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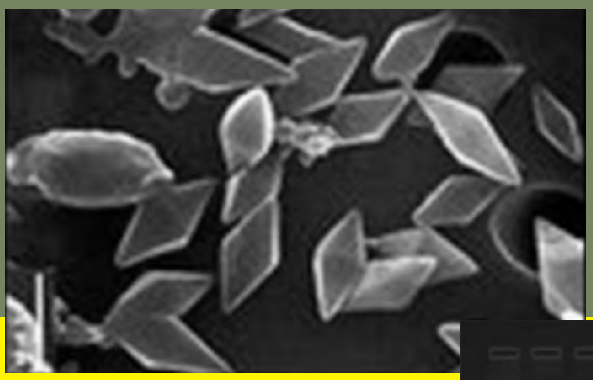

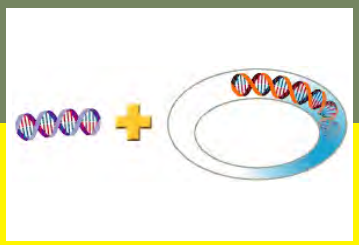

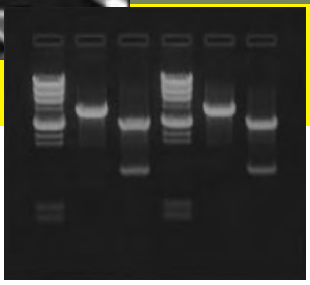

CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

CICR

ANNUAL REPORT 2007-08

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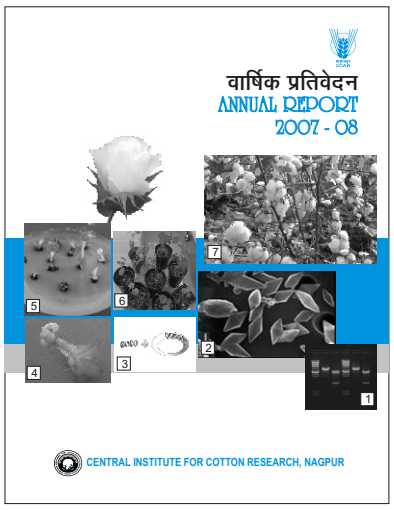

Front Cover :
Process of transgenic cotton development

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2.Bt crystal protein
3.Plasmid DNA
4.Cotton hypocotyl callus
5.Putative transformants
6.Bt transgenic cotton variety: Anjali
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Strip trial of transgenic Bt cotton variety: Anjali

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PREFACE

Cotton, the basic raw material for Indian textile industry is more importantly a cash crop sustaining the rural economy in the semiarid and arid regions of the country. In 2007-08, with an annual productivity of 553 kg lint/ha, cotton production rose to 310 lakh bales. The north, central and southern regions contributed 15.81, 61.61 and 18.06 per cent respectively to this production. The increasing trend in production and productivity of cotton which commenced a few years ago consolidated further in 2007-08. This gain was a result of a further spread of transgenic Bt. cotton hybrids and the concomitant adoption of improved crop production and protection technologies. The institute has been a torch bearer in this cotton revolution by providing the necessary technological backup. This report contains an overview of the research and developmental activities undertaken during 2007-08.

Amongst the various research activities carried out during the year, the following highlights of the results listed below have immense potential to contribute towards enhancing cotton production and productivity.

An intra- *hirsutum* hybrid CSHH243 was identified for release in the North Zone. A bio-safety trial with Bikaneri Nerma Bt in ruminants was completed and results indicated that the Bt protein did not enter into the food chain and is hence safe to human beings and animals. The cotton gene bank of the institute was enriched through 1038 germ- plasm accessions from the USA. Eight cotton germplasm lines viz CIR8, CIR12, CIR23, CIR26, CIR32, CIR38, CIR47 and Raj 2006 were registered. Precision farming technologies like synchronous nutrient release and extended soil moisture supply were further refined to improve the productivity and quality of Bt cotton. Application of Ethrel @ 30 ppm at square formation stage altered the plant morphoframe, facilitated synchronies boll formation and improved the yield and harvest index of Bt cotton. Research and development efforts were strengthened for the management of cotton mealy bug *(Phenacoccus solenopsis)*. Insecticide resistance management technologies were further disseminated in all the three cotton zones across 1727 villages covering 1,01,113 ha. A rapid GUS (glucuronidase) detection assay to detect GUS in GM samples was developed, validated and commercialized.

The research achievements were a result of the untiring efforts by the entire staff of the institute. The technical and financial support 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 provided and also for encouraging new research initiatives.

The Annual Report (2007-08) is being presented herewith with a sense of satisfaction and pride.

(K R Kranthi)
Acting Director

2. EXECUTIVE SUMMARY

2.1 Crop Improvement

Nagpur

- One thousand thirty eight exotic germplasm accessions of *Gossypium hirsutum* and nine wild species were procured from USA under enrichment programme of Cotton gene bank.
- Seeds of 692 accessions of *G. hirsutum*, 267 accessions of *G. arboreum* and two wild species namely *G. raimondii* and *G. anomalum* cotton were deposited for long term cold storage at NBPGR, New Delhi.
- Plants of two wild tetraploid species *i.e. G. darwinii* and *G. tomentosum* were introduced and established in the wild species garden.
- The genotypes with special morphological characters *viz*. zero monopodia, cleistogamy and protruding stigma were confirmed.
- The culture CNHO 12 (yield 14-15 q/ha, Fibre length 25mm , Fibre strength 20.2 g/tex and oil 19 %) has been recommended by AICCIP Group Meeting for Pre-release Agronomy Trial for Central Zone under irrigated conditions for the year 2008-09, while long linted *G. arboreum* strain CINA 347 was retained for further evaluation in central zone rainfed trial of AICCIP 2008-09.
- Improved strains of *G. hirsutum* CNH 1104 (fibre length 34 mm) and of *G. arboreum* CAN 1005, CAN 1006 were sponsored in AICCIP trial.
- Enhancement of boll wt. upto 3.8 g with staple of 28 mm in PKV 081 through backcross (PKV 081 x PIL 8) x PKV 081. Culture CIHS 97-10 had ranked top in station trial 2007-08.
- Improvement of diploid and tetraploid cotton through population improvement approaches is under progress. Fourth cycle of random mating through conventional crossing has been completed while first and second cycle of GMS based random mating has been completed in tetraploid and diploid cotton respectively. Single plants *viz*. 485 *G. arboreum* and 479 *G. hirsutum* were selected from the random mating populations.
- Promotion of *arboreum* varieties PA 255, PA 402 and CINA 316 amongst 33 tribal farmers in the Melghat region of Vidarbha was accomplished.
- Primary putative transformants of CLCUV trangenics were confirmed for the presence of Anti-sense Coat Protein(ACP), Sense Coat Protein(SCP) and Anti- sense Rep (A-Rep) genes.
- T_1 generation of Bt varieties LRA5166 and LRK516 were taken to RCGM strip trial.
- Transformation of *cry* 1 F, *cry*1 Ac (enhancer), *cry*1 Aa3 and Chitinase was done and 12 plants (T_0) of PA 255 and PA 402 have been established.
- Fifty six race 18 isolates of *Xanthomonas axonopodis pv. malvacearum* were characterized using six molecular markers.
- A 3.1 kb plasmid pKSB-Int was constructed for generating double stranded RNA (dsRNA) to affect post-transcriptional silencing of gene for functional analysis and also for developing resistance against plant viruses. Two dsRNA interference constructs for coat protein and C4 gene of CLCuV were developed for transformation of cotton.
- Hardseedness (physical dormancy) was found just after picking but the germination was improved after 20 days of storage by 2-40% in parents whereas in F_1 crosses the germination improved by 4-40%.
- Seed quality was better in seed samples procured from companies from Akola, Parbhani, Jalgaon, and Rahuri. Samples from Srivilliputtur, Rahuri, Dharwad, Bharuch and Kanpur carried lesser load of fungi.
- Seed hardening agents such as di-sodium hydrogen phosphate , mannitol and KCl all @ 2% resulted in increased rate of germination as well as germination percentage under normal germina-tion and osmotic stress germination tested with 10% PEG solution.

- Fifteen hybrids and their parents in *G. hirsutum* have been characterized for 37 morphological characters.

Coimbatore

- Among the 250 germplasm lines assessed, wide variability was noticed for agronomic characters with ICGH 404-1 recording 4044 kg/ha of seed cotton yield (13% yield increase over Sumangala (3568 kg/ha) several lines possessing boll weight of over 5.0 g with highest boll weight of 7.2 g /boll being in ICGH-755-1.
- Male sterile based interspecific hybrid 70 G X SR was the best with 2950 kg/ha of significantly higher seed cotton yield over the best check hybrid DHB 105 with 2348 kg/ha of yield. Conventional interspecific hybrids CCHB-51 (2324 kg/ha), CCHB-56 (2263 kg/ha) and CCHB-7 (2251 kg/ha) were significantly superior in seed cotton yield to the best check hybrid DCH-32 (1670 kg/ha).
- Intra *hirsutum* Bt cotton hybrid MRC 7351 BG II recorded 3887 kg/ha which was significantly higher than the Bt cotton check hybrid RCH 2 Bt (3272 kg/ha). Seven other Bt cotton hybrids also recorded significantly higher yield over RCH 2 Bt. Interspecific Bt cotton hybrid MRC 6918 was noticed to be best for both yield and fibre quality recording a seed cotton yield 3725 kg/ha, fibre length of 35.4 mm and a bundle strength of 24.3 g/tex.
- Among the introgressed lines tested, MM-02-11-7 was the best with a seed cotton yield of 2873 kg/ha with medium staple fibre quality. Culture MM-03-39-4-1was found best with 34.4 mm and the culture MM-03-39-4-1was the best for bundle strength with 24.9 g/tex.
- Variety CCH 510-4 tested in the AICCIP irrigated trials in South Zone during 2003 to 2007 proved its superiority in yield and quality over the check variety and has since been identified for release in South Zone under irrigated conditions.
- Medium staple genotype L (L x IBM) 2629 recorded the highest yield of 4966 kg/ha with a seed cotton yield increase of 48 per cent over the check variety and had high ginning out turn of 38 per cent.
- Pelleting and coating of cotton seeds with polymers resulted in improving viability by 3 to 4 per cent and substantial improvement in field emergence and better protection against pathogenic infection.
- Breeder seed production was taken up for cv. Surabhi, LRA 5166, MCU 5 VT and Suvin varieties and 7.75 q of breeder seeds were produced.

Sirsa

- The intra-*hirsutum* hybrid CSHH 243 was identified for release in North zone and the proposal for notification has been submitted to CVRC, New Delhi.
- The Cotton germplasm, CIR-8,CIR-12,CIR-23,CIR-26,CIR-32,CIR-38 and CIR-47 as CMS restorer lines were registered with National Identities, IC553921, IC553923, IC553924, IC553925 IC553926, IC553927, and IC553928, and Registration numbers, INGR No. 08031, 08032, 08033, 08034, 08035 08036 and 08037, respectively.
- The variety CISA 614 based on five years testing in AICCIP trials (2003-04 to 2007-08) ranked first and was recommended for Agronomy trial in north zone.
- The GMS based hybrid CSHG 1862 recorded the seed cotton yield of 1964 kg/ha and 34.2 % ginning outturn and ranked 4th position in Br 05a1 in north zone.

2.2 Crop Production

Nagpur

- Under long term fertilizer trial the organic carbon content of surface soil was enhanced from 0.41 % to 0. 51 % in both INM and organically treated plots.
- On medium black soils, application of 10 kg each of $ZnSO_4$ and $MnSO_4$ alongwith 3 kg borax / ha improved seed cotton yield by 203 kg / ha (16 % higher than control).
- There were no significant differences between Bt

and Non Bt cotton with regard to soil microbial population, but cotton grown organically recorded higher microbial population.

- On shallow soil, fertigation in hybrid cotton (NHH-44) recorded significantly higher seed cotton yield (17.3 q/ha) with the application of 50 % RDF (120 kg N, 60 kg P_2O_5 and 60 kg K_2O / ha) through drip irrigation coupled with the addition of zinc and biofertilizers over the soil application of RDF alone.
- Higher seed cotton yield, water use efficiency and water productivity was obtained with the *in-situ* moisture conservation through intercropping with greengram followed by bio-mulching with sunhemp. Application of N and NK in 3 splits (10, 30 and 60 DAS) produced significantly higher seed cotton yields. Irrigation through drip at 0.6 Etc with 75 % RDF as fertigation to Bt cotton hybrid (Bunny) recorded optimum seed cotton yield, water use efficiency and water productivity.
- The most profitable cropping system was Bt hybrid cotton intercropped with radish followed by cowpea and cluster-bean.
- Cotton+pigeon-pea planted in 6 : 2 and 12 : 2 proportion was economical and profitable for American hybrid cotton and *desi* cotton, respectively.
- Application of Ethrel @ 30 ppm at square formation stage recorded significant increase in yield and harvest index.
- Twenty four genotypes belonging to *arboreum* races have been evaluated by using three PCR based DNA markers.
- Three defoliants namely Dropp (1 %), ethrel (1 %) and Round up (1.2 %) were tested for defoliation of cotton crop to make it enable for mechanical picking. Ethrel showed maximum percentage defoliation (73 %) but it was statistically at par with drop (71 %) and round up (60 %)
- Trials were conducted with the knapsack type power sprayer engine operated aspiration type cotton picker. Initial evaluation indicated that a team of two persons can use the suction type cotton picker which picks 6 kg cotton / hour.
- Small farm equipments for cotton farmers for increased efficiency such as (i) adjustable hoe, (ii) adjustable ridger and (iii) bund former were developed.
- Total factor productivity of cotton in Maharashtra ranged from 0.7748 to 1.3337 during the period 1995-04, while in Madhya Pradesh it ranged from 0.8264 to 1.6857 during 1996-04.
- Studies on social dynamics of cotton production in distressed areas of Vidarbha region indicated that very high percentage of respondents fall under the score medium to high degree in respect of powerlessness, meaningless and isolation.

Coimbatore

- Cotton in Cotton-Sorghum (1427 kg/ha) system was found significantly superior over cotton-fallow (1160 kg/ha) due to higher efficiencies in terms of nutrient use, water use and moderation of saline water effect (>3.5 EC).
- The highest seed cotton equivalent yield (SCEY) (53.2 q/ha) and gross return (Rs 1,06,435 /ha) and net return (Rs 69,386/ha) were noticed with the multi-tier intercropping of cotton with radish, beet root and coriander with the application of 100 per cent of recommended level of fertilizers to intercrops.
- High density planting maintained through narrow row spacing of 90 x 10 cm in cotton variety (Surabhi with 2241 kg/ha) resulted in seed cotton yield on par with Bt cotton hybrid (RCH-2 with 2554 kg/ha) at optimum spacing of 90 x 45 cm.
- Bt hybrids performed better under low scantyed rainfall situation in comparison to isogenic non Bt hybrids and variety (LRA 5166). Premature senescence in RCH 20 Bt can be managed by balanced fertilization and split application of N and K.
- Around 1464 litres of water was used per kg of seed cotton under 0.8 ETc drip in comparison to 2004 liters/kg of seed cotton in surface furrow irrigation through IW/CPE of 0.6. Thus, for economic water use and without sacrificing on yield, drip irrigation scheduling at 0.8 ETc was optimum.

- Breaking of sub soil compaction by chisel ploughing and adoption of drip system for irrigation and fertigation (low cost drip system) combined with foliar application of poly feed (19:19:19) @ 1 % at 75 and 105 DAS and multi K (13:0:46) at 90 DAS registered higher seed cotton yield (2,732 kg/ha) in the yield maximization trial with ELS Bt hybrid.
- The poly mulch + drip system resulted in higher seed cotton yield ranging from 37.6 to 59.1 per cent over the conventional method.
- The generic simulation model INFOCROP showed that the difference between the observed and simulated yield was of the order of 12.4%. However, the model under-predicted seed cotton yield at higher N levels, which calls for its further fine tuning.
- Simultaneous planting of sunhemp at the seed rate of 15 kg/ha and cotton at the normal seed rate in ridge-furrow planting, followed by burying of green manure *in situ* at 40-45 DAS (but before flowering) with 50% RD-N (30 kg) and earthing up is recommended under medium land and irrigated condition.
- Application of ethylene in the form of ethrel was found to be suitable to bring about a change in crop ideotype that will help in enhancing the yield by 30-40% over the control.
- Regression results on the impact of Bt cotton showed a significant impact on yield, value of output and pesticide cost. Bt cotton farmers attributed more profit (72.14 per cent), less pesticide (52.31 per cent) and comparatively more bolls (49.15 per cent) for the choice of Bt cotton.
- Cost of cultivation was higher with non-contract farming when compared to contract farming by Rs.2500/- which was due to higher labour use in the former case. B:C ratio over total cost and cost of production per quintal was remunerative under contract farming (1.64; Rs.1581.60/q) compared to non-contract farming (1.08; Rs.1911.19/q) in cotton. The returns to scale was more than unity in case of contract farming depicting increasing returns to scale.
- Newer version of contents of CICR website was uploaded at the new web location with new domain name www.cicr.org.in
- A high share of waged work was provided by women at peak times namely at weeding and harvesting. The major farm activities which cause health hazards are also done by women.

Sirsa

- To find out the profitable crop rotation system with Bt cotton hybrids (RCH 134 and MRC 6301) under north zone with normal sowing as well as transplanting of seedling system, six crop combinations (cotton normal, cotton transplanted followed by wheat, barley and mustard) were evaluated. The highest net income/ha Rs 46935 and 51315 was observed in cotton followed by wheat with normal as well as transplanted cotton sown field, respectively whereas minimum net income was observed in cotton-mustard cropping system.
- The contribution of transplanting of raised seedling for improvement in plant stand in field was assessed against normal sowing. The per cent plant stand was significantly higher in both the hybrids (RCH-134 and MRC 6301) when seedlings were raised in medium type container and transplanted at seedling age of 15 days (92.9 %) and 20 days (98.8 %).

2.3 Crop Protection

Nagpur

- Incidence of various diseases was noted at seedling and boll development stage. Analysis of healthy-looking and diseased seed lots of the previous crop season (2006-07) revealed pathogenic infection due to seven cotton pathogens. In the evaluation of storage fungi, nine species of *Aspergillus* were recorded which includes mycotoxin (Aflatoxin) producing *Aspergillus flavus and Aspergillus parasiticus*.
- Bacterial blight X. *a.* pv. *malvacearum*, Race 18 is predominant in Maharashtra and Karnataka.
- Two lines viz. ORS 75 - 75 and Rowden 41 B Watson of *G. hirsutum* were observed to be resistant against race 18 of *Xam*.

- Out of 542 lines of upland cotton evaluated under natural incidence of field conditions, 15 lines exhibited disease free reaction and 32 lines were resistant.
- Isolates of *R. areola* from *G. arboreum* and *G. herbaceum* grow rapidly on new synthetic media/broth as compared to the isolates from the varieties/hybrids of *G. hirsutum*.
- Out of the 58 advance cultures of *G. hirsutum* and 6 of *G. arboreum* screened in sick field, and Agar gel test, 32 strains of *G. hirsutum* and 2 strains of *G. arboreum* were found resistant to root rot and wilt, respectively.
- A survey conducted in 47 locations in the nine cotton-growing states showed that two mealybug species, the solenopsis mealy bug, *Phenacoccus solenopsis* (Tinsley), and the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green) were found to occur on cotton plants of which. *P. solenopsis* was found to be the predominant mealybug species that comprised 95 % of the samples examined.
- The cotton mealy bug was identified as *Phenacoccus solenopsis* (taxonomically) with minimum genetic diversity (molecular analysis) throughout the country.
- Biorationals Neem oil, Herbal product, *Verticillium lecani, Beauveria bassiana*, Buprofezin and Acephate (slightly hazardous WHO class: III organophosphate insecticide) can be part of *P. solenopsis* management strategy in light of their ecological safety.
- Acetamiprid 20SP, Thiomethoxam 25WG and NSKE were found most effective as foliar spray. Acetamiprid 20SP was also found effective as spot soil drenching as well as stem application that was on par with stem application of Chlorpyriphos 20EC and Triazophos 40EC against jassids.
- Taxonomic identity of the two mirids (Miridae; Hemiptera) *viz., Campylomma livida* Reuter and *Hyalopeplus lineifer* Walker was established.
- Jassids and whiteflies between mid-August and September, aphids during mid August, thrips during the second fortnight of August, and mirids between last week of August and first week of November had their peak incidence
- Numerical mean density of the native predators was in the order of spiders > predatory mirids > chrysopids >coccinellids. The 2007-08 cotton season had witnessed 22 % reduction in damage due to all the three bollworms over the 2006-07 season.
- Relying on host plant resistance for jassids, early season sucking pest control with contact insecticides (based on symptom over population counts, use of imidacloprid only for the late season management of sucking pest (jassids & mirids) and management of late season bollworms with insecticides of conventional chemistries other than pyrethroids have been drawn as the overall pest management strategies.
- Five promising cultures *viz.,* CIPT 511 (A), CIPT 50(C), MTHC 53, MTHC 5(B) and JTHC 50(B)) were identified based on their tolerance to jassids and bollworms coupled with higher yields and good fibre quality parameters.
- JTHC 1104, a jassid tolerant high compensating genetic stock possessing the phenological mechanism of compensation for bollworm damage has been developed.
- Raj 2006, a genetic stock has been registered as source of resistance to jassids with registration number INGR No. 08059 at National Bureau of Plant Genetic Resources, New Delhi.
- Yield level of Bt cultivar (Ankur 651) was high under IPM mode with an increased yield and net returns by 3.25 q/ha and Rs.8150/ha, respectively over recommended package of practices.
- Twenty cotton cultivars viz.LRA 5166, LRK516, Surabhi, Sumangala, PKV081, G Cot10, RG 8, NHH 44, Rajat, AKH 4, H 777, CINA 316, AKA 8401, AKA 5, AKA 7,Laxmi, MCU 10, MCU 5, Omshankar, RS 875 screened against root-knot nematode and reniform nematode under pot conditions were found susceptible to both.
- One isolate of Entomopathogenic nematode (EPN) *Heterorhabditis indica* could be made to tolerate high temperatures by periodic exposure to high temperatures and selection of individuals that can tolerate it.

- Five rhizobacterial isolates belonging to *Bacillis spp*. with nematode antagonistic effect were isolated.
- CINH Ti1, CINH Ti2, CINH Ti3, and CINH Ti4 homozygous for trypsin inhibitor properties with comprehensive pest tolerance have been developed in Bikaneri Nerma and G Cot respectively.
- A replicated field trial demonstrated that AR 27, ND 63, Piedmont Cleveland, JR 52 and G-21-617 can be cultivated with zero plant protection to yield a minimum of 12 q/ha under low input cotton cultivation.
- LC_{50} values derived from 17,330 larvae tested, ranged from 0.057 to 1.146 g Cry1Ac/ml of diet with 8.5-fold, 16.61-fold and 14.88 fold variability in susceptibility across the North, Central and South Indian strains of *H. armigera*. The LC_{50} values ranged from 0.009- 0.201 µg *cry* 1Ac/ml of diet with 22.33 fold variability across the country.
- Economic Threshold Levels for *Spodoptera litura* on MRC 6301 Bt and MRC 6301 non Bt was 12 larvae and 4 larvae per plant respectively under rain-fed conditions.
- The frequency of resistant alleles for *cry* 1Ac was found to increase marginally in increments over 2005-2007 in Gujarat, Maharashtra and Andhra Pradesh.
- Primer sets developed for 6 genes (*cry*1F, *cry*1C, *cry*1C, VIP3A, *cry*1Aa and Round-up Ready) amplified the target sequences unambiguously.
- The total additional economic benefit resulting from the IPRM project implementation in the country is estimated at Rs. 5161 lakhs on account of Rs. 4184 lakhs due to enhancement in yields and Rs. 977 lakhs due to savings on insecticides.
- The technology 'GUS detect' was transferred to state agricultural departments all over the country. The kit enables the detection of GUS marker that is tightly linked with *cry*2Ab and also all GM crops that have GUS as the reporter gene
- A total of 10,000 Bt-Express kits were procured by the Agriculture Department of all the nine cotton-growing states for the purposes of Bt-seed purity quality control
- A biopesticide has been developed from primary phase bacterial symbiont of EPN for use against sucking pests of cotton.

Coimbatore

- Acephate, profenophos, thiamethoxam and acetamiprid were effective against aphids.
- Bio-pesticides *Verticillium lecanii*, *Metarhizium anisopliae* and *B. bassiana* and insecticides imidacloprid (Confidor), thiamethoxam, acephate and dimethoate brought down the population of jassids.
- Profenophos, thiamethoxam, chlorpyriphos and acephate were effective against mealy bug. However, acephate and *B. bassiana* reduced the activity of spiders, while thiamethoxam, imidacloprid and acephate reduced the coccinellid predator activity.
- Triazophos (0.05%), Cypermethrin (0.07%) and Thiodicarb (0.075%) were superior to other treatments in controlling pink bollworm (*P. gossypiella).*
- Based on prominence value, *R. reniformis* was identified as key nematode pest of Bt cotton in South India.
- Life cycle studies on *R. reniformis* indicated the susceptibility of Bt cotton hybrids to nematodes. Crop species Brinjal, Tomato, Cowpea, Bhendi, Pigeon pea, Black gram and Castor and weed species *Abution* sp., *Eclypta alba* and *Amaranthus* sp are very good hosts for *R. reniformis*.
- All stages of *Spodoptera litura* were found to be susceptible to EPNs viz., *H.indica , S.siamkayai and S.glaseri* nematode infection. A maximum of 100% mortality was recorded for an initial inoculum of 40 IJ / larva.
- Sixteen isolates of bacterial symbionts of entomopathogenic nematodes were isolated from cotton ecosystem. Three isolates viz., *Xeno -1, Xeno 12* (Bacterial symbionts of *Steinernema* sp.) and *Photo 3* (Bacterial symbionts of *Heterorhabditis indica*) recorded 37-62 % mortality against Mealy bug.

- Avoidable yield loss due to sucking pests damage was higher in RCH 2 Bt (15.3%), followed by Bunny Bt (12.8%) and MRC 6918 Bt (11.3%). It was low in other Bt hybrids viz., RCH 20 Bt (7.5%), RCH B 708 (7.4%), Mallika Bt (8.1%) and MECH 184 Bt (9.2%).
- Seed dressing insecticides helped in inducing ATPase activity at a higher level as compared to control in Bt cotton hybrids. Efficient metabolic status by way of acid Phosphatase and alkaline Phosphatase activity in addition to higher peroxidase activity could be maintained in young seedlings due to seed dressing chemicals.

Sirsa

- Mealy bug was the most important emerging pest of cotton and the predominant species in the region was identified as *Phenacoccus solenopsis* Tinsley. *Meconellicoccus hirsutus* Green was also noted but to a much lesser extent. A total of 36 plants were recorded as its hosts.
- The IPM Bt plots gave better performance over non-IPM plots when B: C ratio was calculated.
- A total of 9353.6 ha area covering 75 villages was covered under IPRM program in Districts of Sirsa, Hisar and Fatehabad where 19.59 to 44.65% reduction in insecticidal sprays over non-IPRM villages was recorded, reducing the expenditure to the tune of Rs 662-1502 per hectare. This led to increase in the C: B ratio which gave Rs 2354 to 4030 more net profit in IPRM villages over non IPRM villages.

3. INTRODUCTION

3.1 Brief history

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

The main mission of CICR is to increase the production, productivity and profitability of cotton cultivation in different agro-ecological cotton growing zones through the development of relevant, feasible and 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 IPR status

As per the guidelines of IPR, the ITMU will pursue the following technology for grant of patent, IP Protection, maintenance, transfer of technology and commercialization of technologies.

S.No.	File No.	Patent Application No.	Title	Filed on
1	1-11/2002-IPR (Part-A)	600/DEL/2002	Rapid detection of Bt Cry toxins	31.5.2002
2	1-11/2002-IPR (Part-B)	PCT/IN03/ 00199/7128	Rapid detection of Bt Cry toxins	29.5.2003
3	1-11/2002-IPR (Part-II)	PA/A2004/011769 National Phase	Rapid detection of Bt Cry toxins	26.11.2004 Mexico
4	1-11/2002-IPR (Part-I)	2004/10268 National Phase	Rapid detection of Bt Cry toxins	21.12.2004 South Africa - Granted
5	1-11/2002-IPR (Part-III)	IAP2004-0451 National Phase	Rapid detection of Bt Cry toxins	30.12.2004 Uzbekistan
6	1-11/2002-IPR (Part-IV)	2004/7019456 National Phase	Rapid detection of Bt Cry toxins	14.1.2005 South Korea
7	1-11/2002-IPR (Part-V)	03817641.6 National Phase	Rapid detection of Bt Cry toxins	25.2.2005 China

Commercialization of technology and resource generation :

(Rs. In lakhs)

Sr.No.	Name of technology	2003-04	2004-05	2005-06	2006-07	Total
1	Bt Express					
2	Bt Quant	5.86	34.15	21.71	42.88	104.66
3	Bt Zygosity PCR					

3.4 Financial Statement

The budget grant and actual expenditure for the year 2007-08 are furnished below:

Budget Sanctioned and Expenditure

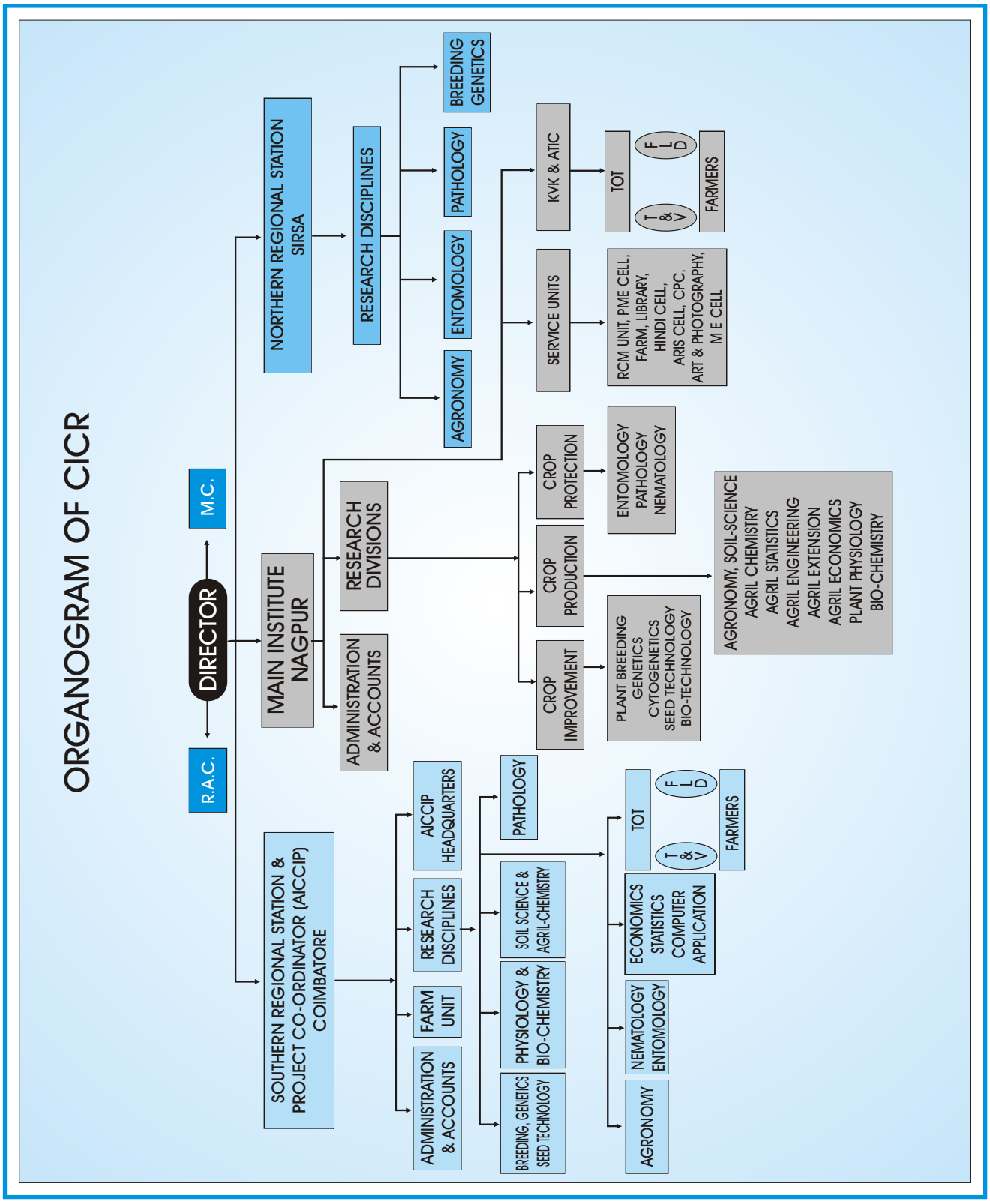
Scheme		Sanctioned	Expenditure
1.	Plan	250.00	250.00
2.	Non-Plan	1104.00	1049.15
PLAN SCHEME			
3.	NSP Crop	0.34	-
4.	AICCIP	589.00	589.00
5.	KVK Scheme	44.95	44.90
6.	TMC MMI	539.00	539.00
7.	MSP	19.53	2.91
AP CESS FUND			
8.	Bt. Resistance	25.75	20.33
9.	ICAR Regional Committee No.VII	4.97	1.43
R DEPOSIT SCHEME			
10.	DBT Scheme (DNA)	2.72	2.04
11.	DST QTLS	1.66	2.77
12.	DST FRCCSHP	5.27	4.39
13.	DBT Bt Cellus	7.00	2.44
14.	DBT MMFQ	27.09	20.75
15.	DST Fast Track	10.50	1.46
16.	DBT DNAi	21.69	4.11
17.	DBT Gene Stratching	15.36	0.02
18.	EPS & C (De Nocil)	-	-
19.	FLD in Cotton	74.00	71.81
20.	TMC MM-I (DAC)	-	-
21.	FLD KVK	2.52	1.65
22.	DUS Scheme Nagpur	3.00	1.56
23.	DUS Coimbatore	6.00	3.78
24.	Maintenance of Breeder Seed	30.00	25.68
25.	GMO Project	18.00	7.42
26.	TMC MM II	197.77	190.75
27.	Bt. Resistance Monitoring (Mahyco) I	5.00	2.88
28.	Bt. Resistance Monitoring (Mahyco) II	10.00	1.60
29.	Dupond	1.06	1.04
30.	Bt. Tech	17.42	-
31.	Transgenic Crops	36.84	22.03
32.	Ratan Tata SGP 445	5.00	2.38
33.	Ratan Tata SGP 452	5.00	2.90

3.5 Staff Position

(As on 31 March 2008)

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	54	26	5	85	37	18	6	61
Technical	50	23	8	81	47	19	8	74
Administrative	33	10	6	49	27	7	5	39
Supporting	65	34	12	111	55	30	12	97
Krishi Vigyan Kendra								
Training Organiser	1	-	-	1	1	-	-	1
Technical	8	-	-	8	8	-	-	8
Administrative	2	-	-	2	2	-	-	2
Supporting	2	-	-	2	2	-	-	2

NGP Nagpur; CBE - Coimbatore


ORGANOGRAM OF CICR
DIRECTOR
R.A.C.
M.C.
MAIN INSTITUTE NAGPUR
ADMINISTRATION & ACCOUNTS
RESEARCH DIVISIONS
CROP IMPROVEMENT
CROP PRODUCTION
CROP PROTECTION
PLANT BREEDING GENETICS CYTOGENETICS SEED TECHNOLOGY BIO-TECHNOLOGY
ENTOMOLOGY PATHOLOGY NEMATOLOGY
AGRONOMY, SOIL-SCIENCE AGRIL CHEMISTRY AGRIL STATISTICS AGRIL ENGINEERING AGRIL EXTENSION AGRIL ECONOMICS PLANT PHYSIOLOGY BIO-CHEMISTRY
NORTHERN REGIONAL STATION SIRSA
RESEARCH DISCIPLINES
AGRONOMY
ENTOMOLOGY
PATHOLOGY
BREEDING GENETICS
SERVICE UNITS
RCM UNIT, PME CELL, FARM, LIBRARY, HINDI CELL, ARIS CELL, CPC, ART & PHOTOGRAPHY, M E CELL
KVK & ATIC
TOT
T & V
F L D
FARMERS
SOUTHERN REGIONAL STATION & PROJECT CO-ORDINATOR (AICCIP) COIMBATORE
ADMINISTRATION & ACCOUNTS
FARM UNIT
RESEARCH DISCIPLINES
AICCIP HEADQUARTERS
BREEDING, GENETICS SEED TECHNOLOGY
PHYSIOLOGY & BIO-CHEMISTRY
SOIL SCIENCE & AGRIL-CHEMISTRY
PATHOLOGY
AGRONOMY
NEMATOLOGY ENTOMOLOGY
ECONOMICS STATISTICS COMPUTER APPLICATION
TOT
T & V
F L D
FARMERS

4. RESEARCH ACHIEVEMENTS

4.1: Cotton Genetic Resources

Nagpur

Collection within country and acquiring of New Germplasm from abroad

One thousand and twenty seven early maturing long staple germplasm lines with big boll size along with nine wild species were received from USA through NBPGR, New Delhi. In addition, 11 long staple lines with high strength and high GOT were received from Pakistan.

Four wild species accessions namely *Gossypium australe, Gossypium darwinii, Gossypium tomentosum* and *Gossypium trilobum* were established in the species garden.

Enrichment of Gene Bank

Ten germplasm lines of *G. hirsutum* with unique and novel traits namely BN Red, BN Okra, Raj 2006, CIR 8, CIR 12, CIR 23, CIR 26, CIR 32, CIR 38 and CIR 4 and one thousand thirty eight exotic germplasm lines of *G. hirsutum* were added to the Gene Bank of CICR, Nagpur.

Conservation of germplasm

Germplasm accessions of *G.hirsutum* (3500), *G.arboreum* (1200) and *G.herbaceum* (49) were grown for rejuvenation and seed multiplication.

Conservation of germplasm (LTS)

Six hundred and ninety two accessions of *G.hirsutum* and 267 accessions of *G.arboreum* were sent to NBPGR, New Delhi for long term cold storage. Duplicate sets were kept in medium term cold storage at CICR, Nagpur.

Evaluation of germplasm

Two hundred accessions each of *G. hirsutum* and *G. arboreum* were evaluated at three locations viz. Sirsa (North zone irrigated), Nagpur (Central zone rainfed) and Coimbatore (South zone - irrigated). The following genotypes were identified for distribution among breeders and researchers.

G. hirsutum

The superior genotypes identified were IC 356819, IC 356787, Ao2N62 and A02N98 for seed cotton yield ; EC 580041 and EC 580028 for ginning outturn and IC 356819, A02N76 and A02N93 for boll weight.

G. arboreum

The superior germplasm accessions identified were AC 3041, AC 3091, AC 3725, AC 3326 for seed cotton yield ; AC 3187, AC 3510 for ginning outturn and AC 3468 for boll weight.

Evaluation of *G. herbaceum* germplasm

One hundred ten germplasm accessions of *G. herbaceum* belonging to different geographical regions were grown for evaluation. However, only 13 germplasm accessions entered the reproductive phase. The important characters namely seed cotton yield, GOT, boll weight and MHL are given in Table 1.

Table 1: Evaluation of *G. herbaceum* germplasm

Name of Accessions	Seed cotton yield/plant (g)	Ginning out turn (%)	Boll weight (g)	MHL (mm)
Baluchistan 6	28.1	33.3	1.2	22.1
Baluchistan 6-2	17.2	34.8	1.0	22.5
Baluchistan 7	50.3	34.1	1.4	20.3
Gohari Itadi Fine (Gujarat)	21.1	30.2	1.2	19.7
HK 86 (Karnataka)	47.1	33.5	1.4	16.5
HP - 23 - 5 - 1 (Karnataka)	40.3	34.7	1.4	20.2
Kalagir (Viramgaon)	70.2	34.1	1.7	19.5
KFT (Dharwar)	19.1	33.8	1.2	21.3
MDS 42 (Dharwar)	22.4	34.7	1.4	20.7
R - 51 - 7A (Raichur)	73.8	33.2	1.7	20.3
SP 3946 Adoni (A.P.)	29.1	35.7	1.5	21.1
SLG 22	21.3	34.3	1.4	18.2
SLG 29	21.9	34.2	1.5	19.1
Range	17.2-73.8	30.2-35.7	1.0-1.7	16.5-22.5

Utilization of germplasm material

Breeding for disease resistance

Four strains *viz.*, CINA 347, CINA 357, CINA 363 and CINA 364 were developed utilizing grey mildew disease resistant cultures and evaluated in station trial for yield and fibre properties. Cultures CINA 363 (1463 kg/ha) and CINA 364 (1427 kg/ha) were superior to the check AKA 8401 (1240 kg/ha) in seed cotton yield. CINA 347 was evaluated in AICCIP Trial (Table 2).

Table 2: Performance of CINA 347

Culture	Seed cotton yield (kg/ha)	Ginning out turn (%)	Boll weight (g)	2.5% Span length (mm)	Micronaire	Bundle strength (g/tex)	Rank
CINA 347	1595	36.34	2.4	26.2	4.9	21.5	3rd
AKA- 5 (ZC)	1208	35.81	2.0	25.2	4.9	21.2	16th

Distribution of germplasm

Seeds of 235 accessions of *hirsutum* and 45 accessions of *arboreum* were distributed to various Cotton Research Stations/ Centers of SAUs and Government Institutions for research purposes only.

Utilization of germplasm

Eleven accessions of *G. hirsutum,* 19 accessions of *arboreum* and 3 accessions of *herbaceum* were utilized in crossing to create more variability.

Distribution of segregating material

F_3 segregating material of 35 crosses of *hirsutum* and 19 crosses of *arboreum* were distributed to different Cotton Research Centres of SAUs for further evaluation, selection and utilization in their breeding programme. Parents involved in the above crosses had big bolls, high yield,GOT, strength and earliness.

Assessment for Gossypol

Seed gossypol content ranged from 0.45 (H 47) to 1.8 (BDN 6529) per cent in the fifteen *G.arboreum* accessions evaluated.

Molecular evaluation of cotton germplasms

Twenty four genotypes of *G. arboreum* were evaluated by using three PCR based DNA markers *viz*., RAPD, ISSR and SSR with which, all the accessions were found to form two major clusters. The range of similarity coefficient varied from 0.58-0.89 in RAPD, 0.56-0.92 in ISSR and 0.58-0.94 in SSR.

Twenty four select *G. hirsutum* germplasm lines were subjected to RAPD, ISSR and SSR (Microsatellite) analysis to generate DNA profiles. Fig.1,2, and 3.

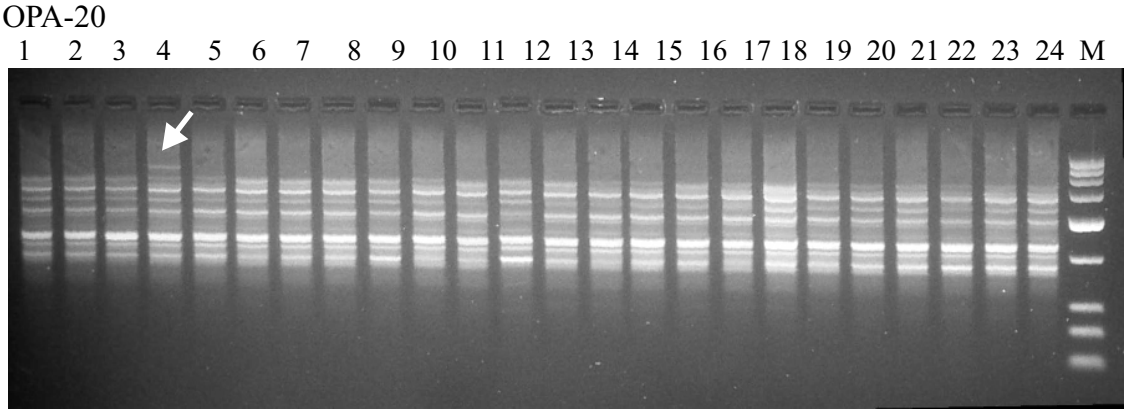


Fig.1: RAPD profile of 24 cotton cultivars obtained with primer OPA-20, 1-24 corresponds to cultivars. Lane 25, M = 3 kb ladder. Arrow- Unique fragment in Lane OIL-1190.

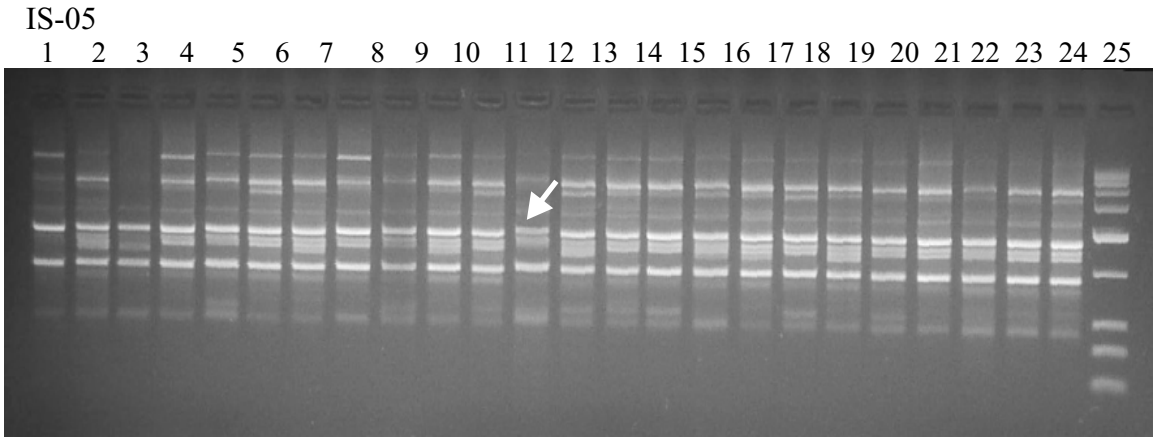


Fig. 2: ISSR profile of 24 cotton cultivars obtained with primer IS-05 Lane 1-24 corresponds to cultivars. Lane 25, M = 3 kb ladder. Arrow- Unique fragment in Lane MAR-868.

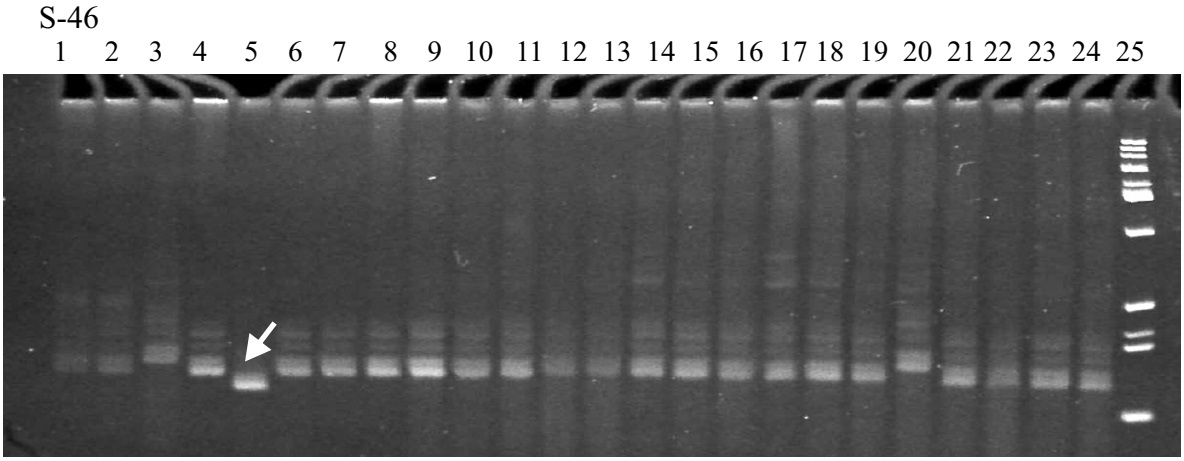


Fig. 3: SSR profile of 24 cotton cultivars obtained with primer S-46, Lane 1-24 corresponds to cultivars. Lane 25, M = 100 bp ladder. Arrow- Unique fragment in lane OIL-1511.

Coimbatore

Field maintenance of 250 *G. hirsutum* accessions was undertaken. Of the 26 elite germplasm lines evaluated, line ICGH 404-1 was found to be the best for yield (4044 kg/ha) with 13% yield increase over the check variety Sumangala (3568 kg/ha).

Two hundred accessions in each of *G. hirsutum* and *G. arboreum* were evaluated in separate trials. The variability noticed for the major characters are furnished in Table 3 and 4.

Table 3: Performance of *G. hirsutum* germplasm accessions

Character	I set			II set		
	Mean	Min.	Max.	Mean	Min.	Max.
Seed Cotton yield (g/plant)	50.9	16.6	106.4	60.0	22.2	111.8
GOT (%)	38.8	26.5	45.3			
Boll wt. (g)	2.6	1.9	3.9	2.6	1.8	3.7
Total boll No.	20.6	7.9	39.9	22.9	9.4	45.6

Table 4: Performance of *G. arboreum* germplasm accessions

Character	I set			II set		
	Mean	Min.	Max.	Mean	Min.	Max.
Seede Cotton yield (g/plant)	39.6	16.8	58.8	43.4	22.5	84.1
2.5%SL (mm)	36.9	30.5	45.7			
GOT (%)	22.7	17.3	26.8			
Boll wt. (g)	1.8	1.4	2.4	2.2	1.6	2.8
Total boll No.	26.6	11.3	40.9	20.3	9.9	45.3

Evaluation of the superior single plant selections in *G. barbadense* L germplasm

Nineteen single plant selections were made from *G. barbadense* germplasm. ICB-20 selections showed the best performance for yield (2300 kg/ha) as against 1600 kg/ha in the check variety Suvin.

Sirsa

Evaluation and maintenance of genetic resources

Sufficient variability was noticed among the various *G.hirsutum* (282 lines) and *G.arboreum* (231 lines) genotypes evaluated during the year. The range of variability for the superior 20 lines is furnished in Table 5.

Table 5: Range for traits in 20 superior accessions of *G. hirsutum* and *G. arboreum*

Parameters	*G. hirsutum*	*G. arboreum*
Seed cotton yield/plant (g)	140-200	112-163
Boll weight (g)	3.7-4.0	2.6-3.2
Boll number	49-58	48-64
Ginning Outturn (%)	37.5-40.0	38.2-41.9
Seed Index (g)	10-12.1	6.1-6.8
Lint Index (g)	5.2-6.5	3.3-4.0
Number of monopods	5-7	6-8
Number of sympods	16-21	13-20
Plant height (cm)	150-170	155-180
2.5 % Span length (mm)	28.7-31.6	25.3-28.8
Uniformity Ratio (%)	52-54	53-55
Fineness micronaire (10-6 g/in)	3.8-3.3	4.6-3.4
Fibre Strength '3.2' gauge (g/tex)	25.1-27.1	22.4-26.0
Boll damage (%)	0-17.8	0-8.6
Jassid/ leaf	0-1.8	0-1.6
Whitefly per leaf	0-2.8	0-2.6
CLCuV (%)	0-100	Nil
Shattering percentage	-	0-5

Registration of germplasm

Seven cotton germplasm lines viz., CIR-8,CIR-12,CIR-23,CIR-26,CIR-32,CIR-38 and CIR-47 as CMS restorer lines with distinguishing characters from sirsa station along with a jassid tolerant genetic stock of upland cotton Raj 2006 from Nagpur have been registered with NBPGR, New Delhi.

4.2: Hybrid Cotton

Nagpur

The existing CMS, GMS and restorer lines were maintained through crossing with their counterpart B lines, sibmating and selfing.

GMS hybrid NGMSH 5-08 recorded 2746 kg/ha seed cotton yield with 161 and 20 per cent increase over H 8 and NHH 44, respectively with a mean halo length of 27 mm, boll weight of 4.2 g and GOT of 40 per cent. In another trial, NGMSH 37-08 was the best hybrid with 114 and 37 per cent heterosis over H 8 and NHH 44, respectively. It recorded mean halo length of 26.3 mm, boll weight of 3.9 g and GOT of 40.8 per cent.

Exploitation of Apomixis and TGMS systems in hybrid cotton seed production

Confirmation of a pomictic phenomena in tetraploids:

Confirmation studies on apomictic phenomenon on four lines were conducted by emasculating and selfing, crossing with dominant markers and crossing with CMS A lines. Four tetraploid TGMS lines *viz.* EGMS H 2-8-4-3, EGMS H-5-7-3-5, EGMS H-3-7-5-8 and EGMS H-5-12-8-6 obtained from ANGRAU, ARS Station, Mudhol were maintained.

Coimbatore

Agronomically superior cultures *viz.*, LRA 5166, MCU5, Supriya, HLS 72, 70 E, 70 G, 22-29 HS, IRH 1-4, IRH 1-6, RKR 415, Palmeri and SH 2374 have been successfully converted into CMS lines by back cross method. Cultivars MCU4 and MCU 5 have been converted into GMS lines. The extra long staple *G.barbadense* cultivar Suvin was converted successfully into restorer line. These lines were found to be stable in expression for male sterility and restorability, respectively. Of the 24 GMS based intra *hirsutum* hybrids evaluated, LRA 5166 x Sumangala (3638 kg/ha) with 5% yield increase over DHH 11 (3470 kg/ha) was the best hybrid.

Development of interspecific (H x B) hybrid

The male sterile based test hybrid 70 G x SR was the best with 2950 kg/ha of seed cotton yield and was significantly higher than the best check hybrid DHB 105 (2348 kg/ha). The yield increase was of the order of 26 %. Two other hybrids *viz.* IRh 1-6 x PR and Abadhita x PR recorded higher yield than DHB 105.

Of the fifty-six conventional interspecific hybrids evaluated, CCHB-51 (2324 kg/ha), CCHB-56 (2263 kg/ha) and CCHB-7 (2251 kg/ha) were significantly superior in seed cotton yield to the best check hybrid DCH-32 (1670 kg/ha).

Pooled yield data of the advance interspecific hybrids showed that CCHB-51 (2426 kg/ha) continuously performed better in yield than the other hybrids and checks (Table 6). CCHB-4 recorded the maximum GOT % of 35.

Table 6: Pooled yield data and fibre qualities of advanced interspecific hybrids

Hybrids/checks	Seed cotton yield (kg/ha)	Ginning per cent	Fibre properties		
			2.5% SL (mm)	Mic. (ug/inch)	Bundle strength (g/tex)
CCHB-51	2426*	34	35	4.1	25
CCHB-4	2361*	35	36	4.0	26
CCHB-48	2209*	32	35	4.0	24
DCH-32 (C)	1699	33	35	3.9	24
TCHB-213 (C)	1322	32	34	3.8	26
Sruthi (C)	1144	32	35	3.6	25
CD @ 5%	457	-	-	-	-
CV %	16.45	-	-	-	-

Evaluation of Bt cotton hybrids released for South Zone

Fifty two intra-*hirsutum* Bt cotton hybrids and three interspecific hybrids were evaluated along with respective check hybrids. MRC 7351 BG II was the best hybrid recording 3887 kg/ha (Table 7) and was significantly higher than the Bt cotton check hybrid RCH 2 Bt (3272 kg/ha).

Seven other Bt cotton hybrids also recorded significantly higher yield over RCH 2 Bt. Fibre quality wise NCS 950 was the best having 32.3 mm length and 22.8 g/tex bundle strength.

Among the interspecific Bt cotton hybrid evaluated, MRC 6918 was the best for both yield (3725 kg/ha) and fibre quality (35.4 mm fibre length, 24.3 g/tex bundle strength.) (Table 8).

Table 7: Performance of select intra-*hirsutum* Bt cotton hybrids for yield and other characters

Name of the Bt hybrid	Seed cotton yield(kg/ha)	Boll weight (g)	2.5% SL (mm)	Mic.	Bundle strength (g/tex)
MRCH 7351 BG II	3887*	7.1	30.8	5.0	19.9
Tulasi 117	3747*	6.6	29.4	4.5	20.0
RCH 533 BG II	3664*	6.2	31.4	4.7	20.8
ACH 33-2 BG II	3615*	5.2	27.6	4.7	19.3
KDCH 621	3552*	6.8	28.6	4.9	18.9
NSPL 999	3549*	7.3	29.6	4.8	22.3
RCH 530 BG II	3549*	7.0	31.6	4.4	22.0
Tulasi 9	3531*	7.7	30.3	4.7	20.1
RCH 2 (Bt Check)	3272	6.1	30.4	4.9	19.3
Bunny (Non Bt check)	2655	6.4	30.4	4.4	20.3
CV %	13				

* Sig. at 5%

Table 8: Performance of interspecific Bt cotton hybrids for yield and other characters

Name of the Bt hybrid	Seed cotton yield (kg/ha)	Boll weight (g)	2.5% SL (mm)	Mic.	Bundle strength (g/tex)
MRC 6918 (C)	3725	4.8	35.4	4.0	24.3
NCS 990	3200	5.6	33.3	4.1	23.3
NCHB 992	2986	4.9	32.9	4.0	22.7
Kasinath	2548	5.1	33.8	3.5	22.3
CD @ 5 %	814				
CV %	13				

Sirsa

Tetraploid cotton

Eleven CMS lines representing parents of promising hybrids *viz*., LRA 5166, Jhorar, RB 281, LH 1134, Pusa 31, HS 6, K 34007, F 505, F 1183, CSHH 25 M and SH 2379 were maintained through sib mating. Ten restorer lines were maintained through selfing. Twenty two new restorer lines were identified and maintained.

The highest seed cotton yield was recorded in the conventional hybrid S 123 x 0006 DA and S 123 x 002NAH (2435 kg/ha) and 25M x 007 DA (2389 kg/ha) as against 2088 kg/ha of check hybrid CSHH 198. Maximum ginning out turn of 34.3 per cent was recorded in the hybrid F 1861 x 001 NAH followed by 34.1 per cent in 235M x 006DA.

Of the ten promising GMS hybrids evaluated, CSHG 1862 gave the highest yield of 2273 kg/ha, which was better than the best conventional check hybrid CSHH 243 (1877 kg/ha). The highest ginning outturn was recorded by the hybrid CSHG 2612 (35.0 %) followed by CSHG 1862 (33.5 %). The hybrid CSHG 3108 recorded the highest 2.5% span length (27.5 mm), whereas the highest bundle strength of 24.4 g/tex and 24.2 g/tex was observed in hybrids CSHC 195 and CSHG 2033, respectively.

Fifty three GMS hybrids were tested in the intial evaluation trial. The highest seed cotton yield was recorded in GMS 21x 002NAH (1713 kg/ha), followed by GMS 19 x 002NAH (1667 kg/ha) as against 1574 kg/ha of conventional check hybrid CSHH 198. Maximum ginning out turn of 35.6 % was recorded by the hybrid GMS 28 x 006DA. The highest 2.5 % span length (31.1 mm) and tenacity (24.7 g/tex) was recorded by the hybrid GMS 15 x 007DA and GMS 21 x 007DA, respectively .

Among the 39 CMS based hybrids evaluated, the highest seed cotton yield was recorded by hybrid P31 x SPC 920 P1-P3 (3083 kg/ha), followed by 2944 kg/ha in LRA 5166 x SPC 920 P1-P3. The highest ginning out turn of 34.0 per cent was recorded by the hybrid SH 2379 x SPC 920 P1-P3, followed by 33.8 per cent in SH 2379 x SPC 526 P2.

In the AICCIP North Zone trials, GMS based hybrid CSHG 1862 recorded a mean seed cotton yield of 1964 kg/ha with 34.2 per cent ginning outturn and ranked 4th position as compared to 1871 kg/ha of conventional zonal check hybrid CSHH 198. The hybrid also recorded a higher 2.5 % span length of 27.7 mm, micronaire value of 4.1 and bundle strength of 23.2 g/tex (Table 9).

Table 9: Performance of GMS based hybrids in AICCIP trial

Sr. No	Entry	Seed cotton yield (kg/ha)	Lint yield (kg/ha)	Ginning Out turn	2.5% Span length (%)	Micro-naire (mm)	Bundle strength (g/tex)
1	CSHG 1862	1961 (4)	671	34.2	27.7	4.1	23.2
2	SVHH 139	2248 (2)	760	33.6	25.4	4.6	21.6
3	CSHH 198 (ZC)	1871 (5)	619	33.0	26.7	4.4	21.9
	CD@5%	254	102	2.6			
	CV (%)	8.3	8.4	3.6			

(Figures in parenthesis indicate rank)

G. arboreum

New GMS lines identified

8 lines having red flower colour were identified and maintained.

Genetic study of GMS lines

It was seen that out of 137 plants, 135 fertile plants were obtained while crossing CISA 2(GMS) and DS 5(GMS) lines with GAK 413A indicating that the gene for sterility is different from GAK 413A.

Demonstration of Bt hybrids for North Zone

Among the 14 Bt hybrids evaluated, the hybrid MRC 6301 gave the highest yield of 3194 kg/ha followed by NCS-913 (3083 kg/ha) and RCH-317(3074 kg/ha).The highest ginning outturn was recorded by RCH-308 (39.0 %) followed by RCH-134 (38.5 %). The Bt hybrid RCH 317 recorded the highest 2.5% span length (30.3 mm) followed by NCS-913 (29.1 mm) and MRC 6304 (29.0 mm) whereas the highest bundle strength of 23.8 g/tex was observed in hybrid NCS-138 followed by 23.3 g/tex in MRC 6025.

4.3: Genetic Improvement

Nagpur

G. arboreum

Of the twenty-eight entries received from different centres and evaluated, the top five high yielding genotypes were KWA 228 (883 kg/ha), MDL 2463 (863 kg/ha), PA 531 (839 kg/ha), AKA 8 (742 kg/ha) and CINA 343 (721 kg/ha). The high GOT cultures included PA 531, CISA 281, AKA 0210, KWA 225 and BBLS-1. Long linted genotypes included DELA 3, RAC 04, CINA 344, KWA 25 and CINA 343. In these genotypes, the halo length ranged from 26.1 mm to 27.4 mm.

Random mating population

Twenty half-sibs were subjected to random crossing. The crossed seeds from each half-sib were harvested and again maintained as half-sibs. The fourth cycle of random mating has been completed. Crossed boll seeds obtained from sterile plants during the previous year were grown. All the bolls from the sterile plants in the current population were bulk harvested. Thus, a second cycle of GMS based random mating has been completed.

Heterotic pool development

In the studies conducted on development of heterotic pool for superior medium staple in tetraploid cotton, based on specific combining ability effects of crosses, 12 parents were grouped into two. First group parents were PKV Rajat, NH 545, DHY186, LRK 516 and IC 356590, while in second group, parents were MCU 9, Surabhi, GSH 2, Sahana, H 1948, ACCLD 163 and H 1252.

Abiotic stress

G. hirsutum

Two cultures *viz.* CNDTS 101 and CNDTS 102 were tested in Institute Common Trial. CNDTS 101 ranked first among the cultures tested with 67 per cent increase over LRA 5166 (check).

One hundred and forty two single plant selections were tested under rainfed conditions. Fourteen single plant selections were at par to the check LRA 5166 (938 kg/ha). SPS 19 (12) 10 recorded highest yield of 1853 kg/ha with 97 per cent increase over LRA 5166 with a GOT of 36.5%, MHL of 25 mm and boll weight of 4.2 g. SPS 44(44)12 and SPS 26(45)3 recorded highest GOT of 37 per cent. In the third trial, sixty six single plant selections were tested and signticantly different with respect to seed cotton yield. SPS 1(12)1 recorded 1535 kg/ha seed cotton yield with 75 per cent increase over the check LRA 5166.

Biotic stress

Forty-five F_1s along with parents were evaluated for tolerance to jassid and bollworms. The parents PKV Rajat, AKH 081 and G.Cot 18 showed significant general combining ability effects for tolerance to jassid and bollworms. Crosses AKH 081×Acala 1517, Khandwa 3×Acala 1517, PKVR×CIPT 511, Khandwa 2×CIPT 501, G Cot 18×CIPT 530 and NH 545×ND 63 were tolerant to jassid and bollworm incidence.

Thermosensitive Genetic Male Sterility System (TGMS)

In the thermo-sensitive diploid lines of *G. arboreum*, percentage of fertile flowers was zero during the month of September and the percentage boll set was also zero. During October, maximum percentage of fertile flowers (48 %) along with high boll set percentage (43.6 %) was observed in both the lines. This could be correlated with the decrease in mean minimum temperature to 18°C.

Four tetraploid EGMS lines were obtained from ANGRAU, ARS, Mudhol *viz.* EGMS H2-8-4-3, EGMS H-5-7-3-5, EGMS H-3-7-5-8 and EGMS H-5-12-8-6. All the plants of these EGMS lines were fertile till 29th March 2008. Sterility was observed above 40ºC in these lines.

Oil Improvement

Two genotypes *viz.* B 58-1290 (low) and VCH (F) (high) with contrasting seed oil content were chosen to develop six generations (P_1, P_2, F_1, BC_1, BC_2 and F_2) and were evaluated during the current year. Range of variability for economic characters is given in Table 10.

Genetic Enhancement of Upland Cotton

In F_5 populations, advanced pre-bred cross combinations *viz.*, LRA 5166 x A 678 (28.2 mm), MCU 5 x G-21-17-619-3 (28 mm) and PKV 081 x G 21-17-619-3 (28 mm) were found superior in staple length with higher yields as compared to check LRK 516 . Three crosses *viz.*, PKV o81 x

Table 10: Range and mean of important economic characters in different generation material

Generation	Seed cotton yield/plant (g)	Boll weight (g)	Ginning outturn (%)	Lint index (g)	Seed index (g)
Range and mean of 5 plants					
P_1	37-50	3.3-3.8	37.3-37.8	4.7-5.1	7.5-8.5
	48.5	3.5	37.5	4.9	8.0
P_2	45-78	3.1-3.5	37.1-37.8	4.5-4.9	7.5-8.0
	61.5	3.3	37.4	4.7	7.7
F_1	57-77	3.2-3.6	39.3-39.8	5.3-5.6	8.0-8.5
	67.0	3.4	39.5	5.4	8.2
Range and mean of 30 plants					
BC_1	69-90	3.5-4.0	35.2-38.3	3.5-4.6	7.1-8.6
	79.5	3.7	36.7	4.0	7.8
BC_2	72-101	3.3-4.2	34.4-37.2	3.5-4.8	7.0-9.0
	86.5	3.7	35.8	4.1	8.0
Range and mean of 550 plants					
F_2	9-175	1.5-4.5	29.4-40.0	3.6-4.9	6.0-10.0
	92.0	3.0	34.7	4.2	8.0

Deltapine 66, LRA-5166 x CIHS-97-10 and GCOT 10 x Deltapine 66 were superior with yield levels up to 1300 kg/ha under rainfed situation.

Culture CNHO 12 with an averge yield of 1400-1500 kg/ha under AICCIP trials has been recommended for Agronomy trials. It has a fibre length of 25 mm and fibre strength of 20.2 g/tex with seed oil content of 19 %.

Identification of genotypes suitable for mechanical picking

Under a close spacing of 100 x 10 cms, Khandwa 3 recorded the highest seed cotton yield (3617 kg/ha) as compared to the varietal check LRA 5166 (3283 kg/ha) and Bt hybrid check RCH 2 Bt (1786 kg/ha).

In antother station trial, under a close spacing of 100 x 10 cm, entry 28 I recorded the highest seed cotton yield of 5358 kg/ha as compared to the varietal check LRA 5166 (3034 kg/ha) and hybrid check RCH 2 Bt (5082 kg/ha). Other superior genotypes were CIPT 4 (4632 kg/ha), CIPT 1 (4396 kg/ha) and CNH 30 I (4233 kg/ha). Under 100 x 20 cm spacing also, the genotype 28 I recorded the highest yield (3228 kg/ha) followed by CNH 30 I (2945 kg/ha), CIPT 4 (2747 kg/ha) against the varietal check LRA 5166 (1939 kg/ha) and hybrid check RCH 2 Bt (2673 kg/ha).

Three introgressed genotypes recorded higher yields *viz.* NISC 35 (2923 kg/ha), NISC 34 (2803 kg/ha) and NISC 3 (2723 kg/ha) as compared to the varietal check LRA 5166 (1939 kg/ha) and hybrid check RCH 2 Bt (2673 kg/ha).

Random mating population in *G. hirsutum*

Twenty half-sib progenies obtained through conventional crossing with composite pollen, in the previous year, were grown in multiple row plots and subjected to random mating. Pollen of all half-sibs were bulked and used for pollination. The crossed seed from each half-sib family was bulk harvested and again maintained as half-sibs. Thus, the fourth cycle of random mating was completed in upland cotton.

Seed cotton from GMS plants were bulk harvested completing the first cycle of GMS based random mating.

Coimbatore

Genetic improvement of introgressed lines

Of the twenty medium staple introgression lines evaluated, the highest seed cotton yield of 2873 kg/ha was recorded in MM-02-11-7 with 28 % yield increase over check variety (2248 kg/ha) (Table 11). Five other lines recorded significantly higher yield over the check variety with 16 to 28 % yield increase. These lines belong to medium staple category and were superior to the check variety Sumangala.

In another station trial with six long staple introgression lines, the highest seed cotton yield was recorded in the check variety MCU 13 with 2913 kg/ha. However, quality wise several lines were superior to both the check varieties in terms of both fibre length and bundle strength. For 2.5 % span length, the culture MM-03-39-4-1was the best with 34.4 mm and for bundle strength, the culture MM-03-39-4-1was the best with 24.9 g/tex. The culture MM-03-39-4-1is also characterized by very good boll weight of 6.5 g.

Development of medium staple varieties

Nineteen medium staple genotypes were evaluated in the station trial. Seven genotypes were found to be statistically superior to the check variety LRA 5166. Culture L (L x IBM) 2629 recorded the highest yield of 4966 kg/ha with a seed cotton yield increase of 48 per cent over the check variety. It was also characterized by a high ginning out turn of 38 per cent.

Development of short duration compact genotypes

Ten compact genotypes were evaluated for their yield and earliness. Culture CCH 724-5 was found to be early (150 days) and compact. It recorded a mean seed cotton yield of 3751 kg/ha as against 3392 kg/ha of Anjali. The variety was also tested under rainfed conditions in Central Zone for three years from 2004 to 2007 and recorded a mean seed cotton yield of 1297 kg/ha, as against 1094 kg/ha of LRA 5166. The seed cotton yield increase was of the order of 19 per cent.

Development of high yielding and high spinning extra long staple cotton

Culture CCH 510-4 was tested in the AICCIP irrigated trials in South Zone during 2003 to 2007 (Table 12). It recorded a mean seed cotton yield of 1799 kg/ha as against 1655 kg/ha of the control variety Surabhi. The increase in seed cotton yield was of the order of 16.2 per cent. Culture CCH 510-4 was also characterized by a high ginning out turn of 36.3 per cent as against 33.9 per cent of Surabhi. Because of its high ginning out turn, Culture CCH 510-4 recorded a mean lint yield of 674 kg/ha, as against 554 kg/ha of the check variety Surabhi. The increase in lint yield was of the order of 21.6 per cent.

Table 11: Performance of stable medium staple introgression lines evaluated in station trial

Genotype	Seed cotton yield(kg/ha)	% Inc. over Surabhi	2.5% Span length (mm)	Mic.	Bundle strength (g/tex)
MM-02-11-7	2873*	28	27.5	5.1	21.5
MM-02-6-4	2868*	28	28.9	4.9	19.8
MM-02-22-2	2840*	26	29.3	4.4	19.2
MM-02-16-5	2742*	22	27.5	4.9	21.7
MM-02-9-3	2654*	18	30.7	4.0	18.8
MM-02-6-1	2613*	16	27.6	5.0	18.4
Surabhi (C)	2248	-	33.1	4.3	23.0
Sumangala (C)	2240	0	25.7	5.0	18.7
CD @ 5%	357				
CV %	17				

Culture CCH 510-4 was characterized by a mean fibre length of 31.7 mm, micronaire of 3.8 and fibre strength of 25.9 g/tex and was found to spin up to 60s count yarn. A spacing of 90 x 45 cm with a fertilizer dose of 80:40:40 NPK kg/ha was found to be optimum for the variety CCH 510-4. The variety has since been identified for release in South Zone under irrigated conditions.

Of the Nineteen extra long staple *G. hirsutum* cotton genotypes evaluated, culture 7122-445 with a mean seed cotton yield of 3906 kg/ha was found to be significantly superior both in yield and quality to the check variety Surabhi (3184 kg/ha).

Sirsa

G. arboreum

Performance of advanced cultures in AICCIP trial

CISA 614 was tested for five years from 2003-04 to 2007-08. It recorded the highest yield with an increase of 23.9 percent over the zonal check HD 123 and has been recommended for agronomy trials under AICCIP.

Culture CISA 405 ranked 5th in the seed cotton yield in the initial evaluation trial with 36.0% GOT, 23.5 mm span length and 20.2 g/tex bundle strength. Another Culture CISA 294 ranked 4th with 38.5% GOT, 21.9 mm span length and 18.0 g/tex bundle strength.

Evaluation of advance cultures: Eight advance cultures were evaluated. Culture CISA-6-187 gave significantly higher seed cotton yield (2454 kg/ha), followed by CISA-6-295 (2240 kg/ha), CISA-6-209 (2210 kg/ha), CISA-6-350 (2134 kg/ha) and CISA-6-123 (2134 kg/ha). Maximum span length and strength was recorded by CISA-6-350 (27.5 mm, 22.0 g/tex). The highest GOT (38.4%) was recorded by CISA-6-214 (Table 13).

Table 12: Mean Performance of CCH 510-4 in South Zone (AICCIP trial)

	Variety CCH 510-4	Zonal check variety Surabhi	Local check variety	% inc. over zonal check
Seed cotton yield (kg/ha)	1799	1548	1848	16.2
Ginning outturn (%)	36.3	33.9	36.2	+ 2.4
Lint yield (kg/ha)	674	554	714	21.6

Table 13: Mean performances of advance cultures

Sr. No.	Entry	Seed cotton yield (kg/ha)	Boll wt. (g)	Ginning outturn (%)	2.5% Span length (mm)	Micr-onaire	Bundle strength (g/tex)
1	CISA-6-187	2454	2.3	35.4	24.4	4.1	21.0
2	CISA-6-214	2027	2.5	38.4	23.7	5.3	20.5
3	CISA-6-286	2081	2.3	37.4	25.4	5.2	20.1
4	CISA-6-295	2241	2.3	37.2	25.8	5.5	20.0
5	CISA-6-350	2134	2.4	37.3	27.5	5.5	22.0
6	CISA-6-165	2012	2.3	37.2	23.8	5.5	20.6
7	CISA-6-123	2134	2.3	38.1	26.1	5.0	19.5
8	CISA-6-209	2210	2.3	37.6	22.8	5.6	20.1
9	RG 8 ©	2004	2.1	37.5	19.8	6.9	19.7
	CD at 5%	302	0.2	3.0			
	CV	7	5.0	5.1			

Evaluation of promising varieties

Of the six cultures evaluated in the second trial, CISA 6 and CISA 10 were promising for yield. CISA 10 recorded the highest fibre length of 25.6 mm and strength of 21.2 g/tex. (Table 14).

Table 14: Mean performance of advance generation

Varieties	Seed cotton yield (kg/ha)	Boll wt.(g)	Ginning outturn (%)	2.5% SL (mm)	Micronaire	Bundle strength (g/tex)
CISA 6	2225	2.5	34.5	24.6	6.2	19.9
CISA 7	2035	2.4	34.8	22.5	6.5	18.3
CISA 8	2149	2.5	34.4	20.6	>7.0	17.4
CISA 10	2210	2.4	35.2	25.6	5.1	21.2
AKA-9503	2035	2.2	37.0	24.5	6.2	20.1
CISA 310	2004	2.1	36.9	19.6	>7.0	15.9
CD at 5%	375	0.4	0.9	-	-	-
CV %	8	8.7	1.2	-	-	-

4.4: Genetic Diversity through Introgression

Nagpur

Maintenance of wild species, races and perennials

26 wild species , 15 races, perennials and synthetic polyploids (32) as well as strerile interspecific hybrids (17) are maintained in the species garden. Six new F_1 hybrids were also established. Interspecific derivatives were evaluated for yield and yield contributing characters and also for biotic and abiotic stress resistance.

Development of zero monopodial plant type

Inter- racial crosses in *G. hirsutum* and *G. arboreum* were developed. Genotypes with zero monopodia, cliestogamy and protruding stigma were also confirmed. (*G.herbaceum* x *G.anomalum*) F_1 plant which exhibited very high strength upto 36.7 g/tex is maintained as a perennial plant of which 64 F_2 plants have been established and selfed seeds have been collected to make a mapping population.

Sirsa

Genetic diversity through introgression of useful genes in cultivated species

Introgressed lines for high fibre strength (7 lines) and high ginning out turn (7 lines) were identified. Twenty five introgressed lines were developed by crossing *G. harknessii* with *G. hirsutum* lines and were distributed among the participating centres. In the Station trial, 19 bulks were evaluated against local checks. Four introgressed lines (F1378 x Anjali P4-P2, ARCHH 650 P3, G.Cot 16 x GISV 61 P5, G.Cot 16 x GISV 61 P7) recorded the higher seed cotton yield over the check variety H 1117. The highest ginning out turn of 40.0 % was recorded by 25 F P16 P3, followed by 38.67 % in F1378 x Anjali P2-P1. The highest fibre strength of 24.8 g/tex was recorded by 25 F P16 P1, followed by 24.4 g/tex in ARCHH 650 P3 and G.Cot 16 x GISV 61 P3 P1.

4.5: Development of Transgenics

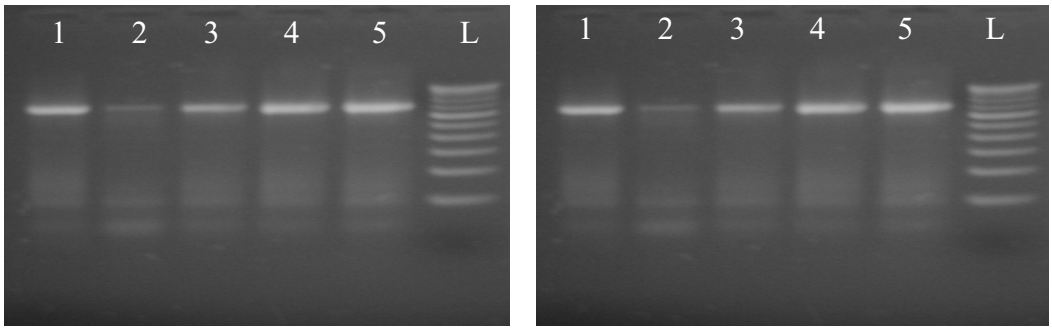
Nagpur

Development of Bt - transgenic cotton with indigenous Bt genes for insect resistance

Indigenously developed Bt *cry* genes *viz*., Bt *cry*1Aa3, Bt *cry*1F and *cry*1Ac (Enh) along with c*ry*1Ac are being transferred by *Agrobacterium tumefaciens* in adaptable cultiviars of *G hirsutum viz*., Anjali, LRA 5166, Surabhi and G.cot-10 and *G. arboreum* cultivars viz., PA 255, PA 402 and PA 405. The transformed plantlets were regenerated in the

kanamycin selection medium. Primary putative transformants (172) were regenerated with *G. hirsutum* cultivars using four Bt *cry* genes and 66 transformants with *G. arboreum* cultivars. Among 172 putative transformants, 54 plants were found *npt*-II positive by PCR analysis (Fig. 3a), while *npt* II test transformation frequency was calculated in *G. arboreum* on the basis of putative transformants (Table 15 & 16). Seventeen independent events of Anjali and three LRA-5166 plants were subjected to Cry protein analysis by ELISA . The protein concentration varied between 2.57- 4.11ppm.

Fig. 3a : Molecular analysis of transgenics: PCR- analysis (Plates a and b)



a **b**

Npt-II positive Anjali and LRA 5166 plants.
a). Lane - 1-3- *npt*-II + ve with Bt *cry* 1 F plants, Lane 4-5 *npt*-II + ve (Ac enhancer) b) Lane - 1-5- *npt*-II + ve with Bt *cry*1Aa3 LRA 5166 plants
L:Ladder (100 bp)

Table 15: Gene constructs used in *G. hirsutum* for the generation of Bt transgenics

Genotypes	Gene construct	No. of explants	No. of Putative transformants	Npt-II positive plants	Transformation frequency*
G. hirsutum Anjali	*cry*1Ac *cry*1Aa3 *cry*1F *cry*1Ac (Enh)	1230 1655 1220 930	18 28 18 7	7 6 3 2	0.57% 0.36% 0.24% 0.24%
G. hirsutum LRA-5166	*cry*1Ac *cry*1Aa3 *cry*1F *cry*1Ac (Enh)	820 560 350 220	10 20 5 12	4 5 4 2	0.48% 0.89% 1.14% 0.90%
G. hirsutum Surabhi	*cry*1Ac *cry*1Aa3	725 1510	6 25	5 6	0.68% 0.39%
G. hirsutum G. Cot -10	*cry*1Ac *cry*1Aa3	820 1420	5 18	4 6	0.48% 0.42%
Total No. of plants *G. hirsutum*	-	11460	172	54	0.28%

* Based on *npt*-II positive

Table 16: Gene constructs used in *G. arboreum* for the generation of BT transgenic

Genotypes	Gene construct	No. of explants	No. of Putative transformants	Transformation frequency*
G. arboreum PA 255	*cry*1Aa3 *cry*1F *cry*1Ac (Enh)	646 467 558	8 7 15	1.23% 1.49% 2.68%
G. arboreum PA 402	*cry*1Aa3 *cry*1F *cry*1Ac (Enh)	545 632 539	9 8 12	1.65% 1.26% 2.22%
G. arboreum PA 405	*cry*1Aa3 *cry*1 F *cry*1Ac (Enh)	256 342 228	6 - 1	2.34% - 0.43%
Total No. of plants *G. arboreum*		4213	66	1.66%

Gene expression and quantification analysis of *cry* 1 Ac progenies of T4 RG8 Bt, T3 PA 255 Bt and PA 402 Bt was carried out by ELISA. Ten RG 8 Bt lines recorded toxin in the range of 2.56 to 8.52 ppm.

In PA 255 Bt transgenic lines, the high expression of Bt protein was observed in transgenic lines PA 255 Bt (5.15 ppm), PA 255 Bt (5.46 ppm), PA 255 Bt (5.95 ppm) and PA 255 Bt.

With regard to *cry*1Aa3 gene, the transgenic lines of cv PA 402 which have recorded higher values are PA 402 Bt line 4 (3.58 ppm), PA 402 Bt line 14 (6.12 ppm), PA 402 Bt line 22 (5.7 ppm) and PA 402 Bt line 24 (5.01 ppm).

RCGM Strip Trial

Evaluation of transgenics for the targeted trait expression

Transgenic events, T_0 plants were advanced to T_1 generation in the 2007-08 seasons. Permission from IBSC / RCGM was obtained to screen and select the best single event of Bt transgenics under strip trial in the polyhouse. Anjali -Bt and LRA-5166 Bt, RG 8 Bt, PA 255 Bt and PA 402 Bt carrying *cry*1Ac and *cry*1Aa3 were raised as boll to row progeny. Plants were screened for gene integration expression by PCR and ELISA respectively. Cry toxin expression ranged from 2.2-3.9 ppm in *hirsutum* and from 4.6-6.0 ppm in *arboreum*.

Development of Bt transgenic cotton with indigenously synthesized gene

Twenty four genotypes of different groups from working germplasm have been taken for analysis. PCR based markers such as RAPD, ISSR, SSR have been used to see the polymorphism and genetic diversity besides any association with this marker with economically important traits. Interestingly, highest percentage of polymorphism was observed in SSR based analysis which reveals more than 67% of polymorphism compared with ISSR and RAPD which showed little above 54% and 62%, respectively. All the markers system form two major clusters. Rare alleles were also observed with different markers.

Genetic improvement through introgression of useful genes in cultivated species of cotton

Isolation and characterization of dehydrin gene

Osmotin and dehydrin gene specific primers were designed based on the conserved sequence in cotton. The genomic DNA from *G. hirsutum* cv. Anjali, LRA 5166 and MHL 685 and *G. arboreum* cultivar AKH-4 were used for PCR amplication and amplified products were cloned and characterized (0.6 kb of dehydrin and 0.6 kb of osmotin). Analysis of sequence revealed that these fragments were a part of the dehydrin and osmotin genes. Sequencing of full length genes are in progress.

Pathogen derived resistance for cotton leaf curl virus resistance by antisense approach

Development of leaf curl virus resistance cotton (NPTC)

Three genotypes *viz.* HS-6, H777 and F846 were transferred with three genes constructs *viz.*, Sense coat protein, anti-sense coat protein and antisense-Rep. Transformants were generated using embryonic axis as an explant with Sense Coat Protein (SCP), Antisense Coat Protein(ACP), Antisense Rep (ARep) gene constructs driven by 35 S CaMV and *npt II* as plant selection marker by *Agrobacterium* mediated transformation (Table 17). The transformed plantlets were selected in the kanamycin selection medium. The surviving shoots were subcultured on shoot elongation and then rooting medium. The regenerated plants were transferred to autoclaved soil rite pots. Molecular confirmation by PCR for the presence of *npt*-II gene with forward and reverse primer has shown the presence of 100 bp fragment in the putative transformants (Table 17).

The putative *npt*-II positive plants were further confirmed for the presence of the Sense CP, Antisense CP and Antisense Rep genes using forward and reverse primers in three genotypes *viz*. H 777, HS 6 and F 846. The forward and reverse primer for Sense CP, Antisense CP and Antisense Rep gene are as follows:

•Sense CP F-5' AATTATGTCGAAGCGAGCTGC-3',

R-5' TATAGTTAAGCAATGTCTCAG3',

•Antisense CP F5 'TTAATACAGCTTCGCTCGACG 3',

R-5' ATATCAATTCGTTACAGAGTC and

- Antisense Rep gene F-5' ATGCCACGTGATTTAAAAACA 3',

R-5' GTGGGGAGAGTTTCAGATCG-3'.

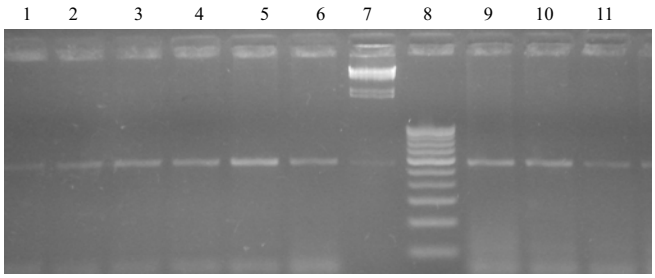
PCR amplication of the genomic DNA by the respective ACP, SCP and A Rep primers in three genotypes revealed positive putative transformants. In H 777, three putative transformants each with SCP, ACP and ARep were found positive (Fig. 4) for the presence of 770 bp for SCP, ACP and 540 bp for A Rep.

In HS 6, two transformants with ACP and ARep were found to be positive for the presence of gene integration respectively. In F 846, three T_0 plants each with SCP, ACP and ARep were positive (Fig. 5) and T_1 seeds were raised in the poly house and screening for the presence of the *npt* II gene was carried by PCR. Generation of T_2 plants is in progress.

Table 17: Regeneration of transformants (CLCuV) and transformation frequency

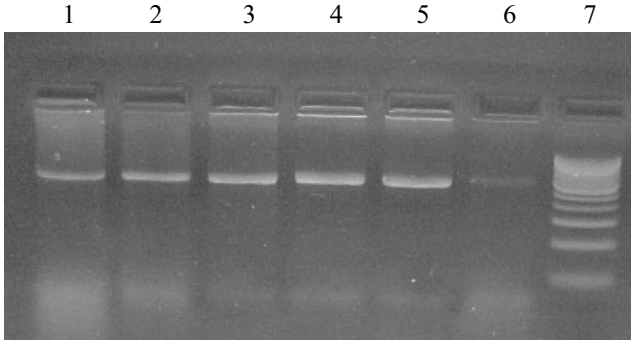
Genotypes	Gene construct	Number of explants used	Putative Transformants	*npt*-II positive	Transformation frequency (%)
H 777	*SCP*	990	13	4	0.30
	ACP	890	9	3	0.33
	Antisense Rep	945	12	5	0.41
F 846	*SCP*	943	3	2	0.60
	ACP	909	5	4	0.80
	Antisense Rep	985	10	4	0.40
HS-6	*SCP*	996	10	6	0.60
	ACP	940	4	2	0.50
	Antisense Rep	915	12	6	0.50

Fig. 4: Confirmation of Antisense Replicase gene integration in putative transformants



Lane 1-3: H777(Rep),4-6:HS6 Lane 7: Lamda(dd), Lane 8: M, Lane 9-11: F 846

Fig. 5: Confirmation of Sense coat protein, Antisense coat protein gene in putative transformants



Lane 1 : H777(Scp),2:H777(Acp),3:HS6 (Scp), 4:HS6(Acp),5:F846(Scp),6:F 846(Acp), 7:Lamda(dd)

Virus resistant cotton through dsRNAi-mediated targeting of cotton leaf curl virus

Development of plasmid vectors for creating SiRNA

Plasmid vectors for generating double stranded RNA (dsRNA) of CLCuV sequences targeted for disruption of CLCuV was constructed by modifying cloning vector pBluescript (Stratagene). In addition to plasmid pKSB-Gus (3.9 kb) constructed earlier, a new plasmid pKSB-Int (3.1 kb) was developed for the purpose. The new plasmid was constructed by cloning 125 bp intron sequence present in the chitinase gene from cotton (*G. hirsutum*). The intron sequence was cloned in the *Eco*RI-*Bam*HI site in the polylinker of the pBluescript (3.0 kb).

Development of constructs for RNA interference

The nucleotide sequences of CLCuV strains associated with different symptom types of the disease documented in three states *viz.* Punjab, Haryana and Rajasthan of North India along with other sequences of CLCuV and related begomoviruses available in GenBank were subjected to multiple alignments. The core sequences conserved among majority of the strains were selected to design double stranded RNA interference constructs (dsRNAi) that should serve as consensus sequence specific to majority of CLCuV strains.

Based upon conserved sequences in DNA A and β DNA components of CLCuV, five sets of primers pertaining to five different genes/ regions of viral genome were designed in such a way that each sequence can be amplified for cloning in two orientations on either side of a stuffer fragments, i.e. *Gus* or intron respectively in pKSB-*Gus* or pKSB-Int, respectively. The said DNA construct on transcription is expected to transcribe an RNA that would fold to form a double stranded RNA (dsRNA) with stuffer fragment forming a hairpin loop.

Using two sets of primers, coat-protein and BC4 genes on DNA-A and β-DNA components respectively were amplified separately. Each gene in sense and anti-sense orientations were cloned individually in pGemT and eventually on either side of the *Gus* fragment in plasmid pKSB*Gus* to generate plasmids pKSB*Gus*CP-S-A (Fig. 6a) and pKSBGusBC4-S-A (Fig.6 b). These viral sequences cloned in sense and antisenese orientations around the stuffer fragments in above two constructs will be cloned into pBinAR for transformation in *Agrobacterium* and subsequently in cotton.

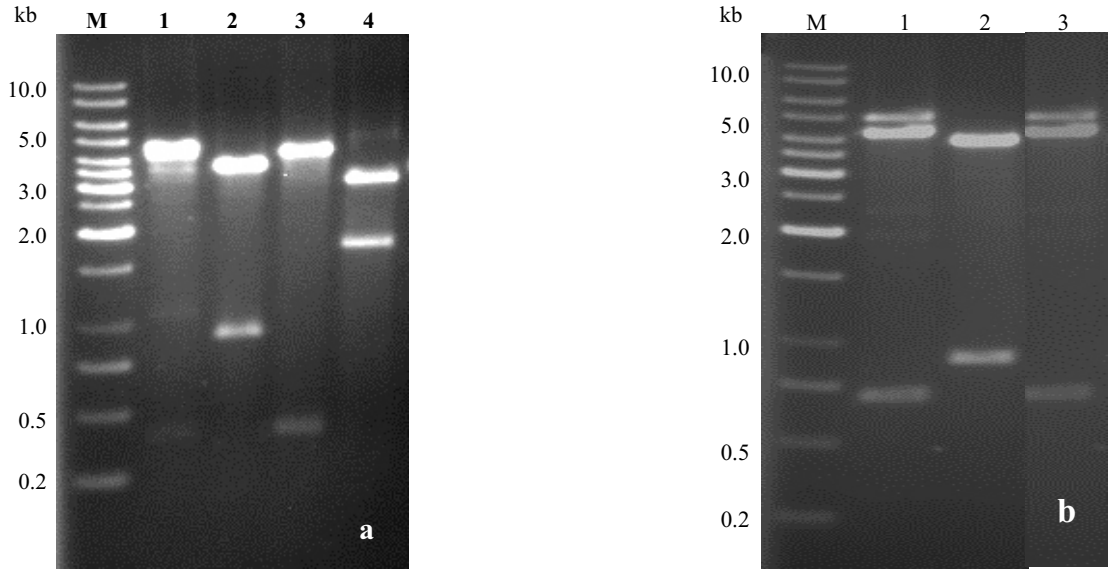


Fig. 6. Sense and antisense strands of *C4* (a) and *CP* genes (b) cloned in pKSB-Gus (3.9 kb) to generate pKS. BGusBC4-S-A (4.6 kb) and pKSBGusCP-S-A (5.4 kb). **a**: lane 1, pKBgusBC4-SA digested with *Kpn*I & *EcoR*I to release sense strand of *BC4* gene (0.37 kb), 2, digested with *Eco*RI and *Bam*HI to release *Gus* fragment (0.9 kb), 3.digested with *Bam*HI & *Xba*I to release antisense sense strand of *BC4* gene (0.37 kb) , 4, Digested with *Kpn*I & *Xba*I to release *BC4* sense +*Gus* + antisense strand (1.64 kb); **b**: lanes 1, pKSBGusCP-S-A (5.4 kb) digested with *Kpn*I & *Eco*RI to release sense strand of *CP* gene (0.76 kb); 2, digested with *Eco*RI and *Bam*HI- to release *Gus* fragment (0.9 kb); 3, digested with *Bam*HI and *Xba*I to release anti sense strand of *CP* gene (0.76 kb).

Biosafety of Bt Cotton

The advanced lines of BN-Bt underwent all the Biosafety studies. Biosafety studies were completed with large animals (Cow and Goat) as per the RCGM guidelines and the reports were submitted to RCGM and GEAC, New Delhi. The biosafety experiment of toxicity and Allergenicity study on large animal (Cow) with BN Bt was conducted at NDRI, Karnal. The results revealed that the feed intake and milk production performance of crossbred cows fed Bt and Non Bt cottonseeds @ 2 kg /day on fresh basis or about 11% of their ration on DM basis was similar during the feeding trial of 4 weeks. *Cry*1Ac proteins were neither detected in the milk nor in blood of cows fed Bt cottonseed during the four week trial and there is no effect of Bt cottonseed containing cry protein on milking cows. Hence, feeding of Bt cottonseed as a source of protein and energy in the ration of crossbred cows is safe and as nutritious as Non Bt cottonseed. Similarly, biosafety experiment on large animal sheep/lamb was conducted at Central Sheep and Wool Research Institute, Avikanagar. The results revealed that rumen fermentation characteristics *viz,* pH, TVFA and NH3-N concentrations was not influenced by feeding BT cotton seed or Non-BT-cotton seed in lamb diets. Heamatological observations did not change due to BT-cotton seed feeding compared to non-BT cottonseed. Serum IgG level did not change due to BT and non-BT cotton seed feeding. Thus, feeding of BT cottonseed to lambs did not alter immunity and allergen status and safe to use.

A biosafety trial with Bikaneri Nerma Bt in ruminants was completed and results indicated that the Bt protein did not enter into the food chain and is hence safe to human beings and animals.

Performance of *Osmanabadi* goats under feeding of Bt and Non Bt cotton leaves

Cotton crop both Bt and non Bt variety NCS145 was cultivated on two acres land each. When sufficient foliage developed was fed to experimental goats. There were three experimental groups *viz.* T_1

(experimental group fed with leaves of Bt cotton in addition to browsing) ,T_2 (experimental group fed with leaves of non Bt cotton in addition to browsing) and T_3(control group) .There were six goats in each group. The feeding continued for three months and the growth parameters like reproductive, productive, Haematological parameters and health status of *Osmanabadi* goats were studied.

Growth performance: It was observed that the live body weights of experimental goats in the group fed with Bt leaves were better than the live body weights of experimental goats in the group fed with non Bt cotton leaves. The differences amongst the three treatments were 0.786, 0.611 and 0.366 kg respectively. From this, it is evident that the feeding treatment T_1 i.e. feeding with Bt cotton leaves was superior than T_2 i.e. feeding with non Bt cotton leaves and T_3 i.e. control. The analysis of variance also indicated that the effect of feeding treatment on the live body weights, body length, heart girth i.e. chest girth, abdominal girth height at withers and width between pinbobes of experimental goats was highly significant ($P<0.01$).

Haematological studies: The blood samples of all the eighteen experimental goats were taken twice during the experimental period first prior to initiation of experimentation to know their composition and secondly after the feeding trial was over i.e. after three months. The results revealed that the total protein content (mg/dl) in the blood plasma of goats in T_1, T_2 and T_3 (control) groups were 34.03, 33.81 and 43.07 mg/dl respectively. From this it is evident that there is clear cut difference in the total protein content (mg/dl) in the blood plasma of goats. This was further supported by the analysis of variance which revealed that the effect of feeding Bt and non Bt cotton leaves on the total protein content (mg/dl) in the blood plasma of all the eighteen experimental goats was found to be significantly different ($P<0.05$). But the effect of feeding Bt and non Bt cotton leaves on the total albumin content, SGOT, SGPT, Creatinine, W.B.C count, R.B.C count, haemoblobin content and packed cell volume were found to be non significant indicating that there was no effect of feeding of Bt cotton leaves on the haematological parameters studied.

Health status: The health of all the 18 experimental goats was observed to be good throughout the experimental period. No ailments/ gastrointestinal or any other diseases were observed in case of any of the goats. No adverse/ deleterious effect of feeding Bt cotton leaves on the health of goats was observed.

Survivability: There was no mortality in any of the 3 experimental groups during the entire length of experimentation.

Nutritional parameters: The dry matter content of both Bt and non Bt cotton leaves was 20 per cent whereas, the crude protein content of Bt cotton leaves was observed to be more (19.8 per cent) and 17 per cent in non Bt cotton leaves.

4.6: Molecular Breeding

Nagpur

Diploid cotton

An interspecific F_2 mapping population involving *G. arboreum* var. KWAN-3 and *G. herbaceum* var. Jayadhar was developed. In 2007-08, the F_2 population was maintained as a ratoon crop (439 plants). Phenotyping for morphological variation on all the individual F_2 plants of the mapping population and parental genotypes was completed. Extraction of genomic DNA of parental genotypes and individual F_2 plants in the population has been completed, the genomic DNA has been purified and quantified. About 25 SSR primers have been checked for polymorphism.

Upland cotton (*Gossypium hirsutum* L.)

An intraspecific F_2 mapping population (310 F_2 plants) involving *G. hirsutum* genotypes EL 958 and UPA 57-17 was developed and maintained as a ratoon crop in 2007-08. Phenotyping for morphological variation on each individual F_2 plants of the mapping population and parental genotypes have been completed. Extraction of genomic DNA of parental genotypes and individual F_2 plants in the population has been done. The SSR primers are being employed in both diploid and tetraploid parental genotypes.

Development of permanent mapping populations (RIL's) for fibre quality traits in diploid and tetraploid cotton:

Developed F_2 mapping populations in diploid and tetraploid for fibre quality traits. In diploid, F_2 population size was 439 plants while in tetraploid 310 plants with individual single plants being selfed and

carried forward to F_3 as plant/boll to row progeny. In *G. arboreum*, 205 of the 210 plant progenies and in *G. hirsutum* 298 plant progenies would be selfed to carry forward to F_4 generation to be raised during 2008-09.

Molecular mapping of leaf curl virus resistance gene in the cotton genome

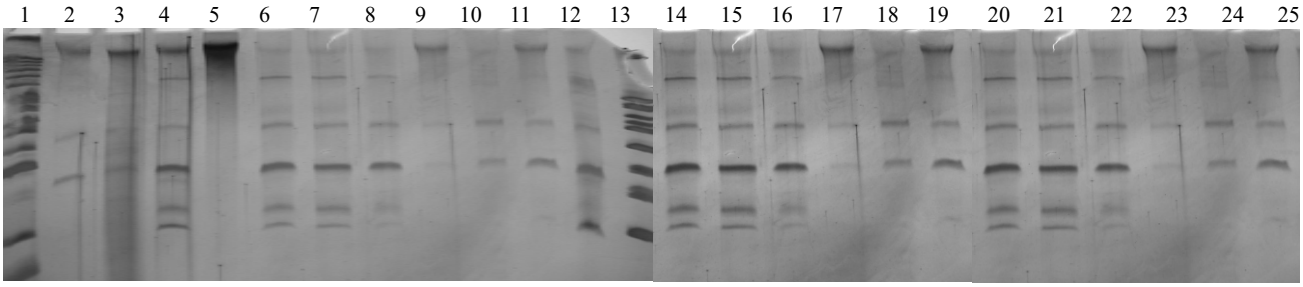
Molecular markers were identified for cotton leaf curl virus resistance in the F_2 mapping population using cotton leafcurl virus resistant line CNH 123 and susceptible line CNH 1020 by RAPD and SSR analysis. The F_2 mapping population was developed by crossing the CNH 123 (resistant line) x CNH 1020(susceptible line). Genomic DNA was isolated from the parents and F_2 mapping population. Amplification of the genomic DNA of the parents with the SSR primers could detect polymorphism for five primers out of 38 used for the parental survey. Primer JESPR 67 produced two 100bp and 150 bp fragments which were present in the susceptible and not in the resistant parent and segregated among the 25 F_2 population progenies (Fig. 7).

Molecular characterization of diversity in race 18 of X*anthomonas axonopodis* pv. *malvacearum*

Race 18 of X*anthomonas axonopodis* pv. *malvacearum* strains exhibited wide degree of variation in their aggressiveness as evident from severity of symptoms induced on same plants and their growth curve analysis. Conventional method of identification and differentiation of races using standard cotton (*Gossypium hirsutum*) differentials is not able to identify the variants (biotypes) of race 18. It is essential to document and characterize highly aggressive variants of the pathogen which can be employed to screen varieties of cotton for sustainable protection against bacterial blight.

Fifty-six race 18 isolates collected from different regions of Maharashtra and MP were subjected to molecular characterization using number of DNA markers including randomly amplified polymorphic DNA (RAPD), Insertial Sequence IS112, Enterobacterial repetitive intragenic consensus sequences (ERIC) and restriction fragmentation length polymorphism (RFLP) markers. Based on DNA fingerprinting using molecular markers, a set pattern of signatures for each race 18 variant was obtained. Cluster analysis using fingerprinting data generated by above markers revealed distinct genetic variability, based on which they were grouped in 5- 13 clusters depending upon the markers surveyed (Table 18).

Fig. 7: Electrophoretic pattern of F_2 and parental lines with JESPR 67



Lane 1:Marker, 2:CNH 123, 4:CNH 1020, 512: F2 lines, Lane 14-25: F_2 population progenies

Table 18: Cluster analysis and grouping of race 18 isolates based uponDNA fingerprinting using molecular markers

Sr.No	Markers surveyed	Groups
1	RAPD fingerprinting	8
2	IS112 element	8
3	ERIC PCR	13
4	BOX PCR	9
5	REP PCR	5
6	RFLP	7

While ERIC-PCR markers delineated highest degree of variability grouping 56 isolates in 13 clusters, Box primer grouped them in 9 clusters. RAPD and 112 markers grouped isolates in 8 clusters each, while RFLP (using pathogenicity gene as DNA probe) and Rep-PCR primer grouped 56 isolates in 7 and 5 major clusters, respectively (Fig. 8). Each cluster accommodated minimum of 2 isolates to a maximum of 21 isolates (in RFLP marker based grouping). Combined analysis of DNA fingerprinting data generated using all the six markers delineated finer genetic variation among the isolates with most of them retaining individual identity. Cluster analysis grouped only six isolates in 3 groups with two isolates in each group. Both isolates under each group showed 100% identity with remaining isolates showing genetic similarity ranging between 27 to 98 %. Based on combined analysis, 56 isolates formed 10 major clusters with genetic distances ranging between 30-67%. The markers that correlate positively with aggressiveness of the isolate will serve as biotype-specific marker.

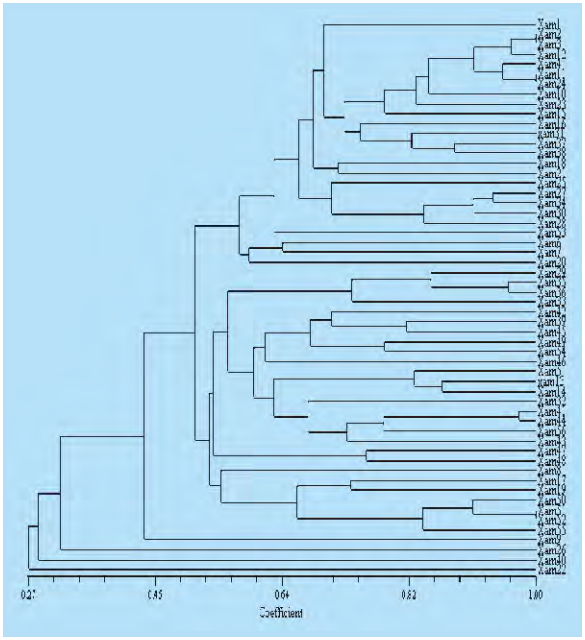


Fig.8: Dendrogram generated based on UPGMA analysis by using RAPD, IS112 element, BOX, ERIC, REP and RFLP markers of 56 isolates of *Xam*

Molecular evaluation of Diploid cotton (G. *arboreum*) using PCR based DNA markers

Diploid cotton species have wide adaptability and are relatively tolerant to biotic and abiotic stresses. *Gossypium arboreum* varieties are preferred for rainfed cultivation in low rainfall areas. Twenty four genotypes belonging to G. *arboreum* races i.e. i)Bengalense (ii)Indicum (iii) Sinense (iv)Cernuum having I/C No. 1)439625, 2)439626, 3)439627, 4)439628, 5)439629, 6)439630, 7)439631, 8)439632, 9)439633, 10)439634, 11)439635, 12)439636, 13)439637, 14)439638, 15)439639, 16)439640, 17)439641, 18)439642, 19)439643, 20)439644, 21)440886, 22)440887, 23)440888, 24)440889 were evaluated for diversity analysis by using 40 RAPD, 19 ISSR and 25 SSR markers. (Fig.9,10 and 11).

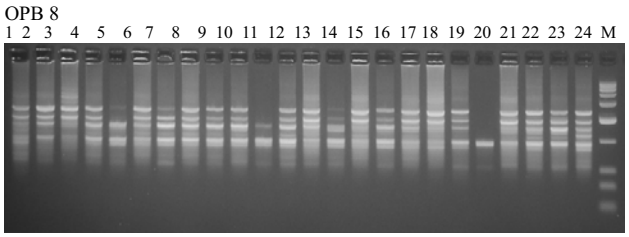


Fig. 9: RAPD profile of 24 cotton cultivars obtained with primer OPB-8, Lane 1-24 corresponds to cultivars. Lane 25, M = 3 kb ladder.

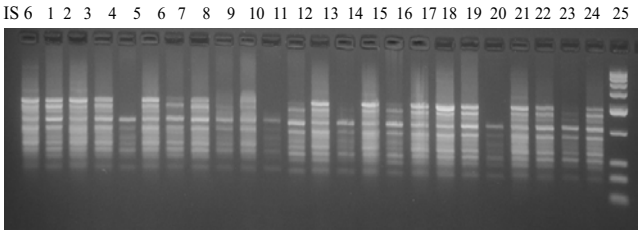


Fig. 10: ISSR profile of 24 cotton cultivars obtained with primer IS-6 Lane 1-24 corresponds to cultivars. Lane 25, M = 3 kb ladder.

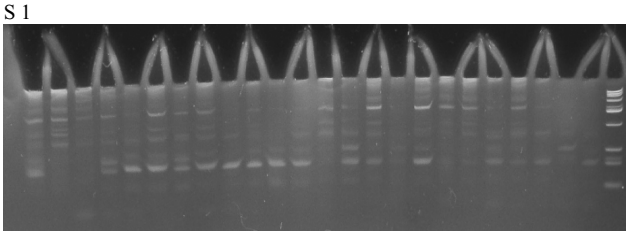


Fig. 11: SSR profile of 24 cotton cultivars obtained with primer S-1 Lane 1-24 corresponds to cultivars. Lane 25, M = 100 bp ladder.

RAPD analysis of ruling cotton cultivars

Twenty four (fifteen *G. hirsutum*, six *G. arboreum* and three *G. herbaceum*) elite cotton varieties i.e. 1)Sahana, 2)DLSa-17, 3)F1861, 4)Y-1, 5)LH1556, 6) LD694, 7)LD327, 8)DDhC-11, 9)JAYADHAR, 10)RHC-004, 11)J. Tapti, 12)JK4, 13)RS 810, 14)RS 875, 15)RS 2013, 16)HS 6, 17)H 117, 18)HD 123, 19) RARS,LAM, 20)LRA-5166, 21)K2 (MB), 22)Gcot-10, 23)SRTGMS-1, 24)BN-1 were successfully discriminated on the basis of their RAPD pattern. Thirty-six primers were amplified total 332 bands with an average of 8.97 bands per primer. Out of 332 bands, 306 were found to be polymorphic. They showed 90.52 per cent polymorphism and the average number of polymorphic bands per primer were observed 8.9 (Fig.12).

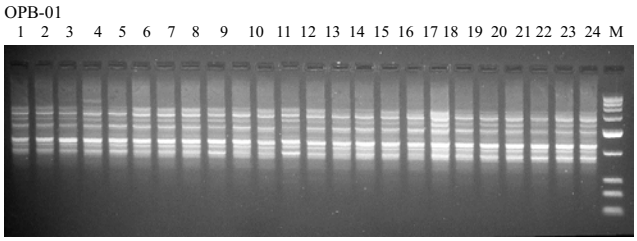


Fig.12: RAPD profile of 24 cotton cultivars obtained with primer OPB-01 Lane 1-24 corresponds to cultivars. Lane 25, M = 3 kb ladder. Arrow- Unique fragment in Lane Y-1.

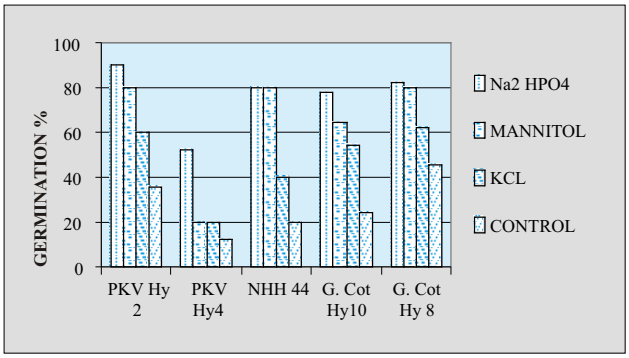
4.7: Seed Production and Seed Quality Improvement

Nagpur

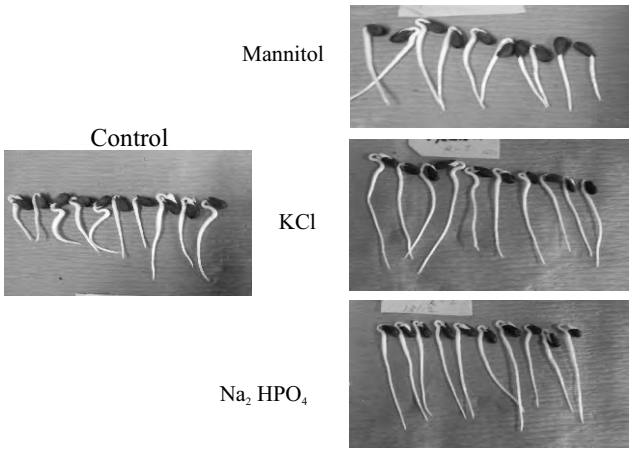
Seed vigour traits studies in cotton

Di-sodium hydrogen phosphate (0.05 %), Mannitol (2%) and KCl (2%) were found to be highly effective in increasing the rate of germination as well as imparting stress tolerance in 10% PEG stress in hybrids (Fig. 13). Associated increase in the alcohol dehydrogenase enzyme activity also confirmed the same.

Fig. 13 : Effect of seed hardening agents on germination% in hybrids



Comparison of treatments for germination in PEG in hybrid NHH_{44}



Pre sowing seed treatments for invigoration and better crop establishment

Pre sowing seed treatment of hydration (6 hrs) and drying below 25˚C followed by dry dressing with thiram @ 0.25 % showed significant improvement in seed germination.

Maintenance of Nucleus and Breeder seeds

At Coimbatore, maintenance of four varieties *viz.,* Surabhi, LRA 5166, MCU 5 VT and Suvin was taken up. Sixty progenies were evaluated in an area of 0.1 ha. Thirty five kgs of Nucleus seed was produced.

Breeder seed production

Breeder seed production of seven varieties was taken up and the production exceeded the indent (Table 19).

At Sirsa, Breeder seed production in respect of *Desi* variety CISA 310 and parents of intra-*hirsutum* hybrids CSHH 198 and CSHH 238 and *Desi* hybrid CISAA 2 were taken up.

Table 19: Breeder seed indent and production

Variety	Breeder Seed Indent (q)	Production (q)
LRA 5166	0.76	1.50
Anjali	0.01	0.50
Surabhi	0.56	2.50
Supriya	0.10	0.50
MCU 5 VT	0.50	1.50
Sumangala	0.03	0.25
Suvin	Nil	1.50

Seed quality

studies indicated that seeds produced from Akola, Parbhani, Jalgaon and Rahuri were better. As far as seed health was concerned, seeds produced from Srivilliputtur, Rahuri, Dharwad, Bharuch and Kanpur carried lesser load of fungi.

Germination percentage was (1st picking) highest in shallow soil compared to medium and deep soil. In the second picking, germination was significantly higher than other two soil depths. In the third picking, medium and deep soil had significantly higher germination percentage compared to shallow soil, former two being at par with each other.

Of the two seed lots of the species tested, *G. arboreum* had significantly superior germination percentage over *G. hirsutum* species in all the three pickings. Of the eight *G. arboreum* genotypes tested, PA 255 and PA 402 gave the highest germination percentage values as compared to remaining genotypes over all the pickings.

Fourteen varieties were stored over one year period (seed lot produced during 2006-07). It was seen that varieties of *G. arboreum* (7 varieties) group, particularly, of first picking had significantly higher storability over *G. hirsutum* group (7 varieties). This was also true in case of seedling vigour.

DUS Testing

Forty seven genotypes were characterized for different characters under DUS testing programme. These include fourteen hybrids, twenty eight parents and five varieties.

Coimbatore

Film coating of cotton seeds using polymers

Polykote @ 3 ml kg^{-1} + Thiram 75% WDP @ 2.5 g kg^{-1} + Super red @ 5 ml kg^{-1} + Cruiser 75% WP @ 5 g kg^{-1} coating improved viability from 90% to 94%. Similarly, viability improved from 90% to 93% in case of polyloc. Coating seeds either with polykote or polyloc have shown improvement in field emergence. There was no change in seed moisture content.

During the storage of coated seeds for a period of 4 months, reduction in viability was noticed in all the treatments. Coating of cotton seeds with Thiram @ 2g kg^{-1} + Gypsum @ 60g kg^{-1} + Micronutrient @ 20g kg^{-1} + Imidacloprid @ 7g kg^{-1} + DAP @ 20g kg^{-1} in five layers sequentially would significantly enhance the viability.

Establishment of genetic purity of hybrid seeds through bio molecular profile

Genetic purity testing of cotton hybrids using seed protein profile through SDS PAGE electrophoresis, indicated the presence of additional bands in hybrids. This will help to ascertain the level of genetic purity of the hybrids.

Distinctiveness, Uniformity and Stability testing of cotton genotypes

Maintenance of reference collection

Cotton seeds of 245 varieties including parental lines and hybrids were multiplied, purified and kept under reference collection. There were 82 *G. hirsutum*, 2 *G. barbadense*, 34 *G. arboreum*, 8 *G. herbaceum*, 26 parental lines of intra *hirsutum* hybrids, 5 *G. hirsutum* x *G. barbadense* hybrids, 4 intra *arboreum* hybrids and 2 *G. herbaceum* x *G. arboreum* hybrids. Morphological characters of all the genotypes were observed as per the guide lines drawn separately for tetraploid and diploid cottons.

Sirsa

Technology to enhance crop establishment and yield in cotton

The germination percentage of seeds was significantly higher in seed lots with higher seed index and medium seed index and declined in lower seed index lot in hybrid CSHH 198. The seed cotton yield, GOT, lint index and seed index were also higher in crop raised using the seeds of higher and medium level of seed index than the lower seed index. The same trend was observed in desi hybrid also.

Among various pre -sowing seed treatments, the plant stand was higher in seed lot treated with KNO_3 100 mM + imidacloprid + vitavax (86% in CSHH 198 and 84.2% in CICR 2 followed by treatment of DAP 1% + imidacloprid + vitavax (85% in CSHH 198 and 79.4% in CICR 2. The yield was also noticed higher (2950 kg/ha in CSHH 198 and 2980 kg/ha in CICR 2) in these treatments.

The per cent plant stand was significantly higher when seedlings were raised in medium type container and transplanted at seedling age of 15 days (92.9 %) and 20 days (98.8 %).

Pre sowing seed treatments for invigoration and better crop establishment

Pre sowing seed treatment of hydration (6 hrs) and drying below 25˚C followed by dry dressing with thiram @ 0.25 % showed significant improvement in seed germination.

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Suvin	Nil	1.50

4.8: Nutrient Management

Nagpur

Long term effects of fertilizer and INM (Integrated Nutrient Management) on productivity, soil fertility and quality of cotton under rainfed condition

In Bt cotton, continuous adoption (4th year) of integrated nutrient management practice (N_{60} P_{30} K_{30} S_{20} $Zn_{4.5}$ + 5 t FYM +PSB+ 2 % DAP spray) produced 18.2 q/ha of seed cotton which was significantly higher than that obtained through the application of RDF + 2 t/ha goat manure + 2 t / ha FYM (16.2 q/ha) or 15 t/ha of FYM alone (15.3 q/ha) or under farmers' practice (13.7 q/ha). Deletion of K from the recommended NPK dose significantly reduced the yield. The INM treatment also increased the yield of strip intercropped (8:2) pigeon-pea. Higher nutrient use efficiency, organic carbon and microbial population of phospho-bacteria were observed in INM and organic plots.

Efficacy of micronutrients and moisture management in improving growth, yield and fibre properties of hybrid cotton in vertisols

Studies on hybrid (NHH 44) cotton under rainfed conditions of CICR farm for four years (2004-07) on shallow soils and six years (2002-09) on medium deep soils indicated that there was no significant response to micronutrient (Zn, Mn and B) supplementation in shallow soil but medium deep soils were benefited by their application. On medium deep soils, application of 10 kg each of $ZnSO_4$ and $MnSO_4$ alongwith 3 kg Borax per ha improved seed cotton yield by 203 kg /ha (16 % higher than control). Providing 2 supplemental irrigations (at flowering and boll formation stages) alongwith the above micronutrients improved the yield by 250 kg /ha (19 % higher than control). Under irrigated conditions, shallow soils may respond to B application (@ 3 kg/'ha Borax) to the extent of 200 kg/ha (21 % higher than control).

Integrated approach for yield maximization of hybrid cotton under drip irrigation

On shallow soil, fertigation i.e. application of 50% of N120 P60 K60 through soil + 50% of N120 P60K60 through drip irrigation (fertigation) along with addition of zinc and bio-fertilizer significantly increased seed cotton yield of hybrid (NHH 44) over soil application alone.

Reddening in Bt cotton leaves was reduced by 30-40 % with foliar application of Urea @ 2% +DAP @ 2% +$MgSO_4$ @ 1% given at boll formation stage.

Synchronizing N and K supply with crop demand

At Nagpur, synchronizing the N and K supply in Bt cotton in relation to Bt cotton crop demand through the application of N and NK in 3 splits (10, 30 and 60 DAS) produced higher seed cotton yields of 24.0 q/ha and 24.5q/ha, respectively.

Synchronizing N and K supply with crop demand to enhance water and nutrient use efficiency

At Coimbatore, highest yield (3570 kg/ha) was recorded under 4 splits followed by 3 splits (3495 kg/ha), 5 splits (3463 kg/ha) and 2 splits (3120 kg/ha).There was also a progressive decrease in crop water use from 2 splits (66.2 cm) to 5 splits (63.8 cm). The increase in water use in 2 splits, 3 splits and 4 splits was 2.4, 2.5 and 1.2 cm over that in 5 splits. Consequently, highest WUE was observed in 4 splits (55 kg/ha-cm) followed by 5 splits (54.3 kg/ha-cm), 3 splits (52.7 kg/ha-cm) and 2 splits (47.1 kg/ha-cm). Thus, under the existing situation of semi arid condition, 4 splits of N only may be required for highest efficiency.

Among the fertilization techniques, application of 100 % of recommended NPK (120:60:60 kg/ha, N and K in four equal splits) with either foliar spraying of 0.15 % boron as solubor (twice) during flowering to boll development stages or magnesium sulphate @ 50 kg/ha as drip fertigation were on par with application of either 100 % of NPK with 50 kg each of zinc sulphate, magnesium sulphate and foliar spraying of boron 0.15 % as solubor or 75 % of all the above combination.

N application significantly improved the seed cotton yield of Bt cotton (RCH 2). However, there was no significant difference in the seed cotton or lint yield due to 60, 90 and 120 kg N/ha. There was significant reduction in the earliness index at higher irrigation and nitrogen levels.

There was increase in the water use efficiency due to N application @ 60 and 90 kg N/ha over no nitrogen control in Bt cotton (RCH 2) grown under irrigated conditions at Coimbatore on a vertic ustropept.

However, there was no significant difference in the water use efficiency due to 60, 90 and 120 kg N/ha. The water productivity (i.e. Rupees earned through cotton produce per m^3 of water consumed) also followed the similar trend as that of water use efficiency. N levels (60, 90 and 120 kg N/ha) did not influence the nitrogen utilization efficiency significantly. However, partial factor productivity of nitrogen (PFPN) (i.e. kg seed cotton yield per kg N applied) decreased significantly with the increase in N levels. The nitrogen use by cotton (kg N uptake/ tonne of seed cotton yield) was statistically at par for the N levels used.

Organic recycling and integrated nutrient management

At Coimbatore, an integrated plant nutrient system involving rational and appropriate use of dried neem leaves/twigs @ 5 t/ha applied as a soil cover or incorporated in the furrows along with recommended NPK (60:13:25 kg/ha) is suggested for higher production, net returns and improved physico-chemical properties of soil.

Outcome of the trials at Coimbatore, confirms that simultaneous planting of sunnhemp at the seed rate of 15 kg/ha and cotton at the normal seed rate in ridge-furrow planting, followed by burying of green manure *in situ* at 40-45 DAS (but before flowering) with 50% RD-N (30 kg) and earthing up is recommended under medium land and irrigated condition. N application can be skipped if FYM @ 5 t/ha is applied at pre-planting as maximum biological efficiency (11.6 kg dry weight/kg NPK) was observed under green manure +FYM @ 5 t/ha. Under rainfed conditions in Nagpur, application of 50% of the recommended N through organic sources and remaining N through fertilizers improved the yield and N use efficiency in Bt cotton (NCS-145) over application of 100% N through fertilizers.

Nutritional management to reduce the premature senescence in Bt cotton

The balanced fertilization package includes, application of recommended NPK with N and K in splits of either at 4,6 or 8 applications along with magnesium sulphate (50 kg as basal) and boron as solubor at 1 kg basal) combined with foliar spraying of DAP (1.5 %) + K (0.5 %) + magnesium sulphate (0.5 %) + solubor (0.15 %) twice during flowering to boll development stages.

Among the fertigation schedules tested, application of 100 per cent recommended level of fertilizer (90:45:45 kg NPK ha^{-1}) through drip recorded significantly highest (3345 kg ha^{-1}) seed cotton yield and was on par with the 125 per cent of recommended fertilizer but, significantly higher than 75% RDF (Table 20). Soil application of recommended fertilizer (3 splits) had produced (3063 kg ha^{-1}) statistically equal to the yield with fertigation of 75% RDF (3006 kg ha^{-1}). Thus, it indicates that 25 % of fertilizer saving is achieved in drip fertigation as compared to soil application of fertilizers. Economic analysis revealed that drip irrigation scheduling @ 0.8 ETc combined with fertigation of 100 per cent RDF recorded highest gross return (Rs.110623/ha), net return (Rs.70338/ha) and benefit cost ratio of 2.7

Table 20: Seed cotton yield (kg/ha) maximization techniques

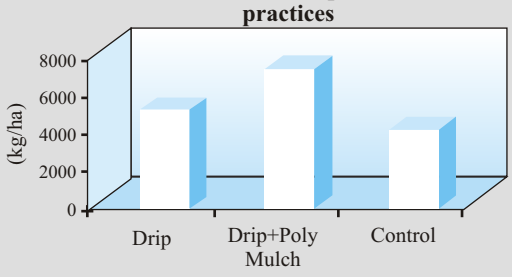
Fertilizer Levels	Seed cotton yield (kg/ha)			Water used (cm)	WUE (kg/ha-cm)	Water productivity
	I Pick	II Pick	Total			
F1.75% RDF(Fertigation)	2037	969	3006	52.7	57.0	1753
F2.100% RDF(Fertigation)	2460	885	3345	52.7	63.5	1575
F3.125% RDF(Fertigation)	2285	942	3227	52.5	61.5	1627
F1.100% RDF (Soil)	2139	924	3063	52.6	58.2	1717
SEd	102	75	111			
CD(5%)	221	NS	229			
CV(%)	11	20	9			

4.9 : Irrigation Water Management

Drip fertigation of major, secondary and micronutrients for enhancing the productivity of ELS Bt Cotton

Field experiment was conducted at Coimbatore, in factorial RBD with three water conservation techniques *viz.,* drip, drip + poly mulch and conventional irrigation along with six fertilization practices to find out the optimum water conservation method and to standardize the optimum fertilization technique for ELS Bt cotton, RCHB 708. The results revealed that the ELS Bt cotton responded significantly to poly mulch + drip and drip method. The enhancement in seed cotton yield was 27.7% due to drip and 86.5% due to drip + poly mulching .

Fig. 14 : Yield kg/ha in ELS cotton influenced by water conservation techniques & fertilisation practices



Effect of precision application of irrigation through drip on productivity and fibre quality of Bt cotton

Highest seed cotton yield of 3369 kg ha^{-1} was harvested from the plot that received irrigation through drip @ 0.8 ETc. However, surface method of irrigation @ 0.6 IW/CPE produced (3185 kg ha^{-1}) on par results with that of drip irrigation @ 0.8 Etc (Table 21).

Crop water use (Table.21) progressively increased from 0.6 ETc (38.7 cm) to 1.0 ETc (59 cm) and 0.6 IW/CPE ratio (63.3 cm). Thus, there was an average 30 % higher water use in surface irrigation applied at 0.6 IW/CPE ratio (64 cm) over the mean water use (49.3 cm) through drip. Consequently, highest WUE (in terms of kg/ha^{-cm}) was observed in 0.6 ETc (70.8) followed by 0.8 ETc (68.3), 1.0 ETc (56) and 0.6 IW/CPE (49.9), thereby indicating the highest productivity efficiency per unit water use at 0.6 and 0.8 ETc. Based on consumptive use of water, around 1464 litres of water was used per kg of seed cotton under 0.8 ETc drip (1412 litres in 0.6 ETc) in comparison to 2004 litres/kg of seed cotton in surface furrow irrigation through IW/CPE of 0.6. Thus, economizing in crop water use without impacting yield, drip irrigation scheduling at 0.8 ETc was optimum.

4.10 : Soil Moisture Conservation

Different soil moisture conservation techniques along with fertilizers were evaluated in Bt cotton (NCS 145) on a deep black soil at Nagpur. Results indicate that highest seed cotton yield as well as cotton equivalent yield was obtained through the intercropping with green gram (Fig 15). Application of 50% N of recommended dose through organic manure (FYM) +50% N through inorganic fertilizer was superior to RDF. Cotton intercropped with green gram also gave significantly higher economic yield over ridges and furrows. Seed cotton yield enhanced by about 2 q/ha by mulching with sunnhemp (over ridges and furrows practice). Higher WUE and water productivity was found under intercropping with green gram in cotton and *in situ* mulch treatments (Fig. 15).

Table 21: Water Use Efficiency (WUE) under drip and surface irrigation

Irrigation Schedule	Water used (cm)	WUE (kg/ha-cm)	Water Productivity
1. Drip 0.6ETc	38.7	72.0	1390
2. Drip 0.8 Etc	49.4	68.2	1466
3. Drip 1.0 ETc	59.0	56.0	1787
4. Surface 0.6 IW/CPE	63.3	50.3	1987

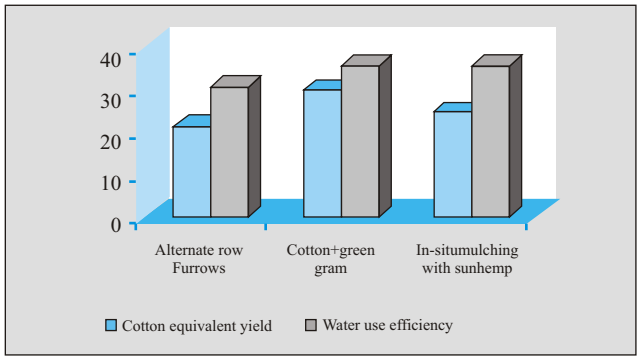


Fig. 15: Cotton equivalent yield (q/ha) and water use efficiency (kg seed cotton / ha-cm) under different soil moisture conservation measures

4.11 : Cropping Systems

Identification of innovative Bt cotton based cropping systems at Nagpur

Among the legumes, soybean offered maximum competition which significantly lowered the cotton yield. Similar to cotton + pigeon pea, cotton + cowpea /cluster bean/ radish had positive effect on seed cotton yield. There was significantly higher competition for N with cotton+ soybean, cow pea, cluster bean, and marigold. The best cropping system was Bt hybrid cotton + radish in terms of water use and nutrient uptake. Cotton + marigold, green gram or spinach were statistically similar to sole cotton yield, but offers better rural food security. The net profits were statistically similar among cotton + spinach (69%), marigold (76%), soybean (71%) and black gram (80%) as intercrop in Bt hybrid cotton. The next best group is cotton + green gram (96%), cluster bean (103%) and radish (194%) among vegetable group. The cotton plant analysis at 90 DAS indicated a significant competition for N, K in cotton with soybean and other intercrops, besides other legumes such as cowpea cluster bean.

Improving the efficiency of cotton + pigeon pea strip cropping

The pooled analysis of data indicated that cotton + pigeon pea planted in 6:2 and 12 : 2 ratio was economic and profitable for hybrid and *desi* cotton, respectively. *Desi* cotton responded favourably to plant populations beyond 28 thousand and therefore needs to be planted as close as possible. Failure to flower in 1 out of 6 years was also noticed. In hybrid cotton as well as in *desi* cotton, application of 50% RDF + Bio-fertilizers consortia (*Azotobacter, Azospirillum,* PSB, *Trichoderma viridae* and *Pseudomonas* sp as seed treatment + 2% urea/ D.A.P. + 1% Potash and micronutrient spray twice at flowering produced statistically similar yields to that of recommended dose of fertilizers.

Effects of Crop Rotation (Coimbatore)

Cotton in cotton-sorghum (pooled over 5 years) significantly out yielded (1427 kg/ha) cotton-fallow (1160 kg/ha) due to higher efficiencies in terms of nutrient use, water use and moderation of saline water effect (>3.5 EC). Besides improving efficiency of crop production, quality of seed cotton and sustainable yield index (SYI) in cotton, productivity of cotton-sorghum system was supplemented with 6547 kg/ha of grain sorghum (Table 22). Application of 90 kg N/ha (with no P & K) to sorghum also increased its grain yield by 4.2 q/ha over control (sorghum grown on residual fertility) over the years (Table 22). Based on consumptive use of water, around 4048 and 3257 litres of water were used per kg of seed cotton under cotton-fallow and cotton-sorghum, respectively. Highest WUE (30.7 kg/ha-cm) along with low water use (58.8 cm) was measured in cotton under cotton-sorghum system (24.7 kg/ha-cm and 63.6 cm respectively under cotton-fallow). In addition, highest water productivity (WP, Rs.6.86/M^3) and highest nutrient use efficiency (NUE, 17.8 kg seed cotton/kg NPK uptake) were calculated under cotton-sorghum in comparison to cotton-fallow (WP of Rs.5.52/M^3 and NUE of 13.6 kg seed cotton/kg NPK), thereby reiterating the positive effect of sorghum on cotton.

Application of INM (*viz.,* NPK@ 30:30:30+ 5t/ha of FYM added annually) followed by RDF (60:30:30 kg NPK/ha) registered significant yield increase over control during the years (Pooled data, Table 22). Although RDF (balanced NPK) was optimum under the existing condition, yet INM was better in terms of crop performance and soil fertility. Highest WUE (32.9 kg/ha-cm) along with low water use (56.5 cm) was also observed with INM practice. In addition, maximum water productivity of Rs. 7.35/M^3 was also calculated with INM practice followed by that in RDF (Rs.6.98/M^3). Yet, in case of marginal and small land holdings, RDF alone (with WUE of 31.3 kg/ha-cm and water use of 55.3 cm) was economical and was sufficient to sustain the yield.

Since productivity responses to higher levels of NPK @ 90:19:37 and 90:19:0 were similar, K application can be made once in 2-3 years depending upon crop rotation for maintenance only.

Multi-tier cropping system for Coimbatore

Three multi tier cropping systems (cotton + radish + beet root + coriander, cotton + radish + cluster bean + beetroot and cotton + coriander + vegetable cowpea+ cluster bean) were selected by consecutive experimentation of three years. Identified multi-tier systems are highly intensive one, which resulted in reduction in available nutrient status and yield reduction of base crop of cotton in some of the years.

In general, none of the systems and fertilizer levels had significantly influenced the seed cotton yield of base crop of cotton. However, systems and fertilizer levels (intercrops) had influenced significantly the intercrop yield, system productivity and profitability. Amongst the intercrops tested, coriander and cluster bean yield were significantly influenced by the systems. Fertilizer levels significantly influenced the radish and cluster bean yield. Beet root yield was influenced significantly either by system or fertilizer levels.

The highest seed cotton equivalent yield (53.2 q/ha) and gross return (Rs 1,06,435 /ha) and net return (Rs 69,386/ha) were arrived with the multi-tier intercropping of cotton with radish, beet root and coriander with the application of 100 per cent of recommended level of fertilizers to intercrops (Table 23).

Table 22: Interaction effects of cropping systems and nutrient levels on crop yield (Pooled analysis over five years)

Nutrient levels (kg/ha)	Seed cotton yield (kg/ha)			Sorghum grain yield (kg/ha)
	cotton-fallow	cotton-sorghum	Mean	
Control	1071	1313	1192	6181
RDF (60:13:25)	1246	1435	1340	6551
N (90)	1136	1456	1296	6566
NP (90:19)	1213	1446	1329	6768
NPK (90:19:37)	1176	1354	1265	6552
15 t FYM	1211	1357	1284	6712
RDF+ 5 t FYM	1126	1556	1341	6556
RDF+ 2.5 t CRI*	1100	1494	1297	6492
Mean	**1160**	**1427**	**-**	**6547**
	Crop. Sys.	**Nut. Lev.**	**Interaction**	
SE (d)	27.9	46.5	65.7	149
C.D.(0.05)	62.2	92.2	130.4	316
C.V. (%)	16.7	13.9	13.9	5.9

*Crop Residue Incorporation

Table 23: Yield, equivalent yield and economics as influenced by multi tier system and fertilizer levels

Treatments	Seed cotton yield (q/ha)	Equivalent yield (q/ha)	Gross return (Rs/ha)	Net return (Rs/ha)
T1.50%RDF(IC).+C+Co+V.C+C.b	27.4	43.8	87639	46429
T2.75%RDF(IC)+C+Co+V.C+C.b	29.1	51.7	103322	56894
T3.100%RDF(IC)+C+Co+V.C+C.b	28.6	52.9	105779	58857
T4.50% RDF(IC).+C+R+B+Co	27.3	45.8	91687	56308
T5.75% RDF(IC)+C+R+B+Co	28.6	50.3	100629	64137
T6.100% RDF(IC)+C+R+B+Co	28.4	53.2	106435	69386
T7.50% RDF(IC)+C+R+C.b+B	24.3	43.2	86334	43678
T8.75% RDF(IC)+C+R+C.b+B	26.6	53.2	106498	58200
T9.100% RDF(IC)+C+R+C.b+B	27.6	51.8	103674	56751
T10.Sole cotton	26.2	26.2	52301	27584
SEd	3.3			
CD(5%)	NS			
CV(%)	15.0			

C=Cotton, R=Radish, Co=Coriander, B=Beet root, C.b=Cluster bean,
V.C.= Vegetable Cowpea, RDF= Recommended Dose of Fertilizers

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

Double cropping system

To find out the profitable crop rotation system with Bt cotton hybrids (RCH 134 and MRC 6304) under north zone with normal sowing as well as transplanting of seedling system, six crop combinations (Cotton normal, Cotton transplanted followed by wheat, barley and mustard in both cases) were evaluated with recommended agronomic and plant protection measures. The boll per plant, dry matter and seed cotton yield were observed significantly higher in transplanted cotton crop. Among *rabi* crops, the yield/ha of barley after cotton was 38.63 quintal in normal cotton sown field and 39.41 quintal in transplanted cotton field. This in turn was slightly higher to wheat after cotton (38.13 quintal in normal cotton sown field, 38.00 quintal in transplanted cotton field) where as the yield/ha was minimum of mustard after cotton (13.50 quintal in normal cotton sown field, 12.90 quintal in transplanted cotton field). The highest net income per hectare of Rs 46935 and 51315 was observed in cotton followed by wheat with normal as well as transplanted cotton sown field, respectively where as minimum net income was observed in cotton-mustard cropping system.

***Kharif* intercropping system**

Experiments were carried out with the aim to find out the economical intercrop (cotton with groundnut, moong bean, cluster bean and sesamum) combination for this zone. The yield was higher in paired row crop without any intercrop because of higher plant population per hectare. The net return Rs. 50766 /ha and B : C ratio (3.2) was higher under paired row cotton without any intercrops followed by paired row cotton with mungbean inter crop Rs. 49920 /ha. None of the evaluated integrates were suitable.

4.12 : Planting Geometry

Growth and yield performance of Bt and non Bt cotton under poly mulching and planting techniques

At Coimbatore, though the single row and triangular planting produced higher number of harvestable bolls/plant, the enhanced boll load could not compensate the population loss as compared to double row planting . The poly mulched Bt under double row planting recorded the highest seed cotton yield of 5670 kg/ha as compared to 3330 kg/ha under non mulching. The triangular planting was on par with double row planting in terms of seed cotton equivalent yield.

Agronomy of population density in variety vs. Bt hybrid

High density planting maintained through narrow row spacing of 90 x 10 cm in cotton variety (Surabhi with 2241 kg/ha) resulted in seed cotton yield on par with Bt cotton hybrid (RCH-2 with 2554 kg/ha) at a spacing of 90 x 45 cm. Thus, comparable yields can be realized with the existing straight varieties with that of Bt hybrids. Moreover, significantly lower seed cotton yield was obtained in varieties (2043 kg/ha) with wider spacing viz., 75 x 30 cm (recommended spacing) and 60 x 15 cm (1936 kg/ha). Therefore, higher yield (and nutrient uptake) realized under narrow row planting (90 x 10 cm) depicted the role of high density planting for realizing higher yield especially in varieties.

4.13 : Agronomy for Extra Long Staple Cotton

Yield maximization trial was conducted at Coimbatore to identify packages to increase the productivity of ELS Bt hybrid. Breaking of sub soil compaction by chisel ploughing and adoption of drip system for irrigation and fertigation (low cost drip system) combined with foliar application of poly feed (19:19:19) @ 1 % at 75 and 105 DAS and multi K (13:0:46) at 90 DAS registered the highest seed cotton yield (2732 kg/ha). Chisel ploughing, foliar sprays and drip fertigation increased seed cotton yield of ELS hybrid over control by 5, 7, and 10 per cent respectively (Table 24). The least total quantity of water used (49.4 cm), and the amount of water required (liters) to produce one kg of seed cotton (1808 lit) and the highest water use efficiency (55.31 kg ha-cm) were calculated with the above said package.

Table 24: Seed cotton yield (kg/ha), economics, water use efficiency (WUE) of yield maximization techniques

Techniques	Seed cotton yield (kg/ha)	GR (Rs/ha)	NR (Rs/ha)	B/C ratio	Water used (cm)	WUE (kg/ha-cm)	W.Pdy (l/kg)
Y1.Control	2288	68640	41200	2.50	63.3	36.1	2767
Y2.Chisel	2431	72930	42275	2.38	63.3	38.4	2604
Y3.Foliar (2 sprays)	2410	72300	42750	2.45	63.3	38.1	2627
Y4.Chisel + Foliar (2 sprays)	2567	77010	44175	2.35	63.3	40.6	2466
Y5.Chisel + Drip	2646	79380	43150	2.19	49.4	53.6	1867
Y6.Chisel + Drip + Foliar (2 sprays)	2675	80250	42375	2.12	49.4	54.1	1847
Y7.Chisel + Drip + Foliar (3 sprays)	2732	81960	43050	2.11	49.4	55.3	1808
SEd	165						
CD(5%)	359						
CV(%)	8						

Water Management of ELS Bt Cotton

Field experiment was conducted during Winter 2007 - 08 to find out the response of ELS Bt cotton, RCHB 708 under drip, poly mulching and drip + poly mulching as compared to conventional irrigation. The highly conducive growth environment under poly ethylene mulching and poly mulch + drip system has resulted in significant increase in harvestable bolls contributing significantly to higher seed cotton yield ranging from 37.6 to 59.1 per cent higher yield than conventional method (Table 25). The yield enhancement due to drip system was 8.16 21.6 % higher than conventional method. The poly ethylene mulch + drip at 0.4 Etc recorded 30.9% higher seed cotton yield than drip at 0.8 Etc without poly ethylene mulching. Among the treatments, poly mulch + drip at 0.4 Etc was on par with poly mulch + drip at 0.8 Etc and found significantly superior to rest of the treatments.

Table 25: Yield attributes, seed cotton yield, water requirement and water use efficiency of RCHB 708 Bt as influenced by drip, poly mulching and drip + poly mulching

Treatments	Bolls/ plant	Boll wt (g/boll)	Seed cotton yield (kg/ha)	WR*	WUE
T1- Control	58.3	4.93	3825	77.54	49.4
T2 - Poly mulching	71.2	5.34	5262	45.54	115.6
T3 - 0.4 Etc (Drip)	59.8	5.41	4137	37.60	110.0
T4 - 0.4 Etc (Drip) + PM	77.4	5.60	6087	37.60	161.9
T5- 0.8 Etc (Drip)	64.3	5.29	4650	40.58	114.6
T6 - 0.8 Etc (Drip) + PM	72.8	5.47	5637	40.58	138.9
CD (P=0.05)	11.7	NS	551		

WR*includes 25. 54 cm of effective rainfall

The cropping season witnessed a heavy effective rainfall of 25.54 cm and the total water requirement ranged from 37.60 to 77.54 ha cm for various treatments. Poly mulched cotton with or without drip recorded higher water use efficiency than drip alone without poly mulching. Among the treatments, drip at 0.4 Etc + polyethylene mulching recorded the highest water use efficiency of 161.9 kg seed cotton /ha-cm in RCHB 708 Bt as against 114.6 kg seed cotton/ha-cm at drip at 0.8 Etc without poly ethylene mulching. The lowest water use efficiency of 49.4 kg/ ha-cm has been recorded under conventional method.

4.14 : Soil Depth

Seed yield and quality in released *G. hirsutum* and *G. arboreum* cultivars in relation to soil depths at Nagpur

Growth responses of *G. arboreum* (CINA 2, CINA 316, PA 255, PA 402) and *G. hirsutum* cultivars (PKV 081, PKV 8828, NH 615, NCS 145) were studied in relation to shallow, medium and deep soils. *G. hirsutum* cultivars possessed more number of squares per plant in all the soil types. In both diploid and tetraploid cotton, distribution of biomass into root, stem and fruiting parts remained higher under shallow soil growing condition, whereas leaf biomass was higher in cultivars grown in medium soil.

4.15 : Soil Microbiology

Effect of Bt cotton production technologies on soil microbial population

Rhizosphere soils were analyzed for the microbiological properties under the experiment "Long term effect of fertilizers and INM on productivity, soil fertility and quality of cotton". Higher microbial population (general) was observed in the treatment

(N_{90}:P_{45}:K_{45}:S_{20}:Zn_{20}) followed the treatment (N_{60}:P_{30}:K_{30}:S_{20}:Zn_{20} and FYM 5T). Under the physiological groups of microbes, higher population was recorded with the treatment of INM all the years.

Analysis of soil microbial population between Bt and Non Bt Bunny cotton revealed no significant differences with regard to microbial population between Bt and Non Bt cotton, but higher microbial population was recorded in Qrganic blocks which acted as absolute control in the experiment (Fig. 16).

4.16 : Cotton Simulation Modelling

The validation of the generic simulation model

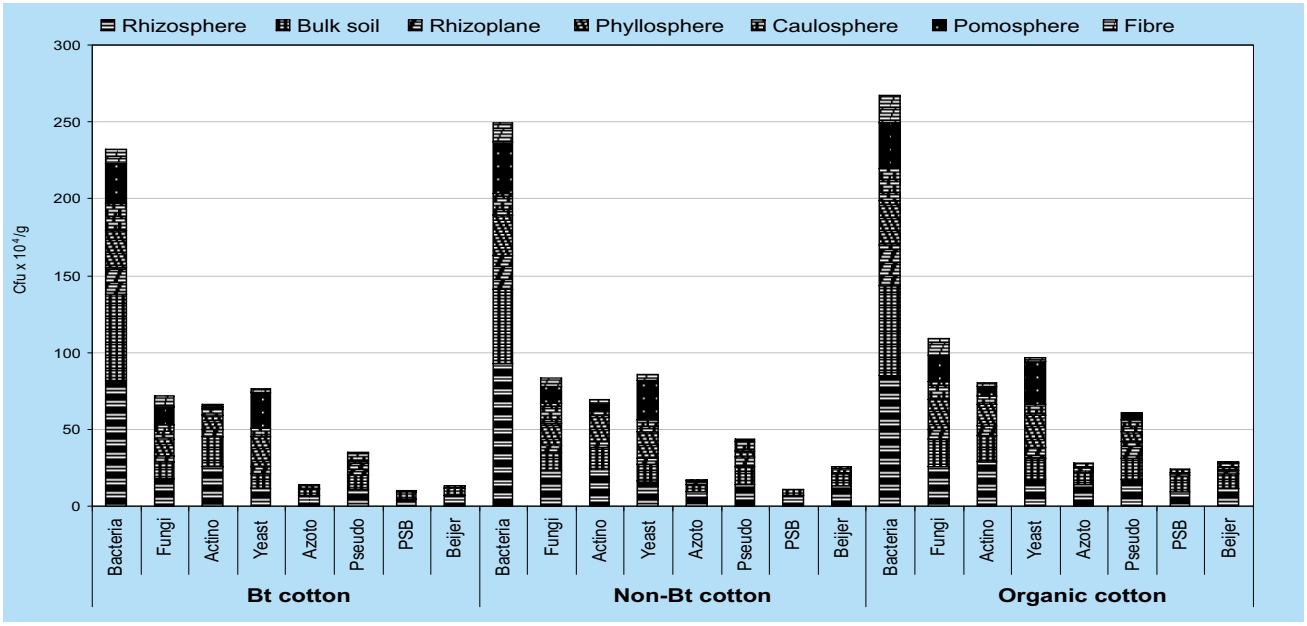


Fig. 16: Rhizosphere microbiology of Bt, Non Bt and organic cotton

Table 26: Observed and simulated seed cotton yield of RCH 2 Bt cotton under varied irrigation and nitrogen levels (Pooled over 2006-07 and 2007-08)

Treatment	Observed seed cotton yield (kg/ha)	Simulated seed cotton yield (kg/ha)	Deviation (%)
Irrigation			
Control (Protective irrigation)	2158	1906	-11.7
0.6 IW/CPE	2056	1970	-4.2
0.8 IW/CPE	1980	1968	-0.6
1.0 IW/CPE	2103	1961	-6.7
Nitrogen			
Control	1819	1866	+2.6
60 kg N/ha	2087	1960	-6.1
90 kg N/ha	2203	1980	-10.1
120 kg N/ha	2188	1998	-8.7
#RMSE = 257 (12.4%); D = 0.492; MSEs = 588685; MSEu = 7458			

(RMSE = root mean square error; D = index of agreement; MSEs = Mean systematic error and MSEu = mean unsystematic error)

INFOCROP showed that the root mean square error between the observed and simulated yield was 257.1, which was 12.4% of the mean observed seed cotton yield (Table 26). However, the model under-predicted seed cotton yield at higher N levels, warranting further fine tuning. The index of agreement (D index) between the observed and simulated seed cotton yield was 0.492.

4.17 : Cotton Mechanisation

Development of small farm equipment for cotton farmers Improved bullock drawn implements were developed for increased efficiency for the small and marginal cotton farmers.

Bullock drawn vertical rotor precision planter

A bullock drawn precision planter with an innovative vertical rotor metering mechanism having the advantages of reduced seed damage and uniform seed placement was developed. This was tested at CICR farm and the results revealed that the average depth of seed placement was 6 cm, the seed rate was 5.2 kg/ha, field germination percentage was 84 per cent and the field capacity was 4.5 hours / ha.

Iron plough with sowing attachment For primary tillage operation of ploughing and sowing of rabi crops like gram.

Ridger For making ridges in between the rows in standing crop of cotton for enhanced soil moisture conservation and also act as a channel for irrigation. It can also create ridges and furrows before sowing.

Iron Plough

Adjustable hoe

Ridger

Bund former

Adjustable hoe For interculture operation in cotton based cropping systems. Various sizes of blades (9", 12" & 18") can be accommodated in a frame, with quick coupling and decoupling.

Bund former For making bunds in the fields to facilitate easy surface irrigation

Identification of suitable genotypes for mechanical picking

Four genotypes namely, PKV 08, Khandwa 2, G Cot 16, and NH 452 at three spacings 90x10, 90x20 and 90x30 cm were planted to study the effect of closer spacing on plant characteristics affecting mechanical picking. Among them G. Cot 16 was found to be most compact and suitable genotype amenable to mechanical picking.

Evaluation of different defoliants for their suitability to mechanical picking of cotton

Three defoliants namely Dropp (Thiadizuron) (50 % WP), Roundup (41 % SL) and Ethrel (39 % SL) were applied at 1% concentration (5000 ppm) over varieties PKV 08, Khandwa 2, G Cot 16, and NH 452 with three different spacings 90x10, 90x20 and 90x30 cm. The results indicated that defoliation in variety Khandwa 2 was the highest (78 per cent) and was significantly superior over all other varieties which were in turn at par with each other. Various spacings used did not show any significant difference among them in respect of per cent defoliation.

Among the different defoliants tested, Ethrel showed maximum per cent of defoliation (73%) which was statistically at par with Dropp (71%). Defoliant D2 (Round up) recorded lesser level of defoliation (60%). The variety x defoliant and variety x spacing x

defoliant effects were significant. Maximum per cent of defoliation was observed in the variety Khandwa 2 by using defoliant Dropp followed by using defoliant Ethrel in same variety. Maximum per cent defoliation was recorded in the variety Khandwa 2 in the spacing 90x10 cm and 90x30 cm by using defoliant Dropp.

On Farm Trials for improvement of productivity and quality of Bt cotton at village level in Sirsa and Hanumangarh Districts

The studies were undertaken in two villages each in Sirsa district of Haryana (Aleekan and Burj bhangu) and Hanumangarh district of Rajasthan (Sherekhan and Salemgarh masani). An area of around 400 ha was covered in the study with one hundred and seventy eight farmers where select higher yielding and better quality Bt cotton hybrids were promoted along with available technological back up. The farmers were trained on integrated nutrient management and integrated pest management aspects along with quality of cotton. The area covered by three prescribed Bt cotton hybrids (RCH-134; MRC-6304; NCS-913) significantly increased during 2007-08. In general, the illegal Bt hybrids showed poor yields when compared to legal ones and hence farmers were urged to discourage such hybrids. The prescribed Bt hybrids of project farmers showed 7.22 to 8.12 q/ha higher seed cotton yield as compared to varieties in Rajasthan and 5.0 to 5.1 q/ha more seed cotton yield in Haryana during the 2007-08 season. The requirement of spray was less in Bt cotton as compared to non Bt cotton varieties. The farmers were educated about the importance of cotton leaf curl virus disease in reducing yield and it was demonstrated that illegal Bt cotton hybrid and non-descript cotton varieties showed higher leaf curl virus disease incidence and thereby led to lower production. The role of quality was highlighted. The overall poor quality characteristics and lesser price for the illegal Bt hybrids and non-descript varieties were explained. The average yield increase over varieties in case of Bt hybrids in both the states came to 636 kg/ha. Keeping the price of seed cotton at Rs 2500/- per quintal during the season, the net monetary gain out of the project came to Rs. 63 lakhs in addition to long term benefits in terms of technological dissemination.

4.18 : Morphoframe / Boll Load Management

Nagpur

Physiological manipulation of Bt plant morphoframe for enhanced productivity under varied agroclimatic conditions

In a rainfed field experiment at Nagpur, MECH 184 Bt, Bunny Bt and NHH 44 were given foliar sprays of plant growth regulators and nutrients during flowering. The treatments consisted of control, water spray, Gibberellic acid 100 ppm, Kinetin 50 ppm, Naphthalene acetic acid 0.45ml /l, Urea 2%, Single super phosphate and Muriate of potash (1%). .

The treatments both plant growth regulators and nutrients particularly Gibberellic acid, Muriate of potash and Urea given as foliar spray during flowering showed a tendency to decrease leaf reddening in all the three cultivars. Urea as 2% spray significantly increased number of green bolls in the Bt cultivars. However, the treatment effects on seed-yield realization remained non-significant.

At Coimbatore, the genotypes utilized for the experiments are Bunny Bt and Non Bt, Mallika Bt and Non Bt, JKCH 99 Bt and NCS 138 Bt. The treatments were control, Ethrel @ 5.7 & 8.56 mM foliar spray and mechanical removal of squares on the day of foliar spray. There was a significant difference between control and plants treated with Ethrel @ 5.7 and 8.56 mM in NR activity, root and shoot growth, LAI and other parameters. It has been now identified that application of ethylene in the form of ethrel was found to be suitable to bring about a change in crop ideotype that will help in enhancing the yield by 30-40% over the control.

Sirsa

The effect of 500 ppm, 650 ppm and 800 ppm concentration of defoliant (ethrel) was evaluated at Sirsa on the crop of Bt. hybrids RCH-134 and MRC-6301. The yield/plant was higher when defoliant was sprayed at 145 DAS with 800 ppm concentration in both the hybrids.

4.19 : Studies on Abiotic Stress

Heat and drought

Cultivar LRA 5166 was grown under high temperature and low humidity during summer season (2007) in China pots and drought treatment was inducted during flowering. The leaf temperature remained higher-approaching 41.9 ^{0}C and the relative humidity was 30%. The study revealed that dry matter distribution in root and leaves remained lower in stressed plants. Water stress induction under high temperature markedly increased stomatal resistance and decreased the leaf relative water content by 24.5 per cent. During the period of recovery from drought, the relative water content increased in the stressed plants and the difference narrowed down to 5.9 per cent between control and water stress treatments.

13 genotypes *viz.*, LRA 5166, NHH 44, CAT 3640, CAT 3845, CAT 3874, CAT 1911, CAT 3719, CAT 379, Bunny and Bunny bt (*G. hirsutum*), AC 7602, AC 6755, AKA 8401 (*G. arboreum*) were sown in pots during March, 2008. Water stress was inducted during seedling stage to study the growth and leaf relative water content responses of the genotypes under high temperature and low relative humidity environment. The study showed that imposition of water stress at high temperature decreased root and leaf growth at seedling stage. There was not marked difference in shoot growth between the treatments. Leaf relative water content declined under water stress condition (78.6% in water stressed plants as against 84.4% in control -mean over 13 genotypes). Dry matter distribution in roots during seedling stage remained markedly higher due to water stress under higher temperature environment.

Screening of cotton genotypes for drought tolerance

11 cotton genotypes *viz.*, LRA 5166, NHH 44, CAT 3640, CAT 3845, CAT 3874, CAT 1911, CAT 3719, CAT 379 (*G. hirsutum*), AC 7602, AC 6755, AKA 8401 (*G. arboreum*) were grown in pots and water stress was inducted at flowering during the main season. The genotypes with relatively better drought tolerance traits were identified.

Morpho physiological and biochemical trends indicated that leaf water potential was maintained significantly higher in *G. hirsutum* genotypes both in control and stressed plants as compared to *G. arboreum* genotypes. Among the genotypes, CAT 3640 recorded relatively higher leaf water potential under water stress condition. Higher leaf solute concentration was noticed in *G. arboreum* genotypes indicating a trend towards higher osmotic adjustment during water stress condition. It remained relatively higher in AC 6755 (*G. arboreum*). With regard to stomatal traits, stomatal resistance significantly increased due to water stress particularly in *G. hirsutum* genotypes which may facilitate dehydration avoidance of leaf water status during the stress period. Transpiration rate decreased due to water stress and it remained relatively higher in control plants of *G. hirsutum* genotypes. Nitrate reductase activity was maintained higher in CAT 3719, CAT 379 (*G. hirsutum*) and AC 7602 (*G. arboreum*) during water stress.

Total biomass production however decreased due to water stress. Among the genotypes, it remained higher in genotypes CAT 3874 (*G. hirsutum*) and AC 6755 (*G. arboreum*). Biomass distribution trends indicated that root and shoot biomass production increased while it was decreased due to water stress in the leaf and fruiting parts. Among the components, the dry matter distribution in stem remained markedly higher in control and water stressed treatments in genotypes belonging to both the species. During recovery, stressed plants tended to increase biomass production in the vegetative parts. Root-shoot ratio increased under drought stress and the ratio did not show any marked difference among genotypes in both the species under stress induction and during recovery status. Water stress inducted during flowering decreased seed-cotton yield and it was more prominent in diploid cotton genotypes whereas *G. hirsutum* genotypes mostly showed yield stability.

Biochemical studies on abiotic stresses with particular reference to heat and drought in cotton, Nitrate reductase activity was estimated at 90 DAS in leaf samples of cotton genotypes (14 *G. hirsutum* and 5 *G. arboreum* lines) under control and moisture stress conditions. Nitrate reductase activity has been found to increase during stress in only four genotypes.

Water-logging

Seven Bt cotton hybrids *viz.,* RCHB 708, Mallika, RCH 20, RCH 2, Bunny, MECH and MRC 6918 were raised in the field. As a result of water logging, plant

growth in terms of plant height was significantly affected from 60th day and continued up to 90th day and there after the growth was faster attaining the same height to that of control. Reproductive parts like squares and flowers were either delayed or reduced as a result of water logging. For instance, on 90th day, total reproductive parts were 34 in control plants compared to 20 in water logged plants irrespective of the Bt cotton tried.

Similarly, water logging retarded the production of leaves until 90 days of sowing. Among the Bt hybrids, the maximum production of leaves was noticeable at 120 days after sowing. RCHB 708, Mallika and MRC 6918 put forth the highest number of leaves with 120 leaves in control compared to 106 leaves in control with senescence occurring thereafter. RCHB -708 and MRC 6918 produced the maximum leaf of 120 under normal condition compared to 106 as recorded on 120th day. Irrespective of the Bt cotton hybrid, water logging, in general, affected the leaf production significantly at all stages.

Boll number was significantly influenced by water logging. Control plants recorded 25 bolls per plant compared to 20 bolls in plants that suffered water logging irrespective of the Bt cotton (Table 27). Among the Bt cotton, RCHB 708 and Mallika recorded the maximum boll number per plant followed by MRC 6918. Significant reduction was evident in water logging with an average boll weight of 5.22 g/ boll due to water logging, while the control plants recorded 5.47 g/ boll.

About 24 % decline in yield was obvious due to water logging irrespective of the genotypes studied. Among the Bt hybrids, maximum yield was observed in MRC 6918 followed by RCH 20,Bunny, RCHB 708, MECH and RCH 2. Water logging at 30 days after sowing brought down the yield significantly depending on the Bt cotton hybrid. Bunny and RCHB 708 appeared to be more tolerant. The other hybrids like MECH, MRC 6918 and RCH 20 were moderately tolerant.

Hoagland nutrient solution which contains all the major secondary and micro nutrients were sprayed as foliar spray in various dilutions 10 days after water logging. Biochemical estimations were done 20 days later. Chlorophyll content in the leaves declined significantly in all he treatments under water logging

Table 27: Effect of water logging on boll number, weight and yield

Bt Cotton	Treatment	Boll number	Boll weight (g)	Yield per plant (g)
RCH 708	Control Water log	32 25	3.95 3.55	126.4 88.7
Mallika	Control Water log	22 19	6.04 5.74	132.8 109.0
RCH 20	Control Water log	24 19	6.21 5.97	149.0 113.4
RCH 2	Control Water log	22 15	5.09 4.91	11.9 74.8
Bunny	Control Water log	23 20	6.10 5.91	140.9 118.2
MECH	Control Water log	22 18	5.73 5.53	126.0 99.5
MRC 6918	Control Water log	29 23	5.40 5.22	156.0 120.0
Mean	Control Water log	25 20	5.47 5.22	132.2 100.8
C.D. (5%)	3	0.24	18.2	

treatment. Among the treatments, DAP 1% + 1% KCl spray could maintain better status chlorophyll in both control and waterlogged situation followed by DAP2% and Hoagland solution of full strength (Table 28). Nitrate reductase activity also followed the same trend to that of chlorophyll with significant decline in the enzyme activity after 20 days under water logged situation. Activity of Nitrate reductase was better where foliar sprays of DAP 1% + 1 % KCl, DAP 2% and Hoagland solution of full strength was sprayed. Photosynthetic rate was significantly affected by water logging with about 50% reduction in photosynthetic rate by 20th day of water logging with gradual recovery soon after withdrawal of water logging. None of the nutrient spray could bring about significant improvement in photosynthetic rate (Table 28).

Table 28: Foliar application of nutrients on chlorophyll content, Ps rate and NR activity under water logged conditions

Treatment		Chlorophyll (mg/g fresh wt)	NR activity (µmol NO_2/g/h^{-1})	Ps rate (µmol CO_2/m^{-2} s^{-1})
Hoagland 25%	Control WL	3.23 2.85	4.84 3.12	20.17 5.68
Hoagland 50%	Control WL	3.25 2.84	4.93 3.41	22.60 6.82
Hoagland 100%	Control WL	3.34 3.10	4.83 3.55	21.08 6.88
DAP 2%	Control WL	3.35 3.06	4.91 3.53	21.94 7.25
DAP 1% + 1% KCl	Control WL	3.44 3.19	5.11 3.62	21.64 7.80
Water Spray	Control WL	3.13 2.82	4.84 3.18	21.0 6.58
C.D. (5%)	0.22	0.33	2.15	

Chlorophyll content in the leaves started declining gradually after the onset of water logging in all the hybrids studied. For instance, Bunny cotton the chlorophyll content started declining from 3.33 to 2.66 mg/g by 20th day.

Similarly, nitrate reductase activity started declining gradually from 4.82 to 4.00 µ mol after 15 days of water logging. However, the decrease was at a faster rate after this period with 2.82 µ mol by 20th day. Among the Bt cotton, Bunny exhibited comparatively higher activity of nitrate reductase than other Bt cottons.

During the recovery period (after water logging), the nitrate reductase activity was more in water logged plants compared to control plants irrespective of the hybrids. Among the Bt hybrids, Bunny had better activity of 4.52 µ mol in control plant and water logged plants during the recovery period recorded 4.89 µ mol. Photosynthetic rate also followed the same trend with activity being higher in plants recovering from the water logged situation and the differences were statistically significant.

4.20 : Fibre Development

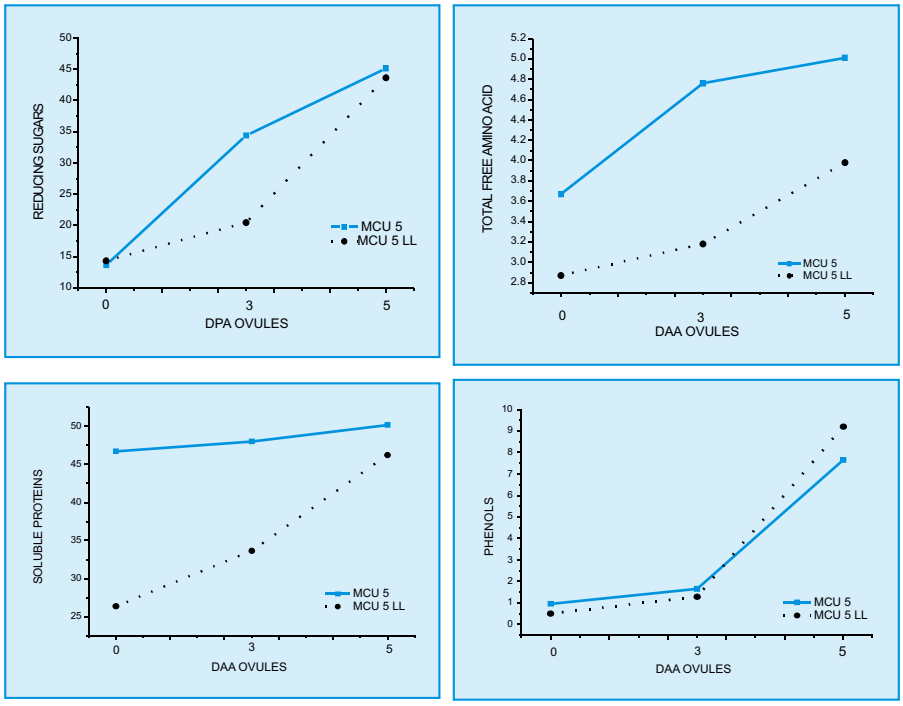
Physiological, biochemical and molecular elucidation of fibre development process in cotton for enhancing fibre yield

Biochemical analysis of the ovules of genotype MCU 5 and its lintless mutant MCU 5LL revealed that reducing sugar content showed a steep increase from anthesis in MCU 5 ovules and the content increased till 10 DPA. It was 13.67 mg.g^{-1}FW at anthesis and reached

34.41 and 45.15 mg.g^{-1}FW on 5th and 10th DPA. In contrast, the ovules of MCU 5 LL showed a slow start till 5 DPA (20.45 mg.g^{-1}FW) then increased to 43.66 mg.g^{-1}FW by 10 DPA (Fig.17). Similarly, the total free amino acid and phenol content was less in the initial stages in MCU 5 LL ovules. While there was no marked variation among the two genotypes in the amount of proline accumulated. These solutes are the important factor for creating positive turgor for fiber cell protrusion.

Genomic DNA extracted from 5 day old ovules was utilized for the RAPD analysis of cotton genotypes-MCU 5 and its mutant MCU 5LL. One hundred oligo-primers were tested for its amplification. Most of them failed to amplify in both the species. Among them twenty primers which showed good expression in the preliminary experiments was selected for further standardization. The amplified products of the primer 3` GAGAGGCTCC 5` gave two additional bands of the size of 2040(± 10) bp and 630 (± 10) bp and a band sized 1160 (± 10) bp with the primer 3`TCCGTGCTGA 5 ,in the MCU 5 and which are lacking in the MCU 5LL . All the other 18 primers gave similar banding pattern and 100 % polymorphism among the mutants.

Fig. 17: Differential accumulation of biochemical constituents in MCU 5 & MCU 5 LL ovules at 0-5 DAA



4.21 : Seed Oil

Seed oil content in Bt cotton hybrids

Oil content in 5 Bt and its corresponding non Bt hybrid was found to be in the range 18-23%. However, there was narrow difference in the oil content of non-Bt and respective Bt hybrids.

Name of hybrid	Per cent oil content	
	Bt	Non- Bt
RCH 2	20.8	21.4
KDCHH 441	22.6	20.7
NCEH - 2R	19.7	19.3
JK Varun	21.8	20.2
Bunny	18.3	20.4

4.22 : Socio Economic Dimensions of Cotton Farming

Accessibility to Mass Media and Information Technology of Potential Users in Cotton Based Production System

Information was collected from 250 randomly selected farmers comprising of progressive, less progressive and backward villages from Nagpur and Wardha district in Vidharbha region of Maharashtra and analysed with respect of access to and use of modern Mass Media i.e. Electronic Media-Radio & Television, Print Media-Newspaper and farm magazines and Information Technologies-Internet, cellular/mobile phones, etc by various categories of farmers. Study revealed that 49 per cent progressive farmers regularly used newspapers like Lokmat, Navbharat, Lokmat Samachar and Sakal for getting information on cotton. Majority (56 & 46 per cent) of the progressive farmer respondents listen to agriculture related programmes, especially on cotton crop 'regularly' from radio and watch TV programmes, respectively. The viewers were also influenced by ETV programme 'Annadata' as 28 per cent progressive farmers watched 'regularly' the use of pesticide, organic cultivation, market information and price trend whenever transmitted from the channel. Overall, the utilization of mass media such as newspapers, printed literature, radio, television and cell phone was comparatively higher i.e. 42.3, 17.0, 49. 7, 44.0 and 42. 7 per cent in progressive villages, respectively, as compared to less progressive and backward villages. Though most of the farmers were not subscriber of newspapers at their own, they read cotton related information at Grampanchayat or shops or restaurant in the villages. However, the overall utilization of various mass media was very poor among villagers irrespective of their status. The farmers who utilized various media were not so satisfied with the coverage, content and timeliness. The utilization of Kisan Call Centre by the villagers was not to the expectation. The extension workers and media personnel should therefore disseminate up to date information through these media regularly to speed up the process of adoption of cotton related innovations.

Social dynamics of cotton production in distress areas

The study was conducted in two highly suicide prone districts of Wardha and Yeotmal in Vidarbha region of Maharashtra. A sample of 200 farmers having land holding up to 2 ha and more than 2 ha from 40 randomly identified villages and where comparatively larger number of suicides occurred were selected. The data was analyzed for sub-construct powerlessness, meaninglessness, isolation and self-estrangement of alienation from land. The data reveals that a very high percentage of respondents 85, 57 and 81 respectively fall under the score medium to high degree between scores 33.34 to 66.66 and 66.67 in case of powerlessness, meaningless and isolation, while majority of 58.5 per cent exists in self-estrangement of high degree level (66.67 and above). The high level of alienation arises because of farmers' perception that they can neither control the market forces and nor can influence the farm policies of government. The social dynamic indicators show large percentage (72.5%) under rainfed land holding, more than half (51.5%) proportion had low annual income up to Rs. 25,000/- only. Expenditure on events per annum was more than the net income. Three-forth of respondents (76.5%) have single cropping patterns and there is migration of one- fourth respondents in search of job to various places. Since the net return in cotton farming is very less due to increased cost of production, 91% borrowed loan. The possible causes and issues of agrarian distress as reported by the respondent farmers were high costs and low returns, deteriorating financial condition, lack of contingent support from Govt. agency, deterioration in quality of life, fall in social and economic status, crop failures and alcoholism.

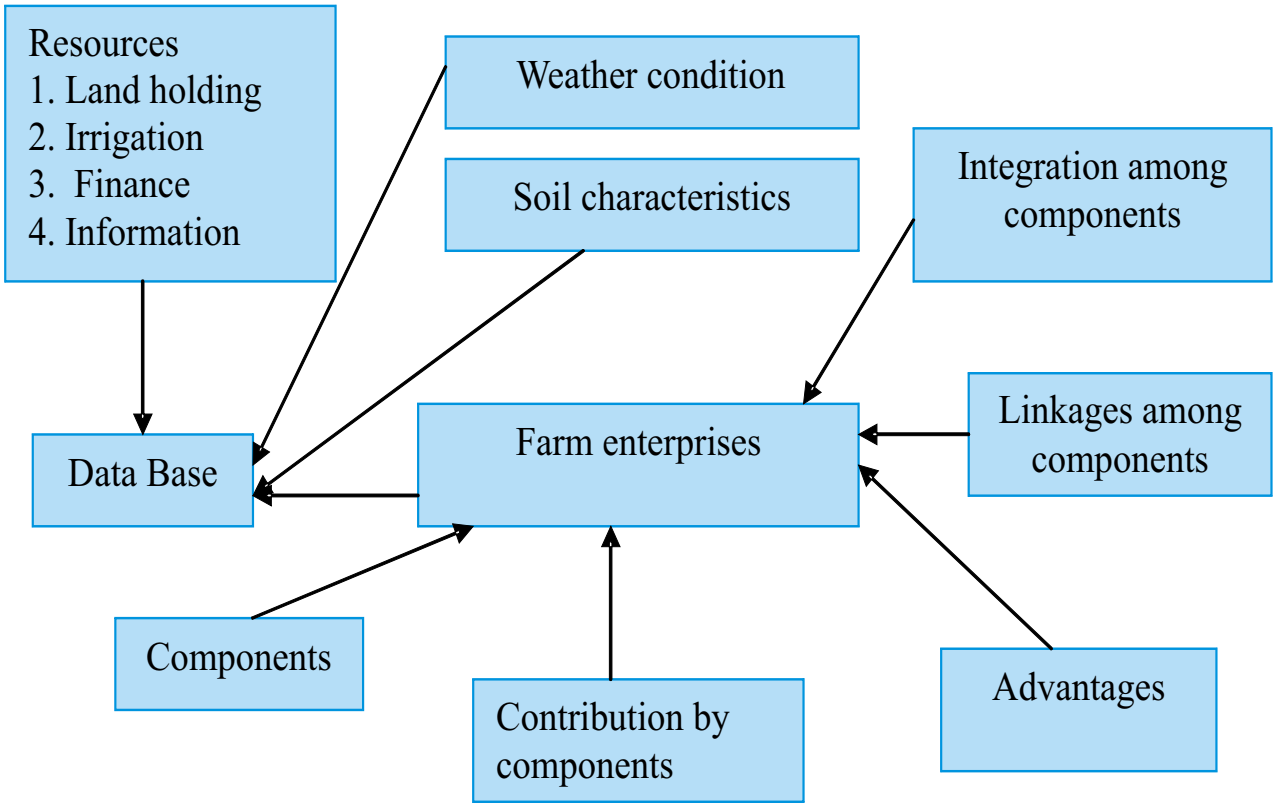
Gender role in Cotton - Role of Women in Cotton Based Cropping Systems

Expost facto research design with simple random sampling was followed using survey methodologies for data collection. Data were collected from 60 cotton farmers in Erode district of Tamil Nadu and 60 cotton farmers from Coimbatore district of Tamil Nadu. More than 60 per cent of the cotton growers perceived that the major activities performed by the farmwomen in cotton are stubble removal, sowing, gap filling, intercropping, thinning, weeding, fetching water for pesticide application, de-topping, labour supervision, harvesting of crop and intercrop and cotton grading. More than 70 per cent of the cotton growers perceived that a high share of waged work was provided by

women at peak times namely at weeding and harvesting. According to 82% of them, the major farm activities which cause health hazards are weeding, mixing concentrated chemicals with water and filling spray tanks, mixing and subsequently working in the fields, working in a recently sprayed field and applying pesticides was opened by 73%. Farm women in cotton based production systems have employment for four months in a year. Hence, they suggested that viable value added agriculture and processes need to be promoted in cotton farming and possibilities of identifying the shift in cropping pattern or crop diversification may be proposed to provide employment opportunities to the farm women through out the year. Majority of the farmers suggested that the technology transfer activities related to post harvest and processing practices need to be given special focus so as to motivate and build the capacity of farm women into value added agriculture.

Documentation and Validation of Farmers' Indigenous Knowledge on Farming System Approaches (FSA) in Cotton

During the year, Rapid Rural Appraisal was conducted in the cotton growing villages of Coimbatore district, Tamil Nadu (non-sample area). Consultation with the scientists of Central Institute for Cotton Research (CICR) and Tamil Nadu Agricultural University (TNAU) and perusal of past literature was done. Using the results of the survey and discussion, the following framework for preparation of Inventory of Farmers Knowledge on Farming System Approaches in Cotton was developed



Based on the survey results, the components ranked by the respondents viz., Crop (I), Dairy (II), Poultry (III), Goats and Sheep (IV), Biogas (V), Sericulture (VI), Vermiculture (VII), Silviculture (VIII), Mushroom cultivation (IX), Farm machineries (X), Rabbits rearing (XI), Piggery (XII) and aquaculture (XIII) were selected as important components to be recorded in the cotton based farming system. Indicators to assess the contribution by components, parameters to analyze the advantages of individual components and indices for studying the sustainability of diversified and non-diversified farms were also identified.

Post Evaluation of Farmers' Field Schools (FFS) on Cotton

In order to document the problems faced by farmers during pre-implementation period of FFS, the variables *viz.*, Productivity of cotton, Net returns from cotton, Pesticides used, Spraying Operations and division of labour, signs and symptoms of pesticide poisoning, Input use in cotton cultivation, Knowledge level of Farmers, Attitude towards IPM and Capacity building programme were selected and operationalised for the construction of interview schedules and questionnaires. To collect data on Pest Management behaviour in cotton, the parameters *viz.*, Irrigation (number of operations per crop cycle), Weeding (number of weeding operations per crop cycle), Organic as well as inorganic fertilization (rates in kg of commercial products/ha) and Pesticides application (toxicity class, rates and number of applications of the formulated products per crop cycle/ha) were selected and operationalised. To assess the Farmers ecological knowledge on cotton farming, the questions *viz.*, List of names of the insects commonly found in cotton fields (Identification score, IS), to define whether the listed insects were pests or predators (Functional score FS) and to describe the feeding habits of the insects, the plant damages in the case of pests and the predatory capacity in the case of beneficial insects (Ecology score ES) were selected and operationalised. To assess the impact created by FFS on cotton farming, the parameters *viz.*, changes in Natural Capital (natural resource stocks from which resource flows are derived, including land, water, biodiversity, landscapes etc.,), Social capital (Social assets networks, membership in groups, relationships and the wider institutions of society), Human capital (Assets such as skills, knowledge, ability to work, health, creativity etc.,), Physical capital (Infrastructure-roads, wells, hospitals, energy, communications etc.,) tools and equipments) and Financial capital (Financial assets-savings, loans, credit, remittances, pension and other transfers) were selected and operationalised.

Performance and behavior of Bt cotton under scanty rainfall situation

The performance of Bt hybrids under low rainfall situation was assessed with assumption that combined effect of early maturity and protection of early formed bolls in Bt cotton, leads to better performance of Bt under low rainfall situation. The total quantity of rainfall received during the cropping period was 438.2 mm out of which 275.9 mm were calculated as effective portion.

The significantly highest seed cotton yield was recorded from RCH 708 Bt (2853 kg ha^{-1}) followed by RCH 20Bt (2408 kg ha^{-1}) .The performance of LRA 5166 was better than non Bt (RCH2 and RCH20) but lesser than Bt (RCH 708 Bt and RCH 20 Bt). Bt hybrids produced mean of 32,31,27, 38 per cent higher yield than non Bt respectively with total, first, second and third pickings. The results point out that Bt hybrids can also perform better under low scanty rainfall situation in comparison to isogenic non Bt hybrids and existing variety (LRA 5166).

Farm Level Economic Benefits of Bt Cotton in Tamil Nadu

Area under Bt cotton increased from 5000 ha to 70000 ha in Tamil Nadu over the past four years. Salem, Perambalur and Coimbatore are the major Bt cotton areas in Tamil Nadu. The average number of sprays reduced from 5 to 3 with reduction in cost by 60 per cent. The yields of Bt cotton are higher than the yields of non Bt cotton by 26 per cent and was found true under irrigated as well as rainfed conditions. Human labour was the major input (35-40 per cent) in both the cases, with higher share of fertilizers and pesticides in case of non Bt (20%, 20%), when compared with Bt cotton (13%, 9%). Regression results on the impact of Bt cotton showed a significant impact on yield, value of output and pesticide cost. Bt cotton farmers attributed more profit (72.14 per cent), less pesticide (52.31 per cent) and comparatively more bolls (49.15 per cent) for the choice of Bt cotton. Seed dealers and seed companies played a major role in the

dissemination of Bt cotton.

Adoption, Impact and Returns to Research Investment on Improved Cotton Cultivars in Tamil Nadu

Education, non farm income, farm size, irrigation, market distance and presence of private seed sector and district dummies were the variables considered for the Tobit analysis, The presence of private seed sector outlets in the locality favoured adoption significantly. The results suggest that Coimbatore and Salem districts provided a better environment for adoption of improved varieties or hybrids than Dharmapuri. Irrigation appears to be a more dominant variable; seed and fertilizer shops are the major source of information as well as of seed for varieties / hybrids, Fellow farmers and relatives also play a major role as sources of information. State Department of Agriculture and co-operatives are also involved in the dissemination of the technology.

Economic Analysis of Contract Farming (CF) in Cotton in Tamil Nadu

The Tripartite model of contract farming was followed. The Department of Agriculture - Chief Coordinator TNAU and CICR to render R&D support, the Cotton Corporation of India (CCI) acted as alternate procurement agency. The Commissionerate of Agriculture gives extension support as well as training to the farmers. Commercial Banks provides credit facilities to the identified farmers with insurance coverage, CCI Operations cover all the cotton growing states in the country comprising of Punjab, Haryana and Rajasthan in Northern Zone, Gujarat, Maharashtra and M.P. in Central Zone, Karnataka, A.P. and Tamil Nadu in Southern Zone as also in Orissa. In the north, the total area covered under CF went up to 9279 ha (1038 cotton farmers) during 07-08 from 4811 ha (1254 farmers) in 2005-06. In Central zone, the area under CF rose from 8332 ha to 13086 ha, while it was 6887 ha to 13393 ha in the South zone during the same period.

CCI operated its contract farming in Avinashi taluk of Coimbatore district covering an area of 200 acres. ELS Bt cotton - Rasi XL708 and Rasi RCH20 were the Bt hybrids taken up for the scheme. XL708 ELS (34 mm & above - 60 acres Irrigated, RCH 20 ELS (32 mm & above) 140 acres rainfed. Total cost of cultivation was higher in case of non contract farming when compared to contract farming by a difference of Rs.2500/- which was due to higher labour use in the former case. B:C ratio over total cost and cost of production per quintal was remunerative under contract farming (1.64; Rs.1581.60/q) compared to non contract farming (1.08; Rs.1911.19/q) in cotton. The returns to scale was more than unity in case of contract farming depicting increasing returns to scale. The yield and price uncertainty ratio was very less under contract farming when compared to the non contract farming

4.23 : Total Factor Productivity analysis:

Review of literature on various studies pertaining to Total Factor Productivity (TFP) was made to extricate the objectives and tools of analysis for the present study on cotton. Four objectives were finalized for the study using Tornquist Theil index to analyse TFP of cotton in India. Sources of data notified were Directorate of Economics and Statistics, MOA, GOI, Fertilizer Statistics of India, CCPC reports at the concerned universities, Season and crop reports at state level, Economic Appraisal reports at the State level, Marketing Abstracts and Statistical reports at the district level. Negative growth rate of cotton area over the years 1980-81 to 2007-08 was recorded in Punjab with positive production and yield during the same period. In case of Haryana and Rajasthan, positive growth rate was recorded with regard to area, production and yield of cotton. In Punjab and Haryana states, the TFP of cotton declined since mid 90's due to over-mechanisation, stagnant yield and high input costs. But TFP for Rajasthan state was comparatively high due to traditional farming, less mechanization, soil and natural suitability of cotton crop in this state. Total Factor Productivity index of cotton in Gujarat ranged from 0.7376 to 1.6824 during the period 1982-04. In Maharashtra, it ranged from 0.7748 to 1.3337 during the period 1995-04. TFP index of cotton in Madhya Pradesh ranged from 0.8264 to 1.6857 during the period 1996-04. Among the southern cotton growing States, TFP was almost more than 1 in Andhra Pradesh since 1994-95 whereas in Karnataka, it declined from 1.66 to 0.47 during the same period. In case of Tamil Nadu, it showed a decline from 0.93 to 0.52.

4.24 : Cotton Information System

Indian Cotton Portal

Newer version of contents of CICR website was uploaded at the new web location with new domain name **www.cicr.org.in**. In the new cotton web portal, many user friendly pages for the user to navigate, especially, cotton research, cotton market, cotton press release, cotton seed industry, cotton textile Industry etc have been included. The new website has been linked with other Government Departments and cotton related websites. Separate web section for Technology Mission on Cotton and AICCIP have also been integrated. Since the control to update the website is available as and when required, a special cell has been created at CICR Regional Station, Coimbatore to update the contents of the CICR web site instantaneously.

Information Retrieval System

Large volume of diversified information on cotton has been collected in Cotton Repository. User friendly, menu driven information retrieval system using the programming tool Visual Basic.NET has been developed. The data sets mainly projected on state level as well as district level which include District wise cotton area, production and productivity; Cloth/Yarn production sector wise as well as state wise; raw cotton consumption state wise as well as staple wise mills consumption; Details of cultivars released; variety wise cotton area; Hybrid, irrigated, rainfed area under cotton; Fertiliser and pesticide consumption etc have been included. CD version of the information retrieval system is ready for distribution and the same will be converted into web enabled version i.e ASP.NET so that the entire information on cotton will be floated at Indian Cotton Portal for global access.

Bt Cotton Production

Performance and behavior of Bt cotton under scanty rainfall situation

The performance of Bt hybrids under low rainfall situation was assessed with assumption that combined effect of early maturity and protection of early formed boles in Bt cotton, leads to better performance of Bt under low rainfall situation. The total quantity of rainfall received during the cropping period was 438.2 mm out of which 275.9 mm were calculated as effective portion.

The significantly highest seed cotton yield was recorded from RCH 708Bt (2853 kg ha^{-1}) followed by RCH 20Bt (2408 kg ha^{-1}) .The performance of LRA 5166 was better than non Bt (RCH 2 and RCH 20) but lesser than Bt (RCH 708Bt and RCH 20Bt). Bt hybrids produced mean of 32,31,27,38 per cent of higher yield than non Bt respectively with total, first, second and third pickings. Data on quality parameters revealed that RCHB 708 non Bt recorded the highest staple length (35.7 mm), fibre strength (23.6 g/tex) and fibre quality index. The results indicate that Bt hybrids perform better under low scanty rainfall situation in comparison to isogenic non Bt hybrids and existing variety (LRA 5166).

4.24: Seasonal Dynamics of Insect Pests and Diseases

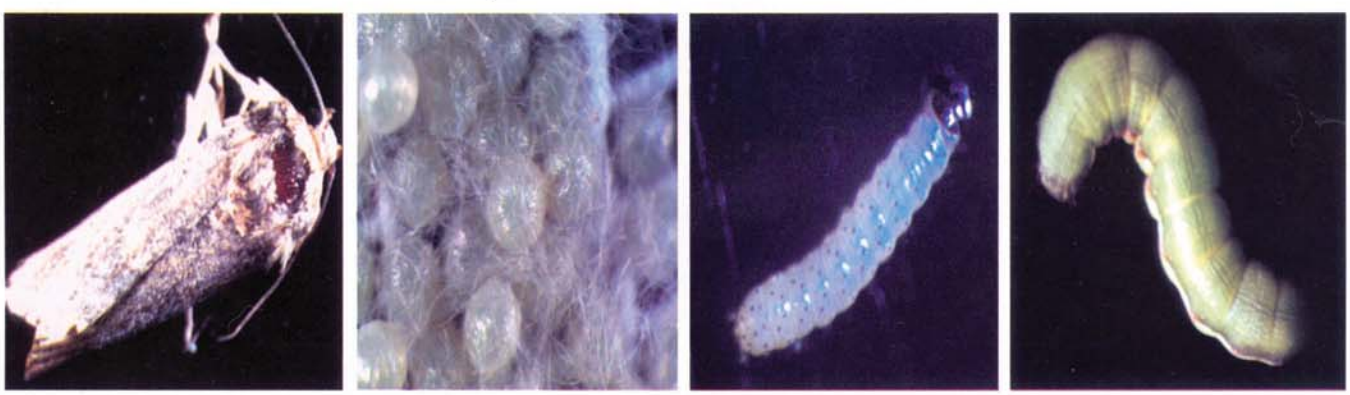
Nagpur

Seasonal dynamics of insect pests

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

Mirid population at different locations during the season showed an increasing trend during 38 to 42nd SW irrespective of the locations. However, their population was minimum in fields adjacent to fallow land. Spider population also indicated similar trend with increase in population during 38 to 44th SW with corresponding increase in mirid population. The spider count was highest in unprotected farm followed by cotton adjacent to road. The corresponding increase in mirid population with respect to decrease in spider population was higher in protected condition due to effect of pesticide application on spider population. Under unprotected condition spider population increased in relation to mirid population. The regression analysis indicated significant increase in spider population with increased mirid population.

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



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

Incidence of diseases

The incidence of various diseases was comparatively less during the crop season 2009-10 In cotton growing areas of North India cotton leaf curl virus (CLCuV) was predominantly observed in certain pockets and was responsible for significant damage to the cotton crop. The *Myrothecium* leaf spot and bacterial blight were observed in early growth stage of crop, with the bacterial blight being more sever as compared to the leaf spot.. The Alternaria leaf spot was recorded in second week of August and disease development was observed till crop termination. However, grey mildew appeared late in fourth week of August and rains in the first week on November as well as cloudy weather influenced its development in the month of November. Tobacco streak virus disease was observed in certain parts of Andhra Pradesh and Marathawada region of Maharashtra.

TSV on Cotton

CLCuV

Alternaria leaf spot

Grey mildew

Outbreak of a new recombinant strain of CLCuV in North India- Molecular characterization

A severe strain of the CLCuV (Rajasthan-DC) was characterised from Rajasthan during 2009-10. The new strain is a recombinant with elements of several Pakistan strains. The strain knocked down resistance of hitherto resistant cotton RS810, RS875, RS 2013, F1861, LHH144, LHH2076 including the prominent RCH134 BG-II cotton. It was noteworthy that the new strain of the virus was predominantly associated with downward curling of lamina and did not show predominant enations, the signs that are divergent from previously documented symptoms of this disease. Complete genome of this strain of the virus, comprising DNA -A and I3-DNA sequences was determined (DNA-A, HM037920; I3-DNA, HM 037921).

Five ORFs were documented on DNA-A component ofthe virus. These included Movement protein, Coat protein, Replication enhancer protein, Transcription activator protein and replication initiator protein. Satellite I3DNA showed 9 ORFs- I3V1, I3V2, I3V3, I3V4, I3C1, I3C2, I3C3, I3C4 and I3C5. While DNA-A is known to harbour essential genes for viral encapsidation, replication and cell to cell movement, I3-DNA is severity determinant of the disease and is essential for symptom expression.

Analysis of the sequences of the viral genomes showed that the new strain was significantly different from the earlier strains that existed in North India (Fig.31). BLAST search and multiple alignment of DNA-A sequences of severe Rajasthan DC strain revealed 99% similarity to severe Pakistan strains including Kokhran, Burewala, Shadabad strains in the movement protein region. These strains had ravaged cotton cultivation in Pakistan during early decades of 1990.

Fig. 31: Variabilty of nucleotide sequence of the new strain vis-à-vis the earlier strain prevalent in North India

Beta DNA component of the recombinant strain showed integration of a stretch of67 bp nucleotide at 738-805 position in f3V4 gene of the previously documented Ganganagar strain AY083590 of CLCuV (Fig.32). Within this stretch of 67 nucleotides, first 22 nucleotides was unique to the new Sri Ganganagar-DC strain while subsequent stretch of 45 nucleotides are conserved in several CLCuV strains. This stretch of 45 nucleotides is also duplicated in the new strain at position 760-805, while in other strains it occur only once within the f3DNA at variable locations. The blast search of the additional stretch in the database showed 97% identity with Burewala betasatellite, Multan betasatellite and Multan virus CR-recombinant isolates, documented earlier in Pakistan along with other Indian and exotic strains. The integration of this new stretch of nucleotide along with other small stretches within f3DNA has increased the size of this relatively conserved component in CLCuV, from 1350 in (Sri Ganganagar strain, AY083590) to 1436 bp, making the severe Sri Ganganagar-DC strain probably biggest of all documented strains.

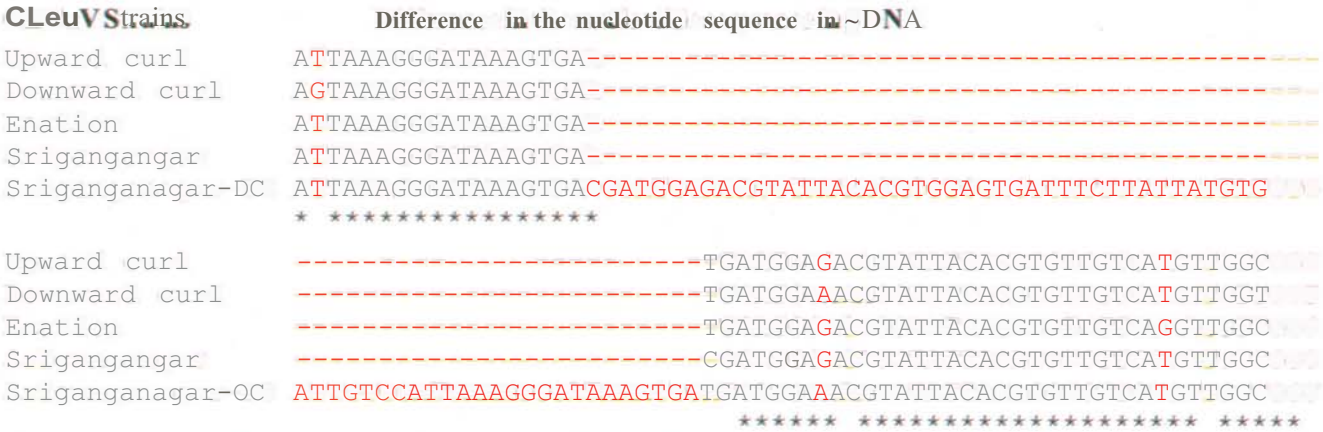
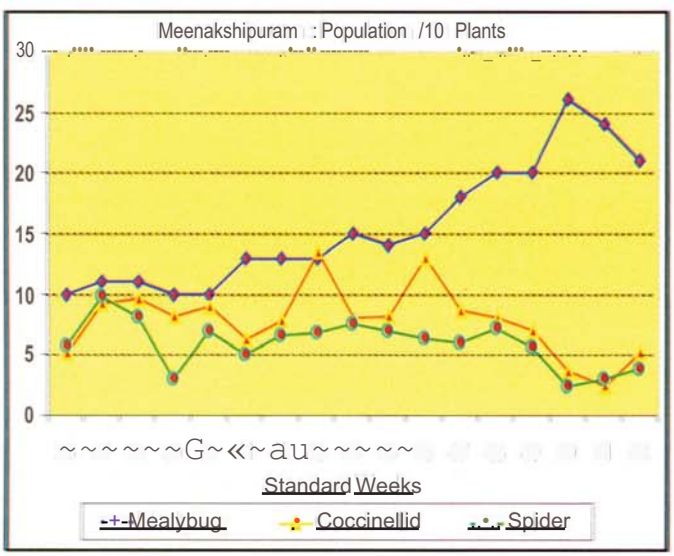


Fig. 32: Additional stretch of nucleotide in β-DNA component of the new recombinant strain of CLCuV

Coimbatore

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

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



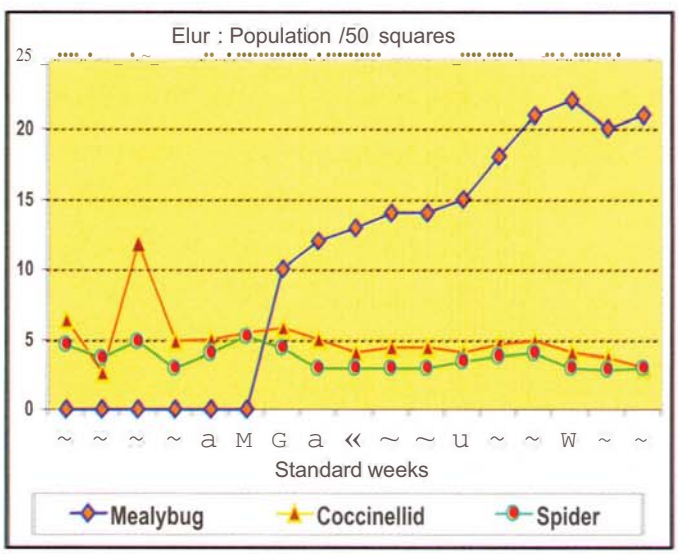


Fig 33: Occurrence and seasonal dynamics of emerging pests and their predators in Meenakshipuram and Elur village

Population dynamics of cotton pests and their natural enemies

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

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

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

Population dynamics of Mirids

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

Determination of sample size for mirid sampling

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

Population dynamics of cotton mealybug and its natural enemies

Population dynamics of mealybug species *viz., Paracoccus marginatus* and *Phenacoccus solenopsis* were observed under cotton + cowpea intercropping system. *P marginatus,* alone dominated this season. The Percent Incidence (PI) & Severity Index (SI) of *P marginatus* ranged from 36 to 96 and 1.109 to 2.375, respectively.

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

Parasitisation of cotton mealybug

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

Alternate Hosts

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

Growth parameters of mealybug on cotton

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

Table 20: Population growth parameters of mealybug on cotton

Parameter	*P. marginatus*	*P. solenopsis*
Gross reproduction rate (GRR)	497	532
Net reproductive rate (Ro)	176.08	157.17
Mean length of generation (Tc)	26.58	30.36
Innate capacity for natural increase (r_c)	0.1945	0.1665
True intrinsic rate of increase (r_m)	0.1952	0.1760
True generation time (T)	26.49	28.73
Finite rate of increase (A)	1.2155	1.1924
Doubling time (DT)	3.55	3.94
Annual rate of increase	9.09×10^{30}	7.93×10^{27}

Where, GRR- Total number of eggs laid per female; Ro- Number of females produced in each generation; r_c - Capacity of species to increase in number (approximate); r_m - Capacity of species to increase in number (accurate); Finite rate of increase (A) - number of times a population increases per unit time; 0 T-time taken by species to double its population

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

Pest status of IRM village at Coimbatore district of Tamil Nadu

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

(a) Sucking pests

Sucking pests *viz.* aphids jassids thrips and whitefly popu a Ion were be ow thres o d level and averaged ~.58, 1.75, 0.88 and 0.14 and 2.57, 2.71,1.47 and 0.02 /3 leaves In IRM and Non IRM villages respectively. The mirid bug population was observed in all the project villages and averaged 0.90and 1.84/ ten squares in IRM and Non IRM villages respectively. The mealy bug population was recorded in all project villages and averaged 0.19 and 0.41 in IRM and Non IRM villages respectively.

(b) Natural enemies

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

(c) Bollworm incidence and damage

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

Sirsa

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

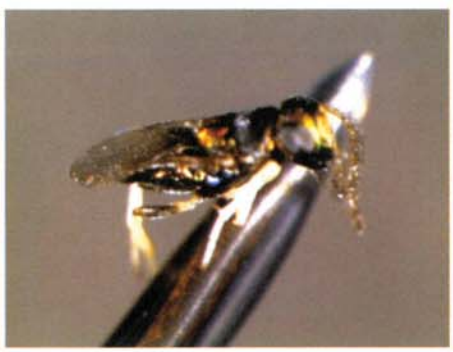
In North, cotton recorded the presence of a single species of mealybug *ie, Pso/enopsis* Tinsley. When sampled parallel to the source, infestation level of P .*solenopsis* Tinsley was highest in fields along the water channel (12.50 to 15.50%) followed by fields on the roadside (9.00 to 12.65%) and clean fields (3.90 to 5.50%). When sampled perpendicular to the source, infestations levels recorded was relatively lower: fields along water channel (6.20 to 9.05%) followed by fields along roadside (4.90 to 10.10%) and clean fields (2.40 to 3.47%). For mealybug, a sample size of 25 to 50 plants per acre were sufficient in fields with known source of infestation such as roadside, weeds and water channels. However, a samples size of 100 plants per acre is necessary for clean fields where prior knowledge of mealybug damage is not available. The reduction in yield of cotton plants was estimated to be 14.87, 30.09, 34.53 and 51.86 per cent for Grade I, II, III and Grade IV mealybug damage levels, respectively during 2009. Bioecology of mealybug was studied. 51 alternate hosts found in cotton-wheat cropping system. *Aenasius bombawalei* a potential parasitoid parasitized mealybugs up to 73.36 % during 38 SWat on-farm trial.

4.25: Biological Diversity of Insect Pests and Pathogens

Nagpur

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

***Metaphycus* sp.**



Promuscidea unifasciativentris

Gitonides perspicax

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

Primers that amplify, COI region of Indian cotton jassid (700bp):
Forward primer 5' GCTCAACAAATCATAAAGATATTGG 3' 25bp
Reverse primer 5' TAAACTTCAGGGTGACCAAAAAATCA 3 26bp
Primers that amplify COil region of Indian cotton jassid (700 bp):
Forward primer 5'TAGTA TGGCA GATTA GTGCAATGAA3'
Reverse primer 5' CCNCAAATTT CNGAN CATTG ACCA 3'
Primers that amplify NADH1 region of Indian cotton jassid (800 bp)
Forward primer3'CCNTCAGAAAAATCAAANGG 5'
Reverse primer 3'GAGTTCAAACCGGCGTAAGCCAGG

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

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

Though the infestation was not alarming in most of the fields, the host range under rainfed cotton +pigeon pea cropping system was much broader. During current year 2009-10, surveys conducted in cotton field during off season and as well as cotton season, a total 68 hosts were recorded across 26 families out of which 58 were botanically identified. Cumulatively 106 host plants were recorded spreading across 27 families. Out of total host plants families *viz.* Asteraceae, Malvaceae, Leguminaceae, and Solanaceae constituted 51 % of host plants of P *solenopsis.* In year 2009-1 0 these families constituted 47% host range. The major families of host with severe infestation and wide host range were Asteraceae, Malvaceae,

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

Genetic diversity in *Fusarium* species infecting cotton

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

Diversity and distribution of cotton leaf curl virus (CLCuV)

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

Morphological variation in *Alternaria* leaf spot pathogens:

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

Protocol for lifecycle studies and sampling techniques for mealybug and mirids

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

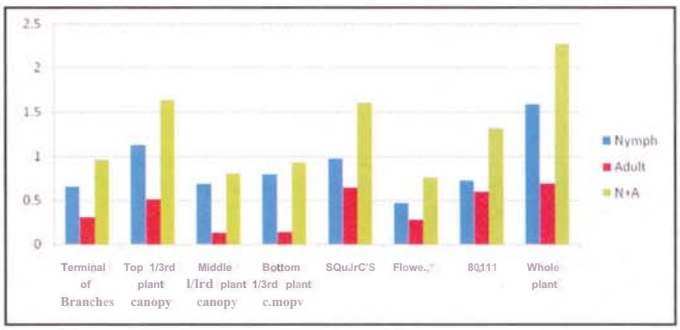


Fig. 34: Mean seasonal counts of C. *livida* nymphs and adults (2009-10)

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

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

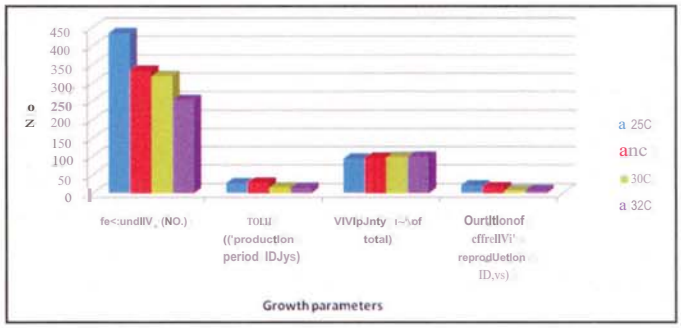


Fig 35: Behavior of Mealybug P *solenopsis* on some growth parameters

Coimbatore

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

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

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

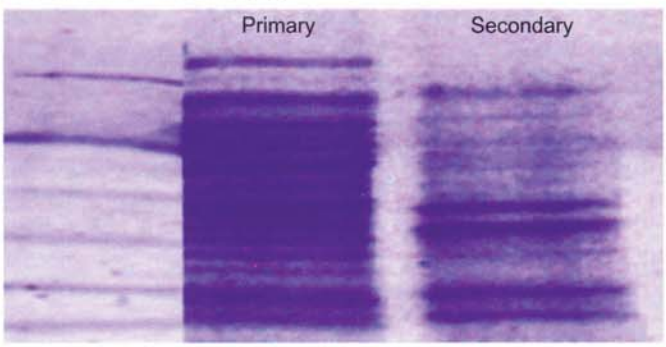
4.26: Isolation and Identification of New Genes and Gene Sources for Pest Management

Nagpur

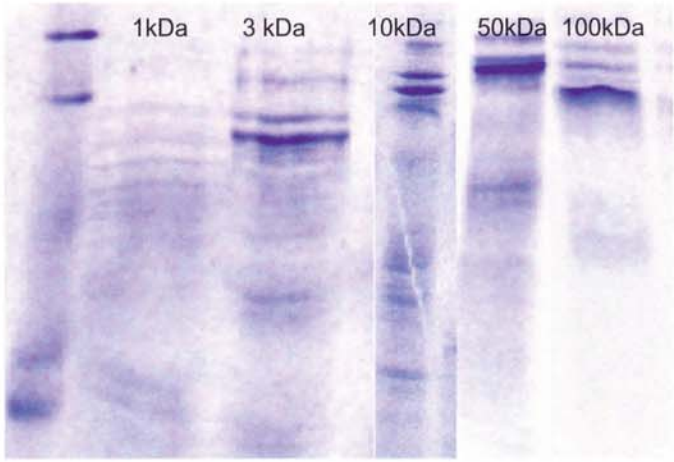
Isolation, identification and characterization of insecticidal toxins in heat tolerant Entomopathogenic nematode-bacterial system with elucidation of factors regulating toxin production

Toxin isolation

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



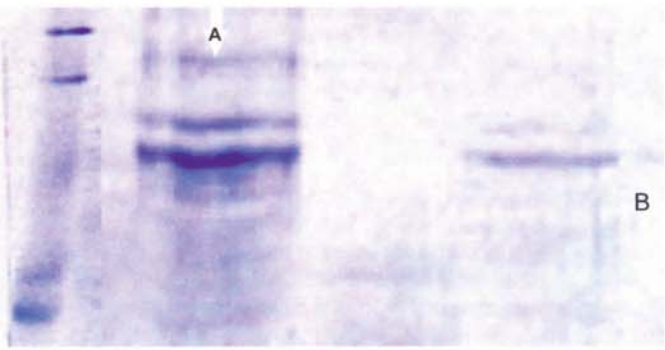
Different fractions from the extracellular and intracellular components of both the phases of bacterium further separated using columns, centrifugal devices and gel filteration were bioassayed against 3"' instar larva of *Helicoverpa armigera* for insecticidal activity. Individual fractions at three different concentrations were (5, 10 and 15jJg) were injected into haemocoel of 3'd instar *H.armigera* larvae. Control was maintained with *H.armigera* larvae injected with physiological saline solution. Observations on insect mortality after 24 hrs revealed that fraction 50 -100 kDa at 10jJg recorded more than 98% mortality after 24 h while 10K fraction recorded 60% 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. 50 -100 kDa fraction was also recorded to have oral toxicity. This fraction was run on native PAGE and individual bands were cut, eluted in buffer (140 mm NaCI, 2.7 mM KCI, 10mM Na_2HP04, 1.8 $mMKH_2P04$' pH 7.3) and analysed for insecticidal activity.



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

Intrahaemocoelic toxicity of different fractions of 50-100 kDa

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



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

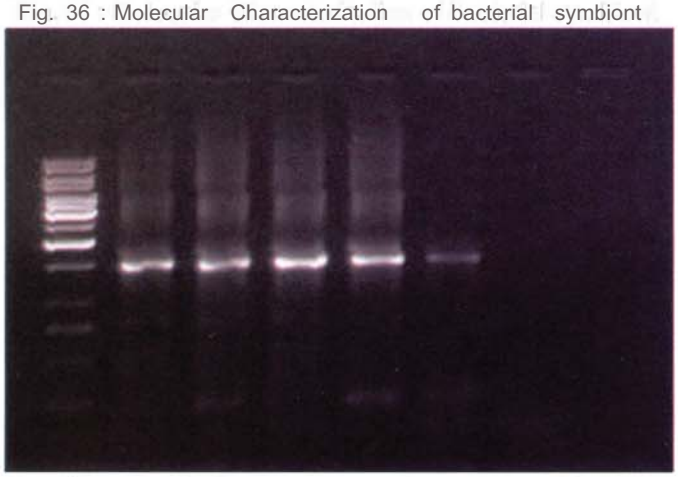
The bacterial symbiont (nonluminescent variant of *Photorhabdus luminescens)* of thermotolerant isolate of EPN *Heterorhabditis indica* developed was taken up for cloning and characterization of potent toxin gene. Toxicity to insects is largely due to toxins produced by bacterial symbiont..

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

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

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

Fig. 36 : Molecular Characterization of bacterial symbiont



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

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

Designing of Primers

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

4.27: Development of New Methods, Tools and Protocols

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

Fifteen lectins, were tested for their toxicity to whiteflies, aphids and jassids using novel artificial diets and bioassay systems that were developed and validated at the institute. The bioassays, were repeated six times in separate assays for repeatability and reliability of performance for aphids, jassids and whiteflies. Median lethal doses from six sets of bioassays with aphids, were deduced to decide upon the most effective lectins that could be used for the development of transgenic plants. Three sets of jassid and whitefly bioassays were conducted with fixed doses of 10 ppm, and for log dose probit assays using a range of concentrations. Amongst 151ectins tested, AMTL and CEAwere the most toxic on aphids with LC_{50} values of 2.2 and 3.9 ppm respectively. CEA, Banana lectin and artocarpin were most toxic to jassids, and AMTL, CEA, Banana lectin and peanut lectins were the most toxic to whiteflies at a range of 1.1-3.3 ppm causing >90% mortality within 72 hours. The genes of the four lectins, were incorporated into plant transformation vectors for the development of sucking pest resistant GM cotton.

Commercialization of Molecular Diagnostic tools

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

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

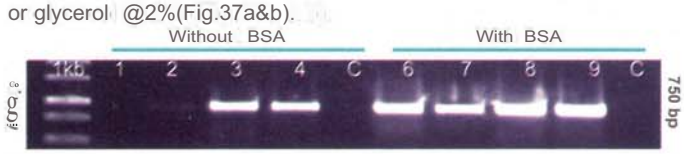


Fig. 37a. PCR Detection of CLCuV in infected cotton through amelioration of PCR inhibitors with BSA., Lanes 1-5: Plant genomic DNA without BSA; Lanes 6-1 0, with BSA (0.2 %)

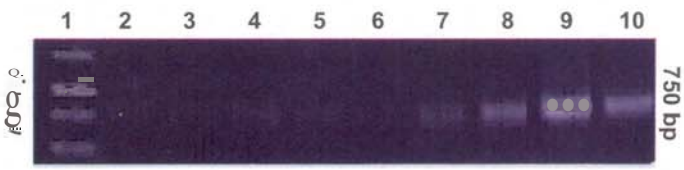


Fig. 37b. PCR Detection of CLCuV in infected cotton through amelioration of PCR inhibitors with increasing concentration of Glycerol.. Lane1, Marker; lanes 2-9,0.2 - 2.0% of Glycerol

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

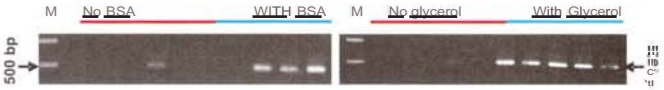


Fig.38 a&b: Increase in efficiency ofPCR detection of *A. macrospora* with 0.2% BSA- a & 2% glycerol b.

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

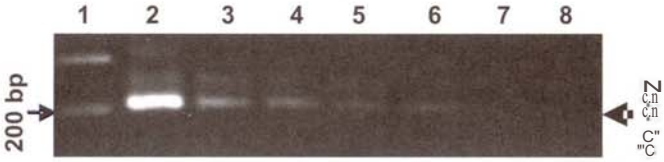


Fig. 39 a: Effect of increasing concentrations of Humic Acid in PCR amplification & detection of R. *so/ani.* Lane 1, Marker; Lanes 2-8, humic acid from 0.004%-0.03%

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

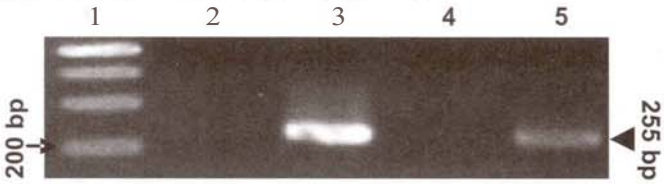


Fig.39 b; Effect of Glycerol on PCR inhibition of R. *so/ani* caused by humic acid. Lane 1 & 3, 0.02% & 0.04% of humic acid; Lanes 2 & 4, 1.4% & 2.8% of Glycerol substituted in reaction along 0.02% & 0.04% humic acid

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

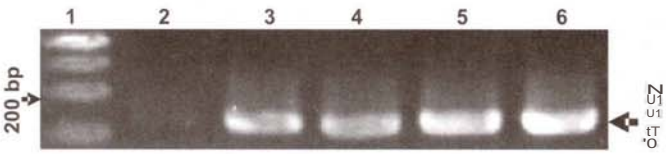


Fig.40: Effect of increasing concentration ofBSAon overcoming the effect of 0.02% humic acid in PCR amplification & detection of R. *so/ani.* Lane 1, Marker; lanes 2-6,0.2%-0.4% of BSA.

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

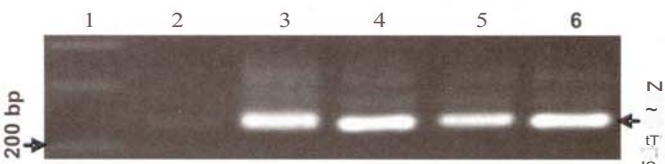


Fig. 41: Effect of combined application ofBSA(O.2%) & Glycerol (1.2%) in overcoming the effect of humic acid (0.02%) in PCR amplification of R. *so/ani.* Lane 1, Marker; lane 2, humic acid alone; lanes 2-5,0.02% humic acid + 0.2% BSA +1.2% Glycerol

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

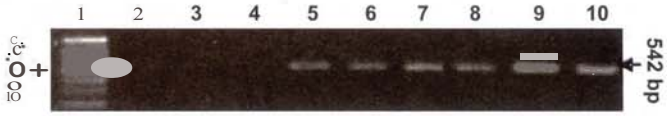
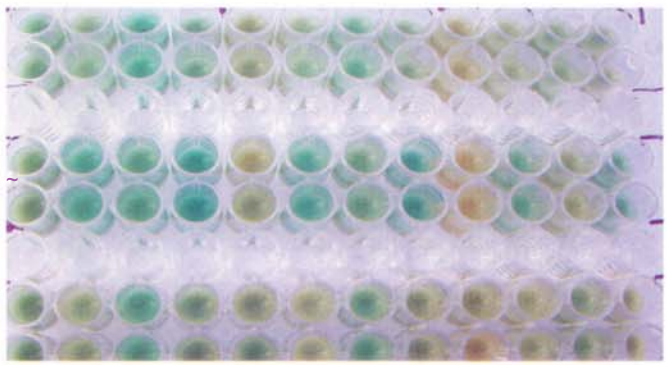


Fig 42: Effect of Phenol on PCR inhibition & its mitigation by BSA & Glycerol.. Lane 1, Marker; lanes 2-4, 1.2%, 1.6%, 2% Phenol; lanes 5-7, 0.2% BSA+2% Phenol; lanes 8-10,2% Glycerol+2% Phenol

Development of Immunodiagnostic kits for new Cry toxins and Bt cotton

Cry1 C and Cry1 B antigens were purified to apparent homogeneity (>99%) using sequential column chromatography and used for the development of polyclonal antisera through immunization and four boosters were administered. The antisera were tested and ELISA kits were developed. The ELISA and Immunochromatographic 'dipstick' kits developed against pat and NPT-II to detect GM crops with kanamycin and bialophos resistance and Cry1 F were validated independently at Innovative Bioscience, Nagpur. The sensitivity of the strip was at a minimum detection level of 1ppm for NPTII and 2-3 ppm for PAT. 'Gus detect', a rapid 10 minute colorimetric test developed to detect GUS marker of Cry2Ab in BG II for UID-Awas validated by NBPGR and commercialized. More than 1000 kits have been used by various stakeholders last year. Three different formats of ELISA kits were developed for the detection of Cry 1C and Cry 1B and were validated for their stability.



4.28: Host-Plant Resistance to Insect Pests and Diseases

Nagpur

Host plant resistance to insect pests

Out of 382 lines sown during 2009-10,10 lines (F3-30, F4-10, F5-63, F6-17, F7- 34, Backcross F4-27, Cultures-35, TWC back cross F4- 82, SV lines-42, Germplasm lines-42) were found tolerant to sucking pest, and bollworms with earliness (150-155 days) and good yield *viz.,* 8 x suvin (B) D 2, 6 x 20 (C), 13 x 2 (B) V, Code 1150 I, Code 420 (A), Code 426 (A), Code 446 (A),16x74Ax8,3917x74A(B)x8 B,L-11 (A)x7xA(B)x8.38 lines were found to yield the highest with a moderate duration of 165 days.

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

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

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

Spodoptera adult *Spodoptera* larva

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

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

Hundred and five lines with bacterial blighU grey mildew resistance were selected from the population involving resistant lines as donor parents. These lines were also observed to be superior in plant quality parameters. Fifteen bacterial blight *1* grey mildew resistant cultures have been identified with better plant quality parameters. These cultures were superior in yield as compared to local check LRK 516. The seed cotton yield of *35.7-60.7 gml* plant was recorded in these cultures with an average boll weight varied from 2.26 - 3.88 gm/boll and 12.54 21.58 bolls/plant.

Out of 329 lines of G. *hirsutum,* 56 lines were resistant for bacterial blight and 15 lines were resistant to grey mildew under field condition. Seven lines *viz.* IC 357599, EC 152285, EC 152280, IC 358905, IC 359051, BWR 58 and BWR 28 were resistant against bacterial blight and grey mildew under natural field condition. Two lines *viz.* 213-1023-1 and 666-56-58-Awere resistant to bacterial blight and grey mildew under controlled field condition.

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

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

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

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

Coimbatore

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

Four commercially popular Bt hybrids *viz.,* RCHB708 Bt (ELS cotton), Mallika Bt, Bunny Bt and RCH 2 Bt were studied for their association to emerging pests in unprotected field condition. All the hybrids recorded high population of mealybug *P. marginatus* ranging from 435 to *7831* plant and 2.0 to 3.5 grade intensity of damage. All of them were susceptible to mirid bug and recorded 2.3 to 3.7 nymphs *1*5 squares (Mean of 15 plants x 5 squares). The yield loss due to the sucking pests including the emerging pests was 8.6,12.6,17.2 and 17.5 q/ha in RCH B708 Bt, Mallika Bt, Bunny Bt and RCH2 Bt respectively.

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

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

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

Cultivars	90 DAS	105 DAS	120 DAS	135 DAS	150 DAS	Mean
RCH 2 Bt	0.00 (0.48)	0.00 (0.48)	1.88 (5.74)	0.63 (2.63)	1.88(5.74)	0.88 (4.23)
RCH 530 BG II	1.88 (5.74)	2.50 (6.70)	6.07 (14.10)	4.20 (10.04)	3.44 (10.44)	3.62 (10.75)
RCH NBt	11.19 (18.72)	11-.32 (18.88)	32.68 (33.68)	16.25 (22.40)	40.72 (39.39)	22.43 (27.50)
MRC 6918 BG II	0.63 (2.63)	7.41 (11.56)	5.51 (13.51)	2.50 (7.90)	3.04 (8.74)	3.82 (10.61)
MRC 7201 BG II	0.63 (2.63)	3.75 (9.81)	3.72 (9.77)	2.19 (6.13)	3.13 (10.05)	2.68(9.11)
MRC 7201 NBt	15.13 (22.42)	14.32 (21.67)	26.26 (30.56)	22.12 (25.86)	53.36 (47.02)	26.24 (30.19)
Bunny Bt	0.00 (0.48)	0.00 (0.48)	3.69 (9.73)	1.88(6.94)	1.24 (4.76)	1.36 (5.24)
Bunny BG II	2.50 (6.70)	5.00 (10.80)	5.51 (11.60)	6.13 (12.45)	5.09 (11.00)	4.85 (12.59)
Bunny NBt	13.13 (20.74)	15.13 (22.45)	18.75 (25.02)	22.81 (27.79)	40.39 (39.22)	22.04 (27.56)
SEd	3.55	5.12	5.55	5.79	5.85	2.79
CO (0.05 %)	7.33	10.56	11.46	11.95	12.07	5.69

Table 22: Larval population in different Bt hybrids

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

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

Sirsa

ETL of *H. armigera* on Bt cotton

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

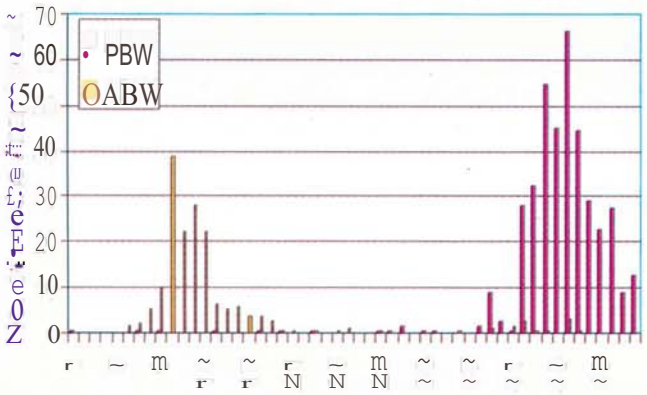
Sucking pests' resistance to insecticides

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

Determining cultivar association with emerging pests

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

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



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

Coimbatore

Three hundred and fifty germplasm accessions of G. *hirsutum* were screened under field condition for their reaction to mealybugs and mirid bugs during 2009-10. Six entries *(viz.,* ICGH250, 252, 276, 288, 341, & 410) were found less susceptible to mealybug and recorded less than 10 numbers *1* plant and grade one damage, while the susceptible entry ICGH 370 recorded 1075 numbers *1* plant and damage grade of 4.0. The same accessions were screened for mirid bugs and five entries *viz.,* ICGH 474, 480, 509, 610 and 630 were found to have less numberofmirid bugs (0 to *0.25/5* squares) as against 4.75 in the susceptible entry ICGH 328.

Screening of breeding material for multiple disease resistance

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

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

Identification of native bioagents by *in vitro* testing

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

4.30: Biological Control

Nagpur

Biological control of insect pests

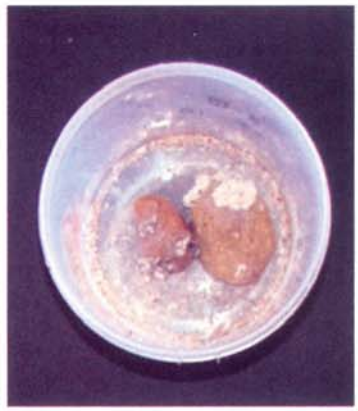
Three parasitoids *viz.,* A. *bambawalei, Metaphycus* sp. (Encyrtidae: Hymenoptera) and *Promoscidia unifaciventris* (Aphelinidae: Hymenoptera) have been observed to parasitize mealybug *P.* solenopsis ranging from 7.28 to 100 %. The mealybug species *Nipaecoccus viridis* was found to be predated by *Gitonides perspicox sp.* Knab (Drosophilidae:Diptera). G. *perspicox* predation of *N. viridis* ranged from 33-90%. Mealybug infesting *Triumfetta rhomboidea* showed 100% parasitization by A. *bambawalei* followed by *Lantana camara.* However, cent per cent emergence of parasitoid was observed from mummified mealybugs from *Xanthium strumarium.* Duration of adult emergence from date of collection varied with respect to host plants and parasitized mealybugs collected from *Parthenium hysterophorus* emerged in least time period (10 days) with about 71 % adult emergence.

Lab multiplication of bio agents

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

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

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



Lab multiplication of A. *bambawalei*

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

Fourteen effective bacterial isolates isolated from the rhizosphere Iphylloplane region of cotton ecosystem were evaluated under *in-vitro* conditions by dual culture method for their antifungal activity. The fast growing strain of Fusarium wilt pathogen *F* o. *sp. vasinfectum,* dry root rot pathogen *Macrophomina phaseolina* and fast growing strain of *Alternaria* leaf spot pathogen *Alternaria alternata* were used as test pathogens. Six bacterial isolates were effective and inhibited 62.37 - 76.82 per cent growth of. F o. f. sp. *vasinfectum* with an inhibition zone of 25.0-30.8 mm. The inhibition of 62.65-76.70 per cent was also observed with six bacterial isolates in A. *alternata* with an inhibition zone of 18.0- 22.5 mm. However, four bacterial isolates exhibited an inhibition zone of 30.9- 32.67 mm with an inhibition of71.03- 74.95 per cent against M. *phaseolina.*

The virulent cultures of *F* o. *sp. vasinfectum* and M. *phaseolina* were multiplied individually on sorghum seed meal and inoculated separately in a mixture of sterilized soil, sand and FYM. The mixture of soil, sand and FYM having inoculums of respective pathogens was allowed for 10 days to multiply in the earthen pots. Treated seed of susceptible cultivars with effective bacterial isolates was sown in the earthen pots. Seed treatment with effective bacterial isolates suppressed the seedling infection by 61.54- 82.05 and 51.35- 78.38 per cent under pot culture by F o. f. sp. *vasinfectum* and M. *phaseolina,* respectively. Promising increase in root length and shoot length of seedlings was also observed with seed treatment using these bacterial isolates against F o. f. sp. *vasinfectum* and M. *phaseolina.*

Role of PGPR bacterial strain and SAR inducing chemicals in yield improvement and bio-control of diseases

Areplicated field trial was conducted in RBD with *Pseudomonas f1uorescens* strain CICR H,a to test the efficacy of PGPR strain in enhancing productivity and protection of cotton against Bacterial blight, Myrothecium leaf spot and Grey mildew. Besides, SAR inducing chemicals like salicylic and isonicotinic acid were also evaluated for their efficacy in conferring protection against the diseases.

Application of the bacterial strain enhanced the productivity of cotton besides protecting the plant from disease. Highest yield (1834 kg/ha) was obtained where the seeds were treated with talc formulation of *Pseudomonas f1uorescens* containing 1 x 10 *cfu/ml* @ 5 *g/kg* seeds with three applications as foliar spray. This was followed by the treatment (1815 kg/ha) where the PGPR strain was applied in soil @ 5 *g/kg* supplemented with three sprays at monthly interval. Treatments where *Pseudomonas f1uorescens* strain was applied alone either as seed, soil or foliar application did not result in appreciable increase in productivity. Surprisingly, the SAR inducing chemicals salicylic and isonicotinic acids resulted in appreciable increase in the yield. The treatment effects however were non-significant.

All the treatments resulted in lowering the severity and incidence of Bacterial blight, Myrothecium leaf spot and Grey mildew in cotton. Intensity of Bacterial blight ranged from 0.8% to 1.5% in different treatments compared to 2.5% in Control. Not much variation was observed in incidence of Myrothecium leaf spot disease that ranged from 80-100% in different treatments. Seed treatment or soil application of *Pseudomonas f1uorescens* combined with foliar spray or application of salicylic acid or isonicotinic acid were effective in reducing incidence of Grey mildew to 10-20% from 50% observed in control.

Coimbatore

Natural occurrence and predatory potential of *Spalgis epius*

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

Pathogenicity of entomopathogenic fungus

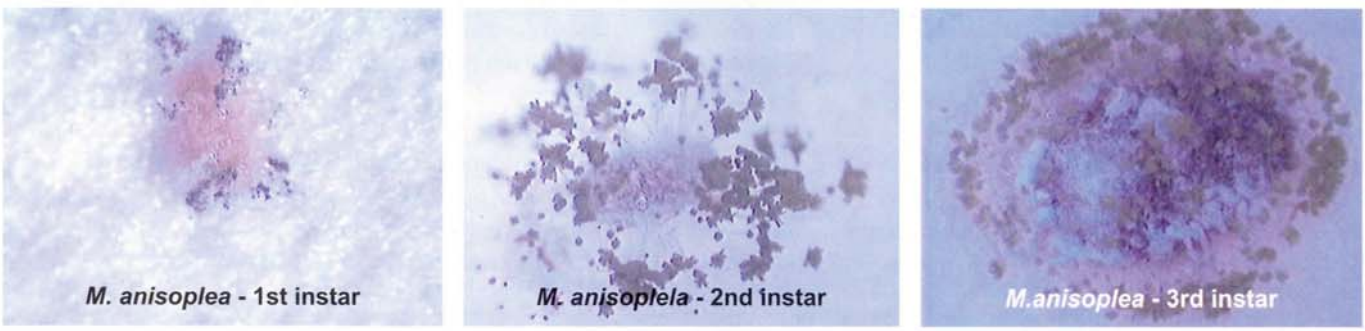
LD_{50} and LT_{50} were calculated for fungal pathogens *viz., Metarhizium anisop/iae, Vertici/lium lecanii* and *Beauveria bassiana* against all three instars of cotton mealybugs *viz.,* P *marginatus* and P *solenopsis*.

M. anisopliae: LD_{50} values for 1st instar, 2nd instar and adults of P *solenopsis* were 8.7x1 05, 1.3x1 0^6 and 5.4x1 0^6 and the same for P *marginatus* were 5.0x10^5, 9.8x10^5 and 1.3x10^6 respectively. LT_{50} values for 1st, 2nd instars and adults of P *solenopsis* at 10^5 were 4.50, 5.97 and 6.27 days and the same for P *marginatus* were 4.20, 5.03 and 6.00 days respectively. At 10^6 LT_{50} values for 1st, 2nd instars and adults of P *solenopsis* were 4.47, 5.67 and 6.24 and the same for P *marginatus* were 3.99, 4.89 and 5.77 respectively. At 10', LT_{50} values for 1st, 2nd instars and adults of P *solenopsis* were 3.94, 5.45 and 6.22 and the same for P *marginatuswere* 3.56, 4.87 and 5.66 respectively.

B. bassiana: LD_{50} values for 1st, 2nd instars and adults of P *solenopsis* were 9x1 05, 3.9x1 0^6 and 5.3x1 0^7 and the same for P *marginatus* were 8.2x1 05, 2.5x1 0^6 and 1.4x1 0^7 respectively. LT_{50} values for 1st, 2nd instars and adults of P *solenopsis* at 10^5 were 4.95, 6.10 and 7.17 days and the same for P *marginatus* were 4.68, 6.00 and 7.02 days respectively. At 10^6 LT_{50} values for 1st, 2nd instars and adults of P *solenopsis* were 4.60, 5.89 and 6.83 and the same for P *marginatus* were 4.71, 5.37 and 6.80 respectively. At 10', LT_{50} values for 1st, 2nd instars and adults of P *solenopsis* were 4.09, 5.60 and 6.71 and the same for P *marginatus* were 3.88, 5.19 and 6.52 respectively.

V. lecanii: LD_{50} values for 1st, 2nd instars and adults of P *solenopsis* were 1.5x1 0^6, 3.2x1 0^6 and 1.3x1 0^7 and the same for P *marginatus* were 1.2x1 0^7, 1.7x1 0^6 and 5.9x10^5 respectively. LT_{50} values for 1st, 2nd instars and adults of P *solenopsis* at 10^5 were 5.72, 6.47 and 7.22 days and the same for P *marginatus* were 5.46, 6.21 and 6.93 days respectively. At 10^6 LT_{50} values for 1st, 2nd instars and adults of P *solenopsis* were 5.35, 5.99 and 7.05 and the same for P *marginatus* were 4.82, 5.57 and 6.96 respectively. At 10', LT_{50} values for 1st, 2nd instars and adults of P

M. anisopliae infected mealybug



B. bassiana infected mealybug

V. lecanii infected mealybug

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

Histopathological studies on entomopathogenic fungus against cotton mealybug

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

Biochemical content changes during pathogenesis

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

Isolation of native entomopathogenic nematodes

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

Identification of bacterial symbionts of entomopathogenic nematodes

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

Ecological characterization of native entomiopathogenic nematode

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

Isolation and identification of native entomopathogenic fungi from mealy bug

A survey was conducted to isolate and identify entomopathogenic fungi associated with cotton mealy bug. Out of several fungi screened, 43 isolates were reported to cause mortality under laboratory condition. All the cultures were sent to Agharkhar Research Institute, Pune, IARI, New Delhi and USDA ARS Biological IPM Research, USA.. for identification. Out of 43 fungi screened, *Lecanicillium lecanii* (Zim, Zare & Gam) was found to be highly virulent against *Phenacoccus solenopsis* and *Paracaccus marginatus.* Natural occurrence of *L./ecanii* and *Cladosporium c1adosporoides* was reported for the first time in India.

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

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

Lab evaluation of isolates against mealy bug (Dose response relationships LD ••)

To determine dose-mortality response (LD_{50}) and time-mortality response (LT_{50}) different concentrations *viz.,* 10^4, 10^5, 10^6, 10^7, 10^8 and 10^9 spores ml^{-1} of test fungi *(M.anisopliae, B.bassiana-1 ,2 , C.c1adopporoides and L./ecanii)* were prepared and tested against nymphs and adults of *Phenococcus solenopsis* and *Paracoccus marginatus* under laboratory condition by spraying suspension on the leaves which were inoculated with nymphs or adult.. Among different fungi tested, *L. lecanii* recorded the lowest LD_{50} value of2.1×10^7 and 4.5×10^6 spores ml^{-1}againstadult and nymph of P *solenopsis* respectively. The data on dose-mortality of three entomopathogenic fungi against *Pmarginatus* revealed that *L./ecanii* recorded lowest LD_{50} of 2.2×10^7 and 4.7×10^6 spores ml^{-1} against adult and nymph respectively.

Lab evaluation of isolates against mealy bug (Time response relationships LT ••)

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

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

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

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

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

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

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

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

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

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

Studies were conducted to determine the favourable culture media for the growth and sporulation of *L./ecanii.* Rice, sorghum, pearl millet, finger millet and wheat based media were included in the study. The radial growth, biomass and spore production of *L./ecanii* varied significantly with various culture media tested. The radial growth was maximum in SDAY medium followed by sorghum and PDA. Least radial growth was recorded in pearl millet based media. The biomass production was found to be significantly higher in sorghum followed by SDAY. Sorghum based medium was found to be significantly superior in spore production which was 4.27x10 spores mr' followed by SDAY medium. Minimum spore production was observed on finger millet based media.

4.31: Integrated Pest Management

Nagpur

Pigeon pea as border and intercrop crop harbors less number of aphids and more number of coccinellids. Mirid population was at par in cowpea and Pigeon pea. Mirid population was maximum in sole cotton as compared to other border crop treatments. Thus pigeon pea was found to be compatible crop in cotton cropping system as compared to cowpea, jowar and maize as the latter harbor higher sucking pest population .Cowpea, jowar and maize impede intercultural operation for successful. .

Cotton+ pigeon pea cropping system most suitable in Central India

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

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

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

Table 23: Induced host plant resistance for cotton pest management

Chemical	Structural group	LC_{50} in the lab	Method of testing	Insect against which tested
Limonene	Terpenoid	0.143% 0,421% 0.342%	Leaf dip Diet incorporation Direct spray	Jassid nymphs Aphids Mealy bugs
Ocimene	Terpenoid	0.123% 0.177%	Leaf dip Diet incorporation	Jassid nymphs, Aphids
Jasmine perfume	Terpenoid	0.601% 0.191%	Leaf dip Diet incorporation	Jassid nymphs Aphids

Rasi 2 Bt Gaucho untreated was sprayed 5 times during the season at fortnightly intervals. At 45 DAS confidor was the best treatment Uassid nymph reduction, 41%) and was on par to Limonene 1.5m1/L Uassid nymph reduction 31%) and jasmine perfume 2.5m1/L (25.8% jassid nymph reduction) superior to external control. Ocimene 3mllL was on par with confidor 50 DAS (41.4% jassid nymph reduction). Sprays at 60 DAS demonstrated that limonene 3ml/L and ocimene 0.5m1/L were on par with confidor causing jassid nymph reduction of 43.9%, 42.6% and 54.2% respectively over external control. Thus experimental evidence is provided to demonstrate that jasmine perfume (2.5ml/L), ocimene (3mllL), limonene (3mllL) can effectively be used against jassids in place of neonicotinoid sprays. Jasmine perfumel ocimene may be used between 45-50 DAS, while limonene may be used at 60 DAS, thereby preventing repeated use of the same molecule. The choice of placement of these molecules was decided based on their effect on jassid damage grade. These molecules also induced host plant resistance enzymes such as LOX1 and LOX3.

Identification of botanical soap products as emulsifiers

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

Multi-location trials with Mealy Kill

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

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

Jassids collected from North South and Central India was tested for their tolerance to both conventional and new chemistries. Imidaclorprid, Thiamethoxam belonging to the new class of chemicals, namely neonicotinoids; acephate, a Class III group of chemical according to WHO category that is ecologically safe; Monocrotophos and Chlorpyriphos conventional OP chemistries were selected for evaluation. Six concentrations ranging from 0.0001 milL to 2.0 milL, including one control were tested. This study was carried out at Sirsa, Nagpur, Surat and Coimbatore.

The LC_{50} for conventional insecticides such as acephate against jassids ranged from 0.0001 *mg/L* (Rajkot) to 0.011 *mg/L* (Indore) and the resistance was 110 fold in the latter. The LC_{50} for monocrotophos ranged from 0.0001 (Junagarh)mg/L to 0.0113 *mg/l* with populations from Surendranagar and the resistance ratio was 57 fold. LC_{50} for thiamethoxam ranged from *0.0002mg/l* (Junagarh) to *0.5mg/l* (Indore) and the resistance fold was found to be 2500X. LC_{50} for imidachlorprid ranged from *0.00002mg/l* (Bhatinda) to 0.109 *mg/l* (Wardha) and the resistance fold was found to be 5450X. Coimbatore, Junagarh and Hisar jassid populations were susceptible to all the insecticides tested. Central India jassid populations were tolerant to neonicotinoids.

Stacking of trypsin inhibitor gene into Bikaneri Nerma Bt

F_2 progeny of reciprocal crosses between BN Bt and CINHTI1 were raised boll to row from F, progeny expressing high Ti and Cry toxin. It was observed that progeny from the cross where female parent CINHTi1 were tolerant to sucking pests as compared to progeny that had BN Bt as the female parent. The F_2 progeny was selfed and each selfed boll picked separately to identify homozygous high Ti and high Cry toxin expressing plants in the F_3 generation. Segregating populations of reciprocal crosses of CINHTi1 and BNBT had a short duration of 80 days with each plant harboring just 5-6 small bolls with synchronous boll opening thus these populations escaped pink bollworm damage completely. It also gives a scope of manipulating plant population for higher yields.

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

Soil samples were further collected from Ladakh, Barrackpore and Pasighat in 2009-10. Soil samples of Buldana, Parbhani, Amravati, Aurangabad, Guntur, Hingoli, Abohar Sriganganagar, Mansa, Yavatmal, Wardha, Washim, and Jalna (collected in 2008-09) were subjected to the isolation of Bt strains using the selective sodium acetate method and Bt index was calculated.

Toxin was isolated from these strains and subjected to bioassays by the diet incorporation method for both *H. armigera* and S. *litura.* Of these strains, native Bt from Yavatmal, Jalna and Hingoli demonstrated a mortality of 28%, 64% and 58% respectively against *H. armigera* but were less effective than the

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

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

5'CTGGATTTACAGGTGGGGATAT3' FP

5TGAGTCGCTTCGCATATTTGACT3' RP

For amplification ofCry1 class

5TTAATCGACAAGTAGATAAYTT3' FP

5'AACTCCATCGTTATTTGTRG3' RP

For Cry2 category have been designed and sent for synthesis.

Coimbatore

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

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

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

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

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

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

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

Identification of reinfestation level of sucking pests after insecticidal application

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

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

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

5irsa

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

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

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

Biological control to strengthen IPM

Among various insecticides and biopesticides, acephate (72.86%) and chlorpyriphos (69.13) were resulted into max reduction of mealybug after spray followed by *Metarrhizium anisoplae* (41.53 %), *Beauveria bassiana* (37.71 %), new botanical (34.81%), V. *lecanii* (33.79%). The population of spiders was not affected adversely in any treatment but the lacewings and ladybird beetle were affected adversely by different treatments. Maximum reduction in parasitisation of mealybug by *Aenasius* as compared to control was recorded in Monocrotophos (58.65 %). Under integration of all eco-friendly strategies and validation of IPM packages *(use of botanicals/biopesticides/barrier crops and mechanical collection of/arval population and avoid in use ofneonicotinoids during the earlier part of the cotton season)* sucking pests Uassids, whitefly and thrips) recorded were 1.13, 5.79 and 9.79 (per 3 leaves) in IPM and 1.27, 5.49 and 11.28 under RPP, respectively ;0.51 and 0.51 damaged fruiting bodies and 0.11 and 0.14 rosetted flowers were recorded under IPM and RPP , respectively. The Cost:. benefit ratio was calculated as 1:3.70 in IPM and 1:3.29 under RPP.

Insecticide Resistance Management

Nagpur

Insecticide resistance management strategies were implemented in 100918 hectares area in 665 villages of 33 districts in 10 cotton-growing states of India. Forty six thousand five hundred and fifty four farmers were enrolled as IRM farmers during the crop season. A total of 30281 farmers of 330 villages implemented the programme in 72498 hectares in the North Indian states of Punjab, Haryana and Rajasthan. In Central India (Gujarat, Maharashtra and MP) 6723 farmers implemented the programme in an area of 9502 hectares in 170 villages. In West Bengal and South India (Andhra Pradesh, Karnataka, and Tamilnadu) the programme was implemented in 18928 hectares of 9550 farmers in 165 villages. Yields increased by 10-12% and Insecticide usage was reduced by 35-60% in the participating villages. The IRM strategies were refined and a bulletin was published fordissemination in 201 O. An algorithm was developed to assess resistance risk with individual genes and in dual gene combination. A stochastic Model Bt Adapt II-A was developed and sent to all the project [partners for evaluation and assessment with real time input

parameters.

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

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

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

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

Validation of LC_{50} for populations of *H. armigera* from regions showing unusual LC_{50} values

Ten populations were retested at the LC_{50} value of *cry* 1Ac obtained in the first set of bioassays. Of the ten, two populations showing high LC_{50} values did not confirm to the results of the first bioassay while the rest did.

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

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

Biochemical mechanism mediating resistance! tolerance in field strains of *H. armi"gera*

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

Monitoring changes in baseline susceptibility (development oftolerance) in *H. armigera* against) JK event

Log dose probit assays were carried out on 13 populations of *H. armigera* to determine the LC_{50} and EC_{50} values. 2008-09 data reveal that the populations of *H. armigera* are also developing tolerance to *cry 1Ac* (JK event 1).

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

Sirsa

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

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

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

Insecticide Induced Resurgence

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

5. TECHNOLOGY ASSESSED AND TRANSFERRED

Nagpur

Frontline Demonstrations (FLD)

Cotton based technologies of INM in cotton, cotton based inter cropping with soybean, opening of ridges and furrows for moisture conservation, foliar application of nitrogen along with Magnesium sulphate, Zinc sulphate and Borax and detopping for management of leaf reddening disorder in cotton, *G. arboreum* cultivar Turab, *G. hirsutum* cultivar NH 615 and IPM in conventional hybrid NHH 44 and Bt hybrid NCS 145 were demonstrated on farmers' fields. The improved technologies were demonstrated in fields of 145 adopted farmers of Atmuddi, Belgaon and Jalka villages of Warora taluka of Chandrapur District and Khairi, Kosara, Sukali and Takali villages of Yeotmal district. An average seed cotton yield of 1071 kg/ha was obtained with the various demonstrated technologies as against 937 kg/ha with the farmers practice. An increase in seed cotton yield ranged from 11.67 to 42.80 per cent with an average of 14.30 per cent. Spraying with power sprayer and battery operated sprayer was demonstrated. Battery operated sprayer showed better efficiency without spray drift and covered more surface area with fine spray. Cotton stalk slasher was demonstrated for improving the organic content in the soil.

Coimbatore

Demonstration of Multi-tier cropping system for enhanced profitability and sustainability in cotton

The newly developed cotton based multi-tier system (cotton+radish+beet root+coriander)was demonstrated in Field no 20 of main farm. Hybrid cotton is followed at 120 x 45 cm. Two ridges at 60 cm apart are formed making 120 cm. Cotton, radish, beet root and coriander are planted on 4 sides of the 2 ridges in sequence. Periodic harvest of intercrops (Coriander at 35 DAS, Radish at 45 DAS and Beet root at 75 DAS) resulted in less competition within the components of multi-tier crops leading to yield equal (21.5 q/ha) to sole cotton (22.1 q/ha). Per hectare gross return of Rs. 1,18,440 was realized from multi tier intercropping as compared to sole cotton raised plot of Rs 44,200/ha.

Low cost drip irrigation system in cotton use of micro tubes & poly-tubes

Even though drip is an acceptable technology, its adoption by Indian farmers, is very slow mainly due to high initial installation cost of the system especially for annual crops including cotton. Thus, developing low cost drip irrigation system by suitable means is of immense help for wider adoption of this technology. After three years of testing and subsequent modification, two low cost drip systems (micro tube and poly tube drip systems) were developed for cotton successfully at CICR, Coimbatore. In micro tube drip system, Cotton is planted in paired rows (60/120 cm) and single lateral (LLDPE) is placed in the middle of the two paired row (60/120-60/120). Micro-tubes are connected to the laterals to deliver water on either side of the pair to supply water for two plants**.** Polytube drip system, polytubes (150 gauge thickness) punctured at regular intervals (60 cm) on single side, tied by waste cloth to avoid jet action are placed in between the paired row/single row. Microtubes (Rs 32,000/ha) and poly tubes (Rs 17,000/ha) drip systems are 49 and 73 per cent cheaper respectively as compared to the existing drip system (Rs 62,750/ha). Water saving to the tune of 44 per cent is achieved following adoption of low cost drip system.

Sirsa

Demonstration of newly released *arboreum* hybrid CICR 2

Demonstration of *G. arboreum* hybrid CICR-2 was conducted at 24 farmers' fields. In the FLD plots as well as in the check plots, average of 5.3 sprays were resorted to. The hybrid CICR-2 out yielded the other cultivars grown by the farmers with 5.0 -29% yield increase.

Demonstration of newly released *G. arboreum* variety CISA 310

The newly released *desi* variety CISA 310 was demonstrated at four farmers' fields. In case of CISA-310 and local cultivars, similar number of sprays and other practices were followed. In the demonstration plot, CISA-310 recorded the average seed cotton yield of 11.25 q/acre as compared to 10.12 q/acre in the traditional varieties with an increase of 11%.

Demonstration of intra-*hirsutum* hybrid CSHH 198

The hybrid CSHH 198 was demonstrated at seven farmers' fields. In the FLD plots, 6.1 sprays were done, while in farmers practice 5.3 sprays were done. For yield comparison, the hybrid CSHH 198 out yielded the other cultivars grown by the farmers with an

increase of 12.27%.

Hybrid seed production of CICR 2 and CSHH 198 at Farmers' field: Front Line Demonstrations on hybrid seed production were conducted in the fields of Smt Manpreet Kaur, Smt Lalita Devi and Smt Kaushalaya Devi, wherein profit of Rs 88050, Rs 85600 and Rs 80625 per acre respectively were recorded.

Integrated Pest Management (IPM) Technology

The average population of sucking pests in IPM was comparatively less than non-IPM practices both in varieties and Bt cotton hybrids but the damage to the fruiting bodies like square and bolls is significantly more in non-IPM fields (3.46 & 3.49%), whereas the population of natural enemies like spider, *Chrysoperla* and Coccinellids remain the same. The maximum pheromone traps catch (50.64/traps) was found to be in *Spodoptera litura* followed by *Pectinophora gossypiella* (+18.39/traps), while it was found minimum in *Helicoverpa armigera* (0.07/traps) and the trap catch of *Earias* spp (+0.67/traps). The average yield obtained in IPM and non-IPM plots of Bt cotton hybrids was 28q and 25.5 q/ha as but it was 23 and 22 q/ha in IPM and non-IPM plots of varieties. The number of sprays applied both in IPM and non-IPM are 5 but in non-IPM plots the mixture of insecticides was used. The total reduction in cost in IPM plots of Bt cotton hybrid and varieties was Rs 2920. The net profit gained per hectare was Rs.55750 and Rs. 46767 in IPM and non-IPM plots of hybrids alongwith C:B ratio of 1:5.58 and 1:4.10. Simultaneously, in case of varieties, the net profit per hectare Rs. 45625 and 40280 in both IPM and non-IPM plots with a C:B ratio of 1:5.50 and 1:4.08, respectively.

FLD on Implement Demonstration

An increase of 5.88 % in seed cotton yield/ha 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 pests. The use of rotavator was more beneficial in term of inter cultivation and removal of weeds between the rows as compared to the cultivator being used by the farmers. The farmer got 27.0 q/ha while using deep plough and Rotavator with farmers' practices yielding 25.5 q/ha with more number of sprays.

6. EDUCATION AND TRAINING

Training received

(A) Overseas associateship

Dr. Nandini Gokte-Narkhedkar, Principal Scientist was deputed for six months (March 1, 2007 to August 31, 2007) at National University of Ireland, Maynooth under DBT Overseas Associateship (Short Term). Main Area of Research was 'Characterization of genes expressed by insect parasitic nematode, *Steinernema carpocapsae'*. During this period, she worked on identification of Entomopathogenic nematodes by amplification of ribosomal 18 ITS, Biolistic Trasformation of Nematodes, RNAi in all strain of *Steninernema Carpocapsae* and Expression of RIC1 Gene.

(B) National Trainings

Name of Scientist	Name of the Course	Place	Period
Coimbatore			
Dr. S. Manickam Dr. K. Sankaranarayanan	Training programme on e- learning in Agriculture	TNAU, Coimbatore	26th Nov. to 6th Dec., 2007
Dr. S. Usha Rani	Training programme on Commercial Agriculture	TNAU, Coimbatore	21st Jan. to 10th Feb., 2008
Dr. K. Rathinavel	Short course on Strategies for upgrading marginal seed lots	TNAU,Coimbatore	21st Jan. to 30 Jan., 2008
Dr. K. P. M. Dhamayanthi	Training programme on DUS testing for plant variety protection-Principles and procedures	New Delhi	26th Feb. to 3rd March, 2008
Sirsa			
Dr. S. K. Verma	Training programme on Bioinformatics	CCMB, Hyderabad	12 Sep. to 18 Sep., 2007

Training Imparted

Nagpur

Training on cotton production technology

One day training programme was organized on cotton production technology sponsored by ATMA, under ICDP programme at CICR, Nagpur for two batches of farmers from Guntur and Srikrishna district, (A.P.). The training programme was attended by 120 farmers and extension workers. One more training programme of two days duration was organized for the farmers from Pandhurna, M.P. An eight day National Level, Model Training Course on Insecticide Resistance Management was organized on behalf of the Directorate of Extension, Ministry of Agriculture at CICR Nagpur between 23rd - 30th Oct 2007.

Coimbatore

Certificate Course on Cotton Production Technology

A certificate course on cotton production technology for cotton farmers was organized at the CICR, Regional Station, Coimbatore in collaboration with the Directorate of Open and Distance Learning, Tamil Nadu Agricultural University, Coimbatore. It was organized over a period of two months at fortnightly intervals from October-December, 2007 with field, laboratory and outreach activities so that the farmers stand to gain additional knowledge and know-how of cotton cultivation practices. Around 20 farmers from the CICR adopted villages of Tamil Nadu participated

in the training program.

Model Training Course on Cultivation of Extra Long Staple Cotton (ELS)

A model training course on cultivation of extra long staple cotton (ELS) at Coimbatore for Agriculture Development Officers of different states was organized at CICR, Regional Station, Coimbatore with the sponsorship of the Directorate of Extension, Department of Agriculture and Cooperation, Govt. of India during December 15-22, 2007. Around 15 trainees from different State Departments of Agriculture participated in the training programme, wherein lectures were delivered by eminent Scientists, personnel from private sector R & D; besides, Scientists from CICR, Nagpur and Coimbatore delivered special lectures on Status of ELS Cotton in India and world on this occasion. An electronic version of all lectures was compiled and edited by Dr. N. Gopalakrishnan, Dr. S. Manickam and Mr. M. Sabesh, CICR, Regional Station, Coimbatore and released for use by participants.

Sirsa

Bt Cotton Training Programme

Bt Cotton Training Programme was organized jointly by National Centre for Integrated Pest Management (NCIPM), New Delhi and Central Institute for Cotton Research, Regional Station, Sirsa from Oct. 10-17, 2007. Twenty participants from North Zone (Rajasthan, Haryana & Punjab) participated in the programme. The programme, sponsored by DAC, Ministry of Agriculture, Govt. of India.

Training On Cotton Production Technology

Six state level training programmes of two days duration were organized on 'Cotton Production Technology' under implementation of Action Plan of ICDP Mini Mission-II for Technology Mission on Cotton. These programmes were organized on Nov. 16, 17, 21, 22, 28, & 29, 2007. These training programmes were attended by officials of Haryana State Agriculture Department. A capsule of ten lectures i.e. four in Crop Improvement, three in Crop Production and three in Crop Protection technologies was prepared for these programmes. The training programmes were coordinated by Dr. S. K. Verma, Sr. Scientist. A Training Manual compiled and edited by Dr. S. K. Verma and Dr. D. Monga for state level training on Cotton Production Technologies-2007 was also supplied to the participants for further use.

Training imparted to HAFED and NITMA scouts

A training was organized on 9th July at the Station. Dr. D. Monga, Principal Scientist & Head Regional Station, Sirsa welcomed the incharge of HAFED and NITMA and the scouts and gave brief introduction and achievements of the station. Later Dr. O. P. Tuteja briefed about promising varieties and hybrids of cotton in north zone. Then Drs. K. L. Chhabra, S. L. Ahuja, P. Jeyakumar talked on agronomic practices, Bt cotton and insect pest of cotton and their management. Dr.D.Monga apprised them about diseases of cotton and their management.

Training on Cotton Production Technology & Mealy Bug Management

A two days state level training programme was organized on cotton production technology and Mealy bug Management under implementation of Action Plan of ICDP Mini Mission-II for TMC. Five training programmes were organized with their dates mentioned as under.

1. 05-02-08 & 06-02-08
2. 12-02-08 & 13-02-08
3. 18-02-08 & 19-02-08
4. 25-02-08 & 26-02-08
5. 27-02-08 & 28-02-08

These training programmes were attended by officials of State Agriculture department of Haryana. A capsule of ten lectures i.e. four in Crop Improvement, one in Crop Production and five in Crop Protection technologies covering mealy bug management area was prepared to impart these training. All the scientists of this Regional Station and agronomist from CRS, CCSHAU, Sirsa were involved in imparting these trainings. These training programmes were conducted under the direction of Dr. Monga, Head, CICR, Sirsa whereas Dr. S. K.Verma, Sr. Scientist, coordinated it. In addition to this a Training Manual compiled and edited by Dr. S.K. Verma and Dr. D. Monga for state level training on cotton production technology Mealy bug Management 2008 was also supplied to the participants for their further use.

7. AWARDS AND RECOGNITIONS

Chaudhary Devi Lal Outstanding AICRP Award

All India Coordinated Cotton Improvement Project of ICAR with its headquarters at CICR, Regional Station, Coimbatore has been awarded the prestigious Chaudhary Devi Lal Outstanding AICRP Award for the year 2006 and the Coveted Award was presented to Dr.N.Gopalakrishnan, Project Coordinator (Cotton Improvement) and Head, CICR, Regional Station, Coimbatore on 16th July, 2007 (ICAR Foundation Day) by the Hon'ble Union Agriculture Minister in the august presence of Hon'ble Minister of State for Agriculture and Hon'ble Director General of ICAR in New Delhi. This is a joint venture endeavour and all the Scientists and other personnel at CICR, Nagpur, and its Regional Stations at Coimbatore and Sirsa besides the AICCIP Scientists and Staff were commended for high yielding varieties/hybrids, cotton production and protection technologies. The establishment and development of AICRP on Cotton has led to development of many deliverable technologies and implementable farm practices for sustainable income to farm families and livelihood security to rural womenfolk.

NAAS Associateship

Dr. K. K. Bandyopadhyay, Sr. Scientist (Soil Science), CICR Regional Station, Coimbatore was selected Associate of the National Academy of Agricultural Sciences (NAAS), New Delhi under Natural Resource Management Section for a period of 5 years i.e. from 1.1.2008 to 31.12.2012.

Environmentalist of the year 2007

Dr. J. Gulsar Banu, Sr. Scientist (Nematology), CICR Regional Station, Coimbatore was awarded Environmentalist of the year 2007 by National Environmental Science Academy , New Delhi.

Fellow award

Dr. D. Monga, Head, CICR Regional Station, Sirsa and Dr. S. L. Ahuja, Principal Scientist, CICR Regional Station, Sirsa were Conferred Fellow award of Cotton Research and Development Association.

Certification of appreciation

Dr. C.S. Praharaj, Sr. Scientist (Agronomy), CICR Regional Station, Coimbatore has received Certification of appreciation at National Seminar on "INM in Rainfed Agro-ecosystem" at CRIDA, Hyderabad during 3-4th March, 2008 following presentation of a research article entitled "Sustaining cotton acreage and productivity through *ex-situ* and *in-situ* management of farm wastes in semiarid tract of western Tamil Nadu".

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	NSP
Development of *cry* 1 A(a) gene construct	NBRI
Supply of gene construct and molecular evaluation of transgenic plant.	NRC Plant Biotechnology
DNA finger printing of cotton	NRC DNA Finger Printing
Insecticide resistance and genetic diversity in sucking pests	DBT funded IIHR Bangalore and UAS Dharwad
Efficacy of lectins on sucking pests	NIMITLI project with CISR Institutes
Technology for pink bollworm management	NCIPM, New Delhi

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 Trials

- Ten National trials with an objective of improvement of *G. hirsutum* and *desi* varieties and intra *hirsutum* interspecific and *desi* hybrids were conducted during the year 2007-08.
- In the initial evaluation trial of *G. hirsutum* genotypes P 57-6 recorded the highest yield in both North and South Zones. BS 279 and GISV 218 were promising in both Central and South Zones. Under rainfed situation, TSH 9975 was promising in Central and South Zones.
- Among the conventional intra *hirsutum* hybrids, ARBHH 51 in North and Central Zones, NSPL 423 and RAHH 255 in Central and South Zones were promising. Under rainfed situation, DHH 0761 was promising in both Central and South Zones.
- Among the interspeficic *(G.hirsutum* x *G.barbadense)* hybrids JKCHB 216 was promising in both Central and South Zones.
- Among the *G. arboreum* varieties, LD 937, FDK 118 and CASA 294 were promising under North Zone conditions under rainfed situations. AKA 0110 and CINA 347 in Central Zone and DLSa 1004 and RAAS 8 in South Zone were promising.
- In the *desi* hybrid trial, FMDH 8 was promising in North and South Zone. In Central Zone, JKCDH 505 recorded the highest yield. Raj DH 279 was promising in both Central and South Zones.

North Zone Trials

- Bihani 161 and H 1300 and LH 2111 were the promising *G. hirsutum* varieties in the varietal trial.
- Among the intra hirsutum hybrids, SAHIB 274 and SVHH 139 were promising.
- In the Coordinated varietal trial, *G. arboreum* genotypes CISA 614 recorded the highest yield followed by FKD 124.
- Among the *desi* hybrids, FMDH 7 and KR 64 were superior to the check varieties.

Central Zone Trials

- In the *G. hirsutum* varietal trial, varieties GSHV 01/1338, CNH 012 and TCH 1705 under irrigated conditions and GSHV 01/26, KH 155 and NH 630 under rainfed situations were promising.
- Among the *G. arboreum* genotypes, GAM 67, GAM 141 and JLA 1799 were promising.
- Among the intra *hirsutum* hybrids, ARCHH 8188, GGCH 70 and Tulasi 27 under irrigated conditions and PMCH 99, MLCH 318 and DHH 66 under Rainfed conditions were promising.
- Among the interspecific hybrids JKCH B 214 (H x B hybrid) and GGCH 81 (*desi* hybrid) were promising.

South Zone Trials

- *G. hirsutum* genotypes ARBH 813 and RAH 216 were promising in the Co-ordinated irrigated Vareital trial. *G. arboreum* genotypes KWA 2-3 and DLSa 102 were superior to the zonal and local checks in seed cotton yield and fibre quality.
- Intra *hirsutum* hybrids KDCHH 712, ARCHH 9770, JKCH 2245 and SSB3 were promising under irrigated conditions.
- Inter specific *(G. hirsutum* x *G. barbadense*) hybrid JKCHB 215 and PSCHB 901 were superior to the check hybrid DCH 32 in seed cotton yield and fibre strength.
- Among the *desi* hybrids KR 32, GGCH 81 and NACH 12 were promising.
- Among the *G. herbaceum* genotypes DDhc 1001 was superior to the check variety Jayadhar.

Crop Production

- Integrated weed control practice *viz.*, Pendimenthalin @ 1.0 kg a.i./ha pre-emergence + hand weeding at 30 and 60 DAS followed by Fluchloralin @ 1.00 kg a.i./ha pre + Quizalofop-ethyl @ 0.05 kg a.i./ha at 30 and 60 DAS are effective weed control technology at Surat.
- At Rahuri and Lam, although higher yield was realized with the farmers' practice (HW at 20, 40 &

60 DAS and again interculture at 45 & 90 DAS), yet Pendimenthalin / Fluchloralin + Quizalofop-ethyl at the above dose amd time was economical and effective. At Dharwad, Pendimenthalin @ 1.5 kg a.i./ha pre +Quizalofop-ethyl @ 0.05 kg a.i./ha at 30 and 60 DAS+HW at 45 DAS was seen the best.

- Application of recommended dose of NPK along with FYM @ 10 t/ha at Khandwa, and that (RDF) with 5 t FYM produced highest seed cotton yield at Siruguppa.
- Foliar feeding of $MgSO_4$@ 1.0 % + $ZnSO_4$ @ 0.5% improved the seed cotton yield at all the locations in comparison to individual micronutrient sprays including that in control.
- Full dose of MOP at sowing at Sriganganagar and two sprays of 3% KNO_3 at Kanpur resulted in realizing significantly higher seed cotton yield.
- Three sprays of 3% KNO_3 gave significantly higher seed cotton yield at Banswara, Surat, Junagarh and Siruguppa where as four sprays of 2% KNO_3 and four sprays of 3% KNO_3 showed its superiority at Nanded and Indore, respectively.
- A combined application of N, P, K, S and Zn yielded higher over the rest of the treatments at Sriganganagar.
- A combination of INM components *viz.*, FYM @ 5 t/ha, green manuring of *dhaincha in situ*, Azotobactor, Azospirillum and PSB (seed treatment) to cotton is the best under cotton-chickpea crop sequence at Rahuri.
- In a fertigation trial, higher seed cotton yield was realized with the application of 125% N and K applied as 10% basal + 90% from 30-120 days in 9 splits (1802 kg/ha) followed by 125% N and K applied as 10% basal + 90% from 30-120 days in 6 splits. Quality parameters were not influenced by different fertigation treatments except strength which was higher.
- Application of 60 kg N /ha, 40 kg S/ha and vermicompost @ 1.25 t/ha, Azospirillum and PSB was effective in cotton under rainfed condition at Indore.
- Seed cotton yield was significantly higher with recommended plant protection measures than with bio-pesticides only at Khandwa, Rahuri and Nanded.
- Higher seed cotton yield (1882 kg/ha) was obtained by detopping at 65 DAS as compared to the control (1495 kg/ha) at Khandwa.
- Highest seed cotton yield of 1593 kg/ha was recorded with single row 80% ET but it was at par with single row 60% ET, paired row 80% ET and paired row surface method at Nandyal.
- Application of Mercaptethyl amine has been found to increase seed cotton yield.
- Seed cotton yield and quality obtained under early planted condition was significantly higher over that in late planted situation.
- Foliar spray of $CaCl_2$ 0.25% + KNO_3 0.5% sprayed at peak flowering and boll development stages (twice) was shown to increase the yield significantly over control and was supported by observations on biophysical parameters like photosynthesis, stomatal conductance, transpiration rate, leaf temperature and relative water content.

Crop protection

Entomology

- Cultures tolerant to jassid and bollworms were identified from breeder's material from three cotton growing zones of India.
- In North Zone, among the sucking pests, jassid alone severe in Ludhiana, while other sucking pests were very low in all the centres. Spotted bollworm was at moderate level (1.4 to 5.1/ 5 plants) and pink bollworm was high (2.2 to 7.0/ 20 green bolls) in Sriganganagar, while *Heliothis* and pink bollworm were almost nil in all the centres.
- Except Nanded all the centres in Central zone recorded moderately higher level of jassid population, 6.3 to 18.7 / 3 leaves in Banswara, 6.2 to 15.4 in Surat and 6.8 to 10.9 in Rahuri. Nanded recorded higher population of thrips (36 to 90 / 3 leaves) followed by Rahuri (30 to 39). Junagadh recorded higher population of whitefly (39 to 62 / 3 leaves), while it was very low in other centres.
- Spotted bollworm was at moderate level in Khandwa (2.1 to 5.9 / 5 plants), Bhawanipatna (5.0 to 9.2) and Akola (3.5 to 10.5). Very high population of pink bollworm recorded in Akola (7.3 to 45.3 / 20

green bolls) followed by Khandwa (1.7 to 8.3), Rahuri (2 to 10), while it was almost nil in other centres.

- In South zone, Dharwad recorded higher population of aphid (34 to 128 / 3 leaves), Jassid (6.1 to 7.8) and thrips (30 to 56), while all other centres recorded very low population of sucking pests.
- Mealybug which was originally considered as minor pest emerged as a major key pest and poses severe threat to cotton crop. Mealybug was found almost in all the centres of the three zones. Low temperature and high humidity favours the build up of pest. Discarding the uprooted infested plants, unnoticed infestation in the border rows, weed host and extended duration of cotton crop with irrigation and fertilizer, unfavourable abiotic factors etc. helped faster development and spread of the pest.
- New insecticides BYI 08330, SYN 13623 and spinosad at 187.5 ml were effective against sucking pests and recorded higher yield 55.8, 55.2 and 48.5 per cent, respectively over check.
- The treatments spirotetramat and spirotetramat + imidacloprid were found effective against mealy bug and recorded significantly higher yield of 11.78 and 10.59 q/ha as compared to 6.08 q/ha in control.
- Spinosad and Bt cotton treatments were effective against bollworms and recorded 46.0 and 39.0% higher yield over control, respectively.
- Adoption of IPM with Bt cotton hybrids revealed an increase of 12.7 % net returns *viz*., Rs. 37,097/ha as compared to Rs. 32,911/ha in non IPM with the same Bt hybrids.

Plant pathology

- Cotton Leaf Curl Disease (CLCuD) continued to be the major disease of the North Zone States of Punjab, Haryana and Rajasthan affecting both Bt and non Bt cotton crops with the disease intensity varying from traces to 100 per cent in Punjab and traces to 80 per cent in Haryana and Rajasthan.
- High incidence of Alternaria leaf spot (ALS) was observed in Maharashtra (up to 24.66 %), Karnataka (40.00 %) and late in the season in Tamil Nadu (85.62 %).
- Grey Mildew (GM) was the important disease of cotton in Maharashtra (Max 63.33%), Karnataka (30.00%) and Andra Pradesh (19.00 %).
- Myrothecium leaf spot (MLS) was an important disease in Madhya Pradesh recording a maximum incidence of 34.00 %.
- Bacterial leaf blight (BLB) was a major disease in Gujarat (Max. 30.00 %), Madhya Pradesh (36.00 %), Maharashtra (55.00 %) and Andra Pradesh (26.00 %).
- Ten entries from various screening trials have been found resistant to Cotton Leaf Curl Disease.
- The test fungicide, Taqat 75 W.P., was effective at both doses *viz*. 500 and 750 g/ha of formulation and on par with the standard fungicide, Propiconazole @ 0.1% in significantly reducing the incidences of alternaria leaf spot in Faridkot, Junagadh and Dharwad and of Myrothecium and Cercospora leaf spots in Faridkot. Taqat @ 750 g/ha gave better control than Propiconazole against grey mildew in Dharwad.
- The test bactericide, Copper Hydroxide 46.1 % DF @1000, 1250 and 1500 g/ha of the product significantly reduced bacterial leaf blight incidence and on par with the standard Copper oxychloride plus streptocycline. Highest concentration of the product gave the maximum control of the disease. It was also effective against Alternaria leaf spot.
- Seed treatment with the talc formulation of *Pseudomonas fluorescens* Pf 1 @ 10 g/kg seed followed by foliar spray of the same on 30, 40, 50, 60, 70, 80 and 90 DAS has once again proved effective in reducing the incidences of alternaria leaf spot and grey mildew.
- Spraying of Carbendazim @ 0.1% against grey mildew and Propiconazole @ 0.1% against alternaria leaf spot on 50, 65, 80 and 95 DAS gave maximum control of the diseases. An yield loss of 16 per cent in seed cotton occurred due to grey mildew when no prophylactic measure was taken up.
- Similarly spraying of Propiconazole (0.1%) against Myrothecium leaf spot and Streptocycline (100 ppm) plus Copper oxychloride (0.3%) against Bacterial Leaf Blight on 35, 50, 65, 80 and 90 DAS gave maximum control of the diseases and averted yield losses respectively of 26.8 per cent and 39.3 per cent.

Front Line Demonstration in Cotton

During the year 2007-08, 1400 Front Line Demonstrations (FLDs) on Cotton Production Technology, 24 unit demonstrations on cotton Integrated Pest Management (IPM) and 22 unit demonstrations on Farm Implements were conducted all over India under the aegis of All India Coordinated Cotton Improvement Project with supervision by Dr.N.Gopalakrishnan, Project Coordinator (Cotton Improvement) and Head, CICR Regional Station, Coimbatore.

North Zone

Punjab Agricultural University, Faridkot

The technologies demonstrated under cotton production technologies were improved cotton varieties / hybrids MRC 6304 Bt, RCH 314 Bt, RCH 134 Bt, MRC 6301 Bt, PAU 626 H and JK 1947, optimal plant population, time of sowing, weed control and balanced nutrition. In all the demonstrations, the demonstrated hybrids / varieties recorded higher seed cotton yield than the respective checks. It was observed that there was 10-50% per cent increase in the mean yield of Bt hybrids compared to respective check hybrids. Demonstration on cotton IPM was conducted in an area of 50 hectares in 12 different units using the PAU - IPM module. Overall, there was 16.3% increase in seed cotton yield due to IPM demonstrations. Demonstrations on farm implements *viz.*, disc harrow, aero blast sprayer and rotavator were conducted in an area of 48 hectares. Also, hybrid cotton planter and disc harrow were demonstrated in an area of 18.4 hectares.

Haryana Agricultural University, Hisar

The technologies demonstrated under cotton production technology were yield maximization of cotton varieties / hybrids AAH 1, HD 123, HD 324, H 1117 and H 1226. The average range of yield increase in these improved varieties and hybrids was between 10 to 12 %. One unit of demonstration on cotton IPM was carried out on farmers' fields of Hisar district. Deep ploughing, selection of variety, seed treatment, balanced use of fertilizer, regular monitoring of pest, spray at ETL level, proper dose of pesticide and water were adopted in the IPM demonstration. Highest seed cotton yield (2190 kg/ha) was obtained in the demonstration field of Shri. Prem Singh S/o Chalu Ram of Village Dhiranwas. In IPM trials, 10.78 per cent higher seed cotton yield was recorded as compared to the local farmers' practices. To demonstrate implements like Sub soiler for deep ploughing and Rotavator for hoeing one unit of demonstration was conducted in the Village Shahpur Begu of Sirsa district. It was observed that Shri. Ramdev S/o Nanak Ram picked (1570 kg/ha) seed cotton yield against (1350 kg/ha) local check. On average basis, seed cotton yield in Farm implements trials was 10% higher than farmers' practices.

Rajasthan Agricultural University, Sriganganagar

Front line demonstrations were conducted during *Kharif* season of 2007 on different farmers' fields of Sriganganagar and Hanumangarh districts. *G. hirsutum* Bt hybrids RCH-134, MRC-6029, MRC-6304, Variety RS-810, RST-9 G. *arborium* hybrid Raj DH 9, AAH-1, CICR-2 and variety RG-8 were demonstrated as against local cultivars Bikaneri nerma, RST-9 and F-846. Improved varieties / hybrids recorded an average of 21.53% higher seed cotton yield than local cultivars. One unit of demonstration was conducted on cotton IPM. During the season 4 and 6 sprays were given to the crop raised under IPM and non-IPM, respectively. The average seed cotton yield was recorded at 20.30 q/ha in IPM as compared 18.50 q/ha of non-IPM. Considering the total income and expenditure incurred on IPM and N-IPM fields, IPM led to more profit (1:2.63) than farmers practice (N-IPM) (1:2.15).

MPUAT, Banswara

The technologies demonstrated under production technology were improved varieties / hybrids H 8 and PA 255. One unit of demonstration was conducted on IPM with the techniques *viz.*, Deep summer ploughing, seed treatment, Okra as trap crop, hand picking of early shoot borer damage, use of pheromone traps and use of neem products. Under the demonstration on farm implements, the implements like Rotary tiller, ridger plough, power weeder, power sprayer, local improved weeder, wheel hoe and tractor mounted high capacity sprayer were demonstrated.

Central Institute for Cotton Research, Sirsa

The newly released cotton hybrid CICR 2, variety CISA 310, intra-*hirsutum* hybrid CSHH 198 and hybrid seed production of CICR 2 and CSHH 198 were

the cotton production technologies demonstrated during the year. One unit of demonstration on cotton IPM with the technologies *viz.*, deep ploughing after harvest of the wheat, FYM or decomposed compost application, recommended fertilizers application, resistant /Bt hybrid/variety against insect- pest and diseases, use of pheromone traps, application of pest management interventions based on pest surveillance and Economic Threshold Levels (ETL) and use of plant products and bio-agents were demonstrated. The average yield obtained in IPM and non-IPM plots of Bt cotton hybrids was 28 q and 25.5 q/ha as but it was 23 and 22 q/ha in IPM and non-IPM plots of varieties. The net profit gained per hectare was Rs.55750 and Rs. 46767 in IPM and non-IPM plots of hybrids along with C:B ratio of 1:5.58 and 1:4.10.

Central Zone

Navsari Agricultural University, Surat

During the year 2007-08, seventy five demonstrations on cotton production technology, two units demonstration on cotton IPM and one unit demonstration on farm implements were conducted by NAU, Surat. The improved varieties/ hybrids demonstrated were G.Cot Hy 12, G.Cot Hy 10, G.Cot 23, G.Cot 21, approved Bt cotton hybrids, balanced nutrition and correct spacing.

Junagadh Agicultural University, Junagadh

Fifty demonstrations on cotton production technologies, one unit demonstration on cotton IPM and one unit demonstration on farm implements were conducted by JAU, Junagadh during the year 2007-08. The varieties / hybrids demonstrated were Vikram 5, Ankur -9, Alto 377, Gopal, Rasi-sai. Parash Brahma, MRCH 6301, RCH 2, RCH 2BG II, Mallika, Vijai 1, Tulsi 117, RCH 118 (Sai), Ajita 155, Mallika 207, MRC 7301, Ganesh 205, Parash bramha, Dolarmaruti (441 BG II), Bunny 245, MRC 7351, Gold 50, Narmada 145, Deviraj, intercropping with greengram, groundnut and urad bean, alternate furrow irrigation and skipping DAP application. Results of varietal FLDs indicated 9.60 per cent average yield increase over check with a range of 2.33 to 50.00 per cent. Demonstration on IPM saved an average of five pesticides sprays.

J.N. Krishi Vishwa Vidyalaya, Khandwa

Thirty three demonstrations conducted on Integrated Nutrient Management in cotton produced on an average 29.29 q/ha seed cotton as compared to 25.95 q from the farmer's practices. Seven front line demonstrations were conducted on intercropping pigeon pea with cotton in the ratio of 4:2 rows, respectively. The results indicated that intercropping of pigeon pea with cotton recorded monetary returns in the range of Rs 76130 - 48200/-per hectare and the average returns were Rs 61515/-per hectare. The sole crop of Bt cotton recorded maximum monetary returns of Rs 66250/- while minimum was Rs 42500/- per hectare.

J.N. Krishi Vishwa Vidyalaya, Indore

JNKVV, Indore had conducted forty demonstrations on cotton production technology and one unit demonstration on farm implements. The technologies demonstrated under production technology were improved cotton varieties / hybrids *viz.,* VICH 05, VICH 15, VICH 09, MRC 6301 Bt, DCH 32, JK 35, Phule 358, IH 63, intercropping with maize (2:1) ratio and Integrated Nutrient Management. Results indicated that the improved varieties / hybrids recorded on an average 12.4% to 25.3% higher yield over farmer's practices. Intercropping system of Cotton + Maize 2:1 row ratio was found more remunerative by Rs. 12620/ha to Rs. 15910/ha more income as compared to sole crop of Cotton/Farmer's practices. The INM practices in cotton recorded an average range of 13.8 % to 27.0 % higher yield over application of chemical fertilizer/farmers' practices. IPM demonstrations recorded 19.5% to 30.2 % higher yield as compared to farmer's practices/pest management through chemicals.

PDKV, Akola

One hundred and twenty demonstrations on cotton production technology, two unit demonstrations on cotton IPM and one unit demonstration on farm implements were conducted by PDKV, Akola. Improved varieties / hybrids, soil management, *in situ* soil moisture conservation, crop canopy management, clean cotton pickings, organic cotton production and plant spacing were the technologies demonstrated.

MAU, Naded

One hundred and twenty demonstrations on cotton production technology, two unit demonstrations on cotton IPM and one unit demonstration on farm implements were conducted by MAU, Nanded.

Improved *desi* cotton varieties, plant population, INM, strip cropping of red gram (6:2), intercropping of green gram (1:1), spraying of micro nutrients, rain water management techniques, spraying of urea and DAP at 45 and 75 DAS and application of organic manures were the technologies demonstrated.

MPKV, Rahuri

The centre had conducted fifty demonstrations on cotton production technology, one unit demonstration on cotton IPM and one unit demonstration on farm implements. Intercropping, improved varieties and hybrids, INM and IDM were the technologies demonstrated under the programme.

OUAT, Bhawanipatna

One hundred and fifty demonstrations on cotton production technology, one unit of demonstration on cotton IPM and one unit of demonstration on farm implements were conducted by OUAT, Bhawanipatna. Integrated cotton management practices *viz.*, application of 12 cart loads of FYM, supply of arhar seeds for inter-cropping, fertilizer application based on soil test report, use of tricho cards, pheromone traps and HaNPV, foliar spray of NAA at flowering period, foliar spray of DAP at boll formation stage and clean picking were demonstrated. The FLD farmers obtained gross return of Rs.35,111/- for a lower cost of cultivation of Rs.11,938/- as compared to Rs.29,618/- for an investment of Rs.12,538/- in the farmer's own practice. The cotton equivalent yield advantage was 21.4 per cent in the demonstrated plots compared to the farmers practice. The return per rupee invested was 2.9 in the production technology plots and 2.4 in the farmers' plots.

CICR, Nagpur

Cotton based technologies - INM, inter cropping with soybean, opening of ridges and furrows for moisture conservation, foliar application of nitrogen along with Magnesium sulphate, Zinc sulphate and Borax and detopping for management of reddening of cotton leaf disorder, *G. arboreum* cultivar Turab, *G. hirsutum* cultivar NH 615 and IPM in conventional hybrid NHH 44 and Bt hybrid NCS 145 were demonstrated on farmers fields of 145 adopted farmers of Atmuddi, Belgaon and Jalka villages in Warora Taluka of Chandrapur Disrict and Khairi, Kosara, Sukali and Takali villages of Yeotmal district. An average seed cotton yield 1071 kg/ha was recorded with the various demonstrated technologies as against 937 kg/ha with the farmers practice. An increase in seed cotton yield ranged from 11.67 to 42.80 per cent with an average of 14.30 per cent. Spraying with power sprayer and battery operated sprayer was also demonstrated and latter showed better efficiency had lower spray drift, covered more surface area and provided finer spray droplets. Use of cotton stalk slasher was demonstrated for residue management through soil incorporation.

South Zone

ANGRAU, Guntur

The centre had conducted seventy five demonstrations on cotton production technology, two unit demonstrations on cotton IPM and two unit demonstrations on farm implements. Performance of Bt hybrids with improved technologies *viz.*, high yielding Bt hybrids, modified scheduled of fertilizer application (at 30, 50, 70 DAS), foliar application of micronutrients (boron @ 0.1% and $Mgso_4$ @1% at 60, 90 DAS) and foliar application of multi 'K' at 60, 90 and 110 DAS were demonstrated as against farmers' practices. FLD plots recorded an average of 39.2 q/ha with net returns of Rs.54068/ha and B: C ratio of 1.7. Under farmers' practice, the productivity was reduced by 5.2 q/ha with net returns of Rs.43059/ha with B:C ratio 1.35. Under IPM demonstration, IPM components like seed treatment with imidacloprid, stem application of Moncrotophos , (1:4) - *s*owing of intercrop of redgram, jowar and maize as guard crops, installation of pheromone traps for monitoring of *Spodoptera*, erection of bird perches, application NSKE thrice during the crop period and need based application of pesticides when the pest was noticed above ETL were demonstrated as against the farmers' practices. By adopting IPM practices, farmers were benefited with higher yield of 36.3 q/ha and Rs. 50102/ as returns as against farmers' practice of 33.2 q/ha with Rs. 41013 returns. Farmers were benefited with an additional income of Rs 0.45 for every rupee spent in IPM when compared with non IPM. Under demonstration on farm implements, cotton stalks were incorporated in the field itself with rotavator. This

practice reduced the labour cost on removal of cotton stalks after pickings and also added organic matter to the soil which improved physical properties of soil. Use of Taiwan sprayer has improved the effectiveness of spray fluid by higher atomization and uniform coverage. Besides the area covered in a day of six working hours has increased by reducing the cost per unit area (ha) to an extent of Rs 700/- over seven sprayings in a crop season.

CRIDA, Hyderabad

The centre had conducted one hundred demonstrations on cotton production technology and one unit demonstration on cotton IPM. The technologies demonstrated were Bunny Bt, Mallika Bt, PCH 2171 Bt, deep summer ploughing, crop rotation, avoiding crop rationing, certified seeds, acid de-linting, seed treatment, timely sowings, weed management, intercrops, removal of crop residues, topping and pest management practices. The APAU-IPM module was used for demonstrations on cotton IPM.

UAS, Dharwad

Seventy five demonstrations on cotton production technology, two unit demonstrations on cotton IPM and two unit demonstrations on farm implements were conducted by UAS, Dharwad. The varieties /hybrids demonstrated were Interspecific hybrids *viz.*, DHB-105 v/s DCH-32, RAHB-87 v/s DCH-32, DHB - 290 v/s DCH-32, Inter *hirsutum* hybrids *viz.*, DHH - 11 v/s DHH-543, *Hirsutum /Arboreum* varieties *viz.*, Sahana v/s DLSa-17 and *herbaceum* varieties *viz.*, DDhc-11 v/s Jayadhar. The other technologies demonstrated were intercropping in cotton (Cotton + beans (1:1)) v/s Sole cotton, 25% N, K and full dose P as basal dose, 50% N and K at 30 DAS and 25% N and K at 60 DAS v/s RDF or Farmers practice, INM, leaf reddening management and Integrated Crop Management. An increase of about 15-30% in the seed cotton yield was obtained due to replacement of old hybrids / varieties with newly released genotypes. The implements demonstrated were Self propelled cotton stalk slasher-with 5 HP diesel engine, cotton stalk shredder with 10 HP motor, Grass cutter/ cotton stalk cutter with 2-extra blades, Cloy gin (Modified), Lilliput gin (4-5 kg capacity), Brahama bullock drawn sprayer, Taiwan sprayer with Konabsu engine (AP Agro. Industries) HTP-Power sprayer and Agrimate- Electric sprayer (Knapsack).

TNAU, Coimbatore

The centre had conducted seventy five demonstrations on cotton production technology, one unit demonstration on cotton IPM and two unit demonstrations on farm implements. The imposed components in Adoptable Srivilliputur IPM (ASIPM) module with the technologies basal application of neem cake @150 kg/ha, seed treatment with *Pseudomonas fluorescens* @ 10 g/kg, soil application of *Pseudomonas fluorescens* @ 1 kg/acre, sowing in ridges and furrows, acid delinting of cotton fuzzy seeds with 100 ml of Sulphuric acid per kg of seeds, drenching with 1% neem oil at 20 DAS, trap crops castor and sunflower, eco-feast crops- Maize and cowpea, installation of pheromone and yellow sticky traps, clipping of terminals at 75DAS and need based application of safer insecticides was demonstrated under IPM demonstrations. The yield in ASIPM based FLD plots, ranged from 1099 to 1638 kg/ha, whereas under farmers' plant protection practices the yield varied between 774 and 1001 kg/ha. The B:C ratio ranged from 1.92 to 2.58 under IPM demonstrations. Under non-IPM, it ranged from 1.05 to 1.40.

CICR, Regional Station, Coimbatore

Twenty five demonstrations on cotton production technology, one unit demonstration each in cotton IPM and farm implements were conducted by CICR, Regional Station, Coimbatore. The technologies demonstrated under production technology were improved cotton varieties Surabhi and Sumangala, Bt cotton hybrids RCH 2Bt and RCH 20 Bt, ELS cotton hybrids DCH 32 and RCH 708Bt, INM, Intercropping with vegetables and Integrated Weed Management. Demonstrations on improved varieties and Bt cotton hybrids increased the seed cotton yield to the maximum of 50 per cent. The IPM module developed by CICR, Coimbatore was adopted for IPM demonstration. Demonstrations on IPM reduced the number of sprays from six to three. Bullock drawn ridger and junior hoe were demonstrated under farm implements. It reduced the cost of weeding to the extent of Rs. 4350/- per hectare.

10. KRISHI VIGYAN KENDRA

Training Achievements

Ninety six short duration (1 to 3 days) on campus and off campus training courses were conducted in different disciplines for 1176 practicing farmers,

504 rural youths and 592 extension functionaries. 2282 participants benefited from the courses.

Similarly, 13 sponsored training courses were organized for 1 to 3 days duration in different discipline like crop production, horticulture, plant protection, veterinary science, home science and extension deputed by sate Agriculture Department Maharashtra, Bank of India, CIPM Nagpur, MAFSU Nagpur, MCED and ICDS Nagpur. In all 550 participants attended the course.

Short duration training courses

Discipline	No of courses	No. of participant			Total
		Practicing farmers	Rural youth	Extension functionaries	
Crop Production	15	199	56	21	276
Horticulture	16	240	36	57	333
Plant Protection	16	159	101	42	302
Veterinary Science	21	216	151	45	412
Home Science	15	165	89	337	602
Extension	13	196	71	90	357
Total	**96**	**1176**	**504**	**592**	**2282**

Sponsored training courses

Discipline	No. of courses	No. of participants	Sponsoring agency
Crop Production	2	37	StateAgrilDeptt., Maharashtra
Horticulture	3	63	State Agril Deptt., MS and MP
Plant Protection	2	46	State Agril. Deptt., AP, MP and CIPM, Nagpur
Veterinary Science	3	64	MCDC, Nagpur
Home Science	2	311	ICDS, Nagpur
Extension	1	29	State Agril. Deptt., Maharashtra
Total	**13**	**550**	

Collaborative Training Progrmmes

On Citrus Production and Protection technology

KVK conducted 14 training programmes on "Citrus Production & Protection Technology", in collaboration with NRCC, Nagpur in 14 Villages of 6 Tahsils of Nagpur District and 315 trainees (P.F. 227, R.Y. 13, EF -77) participated in the programme. Diagnostic surveys were conducted on 42.5 acre of land and 73 farmers were benefited.

On Technique of Soybean processing

KVK conducted three training programmes on "Technique of Soybean processing", in collaboration with ICDS, Nagpur District in 3 tahsils of Nagpur District and 319 Anganwadi Workers, Supervisors and SHGs participated in the programme. In these training programmes, participants were imparted skills of preparation of soy-milk, soy-nut and soy-flour.

Front Line Demonstrations

Fifteen technologies in agriculture and allied fields were demonstrated under FLD in KVK adopted villages namely Mandavghorad and Mangli during 2007-08. Several extension activities like field days, field visits of farmers to FLD demonstrations, group discussions, scientists-farmers meet, etc. were conducted for effective implementation of FLDs. The data on certain production parameters as well as feedback from farmers and visitors was recorded.

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

Sr. No.	Crop/Animal	Technologies Demonstrated	No. of farmers	Area covered (ha)	Yield (q/ha)		% Increase Over FP
					Demo.	FP	
1.	Cotton	NCH 145 Bt + INM	50	20	19.10	13.88	37.60
2.	Soybean	INM	25	10	17.60	14.10	24.82
3.	Pigeonpea	ICPL 87119 (Asha)	25	10	20.27	16.10	25.90
4.	Chickpea	Saki 9516	25	10	13.10	10.25	27.80
5.	Wheat (Timely sown)	AKW 3722 (Vimal)	9	2	32.10	24.30	32.99
6.	Wheat (Late sown)	AKW 1071 (purna)	5	1	25.40	20.29	25.12
7.	Brinjal	Management of shoot and Fruit borer	16	4	205	188	10.3
8.	Chickpea	Management of *Helicoverpa armigera*	15	6	12.8	11.3	13.3
9.	Okra	Varietal Akola bahar	15	6	65.75	57	15.35
10.	Onion	Varietal Akola Safed	19	6	83.52	70.00	19.31
11.	Nagpur mandarin	Rejuvenation of old Nagpur mandarin	13	5	-	-	-
12.	Nagpur mandarin	Nutrient management	13	5	-	-	-
13.	Cowpea & wheat	Reduction of women drudgery through improved sickle	12	-	0.024 ha/hr	0.009 ha/hr	0.015 ha/hr
14.	Cross bred jersey cow	Feed supplementation of diet with mineral mixture in cross bred jersey cows	10	10 cows	9.2 lit/cow/ day	7.5 lit/cow/ day	22.66
15.	Goat	Use of ecto & endo parasiticidal drugs in goat	10	20 goats	Avg. live body wt. - 21.88 kg	Avg. live body wt. - 20.04 kg	9.18
		Total	**139**	**63**			

On Campus Crop Demonstrations

Twenty two crop demonstrations on cotton, pigeonpea, soybean, fodder Jawar, fodder Maize, Lucerne, berseem, vegetables, fruits and flowers were undertaken on KVK's instructional farm. The production and protection technologies of these crops were demonstrated on area ranging from 0.2 ha to 0.4 ha for each crop. Several farmers, farmwomen and extension functionaries from Nagpur district and other states visited these demonstrations and were benefitted.

On Farm Testing

On farm testing for assessment of technology was undertaken for the management of inferior hide quality and increasing the body weight gain in goats. The result revealed that the goats grazed for 6-8 hrs + supplemented with home made concentration feed + sprayed with cypermethrine (1 ml/ liter water) showed significant improvement in live body weight and improved the hide quality as compared to farmers practice i.e. sole grazing + use of lindane powder for ectoparasitic control in goats.

On farm testing was conducted on anaemia in rural pregnant women in the age group of 20- 35 years. The result revealed that the pregnant women supplemented with daily routine diet with green leafy vegetables, soybean flour and jaggary significantly increased the haemoglobin percentage as well as improved the body weight gain which leads to best development and nourishment of foetus as compared to normal diet and recommended diet.

Insecticide Resistance Management(IRM) Project under TMC MM-II

Insecticide Resistance Management (IRM) Project on cotton was started in Nagpur district of Maharashtra state during year 2006-07. In 2007-08, the project has been implemented in 60 villages of 4 tahsils namely, Kalmeshwar, Katol, Narkhed and Saoner of Nagpur district on the fields of 1308 cotton growing farmers covering 1774.6 hectares area. The aim of this project is to establish a sustainable cotton pest management system which will lead to the following goals :

- Overall reduction in insecticidal resistance already developed in cotton bollworms.
- Enhanced pest control efficacy of the recommended insecticides
- Reduce the number of insecticidal sprays and simultaneously reduce the expenditure on crop protection in cotton.

During this year, 60 field workers were appointed and trained in IRM strategies by imparting skill- oriented training and practical demonstrations to implement in the adopted villages at farmer's fields for keeping day to day contact with the client farmers, to get feed-back from them and to disseminate the IRM technology. Several extension activities like field days, farmers meet, group discussions, diagnostic surveys, field visits were conducted. Kisan Melas in four distinct villages of Nagpur district were conducted and the visits of Monitoring Committee constituted by Director, CICR, Nagpur to the cotton fields of adopted farmers were arranged under IRM project. A team of NaLMoT Committee constituted by Ministry of Agriculture, Govt. of India also visited the IRM demonstrations in Nagpur district.

Due to the implementation of IRM strategies under this project, the farmers were convinced to reduce the number of insecticidal sprays from 3.3 to 1.48 approx. Hence, the cost of cultivation has been reduced from Rs. 20700/ha to 19800/ha. Moreover seed cotton yield also increased to 15.05 q/ha from 13.25 q/ha.

Extension Activities

Four field days were organized on cotton, pigeonpea, floriculture and women in agriculture day in which 239 farmers, farm women and rural youths participated. During the year 2007-08, KVK has participated in one Kisan Mela and six National and State level agricultural and animal exhibitions organized by the different organizations throughout the country and displayed KVK activities and cotton production and protection technologies developed by CICR. Eight radio talks and one television shows on various topics of agriculture, animal science, home science and allied subjects were delivered on AIR, Nagpur and Doordarshan Kendra, Nagpur respectively. Three Animal treatment and vaccination camps and one ectoparasitic control and deworming camp were organized in Mangli and Mandavghorad villages benefiting more than 150 farmers. In these camps, 317 animals including goats, cows, buffaloes, bullocks

were treated and vaccinated.

Diagnostic Survey

Twenty nine diagnostic surveys in adopted villages and other villages of Nagpur district were undertaken to suggest the remedies to overcome specific problems in field crops, citrus and animals covering more than 56 ha cropping area and 114 animals in 20 villages of six tahsils of Nagpur district.

Scientific Advisory Committee Meeting

The 11th and 12th SAC meetings of KVK, CICR, Nagpur were held on 25th May, 2007 and 27th Nov, 2007 under the Chairmanship of Director, CICR, Nagpur. More than 20 members from agriculture and allied departments participated

11. GENERAL

11.1 List of Publications

Papers Published in Research Journals

Ahuja, S.L., Dhayal Laxman and JeyaKumar P. (2008). Stability analysis for bollworm complex in *Gossypium hirsutum* L DOI: 10.1007/s10681-007-9504-5 Euphytica.

Ahuja, S.L., Dhayal. Laxman and Ram Prakash (2008). Comparative yield component analysis in *Gossypium hirsutum* parents using fibre quality grouping. DOI: 10.1007/s10681-007-9588-y. Euphytica.

Bandyopadhyay, K.K., Ghosh, P.K., Chaudhary, R.S., Hati, K.M. and Misra, A.K. (2007) Effect of initial profile moisture regimes and N levels on productivity and water and nitrogen use efficiency of wheat in a Vertisol of Central India. Environment and Ecology, 25S (1): 197-201.

Blaise D., Ravindran CD and Singh J.V (2007). Effect of nutrient management practices on growth, fruiting pattern and yield of Asiatic cotton (G. *arboreum* L.). J. Plant Nutr. Soil Science, 170 : 1-8

Dash, A.K., Mishra, B.K., Bandyopadhyay, K.K. and Jena, D.(2007). Transport and transformation of prilled urea and nimin coated prilled urea through soil columns. Ecology, Environment and Conservation.13 (4):815-819.

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Dongre A. B. and Bhandarkar Manoj R. (2007). Introgression and genetic diversity analysis of Indian cotton cultivars by ISSR and RAPD markers, The Indian Journal of Agricultural Sciences, 77(7) :438-42.

Dongre A. B., Bhandarkar Manoj R. and Banerjee Shubha (2007), Genetic Diversity analysis of diploid and tetraploid Indian Cotton cultivars through ISSR and Microsatellite markers, Indian Journal of Biotechnology, Vol 6, pp 349-353.

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Ghosh, P.K., Bandyopadhyay, K.K., Wanjari, R.H., Manna, M.C., Misra, A.K., Mohanty, M. and Subbba Rao, A. (2007). Legume effect for enhancing productivity and nutrient use efficiency in major cropping systems- An Indian perspective: A review. Journal of Sustainable Agriculture. 30 (1): 59-86.

Gulsar Banu, J., Dhara jothi B. and Narkhedkar-Nandini-Gokte (2007). Susceptibility of different stages of cotton bollworm, *Helicoverpa armigera* (Lepidoptera: Noctuidae) to entomopathogenic nematodes. International Journal of Nematology, 17 (1), pp.41-45.

Jeyakumar, P., Chander, S., Singh, A., Jat, M C and Monga, D (2007). Role of light traps in cotton IPM and the effect of lunar cycle. Indian J. Agric. Sci. 77 (5) : 327-328.

Jeyakumar, P., Tanwar, R K., Jat, M C., Dhandapani, A. Bambawale, O M and Monga, D (2007). *Spodoptera litura*: An emerging pest on Bt cotton (*cry* 1Ac) under North Indian conditions. Pesticide Research Journal 19 (2) :197-200.

Meena, R A, Monga D, Rajiv Kumar and Hamid Hasan. 2006. Screening of germplasm for fibre quality traits in American (*Gossypium hirsutum*) and Desi Cotton (*G. arboreum*) Indian Journal of plant genetic resources 19(1) 122-124.

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Sankaranarayanan, K, Praharaj C.S. and Gopalakrishnan N.(2007). Precision Management of water and Nutrient in ELS cotton Production- a review. Journal of Indian Soc. Cotton Improv., 32(3):143-152.

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Santhy V. and Deshmukh R.K. (2008). Methanol stress to evaluate initial seed vigor in cotton. Seed Research, 36 (1): 78-80.

Singh Phundan, Singh V.V. and Singh S.B. (2007). Genetic improvement of cotton in Andhra Pradesh. In Book 'Cotton in Andhra Pradesh' : Edited by N.G.P. Rao, A. Appa Rao and E.A.Siddiq, pp. 72-77.

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Tuteja, O. P., Verma S. K., Singh Mahendar, and Khadi B. M. (2007) Effect of restorer lines and *Gossypium harknessii* based cytoplasmic male sterility on yield and fibre quality traits in cotton. J. Indian Soc. Cotton Improv, 32:41-49.

Tuteja, O.P., Verma S.K., Singh Mahendar and Khadi B. M.. (2007). Effect of Restorer Lines and *Gossypium harknessii* based cytoplasmic male sterility on yield and fibre quality trails in cotton. Journal of the Indian Society for Cotton Improvement, Vol. 32 (1):41-49.

Verma, S.K., Bhutani Seema, Bhatia Pankaj, Jain R.K. and Chowdhury V.K. (2007). Histochemical Gus Assay in Transformed Calli of Cotton (*G. hirsutum* L.). Journal of the Indian Society for cotton Improvement. 32(2): 93-96.

Verma, S.K., Tuteja O.P. and Monga D. (2008). Evaluation for genotype x environment interactions in relation to stable GMS based hybrids of north zone in Asiatic cotton *(Gossypium arboreum* L.) Indian J. Agric. Sci,78(4):375-8.

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11.2 List of on-going Projects

Institute Projects

	Name of the Project	Name of the Project Leader and Associate(s)
	NAGPUR	
	Crop Improvement	
1.	Collection, conservation, evaluation, documentation and utilization of cultivated species of *Gossypium*	PL: Punit Mohan
2.	Conservation of wild species of *Gossypium* and introgressive hybridization for the improvement of cultivated cotton	PL: Vinita Gotmare, Asso.:S.Venilla, M.K. Meshram
3.	Development of long linted and high fibre strength genotypes of *G. arboreum*	PL: T.R. Loknathan Asso.:P. Singh
4.	Breeding and evaluation of upland cotton for improved fibre yield, quality and biotic stress (bollworm and jassids)	PL : S.M. Palve, Asso.:Vinita Gotmare S.Vennila, M.K. Meshram
5.	Genetical and anatomical studies on drought tolerance in cotton (*G. hirsutum*)	PL : Suman Bala Singh Asso.: N.K. Perumal
6.	Development of heterotic pools for superior medium staple in tetraploid cotton (*G. hirsutum*)	PL : S.M. Palve
7.	Studies on genetic enhancement of upland cotton	PL : T.R. Loknathan Asso.: D.K. Agarwal P. Singh, Vinita Gotmare S.Vennila, M.K. Meshram
8.	Improvement of tetraploid and diploid cotton for GOT and fibre properties through population improvement approaches	PL : V.N. Waghmare Asso.: P. Singh, Vinita Gotmare
9.	Studies on development of practically usable cytoplasmic genic male sterility and restorer lines and genetic male sterility system in cotton	PL : Suman Bala Singh
10.	Assessment of seed vigor traits in cotton	PL : V. Santhy Asso.: P.R.Vijayakumari R.K. Deshmukh
11.	Studies on cotton seed with particular reference to germination and dormancy	PL : P.R.Vijayakumari Asso.: R.K. Deshmukh V. Santhy, R.A. Meena K. Rathinavel
12.	Identification of suitable areas in India for quality cotton seed production with better seed health	PL : P.R.Vijayakumari Asso.: M.K. Meshram R.K. Deshmukh
13.	Seed yield and seed quality in *G. arboreum* and *G. hirsutum* varieties with low input management in different soil depths	PL : R.K. Deshmukh Asso.: P.R.Vijayakumari V. Santhy, N.K. Perumal

14.	Molecular mapping of leaf curl virus resistant gene in cotton genome	PL : J. Amudha Asso.: B.M. Khadi, D. Monga G. Balasubramani
15.	Molecular basis of pathogenicity and race-specificity of *Xam* and characterization of antagonists of foliar pathogens of cotton for biocontrol	PL : P.K. Chakrabarty Asso.: M.K. Meshram
16.	Development of Bt transgenic diploid cotton against bollworms	PL : S.B. Nandeshwar Asso.: B.M. Khadi L. A. Deshpande G. Balasubramani, J. Amudha
	Crop Production	
17.	Integrated approach for yield maximization of hybrid cotton under drip irrigation	PL: Jagvir Singh
18.	Long term effect of fertilizer and INM on productivity, soil fertility and quality of rainfed hybrid cotton	PL: Jagvir Singh Assoc: D. Blaise
19.	Effects of foliar-N application on yield and fibre quality and crystal toxin expression in Bt transgenic	PL: D. Blaise Assoc: KR Kranthi
20.	Tillage and green manure effects on growth and yield of cotton and soil properties	PL: D. Blaise
21.	Improving the efficiency of cotton+arhar strip cropping in vertisols	PL: A.R. Raju
22.	Studies on the efficacy of micro nutrients application and moisture management on yield and fibre properties of rainfed cotton	PL: A.R. Raju
23.	Development of package of practices for organic cotton production	PL: A.R. Raju
24.	Physiological evaluation of cotton germplasm under rainfed conditions	PL: M. R. K. Rao
25.	Physiological and biochemical studies on abiotic stress with particular reference to heat and drought in cotton	PL: N. K. Perumal
26.	Effect of nitrogen levels on cry protein and oil content in Bt cotton	PL: Mukta Chakrabarty
27.	Assessment of gossypol content in cotton germplasm	PL: Mukta Chakrabarty
28.	Physiological and biochemical basis of salinity tolerance	PL: M. R. K. Rao
29.	Physiological and biochemical basis of waterlogging tolerance	PL: M. R. K. Rao
30.	Source sink alternation with reference to flower induction as a tool to improve physiology efficiency and productivity in cotton	PL: M. R. K. Rao
31.	Assessing the genotypic variation in water use efficiency and carbon isotope discrimination of cotton : leaf gas exchange and whole plant studies	PL: M. R. K. Rao
32.	Molecular evaluation of cotton germplasms	PL: A.B. Dongre
33.	Molecular evaluation of diploid cotton using PCAR and	PL: A.B. Dongre

	DNA markers	
34.	Study on accessibility to mass media and information technology of potential users in cotton based production system	PL: S. M. Wasnik Assoc.: P. R. Deoghare
35.	Economic analysis of cotton based farming system	PL: P. R. Deoghare
	Crop Protection	
36.	Identification and characterisation of elite germplasm lines against key pests of cotton	PL: S. Kranthi Assoc: V. V. Singh
37.	Biochemical basis of induction of defense related proteins in cotton against the Gram pod borer *Helicoverpa armigera*	PL: S. Kranthi Assoc: S. B. Nandeshwar
38.	Testing of new mulecules: Efficacy of newer insecticide molecules against suckng pests and bollworms of cotton	PL: S. Kranthi
39.	Population and community ecology of cotton entomofauna	PL: S. Vennila
40.	Study of crop pest interactions for improving cotton pest management	PL: S. Vennila
41.	Evaluation and exploitation of compensation as a mechanism for comprehensive insect pest tolerance	PL: S. Vennila Assoc: Vinita Gotmare
42.	Studies on seed transmitted pathogenic infections and other seed microflora of cotton	PL: P. M. Mukewar
43.	Studies on evolution of races of *Xanthomonas axonopodis* pv. *malvacearum* (*Xam*) and utilization of HVS in identification of resistant sources	PL: M. K. Meshram
44.	Biochemical, molecular and genetic basis of host plant resistance to cotton nematodes	PL: N. G. Narkhedkar
45.	Potential of rhizobacteria in management of cotton nematodes	PL: N. G. Narkhedkar
46.	Identification of sources of resistance against Rhizoctonia root rot in tetraploid and fusarium wilt in diploid cotton and their utilization in breeding program	PL: R. C. Ukey Asso.: V. N. Waghmare
	Regional Station, Coimbatore	
47.	Development of high yielding intra *hirsutum* hybrid	PL: D. K. Agarwal Assoc: S. Manickam
48.	Breeding new *G. hirsutum* cotton varieties with new plant types - Development of medium staple varieties	PL : K. N. Gururajan Assoc: S. Manickam
49.	Development of high yielding and high spinning Extra long staple cotton	PL: K. N. Gururajan Assoc: S. Manickam
50.	Development of Extra long staple high spinning hybrids of interspecific origin with wide adaptability	PL: K. P. M. Dhamayanthi
51.	Development, maintenance and utilization of cytoplasmic and genetic male sterility for hybrid cotton seed production and fertility restoration in cotton	PL : S. Manickam
52.	Maintenance and evaluation of cotton germplasm	PL: S. Manickam

53.	Studies on viability, vigour and longevity of cotton seeds	PL: K.Rathinavel Assoc: K. Natarajan P.Chidambaram
54.	Studies on the long term effect of continuous application of nutrients in fixed cotton based crop rotation on the productivity, nutrient balance and sustainability of the cropping system	PL: C.S. Praharaj Assoc: K. Sankaranarayanan S.E.S.A. Khader K.K. Bandyopadhyay
55.	Assessment of organic residues along with *in situ* incorporation of green manures on soil fertility dynamics and cotton productivity.	PL : C.S.Praharaj Assoc: K. Sankaranarayanan S. E. S. A. Khader
56.	Water management in *G. hirsutum* and *G. barbadense* cotton	PL : K. Sankaranarayanan Assoc: P. Nalayini C.S. Praharaj K.K. Bandyopadhyay
57.	Evaluation of cotton based cropping system for higher production and economic return	PL : K. Sankaranarayanan Assoc: P. Nalayini C.S. Praharaj K.K. Bandyopadhyay
58.	Polymulching for water, weed and nutrient management in cotton based cropping system	PL : P. Nalayini Assoc: K. Sankaranarayanan
59.	Simulation of effect of irrigation and nitrogen on soil water and nitrogen dynamics, productivity and input use efficiency of Bt cotton in a vertic Ustropept	PL : K.K. Bandyopadhyay Assoc : A.H. Prakash K.Sankaranarayanan B. Dharajothi
60.	Identification and utilization of adaptive responses to abiotic stress in cultivated species of cotton	PL: S.E.S.A. Khader Assoc: N. Gopalakrishnan K.N. Gururajan
61.	Physiological and molecular elucidation of fibre development process in cotton for enhancing fibre yield	PL: A.H. Prakash Assoc: N. Gopalakrishnan
62.	Source-sink alteration with reference to flower induction as a tool to improve physiological efficiency and productivity in cotton	PL: A.H. Prakash Assoc: N. Gopalakrishnan
63.	Studies on biochemical mechanisms of resistance to bollworm of cotton	PL: N. Gopalakrishnan Assoc: T. Surulivelu
64.	Studies on developmental biochemistry of cotton pest/ Disease interaction	PL: N. Gopalakrishnan Assoc: T. Surulivelu K. Natarajan P. Chidambaram
65.	Studies on the role and effect of insecticides in cotton ecosystem	PL : T. Surulivelu Assoc: K. Natarajan,
66.	Studies on the host plant relationship and development of resistant/tolerant varieties to insect pests of cotton	PL: K. Natarajan Assoc: T. Surulivelu S. Manickam
67.	Studies on population dynamics of cotton pests and their	PL : K. Natarajan

	natural enemies	Assoc: B. Dhara Jothi
68.	Bio ecological studies in Pink Bollworm	PL: B. Dhara Jothi Assoc: K. Natarajan
69.	Studies on the epidemiology and management of fungal foliar diseases of cotton	PL: P. Chidambaram Assoc: K. N.Gururajan N. Gopalakrishnan
70.	Identification of hotspots for plant parasitic nematodes in cotton growing zones of India	PL: Gulsar Banu
71.	Exploration of novel insecticidal proteins from bacterial symbionts of native entomopathogenic nematodes	PL: Gulsar Banu
72.	Farm level economic benefits of Bt cotton in Tamilnadu	PL: Isabella Agarwal
73.	Adoption, impact and returns to research investment on improved cotton cultivars in Tamilnadu	PL: Isabella Agarwal
74.	Economic analysis of contract farming in cotton in Tamilnadu	PL: Isabella Agarwal
75.	Expert system on cotton pest/insect	PI: M. Sabesh Assoc.: S. Vennila B. Dhara Jothi
	Regional Station, Sirsa	
76.	Evaluation of parents in *Gossypium hirsutum* for heterotic potential and useful heterosis for replacement of existing cultivars under north Indian conditions	PL: O. P. Tuteja
77.	Development of varieties and hybrids (MS based) of medium staple length in *Gossypium arboreum* L.	PL: S. K. Verma
78.	Development of male sterility based hybrids of *G. hirsutum* for north India	PL: O. P. Tuteja Assoc: D. Monga P. Jeyakumar
79.	Development of *G. hirsutum* cultivars with high fibre strength suitable for high speed spinning	PL: S. L. Ahuja Assoc: O.P.Tuteja, S.K.Verma R. A. Meena, D. Monga, P. Jeyakumar, V. V. Singh K. N. Gururajan
80.	Genetic enhancement in diploid cotton	PL: S. L. Ahuja Assoc: S. K. Verma Punit Mohan Vinita Gotmare TR Loknathan P. Jeyakumar, D. Monga
81.	Development of male sterility based hybrids of G. hirsutum for north India	PL: O. P. Tuteja Asso.: D. Monga P. Jeyakumar
82.	Collection, conservation, evaluation and maintenance of genetic resources	PL: R. A. Meena

83.	Studies on seed technological aspects of hybrids and varietal seed production in north zone	PL: R. A. Meena Assoc: O. P.Tuteja, D. Monga
84.	Effect of light on stability and efficacy of neem in IPM	PL: P. Jeyakumar Assoc: D. Monga
85.	Studies on cotton leaf curl virus disease and development of resistant varieties and hybrids for its management	PL: D. Monga Assoc:O.P.Tuteja, R.A. Meena S.K. Verma, P. Jeyakumar
	Externally Funded Projects	
	DBT Projects	
1	Identification of molecular markers linked to QTLs for fibre strength and oil content in cotton (*G. hirsutum* L.)	V.V. Singh
2	Molecular mapping of fibre quality and lint yield traits : construction of a frame work linkage map in *desi* cotton (*Gossypium* spp.)	V.N. Waghmare, A.B. Dongre Vinita Gotmare
3	DNA based diagnostic approaches to identify biotype diversity in race 18 of *Xanthomonas axonopodis* pv. *malvacearum* and commercialization of a PCR detection kit	P.K. Chakrabarty
4	Development of disease resistant transgenic cotton against CLCuV	P.K. Chakrabarty S.B. Nandeshwar
5	Engineering virus resistant cotton through dsRNAi mediated targeting of cotton leaf curl virus	P.K. Chakrabarty B.M. Khadi, D. Monga S.B. Nandeshwar
6	Development of cotton transgenics with improved fibre strength using cellulose synthase gene from Arabidopsis	B.M. Khadi G. Balasubramani P.K. Chakrabarty
7	Genetic improvement of strains of entomopathogenic nematodes for tolerance to environment and enhanced efficacy against *Helicoverpa armigera*, cotton bollworm	PL: N-G-Narkhedkar
	Mega Seed Project	
8	Seed production in Agricultural Crops and Fisheries	L.A. Deshpande P.R. Vijayakumari R.A. Meena, K. Rathinavel
	DUS Project	
9	Characterisation of genotypes for DUS testing under PVP and FR Act	V. Santhy, P.R. Vijayakumari R.K. Deshmukh
	Network Project	
10	Transgenics in Crops (NPTC)	G. Balasubramani K.R. Kranthi S.B. Nandeshwar Suman Bala Singh, J. Amudha

	Mahyco Funded	
11	Monitoring for shifts in baseline susceptibility (development of tolerance/resistance) in the cotton bollworms (*Helicoverpa armigera, Pectinophora gossypiella* and *Earias vitella*) against *cry*1 Ac toxin in various cotton growing regions of the country	PL: S. Kranthi
12	Monitoring for shifts in baseline susceptibility (development of tolerance/resistance) in the cotton bollworms (*Helicoverpa armigera, Pectinophora gossypiella* and *Earias vitella*) against *cry*2 Ab and bollgard II toxin in various cotton growing regions of the country	PL: S. Kranthi
13	Monitoring for shifts in baseline susceptibility (development of tolerance/resistance) in the cotton bollworms (*Helicoverpa armigera, Pectinophora gossypiella* and *Earias vitella*) against JK-*cry*1 Ac toxin in various cotton growing regions of the country	PL: S. Kranthi
	Dupont, India Funded	
14	Studies on *Helicoverpa armigera* response to new proprietary molecules of Dupont	PL: K. R. Kranthi Assoc: S. K.ranthi
	Ministry of Agriculture, GOI, New Delhi	
15	Development of technology for detecting of GMO in an unknown sample and its utilization in dealing with bulk samples	PL: K. R. Kranthi
	DST	
16	DNA fingerprinting of released cotton cultivars hybrids and their parents	PL : S. K. Verma
	SRTT	
17	Promotion of cotton varietals and hybrid seed production technology at village level to improve farmers livelihood	PL : R. A. Meena
18	Improvement of productivity and quality of cotton at village level	PL : D. Monga
	IOC	
19	Indian oil Experiment	PL : Rishi Kumar
	Fast Track Project of DST	
20	Molecular mapping of fibre quality trait QTL's and marker assisted selection (MAS) in upland cotton (*Gossypium hirsutum* L.) -	PL: V. N. Waghmare
	NAIP	
21	A Value Chain for Cotton Fibre, Seed and Stalks: an innovation for higher economic return to farmers allied stakeholders	Consortium Lead partner: N.Gopalakrishnan CoPI: Sankaranarayanan Team Leader : PR.Bharambe, Dilip Monga

Technology Mission on Cotton (TMC)

Project code	Name of the Project	Name of the Project Leader 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 Associates: 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	PI: Dr. K. N. Gururajan / Dr. Damayanti
MM 1.3	Identification of *G. hirsutum* genotypes suitable for machine picking and development of agronomic package	Associates: Dr. V.V.Singh / Dr. V. Gotmare Dr. S.L.Ahuja
MM 1.4	Development and promotion of Bt transgenic cotton for bollworm resistance	Associates: Dr.Suman BalaSingh Dr. S. B. Nandeshwar / Dr. S.M.Palve, Dr. Manickam
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 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 of innovative Bt. cotton based cropping systems, improvement of water and nutrient use efficiency with precision farming techniques	Associates: Dr A.R. Raju Dr. R. A. Meena
MM 2.3	Mechanization of cotton production	PI: Er. Gautam Majumdar Associates: Dr. A. R. Raju
MM 2.4	Physiological manipulation of Bt plant morphoframe for enhanced productivity under varied agro-climatic conditions	PI: Dr. A. H. Prakash Associates: Dr. R. K. Deshmukh
MM 3.1	Emerging and key pests of Bt cotton- their characterization, taxonomy, genetic diversity and control	PI: Dr. K. R. Kranthi Associates: Dr. Sandya Kranthi / Dr. S. Vennila Dr. Vishlesh Nagarale Dr. D. Monga Dr. T. Surulivelu, Dr. Dharajyoti Dr. P. Chidambaram
MM 3.2	Development and validation of IPM/ IRM strategies for Bt cotton under different ecosystems	Associates: Dr. S. Vennila Dr. D. Monga

MM 3.3	Development, validation, utilization and / or commercialization of bio-pesticides and bio inoculants	Associates: Dr. N. Narkhedkar Dr. S. Vennila Dr. D. Monga Dr. Dharajyoti, Dr. Gulsar Bhanu
MM 3.4	Development of farmer friendly diagnostic kits for transgenic event seed purity	Associates: Dr. K. Kranthi
MM 5.1	Total factor productivity of cotton in India	PI: Dr. Isabella Agarwal Associates: Dr. A.R.Reddy
MM 5.2	Studies on social dynamics of cotton production in distress areas	Associates: Dr. S. M. Wasnik
MM 5.3	Indian cotton portal	PI: Sh. M. Sabesh Associates: Er. G. Majumdar
MM 5.4	TMC MMI Co-ordination and Monitoring Cell	PI: Dr. V. Santhy

11.3: Consultancy, Patents, Commercialization of Technology

Breeder Seed Production

Breeder seed production for the following varieties was under taken as per the Govt. of India (Dept. of Agril. & Cooperation) indent.

Variety	Breeder Seed Indent (q)	Production (q)
LRA 5166	0.76	1.50
Anjali	0.01	0.50
Surabhi	0.56	2.50
Supriya	0.10	0.50
MCU 5 VT	0.50	1.50
Sumangala	0.03	0.25
Suvin	Nil	1.50

Following patents are under processing by ITMC, CICR, Nagpur

- Bullock drawn vertical rotor precision planter
- Cotton seed blower

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

Research Advisory Committee (RAC)

The 3rd meeting of the Research Advisory Committee was held on 3 August 2007 at the CICR, Nagpur. Dr. S. N. Puri, Vice-Chancellor, CAU, Imphal (Manipur) as Chairman of the RAC presided over the meeting. The following members attended the meeting 1) Dr. S. Sreenivasan, Director, CIRCOT, Mumbai, 2) Dr. N. K. Singh, Principal Scientist, NRCPB, New Delhi, 3) Dr. S. K. Ghosh, Principal Scientist, CRIJAF, Barrackpore, 4) Dr. J. Prasad, Principal Scientist, CIAE, Bhopal, 5) Dr. B. M. Khadi, Director, CICR, 6) Shri Nanabhau Embadwar 7) Shri Ankushrao Tope, Non-official member.

Dr. Puri, in his introductory remarks, appreciated the efforts made in the development of indigenous Bt genotypes and expressed his concern about the spurious Bt seeds which are posing major problems. Dr. Khadi presented the status of cotton production in the country in the year 2006-07 and highlighted the fact that states like Gujarat and Punjab achieved productivity levels close to the world average productivity figures of 715 kg/ha. Dr. Khadi presented in detail the scientific achievements of the Institute and Regional Stations and informed the house that CICR had received its first International patent for the Bt kits from South Africa.

Shri Embadwar suggested that not more than 2-3 varieties of cotton be cultivated in a region in rotation with other crops. He emphasized the need for public sector Bt hybrids/varieties, and a bullock drawn planter and picker. Shri Tope emphasized the adoption of technologies and practical utility of research. Utility

of polymulch as a tool to conserve moisture and nutrients needs to be demonstrated to farmers growing cotton under rainfed situation and contract farming should be promoted.

Dr. Sreenivasan mentioned that China was actively promoting the concept of value added products. On similar lines, he desired that the machinery required for the production of value added products in the cotton sector in the country be strengthened. Dr. Singh emphasized that DNA marker assisted selection for biotic and aboitic stresses needs to be strengthened. Dr. Ghosh appreciated the work carried out in the area of diagnostics and requested that it be documented. Dr. Prasad informed that intercultural machinery, tractor operated poly mulch spreading machine could be developed in due course of time.

Dr. Puri in his concluding remarks desired to know as to when the Public sector Bt hybrids/varieties would be released. Transfer of Technology to farmers is weak; hence, the need for strengthening of Social Sciences and collaboration with the State Agriculture Departments was also expressed. He felt that machines need to be developed for the plant types rather than tailoring plant to suit the machine. Dr. Puri was also concerned on the reduction in susceptibility to *Cry*1Ac in the bollworm populations of Gujarat. He was happy that the productivity figure of the country now stands at 525 *k*g/ha. The meeting ended with a formal vote of thanks proposed by Sh. M. K. Meshram.

The proceedings of the meeting were approved by the Council. The following are specific RAC recommendations / suggestions :

1) Commercial release of public sector Bt hybrids within the next 2 years.
2) Develop robust resistance management strategies for delaying the development of resistance in the bollworm.
3) Validate the use of polymulch in Vidarbha as a method of water conservation in rainfed cotton cultivation.
4) Strengthening of facilities for marker assisted breeding for biotic and abiotic stresses.

Institute Research Council (IRC)

The Annual Institute Research Council Meeting of CICR was held at CICR, Nagpur from 15-17 May, 2007 under the Chairmanship of Dr. B. M. Khadi, Director, who presented cotton scenario during 2006-07 in India. He reiterated that increase in production was due to cultivation of Bt cotton hybrids in larger area and adoption of IPM and IRM technology. During 2006-07, 92 Bt cotton hybrids have been released for commercial cultivation in different cotton growing areas. Director suggested that the criteria for release of Bt hybrids should include yield, G.P., fibre quality and mill test. Research findings of work carried out during 2006-07 were presented by each scientist and technical programme for each project was also finalized by the house after detailed discussion. Director critically reviewed all the research projects including TMC and made his valuable comments and suggestions for further improvement.

The IRC meeting of Regional Station, Sirsa was held on 29th April, 2007. Dr. B. M. Khadi, Director CICR, Nagpur chaired the meeting. Dr. D. Monga, Head, CICR Regional Station, Sirsa welcomed the Director and appraised the house about the on-going research programmes at the station. All the scientists of the station presented their results obtained during 2006-07 and technical programmes for the 2007-08 were approved by the house. Dr. B. M. Khadi appreciated the good work done at CICR Regional Station, Sirsa and congratulated the scientists for their concerted efforts to develop the hybrids and varieties.

At CICR, Regional station Coimbatore, IRC was held on 31 July and 1 August 2007 under the chairmanship of Dr. B. M. Khadi, Director, CICR, Nagpur. Dr. N Gopalakrishnan, PC & Head, CICR RS, Coimbatore explained in detail about the achievements made by Scientists of the Regional Station and presented the research findings, which were critically assessed by the members of the IRC. Dr. K. R. Kranthi, Dr. P. R. Bharambe, Dr. L. A. Deshpande, Heads of divisions of CICR, Nagpur, Crop Protection, Production and Improvement, respectively, also attended the meeting. After detailed presentations by individual scientists, the technical programme for year 2007-08 was finalized.

Review Meeting of ICAR Regional Committee No. VII

A meeting was convened on 28 June, 2007 to review to status of Action Taken on various points of recommendations made in XIX meeting of ICAR Regional Committee No. VII held on 18-19

November, 2005. Chairman Dr. Nawab Ali, DDG, (Agrl. Engg.), ICAR, New Delhi in his opening remarks mentioned the purpose of review committee meeting and highlighted the two way interaction channel operating between farmers and SAU's /State Departments. He appraised that the transfer of technology to the farmers from the source of origin, and feedback on their performance with associated problems obtained serve to revise the research programmes that would provide best possible solutions on mission mode. Hence, he suggested the review of action taken report to be timely and critical. Dr. Khadi, Director, CICR presented the ATR consisting a total of 52 points that included 18 from Crop Sciences, four of Horticulture, three of NRM, nine of Animal Sciences, 12 from Fisheries, one from Agriculture Engineering, and three each of Extension and Agriculture Education. Review of each point for action was made. Dr. P. Chandra, ADG (PE), Dr. B. M. Khadi, Director, CICR; Dr. S. Singh, Director, NRCC; Dr. P. S. Lonkar, DoR, MAFSU; Dr. A. Chaturvrdi, Head, Land Use Planning, NBSSLUP; Dr. R. H. Pandey, DCF, Dr. P. G. Patil, Head, GTC; Dr. L. A. Deshpande, Head, Crop Improvement, ICR; Dr. P. R. Bharambe, Head, Crop Production, Dr. M. R. K. Rao, Head, RCM Unit; Sh. M. B. Yeole, Technical Officer, S. L. Baviskar, Divn. SAO, JDA, Nagpur; Dr. (Mrs.) K. A. Serothia, Research Officer, MAFSU, Nagpur were also present.

20th Meeting of ICAR Regional Committee No. VII

The 20th Meeting of the ICAR Regional Committee No. VII was organized by the Central Institute for Cotton Research, Nagpur on 29th February & 1st March, 2008 at Nagpur to discuss key issues related to agricultural research, education and extension of the region which includes Maharashtra, Madhya Pradesh, Chhattisgarh and Goa. Dr. Mangala Rai, Secretary DARE & Director General, ICAR, chaired the meeting. Dr. B. M. Khadi, Director, CICR, Nagpur & Member Secretary of ICAR Regional Committee No. VII welcomed the chairman and members of the committee. Dr. Nawab Ali, Deputy Director General (Agriculture Engineering) & Nodal Officer of the region gave a brief outline of priorities of the region particularly soybean and its value addition. The Director General, ICAR and Chairman expressed the importance of agriculture of the region in national perspective and requested the members to focus the discussion on emerging issues and problems of the region and to find out plan of action to overcome the problems. The Chairman emphasized the need to re-orient agriculture research and education, in view of the emerging global scenario. He also stressed the need to develop expertise in form of human resources and infrastructure facilities. The need to develop modalities for diversification and commercialization of Agriculture was also emphasized. The Chairman urged the members to identify the potential and opportunities of the zone for increasing agricultural productivity. The major priority areas as deliberated by the members included quality seed production and distribution, rainwater harvesting and utilization, crop diversification, farm mechanization, processing and value addition etc. The Chairman felt that there is need to give priority to live stock development and arid horticulture in rain fed areas and further research on fertigation relating to different crops. He emphasized the need to develop innovative methods for technology transfer as many of the technologies developed were not satisfactorily transferred to the stake holders.

Two publications namely 'CICR-at a glance-2008' and 'Cotton bollworm control in small-scale production systems-A hand book' were released by the Hon'ble Secretary, DARE and Director General, ICAR on 29th Feb, 2008.

The meeting was attended by Dr. P. L. Gautam, DDG (Crop Science), Dr. H. P. Singh, DDG (Horti.), Dr. A. K. Singh, DDG (NRM), Dr. S. Ayyappan, DDG (Fy.), Dr. P. Das, DDG (Agri. Extn.), Dr. K. M. Bujarbaruah, DDG (AS), Dr. R. K. Mittal, ADG (EQR), Dr. J. P. Mishra, ADG (Coord.) from ICAR Head quarters; Dr. J. S. Samra, CEO, National Rainfed Authority of India; Dr. G. Kalloo, VC, JNKVV, Jabalpur, Dr. Arun Ninawe, VC, MAFSU, Nagpur, Dr. V. M. Mayande, VC, Dr. PDKV, Akola, Dr. R. B. Deshmukh, VC, MPKV, Rahuri, Dr. S S Kadam, VC, MAU, Parbhani, Dr. Vijay Mehta, VC, Dr. BS KKV, Dapoli, Director of Research, Extension and Dean from seven agricultural universities of this region, Directors of ICAR Institutes of the region, Project Coordinators and Head of Regional Stations of this region as well as Directors of NBPGR, New Delhi and IGFRI, Jhansi attended the meeting. The senior officers from various State Departments of Maharashtra, Madhya Pradesh, Chhattisgarh & Goa also attended the meeting.

11.5 : Workshops/Farmer's Day Organized

AICCIP Annual Workshop

Annual Workshop of All India Coordinated Cotton Improvement Project was organised at Navsari Agricultural University, Navsari (Gujarat) during 11-13, April, 2007. It was marked by the gracious presence of Hon'ble Director General, ICAR, ADG (CC), ICAR, Director, CICR,Nagpur, Director, CIRCOT,Mumbai, Hon'ble Vice-Chancellor, NAU, Navsari, Hon'ble Chairman and Hon'ble Members of QRT, CICR & AICCIP. Project Coordinator (Cotton) presented the highlights of the activities of AICCIP. More than 300 delegates participated in the workshop and deliberations were fruitful for formulation of cotton R&D programme.

Kapas Field Day

Kapas Field Day was organized at premises of CICR Nagpur on 10th January, 2008 to build up the confidence of the villagers in scientific innovations and to create general awareness about latest cotton production technologies in the districts of Vidharbha. Dr. B.M. Khadi, Director, CICR Nagpur appealed to the farmers to adopt full packages of low cost production technologies generated by CICR and reduce production costs in cotton farming. He advised the farmers to select only best 3-4 promising varieties/hybrids demonstrated at CICR Nagpur instead of testing a large number of varieties available in markets. Dr. L. A. Deshpande, Head, Division of Crop Improvement educated the farmer about the improved cotton varieties and hybrids including Bt cotton recommended for commercial cultivation. Dr. P. R. Bharambe, Head Division of Crop Production gave tips for increasing cotton productivity. He advised the farmers to get their soil tested and use micro-nutrients in addition to the major nutrient requirement as per soil test report. Dr. K. R. Kranthi, Head, Division of Crop Protection discussed the importance of plant protection in cotton production. He cautioned the farmers about the threats of emerging minor pests like mealy bug and mirid bug in cotton. Dr. S.M. Wasnik, Principal Scientist (Agriculture Extension) and Coordinator of the programme requested officials to provide timely guidance to farmers timely for full adoption of latest scientific innovations to get maximum benefits from the available cotton production technologies. A visit to various experimental fields and demonstration plots was also organized on the occasion. The farmers were satisfied with the performance of latest cotton technologies demonstrated at experimental fields. A question-answer session was also organized.

11.6 : Participation of Scientists in Seminars/Symposia/ Workshops/Trainings

Sr. No.	Seminars/Conferences /Symposia/ Workshops/Trainings	Place and Date	Participants
1.	Annual Group Meeting of All India Co-ordinated Cotton Improvement Project	Navsari Agricultural University, Navsari, Gujarat 11 - 13 April, 2007	Dr.B.M.Khadi Dr. N.Gopalakrishnan Dr.K.R.Kranthi Dr. P. R. Bharambe Dr.P.K.Chakraborty Dr. T.Surulivelu Dr. P.Chidambaram Sh. K.N.Gururajan Dr.S.M.Palve Dr. S.Manickam Dr. A.H.Prakash Dr. C.S.Praharaj Dr. B.Dharajothi Dr. S.Usharani Dr. M.Sabesh
2.	One day methodology workshop for DBT-Project "Policy Initiatives in Biotechnology"	TNAU, Coimbatore April 20, 2007.	Dr. N.Gopalakrishnan Dr. S,Usha Rani
3.	XXII Annual group meeting of AICRP - National Seed Project (Crops)	UAS, Dharwad April 24 - 26, 2007	Dr. K.Rathinavel
4.	Standing committee meeting on Technology Mission-II	New Delhi May 16, 2007	Dr. K.R.Kranthi
5.	National level consultation on Agro-Biodiversity hot spots and Biodiversity heritage sites	Shillong, Megalaya June 1-2, 2007	Dr. K.Rathinavel
6.	Novel genes for sucking pest management in cotton' at the CSIR center for the NMITLI project	CSIR center, New Delhi June 10, 2007	Dr. K.R.Kranthi
7.	One day orientation meeting of Vidharbha KVKs for finalization of Cropping System Model	Nagpur June 12, 2007	Dr. S.M. Wasnik
8.	Cotton scientist meet organized by Centre for plant Breeding and Genetics,	TNAU, Coimbatore June 16,2007	Dr. K.Sankaranarayanan
9.	Workshop on Genetically Modified Crops	Virudhunagar July 3,2007	Dr. K.Sankaranarayanan
10.	National Seminar on "Implications of the Protection of Plant varieties and Farmers Rights Act 2001 to Forestry sector"	Coimbatore July 4-5, 2007	Dr. K.Rathinavel
11.	Pre Seasonal area conference	Tiruchirapalli July, 13, 2007	Dr. N.Gopalakrishnan Dr. K.Rathinavel

12.	National Consultation workshop on "Agro-biodiversity Hotspots and Access and Benefit Sharing"	Annamalai University, Chidambaram July 19-20th 2007	Dr. S. Manickam Dr. Punit Mohan
13.	Stakeholders meet of NAIP project "A Value Chain for Cotton Fibre, Seed and Stalks: An innovation for higher economic returns to farmers and allied stakeholders"	CIRCOT,Mumbai July19-20,2007	Dr. N.Gopalakrishnan Dr. K.Sankaranarayanan
14.	Cotton Advisory Board Meeting	August 8th, 2007	Dr. P.R. Bharambe
15.	World Cotton Research Conference'.	Lubbock, Texas, USA, September 12, 2007	Dr. B. M. Khadi Dr. K.R.Kranthi
16.	National Seminar on Green Treasure : An Interdisplinary approach : Prospects and Promise for Human welfare	Nagpur October 6th, 2007	Dr. A. B. Dongre
17.	Model Training Course on Insecticide Resistance Management in Cotton	CICR, Nagpur, October 23- 30th, 2007	Dr. Vishlesh Nagrare
18.	The special interactive workshop on 'Administrative and financial matters' for the ICAR institutes placed under southern/western zone	NIANP, Bangalore October 26-27, 2007	Dr. K.R.Kranthi
19.	National Symposium on Potentials of Bio-Control Agents in Agriculture - Prospects and Perspective	College of Agriculture, Nagpur October 27-28, 2007	Dr. P.M. Mukewar, Shri M. K. Meshram, Dr. N.G.Narkhedkar Dr. A. B. Dongre
20.	Annual convention of the Indian Society of Soil Science	Ranchi November 2-5,2007	Dr. K.K.Bandyopadhyay
21.	Management of rain fed cotton	Perambalur November 4-5, ,2007	Dr. N.Gopalakrishnan Dr. K.Rathinavel
22.	Workshop on Biosafety Capacity building project	New Delhi November 6, 2007	Dr. G. Balasubramani
23.	Workshop on "Consultation of Libability Redress in the context of Cartagena Protocol on Biosafety"	New Delhi Nov. 14-17, 2007	Dr. G. Balasubramani
24.	World Neem Conference	Coimbatore, Nov. 21-24 , 2007	Dr. T,Surulivelu Dr. K.Natarajan Dr. B.Dharajothi
25.	National Workshop on Agrarian Crisis and farmers' suicide in ndia	Mussoorie, November 23-24, 2007	Dr. P.R. Bharambe
26.	National Seminar on microbial developments and biochemical research.	UGC, New Delhi. November 29-30, 2007	Dr. K.R.Kranthi
27.	International Conference on Emerging and Re-emerging Viral diseases of the	New Delhi Dec 10- 14, 2007	Dr (Mrs) J.Amudha

	Tropics and Sub-tropics		
28.	National meeting on consultation of herbicides tolerant G.M. crops	NASC complex, New Delhi, Dec. 11, 2007	Dr. P.R. Bharambe
29.	48th Annual Conference, Association of Microbiologists of India, Microbes: Biofactories of the future	Madras, Chennai December 18 - 21, 2007	Dr. Ashok B. Dongre,
30.	National Conference on Current Trends in Biochemistry,	Nagpur December 27-29, 2007	Dr. A. B. Dongre, Dr. Punit Mohan
31.	Workshop on Prospects of Bt cotton in India	Jalna, January 8, 2008	Dr. Vishlesh Nagrare
32.	Launching workshop and consortium advisory committee meeting of NAIP project-A Value Chain for Cotton Fibre, Seed and Stalks: An innovation for higher economic returns to farmers and allied stakeholders	CIRCOT, Mumbai Jan.9-10,2008	Dr. N.Gopalakrishnan Dr. K.Sankaranarayanan
33.	Meeting of DBT Task Force on 'Biopesticides and Crop Management'	New Delhi Jan.10, 2008.	Dr. N. G. Narkhedkar
34.	Cotton Advisory Board Meeting	January 11, 2007	Dr. P. R. Bharambe
35.	National Consultation on Insecticide Resistance Management on Bt cotton	New Delhi. Jan 21 and 22 , 2008,	Dr. K. R. Kranthi, Dr. S. Kranthi
36.	National seminar on Livelihood security through rainwater management	Nagpur Jan. 22-23, 2008	Dr. Jagvir Singh
37.	13th Vasantrao Naik Memorial National Agriculture Seminar on Livelihood Security through Rainwater Management	College of Agrl., Nagpur Jan 22-23, 2008	Dr. K. Sankaranarayanan
38.	National consultation meet on Mealy bugs	CICR, Nagpur. 28-29 January, 2008.	Dr. S.Vennila Shri M.K.Meshram, Dr. V. Nagrare, Dr. Sandhya Kranthi, Dr. K.R.Kranthi Dr. T. Surulivelu Dr. B. Dharajothi
39.	Stakeholders's workshop of NAIP for full project proposals	PDBC Bangalore 24 - 25 January, 2008	Dr. S.Vennila
40.	India Regional Meeting of Organic Exchange - 2008	Organic Exchange Aurangabad, January 25-29, 2008	Dr S. Manickam
41.	National Workshop on Technology Impact Assessment in Agricultural Crops	NCAP, Pusa, New Delhi Jan. 30-31, 2008	Dr. P.R. Bharambe
42.	ICAR-CAS training on Modern	TNAU, Coimbatore.	Dr. V.Santhy

	Approaches in Heterosis Breeding	Feb. 12-3, March, 2008	
43.	Meeting of Scientific Advisory Committee of Krishi Vigyan Kendra, Yeotmal.	KVK, Yeotmal 12 Feb. 2008.	Shri M.K.Meshram
44.	Capacity Building Programme on Intellectual Property Protection and Technology Licensing in Agriculture under Indo-US Agricultural Knowledge Initiation	Kerala Agricultural University February 18-20, 2008	Dr. Vinita Gotmare
45.	National Training on Seed Quality Regulation and Seed Health Testing	Varanasi February 18-22, 2008	Dr. Vinita Gotmare
46.	National Level Training Programme on Cotton seed and its utilization	Guntur February 21-22, 2008.	Dr. S.M.Palve
47.	International Conference on Plastics and Environment	Chennai. February 22-23 , 2008	Dr. P. Nalayini
48.	National Seminar on Integrated Nutrient Management in Rainfed Agro-ecosystem	CRIDA, Hyderabad March 3-4, 2008	Dr. C. S. Praharaj Dr. Jagvir Singh
49.	Training programme on Intellectual Property Rights	NIIPM, Nagpur 10-14 March 2008.	Dr. S.M.Palve
50.	National Seminar on Advances in Legume Research (ALR 2008)	Annamalai University, Chidambaram March 6-7, 2008	Dr. K.Sankaranarayanan
51.	Training on Entrepreneurship Development in Agriculture	Dr. PDKV, Akola March 17-18, 2008	Shri M.K.Meshram
52.	Training programme on Imparting Journalistic skills to enhance the communication performance of extension workers in scientific conservation and management of land and water	TNAU, Coimbatore. March 18-20,2008	Dr. K.K.Bandyopadhyay Dr. P.Nalayini Dr. S.Usharani
53.	Training cum workshop on Sustainability of Bt Cotton, Detection and Quantification of Cry Toxins	ANGRAU, Hydrabad, March 24 to 26, 2008	Dr. B.Dharajothi
54.	Workshop on Harnessing the benefits of Biotechnology under the Indo-US Agricultural Knowledge Initiative (AKI)	NASC, New Delhi March 27-29, 2008	Dr (Mrs) J.Amudha
55.	Regional Workshop on Management and monitoring of field trials of genetically modified crops	CICR Nagpur March 28, 2008	Dr. S. M. Palve Dr. Suman Bala Singh Dr. Vinita Gotmare Dr.G. Balasubramni
56.	Regional workshop on management and monitoring of field trials of genetically modified crops	CICR, Nagpur. 28 March, 2008	Dr. S.Vennila. Dr. S.Kranthi, Shri M.K.Meshram

11.7 : Distinguished Visitors

Name & Designation	Organisation	Date
Nagpur		
Dr. Nawab Ali, DDG (Agrl. Engg.)	ICAR, New Delhi	28.06.2007
Dr. P. Chandra, ADG (PE)	ICAR, New Delhi	28.06.2007
Dr. S. N. Puri, Vice Chancellor & Chairman, RAC, CICR	CAU, Imphal	03-08-2007
Dr. S. Sreenivasan, Director	CIRCOT, Mumbai	03-08-2007
Dr. P. L. Gautam, DDG (CS)	ICAR, New Delhi	29.02.2008
Dr. H. P. Singh, DDG (Hort.)	ICAR, New Delhi	29.02.2008
Dr. G. Kalloo, Vice Chancellor	JNKVV, Jabalpur	29.02.2008
Coimbatore		
Dr. S.Sreenivasan, Director	CIRCOT, Mumbai	20-06-2007
Dr.T.P.Rajendran , ADG (Plant Protection)	ICAR, New Delhi	25-06-2007
Dr V. Santhanam, , Ex-FAO expert (Cotton)		15-12-2007
Dr Anupam Barik, Director	DOCD, Mumbai	27-02-2008
Dr M.S. Khairon, Ex-Director, CICR, Nagpur		26-02-2008
Dr.K.C.Jain, ADG (Commercial Crops)	ICAR, New Delhi	18-03-2008
Dr S. Nagarajan, Chairman	PPV&FRA, New Delhi	20-03-2008
Sirsa		
Dr.S.N.Puri, Chairman, Dr. S.S. Narayanam, Member Dr. Siwa Reddy, Member Dr.Narayan Rishi, Member Dr.N.Gopalakrishnan, Secretary Dr. B.M. Khadi, Director	QRT-CICR & AICCIP CICR, Nagpur	28-29 April, 2007 5-08-2007
Sh. Ankushraoji Tope, Member CICR IMC Sh. Nanabhau Embadwar, Member CICR IMC.	Ex-MP, Maharashtra Ex-Agriculture Minister of Maharashtra Govt.	
Dr. O.M. Bambawale, Director	NCIPM, New Delhi	10-10-07
Dr. B.L. Jalali, Ex-Director of Research	CCS HAU, Hisar	
Dr. O.M. Bambawale, Director	NCIPM, New Delhi	17-10-07
Dr. Clive James, Chairperson ISAAA	Directors of ISAAA	24-10-07
Sh. Anup Malik, Director (Plant Protection) Dr. O.M. Bambawale, Director	Department of Agriculture & Cooperation, Ministry of Agriculture, New Delhi NCIPM, New Delhi	5-2-08

11.8 : Personnel

Name of Officers/Scientists	Designation
DIRECTOR	
B M Khadi	Director
PROJECT COORDINATOR (Cotton)	
Coimbatore	
N Gopalakrishnan	Project Coordinator (Cotton) & Head
PLANT BREEDING	
Nagpur	
L. A. Deshpande	Head, Crop Improvement Division
Phundan Singh	Principal Scientist
V V Singh	Principal Scientist
Smt. S B Singh	Principal Scientist
S M Palve	Principal Scientist
T R Loknathan	Senior Scientist
V N Waghmare	Senior Scientist
Coimbatore	
KN Gururajan	Principal Scientist
D K Agarwal	Scientist (SG)
Sirsa	
S L Ahuja	Principal Scientist
O P Tuteja	Principal Scientist
S K Verma	Senior Scientist
GENETICS & CYTOGENETICS	
Nagpur	
S B Nandeshwar	Principal Scientist
Smt. V Gotmare	Scientist (SS)
Coimbatore	
Smt. K P M Damayanthi	Senior Scientist
S Manickam	Senior Scientist
SEED TECHNOLOGY	
Nagpur	
R K Deshmukh	Principal Scientist
Smt. P R Vijaya Kumari	Senior Scientist
Smt. V Santhy	Scientist (SS)

Coimbatore	
K Rathinavel	Principal Scientist
Sirsa	
R A Meena	Principal Scientist
ECONOMIC BOTANY	
Nagpur	
Punit Mohan	Senior Scientist
AGRONOMY	
Nagpur	
PR Bharambe	Head, Crop Production Division
D. Blaise	Senior Scientist (Transferred to IISS, Bhopal on22.12.2007)
A R Raju	Scientist
Coimbatore	
C S Praharaj	Senior Scientist
K Shankaranarayanan	Senior Scientist
Smt.P Nalayani	Senior Scientist
SOIL SCIENCE	
Nagpur	
Jagvir Singh	Principal Scientist
Coimbatore	
K. K. Bandyopadhyay	Senior Scientist
AGRICULTURAL ENGINEERING	
G Majumdar	Scientist (SG)
PLANT PATHOLOGY	
Nagpur	
P M Mukewar	Principal Scientist
N K Taneja	Principal Scientist (Retd. on 30.4.07)
M K Meshram	Principal Scientist
R C Ukey	Principal Scientist
SG Gawande	Scientist (Joined on 03.03.08)
Coimbatore	
P Chidambaram	Principal Scientist (Retd. on 31.03.08))
Sirsa	
Dilip Monga	Head, Regional Station, Sirsa

ENTOMOLOGY	
Nagpur	
K R Kranthi	Head, Crop Protection
Smt. S Kranthi	Senior Scientist
Smt. S Vennila	Senior Scientist
VS Nagrare	Scientist (SS) (Joined on 16.07.07)
Smt. M Amutha	Scientist (Joined on 18.05.07)
Coimbatore	
T Surulivellu	Principal Scientist
K Natarajan	Principal Scientist
Smt. B Dhara Jothi	Senior Scientist
Sirsa	
Rishi Kumar	Senior Scientist (Joined on 05.10.2007)
NEMATOLOGY	
Nagpur	
Smt. Nandini Narkhedkar	Principal Scientist
Coimbatore	
Smt. J Gulsar Banu	Senior Scientist
PLANT PHYSIOLOGY	
Nagpur	
M R K Rao	Principal Scientist
N K Perumal	Principal Scientist
K B Hebbar	Senior Scientist (Transferred to IISS, Bhopal on 11.7.07)
Coimbatore	
S. E. S. A. Khader	Principal Scientist
A H Prakash	Senior Scientist
BIOCHEMISTRY	
Nagpur	
A B Dongre	Principal Scientist
Smt. M. Chakrabarty	Scientist (SG)
MICROBIOLOGY (PS)	
K. Velmourougane	Scientist (Joined on 18.05.07)
BIOTECHNOLOGY	
P K Chakrabarty	Principal Scientist

G Balasubramani	Senior Scientist
Smt. J Amudha	Senior Scientist
AGRICULTURE EXTENSION	
Nagpur	
H L Gajbhiye	Principal Scientist (expired on 19.06.07)
S M Wasnik	Principal Scientist
Coimbatore	
Usha Rani	Scientist (SS)
AGRICULTURAL ECONOMICS	
Nagpur	
P R Deoghare	Principal Scientist
AR Reddy	Senior Scientist
Coimbatore	
Smt. Isabella Agarwal	Senior Scientist
COMPUTER APPLICATION	
Coimbatore	
M Sabesh	Scientist (SS)
KVK	
S N Rokade	Senior Scientist
Administrative Officer	
MS Murthy	
Finance and Accounts Officer	
Prashant Kumar	(transferred to IVRI on 09.07.07)
GC Pant	(Joined on 06.9.07)