively. The parasitoid, *Aenasius* sp. was found to parasitize *P solenopsis* up to a maximum of 45%.

Pathogenicity of entomopathogenic fungus

The fungal biopesticide strains of *M. anisopliae, V. lecanii* & *B. bassiana* were tested on the mealybug *P marginatus* and were found to cause mortality of 63.3%, 15.6% and 46.9% respectively. Probit analysis of time mortality (LT_{50} values) was 7.45, 6.24 and 9.04 days for *B. bassiana, M. anisopliae* and *V. lecanii* respectively. For *P solenopsis* mortality rate recorded was 51.3%, 12.9% and 39.9% for *M. anisopliae, V.lecanii* andB. *bassiana* respectively. Probit analysis of time mortality (LT_{50} values) was 8.03, 7.20 and 10.30 days for *B. bassiana, M. anisopliae* and *V.lecanii* respectively (Table 4.28).

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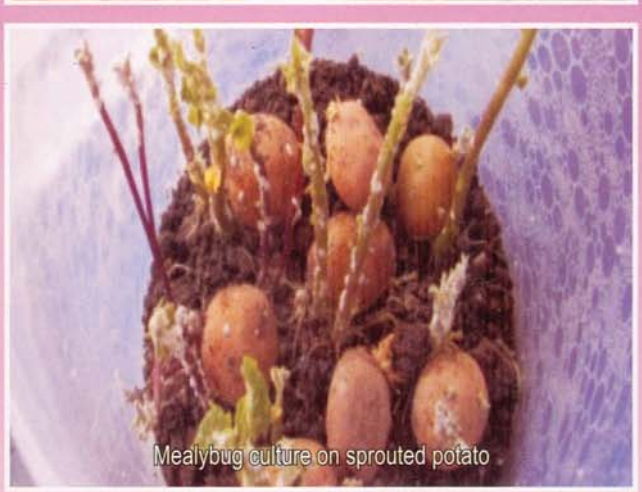
Mummified *P.solenopsis* due to parasitisation by *A.bambawalei* & *P.unfasciativentris*

Papaya mealybug (Paracoccus marginatus)

Low cost cage



Mealybug culture on sprouted potato

Mealybug culture room

Scymnus coccivora

Table 4.28. Pathogenicity of entomopathogenic fungus against cotton mealybug

Fungal Pathogen	*P. mirginatus*					*P. soleno psis*				
	r	Regression equation	LT. (days)	Fiducial Limits		x^2	Regression equation	LT• (days)	Fiduetaillmits	
				Lower	Upper				Lower	Upper
B. bassian	0.86	4.09x+1.42	7,45	6.57	8.46	0.76	3.60x+1.74	8.03	6.88	9.38
M.anisopliae	*1.59*	3,42x+2.27	6.24	5,46	7.15	1.88	3.87x+1.68	7.20	6,32	8,19
V lecanii	0.53	2.92x+2.20	9.07	7.29	11.29	0.39	2.82x+2.13	10.30	7.87	13,48

Compatability of entomopathogenic fungus

Compability of entomopathogenic fungus with insecticides

Twelve insecticides were evaluated with three entomopathogenic fungal pathogens for compatibility tests. For *B. bassiana,* only Chlorpyriphos was found to be compatible whereas, Spinosad, Econeem, Quinalphos, Acetamprid, Endosulfan and Thiodicarb were slightly toxic. Imidacloprid and Triazophos, were moderately toxic and Profenofos, Indoxacarb and Methyldemeton were highly toxic to *B. bassiana.* Insecticide compatibility studies with *M. anisopliae,* showed that Chlorpyriphos and Econeem were compatible, while, Spinosad, Acetamprid, Quinalphos, Endosulfan and Thiodicarb were slightly toxic to the fungus, Imidacloprid and Triazophos were moderately toxic and Profenofos, Indoxacarb and Methyldemeton were highly toxic to *M. anisopliae.* For *V. lecanii,* Chlorpyriphos was compatible, while Econeem, Acetamprid, Endosulfan and Thiodicarb were slightly toxic, Spinosad and Quinalphos were moderately toxic and Profenofos, Triazophos, Imidacloprid, Indoxacarb and Methyldemeton were highly toxic.

Evaluation of bacterial symbiont ofEPN

Pathogenicity of bacterial symbiont of EPN viz., *Photorhabdus lumunescens* and *Xenorhabdus* sp. was studied under laboratory condition against *Galleria mellonella, Helicoverpa armigera* and *Spodoptera litura.* Both bacteria were able to cause mortality of test insects at varying levels. The results proved the insecticidal property of bacteria. The symbionts *Photorhabdus luminescens* and *Xenorhabdus* sp. were characterized based on 42 biochemical and morphometric characters.

Antimicrobial property of bacterial symbiont ofEPN

Antimicrobial property of bacterial symbiont of EPN *(P lumunescens* and *Xenorhabdus* sp.) was evaluated against plant pathogens *Fusarium* sp. and *Alternaria* sp. and entomopathogenic *(Metarhizium anisopliae, Beuveria bessiana* and *Verticillium lecanii). P luminescens* was found to significantly inhibit the growth of both plant pathogenic and entomopathogenic fungi.

Isolation and identification of potent microbes from mealy bug

A survey was conducted to isolate and identify entomogenous fungi associated with mealy bug. A total of two entomopathogenic nematodes and 25 isolates of fungi were collected. Natural infestation of mealy bug with *Lecanicillium lecanii* (Zim Zare & Gam) was recorded under farmer's field condition. Out of 25 fungi screened, *L. lecanii* was found to be highly virulent against both *Phenacoccus solenopsis* and *Paracoccus marginatus* under laboratory, green house and small-scale field studies.

Four biocontrol agents viz., *Lecanicillium lecanii, Beuaveria bessiana, Metarhizium anisopliae,* and a bacterial symbiont of entomopathogenic nematode were evaluated against *Phenacoccus solonopsis* and *Paracoccus marginatus* (nymphs and adults). Mortality was recorded at 3, 5 and 7 days after treatment. In general, insect mortality was increased with increase in exposure period. Irrespective of treatments, nymphs were found to be more susceptible to infection than adults. Among different isolates tested, VI-3, VI-5 *(V lecanii* from PDBC), and*L. lecanii* (native isolate) recorded 53.33, 55.55, 55.83 and 64.17 %

mortality at five days after spraying. Under field condition, biocontrol agents *(V lecanii, M. anisopliae, B. bassiana* and *P luminescens)* recorded 26.81 to 41.27% reduction in mealy bug population seven days after treatment at three sprays with one week interval on Bt-cotton. Seven isolates of *Verticillium lecanii* from PDBC, Bangalore were tested against *Phenacoccus solenopsis* and *Para coccus marginatus* (nymphs and adults) under laboratory and pot culture studies. Among seven isolates, three isolates namely VI-5, VI-9 and VI-2c were effective in causing mortality of both nymphs and adults of *Paracoccus marginatus,* whereas isolates V1-1 and VI-5 alone were highly effective against *Phenacoccus solenopsis.* The results clearly indicate the variation in virulence of fungi against different species of mealy bug.

Sirs a

Biological control of mealybug

Surveys were conducted during the 2008-09 off-season, to collect mealy bug cadavers from cotton stalks in Haryana and Punjab. The cadavers revealed the presence of *Fusarium* species which was later confirmed from ITCC, division of Mycology and Plant Pathology, IARI, New Delhi as *Fusarium pallidoroseum* (identification number-6974-08 to 6976-08) .The compatibility of *Fusarium pallidoroseum* with insecticides, especially which are effective against mealy bug was tested using "poison food inhibition technique" at recommended dosage of insecticides. Profenofos showed maximum inhibition of *Fusarium pallidoroseum* after one week of inoculation whereas minimum inhibition was observed in Confidor, Admire and Fipronil. After one week maximum mycelial growth was inhibited by Profenofos (86.3 per cent) followed by Spirotetramat (75.7 per cent). Confidor, Fipronil,Admire and Thio~thoxam, the inhibited growth by 17.9, 32.4,' 36.0 and 40.1 %, respectively.

Actinomycetes, Xenorhabdus, Fusarium pallidoroseum, neem+FORS, nirma detergent, nirma soap, chilli+garlic, sticker and water were tested against different stages of mealybug (5, 10 and 15 days old crwalers) and Profenofos was kept as standard check.. Mortality ranged from 60-100% with five-day-old crawlers. Fifteen days old crawlers showed lower mortality upto a maximum of 40% in case of *F pallidoroseum.* Three commercially available formulations of *Verticillium lecanii* (10^8 cfu / g) namely vertiguard (Ajay Biotech), Bio-catch (T-stains company limited) and Vercitile (Indore biotech inputs pvt ltd) were also tested under field conditions at two locations. Formulations of *Verticillium lecanii* controlled 57.8 to 66.1 % mealybug after two sprays at weekly interval..

4.30: Integrated Pest Management

Nagpur

Host range of mealybugs

The Mealybug *P solenopsis* was recorded on 91 plant species of 24 families, whereas the pink mealybug *M hirsutus* was found to occur on 16 host plants spreading across 11 families. *Parthenium hysterophorus* and *Abutilon indicum* were the most common and favorable hosts.

Yield loss estimates

Yield losses due to *M. hirsutus* were 36.5% at grade-I, 46.6% at grade-2, 63.5% grade-3 and 76.4% at grade-4 severity of mealybug infestation. The yield losses due to *Psolenopsis* were 2.4% at Grade-I, 31.5% at grade-2, 39.9% at grade-3 and 43.9% at grade-4. Five per cent open boll damage due to boll feeding by mirid bugs *Campylomma livida* resulting in an yield loss was of 85 kg/ha was estimated at Central zone.

Loss appraisal due to grey mildew disease of cotton

The incidence of grey mildew on four each of Bt and non- Bt hybrids and its influence on seed cotton yield was recorded under protected and unprotected conditions of rainfed situation. Higher incidence of grey mildew and maximum loss of 16.25 per cent was recorded in Bt hybrid Ganga Kaveri under unprotected conditions. This was followed by Bunny Bt 2 and Jai Bt with an average loss of 13.27 and 12.83%, respectively. The loss of 8.37 and 9.38% was recorded in hybrid H 10 and NHH 44, respectively with the lowest incidence of grey mildew. The avoidable quantitative yield losses due to grey mildew disease were higher in susceptible Bt-hybrids as compared to non-Bt hybrid H 10. Early senescence and exposure to favorable weather during that particular stage

could be one of the reasons for higher incidence of grey mildew on Bt-hybrids.

Effect of crop rotation on pest infestation

Crop rotation with sorghum and maize reduced the population of reniform nematode in cotton. Crop rotation of cotton with tomato drastically reduced root-knot nematode, *Meloidogyne incognita* population in tomato under farmer's field condition. Cotton was identified as non-host for Race 4 of *M. incognita.* Cotton+cowpea intercropping system significantly reduced sucking pest nymphs, square and boll damage over the cotton sole crop and cotton adjacent to tomato fields

Evaluation of effective control methods against sucking pests

Eight products, Neem oil, *Verticillium lecani,* Mealy-Quit, Imidacloprid, Acetamiprid, Chlorpyriphos, Thiomethoxam andAcephate were tested through foliar application; stem application and soil drenching. It was found that foliar application of Acetamiprid, Thiomethoxam, Acephate at recommended doses and stem application of Thiomethoxam,Chlorpyriphos and Imidacloprid at 10 times higher doses were found effective in controlling sucking pests aphid, jassids, thrips populations. Foliar spray of Imidacloprid, Acetamipird, Chlorpyriphos, Acephate and Mealy-Quit at recommended doses and stem application of Thiomethoxam and Imidacloprid at 10 times higher doses found to be useful in reducing mirid bug population and enhancing yield.

Among the two Bt (Ankur 651 BG 1 and Bunny BGII) and three non Bt (Ankur 651, Bunny and NHH 44) studied for their phenology under natural levels of insects pests without any protection, entomological shedding of squares was significantly lower in Bt-cotton as compared to non-Bt with no differences for boll shed due to bollworms or physiological reasons. During the season the physiological shedding of bolls were higher between last week of September and during the first fortnight of October. In a season of early withdrawal of monsoon with consequent moisture stress during boll development stage early maturing Bt cultivars proved to be better over mid or long duration genotypes.

In case ofBt as well as non Bt hybrids, insecticidal protection significantly reduced jassids, thrips semilooper larvae and also spider populations. Conversely, significantly higher number of *H.armigera* larvae and damage to squares and bolls was recorded on the insecticide treated crop. Whitefly population following Imidacloprid spray was significantly higher over the unprotected crop ofLRA5166.

Development and validation of IPM and IRM strategies for conventional and Bt cotton Economic threshold levels for *Spodoptera litura* on Bt cotton

The ETL of Spodoptera litura was determined on Bollgard, (MRC 6301) Bollgard II (MRC 7301), Bunny Bt and non Bt. Artificial release of S. *litura* was made in cages, at 95 DAS and 110 DAS. The ETL (Economic Threshold Level) for S. *litura* was 2.0 ± 0.7 on non-Bt.. The ETL was slightly higher on MRC 7301 at 5.3 ± 0.9 larvae per plant.. The ETL levels did not change much at 110 DAS on non-Bt and was recorded at 2.1 ± 0.8 larvae per plant.. However, ETL levels declined marginally on MRC 6301 and were found to be 0.362 ±0.016 larvae per plant..

Laboratory bioassay were carried out with terminal leaves ofMRC 6301, MRC 7301 and non Bt using 2nd instar larvae of *Spodoptera.* Twenty five pe rcent of larval survivors were observed even on leaves ofMRC 7301 at the end of the 7 day bioassay period. Quantification of the temporal variation in Cry toxin expression showed that the crylAc expression declined between 95-110 DAS and expression levels were lowest in the boll rind, ovary and square bud.

On farm validation of IPM on Bt cotton: On farm validation of IPM using cultivar Ankur 651 Bt cotton following symptom based sucking pest management in comparison with recommended package of practices (RPP) that had early and mid season sucking pest and need based disease management was done at Alagondi village of Nagpur district.. Crop season 2008-09 did not witness significant attack of all the sap feeders except the dominance of jassids at around 60 DAS. With no differences in the number of insecticidal sprays and the insecticide between IPM and RPP farms, numerical differences for the plant-based yield levels are attributed the timing of insecticidal spray. The phenology of

harvestable bolls indicated the contribution of early opened bolls over the late season in case of IPM as against the RPP farm wherein the situation was reverse.Notwithstanding the plant based yield differences, the field based yields of IPM farm with an increased returns of Rs. 1300 per hectare over RPP indicated the superiority of the symptom based insecticidal intervention in IPM and its feasibility for use in Bt cotton sucking pest management. .

Coimbatore

Evaluation ofBiopesticides and Insecticides

Acephate and Chlorpyriphos were more effective against the emerging pests (mealy bug and mirid bug) and recorded significantly higher yield (58.4 % and 51.0 %) over other treatments and control.. Fish Oil Rosin soap was moderately effective against these pests and it recorded significantly higher yield (50.5 %). Botanical formulation 'Mealy-Quit' was moderately effective against mealybugs and mirid bugs (Table 4.29).

Evaluation of newer insecticides against sucking pests and bollworms

Two new insecticides (Flubendiamide & Thiocloprid) individually and in combination along with three standard check (Spinosad, Quinalphos, Thiodicarb, a Bt cotton check (Bunny Bt) and untreated control were evaluated against major pests of cotton).

Quinalphos at 500 gm recorded consistently low population of mealy bug 0.2 to 0.5/ plant) followed by Thiodicarb at 60 gm (0 to 1.2). Spinosad consistently recorded higher population of 5.5 to 7.3 / plant as compared 2 to 2.5 in control.. At harvest, infested plants were low in Quinalphos treatment (9.72%) followed by Thiodicarb (23.60%) as compared to 45.83 % in control.. The intensity of mealy bug infestation was also significantly low (0.33 grade) in quinalphos treatment as compared to rest of the treatments (1.00 to 1.40) and control (1.10).

Thiodicarb followed by Flubendiamide +Thiocloprid and Thiocloprid treatments were effective against mirid bug and reduced the infestation significantly over other treatments and control.. Thiodicarb and Bunny Bt treatments recorded very low damage of2.9 to 3.4 % in open bolls as compared to 6.1 to 8.6 % in other treatments and 14.6 % in control.. Thiodicarb and Flubendiamide+Thiocloprid treatments were significantly superior to rest of the treatments and on par with each other in recording higher seed cotton yield, 21.08 and 19.92 q/ha respectively. Moderate to higher-level infestation of mealy bug brought down the yield significantly in Flubendiamide (9.42 qiha), Spinosad (6.92 qiha) and control (5.25 qiha).

Pheromone trap catches and the level of incidence of *P. gossypiella*

Pheromone trap catches of *P gossypiella* recorded throughout the cropping season were correlated with the level of infestation. Infestation started in November with a peak adult moth catch during the month of February that correlated with the maximum larval infestation.

Sirsa

Inoculum source and economic thresholds of cotton leaf curl virus disease

Studies on inoculum source and economic thresholds of cotton leaf curl virus disease showed lower population of whitefly ranging from 0.00-0.87 (Punjab), 0.20-0.93 (Haryana) and Rajasthan (0.67-2.20) per three leaves, during August to September 2008 on commonly occurring weeds (Peeli *buti-Sida sps, Kanghi buti-Abutilon sps, Gutpatna- Xanthium strumarium, Puth kanda-Achyranthus sps, Bhakri-Tribulus teresterius, Itsit- Trianthema monogyna* and *Tandla- Digeria avensis)*. Further, lower population of whitefly (0.00-1.33 in Punjab; 0.00-1.00 in Haryana and 0.00-1.33 in Rajasthan/three leaves per plant) was noted in cotton. Cotton leaf curl virus disease on these plants was also quite low and ranged between 0.00-0.44% only during August to September 2009 in the three states. DNA isolation from 124 weeds collected from Haryana, Punjab and Rajasthan during April|May 2008 followed by their DNA isolation and amplification using CP primer did not show presence of virus in any weed.

In another experiment, graded Percent Disease Index (5, 10, 20, 40 & 60%) of cotton leaf curl virus disease in Bt cotton hybrid 6488 Bt at village Khippanwali in Ferozepur district of Punjab revealed reduction in seed cotton yield to the extent of 0.08, 0.29, 14.5, 17.2 & 40.0% respectively. Similarly, 23.8 to 63.1 % seed cotton yield reduction was observed in case of one to four severity grades in case of Bt cotton hybrid Sigma

Table 4.29: Evaluation of effective control methods (Biopesticides and Insecticides)

Treatments	Mealybug		Mirid bug / 10 squares Mean	Seed cotton yield (kg/ha)
	Infested plants (%)	Intensity of infested pants (Grade)		
Acephate 700 g a.i./ha	11.11 (11.95)	1.07 (1.03)	1.04 (1.02)	2252
Chlorpyriphos 500 g a.i./ha	18.05 (23.77)	0.48 (0.58)	1.58 (1.26)	2147
NSKE5 %	69.77 (61.69)	1.73 (1.31)	2.16 (1.47)	1844
Neem oil (2.5 l/ha) +Nirma Powder (0.1 %)	63.89 (58.31)	1.76 (1.32)	2.27 (1.51)	1817
Nirma Powder (0.1 %)	45.83 (42.45)	2.15 (1.45)	2.20 (1.48)	2186
Verticillium lecani 5 gm/lit ($2x10^8$ cfu/gm)	38.41(37.90)	2.19 (1.47)	2.56 (1.60)	1995
Beauveria bassiana 5 gm/lit ($2x10^8$ cfu/gm)	52.78 (46.60)	1.83 (1.34)	2.27 (1.51)	1877
Metarhizium anisopliae 5 gm/lit ($2x10^8$ cfu/gm)	50.83 (45.50)	2.15 (1.45)	3.00 (1.73)	1969
EPN Bacterial symbiont 20 ml/lit($2x10^8$ cfu/gm)	48.61 (44.20)	1.64 (1.28)	2.62 (1.62)	1942
Fish Oil rosin soap (2 ml lit)	46.34 (42.90)	1.66 (1.28)	2.60 (1.61)	2140
New botanical formulation (10 ml/lit) (mealy quit)	38.89 (38.03)	1.24 (L11)	2.02 (1.42)	1738
Control (Water spray)	78.93 (67.49)	2.37 (1.52)	5.47 (2.34)	1422
SEd	11.80	0.202	0.058	116.35
Cn(p= 0.05)	24.46	0.420	0.121	241.29

at Chudiwalan village in Ferozepur district of Punjab.

Economic threshold levels on Bt cotton against *Helicoverpa armigera*

Helicoverpa armigera 3'd instar larvae were released at 90 and 105 days after sowing, but did not establish and cause damage. The 3'd instar larvae released after 120 days of sowing resulted in 4.90 % damage to fruiting bodies at 124 DAS, 2.71-6.04 at 137 DAS, 2.57-5.78 at 144 DAS and 1.41-5.69 at 152 DAS. Total gain threshold obtained was 1.55 and theETLcalculated was 4.25 larvae per plant.. The damage (%) to fruiting bodies by the 3'dinstar larvae of *H. armigera* at 135 DAS ranged between 0-5.16 at 138 DAS, 0-6.94 at 144 DAS and 0-6.78 DAS. Though larvae were not recovered from the cage, the damage recorded on fruiting bodies affected the total yield and ranged between 28.17 to 33.99 q/ha in various treatments. The total gain threshold worked out was 1.55. Hence, the ETL calculated at 135 DAS for *H. armigera* was 3.52 larva / plant..

Pest forewarning and forecasting

A new sampling strategy was devised for mealybug field population assessment based on source of infestation. When sampled parallel to the source, infestation level was highest in fields along with water channel (4.6 to 15.4 %) followed by fields on roadside (5.2-9.8 %) and clean fields (2.07-12.0%). When sampled perpendicular to the

source, infestation levels recorded were relatively lower. Sampling may be done both parallel and perpendicular side of the field. The already existing infestation plays an important role in initial infestation. A sample size of25 to 50 plants per acre was sufficient in fields with known source of infestation such as roadside, and water channels. However, a sample size of 100 plants per acre is necessary for clean fields where prior knowledge of mealybug infestation is not available.

Bio-ecology of Mealy bug in Bt-cotton

The Mealybug *Phenacoccus solenopsis* has 2-4 ovisacs. There are 2 nymphal instars in males and 2 instars in 3 instars in females. Each female produces about 300-500 crawlers. The total life duration extends from 36 to 45 days on cotton. There was a positive correlation between the population increase and temperature where as the relative humidity was negatively correlated.

Insecticide Resistance Management

Nagpur

Elucidation of mechanism of crylAc resistance in *H elicoverpa armigera.*

In *Helicoverpa armigera* the cadherin gene (19,962 bp) comprises of35 exons and 34 introns. The insertion of retrotransposons between exon-eight and exon-nine was found to hamper the expression and subsequent function of the gene. This phenomenon was almost identical to the report from China. Based on the specific resistance mechanism, primers were designed to amplify region between the exon eight and the retrotransposon in case of resistant insect and exon-eight and exon-nine of susceptible insect.. The full-length sequence of the cadherin like gene (AY714876 + DQ223888) was aligned with the mRNA sequences to demarcate the exon-intron boundaries and from the alignment generated, resistance diagnostic primers were designed.

Elucidation of pyrethroid resistance mechanism in *H elicoverpa armigera*

Six *cytochrome p450* genes were tested on Real-Time PCR for their relative quantitative expression levels in pyrethroid resistant and susceptible *H. armigera.* One of the genes *cyp6b7* was found to express selectively in higher quantities in pyrethroid resistant strains.

Monitoring changes in baseline susceptibility in geographic populations of *H.. armigera* against *cry* lAc

Changes in the geographical variability in *H. armigera* susceptibility levels to *cry* lAc toxin from *Bacillus thuringiensis* wer emonitored through log dose probit assays conducted on populations collected from 6 cotton-growing districts of North India, 18 d\stricts of Central India and 4 districts of South India. The LC_{50} values derived from 8426 larvae tested, ranged from 0.040 to 2.14 g *cry* lAc/ml of diet across the North, Central and South Indian strains of *H.. armigera.* The IC_{50} values ranged from 0.010-0.578 flg of *cry* lAc/ml of diet with 57.80 fold variability across the country. LC_{50} values of populations collected on chickpea were higher than the LC_{50} values of populations collected on cotton for a given location in North India while the reverse was true in Central India. This was recorded for the first time since the introduction of Bt cotton since collections on cotton coincided with egg laying of *H.. armigera.*

Monitoring changes in baseline susceptibility in geographic populations of *H.. armigera* against *cry* lAc + *cry* 2Ab

The geographical variability in *H.. armigera* susceptibility levels to *cry* 2Ab toxin was determined through log dose probit assays conducted on populations collected from 22 districts across India in 2007 -08. Collections made in 2007 -08 represent the situation three years after commercial release of dual gene transgenics. LC_{50} values ranged from 2.46 to 34.26 flg *cry* 2Ab/ml of diet with 13.92-fold variability across the strains in 2007-08. The IC_{50} range in 2007-08 indicated 34-fold variability with the values ranging from 0.10 to 3.4 flg/ml of diet, respectively. The probit analysis data of 2007-08 represents that the baseline has not undergone any significant changes three years after cultivation of dual gene Bt transgenics in India

Changes in the geographical variability in *H.. armigera* susceptibility levels to *cry* l*Ac+cry* 2Ab toxins expressed in stacked gene Bollgard II cotton were monitored through log dose probit assays conducted on populations collected from 11

cotton-growing districts of India represented by 6 districts of Central India and 5 districts of South India. The LC_{50} values in the mixture ranged from 0.0016ug to 0.0293g for crylAc/ml of diet with 18.34-fold variability in susceptibility and from 0.010- 0.061!J.gfor *cry* 2Ab/ml of diet with 6.1 fold variability in susceptibility across the strains of *H f}rmigera.*

Monitoring changes in baseline susceptibility in geographic populations of *H. armigera* against *cry* lAc (JK seeds)

Changes in the geographical variability in *H armigera* susceptibility levels to *crylAc* toxin from *JK event-l* were monitored through log dose probit assays conducted on populations collected from 4 cotton-growing districts of North India, 10 districts of Central India and 6 districts of South India. The LC_{50} values derived from 3136 larvae tested, ranged from 0.192 g *cry* lAc/ml of diet to 5.11 g *cry* lAc/ml of diet with 4. ll-fold, 20.60-fold and 5.89 fold variability in susceptibility across the North, Central and South Indian strains of *H armigera.* The EC_{50} values ranged from 0.121- 0.561g *cry* lAc/ml of diet with 4.64 -fold variability across the country.

Sirsa

Insecticide Resistance Management (IRM) strategies were disseminated in 75 villages of three Districts ofHaryana Sirsa, Hisar and Fatehabad to cover a total of 11254 hectares area with 4511 farmers. There was 24.3% reduction in sprays and 31.2% reduction in consumption of insecticides in IRM over non IRM farmers. There was 10% increase in seed cotton yields and overall net profit of IRM farmers over non-IRM was 7140 per hectare. An overall benefit in saving due to reduction in the usage of insecticides in three districts amounted to 1.42 crores and Rs 6.32 crores due to yield increase, thus resulting in a total benefit of 7.74 crores in Haryana state due to dissemination of Insecticide Resistance Management strategies.

Insecticide Induced Resurgence

A total of 11 spray applications of each insecticide were made on cotton plots in three replications. Maximum resurgence (16.90 %) of jassid was reported in treatment Cypermethrin +Monocrotophos (after the 7th spray) followed by Spinosad 9.08 % (after 6th spray) and Acephate 7.67 % (after 3rd spray). Cypermethrin caused 35.64 % resurgence of whitefly followed by Cypermethrin + Monocrotophos (16.18 %), Monocrotophos (12.37%), Cypermethrin +Acephate (10.13 %), Cypermethrin + Ethion (5.41 %) and Cypermethrin +Profenophos (5.37 %). Spinosad alone exhibited mealybug resurgence of2.05 % consistently in all the sprays applied. Spinosad was found to harbor the maximum population of natural enemies after control.. For thrip populations, Spinosad caused 8.33% resurgence and 18.03% with Cypermethrin +Acephate.

Maximum reduction in parasitization by *Aenasius bombawalei* as compared to control was caused by Monocrotophos (60.73 %) followed by Cypermethrin +Monocrotophos (53.60%), Cypermethrin (46.52 %), Acephate (42.08%), Ethion (39.23%) Cypermethrin + Ethion (36.90%), Cypermethrin +Acephate (34.91 %) and Cypermethrin +Profenophos (33.97%).

Evaluation and integration of effective methods of pest control

Among various insecticides, Acephate reduced mealybug population by 78.88%, followed by chlorpyriphos (71.70%). The maximum reduction in the population of mealybug was recorded after 1st day of spray with a decrease after 3rd day and 7th day of application. Among ecofriendly biopesticides, *Metarrhizium anisopliae* was the most effective with 41.33% reduction followed by *Beauveria bassiana* (33.90%) , New botanical (33.83%) and *V. lecanii* (33.10%). Among the bio-pesticides, *Metarhizium anisopliae* treatment resulted in the highest yield of 16.31 q/ha followed by new botanical (Mealy Quit) 15.80 qlha and *Verticillium lecanii* 15.37 qlha

In a study conducted to integrate all eco-friendly strategies and validation of IPM packages, the average yield in IPM plots obtained was 12.80 q/acre as compared to 12.24 q/acre in RPP (recommended package of practices) plots. The total cost of cultivation including insecticides and its application was Rs. 6867 in IPM plots as against Rs. 7658 in RPP plots. The net profit gained was Rs. 28493 in IPM where as it was Rs. 25390 in RPP with a cost: benefit ratio of 1:5.15 and 1:4.30 respectively in IPM and RPP.

Impact of systemic insecticides on sucking pests

Foliar application was more effective than stem application. Clothianidine caused a reduction of 73.61 % injassid, 84.06% in whitefly and 69.98% in thrips populations and was the most effective as foliar spray followed by imidacloprid. Stem application was found effective initially. When applied through stem application, Admire caused 51.85% reduction in jassid population and clothiadinin caused 43.29% reduction in whitefly. The natural enemies' population was significantly more in case of stem application as compare to foliar application.

5. TECHNOLOGY ASSESSED AND TRANSFERRED

Nagpur

- Cotton based intercropping (cotton + soybean)
- Integrated Nutrient Management
- Management of leaf reddening: two foliar sprays of 2 % DAP and 1 % $MgSO_4$ against during flowering to boll development. .
- Weed management : Integrated weed management using pre emergence application ofpendimethalin 1.0 kg a.i. ha^{-1} with two inter-cultures and one hand weeding were found very effective in reducing cost of production of cotton + soybean intercropping system.
- Battery operated sprayer
- Integrated pest management

Coimbatore

Front line Demonstrations

One hundred demonstrations on cotton production technology, two unit demonstrations of cotton IPM and one unit demonstration on farm implements were conducted by the centre during 2008-09. The technologies viz., Bt cotton hybrids RCH 2Bt, RCH 20Bt, RCH 530 Bt BG II and RCH 708 Bt with improved technologies, Integrated Crop Management on DCH 32, INM and Intercropping with pulses were demonstrated. The demonstration on ICM in DCH 32 realized an average of 988 kg seed cotton yield per hectare where as local check yielded 820 kg seed cotton per hectare. Demonstration on RCH 20 Bt gave an average yield of 1473 kg /ha and RCH 2 Bt gave 1526 kg/ha. Demonstrations on RCH 530 Bt BG II yielded an average seed cotton yield of 1972 kg/ha. The local IPM module developed by the centre was demonstrated in 150 acres of farmers' fields. Demonstration on IPM reduced the number of pesticide sprays from six (Non-IPM) to three (IPM). One unit of demonstrations on usage of power weeder for intercultural operations in cotton fields was conducted in the Vadakkipalayam village of Pollachi south Block, Coimbatore district.. The power weeder efficiently controlled the late emerging weeds; it reduced the cost of weeding, bunding and earthing up by 30 per cent and also reduced the man-hour requirement for weeding.

The polyethylene mulch technology and poly mulch + drip technology developed and standardized at CICR Regional station, Coimbatore was demonstrated in large scale of one acre plots in farmers' field in five locations at Koilpalayam, Kanchapalli and Pacham palli villages of Coimbatore district . The improved technologies resulted in 15-20 q/ha of additional seed cotton yield as compared to the conventional method, besides saving water and weed control..

Dissemination oflRM strategies in Coimbatore District:

Impact on yields and insecticides

Implementation of IRM strategies in the project villages resulted in the reduction of number of sprays by 47.10% and the plant protection cost from Rs. 2,147 to Rs. 1,021 besides an increase in yield by 21.24 % over non IRM villages. Further, they obtained on additional income ofRs *2,325/ha* from growing of intercrop (cowpea, black gram, and redgram) and a net profit ofRs. 23,891/ha as compared to Rs. *15,4191* ha by the non IRM farmers.

Additional financial benefit

Increased yield +	-	2.05 q/haxRs. 2650=Rs. *5433/ha*
Saving on plant protection	-	Rs. 1126/ha
Increased additional income	-	Rs. *1370/ha*
Total	=	Rs. *7929/ha*

Sirsa

Demonstration of *arboreum* hybrid CICR 2:- Demonstration of G. *arboreum* hybrid CICR 2 was conducted at 40 farmers' fields. The FLD plots were sprayed five times on an average. The hybrid CICR 2 out yielded the other cultivars (18.8-22.4% yield increase) grown by the farmers. There was an average yield increase by 16.9 %.

Hybrid seed production of CICR 2 and CSHH 198 at Farmer's field: Front Line Demonstration on hybrid seed production were conducted in the fields ofSh. Ratti Ram, Sh. Trilok Chand, Sh. Raja Ram, who got good profit of Rs 2,40,000, Rs 1,25,000, Rs1, 12,000, per acre respectively.

FLD on IPM (Integrated Pest Management) Technology

During the current season four adjoining villages viz., Randhawa, Bakrianawali, Choburja and Gudia Kbera were selected for disseminating the IPM strategies. In total 22 farmers from these villages covering an area of 48 hectares were adopted under IPM. The emphasis was on selection of recommended varieties/hybrids viz., H-1117, H-I098 (American varieties) and Bt hybrids such as RCH-134, Cot-33 and MRC-6025 etc. The average population of sucking pests in IPM was comparatively less than non-IPM both in varieties and Bt cotton hybrids but the damage to the fruiting bodies like square and bolls was significantly more in non-IPM varieties (3.26 & 3.42%) where as higher population of natural enemies like spider, *Chrysoperla* and coccinellids was observed in IPM fields.

The maximum pheromone traps catch (45.44/traps) was found to be in *Spodoptera litura* followed by *Pectinophora gossypiella* (l4.66/traps), while it was found minimum in *Helicoverpa armigera* (0.21/traps) and the trap catch *ofEarias* spp (0.74/traps). The average yield obtained in IPM and non-IPM plots of Bt cotton hybrids was 28.8 q and 27.0 q/ha but it was 22.0 and 20.8 q/ha in IPM and non-IPM plots of varieties. The number of sprays in IPM and Non-IPM were 6 (Bt hybrids) and 7 (varieties) but in non-IPM plots the mixture of insecticides was used. Similarly, 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 ofBt cotonl hybrid and varieties was Rs 2410. The net profit p'er hectare was Rs.61705 and Rs. 54435 in IPM and non-IPM plots of hybrids along with C: B ratio of 1:4.84 and 1:3.95. Simultaneously in case of varieties the net profit per hectare was Rs. 43297 and 39905 under IPM and non-IPM plots with a C: B ratio of 1:3.93 and 1:3.45, respectively.

FLD on Farm Implements (Rotavator & Deep Ploughing): An increase of 14.3 % in seed cotton yield was recorded while adopting the deep plough and Rotavator system of cultivation. This is due to slight improvement in soil health and exposure of hibernating larvae of insect's and pests. The use of rotavator was more beneficial in terms of inter cultivation and removal of weeds between the rows as compared to the cultivator being used by the farmers. The farmer got 32 q/ha while using deep plough and Rotavator and under farmers practices a yield of27 q/ha was obtained with more number of spray.

6. EDUCATION AND TRAINING

6.1 : Training received

Name of the Scientist	Name of the course	Place	Period
Dr. K. Velmourgane	IP and Technology Management - Genetic Engineering	IARI , New Delhi	23rd _25th April 2008
Dr S. Usha Rani	Training programme on "Market Led Extension"	Coimbatore	4th -9th August, 2008
Dr. K. Velmourgane	DNA Sequencing and Microbial Identification	NBAIM & ICAR, MAU, UP	1st_ 7th Sept, 2008
Dr.M.Y.Venugopalan	Management Development Programme on Data Mining and GIS for Decision Support system in Agriculture	Indian Institute of Management, Lucknow	August 25-Sept 5, 2008
Dr V. S. Nagrare	Training course on "Biochemical and Molecular Biology Advanced Techniques,	IARI, New Delhi,	Novl8-Dec 08, 2008
Dr.M. V.Venugopalan	In-house hands -on training on Roth-C carbon model	NBSS&LUP, Nagpur	15th_17th January 2009
Dr.Rishi Kumar	Statistical tools for research under NAIP project	CRIDA, Hyderabad	2nd _7th March, 2009

6.2 : Training Imparted

Nagpur

International training programme on cotton production and value addition

The International training programme on cotton production and value addition was conducted at Central Institute for Cotton Research, Nagpur under the India-Brazil-South Africa (IBSA) trilateral co-operation from 17th to 29th Nov.,2008. Ten participants, including 4 from South Africa, 2 from Dr. PDKV, Akola and 4 from CICR attended this programme. This training programme was sponsored by Government ofIndia.

The programme comprised of lectures, hands on training, method demonstrations, visits to experimental fields and farmers fields and video films. There were four modules in the programme focusing on crop production, cotton improvement, cotton protection and value addition. Crop production module covered-soil and climatic requirements, nutrient and water management, cropping systems, mechanization, abiotic stresses, physiological disorders and their management, organic cotton production, economics and policy issues and TOT. The cotton improvement module comprised of Bt cotton development, DNA finger printing, molecular markers and their application, transgenic development, conventional breeding for biotic stress, yield and fibre quality, germplasm resources, hybrid seed production etc. The topics covered under crop protection included- IPM, IRM, diseases management, host plant resistance,

Bt toxin detection, crop-pest-natural enemy-climate interactions etc. Under value addition cotton seed oil, charcoal production, cotton by-product utilization and a visit GTC Nagpur was covered. The participants also had an opportunity to visit Jalna and acquaint themselves with the seed production /procedures and seed processing/ activities at Krishidhan and MAHYCO units. At Krishidhan, lectures on importance of Seed quality maintenance, production in agriculture and overview on role of biotechnology in seed industry were arranged and the various facilities being used in Seed Testing laboratory were shown. This was followed by exposure to the biotech facilities and interactions with various scientists. Later the trainees were demonstrated pre-cleaning, size grading, weight grading, seed treatment and packaging procedures for all types of seeds including Bt seeds. Field trips was also arranged to Ghanewadi and Pachanwadgoan villages to see the breeding programmes. At MAHYCO, trainees were shown the seed quality control laboratory, biotechnology laboratory, hybrid cotton seed production programme including Bt cotton and various research programmes being carried out. Another highlight was a visit to Gram Vikas Tantra Niketan, Wardha where the participants gathered first hand information about IRM programme operating in Wardha and Yavatmal districts. A novel value addition technology for the conversion of cotton stocks to charcoal was also demonstrated. The trainee officials also had an insight into a typical central Indian village when they visited and interacted with the farmers including farm women at Nagpur village, Sewagram. Dr. K. R Kranthi, Director, CICR was the Convener and Dr. M V Venugopalan, Principal Scientist, was the Coordinator of this programme. A Compendium of lectures was prepared and distributed to the participants.

National training on "Variety Purity Testing of Specified Traits"

A National training on "Variety Purity Testing of Specified Traits" was conducted on February 23 to 27,2009 at CICR, Nagpur in which 30 officials of seed production, seed testing, seed certification etc. participated. Dr. R. K. Deshmukh, Principal Scientist was the Training Organizer and Organizing Secretary was Dr. P. R. Vijaya Kumari, Sr. Scientist..

Two Bulletins namely- 'Legislations for Seed Quality Regulation in India' by V. Santhy, P.R. Vijaya Kumari, Anshu Viswanathan and RK.Deshmukh and 'Hybrid Seed Production in Cotton' by V. Santhy, B.M.Khadi, Phundan Singh, P. R. Vijaya Kumari,Anshu Vaishwanathan andR K. Deshmukh were released in the Inaugural Session. A manual titled "Testing of Specified traits" was complied and edited by Dr. P. R. Vijaya Kumari, Anshu Vishwanathan and Sharmistha Mondal for the participants.

Training on MS-Office & Excel for Administrative and Accounts Staff

Er. G. Majumdar conducted week long training on MS-Office & Excel for Administrative and Accounts Staff of CICR, Nagpur from 11th -18th Sept., 2008 atARIS Cell, CICR, Nagpur.

Training on cotton production technology and IPM

One day training programme was organized on cotton production technology and IPM for all FLD beneficiary farmers in Belgaon and Jalka villages in Warora tahsil of Chandra pur district in Vidarbha region ofMaharashtra.

Coimbatore

Farmers training programme

A training programme on "Integrated Cotton Production" was organized at CICR Regional Station, Coimbatore from Dec., 15-17,2008 under NAIP project on cotton value chain for the project of Vidaputhur village, Pollachi (Taluka), Coimbatore (District). About 57 cotton farmers participated in this training programme. All the scientists of CICR Regional Station, participated and imparted training. The training provided knowhow about recently released varieties, hybrids, Bt hybrids, Extra Long Staple hybrids, *in situ* soil moisture conservation and nutrient management techniques. The demonstration of poly mulch techniques, multi tier system and low cost drip system were explained to trainees. Recent advances in management of sucking pest, stem weevil and Bt IPM were narrated. They were trained to take appropriate control measure for disease and nematode problems. Market oriented information includes MSP and available market facilities were given to enhance the marketing capability of project farmers. Utilisation of cotton expert system in pest management was narrated.

Clean cotton cultivation techniques were explained. Different welfare scheme and development programme available from government agencies were also explained.

Field Experience Training imparted to ARS trainees

A group of six Agricultural Research Service scientist trainees of the 85th Foundation Course for Agricultural Research Service (FOCARS) of the National Academy of Agricultural Sciences, Hyderabad comprising of Dr. Bhuvaneswari, Dr. Sugitha, Dr. Dharumarajan, Mr. Rajesh, Mr. V.V. Patil and Mr. Pruan Chandra were attached to the Central Institute for Cotton Research, RS, Coimbatore for Field Experience Training (FET) from 20.3.09 to 9.4.09. The training programme was coordinated by Dr. KK Bandyopadhyay, Senior Scientist and Dr. S. Usha Rani, Scientist (Senior scale), under the overall guidance of Dr.N.Gopalakrishnan, Project Coordinator (Cotton) and Head, CICR, Regional Station, Coimbatore. As a part of the training, they explored the agricultural situation in Allapalayam village, Annur Block of Coimbatore district from 20.03.09 to 30.03.09 using Participatory Rural Appraisal (PRA) techniques. They identified that water scarcity is a major researchable problem responsible for low agricultural productivity. The trainees developed multi disciplinary action plans based on their fields of specialization to mitigate this problem. They suggested that practicing crop diversification, scientific livestock production, agroforestry, growing drought resistant plant varieties and medicinal plants, aquaculture in water harvesting ponds, improvement of soil health through mulching and encouraging on-farm and non-farm micro enterprises to uplift the socio-economic well being of the region. They delivered a seminar in the Allapalayam village on 30.3.09 in the presence of Dr A. Gopalam, FET monitoring faculty from NAARM. Scientists from CICR and officials from the State Agricultural Department and about 70 farmers of the village participated in this seminar. This event has been covered in the local daily "Dinamalar". These scientist trainees also delivered a seminar in the Institute on 1.4.09. Scientists from ClCR, Tamil Nadu Agricultural University, Central Institute of Agricultural Engineering have participated in the seminar. The seminar was chaired by Dr. N. Gopalakrishnan, Project Coordinator (Cotton) and Head, CICR.. Dr. R. Vijayaraghavan, Professor (Community E-radio centre, TNAU) was the special guest.. This seminar created awareness for development of need based research projects to mitigate water scarcity and efficient utilization of limited available water resources to enhance the water productivity so that the farming community can earn more money per each drop of water used as it is one of the scarce agricultural inputs in the present days. This event has been covered in the news paper "The Hindu".

Sirsa

Training on "Cotton Production Technology & Mealy Bug Management

A state level training (two days) programme was organized on cotton production technology and Mealy bug management under implementation of Action Plan ofICDP Mini Mission-II ofTMC. . Ten such training programmes were organized with their dates mentioned 2s under.

1). 20 & 21-10-08; 2). 22 & 23-10-08; 3). 03-11-08 & 04-11-08; 4).05 & 06-11-08; 5). 10& 11-11-08; 6). 17& 18-11-08; 7).19 & 20-11-08; 8).2 & 3-03-09; 9),4 & 5-03-09; 10).9& 10-03-09.

These training programmes were attended by extension officers from eleven cotton growing districts of Haryana. The programme comprised of a capsule of ten lectures i.e. four in Crop Improvement, one in Crop Production and five in Crop Protection technologies. Special emphasis was made on emerging pest problems like mealy bug and its management. . All the scientists of this Regional Station and agronomist from KGK, CCSHAU, Sirsa were involved. A Training Manual compiled and edited by Dr. S.K Verma and Dr. Monga for state level training on cotton production technology and Mealy bug management 2008 (Oct-Nov., 2008) was also supplied to the participants.

Training imparted to HAFED and NITMA scouts

Seven visits were conducted to the 15 villages of Kalanwali Block adopted by Hafed and NITMA under pilot project of "Village Adoption Program of Cotton" for imparting the technical knowhow to the farmers in cotton production and protection technologies. Awareness among the farmers was created towards the selection of proper hybrid to

proper agronomic practices and insect- pest management and finally the post harvest management.. The farmers were specially trained for mealybug management.. Training on Cotton production and protection technology was imparted to the scouts engaged by Hafed at Regional Station, Central Institute for Cotton Research, Sirsa on 24th _25th July, 2008.

Training on cotton hybrid and varietal seed production

Hybrid and varietal seed production training was provided to 30 farmers of this zone during 2007 -08 under Sir Ratan Tata Project.. Farmers from the districts Sirsa and Fatehabad of Haryana and Hanumangarh of Rajasthan were selected. The training was given mainly on seed production of *intra-hirsutum* hybrid CSHH 198; GMS based intra *arboreum* hybrid CICR-2 and *desi* cotton variety CISA 310 which were released from this station for cultivation under entire north zone. Most of the farmers could get sufficient profit.. Farmers who involved their family members in crossing programme profited 4 to 5 times their expenditure. The profit accrued was higher in hybrid seed production of GMS based *desi* hybrid CICR2.

7. AWARDS AND RECOGNITIONS

Punjabrao Deshmukh Woman Agricultural Scientist Award 2007

Dr. S. Vennila, Sr. Scientist (Entomology), Division of Crop Protection, CICR, Nagpur was awarded the coveted Punjabrao Deshmukh Woman Agricultural Scientist Award 2007 on the eve of ICAR Foundation Day in a Ceremony at NASC, New Delhi on July 16,2008. Dr. Vennila got the Award for her work on cotton crop protection and for development 0f tools for extension workersl researchers for disseminating integrated pest management technologies. She applied weather based forecast model for predicting commencement and severity of pests across cotton growing zones.

Dr. Vennila received the Award consisting of a cash prize of Rs. *50,0001-* and a citation from Shri. Kantilal Bhuria, Union Minister of State for Agriculture in the presence of Shri Sharad Pawar, Union Agriculture Minister, and ICAR President and Dr. Mangala Rai, Director General, ICAR..

ICARAward for Team Research

Dr. M. V. Venugopalan, Principal Scientist (Agronomy), Division of Crop Production, CICR, Nagpur and a member of the research team led by Dr. Tapas Bhattacharya, Principal, Scientist, NBSS&LUP, Nagpur received the prestigious ICAR Award for team research for the Biennium 2005-06. Shri. Sharad Pawar, Hon'ble Union Minister for Agriculture, Government of India, presented this award on July 16,2008 for their contribution in understanding the role of soil in mitigating green house gases and also for identifying 22 bench mark soils and production systems that can contribute to higher carbon sequestration. Their study also recommends a minimum soil organic content of 0.63% (bulk density 1.6 *g/cc)* and a maximum soil organic content 2.42% (bulk density 1.22 *g/cc)* as threshold limits to identify systems for carbon sequestration in soils.

NAASFellow

Dr. K.R. Kranthi, Head, Division of Crop Protection and Acting Director of Central Institute for Cotton Research, Nagpur was selected as a fellow of the National Academy of Agricultural Sciences from 1st January, 2009.

CRDAFellow

Dr. S. K. Verma ,Sr. Scientist (Plant Breeding) was conferred Fellow award of Cotton Research and Development Association.

Best Poster Award

Dr. G. Balasubramani, Sr. Scientist (Biotechnology) received the Best Poster award for the poster entitled "Genetic transformation using Bt *cry* 1 gene through *Agrobacterium* mediation in G. *hirsutum* cultivars present during the National Seminar on "Second Green Revolutio-Necessity or Compulsion" held at Agricultural Research Station, Adilabad, AP, from 16-21 Oct., 2008.

8. LINKAGES AND COLLABORATIONS IN INDIA AND ABROAD INCLUDING EXTERNALLY FUNDED PROJECTS

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 Development of *cry* 1 A(a) gene construct	NSP 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	NCIPM, New Delhi State Department of Agriculture, Haryana, KVKs, CCS HAD, Hisar, NCIPM etc

INTERNATIONAL

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

9. ALL INDIA COORDINATED COTTON IMPROVEMENT PROJECT

Crop Improvement: National Trial

- Nine National Trials (conducted in all the three zones), five North Zone trials, nine Central Zone trials and seven South Zone trials were conducted during the year over 228 locations.
- In irrigated national trials, G. *hirsutum* cultures viz., GSHV 155 and CCH 2623 were promising in North and Central zone, respectively.
- In the preliminary *intra-hirsutum* hybrids trial, the hybrids LHH 1350, RAJHH 743 and SHH 463 ranked first respectively in North, Central and South Zone.
- All the ten *barbadense* cultures recorded higher seed cotton yield over the common check variety Suvin in both Central and South zone locations. The entry GSB 41 occupied first rank in both the zones.
- In the preliminary interspecific hybrids *(G. hirsutum x* G. *barbadense)* trial, the hybrids DHB 872 and JKCHB 217 were promising in Central and South Zone, respectively..
- Some promising G. *arboreum* genotypes have been identified for promotion in each zone which were found better than the check varieties in terms of seed cotton yield and fibre quality. Similarly few *desi* hybrids showed promise in each zone.
- In both Central and South zone locations, the genotype H 1353 was promising and occupied the top rank under rainfed situations.
- In the preliminary *intra-hirsutum* hybrids trial under rainfed conditions, the hybrids RAHH 307 and ARBHH 2062 were promising occupying the top rank in Central and South Zone locations, respectively.
- The G. *arboreum* cultures JLA 802 and ARBa 08-34 showed superior perfomlance over the zonal and local check varieties under rainfed conditions in Central and South zone locations, respectively.
- Among the *desi* hybrids tested, the hybrid CISAA 14 recorded the highest yield of 1976 kg/ha in Central Zone and FMDH recorded the highest yield of2239 kg/ha in South Zone.
- Two G. *herbaceum* cultures were found to perform better than zonal check variety in central zone and none found superior to the local check variety Jayadhar in South zone.

Zonal Trial:

North Zone

- Promising cultures of G. *hirsutum* in preliminary Varietal Trial, were LH 2108 and LH 2107 and in the coordinated varietal trial, H 1300 was promlsmg.
- In the Coordinated hybrid trial, SVHH 139 and FHH 141 were promising in *intra-hirsutum* category and in *desi* hybrids group FMDH 8 was good.
- G. *arboreum* genotypes viz., FKD 124 and LD 937 were promising.

Central Zone

- In irrigated trial, a culture ofBS 279 was the best in the Preliminary Varietal Trials and the genotypes GJHV 374 and GSHV 152 were promising in the coordinated varietal trial.. In rainfed trials, AKH 9916 and CPD 817 were promlsmg.
- In the Coordinated hybrid trial, the hybrid NSPL 423 was superior in *intra-hirsutum* category and RAHB 189 was the best in interspecific *(G. hirsutum* X G. *barbadense)* hybrid category.
- In the Coordinated *intra-hirsutum* hybrid trial, the hybrid VBCH 2213 was the best and JKCDH 505 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.*

South Zone

- The G. *hirsutum* genotype, BS 279 and the hybrid KDCHH 712 was the best entry under irrigated conditions.
- In inter-specific hybrid category, the highest seed cotton yield was recorded in RAHB 170.
- Under rainfed situation, the G. *hirsutum* genotype TSH 9975 and the hybrid NHH 59

were promising.

- In *desi* category, G. *arboreum* variety AKA 0 110 and the hybrid NACH 12 were the best performing entries.

Crop Production

- The plant geometry of 100 x 60, 100 x 75, 67.5 x 60 and 108 x 60 cm seems to be optimum for RCH-134 Bt at Faridkot, Ludhiana, Hisar and Sriganganagar, respectively. As regards fertilizer levels, 100% RDF seems to be optimum at all the locations except Ludhiana, wherein 75% RDF was found better.
- The plant geometry of 90x60 cm for Khandwa and Indore, 90 x 45 cm for Nanded, Akola and Banswara, 90 x 90 cm for Rahuri and 120 x 45 cm for Surat and Junagarh was found optimum for RCH-2 Bt hybrid in Central Zone. As regards fertilizer application, 100% RDF seems to be optimum at Khandwa, Surat, Akola and Banswara, where as 125% RDF gave significantly higher seed cotton yield at Indore, Nanded, Junagargh and Rahuri
- The plant geometry of90x 45 cm for Lam, 90 x 60 cm for Siruguppa and 90 x 90 cm for Coimbatore and Dharwad was found optimum for Bunny Bt in South zone. As regards fertilizer levels, 125% RDF gave significantly higher seed cotton yield at all the locations except at Lam where 100% RDF seems to be optimum.
- Among the herbicidal treatment, significantly higher seed cotton yield was obtained with Pendimethalin @ 1 kg/ha pre-emergence + hand weeding at 30 and 60 DAS closely followed by Pendimethalin @ 0.750 kg/ha pre-emergence + Hand weeding at 30 and 60 DAS and Fluchloralin @ 1 kg/ha pre-emergence + Quizalofop-ethyl @ 0.050 kg/ha at 30 and 60 DAS at Surat.
- At Lam, highest seed cotton yield was recorded in Farmers' practices (Hand weeding at 20,40 & 60 DAS + Interculture), closely followed by Pendimethalin @ 1.00 kg a.i./ha pre-emergence +Quizalofop-ethyl @ 0.05 kg a.i./ha at 30 and 60 DAS + interculture).
- Foliar feeding of MgS04@ 1.0%+$ZnS0_4$@ 0.5% gave highest seed cotton yield at all the locations except atAkola.
- Full recommended dose of MOP as basal application in Sriganganagar, and four sprays of 2% $KN0_3$ at Ludhiana and Kanpur gave significantly higher seed cotton yield and lowest in control at all the locations.
- Three sprays of 3% $KN0_3$ gave significantly higher seed cotton yield at Surat, Junagarh and Banswara, whereas application offour sprays of 2% $KN0_3$ and four sprays of3% KNO_3 shows its superiority at Nanded and Indore, respectively and no response was noticed at Akola. Four sprays and three sprays of 3% KNO_3 gave significantly higher seed cotton yield at Dharwad and Siruguppa, respectively over control.
- At Srivilliputtur, pooled data (three years) analysis revealed of3% $KN0_3$ at 60,75,90 DAS was sufficient to get higher yield which was comparable to the application of MOP in four splits.
- An integrated nutrient management with 100% RDF (60:30:30 kg of NPK / ha) plus FYM @ 12.5 t/ha resulted in better morphophysiological attributes and higher seed cotton yield.
- Genotypes Bihani 161, GJHV 374 and GTHV 0/35 performed better under stress and gave yield of>90 g/plant. Amongst different drought screening indices, PHSI, DMSI and YSI showed a positive significant correlation with yield, under stress.
- Early sowing ofBt hybrids led to 3.0 %, 7.9 % and 31.1 % more number of bolls/plant, boll weight and seed cotton yield, respectively as compared to 20 days late sowing at Dharwad.
- At Hisar, the assimilation rate was seen higher in both the Bt genotypes (RCH 134 and MRC 6301). Increasing salinity of irrigation water generally above 2.5 dSm^{-1} led to a gradual decrease in cotton productivity. An irrigation water E.C. of7.5 dSm^{-1} led to a 60% decrease in cotton production.
- G. Cot. Hy 8 recorded significantly higher oil, protein and nitrate reductase with least content of gossypol.
- Significant variations in nitrate reductase and peroxidase have been found amongst the

genotypes tested at Dharwad. Higher levels of phenolics like tannins and total phenols were observed in select genotypes that exhibited tolerance to insect pests.

Entomology

- Cultures tolerant to Jassid and bollworms were identified from the genotypes of breeding trials of the three cotton growing zones ofIndia.
- **North** Zone: In Bt cotton, jassid incidence was at higher level (6.6 to 9.2 / 3 leaves) in Ludhiana, Thrips population was at higher level (30.5 to *40.4* / 3 leaves) in Sriganganagar, whitefly also at higher level (30 to *34/3* leaves) in Sriganganagar and mealy bug infestation ranged from 28 to 96 per cent in Faridkot.. In other centres the sucking pests were below threshold level.. Almost similar trend was observed with non Bt cotton also.
- In RCH 134 Bt cotton, moderate level of Pink bollworm (2.1 to 2.3 / 20 green bolls) was recorded in Sriganganagar, while in non Bt cotton moderate level of *Earias* bollworm was recorded. Faridkot recorded very high level of Pink bollworm (13 larvae).
- **Central** Zone: In Bt cotton, aphid and jassid population where higher in Junagadh while Jassid alone was higher at Surat, Banswara, Akola and Nanded. A similar trend was also observed in non Bt cotton.
- In Bt cotton, pink bollworm was low level, 0.3 to *1.0* / 20 green bolls in Junagadh and higher level in Banswara and Akola. Moderate level incidence of S. *litura* observed in Junagadh
- In non Bt cotton, moderate incidence of *H.armigera* observed in Khandwa, Bhawanipatna, Rahuri and Surat.. *Earias* bollworm was moderated in Rahuri, Akola, Surat and Khandwa. It was at higher level in Bhawanipatna. Very high population of pink bollworm (2 to 44 larvael 20 green bolls) was observed in Akola and moderate level in Bhawanipatna, Rahuri, Surat, Junagadh and Khandwa. *Spodoptera litura* was recorded at moderated in Khandwa, Rahuri, Bhawanipatna and Surat and higher level at Junagadh (3.0 to 11.5 larvae / 5 plants).
- **South** Zone: In Bt cotton, jassids were above threshold level (6.2 to 18.2 / 3 leaves) in LAM and Dharwad. Thrips were at higher level (31-*501* 3 leaves) in Dharwad, while mirid bug infestation was higher at Dharwad (8.2 to *22/25* squares) at Raichur. Mealy bug infestation was moderate in Raichur and Coimbatore.
- In non Bt cotton (DHB 105, Bunny and Narasimha) jassid population was high (6.1 to *21.1* / 3 leaves) in LAM and Dharwad while aphid population was high at Coimbatore. Dharwad recorded higher population of thrips. Mirid bug infestation was at moderate level in Dharwad (7.2 to 21.3 *125* squares) and Raichur (2 to 9).
- In Bt cotton pink bollworm was at high in Dharwad, Moderate in LAM farm while it was absent in Raichur and Coimbatore. In non Bt cotton *Heliothis* bollworm was high (3.5 to *9.915* plants) in Dharwad and moderate in Raichur, while it was absent in LAM and Coimbatore. Higher incidence of *Earias* bollworm was recorded in Dharwad and Raichur. Pink bollworm also at high (4 to 11 larvae) in Dharwad, LAM and Raichur.
- Spirotetramat @ 90 g a.i./ha was effective against mealy bug and recorded higher yield (30.5 q/ha) over control in Faridkot and Hisar centres.
- Profenophos @750 gm followed by Chlorpyriphos (500 & 1000 gm) and Buprofezin 312.5 g were effective against mealy bug and recorded higher yield.
- Fipronil @ 40 g a.i. / ha was effective against jassid, thrips, aphids and whitefly almost in all the locations and recorded significantly higher yield over control..
- In on farm trial at Srivilliputur, Chlorpyriphos was the most effective treatment for mealy bug control while stem drenching with Chlorpyriphos 2.5 *mV* lit + Carbendazim 1 *g/lit* was the most effective treatment for the control of stem weevil infestation.

Pathology

- The cotton leaf curl virus disease (CLCuD) incidence started late and remained very low in the entire north zone. The incidence was observed in traces to 5% on Bt cotton as well as on varieties in farmer's field in Rajasthan, whereas, in Haryana, it was observed only in traces.

- There was very good precipitation during the vegetative phase (growth stage) of the crop at regular interval prevented the whitefly population build up at the susceptible stage of the crop and inhibited the inoculation of virus by the vector whitefly.
- Bacterial blight was reported as important disease in central zone in Gujarat (Bharuch 0-43.5%) and Maharashtra (Vidarbha 9.0-28.3%, Rahuri 26.6%, Nanded 3-12%) and Karnataka in south zone (5-15%).
- Alternaria blight was serious in Gujarat's Saurashtra area (4.5-15.5%), and Maharashtra's Rahuri (4.5-30.17%) and Nanded (5.0-20.4%) and in south zone Karnataka (5-15%) and Tamil Nadu (7.7-29.4%). *Myrothecium* was severe in Madhya Pradesh (48%).
- Grey mildew occurred in Maharashtra in the irrigated areas ofVidarbha region (4.0- 32.5%). In south zone, it was severe in three states i.e., Karnataka (5-30%), Tamil Nadu (7.2-28.3%) and Andhra Pradesh (37.5%).
- Rust appeared severe in Tamil Nadu (5.3-48.4%) and Andhra Pradesh (30.0%). Tobacco Streak Virus incidence upto 15.7% was also observed in Andhra Pradesh in September.
- The reaction of various entries against CLCuD in different trials showed that in north zone, there were 18,9, 8,22 and 10 entries out of a total of91 entries respectively, in Br 02a, Br 03a, Br 04a, Br 05aI PHT and Br 05A-l CHT in Resistant and Moderately Resistant category.
- The test fungicide Taqat 75WP *(MIS.* Rallis India Ltd.) at two concentrations i.e., 500 g/ha and 750 glha significantly reduced fungal leaf spots and bacterial blight at all five test locations (TNAU Coimbatore, Junagadh, Faridkot, Guntur and Dharwad). Highest seed cotton yield was observed in case ofTaqat spray at 750 g/ha followed by its spray at 500 g/ha and propiconazole at 0.1%.
- The test fungicide copper hydroxide at three concentrations i.e. 1000, 1250 and 1500 g lha led to significant reduction of bacterial blight and Alternaria leaf spot at all the six centers (Dhadwad, Surat, Khandwa, Akola, Nanded and Rahuri). Maximum reduction was noted at highest test concentration. Significantly higher seed cotton yield was observed at all the centres except Surat as compared to check..
- Seed treatment with the talc formulation of *Pseudomonas jluorescens* Pf 1 @ 10 *g/kg* seed followed by foliar spray of the same on 30, 40, 50, 60, 70, 80 and 90 DAS proved effective in reducing the incidences of bacterial blight and fungal foliar spots.
- Four sparys of Carbendazim@ 0.1% at 50, 65, 80 and 95 DAS reduced PDI from 15.5% to 10.1% and reduced 28.3% losses due to grey mildew at Dharwad, Guntur and Nanded.
- Four spays of propiconazole @0.1% at 50, 65, 80 and 95DAS at Dharwad, Guntur and Rahuri reduced Alternaria blight PDI from 30.8 to 14.6% and reduced losses by 22.0%.
- Four sprays of copper oxychloride (0.3%) and 500 ppm streptocyclin at Dharwad at 50, 65, 80 and 95 DAS reduced bacterial blight PDI from 32.3 to 19.0% and reduced 30.2% loss due to disease.
- Five sprays ofPropiconazole @ 0.1% at 35,50, 65, 80, 95 DAS at Khandwa reduced *Myrothecium* leaf spots PDI from 19.4 to 7.3% and reduced loss by 24.1%.

10. KRISHI VIGYAN KENDRA

Training Achievements:

KVK, CICR, Nagpur conducted ninety nine short duration (1 to 3 days) ON and OFF campus training courses in different disciplines for 2108 participants including 1325 farmers, 560 rural youths and 223 extension functionaries.

Discipline Practicing	No of courses	No of participant			Total
		Extension farmers	Rural Youth	Functionaries	
Crop Production	23	296	106	27	429
Horticulture	15	228	61	48	337
Plant Protection	14	203	101	30	334
Veterinary Science	19	200	97	47	344
Home Science	15	165	89	33	287
Extension	13	233	106	38	377
Total	99	1325	560	223	2108

In addition, 18 collaborative sponsored training courses of 1 to 3 days were organized in different disciplines for 821 participants including farmers and extension functionaries deputed by Dr. PDKV, Akola, State Agriculture Department (M.S., A.P. and M.P), ATMA, CIPM, MAFSU, MCED and ICDS Nagpur. These participants were benefited by imparting need based knowledge and skill oriented trainings.

Discipline	No of courses	No of participants	Sponsoring agency
Crop Production	3	127	Dr. PDKV Akola
Horticulture	2	51	State Agril Deptt., (M.S. and M.P.)
Plant Protection	4	121	State Agril., Deptt., AP, MP and CIPM, Nagpur
Veterinary Science	1	45	MCED, Nagpur
Home Science	2	311	ICDS, Nagpur
Extension	6	166	State Agril., Deptt. (M.S.), ATMA
Total	18	821	

Front Line Demonstrations

Fourteen Front Line Demonstrations on recommended technologies in agriculture and allied fields were conducted on 277 farmer's fields ofMandavghorad, Mangli and Ranmangli villages of Nagpur district covering an area of 124.6 ha. Extension activities viz. field days, field visits of farmers and extension functionaries to FLD demonstrations, group discussions, scientists-farmers meet, etc. conducted for effective implementation of FLDs. The data on certain production parameters was recorded and feedback from farmers and other visitors was documented so as to forward to concerned agencies i.e. ICAR or other research institutions, SAU's, extension and development departments, etc. for further dissemination or modification.

Details of Assessment of technologies under Front Line Demonstrations are as follows

Sr. No.	Cropl Animal	Technologies demonstrated	No. of far-mers	Area covered (ha)	Yield (Q/ha)		o/o Increase OverFP
					Demo.	FP	
1	Cotton	NCH 145 Bt + INM	50	20	14,26	10.94	30.34
2	Cotton	NCH 145 Bt + IPM	53	50.6	14.94	11.77	26.93
3	Soybean	INM	25	10	10.50	8.11	29.46
4	Pigeonpea	ICPL 87119 (Asha)	25	10	8.10	5.30	52.83
5	Chickpea	laky 9516	16	8	12,20	10,25	24.48
6	Wheat (Timely sown)	AKW 3722 (Vimal)	9	2	32.10	9.80	32.99
7	Wheat	NIAW 917	5	2	25.90	20.58	25.12
8	Brinjal	Management of shoot and Fruit borer	15	5	175.00	130.00	34.6
9	Chickpea	Management of *Helicoverpa armigera*	15	6	12.1	10.30	17.5
10	Okra	Variety Akola bahar	13	5	56.00	44.50	21.5
11	Onion	Variety Akola Safed	19	6	103.8	80.50	21.85
12	Cowpea & wheat	Reduction drudgery women through improved in sickle	12	-	0.024 ha/hr.	0.009 ha/hr.	0.015 halhr.
13	Cross bred Jersey cow	Feeding of urea treated roughage.	10	20 cows	7.50 lit/cow/day	6.60 lit/cow/day	13.64
14	Goat	Use of ecto & endo parasiticidal drugs	10	20 goats	Avg. live body wt. -21.88 kg	Avg. live body wt. -20.04 kg	9.18
		Total	**277**	**124.6**			

On Campus Crop Demonstrations

A replica of Nagpur district cropping pattern including 20 major crops i.e. cotton, pigeonpea, soybean, fodder jowar, fodder maize, lucerne, berseem, vegetables, fruits, flowers, etc. was demonstrated on the 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, farm women and extension functionaries from Nagpur district and other states visited these demonstrations.

During the period under report, 1274 VISItors including practicing farmers, farm women, rural youths and extension functionaries visited the instructional farm, zero energy cool chamber, goat unit, fruit cafeteria and vermin-compost unit of KVK, CICR, Nagpur.

Osmanabadi Goat unit

KVK has established a Goat Demonstration Unit comprising of parent stock of 10 females and 1 male of Osmanabadi breed. This is one of the

precious breeds out of 20 recognized breeds of India. During this year, a resource ofRs. 51561/- was generated by selling 12 pure Osmanabadi bucks and 5 females to 8 goat entrepreneurs of Nagpur district.. These pure Osmanabadi goats are responsible for genetic improvement in local goats. More than 100 participants were benefited by imparting practical skills of management practices in this goat unit.. More than 600 farmers/livestock owners, rural youth and extension functionaries visited the goat unit..

Animal Health Camps

KVK organized three 'Animal Health Camps' in adopted villages i.e. Mangli and Mandavghorad. Livestock were treated, vaccinated and sprayed for control of ectoparasites in these camps. More than 80 animals were treated and 200 goats were vaccinated against Haemorrhagic septicemia and Enterotoxaemia diseases. All the goats of both the villages were sprayed with new generation ectoparasiticide i.e. cypermethrine for effective control of ectoparasites. More than 100 farmers/livestock owners benefited through this camp.

On Farm Testing

On farm testing was conducted on, "Anaemia in rural pregnant women in the age group of 20- 35 years". The results indicated that the haemoglobin percentage in pregnant women supplemented with green leafy vegetables, soybean flour and jaggary in daily routine diet increased significantly. It also improved their body weight which leads to best development and nourishment of foetus as compared to daily routine diet and recommended diet.

Participation in Exhibitions

KVK participated in "Agriculture Technology Exhibition" organized by SAO, Kadimbagh, Nagpur from 03-05 May, 2008. This exhibition was held under Food Security Scheme run by Government ofIndia. During this mega exhibition, more than 1500 visitors including delegates, progressive farmers, farm women, scientist, extension functionaries of state department and agriculture students visited to the stall. KVK participated in State Agricultural Exhibition held at Dikshabhoomi Nagpur on occasion of "Dhammachakra pravartan Din" from 08/10/08 to 10/10/08. This exhibition was organized by Joint Director Agriculture, Nagpur. More than 4000 farmers visited the exhibition stall ofKVK during exhibition.

KVK participated in state level Agricultural Exhibition at Buldhana on the occasion of "Dr. Panjabrao Deshmukh birthday" from 27/12/08 to 29/12/08 organized by Dr. PDKV, Akola. More than 6000 farmers visited to KVK stall during exhibition.

KVK participated in"Rashtriya Kisan Mela-2009" organized by National Research Centre for Citrus, Nagpur at its campus from 25^{lh} 26th February 2009. More than 1500 fanners visited the stall and appreciated the activities of CICR. Visitors showed keen interest in Bt. Detection Kit and transgenic Bt. cultivers of cotton developed by collaborative efforts of UAS, Dharwad, NRCPB, New Delhi, MAU, Parbhani and CICR, Nagpur.

Insecticide Resistance Management (IRM) Project underTMC MM-II

Insecticide Resistance Management (IRM) Project on cotton was started in Nagpur district of Maharashtra state during year 2006-07. During the crop season 2008-09, the project has been implemented in 60 villages ofKalmeshwar, Katol, Narkhed and Saoner tahsils of Nagpur district on 1535 cotton growing farmers covering 2283 hectares area.

During this year, 60 field workers were appointed and imparted skill- oriented training and practical demonstrations to implement IRM strategies in the adopted villages at farmer's fields to keep day to day contact with the client farmers, to get feed-back from them and to disseminate the IRM technology.

Under this project extension activities like field days, farmers meet, group discussions, diagnostic surveys, field visits were conducted and four Kisan Melas were organized.

Due to the implementation ofIRM strategies under this project farmers were convinced to reduce the number of insecticidal sprays from 1.56 to 0.55 approx. Hence the cost of cultivation has been reduced from Rs. 20700/- per ha to Rs. 19800/- per ha. Moreover seed cotton yield was increased from 14.25 q/ha to 16.59 q/ha.

Extension Activities

Three field days on three topics l.e. cotton,

floriculture and women in agriculture were organized in which 226 farmers, farm women and rural youths were participated. During the year 2008-09, KVK organized one Kisan Mela. One television show and eleven radio talks on various topics of agriculture, animal science, home science and allied subjects were delivered by SMSs of KVK on Doordarshan Kendra and All India Radio, Nagpur, respectively.

Diagnostic Survey

Twenty eight diagnostic surveys in adopted and other villages of Nagpur district were undertaken to suggest the remedies to overcome specific problems in crops, citrus and animals covering more than 56 ha cropping area and 114 animals.

Scientific Advisory **Committee Meeting**

The 13th SAC meeting ofKVK, CICR, Nagpurwas conducted on 22nd October, 2008 under the Chairmanship of Director, CICR, Nagpur. More than 20 members of agriculture and allied departments participated.

CICR

ANNUAL REPORT 2008-09

Dr. Mangala Rai, DG, ICAR chairing the ICAR Standing Committee for TMC MM1

Dr. C.D.Mayee, Chairman, ASRB addressing at Annual Review Workshop of TMC MM1

Dr. M. S. Swaminathan, Chairman, MSSRF, Chennai, discussing about cotton crisis in Vidharbha

Dr. Vennila, receiving best Women Scientist Award from Shri Kantilal Bhuria Union Minister of State for Agriculture

Participants of Indo-Brazil-South-Africa International Training Programme on Cotton Production & Value Addition

Participants of National Training Programme on Variety Purity Testing of Specified Traits

11. GENERAL

11.1 List of Publications

Papers Published in Research Journals

Ahuja, S. L., Dhayal, L. S., Monga, D.(2009). ~erfo~a~ce of upland coloured cotton germplasm hnes m hne 3 tester crosses. Euphytica. DOl *10.1007 /s* 10681-009-9939.

Dhara jothi,B. and Usha, K.Mehta (2008). Pathogenicity and bio-efficacy of entomopathogenic nematodes against sugarcane shoot borer Chilo infuscatellus Snell. . *InternationalJournalofNematology,18(1)47-53.*

Bandyopadhyay, K.K., Misra, A.K., Ghosh, P.K., Hati, K.M., Mohanty, M. and Singh, R.K. (2008). Assessment of critical soil water potential for emergence of wheat, chickpea and linseed seedlings in relation to water stress in a Vertisol.. *Journal of the Indian Society of Soil Science,* 56(3): 267-275.

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Kadam, B.P., Chavhan, RL.., Chakrabarty, P.K. and Patil, F.S. (2009). Characterization of variability in some economically important species of *Alternaria* based on the nucleotide sequences of nuclear ribosomal DNA *J. Plant Biochemistry & Biotechnology, 18:59-64.*

Kranthi, K. R., Davis, M., Mayee, C. D., Russell, D. A., Shukla, R. M., Usha, S., Mansi, K., Divya, and Kranthi, S.,(2009). Development of a colloidal-gold based lateral-flow immunoassay kit for 'quality-control' assessment of pyrethroid and endosulfan formulations in a novel single strip format.. *Crop Protection,* 28,428-434.

Kranthi, S., Dhawad, Naidu, C. S., Bharose, S. A, Chaudhary, A, Sangode,V S.K., Nehare, Bajaj" S R, Kranthi, K. R, (2009). Susceptibility of the cotton bollworm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) to the *Bacillus thuringiensis* toxin *cry* 2Ab before and after the introduction of Bollgard-II. *Crop Protection, 28,* 371-375.

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Nagrare, V S.,Kranthi, S.,Biradar,VK., Zade, N.N., Sangode, V, Kakde, G., Shukla, RM., Shivare, D., Khadi, B.M.,and Kranthi, K. R, i (2009). Widespread infestation of the exotic

mealybug species, *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae), on cotton in India. *Bulletin of Entomological Research,* Published online by Cambridge University Press 19 Feb 2009 doi: 10.1017/S0007485308006573

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Palve. S.M. (2008). Evaluation of Bt hybrids released for central zone under rainfed situation. *CICRNewsletter,* 24 (3), 5 p.

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Ramesh, V, Bandyopadhyay, KK and Sharma, KL.. (2008). Evaluation of infiltration models under different land use and management systems in semi arid tropical Vertisols. *Journal of the Indian Society of Soil Science,* 56(2): 154-160

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Tuteja, O. P. and Khadi,B.M.(2008). Development and characterization of fertility restorers in cytoplasmic male sterile lines of cotton *(Gossypium hirsutum* L.) derived from *Gossypium harknessii. Indian Journal of Genetics and Plant Breeding,* 68: 337-339.

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Verma, S. K, Tuteja, O. P. and Monga, D. (2008). Evaluation for Genotype x Environment interaction in relation to stable GMS based hybrids of north zone in Asiatic cotton *(Gossypium arboreumL.) IndianJ agric. Sci.,* 78: 375-78.

Verma, S. K, Tuteja, O. P., and Monga, D. (2008). Assessment of Genetic divergence among genotypes of upland cotton *(Gossypium hirsutum* L.) developed using different sources of cytoplasm. *Journal Indian Cotton Improv. Society,* 33:1-6

11.2 List of on-going Projects

Institute Projects

Nagpur

Name of project	Name of Project Leader & Associate(s)	Duration
CROP IMPROVEMENT		
Germplasm		
Collection, conservation, evaluation, documentation and maintenance of germplasm of cultivated species of *Gossypium*	Punit Mohan (PL) S. Manickam (PA) S. J Gawande (PA) V. S. Nagrare (PA) R. A. Meena (PA) A. B. Dongre (PA) Anjali Kak (PA)	2006-2013
Development of core assembly of *Gossypium barbadense,* G. *arboreum* and G. *herbaceum* germplasm	Punit Mohan (PL) KPM Dhamayanthi (PA)	2008-2012
Breeding		
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
Improvement of tetraploid and diploid cottons for fibre properties through population improvement approaches	V. N.Waghmare (PL) Vinita Gotmare (PA)	2000-2010
Molecular mapping of fibre quality and lint yield traits: construction of a framework linkage map in *desi* cotton *(Gossypium* sp.)	V.N.Waghmare (PI) A.B.Dongre (PA) Vinita Gotmare (PA) Er. Manoj Kumar (PA)	2006-2009
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. Vennila (PA) V. Gotmare (PA)	2005-2010
Development of heterotic pool for superior medium staple in tetraploid cotton *(G. hirsutum)*	S. M. Palve (PL)	2006-2011
Development of drought tolerant genotype with good fibre quality	S. B Singh (PL) A. H. Prakash (PA)	2008-2013
Development of improved male sterility system through induced mutation	S. B. Singh (PL) O. P. Tuteja	2008-2011

Studies on genetic enhancement of upland cotton	T. R. Loknathan (PL)	2002-2010
Genetics & Cytogenetics		
Conservation, characterization and utilization of wild species, races of cultivated species perennials and synthetic polyploids of *Gossypium*	Vinita Gotmare (PL) G. Balasubramani (PA)	2008-2013
Identification of genetic markers and characterization of fibre strength and drought tolerance traits in interspecific cross between G. *herbaceum* and G. *anomalum*	Vinita Gotmare (PL)	2008-2013
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
Diversification of Male sterile cytotypes genetic studies and utilization of Cliestogamy and protruding stigma in *Gossypium* spp.	Vinita Gotmare (PL)	2008-2013
Development of transgenic diploid cotton for insect resistance	S. B. Nandeshwar (PL) V. S. Nagrare (PA) S. M. Palve (PA)	2008-2011
In-vitro 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
Biotechnology		
Molecular basis of pathogenicity and race-specificity of *Xam* and characterization of antagonists of foliar pathogens of cotton for biocontrol	P.K. Chakrabarty (PL)	1994-2010
Development of transgenic cotton resistant against major diseases of cotton.	P. K. Chakrabarty (PL) S. B. Nandeshwar (PA) A. H. Prakash (PA)	2009-2012
Isolation of fibre specific trichome specific promoter from G. *hirsutum* / *A. thaliana*	G.Balasubramani (PL) J. Amudha (PA)	2008-2011
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
Molecular mapping of Leaf curl virus resistance gene in the cotton genome	J. Amudha (PL) D. Monga (PA) G. Balasubramani (PA)	2002-2009
Molecular evaluation of cotton germplasm	A. B. Dongre (PL) Punit Mohan (PA)	2000-2011
Seed Technology		
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

Performance of new Bt hybrids on large size plots (138.24 sq. mt.).	R. K. Deshmukh (PL) P. R. Vijayakumar i(PA) V. Santhy (PA)	2008-2011
Studies on cotton seed with particular reference to germination and dormancy	P. R. Vijayakumari (PL) R. A. Meena (PA) R. K. Deshmukh (PA) V. Shanthy(PA)	2004-2009
Assessment of working seed sample size for Bt seed testing based on estimation of *cry* lAc protein.	P. R. Vijayakumari (PL) K. R. Kranthi (PA)	2008-2010
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
Assessment of Seed Vigor trait in cotton	V. Santhy (PL) P. R.Vijayakumari (PA) Jagvir Singh (PA)	2003-2010
Phenotyping and genotyping of cotton genotypes	V. Santhy (PL) K. Rathinavel, (PA) G. Balasubramani (PA)	2008-2012
Transgene expression and effect of trans gene on quantity and quality in seeds of Bt cotton hybrids	V. Santhy (PL) S. B.Nandeshwar (PA) G."Balasubramani (PA)	2008-2011
CROP PRODUCTION		
Agronomy		
Nutrition requirement of soybean-Bt hybrid cotton in participatory mode	A. R. Raju (PL) M. K. Meshram (PA) G. Majumdar (PA)	2008-2012
Soil science		
Studies on long term effect of fertilizer and integrated nutrient management on productivity, soil fertility and quality on rainfed hybrid cotton.	Jagvir Singh (PL) M. V. Venugopalan (PA) K. Velmourougane (PA)	2004-2025
Agricultural Microbiology		
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
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
Biochemistry		
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
Assessment of gossypol content in cotton germplasm	M. Chakrabarthy (PL)	2004-2012

Agricultural Economics		
Economic analysis of cotton based farming system in Vidarbha.	P. R Deoghare (PL) S. M. Wasnik (PA)	2007-2010
Capital requirement for modernization of cotton production on marginal and small farm in vidharbha	P. RDeoghare (PL) A. R Reddy (PA) S. M. Wasnik (PA)	2008-2010
Economic impact of Bt cotton cultivation in India	A. R. Reddy (PL) Isabella Agarwal (PA) Rishikumar (PA)	2008-2010
Economic analysis of cotton based cropping systems	A. R Reddy (PL) Isabella Agarwal (PA) R. A. Meena (PA)	2008-2011
Agricultural Extension		
Study on accessibility to mass media and information technology of potential users in cotton production	S. M. Wasnik (PL) P. R. Deoghare (PA)	2005-2008
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
Animal science		
Performance of Osmanabadi goats under feeding ofBt and Non Bt cotton leaves	S. N. Rokde (PL)	2007-2009
CROP PROTECTION		
Entomology		
Exploitation of induced resistance for cotton pest management	S. Kranthi (PL)	2008-2010
Isolation and characterization of native Bt strains using conventional and molecular methods, for cotton pest management	S. Kranthi (PL) K. R. Kranthi (PL)	2008-2010 2008-2010
Monitoring changes in baseline susceptibilities to crylAc in geographic populations of *H armigera.*	S. Kranthi (PI) K. R. Kranthi (PA)	2008-2010
Monitoring changes in baseline susceptibilities to *cry* 2Ab and *cry* 1Ac +*cry2Ab* in geographic populations of *H armigera.*	S. Kranthi (PI) K. R. Kranthi (CCPI)	2002-2012
Monitoring changes in baseline susceptibilities to JK toxin (Event 1) in geographic populations of *H armigera.*	S. Kranthi (PI) K. R. Kranthi (CCPI)	2002-2012
Population and community ecology of cotton entomofauna.	S. Vennila	**2006-2011**
Evaluation and exploitation of compensation as a mechanism for comprehensive insect pest tolerance.	S. Vennila (PL) Vinita Gotmare (PA)	2006-2011

Studies on bionomics and management of mealy bug.	V. S. Nagrare (PL) K R. Kranthi (PA)	2008-2011
Ecological - based approaches for sustainable sucking pests management	V. S. Nagrare (PL)	2008-2010
Plant Pathology		
Studies on seed transmitted pathogenic infections and other seed micro flora of cotton.	P. M. Mukewar (PL)	1989-2009
Screening and identification of effective bio-control agents for the management of foliar cotton diseases.	M. K Meshram (PL) S. J. Gawande (PA)	2008-2011
Identification of bacterial blight and grey mildew disease resistant genotypes in upland cotton.	M. K Meshram (PL)	2008-2011
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
Nematology		
Studies on Biochemical, molecular and genetic basis of host plant resistance to cotton nematodes.	N. G. Narkhedkar (PL)	2006-2010
Potential of rhizobacteria in management of cotton nematodes	N. G. Narkhedkar (PL)	2006-2010
Isolation, identification and characterization of insecticidal toxins from heat tolerant isolate of EPN bacterial system	N. G. Narkhedkar (PL)	2008-2011

Coimbatore

Plant Breeding and Genetics		
Development of conventional *intra-hirsutum* hybrids with superior fibre qualities	Mr. D.KAgarwal (PL)	2008-2013
Development of *hirsutum* genotypes having high oil content coupled with fibre productivity and quality	Mr. D.KAgarwal (PL) Dr. S. M. Palve (PA)	2008-2013
Identification and development of genotypes suitable for ultra narrow spacing and having yield superiority over Bt hybrids	Mr. D.KAgarwal (PL) Dr. C.S.Prahraj (PA)	2008-2013
Breeding new G. *hirsutum* varieties with new plant types - development of medium staple varieties.	Mr. KN.Gururajan (PL) Dr. S.Manickam (PA)	1969-2011
Development high yielding and high spinning extra long cotton staple varieties.	Mr. KN.Gururajan (PL) Dr. S.Manickam (PA)	1979-2011
Development of long staple G. *hirsutum* with improved fibre strength.	S. Manickam (PL) V.N.Waghmare (PA) S.L.Ahuja (PA)	2008-2014

Cytogenetics		
Induction of polyploidy and introgression of agronomical traits from diploid wild species to cultivated tetraploids	Dr. K.P.M.Damayanti (PL) Dr. Vinita Gotmare (PA)	2008-2012
Development and promotion of Bt Transgenic Cotton for Bollworm Resistance	Dr. S. Manickam (PL) Shri D. K. Agarwal (PA)	2007-2012
Development of long staple G. *hirsutum* with improved fibre strength.	Dr. S. Manickam (PL) Dr. VN.Waghmare (PA) Dr. S.L.Ahuja (PA)	2008-2014
Development of extra-long staple high spinning hybrids with wider adaptability	Dr. KPM Dhamayanthi (PL) Dr. S.Manickam (PA)	1986-2011
Development of extra-long staple G. *barbadense* varieties with improved fibre properties for the requirement of textile industry	Dr. KPM Dhamayanthi (PL) Shri K.N.Gururajan (PA)	2007-2011
Exploitation of nano techniques for seed quality management	Dr. K.Rathinavel (PL)	2008-2012
National Seed Project	Dr.K.Rathinavel (CCPI)	1998-Con.
Seed production in agricultural crops & fisheries	Dr. K.Rathinavel (PL)	2006-2014
Crop Production		
Bio-mulching and bio-degradable mulching for Bt cotton based cropping system	Dr.P.Nalayini (PL) Dr.K.Sankaranarayanan (PA) Shri K.Velmourougane (PA)	2008-2010
Herbigating herbicide/ herbicide mixture/ herbicide rotation for efficient and environmentally safe weed control and its effects on succeeding pulses	Dr.P.Nalayini (PL) Dr.K.Sankaranarayanan (PA) Shri K.Velmourougane (PA)	2008-2010
Simulation of effect of irrigation and nitrogen on soil, water and nitrogen dynamics, productivity and input use efficiency ofBt cotton in a vertic Ustropept	Dr.K.K.Bandyopadhya (PL) Dr.A.H.Prakash (PA) Dr.K.Sankaranarayanan (PA) Dr.B.Dharajothi (PA)	2006-2009
Studies on soil aggregation and aggregate associated carbon in cotton based cropping system	Dr.K.K.Bandyopadhya (PL) Shri K.Velmourougane (PA)	2008-2010
Evaluation of cotton base cropping system for higher economic returns	Dr.K.Sankaranarayanan (PL) Dr.P.Nalayini (PA) Dr.C.S.Praharaj (PA) Dr.K.K.Bandyopadhya (PA)	2005-2011
Water management in *hirsutum* and *barbadense* cotton	Dr.K.Sankaranarayanan (PL) Dr.P.Nalayini (PA) Dr.C.S.Praharaj (PA) Dr.K.K.Bandyopadhya (PA)	2004-2010
Economic analysis of contract farming in cotton in Tamilnadu	Dr.Isabella Agarwal (PL)	2005-2009
Adoption, impact and return to research investment in improved cotton cultivars in Tamilnadu	Dr.Isabella Agarwal (PL)	20052009

Documentation and validation of fanners indigenous knowledge on fanning system approach in cotton	Dr.S.Usha Rani (PL) Dr.P.Nalayini (PA)	2007-2010
Post evaluation of fanners field schools on cotton	Dr.S.Usha Rani (PL) Dr.K.Sankaranarayanan (PA)	2007-2010
Comparative analysis of conventional, biotech and organic cotton production systems in India	Dr.S.Usha Rani (PL) Dr.S.M.Wasnik (PA) Dr.K.Sankaranarayanan (PA)	2008-2011
An empirical analysis on cultivation behaviour of Bt cotton growers with regard to insect resistance management technologies	Dr.S.Usha Rani (PL) Dr.S.M.Wasnik (PA)	2008-2011
Physiological and molecular elucidation of fibre development process in cotton for enhanced fibre yield	Dr.A.H.Prakash (PL) Dr.N.Gopalakrishnan (PA)	2004-2009
Physiological manipulation ofBt plant morpho frame for enhanced productivity under varied agroclimatic conditions	Dr.A.H.Prakash (PL) Dr.R.K.. Deshmukh (PA)	2007-2012
Identification and utilization of adaptive responses to abiotic stresses in cotton	Dr.S.E.S.A.Khader (PL) Dr.N.Gopalakrishnan (PA) Shri K.N.Gururajan (PA)	1995-2009
Studies on the mechanism of cuticular absorption of nutrients and honnones in Bt cotton	Dr.S.E.S.A.Khader (PL)	2008-2012
Developmental biochemistry of cotton host-pest/disease interaction	Dr. N.Gopalakrishnan (PL) Dr. B. Dharajothi (PA) Dr.Sandhya Kranthi (PA) Dr. M. K. Meshram (PA) Dr.Rishikumar (PA)	1997-2010
CROP PROTECTION		
Entomology		
Cropping systems based studied on Mirids	Dr. M. Amutha (PL)	2008-2011
Studies on the role and effect of insecticides in cotton ecosystem	Dr. T. Surulivelu (PL) Dr. K. Natarajan (PA)	1989-2011
Studies on the population dynamics of cotton pests and their natural enemies in cotton eco-system.	Dr. K. Natarajan (PL) Dr. B. Dhara Jothi (PA)	2008-2010
Developing resistant genotypes to jassid.	Dr. K. Natarajan (PL) Dr. Damayanthi (PA)	2008-2012
Standardization of bioassays techniques for resistance monitoring in *Pectinophora gossypiella* Saunders to transgenic cotton and development of management strategies.	Dr. B. Dhara Jothi (PL)	2007-2012
Pesticides, sucking pests and predator interaction on Bt cotton.	Dr. B. Dhara Jothi (PL)	2008-2010

Nematology		
Identification of hotspots for plant parasitic nematodes in cotton growing zones of India.	Dr. Gulsar Banu (PL) Dr. N G Narkhedkar (PA)	2006-2011
Development, validation and utilization and/or commercialization of bio-pesticides and bio-inoculants	Dr. Gulsar Banu (PL) Dr. N G Narkhedkar (PA) Dr. B. Dharajothi (PA)	2007--
Isolation of novel insecticidal proteins from bacterial symbionts of native entomo-pathogenic nematodes	Dr. Gulsar Banu (PL) Dr. B. Dharajothi (PA)	2006-2011

Sirsa

Plant Breeding and Genetics		
Development of varieties and hybrids resistant to CLCuV	Dr. O. P. Tuteja (PL) Dr. D. Monga (PA) Dr. Rishi Kumar (PA)	2006-2011
Development of GMS based hybrids and pre-breeding for fibre quality in G. *arboreum*	Dr. S. K. Verma (PL) Dr. S. L. Ahuja (PA)	2008-2013
Development of heterotic pools in G. *arboreum* and G. *hirsutum*	Dr. S. K. Verma (PL) Dr. O. P. Tuteja (PA)	2008-2012
Marker assisted selection for developing elite breeding lines in cotton	Dr. S. K. Verma (PL) Dr. S. L. Ahuja (PA)	2008-2012
Genetic enhancement of diploid cotton *(G. arboreum)*	Dr. S. L. Ahuja (PL) Dr. S. K. Verma (PA) Dr. T. R. Loknathan (PA) Dr. Punit Mohan (PA) Dr. Vinita Gotmare (PA) Dr. P. Jeykumar (PA) Dr. D. Monga (PA)	--
Seed Technology		
Technology to enhance the better crop establishment and yield in cotton	Dr. R. A. Meena (PL) Dr. D. Monga (PA)	2007-2012
Pre-sowing seed treatment for invigoration and better crop establishment	Dr. R. A. Meena (PL)	2007-Cont.
Maintenance of nucleus and breeder seed	Dr. R. A. Meena (PL)	200S-Cont.
Identification of innovative Bt cotton based cropping system	Dr. R. A. Meena (PL)	2007-Cont.
Promotion of cotton varietal and hybrid seed production technology at village level to improve farmers livelihood	Dr. R.A.Meena (PL)	2007-2009
Effect of defoliant on physiological parameters and seed cotton yield	Dr. R.A.Meena (PL)	2007-Cont.

CROP PROTECTION		
Entomology		
Biological and sampling of mealy bug in Bt cotton	Dr. Rishi kumar (PL) Dr. D. Monga (PA)	2008-2011
Evaluation of ecological selectivity of systemic insecticides on sucking pests and non-target arthropod communities.	Dr. Rishi kumar (PL)	2008-2010
Plant Pathology		
Studies on inoculums source and economic thresholds of cotton leaf curl and virus disease.	Dr. D Monga (PL) Dr. Rishi Kumar (PA)	2008-2011

Externally Funded Projects

CROP IMPROVEMENT		
Breeding		
DBT: Identification of molecular markers linked to QTLs for fibre strength and oil content in cotton (G. hirsutum)	V. V. Singh (PI)	2005-2008
DBT: Molecular mapping of fibre quality traits QTLs and marker assisted selection (MAS) in up land cotton (Gossypium hirsutum L.)	V. N. Waghmare (PL)	2007-2010
Biotechnology		
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
DBT: Identification of Molecular markers and tagging genes for Bacterial blight resistance.	P.K. Chakrabarty (PI) PunitMohan (PA) V. N. Waghmare (PA) B. M. Khadi (PA)	2008-2011
ICAR-Network Project on Transgenics in Crops (NPTC): Development of bollworm resistance transgenic cotton	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
DBT : "Gene stacking in Bt Cotton"	G.Balasubramani (PI) S.B.N andeshwar (CCPI) S. B. Singh ((CCPI)	2008-2010
DBT: Development of cotton transgenics with improved fibre strength using cellulose synthase gene from Arabidopsis Seed Technology	G.Balasubramani (PA) J. Amudha (CCPI)	2007-2009

Mega seed project:. Seed production in agricultural crops and fisheries	K. Rathinavel (PI) P. RVijayaKurnari (CCPI)	2006-2014
DUS: Testing & Documentation of Extant Varieties, hybrids and their Parents for Distinctness, Uniformity & Stability (PVP & FRACT, 2001)	N. Gopalakrishnan (PI) K. Rathinavel (CCPI) V.Santhy (CCPI) P.R. Vijayakumari (CCPI) R. K. Deshmukh (CCPI)	2003-2012
CROP PRODUCTION		
Agronomy		
NAIP: Georeferenced Soil Information System (GeoSIS)for Land Use Planning and Monitoring Soil and Land Quality for Agriculture	M.V.Venugopalan (CCPI) K.Velmourougane (CCPI)	2009-2013
ICAR Network project:. Impact, adaptation and vulnerability of Indian agriculture to climate change. Sub project- changes in soil carbon reserves aas influenced by different ecosystems and land uses in India.	M. V. Venugopalan, (CCPI),	2009-2012
Soil science		
NAIP: A Value Chain for Cotton Fibre, Seed and Stalks: An Innovation for Higher Economic Returns to Farmers and Allied Stake holders	P.R Bharambe (CCPI) IV. . Singh (CCPI)	2008-2012
CROP PROTECTION		
Entomology		
NMITLI Project:. "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.
DBT: Indo-Australian Project:. Enhancing sustainability of transgenic crops through gene stacking" Funded by the DBT under 'Indo-Australian -International Science Linkages' programme.	K. R Kranthi (PI)	2008-2012
Ministry of Agriculture, Government ofIndia GMO Project:. "Development of Technology for Detecting Presence ofGMOs in an Unknown Sample and its Utilization in dealing with Bulk Samples"	K. R. Kranthi (PI)	2006-2009
DuPont Project:. Studies on H. armigera response to Rynaxypyr	K. R Kranthi (PI)	2006-2009
NAIP: Research into Development of Decision Support Systems for Management ofInsect Pests of Major Rice and Cotton based Cropping Systems (Comp4/DSS 2046)	S.Vennila (CCPI) G. Majurndar(CoPI) Rishi Kumar (CoPI) B. Dharajothi (CoPI) M. Sabesh (CoPI) M. Amutha (CoPI)	2008-2012

Technology Mission on Cotton (TMC)

Project code	Name of the Project	Name ofthe Project Investigator and Associate(s)
MM 1.1	Development and promotion of medium and long linted diploid cottons *(G. arboreum* and G. *herbaceum)*	PI: Dr. S. K. Verma Associate: Dr. P. R. Loknathan
MM 1.2	Development of Extra long staple G. *barbadense* cotton with improved fibre qualities to meet the requirements of textile industry	Dr. K.N.Gururajan/, K.P.M. Dr. Damayanthi
MM 1.3	Identification of G. *hirsutum* genotypes suitable for machine picking and development of agronomic package	Associate: Dr. V. V.Singh Dr. V. Gotmare Dr. S.L.Ahuja
MM 1.4	Development and promotion ofBt transgenic cotton for bollworm resistance	Associates: Dr. Suman Bala Singh/Dr. S. B. Nandeshwar / Dr. S.M.Palve Dr. S. Manickam, Dr. O. P. Tuteja
MM 1.5	Molecular characterization of cotton germplasm using DNA Markers	Associates: Dr. A. B. Dongre
MM 1.6	Exploitation of Apomixis and TGMS system in hybrid cotton seed production	PI: Dr. S. M.Palve, CICR, Nagpur Associates: Dr. V. Santhy Dr. Vinita Gotmare
MM 2.1	Development of production technologies for Bt cotton and improvement of water and nutrient use efficiency with precision farming techniques	PI: Dr. Jagvir Singh Associates:Dr. P. R. Bharambe, Dr. C. S. Parharaj, Dr. K. Sankaranarayanan
MM 2.2	Identification ofInnovative Bt. cotton based cropping systems, improvement of water and nutrient use efficiency with precision farming techniques	CCPI: Dr A.R. Raju, Associates:Dr. P. R. Bharambe, Dr. R. A. Meena
MM 2.3	Mechanization of cotton production	PI: Er. Gautam Majumdar Associate: Dr. A. R. Raju
MM 2.4	Physiological manipulation ofBt plant morpho frame for enhanced productivity under varied agro-climatic conditions	PI: Dr. A. H. Prakash CCPI: Dr. R. K. Deshmukh
MM 3.1	Emerging and key pests ofBt cotton- their characterization, taxonomy, genetic diversity and control	PI: Dr. K. R. Kranthi Associates: Dr. Sandhya Kranthi / Dr. S. Vennila, Dr. M. K. Meshram / Dr. Vishlesh Nagarale Dr. D. Monga, Dr. T. Surulivelu/Dr.B. Dharajyoti/ Dr. P. Chidambaram

MM 3.2	Development and validation *ofIPMI* IRM strategies for Bt cotton under different ecosystems	Associates: Dr. S. Vennila, Dr. S. Kranthi, Dr. D. Monga
MM 3.3	Development, validation, utilization and / or commercialization ofbio-pesticides and bio inoculants	Associates: Dr. N.G. Narkhedkarl Dr. S. Vennila,Dr. D. Monga, Dr. T. Surulivelu, Dr. B.Dharajyoti *IDr.* Gulsar Bhanu
MM 3.4	Development of farmer friendly diagnostic kits for transgenic event seed purity	Associates: Dr. K. R. Kranthi
MM 5.1	Total Factor Productivity of cotton in India	PI: Dr. Isabella Agarwal Associate: Dr. A.R.Reddy
MM 5.2	Studies on social dynamics of cotton production in distress areas	Associate: Dr. S. M. Wasnik
MM 5.3	Indian cotton portal	PI: Sh. M. Sabesh Associates: Dr. N Gopalakrishanan Er. G. Majumdar
MM 5.4	TMC MMI Co-ordination and Monitoring Cell	PI: Dr. V. Santhy

11.3:Consultancy, Patents, Comme-rcialization of Technology

- S. **Kranthi,** K.R. Kranthi, N.N. Zade, M.Kshirsagar (2009).Patent on 'Enhancing *crylAc* expression in Bt cotton using jasmine perfume' has been filed. (l11/Mumbai/2009).
- S. Kranthi, K. R. Kranthi, V. V. Singh, N. N. Zade, M.Kshirsagar and B. M. Khadi (2008). Registration of CINH Ti 1 and CINH Ti2 as CINH Ti 1 (INGR 08088) and CINHTi 2 (INGR 08089) are the two registered genetic stocks with NBPGR, New Delhi
- K.R. Kranthi (2008). International patent granted in China on 6th July 2008: Bt-Cry toxin detection kits using a novel format.. (FP02228-GB/vcd; ICAR Ref:. 1(l1-2002-IPR): No. lAP 2004-0451; PCT /IN03/00 199
- K.R. Kranthi registered the BN Bt variety and transferred the technology to farmers through state seed agencies in Central and South India.
- IRM strategies {IRM dissemination in India (TM C-MM -II)} were refined and disseminated all across the 10 cotton growing states in India through 9 State Agricultural Universities, State Agricultural Departments, NGOs and KVKs. A total number of5804 farmer visits, 4381 farmer meetings, 208 field days, 1001 farmer trainings and 469 field worker trainings were conducted during the year. About 1800 different pamphlets and charts were prepared and 216 farmer schools were conducted.
- **Bt-detection Kits and GUS testing kits**

  The Bt-Express technology is being used all over the country. A total of 58,000 Bt-Express strips were procured by the Agriculture Department of all the nine cotton-growing states for the purposes ofBt-seed purity quality control..

11.4: Significant Decisions of IRC, IMC and other Important Meetings

Institute Research Council Meeting

Institute Research Council meeting was organized jointly for CICR, Nagpur and its two regional stations at Coimbatore and Sirsa on April 28- May 1,2008. The meeting was h~ld at CICR, Nagpur under the Chairmanship of Dr. B. M. Khadi,

Director, CICR..

All the scientists ofCICR, Nagpur and its regional stations at Coimbatore and Sirsa participated and presented their research findings in the meeting. Each research project was discussed thoroughly and technical program for the year 2008-09 was finalized for each project.. The new research proposals were also presented, discussed and finalized to take up during 2009-1 0 crop season.

At the end IRC also felicited Dr. MRK Rao, and Dr. N. K Perumal, Principal Scientists (Physiology) who will be superannuating by Oct, 2008. The research contribution made by them in the field of cotton physiology was lauded by the Director, CICRandIRe. .

The meeting was ended with vote of thank proposed by Dr. S. B Nandeshwar, Secretary, IRe..

Prior to Annual IRC meeting, Pre- IRC meetings were held at CICR, Nagpur and its regional stations at Sirsa and Coimbatore where in annual progress report for each project was presented in detailed and new project proposal were critically revived. Pre- IRC meeting for regional station, Coimbatore was held on April, 23-25, 2008 under the Chairmanship of Dr. B. M. Khadi, Director, CICR. Pre- IRC meeting at Sirsa was held onApril, 5,2008.

Institute Management Committee Meeting

Forty sixth Institute Management Committee meeting was conducted on 4th Feb.,2009 at Central Institute for Cotton Research, Nagpur. The meeting was chaired by Dr. K.R.Kranthi, Acting Director, CICR, Nagpur and the following committee members were Present..

Dr. O. P. Tuteja, Principal Scientist, CICR, RS, Sirsa- Member

Shri K. N. Gururajan, Principal Scientist, CICR, RS, Coimbatore - Member

Dr. K. B. Hebbar, Principal Scientist, IISS, Bhopal -Member

Dr. (Mrs) Vinita Gotmare, Sr. Scientist, CICR Nagpur - Member

Dr. P. R. Bharambe, Head, Division of Crop Production, CICR, Nagpur - Special Invitee

Dr. V. V. Singh, IIc Head, Division of Crop Improvement, CICR, Nagpur - Special Invitee

Shri M. K. Meshram, Principal Scientist I\c KVK, CICR, Nagpur - Special Invitee

Shri Devesh Nigam, FAa, CICR, Nagpur - Special Invitee

Shri M. S. Murthy, Administrative Officer, CICR, Nagpur - Member Secretary

The following are the major recommendations ofthe committee:

- The committee expressed satisfaction on the progress of expenditure. Further, committee suggested to settle the outstanding advances with CPWD where ever works have been completed on priority basis. As per the recommendation of forty fifth IMC meeting, CPWD Executive Engineer, Shri Rao was invited to furnish the details of works and he informed that only two works are pending completion for settling the advances.
- The committee members appreciated the progress of the civil works and irrigation facilities in the farm. The Chairman infonned that the present budget under the Head Boundary Wall for the farm will be exhausted in the current financial year and ICAR will be approached for more funds for the construction of boundary wall of the farm, members unanimously recommended for the same.
- The committee appreciated the outcome of research its publications, patents etc. in the Institute and two regional stations.
- The Institute has proposed to purchase certain minor equipments costing less than rupees one lakh each as per the list under plan. The members unanimously recommended for the purchase of minor equipments subject to availability of funds under plan budget..
- The Chairman informed that the Institute has already written to ICAR for sanction ofRs 70.00 lakhs (Rupees seventy lakhs) for replacement of 6 vehicles of Nagpur and one Matador of Coimbatore. If no fund is received during the year, the savings of the budget under Non-plan (other charges) will be utilized for the purchase under replacement.. In principal the members agreed for condemnation of all seven vehicles including one tractor and purchase vehicles as proposed for except 52 seater Ashok Leyland and one Swaraj Mazda mini bus which will be auctioned.
- The members suggested to approach ICAR HQ for the approval for conversion of the present Type V Quarter at CICR RS, Coimbatore into a Guest House, since the Regional Station does not have a Guest House.

National Consultation on 'Mealy Bug Management'

National consultation on 'Mealy Bug Management' was organized by the Central Institute for Cotton Research at Nagpur on 28-29 Jan, 2008. Dr. K. R. Kranthi , Head, Division of Crop Protection, CICR, Nagpur gave brief introduction. He mentioned that elucidation of genesis of mealy bug problem on cotton is a new challenge for entomologists who will have to devise strategies for its management..

Dr. O. M. Bambawale, Director, National Centre for Integrated Pest Management, New Delhi chaired the proceedings. In his opening remarks, Dr. Bambawale mentioned contribution of industry in research and emphasized that there should be synergy between private and public sector. He added that for management of mealy bug we should start with workable strategies and should not wait till perfect standardization of technologies.

Dr.. B.M.Khadi, Director, CICR, Nagpur welcomed the participants and enumerated examples of newly emerging pest problem which need to be addressed immediately. Along with mealy bug, Dr. Khadi mentioned pests as thrips, mirid bug and pink bollworm which must engage attention of researchers immediately.

Presentation on different aspect of mealy bug management were made by entomologists from CICR, Nagpur and its regional stations at Coimbatore and Sirsa, TNAU, Coimbatore, IIHR,

11.8. PERSONNEL

Name of the Officers/Scientists	Designation
DIRECTOR	
B M Khadi (Relieved on 24.05.08)	Director
K R Kranthi (w.e.f. 25.05.08)	Acting Director
PROJECT COORDINATOR (Cotton)	
Coimbatore	
N Gopalakrishnan	P.C. (Cotton) & Head
PLANT BREEDING	
Nagpur	
LA Deshpande (Resigned on 9.5.08)	Head (Crop Imp.)
VV Singh	Principal Scientist
Smt. S B Singh	Principal Scientist
T R Loknathan	Principal Scientist
S M Palve	Principal Scientis
VNWaghmare	Senior Scientist
Coimbatore	
K N Gururajan	Principal Scientist
D K Agarwal (Trd to NRCS on 23.05.08)	Scientist (SG)
Sirsa	
S LAhuja	Principal Scientist
O P Tuteja	Principal Scientist
S K Verma	Senior Scientist
GENETICS & CYTOGENETICS	
Nagpur	
S B Nandeshwar	Principal Scientist
Smt. V Gotmare	Senior Scientist
Coimbatore	
Smt. K P M Damayanthi	Senior Scientist
S Manickam	Senior Scientist
SEED TECHNOLOGY	
Nagpur	
RKDeshmukh	Principal Scientist
Smt. P R Vijayakumari	Senior Scientist
Smt. V Santhy	Scientist (SS)
Coimbatore	
K Rathinavel	Principal Scientist
Sirsa	
RAMeena	Principal Scientist

ECONOMIC BOTANY	
Nagpur	
PunitMohan	Principal Scientist
AGRONOMY	
Nagpur	
MV Venugopalan (joined on 13.06.08)	Principal Scientist
ARRaju	Senior Scientist
Coimbatore	
C S Praharaj	Senior Scientist
K Shankaranarayanan	Senior Scientist
Smt P Nalayani	Senior Scientist
SOIL SCIENCE	
Nagpur	
PRBharambe	Head, (Crop Production)
Jagvir Singh	Principal Scientist
Coimbatore	
KKBandyopadhyay	Senior Scientist
Smt TP Swarnam (joined on 16.02.09)	Scientist (SS)
AGRICULTURAL ENGINEERING	
G Majumdar	Scientist (SG)
PLANT PATHOLOGY	
Nagpur	
PMMukewar	Principal Scientist
MKMeshram	Principal Scientist
RCDkey	Principal Scientist
SJ Gawande	Scientist
Coimbatore	
M Gunasekharan (joined on 01.11.08)	Senior Scientist
V Jayakumar (joined on 06.02.09)	Scientist (SS)
Sirsa	
Dilip Monga	Head of Station
ENTOMOLOGY	
Nagpur	
K R Kranthi	Head, (Crop Protection)
Smt. S Kranthi	Senior Scientist
Smt. S Vennila	Senior Scientist
VS Nagrare	Scientist (SS)
Coimbatore	
T Surulivelu	Principal Scientist
K Natarajan	Principal Scientist

Smt. B Dhara Jothi	Senior Scientist
SmtMAmutha	Scientist
Sirsa	
Rishi Kumar	Senior Scientist
NEMATOLOGY	
Nagpur	
Smt. Nandini Narkhedkar	Principal Scientist
Coimbatore	
Smt. J Gulsar Banu	Senior Scientist
PLANT PHYSIOLOGY	
Nagpur	
M R K Rao (Retd on 31.10.08)	Principal Scientist
N K Perumal (Retd.on 31.10.08)	Principal Scientist
Coimbatore	
S E S A Khader	Principal Scientist
AH Prakash	Senior Scientist
BIOCHEMISTRY (PS)	
Nagpur	
AB Dongre	Principal Scientist
Smt. M. Chakrabarty	Scientist (SG)
BIOTECHNOLOGY	
Nagpur	
P K Chakrabarty	Principal Scientist
G Balasubramani	Senior Scientist
Smt. J Amudha	Senior Scientist
Smt S. Choudhary (joined on 18.12.08)	Scientist
MICROBIOLOGY (PS)	
Nagpur	
K Velmourougane	Scientist
AGRICULTURE EXTENSION	
Nagpur	
S MWasnik	Principal Scientist
Coimbatore	
Usha Rani	Scientist (SS)
AGRICULTURAL ECONOMICS	
Nagpur	
PRDeoghare	Principal Scientist
ARReddy	Senior Scientist

Coimbatore	
Smt. Isabella Agarwal	Senior Scientist
COMPUTER APPLICATION	
Coimbatore	
M Sabesh	Scientist (SS)
KVK	
Nagpur	
S N Rokade	Senior Scientist
Administrative Officer	
MS Murthy	
Finance & Accounts Officer	
G C Pant (Trd to IVRI on 15.11.08) Devesh Nigam (joined on 12.11.08)	

11.9. OTHER INFORMATION

Library

Additions

In the period from 2008-09, the Library purchased 83 new books and subscribed to 20 foreignjournals and 25 Indianjournals.

Documentation Services - Library Networking

- As regards the CD-ROM Workstation, the current version of CROP SCIENCE DATABASE CD was purchased and uploaded in the LAN Server and thereby AGRIS, AGRICOLA, BIOTECHNOLOGY ABSTRACTS, CAB ABSTRACTS AND CROP CD are visible and accessible in the Institute Network.. These CDs range from the period 1970-2009.
- Library has developed computerized bibliographic database on cotton to provide comprehensive and updated information on cotton. About 3300 bibliographic references along with abstracts have been stored in it. Based on this bibliographic database the Library publishes a current awareness bulletin namely "COTTON RESEARCH ABSTRACTS". The Bulletin is circulated to all the scientists of the Institute and to all AICCIP Centers in India. In the reported period, four issues of COTTON RESEARCH ABSTRACTS (V22, (No. 2-4),April-December 2008) 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. For better and effective use of this facility, the Library conducted a User Awareness Program on *18/9/2008* for the users of the Institute
- Four User Terminals installed in the Library have facilitated the library users to access the databases uploaded in the Library Setver. 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.
- Using Library Application Software SLIM ++, 3600 books have been computerized and barcodes assigned for the same.

Visit of Parliamentary Sub-Committee on Official Language

Members of 2nd Parliamentary Sub-Committee on Official Language visited CICR Regional Station, Coimbatore on Sept.. 16, 2008 to monitor the progress of implementation of Official Language in official work. The committee was chaired by Hon' ble Dr. Lakshmi Narayan Pandey, M.P (Lok Sabha). The other members of committee were: Shri Kunwar Sarvaraj Singh, M.P (Lok Sabha), Dr. RajeshKumar Mishra, M.P(Lok Sabha), Shri Udai Pratap Singh, M.P (Rajya Sabha), Prof.. Alka Balram Kashtriya, M.P (Rajya Sabha), Smt.. Poonam Juneja, Secretary, Govt.. of India,.Dr. Ramesh Chandra Sharma, Under Secretary, Govt.. ofIndia , Shri Om Prakash Tripathi , Hindi Officer and Shri Devendra Singh, Reporter. From ICAR side, the meeting was attended by Dr. K. C. Jain, ADG (CC), ICAR, New Delhi, Dr. K.R Kranthi, Director (Acting),CICR, Nagpur, Dr.. N. Gopalakrishnan, PC & Head, CICR,RS, Coimbatore , Dr. MRK Rao, Principal Scientist, and Dr. RR Gupta, *IIc* Rajbhasha Anubhag, CICR, Nagpur and Shri Manoj Kumar, Hindi Officer, ICAR, New Delhi.

Dr. N. GopalaKrishnan presented the progress report of use of official language at CICR, RS Coimbatore. The report was critically evaluated by the Hon'ble members of the committee. The Hon'ble Chairman Dr. Lakshmi Narayan Pandey and other members gave valuable suggestions for more use of official language as per the constitutional provision. The attempts made by the PC and Head, CICR, RS, Coimbatore for enhancing use of official language in this station under the category ofC region were appreciated by the committee. The meeting concluded with vote of thanks proposed by Dr. K. R. Kranthi, Director, CICR, Nagpur. Drs. (Smt.) KPM Damyanthi, Smt J. Gulsar Bhanu and K.K.. Bandyopadhyay, Senior Scientist, CICR Regional Station, Coimbatore and Dr. M. S. Yadav, Technical Officer (T7-8), CICR, Nagpur acted as Protocol Officers during the visit of committee from 14-17th Sept.. 2009.

11.10: Technical Bulletins Published

Title of the Technical Bulletin	Bulletin No.	Author (s)
Hybrid Seed Production in Cotton	35	V. Santhy, B.M.Khadi, Phundan Singh, P.R.Vijaya Kumari, R.K. Deshmukh and Anshu Viswanathan
Nectar Glands in *Gossypium*	37	Pun it Mohan B.M.Khadi
Legislations for seed quality regulation in	38	V. Santhy, P.R.Vijaya Kumari, Anshu Viswanathan R.K. Deshmukh

11.11: Weather

Nagpur

Month	Temperature te)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
June, 2008	34.4	25.5	75.5	52.9	175	13
July, 2008	31.9	24.4	85.6	67.0	221	16
August, 2008	30.9	24.3	88.7	70.0	132	11
September, 2008	32.0	23.5	85.5	61.5	113	8
October, 2008	33.7	19.5	76.2	40.8	35	3
November, 2008	31.7	16.8	79.9	37.1	0	0
December, 2008	30.8	13.7	60.8	29.3	0	0
January, 2009	31.4	14.7	70.6	30.0	0	0
February, 2009	34.7	16.8	44.6	20.3	0	0
Total					**676**	**51**

Coimbatore

Month	Temperature (oC)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy days
	Max	Min	Max	Min		
April, 2008	34.2	22.9	88.6	43.2	51.6	3.0
May, 2008	34.8	23.0	84.6	44.5	42.0	2.0
June, 2008	32.1	23.6	77.2	51.3	21.4	2.0
July, 2008	31.3	23.0	82.5	54.6	27.8	3.0
August, 2008	31.6	22.8	88.3	54.4	66.3	4.0
September, 2008	31.6	21.7	83.5	51.3	26.3	4.0
October, 2008	30.4	22.0	91.1	62.0	313.1	14.0
November, 2008	30.2	20.8	91.0	54.6	43.8	5.0
December, 2008	28.6	19.2	90.5	50.7	9.6	1.0
January, 2009	29.9	18.7	87.2	38.7	0.0	0.0
February, 2009	33.6	19.2	82.0	27.9	0.0	0.0
March, 2009	34.6	21.4	83.5	34.4	101.8	3.0
Total					**703.7**	**41**

Sirsa

Month	Temperature (^{0}C)		Relative Humidity(%)		Rainfall Rainy (mm)	No.of days
	Max	Min.	Max.	Min.		
January, 2008	17.60	5.50	56.00	46.00	5.4	1
February, 2008	22.70	7.30	80.00	39.00	1.8	1
March, 2008	31.50	15.10	66.00	40.00	-	-
April, 2008	35.50	20.00	52.00	39.00	19.0	3
May, 2008	37.80	24.60	56.00	37.00	21.6	2
June, 2008	35.70	27.00	71.00	58.00	185.4	6
July, 2008	36.30	27.90	72.00	57.00	7.2	1
August, 2008	34.40	26.30	77.00	64.00	191.8	6
September, 2008	33.50	23.90	71.00	55.00	7.6	1
October, 2008	34.70	19.66	68.00	37.80	-	-
November, 2008	28.75	10.50	62.00	24.25	-	-
December, 2008	23.65	9.05	76.20	37.50	3.2	1
Total					**443.0**	**22**

11.12: National Cotton Scenario

Cotton, the major raw material accounts for 62% of the fibre used in the Indian textile industry. This is in contrast to the global textile industry that has 40:60 mix of cotton and manmade fibres.

India's cotton area represents 30.6% of the global area of cotton, it produced only 21.0% of world production because Indian cotton yields (525 kg /ha) are below the world average (767 kg/ha) in 2008-09 crop season. The ICAC had estimated world cotton output at 23.50 million tons for the year 2008-09 against the estimated world cotton use of 24.01 million tons. The estimated production in 2008-09 is 10.20 % lower than the 2007 -08 output of26.17million tones.

India has a larger area of cotton than any country in the world (9.44 million hectares in 2007 and 9.37 in 2008) and this area is cultivated by approximately 6.4 million farmers in 2007 and 6.2 million farmers in 2008. At a national level, the cotton production in India has declined to 29.0 million bales during 2008-09 from 31.5 million bales in 2007 -08, which was a record cotton crop in India. The yields have declined from 567 kg/ha during 2007-08 to 525kg/ha in 2008-09.

In 2008, 82% of the total cotton area (7.6 million hectares) were under Bt cotton hybrids (the largest hectarage ofBt cotton in any country in the world) with an un-precedent 150- fold increase in adoption from 2002 to 2008. India is the only country to grow all four species of cultivated cotton besides different combinations of hybrid. The majority ofthe 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 (2008-09) 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)	1.215	6.205	1.855
Production (million bales)	3.9	17.0	6.7
Productivity (kg/ha)	546	466	614
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	G.*hirsutum*, G. *arboreum*	G. *hirsutum*, G. *arboreum*, *intra-hirsutum*, G.*herbaceum*	*G.hirsutum*, G. *arboreum*, G. *herbaceum*, G. *barbadence*, 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	2007-2008			2008-2009		
	Area (Lakh ha)	Prod. (Lakh bales)	P (kg/ha)	Area (Lakh ha)	Prod. (Lakh bales)	P (kg/ ha)
Punjab	6.04	22.00	619	5.37	17.50	554
Haryana	4.83	16.00	563	4.55	14.00	523
Rajasthan	3.39	9.00	451	2,23	7.50	572
North Zone	**14.26**	**47.00**	**560**	**12.15**	**39.00**	**546**
Gujarat	24.22	112.00	786	24.17	90.00	633
Maharashtra	31,94	62.00	330	31,33	62.00	336
Madhya Pradesh	6.30	21,00	567	6.55	18.00	467
Central Zone	**62,46**	**195.00**	**531**	**62.05**	**170.00**	**466**
Andhra Pradesh	11,38	46.00	687	13,45	53.00	670
Kamataka	4.02	8.00	338	3.90	9.00	392
Tamil Nadu	1,19	5.00	714	1,20	5.00	708
South Zone	**16.59**	**59.00**	**605**	**18.55**	**67.00**	**614**
Others	1,08	2.00	315	0.98	1,50	260
Total	**94.39**	**303.00**	**546**	**93.73**	**277.50**	**503**
Loose cotton consumed but not counted for in State-wise prod.		12.00			12.00	
Grand Total	**94.39**	**315.00**	**567**	**93.73**	**289.50**	**525**

Prod. = Production P = Productivity 1 bale= 170 kg.
Source: Office of the Textile Commissioner, Mumbai.

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