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2004-05

ANNUAL REPORT 2004-05

केन्द्रीय कपास अनुसंधान संस्थान, नागपुर

CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

M. SATISH.

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CENTRAL INSTITUTE FOR COTTON RESEARCH

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

CICR ANNUAL REPORT 2004-2005

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भाकृअनुप
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Preface

Cotton production in the country has shown a significant rise during the year 2004-05 touching an all time high of 243 lakh bales from around 90 lakh ha. The cotton productivity of the country has crossed the 400 kg mark and stood at 463 kg lint/ha. This phenomenal increase in production and productivity was made possible through the adoption of improved technologies including the cultivation of transgenic cotton hybrids. The IRM technology developed by the institute has been popularised through large scale demonstrations covering 28 major cotton growing districts in the country. The results are quite encouraging and the use of chemical pesticides has been considerably reduced alongwith other ecological benefits. Two hybrids *viz.*, CSHH 198 (Intra-*hirsutum*) and CISAA 2 (MS based intra *arboreum*) developed by the institute were notified for commercial cultivation in northern cotton zone. The Bt referral lab has played a key role in analysing the samples received from different parts of the country and identifying spurious lots. Encouraging results have been obtained with multi-tier intercropping system under irrigated cotton based production system in the southern zone. Considerable headway was made by the institute in the development of diagnostic kits for the detection of diseases affecting cotton. The research programmes are being fine tuned taking into consideration the emerging requirements in respect of high quality and cost competitiveness. Renovation activities undertaken at the institute have brought about considerable improvement in the research infrastructure.

All these have been made possible due to the untiring efforts of my colleagues and also due to the support from Indian Council of Agricultural Research, New Delhi.

I place on record my sense of gratitude for the guidance and leadership provided by hon'ble Dr. Mangala Rai, Secretary DARE & Director General, ICAR and Dr. Gautam Kalloo, Deputy Director General, Crop Sciences, ICAR, New Delhi in developing infrastructural facilities and manpower capabilities of the Institute.

I am presenting the annual report 2004-05 with a sense of fulfilment for public scrutiny.

(B. M. Khadi)
Director

2 Executive Summary

2.1 Crop Improvement

Nagpur

- During the year 101 accessions of *G. hirsutum* and 100 accessions of *G. arboreum* were evaluated in multilocation trials.
- Three thousand base, 300 working and 400 new collections of *G. hirsutum*, 700 *G. arboreum* and 160 *G. herbaceum* accessions were grown for rejuvenation and seed increase. Six hundred and ninety accessions of *G. arboreum* and 550 of *G. herbaceum* were evaluated for fibre properties.
- 1870 accessions of *G. arboreum* were allotted IC/EC numbers by NBPGR, New Delhi.
- Five hundred accessions were stored in medium term storage in the Institute and 300 in long term cold storage at NBPGR, New Delhi.
- A *G. hirsutum* culture CNHO 12 was tested in AICCIP Br 02 (a) trial and was promoted to Br 03 (a) trial in all the three zones based on its superiority for seed cotton yield. This culture is also tolerant to jassid and resistant to cotton leaf curl virus. Another culture CNHO 3 has also been promoted to Br 03 (b) trial in south zone.
- Rai 11-3 possessed high yield (>96 g/plant) potential coupled with early flowering and synchronous maturity (135-145 days) which in turn facilitating escape from bollworm.
- Another line MSH 345, a multispecies hybrid derivative bearing cleistogamous flowers is characterized by big, round bolls with 4-5 locules and boll weight ranging between 3.5 and 4.9 g.
- Two genotypes viz. Khandwa 2 and Laxmi were converted in GMS background and five genotypes viz. IC 321 (EL 958), Acala Glandless, LH 900, Sharda and Reba B 50 were converted in CMS background. Five hybrids viz. NGMSH 106-05, NGMSH 89-05, NGMSH 103-05, NGMSH 109-05 and NGMSH 94-05 were found promising by recording more than 20 % heterosis over the check NHH 44. One GMS based hybrid CINGH 2006 was promoted for testing in south zone centres.
- An unique culture CINA 316 of *G. arboreum* possessing high locule retentivity (17-13 days) and low short fibre content (11.75 %) was registered with NBPGR, New Delhi with INGR No. 04079 and IC No. 296596.
- Two cultures viz. CINA 333 and CINA 334 have been identified for high seed cotton yield (1800-1900 kg/ha), boll weight (3.2 g to 3.5 g), fibre length (26.2 to 29.2 mm) and fibre strength 18.7 to 20.4 g/tex, SFC 3.6 to 5.45 %.
- Highest seed cotton yield of 1187 kg/ha was recorded by culture DTS 23 followed by CNHO 23 (1129 kg/ha) as compared to the check LRA 5166 (562 kg/ha) in Institute trial.
- Two salt tolerant callus lines growing on 25 nM and 75 nM NaCl have been isolated and are being utilised for somatic embryogenesis.
- Elite cotton cultivar Anjali (LRK516) was transformed with Bt Cry 1 A(c). T_1 seeds collected and T_2 generation raised in contained open field trial.
- Large number of putative transformed plants of LRA 5166 and LRK 516 with Bt *cry I Ac*, Bt *cry I Aa3*, Bt *cry I A5* and Bt *cry I F* were developed.

Coimbatore

- The medium staple hybrid LK 1 x TK 43 was found promising among 130 conventional intra-*hirsutum* hybrids evaluated over the past two years.
- Four long staple conventional intra-*hirsutum* hybrids have been identified with superior yield and fibre quality.
- Alternaria leaf spot resistant culture CCH 4 performed better than the check varieties for yield and GOT in central zone.
- The culture CCH 510-4 was found superior in terms of yield and GOT and was on par with check variety in terms of fibre quality.

- Two new wild species *viz.*, *G. nelsonii and G. gossypioides* were established and added to species garden.
- The conventional interspecific hybrid LS 25 x P 28 recorded the highest yield of 2950 kg/ha combining superior fibre quality and was superior than the best check hybrid TCHB 213 (1900 kg/ha).
- The GMS hybrid J 34 x TK 15 recorded the highest seed cotton yield of 1760 kg/ha as against the best check hybrid with 1290 recording 37 % yield increase.
- Among the CMS based intra-*hirsutum* hybrids, RKR 4145 x A was the best with 2270 kg/ha followed by LRA 5166 x AK 2 with 2140 kg/ha of seed cotton yield.
- Of the 22 CMS based interspecific hybrids evaluated in a station trial, the highest seed cotton yield was recorded in the test hybrid 70 G x PR with 1520 kg/ha as against the best check hybrid TCHB 213 with 1400 kg/ha.
- The GMS based interspecific hybrid CCHB 125 has been promoted to coordinated hybrid trial in Central Zone.
- The high strength culture 72 (M5 x Z2) 7132 recorded high seed cotton yield and fibre strength of 25.1 g/tex.
- Under multilocation testing of promising cultures, the genotype CCH 226 recorded the highest yield of 1904 kg/ha, ginning out turn of 36.8 % and fibre strength of 23.3 g/tex.
- Single plant selected from segregating populations *viz.*, TMSGH 20 – (2), TMSGH 20 – (7), TMSGH 18 – (5), TMSGH 18 – (7) possessed around 27% seed oil content.
- In a common trial under NATP-HCP with 12 interspecific hybrids, the hybrid CCCHB 04-2 had superior fibre quality and high yield.
- Delinted seeds of cultivar LRA 5166 treated with bioinoculants *Pseudomonas fluorescens* and *Trichoderma viride* were as effective as fungicides in protecting the seeds from deterioration.
- Supplementary foliar nutrition as DAP @ 2 % + Boron @ 0.6 kg/ha + Zinc @ 0.5% significantly improved the seed quality.
- Polymer coating of cotton seed @ 5 ml kg^{-1} were equally effective in maintaining the seed viability, vigour and seed health.

Sirsa

- Two mutants with pink petal colour and pink filaments in *G. hirsutum* were identified. One new cytoplasmic male sterile line with red-pigmented plant body and petal spot in American cotton and a GMS line CISA 2 with yellow flower in *Desi* cotton were identified.
- In *G. hirsutum*, the new restorer lines namely CIR97P1, CIR97P3, CIR119P1, CIR119P3, CIR126P1, CIR526P1, CIR526P3, CIR 920 P1, CIR 926 P2, CIR 926 P3, CIR 1169 P1 and CIR 1169 P2 have been identified. An intra-*hirsutum* hybrid CSHH 238 and *G. arboreum* culture CISA 310 ranked first over the three years and were recommended for agronomic trials for their identification. The cultures CSH 7106 of *G. hirsutum* and CISA 614 of *G. arboreum* ranked first under zonal trials. An intra-*arboreum* hybrid CISAA 6 and intra-*hirsutum* hybrid CSHH 243 were at 3rd and 5th position, respectively under zonal trials.
- The highest cross boll setting percentage for hybrid seed production was noticed during crossing period from August. 18th to September 7th. Seed soaking in succinic acid for six hours before sowing and foliar spray of 0.1% boron at 60, 75, 90 DAS increased the seed yield in all the hybrids. In varieties the significant and maximum increase in boll number and boll weight was observed when boron was sprayed @ 0.1% at 60 DAS. The topping at 60 DAS and defoliant sprayed at 140 DAS increased seed cotton yield

in *G. hirsutum* and *G. arboreum* varieties. Seed obtained from second picking was found better in quality.

2.2 Crop Production

Nagpur

- Significant mean maximum (23.30 q ha^{-1}) seed cotton yield was recorded with two irrigations @ 4 ha cm of water, first at flowering and second at boll development stage closely followed by (22.64 q ha^{-1}) three irrigations at flowering, early boll development and peak boll development stages.
- Seed cotton yield due to moisture conservation practices was found to increase from 0.61 – 2.4 q ha^{-1} over control. Ridge and furrow system was evaluated as the best over other moisture conservation practices adopted in different toposequence.
- Maximum WUE (2.46 kg $ha^{-1}mm^{-1}$) was recorded in the treatments where greengram was intercropped with cotton closely followed by (2.40 kg ha^{-1} mm^{-1}) cotton intercropped with blackgram and the minimum (2.01 kg $ha^{-1}mm^{-1}$) under control.
- Among the various moisture conservation practices tested over the years in 40 farmers' fields on upper, middle, lower and bottom toposequences, ridge and furrow system across the slope at the end of August was evaluated as the best system and effective in reducing maximum runoff, increasing percolation, conserving maximum rainwater and improving the recharge capacity of irrigation wells.
- A significant effect of nutrient management practices was observed in a field experiment conducted for the second consecutive year. Response to Zn and B was not observed. Yield in the plots with partial supplementation through organics (25 % and 50 %) was at par with the NPK plots. On the other hand, site specific nutrient management for a targetted yield was found to be the best treatment. None of the treatments affected the fibre quality parameters.
- Response of both *G. arboreum* (cv. AKA 8401) and *G. hirsutum* (cv. Rajat) was noticed to foliar application of potassium at early and peak boll formation stages compared to K applied basally as soil application. Furthermore, soil applied K resulted in significant yield increase over the NP plots. However, K application did not impact any of the fibre quality traits.
- Application of micronutrients with supplemental irrigations such as B 3 kg ha^{-1} and Mn 10kg ha^{-1} singly or together soil +foliar application in 3:1 together Zn, Mn and Boron @ 10, 10 and 3 kg ha^{-1} every year significantly improved the seed cotton yield by 25, 20 and 18% or 372, 335 and 332 kg ha^{-1} over rainfed conditions.
- Effects of tillage management practices on *G. arboreum* and *G. hirsutum* were assessed for the third year. Tillage x genotype interaction was significant. Yield of the *G. arboreum* did not differ significantly between tillage systems. On the other hand, yield of the *G. hirsutum* was significantly better in the reduced tillage systems compared to the conventional tillage system.
- In NHH 44 hybrid strip cropping with pigeon pea in 8:2 ratio, biofertilisers in hybrid cotton improved seed cotton yields by 153 (10%) and 93 kg ha^{-1} (7%) at 50% and 100 % recommended fertilizers respectively in 2/3 years. The pigeon pea grain yields were improved by 157 kg ha^{-1} at 50% recommended fertilizers with hybrid cotton strip cropping. The B:C ratio were improved from 2.78 to 3.66 by biofertilisers followed by RDF + biofertilisers 3.47 and biofertilisers with 2% urea as foliar spray by 3.18 in hybrid cotton + pigeon pea strip cropping.
- One year study with extra long staple genotypes found Bunny, Abadhita, Sahana and Swati to be superior to NHH 44 under organic management. N fixing, P solubilising bacteria, *Trichoderma*

viride and *Pseudomonas* application as seed treatment improved seed cotton yield by 21% over farmers' organic practice in long staple Surabhi cotton . Vermi compost improved seed cotton yield by 11%, Neem Seed Kernel Powder (after spray) @ 2 kg ha^{-1} improved by 28% and EM application by 12% over farmers' organic practice.

- NMDS nozzle was found to deliver finer spray followed by hollow cone and BCN single nozzle with minimum ground loss of pesticide and giving maximum deposition on the site of egg laying on the top.
- A generic model INFOCROP has been calibrated and validated using crop, weather and soil as basic inputs. The model has simulated the phenology more accurately and the accuracy of simulated yield and biomass were 92 % and 89 % across the centers.
- Removal of early formed squares either mechanically or using low concentration of ethrel led to more vegetative growth, sympodial node production and spurt in fruiting activity.
- Growth and development of seven *arboreum* genotypes revealed that CINA 348 had better performance in shallow soil.
- Database for gossypol content in working collections of germplasm lines has been further strengthened by estimation of gossypol in 60 additional samples and variability has been observed.
- A few *G. arboreum* germplasm lines and some single plant selections were found to possess higher seed oil content (18.5 to 22.6 % and 22 to 26%) than the average value of 14-16%.
- Foliar spray of 2,4-D (5 ppm) during flowering led to malformation of leaves and flowers. 2,4-D spray led to severe boll drying and reduction in flower size. The response was, however, found to be temperature dependent.
- Nineteen *G. hirsutum* and *G. arboreum* lines were screened for drought tolerance during flowering. Leaf relative water content and water potential are more prominent sustainable tolerance traits in *hirsutum* while solute concentration and root/shoot ratio are conspicuous in *arboreum* genotypes. Nitrate reductase activity was found to be higher during stress period in some *hirsutum* and *arboreum* lines. As a result of stress response, some lines also showed accumulation of proteins. The lines with higher leaf relative water content were identified.
- With regard to salinity, cotton genotypes showed decline in growth and yield beyond 7 EC. *G. arboreum* and *G. herbaceum* genotypes had better tolerance for salinity. Leaf area production was very sensitive to salinity compared to decline in photosynthesis. Tolerant genotypes possessed higher accumulation of proline and higher K/Na ratio. Decline of yield was more marked in *hirsutum* genotypes.
- Continuous water-logging for 15 days led to yellowing and shedding of leaves and squares. Yield reduction was higher in Asiatic genotypes as compared to American cotton. Higher transpiration loss of water in addition to restricted uptake of water due to impaired root activity promoted wilting in hybrids and early maturing genotypes.
- One hundred *G. hirsutum* and fifty *G. arboreum* lines were evaluated for physiological attributes under rain grown conditions. Considerable variability was recorded for growth, yield and process attributes.

Coimbatore

- Combined inoculation of *Azospirillum* + PSB + PPFM at 75 % NP level recorded 412 kg/ha additional seed cotton yield than 100 % NP alone without bio-inoculants.
- Poly mulching benefited the cotton crop to the

tune of 1.88 fold and the maize crop by 2.87 fold than conventional method and recorded higher water use efficiency of 42.7 to 53.6 kg/ha as compared to 23.1 kg /ha under non mulching.

- FYM alone @ 15 t/ha, FYM @ 5 t/ha + RD-NPK, or RD-NPK + crop residues @ 2.5 t/ha had a beneficial effect on both performance of crop and soil.
- Application of FYM @ 5 t/ha along with cotton whole residue @ 2.5 t/ha and green manure sun hemp grown *in situ* and buried at 45 DAS produced significantly higher yield over both control and RD-NPK.
- A multi-tier cropping consisting of cotton + radish + amaranthus gave the highest net return as compared to sole cotton crop.
- The poly tube laterals (600 gauge) drip system with LLDPE (Linear Low Density Poly Ethylene) has been found beneficial and gave a cost benefit ratio of 1:1.56 when compared with ridges and furrow method of irrigation.
- The peroxidase activity was slightly high in fuzzless genotype (76 - 12 units in fibres and 87 - 196 units in ovules) during progressive boll development stage as compared to fuzzy genotype (68 - 10 units in fibre and 74 - 170 units in ovules).
- Application of Ethrel at 45 ppm showed an increase in yield of 40% (2340 kg/ha in LRA 5166 and 2400 kg/ha in Sumangala) over control (1620 kg/ha).
- MS basal medium with phytohormone combination of NAA (0.5 mgL^{-1}) + Kin (0.5 mgL^{-1}) and 2,4-D (1.5 mgL^{-1}) + Kin (0.5 mgL^{-1}) and planting density of 2 x 10^4 protoplasts/ml led to first cell division after three days in culture and subsequently showed quadruplet formation.
- Foliar application of *Pseudomonas fluorescens* pf1 induced higher peroxidase activity (102 -115 units), while the control plants possessed low activity (36-51 units).
- Seed dressing insecticides triggered ATP activity and energy availability in young cotton seedlings.

2.3 Crop Protection

Nagpur

- Out of 229 genotypes involving 131 crosses and 98 single plant selections evaluated for genotypic tolerance using phenological trait of compensation 14, 32 and 21 were susceptible, moderately tolerant and tolerant respectively to early season bollworm damage and had higher compensation.
- Two lines CTI 4-21-14-22-1 and EC 11943 x Jhiang of *G. hirsutum* have exhibited the resistant reactions against virulent race 18 of *Xam* under glass house conditions.
- Out of 3516 *G. hirsutum* germplasm lines screened against fungal foliar pathogens, two namely, RAMPBS 220 and RAMPBS 261 were resistant to Alternaria leaf spot and two viz, Coker 100 AWR cc and 65-2(S)2-3 were resistant to grey mildew and 26 lines showed resistance to Myrothecium leaf spot.
- Reproductive compatibility in interstrain crosses was studied in *H.armigera*. Maternal influences on feeding preferences of inter strain crosses was demonstrated.
- No development of resistance to Bt cotton has been observed till date with LC_{50} well within the range like that of previous years.
- Soil solarization of 15 days was found to reduce population of root-knot nematode from 300 juveniles/ 250 cc soil to 20 juveniles/ 250 cc soil.
- Sixteen isolates of Entomopathogenic nematodes (EPN) belonging to *Heterorhabditis bacteriophora*, *H. indica* and *Steinernema glaseri* isolated from cotton growing ecosystems and found effective against cotton insects particularly cotton bollworms were quantified for variation in tolerance to temperature stress and host finding ability.

- Two *Photorhabdus* isolates, the symbiont of Entomopathogenic nematode which were earlier recorded to be antagonistic towards sucking insect pests of cotton, were field tested and found effective in preliminary field trials. Protocol was developed using soaked grains of rice and jowar fortified with 1 % yeast granules for development of *N. rileyi* and *Metarhizium* mycelia and sporulation.
- Nine potential antagonists comprising eight species of fluorescent and non fluorescent *Pseudomonas* and one species of *Bacillus firmus* isolated from rhizosphere and phylloplane of cotton provided highly effective inhibition of *Xam* and possessed strong PGPR activities including production of H_2S, levan, protease, siderophore, fluorescin and pyocyanin.
- Isolates of *R. areola* made from the cultivars of *G. arboreum* and *G. herbaceum* were observed to be fast in growth as compared to the isolates of *G. hirsutum*. RAPD-PCR pattern of amplification gave indication of variation among the isolates at species level.
- Variability in growth pattern, influence of salt concentration on growth, pigmentation, pathogenicity and RAPD-PCR pattern was observed in 13 isolates of *F.o.f.* sp. *vasinfectum.*
- Based on pathological and molecular data generated on Rep-PCR genomic DNA fingerprinting, RFLP and RAPD, 10 biotypes of race 18 were documented. Specific fingerprinting pattern of each biotype is documented. rDNA genes from representative biotypes were cloned and submitted for nucleotide sequencing. RFLP of genomic and plasmid DNA of isolates belonging to six different races exhibited clear polymorphism. Race 18 isolates possessed few copies of *Xanthomonas* avr pth gene family (predominantly two) compared to less virulent races which possessed up to seven copies of avr/pth genes. Besides, the less virulent races were also differentiated from more virulent races 10, 12 and 18 with conspicuous absence of a plasmid of 31.2 kb.
- Southern hybridization of PCR fragments generated by using coat protein primers from diploid cottons did not hybridize to CP gene probe ruling out any possibility of diploid cotton serving the collateral host to the pathogen. In an effort to further improve expression of recombinant coat protein in *E. coli,* the gene was swapped from pCaln (Stratagene) expression vector into pET 27b (Novagen).
- Based on crop phenology and seasonal occurrence of insect pests in relation to pest management options tested, rainfed IPM system was evolved.
- Early season sucking pest control using systemic insecticides, either through seed treatment or foliar sprays altered the phenology of the cotton plant and predisposed to the higher attack by bollworms especially *H. armigera.*
- Larval survival of *H. armigera* was high on crop that had seed treatment and/or systemic foliar insecticidal sprays.
- Diploids had higher parasitisation levels of *H. armigera* than the *hirsutum* / hybrids
- More than two rainy days each during 35 and 41 standard weeks (SW) led to higher incidence of *H.armigera* in cotton eco system. The critical periods of weather influence were SWs 35, 41, 45 and 47 corresponding to rainy days, maximum temperature and rainfall, respectively.

Coimbatore

- Insecticides Spinosad 45 SC (50, 75, 100 g), NNI 0001 (48, 60 g), KN 128 (75g), RIL 038 (50, 60 g) were found effective against *H .armigera* larval incidence.
- Pink bollworm incidence was significantly low in Spinosad (100 g), Karate Zion 5 CS (20, 25 g), Karate 5 EC (25 g) and Endosulfan (700 g) treated plots as compared to control.
- Four cultures viz. (VRS x V112) 3-2-4, 5(1 x 2)

724- 2, (V22 x V112)(L x M55)-443 and LS 3 have been identified as resistant source to pink bollworm and the BRS-5 (L x BRS) 355 as a tolerant genotype to all the three bollworms.

- The location specific IPM at village level led to reduction in savings in plant protection cost by Rs. 688 / ha and increased seed cotton yield by 350 kg / ha.
- Aphid population was at its peak during December on RCH Bt cotton; leaf hopper infestation was seen throughout the season and natural enemy population of Coccinellids and spiders were more during November-December.
- The population build up of the stem weevil (*Pempherulus affinis* Faust) was maximum during May and extended upto second fortnight of July.
- Neemazal (a neem based formulation) granules @ 12.5 kg/ha, Carbofuran @ 33.33 kg a.i. /ha and Phorate (150 kg/ha) significantly reduced the stem weevil incidence.
- Application of neemcake (150 kg/ha) or Farmboon (1.2 tons/ha) have been found effective in stem weevil management.
- Spraying of talc powder formulations of *Trichoderma harzianum* and *Pseudomonas fluorescens* @ 0.2% at 10 day intervals reduced the grey mildew incidence to the extent of 13-14 %.
- Based on the disease symptoms and the morphology of the pathogen on the hosts, *R.areola* has been placed into four groups. *Euphorbia heterophylla*, a weed has been identified as a possible host for *R. areola.*

Sirsa

- IPM was demonstrated successfully in 23 acres including four acres of Bt cotton (RCH 134, RCH 317, MECH 6301, MECH 6304). In *desi,* the cost: benefit ratio was more in IPM (1: 3.61) than non IPM (1 : 2.65). The C : B ratio of 1 : 3.60 was obtained in IPM plots of American cotton followed by 1 : 3.42 in the hybrids IPM whereas in Bt cotton it ranged from 1 : 3.52 to 1:2.11 and in non Bt it was from 1 : 2.64 to 2.08.
- In epidemiological studies of cotton leaf curl virus disease, the pooled data suggested mostly clustering of infected plants showing that a part of inoculum comes from outside and then the disease spreads from plant to plant within a field. It was observed that higher maximum temperature, lower maximum and minimum relative humidity and lower rainfall up to 30th meteorological week led to lower incidence of leaf curl in 2004 crop season. Prediction equation for the disease was developed.
- The isolates of *Rhizoctonia solani* and *R. bataticola* the causal agents of root rot of cotton were grouped into four and two broad groups using OPM and OPN series primers.

3 Introduction

Brief history with summary of past achievements

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 in the year 1976 by the ICAR. The erstwhile Regional Station of IARI at Coimbatore (Tamil Nadu) became a part of CICR simultaneously to cater to the needs of southern cotton zone. In the year 1985, the IARI Regional Station at Sirsa (Haryana) was transferred to CICR as a regional centre for the northern irrigated cotton zone.

The main mission of CICR is to improve 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 fundamental research.

Two hybrids viz CSHH 198 and CISAA 2 developed by CICR RS, Sirsa were released and notified by Central Varietal Release Committee for commercial cultivation in the northern cotton zone.

Intra - *hirsutum* high fibre quality hybrid (CSHH 198 *Shresth*)

CICR, Regional Station, Sirsa has developed and released an intra-*hirsutum* hybrid CSHH 198 (Shresth) in 2004 for the entire North Zone. The hybrid possesses medium maturity of 162 days and fits well in cotton – wheat rotation of the zone. This superior medium staple hybrid has high fibre strength of 23.5 g / tex and can spin on 50s counts. Yield potential of CSHH 198 has been obtained 32 quintals per hectare which is 20% higher than LHH 144. Its lint yield has been recorded as 21% and 15.8% increase over zonal checks; LHH 144 and Om Shankar respectively. The hybrid developed by the station is leaf curl resistant and tolerant to bollworms and jassids.

GMS based *desi* cotton hybrid CISAA 2

Another hybrid developed and released by this station in 2004 is a first ever GMS based *desi* hybrid CISAA 2 for the entire North Zone. This is an early maturing hybrid (160-170 days) suitable for cotton – wheat rotation of the zone. In the zonal performance this hybrid recorded up to 18.85% increase in yield over the ruling check hybrid (AAH-1). The zonal mean increase in yield more than 4 quintals/ha was recorded over existing predominant hybrid in AICCIP trials and more than 6 quintals/ha in station agronomic trials. It is moderately resistant to Fusarium wilt and at par in fibre quality properties with AAH-1. Being a GMS based hybrid it has low seed production cost and therefore, potential of wide spread among farmers.

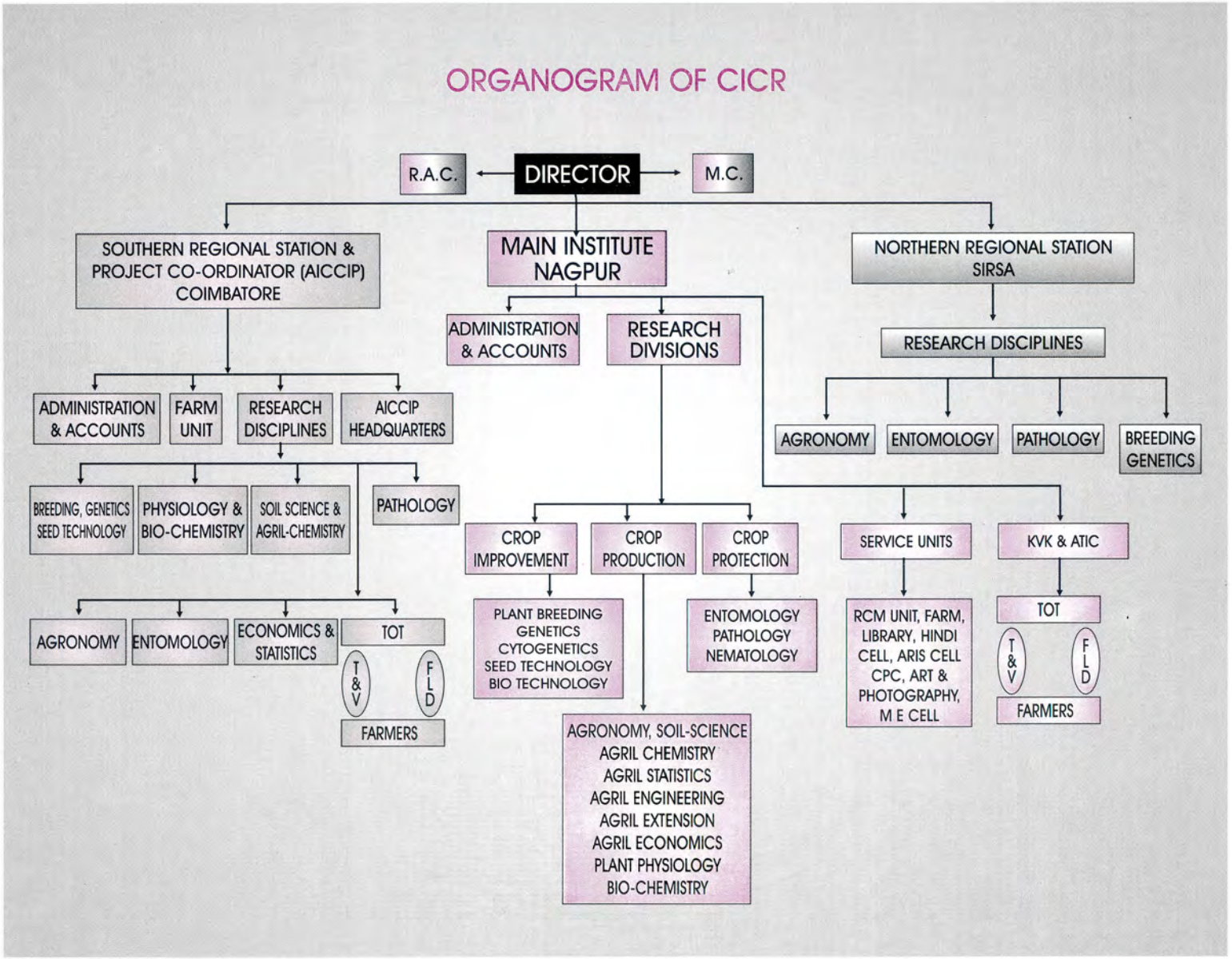
Mandate

- **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.**

- The following unique cultures/lines were registered with NBPGR as Indian National Genetic Resource.

Sr. No.	Name of the material/ designated material	Genera and species	Race	Registration No.	Year of Registration/ Patent	Unique characters
1.	G 135-49	*Gossypium arboreum* L.	Bengalense	INGR No. 00017	Notification date10.5.2000	Immune to all Grey mildew (*Ramularia areola* Atk.) disease isolates existing in nature at present.
2.	30805	*Gossypium arboreum* L.	Cernuum	INGR No. 00018	Notification date 10.5.2000	-do-
3.	CNO 131	*Gossypium hirsutum* L.	Latifolium	INGR No. 00010	Notification date 10.5.2000	Earliness & high seed oil content.
4.	30838	*Gossypium arboreum* L.	Cernuum	INGR No. 02020	Notification date 22.5.2002	Immune to all Grey mildew (*Ramularia areola* Atk.) disease isolates existing in nature at present.
5.	CNH 123	*Gossypium hirsutum* L.	Latifolium	INGR No. 02021	Notification date 22.5.2002	Resistant to Cotton Leaf Curl Virus (CLCuV)
6.	LRA 5166 (GMS)	*Gossypium hirsutum* L.	Latifolium	INGR No. 02012	Notification date 22.5.2002	Converted into GMS line.
7.	CINA 316	*Gossypium arboreum* L.	Bengalense	INGR No. 04079	Notification date 31.5.2004	High locule retentivity and low short fibre content

ORGANOGRAM OF CICR



3.1 Financial Statement

The budget grant and actual expenditure for the year 2004-2005 are furnished below:

Budget Sanctioned and Expenditure (Rs. in Lakhs)

Scheme	Sanctioned	Expenditure
Plan	153.00	153.00
Non-Plan	951.00	940.96
PLAN SCHEME		
NSP Crop	000.00	000.28
AICCIP	400.00	400.00
KVK Scheme	42.90	28.59
TMC Scheme	400.00	396.97
NATP Schemes	97.36	68.73
AP CESS FUND		
IQRC&P Scheme	3.63	3.43
IICBP	-	1.76
R DEPOSIT SCHEME		
NRI (ICAC/CFC/14)	22.27	21.76
EPS&C (DeNocil)	4.50	0.14
FLD in Cotton	97.69	92.37
TMC MM I (DAC)	2.91	1.12
FLD KVK	1.02	0.26
DUS Scheme	30.97	8.45
Maintenance of Breeder Seed	14.32	1.54
Incentive for Breeder Seed production	80.00	80.00
TMC MM II	170.00	165.34
Toxicity of Bt (CRY)	4.17	3.76
Bt. Resistance Monitoring (Mahyco) I	2.36	1.40
Bt. Resistance Monitoring (Mahyco) II	3.00	0.69
Indofil	2.36	0.79
Bt. Tech	14.23	0.05
Potash Test	2.00	0.44
DBT DNA	13.19	6.00
Video Film	1.05	1.05

3.2 Staff Position

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**	39	18	6	**63**
Technical	48	25	10	**83**	44	25	10	**79**
Administrative	33	11	7	**51**	30	11	7	**48**
Supporting	69	37	15	**121**	66	37	15	**118**
KRISHI VIGYAN KENDRA								
Training Organiser	1			**1**	1			**1**
Technical	8			**8**	8			**8**
Administrative	2			**2**	2			**2**
Supporting	2			**2**	1			**1**

ICAR
CICR

GMS based *desi* cotton (intra *arboreum*) hybrid CISAA 2 developed by CICR and notified for cultivation in the northern cotton zone

MSH 345, a multi-species hybrid derivative bearing cleistogamous flowers

Inter specific hybrid of *G. aridum* cross showing protruding stigma

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4 Research Achivements

4.1 Cotton Genetic Resources

Nagpur

One hundred and one exotic and three indigenous lines were added to the germplasm.

Collections evaluated

One hundred and one accessions were evaluated at three locations viz. Nagpur (rainfed), Sirsa and Coimbatore (irrigated) and 104 new collections were evaluated for major economic characteristics. Superior germplasm accessions identified were:

For yield - EC 543417, VCC 3, Cotton 4, EC 543380

For boll weight - EC 543366, DH 6, DH 31, SCC 114, JKCL 708

For GOT - DH 118, C 28, NCAC 5, NCAC 9, SS 116 (H)

For long fibre - ACL 23, NA 920, MC 130 (H)

High fibre strength - NA 920, JKCL 702, HOC 2, GC 110, SS 113, MC 73

Collections conserved

Three thousand accessions of base collections, 300 working collections and 400 new (including exotics) collections were grown for viability and seed increase. Five hundred accessions were stored in medium term and 300 accessions in long term cold storage at NBPGR, New Delhi.

IC/EC numbers of 1870 accessions of *G. arboreum* were allotted by NBPGR, New Delhi. Seeds of 630 accessions will be kept for long term conservation at NBPGR, New Delhi.

Rejuvenation of germplasm

A set of 700 accessions of *G. arboreum* and 160 accessions of *G. herbaceum* were grown for seed multiplication and rejuvenation.

Evaluation of germplasm for fibre quality

A set of 690 accessions of *G. arboreum* and 550 of *G. herbaceum* (irrigated and rainfed) were evaluated for fibre properties. Forty-five accessions of *G. arboreum* of high fibre length coupled with high fibre strength were selected for utilization in breeding programme under Diploid Cotton Improvement Programme. However, 33 accessions of *G. herbaceum* of high span length and 29 accessions of high fibre strength were identified from germplasm collection of *G. herbaceum*.

Evaluation of germplasm for seed oil

Oil content was estimated in 35 seed samples of *G. arboreum* germplasm lines through Soxtec analyser. Some lines were found to possess 18.5-22.6% oil than average value of 14-16%.

Out of 16 germplasm lines of *G. hirsutum* tested, accession CSH 61 recorded the highest seed cotton yield (2255 kg/ha) followed by CSH 18 (1679 kg/ha) against check LRK 516 (1328 kg/ha). Seed oil content ranged from 23.8-27.0%.

Out of 11 germplasm lines of *G. arboreum* evaluated, accession 6694 (2496 kg/ha) recorded the highest cotton yield followed by 6743 (2148 kg/ha) against the check AKH 4 (1604 kg/ha). Seed oil content ranged from 20.4 - 22.5% (By NIR).

Assessment of gossypol content in working collections

During the year, 60 samples consisting of different plant parts of germplasm lines were analyzed and the results indicated that the percent gossypol content ranged from 0.05 to 2.24%. The variability in percent gossypol content is as follows-

G. hirsutum : leaves 0.054-0.073, bolls 0.098-0.105, seeds 0.651-2.340, *G. arboreum* : seeds 0.251 –2.225.

Evaluation of germplasm under Br 01 trial of AICCIP

One hundred accessions of *G. arboreum* were evaluated under Br 01 trial in three zones for seed cotton yield, boll weight, GOT (%) and MHL. Five best genotypes identified for distribution among breeders and researchers were:

For yield - AC 3722, AC 3186, AC 3688, AC 3373 A, AC 3375

For boll weight - AC 3418, AC 3025, AC 3305, AC 3174, AC 3002

For GOT - AC 3128, AC 3111, AC 3506, AC 3551, AC 3694

For mean halo length - AC 3537, AC 3397, AKA 8401 (check), AC 3178, AC 3506

Screening for Diseases

Out of 3516 *G. hirsutum* germplasm lines screened against fungal foliar diseases, namely, RAMPBS 220 and One hundred and twenty seven germplasm lines of *G. hirsutum* were evaluated in pot culture for their reaction to bacterial blight against the virulent race 18 of *Xam* (*Xanthomonas axonopodis pv malvacearum*). Out of these, two lines viz. CTI 4 - 21 - 14 - 22 - 1 and EC 11943 x Jhiang were observed to be resistant and 15 lines have exhibited the moderately resistant reactions. Remaining 53 lines were moderately susceptible and 57 lines susceptible.

Seven hundred forty five lines of *G. hirsutum* were evaluated for bacterial blight reaction under field conditions. Out of these, 65 were observed to be free from the incidence and 51 exhibited the resistant reaction. Remaining 97 were moderately resistant, 258 moderately susceptible and 274 susceptible.

Out of 99 lines of *G. hirsutum* of Br 01 trial evaluated under natural incidence of field conditions, NCAC –3 was free from the incidence whereas nine viz. GC 110, GC 160, NA 1375, NCAC-1, NCAC - 14, VCA - 2, VCA - 4, VCA - 5 and VCC - 12 showed resistant reaction. Remaining 11 were moderately resistant, 33 moderately susceptible and 45 susceptible.

RAMPBS 261 were resistant, 462 moderately resistant, 460 moderately susceptible and 2592 were susceptible to Alternaria leaf spot while 2, Coker 100 AWR cc and 65-2(S)2-3 were resistant, 699 moderately resistant, 337 moderately susceptible and 2478 susceptible to grey mildew. Twenty six were resistant, 655 moderately resistant, 381 moderately susceptible and 2454 were susceptible to Myrothecium leaf spot.

Fourteen lines viz. Arkansas-61-28, B 57-100-CT, B-58-1372, B 59-14-14, B 59-1545, B 59-1679-2, B 61-2031, B 612050, BOSS 111, CC-29-2-3-20, Coker 100, CNH 2713 and CNH 4736 were resistant to CLCuV. Four lines viz. B 58-1372, B 59-1679-2, CB-2482-1 and DHY 286 were tolerant to whitefly, while two lines (B 58-1372 and B 59-1679-2) were tolerant to both.

Physiological evaluation

During the year 100 *G. hirsutum* germplasm lines and 50 *G. arboreum* lines were evaluated under rainfed conditions. Inspite of the weather aberrations considerable variability were seen in respect of morphological, physiological and process related traits in both the species. As in the earlier years, process parameters didn't show significant association with biomass and yield in both the species. However, some of the morphological traits e.g. plant height and sympodidal numbers were found to have positive association with yield. Leaf Area Index (LAI) was found to have positive associations with biomass in both the species, while its correlation with yield was positive and much higher than the *arboreum* even though non significant. Relative water content in both the species didn't have significant association with either the growth trends or yield. Some of the distinctly different lines in both the species were evaluated for photosynthesis, transpiration and stomatal conditions. Variability was evident for all the three traits in both the species.

Evaluation of germplasm through molecular technique

One hundred germplasm lines of cotton belonging to *G. hirsutum* (tetraploid) and *G. arboreum* (diploid) were subjected for molecular evaluation to

characterize the accessions at DNA level and to study the extent of genetic variation in them.

Accessions, morphologically similar were found to have considerable variation at the level of molecular loci. Significant, similarities were found in the clustering of ISSR and RAPD analysis. However, all the three markers showed separate clustering for diploid and tetraploid accessions. No duplicates were observed .

Genetic diversity in *G. hirsutum*

Twenty four accessions of *G. hirsutum* (12 bacterial blight resistant and 12 jassid and bollworm resistant) were evaluated for genetic diversity. Forty RAPD, 30 SSR (Micro satellite) and 19 ISSR primers, were used. Dendrogram of RAPD and SSR markers showed a similarity coefficient of 0.54 and 0.53 respectively. ISSR marker also showed the same similarity coefficient between the species but out of 19 ISSR primers used, 18 primers were polymorphic and produced polymorphic loci primer sequence. Cultivars BBR 310 and BBR 460 showed highest similarity coefficient of 0.98 and 0.82 by ISSR and SSR markers respectively. Cultivars BBR 2138, JBWR 25, JBWR 4 and JBWR 14 were found to be most distant among all the 24 cultivars. The dendograms generated clearly formed two clusters (Fig.1).

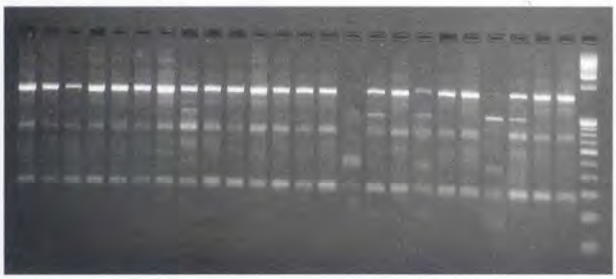


Fig. 1: RAPD profile of 24 cotton cultivars (BBR and JBWR) obtained with primer OPA 12. Lane 1 – 24 corresponds to cultivars. Lane 25, M = 100 bp + 1kb ladder.

Documentation

Four hundred collections were documented in electronic form and index card.

Utilisation of germplasm

Eighty five new crosses were attempted involving three types of donors viz. high boll weight, high ginning outturn and high fibre strength and ten good agronomic base.

Fourteen germplasm lines of high fibre strength and long linted of *G. arboreum* and 12 accessions of *G. herbaceum* were used in crossing programme for development of diploid cotton genotypes with high yield and fibre quality suitable for high speed ginning.

From the population involving four immune lines and five susceptible cultivars, 137 single plant selections have been identified for bacterial blight resistance and quality parameters. The seed cotton yield of these selected plants varied from 42.6 - 75.5 gm/plant with an average of 15.6-24.7 bolls/plant and boll weight of 2.72 - 3.65 gm.

Distribution

Seeds of 300 accessions of *G. hirsutum*, 319 of *G. arboreum*, 29 *G. herbaceum* and F_2 seeds of 10 crosses were distributed to the AICCIP centres and other Government organizations.

Coimbatore

Two sets of trials comprising 100 accessions each were conducted with *G. hirsutum* and *G. arboreum* germplasm separately under Br-01 of AICCIP. Some of the *G. hirsutum* lines were found superior over check cultivar LRA 5166 for yield and other agronomic as well as quality characters (Table1&2).

Table 1: Performance of select *G. hirsutum* germplasm lines evaluated under Br-01 trial (Old Set) for morphological and fibre quality characters

Accession Name	Seed Cotton Yield (g/plant)	Boll Wt. (g)	Bolls/plant	GOT (%)	S.I. (g)	L.I. (g)	2.5% SL (mm)	Micronaire	Strength (g/tex)
SV 413	38.9	4.9	16.3	33.6	**14.4**	7.3	30.5	4.6	23.0
ACC 133	**91.6**	4.7	36.0	33.7	11.2	5.7	-	-	-
NCSS 3	61.5	**5.6**	17.4	37.5	9.5	5.7	-	-	-
NA 1678	52.0	5.4	26.7	**42.0**	10.9	**7.9**	28.4	4.1	21.0
Nagpur 9	58.2	4.5	33.0	34.4	9.9	5.2	**32.0**	4.5	22.9
Cotton 9	62.2	3.8	**40.3**	34.6	8.5	4.5	27.0	3.9	22.8
Cotton 32	70.3	4.0	34.6	31.4	9.6	4.4	29.0	4.0	**24.7**
Average	47.9	4.2	24.3	34.6	9.7	5.2	27.4	4.2	21.3
Maximum	**91.6**	**5.6**	**40.3**	**42.0**	**14.4**	**7.9**	**32.0**	**5.2**	**24.7**
Minimum	15.8	3.0	9.7	24.1	7.0	3.2	23.3	3.2	18.8

Table 2: Performance of select *G. hirsutum* germplasm lines evaluated under Br-01 trial (New Set) for morphological and fibre quality characters

Accession Name	Seed Cotton Yield (g/plant)	Boll Wt. (g)	Total Boll No.	S.I. (g)	L.I. (g)	2.5% SL (mm)	Micronaire	Strength (g/tex)
Cotton 14	63.2	3.6	**35.7**	7.6	3.9	29.0	4.1	22.8
NA 920	75.0	5.7	27.7	**13.0**	5.1	29.5	3.8	18.5
JKCL 702	28.6	4.2	21.4	10.7	5.3	**34.8**	3.4	19.4
VCA 1	**82.1**	5.7	25.0	10.0	5.8	30.1	3.7	21.9
KDGH 50	36.5	**5.8**	19.6	6.9	**6.9**	27.6	4.3	22.8
SS 113	27.5	3.9	14.7	9.1	4.5	30.0	4.1	**25.5**
Average	47.7	4.2	22.5	9.6	5.2	27.9	4.1	21.5
Maximum	**82.1**	**5.8**	**35.7**	**13.0**	**6.9**	**34.8**	**5.1**	**25.5**
Minimum	13.8	3.1	10.0	6.9	3.3	23.4	3.2	18.3

G. barbadense germplasm accessions (225) were multiplied and evaluated for various morphological and biochemical characters like seed oil, seed protein, gossypol content etc. and reaction to pest and diseases. The working collection of *G. hirsutum* was also multiplied. Apart from these, the registered accessions of cotton and some exotic collections maintained under long term storage at NBPGR, New Delhi were multiplied and evaluated.

Sirsa

a) One hundred lines each of *G. hirsutum* and *G. arboreum* under Br 01 trial and 710 lines of *G. hirsutum* and 400 lines of *G. arboreum* of germplasm were evaluated for yield and quality parameters and availability of superior accessions presented in table 3.

b) In addition to above, 215 germplasm lines were evaluated for high GOT of more than 37% (CSH 3036, 3037, 3090, 3117, 3118, 3123, 3035, 3152, 3143 and CSH-3086) and high fiber strength of more than 23.0 g/tex (CSH 3003, 3005, 3031, 3047, 3097, 3118, 3119, 3132, 3167 and 3185)

(c) A new uncommon mutant in *G. hirsutum* cotton with light and dark pink filament mutant with light and dark pink margins in their petals and without petal spots were discovered in the population of AKH 0308 which bred true in the progeny testing.

(d) An uncommon spontaneous pink petal colour mutant was identified from F_3 population of a cross T-7 x LSC-5 involving parents; T-7 a cream petal, yellow anther and LSC-5, cream petal segregating for anther colour cream or yellow. This mutant bred true in the progeny testing.

(e) Thirty nine of *desi* cotton germplasm lines procured from Hisar, Faridkot (Br 22 a/b entries), Coimbatore, Gujarat and Assam cottons were evaluated for fibre properties along with RG 8, DS 5. Single plant selections made from the genotypes CINA 318, KWA 142, JLH-26, DH 149 MALJARI, LAS 4, AC 3370-1, AC 3590 and AC 3504 gave fibre strength >22 g/tex, fibre length above 25 mm and micronaire value around 5.00.

Table 3: Availability of superior accessions for yield and quality traits

Parameter	*G. hirsutum*	*G. arboreum*
Seed cotton yield (g)	>150=15	>120=12
Boll weight (gm)	>4.0=10	>3.0=15
Boll number	>50=10	>47=10
Ginning Outturn (%)	>38=18	>37=15
Seed Index (gm)	>12.0=15	>7.8=14
Lint Index (gm)	>6.0=15	>4.2=12
2.5 % Span length (mm)	>29.0=15	>26.0=10
Uniformity Ratio (%)	>54=12	>54=14
Fineness Micronaire ($10^{-6g/in}$)	<3.7=15	<4.5=15
Fibre Strength '3.2' gauge (g/tex)	> 26=10	>23=15

4.2 Hybrid Cotton

Nagpur

During the crop season, 36 CMS, 13 GMS and seven restorer lines were maintained in addition to, 59 CMS, 37 restorer and 15 GMS lines received from collaborating centres. Nineteen CMS/B, 10 restorer and 5 GMS lines were evaluated under sprayed and unsprayed conditions. Six B lines viz. AK 2173 (1426 kg/ha), Anjali (1319 kg/ha), RCMS 7 (1277 kg/ha), RCMS 8 (1180 kg/ha) and HCMS 3 (1131 kg/ha) were found promising. They recorded more than 50% increase over the check LRA 5166 (729 kg/ha). Among the ten restorer lines evaluated under common trial, AKA 785 R recorded the highest yield of 1292 kg/ha followed by AKH 03-16R (1287 kg/ha) and LR 18 (1210 kg/ha). Among the GMS lines, HGMS-9 was the best line identified by recording 1708 kg/ha seed cotton yield and 1:1 segregation for male sterile and fertile plants. Seven, 32, 40 and 10 genotypes are under conversion into GMS, restorer, CMS (*harknessii*) and CMS (*aridum*) background. They are in various backcross generations. Two genotypes, viz. K2 and Laxmi have been converted into GMS background. The single plant selections showing 1:1 segregation were tested for two consecutive years. Five genotypes viz. IC 321, Acala glandless, LH 900, Sharda and Reba B-50 have been converted into CMS background. Fifty six single plant progenies were raised for RxR, AxR and (AxR)xP crosses. The progenies were selfed for further testing.

One hundred and thirty three GMS and 67 CMS hybrids were evaluated in five different trials. The seed cotton yield ranged from 1055.91 to 1677.33 kg/ha. Hybrid NGMSH 106-05, 89-05, 103-05, 109-05 and 94-05 were some of the promising GMS hybrids identified. They recorded more than 20% heterosis over the check NHH 44. Among the CMS hybrids, AK 32 x AKH 98-81R, Ar3 x AKH 98-81R were the best. They recorded 1527.77 and 1458.33 kg/ha seed cotton yield. Three CMS hybrids viz. AK 32 x AKH 98-81, Ar1 x AKH 26R and Ar3 x AKH 26R recorded seed cotton yield at par to their B x R counterpart.

Under common trial, 27 male sterile based hybrids were tested alongwith two checks PKV Hy4 and NHH 44. Seed cotton yield ranged from 437 kg/ha to 2019 kg/ha. Three hybrids were at par with the check PKV Hy4 which recorded 1499 kg/ha seed cotton yield while only one hybrid out yielded the check NHH 44 which recorded 1781 kg/ha seed cotton yield. HHH 400 was the best hybrid and recorded 2019 kg/ha seed cotton yield. Eleven *desi* male sterile hybrids were tested in common trial alongwith check PKV DH-1. The seed cotton yield ranged from 847 kg/ha to 2139 kg/ha. Hybrid AKDH 32 was at par with the check PKV DH-1 which recorded 2092 kg/ha seed cotton yield.

One hybrid CINGH 2006, which ranked third in south zone, was sponsored. The hybrid has been promoted for testing in south zone. Hybrid CINHH 121 has been sponsored for testing in Br 05 (b)-2 and national trial.

Coimbatore

Development of high yielding conventional intra *hirsutum* hybrids

One hundred and thirty intra *hirsutum* hybrids were evaluated in a replicated trial for two years. A perusal of two years' data indicated that LK1 x TK 43 recorded the highest yield of 2669 kg/ha with a mean ginning out turn of 38.3 percent (Table 4).

Table 4: Performance of select medium staple intra-*hirsutum* hybrids (mean of two years)

Hybrid	Mean Seed Cotton Yield (kg/ha)	GOT (%)	2.5% SL (mm)	Micronaire	Strength (g/tex)
LK1 x TK 43	2669	38.3	29.4	4.3	21.5
LK1 x TK 44	2464	**39.0**	28.1	4.3	21.6
LK22 x TK 33	2429	37.5	27.3	4.8	20.1
LK 21 x TK 43	2342	37.3	29.4	4.3	21.5
Surya (C)	2257	36.5	**30.8**	**4.2**	**23.8**
NHH 44 (C)	2209	38.5	25.6	4.6	18.9

In the second trial, 60 long staple hybrids were evaluated for two years. Four hybrids viz., LS3 x LS11, LS1 x LS18, LS1 x 23 and LS1 x 21 combined yield and superior fibre properties (Table 5).

Table 5: Performance of select long staple intra-*hirsutum* hybrids (mean of two years)

Hybrid	Mean Seed Cotton Yield (kg/ha)	GOT (%)	2.5% SL (mm)	Micronaire	Strength (g/tex)
LS3 x LS11	**1854**	35	29.3	4.2	22.6
LS1 x LS18	1777	37	29.0	5.4	22.7
LS1 x LS23	1708	37	**31.5**	4.3	**23.7**
LS1 x LS21	1706	37	30.8	**4.0**	23.4
Surya (C)	1645	**38**	**31.5**	4.3	22.0
NHH 44 (C)	1500	37	26.7	4.2	21.6

Development of conventional extra long staple interspecific hybrids

Eighty four interspecific hybrids (*G. hirsutum x G. barbadense*) were evaluated for yield and other agronomic parameters along with check hybrids TCHB-213 and Sruthi. Several hybrids were found superior in terms of seed cotton yield and fibre quality. The hybrid LS 25 x P 28 has out yielded (2950 kg/ha) both the check hybrids Sruthi (1860 kg/ha) and TCHB-213 (1900 kg/ha) (Table 6).

Table 6: Performance of select inter specific hybrids for yield and quality

Genotypes	Seed Cotton Yield (kg/ha)	LI (g)	SI (g)	GOT (%)	2.5% SL (mm)	Micro-naire (µg)	Strength (g/tex)
LS25 x P28	2950	3.6	10.2	26.0	34.2	2.7	28.4
LS 25 x P 29	2900	3.6	10.2	26.0	32.4	2.8	29.6
LS24 x P29	2840	3.5	10.0	28.5	32.5	2.8	26.4
LS 9 x P25	2800	3.5	8.6	27.0	30.5	2.7	26.2
LS26 x P28	2730	3.8	9.1	26.8	32.5	2.8	27.9
TCHB-213 (C)	1900	3.4	9.3	29.0	32.2	3.0	26.4
Sruthi (C)	1860	4.1	9.8	28.5	33.1	2.8	26.1

Development and utilization of cytoplasmic and genetic male sterility for hybrid seed production and fertility restoration in cotton

In a replicated trial, 22 GMS based intra *hirsutum* hybrids evaluated for yield and other characters indicated significant difference between the entries.

Four separate station trials were conducted to evaluate the performance of 54 CMS based intra-*hirsutum* hybrids. In the first trial, analysis of data on seed cotton yield of 14 hybrids indicated significant difference among the hybrids. The test hybrid RKR 4145 x A (2270 kg/ha) recorded the highest seed cotton yield followed by LRA 5166 x AK 2 (2140 kg/ha). In another trial, with 17 other hybrids, none showed significantly higher yield over the check hybrid NHH 44 (1650 kg/ha).

Twenty two CMS based inter specific hybrids were evaluated in a station trial along with Sruthi and TCHB 213 as check hybrids. There was significant difference in seed cotton yield among the hybrids. The highest seed cotton yield was recorded in the test hybrid 70 G x PR (1520 kg/ha) followed by HLS 72 x PR (1480 kg/ha).

The GMS based inter specific hybrid CCHB 727, which has been tested in coordinated hybrid trial of South Zone in AICCIP during the year 2004-05, was retained for testing one more year, since it recorded higher yield over the zonal check hybrid DCH 32. Another GMS based inter specific hybrid CCHB 125, which performed well in the preliminary hybrid trial of AICCIP during the year 2004-05, has been promoted to coordinated hybrid trial in Central Zone.

In a common replicated trial, 30 intra-*hirsutum* hybrids including PKV Hy 4, NHH-44 and Bunny were evaluated. Analysis of data on seed cotton yield indicated significant difference among the entries and the check hybrid Bunny recorded the highest yield of 1920 kg/ha and none of the test hybrids proved superior to them.

Of the six new *desi* GMS lines evaluated for stability, the segregation for fertile and sterile was found to be in 1:1 ratio.

In a common replicated trial, 12 inter specific hybrids were evaluated. The check hybrid TCHB 213 recorded the highest seed cotton yield of 1130 kg/ha followed by CCCHB 04-2 with 1090 kg/ha. Quality-wise, the above test hybrid was better for bundle strength recording 30.0 g/tex as compared to 27.9 g/tex recorded in the check hybrid.

Sirsa

Development of productive intra-*hirsutum* hybrids with superior quality

Demonstration of promising hybrids: The demonstration trial consisted of eight hybrids along with two checks Om Shankar and LHH 144. Highest yield of 3206 kg/ha was given by CSHH 258 followed by CSHG 26 (2983 kg/ha) and CSHH 238 (2875 kg/ha), the highest ginning outturn by Om Shankar (34.6 %) followed by CSHG 26 (33.6 %), the highest 2.5 % span length 28.2 mm by CSHG 26, whereas the highest bundle strength of 22.5 g/tex was observed in hybrid CSHH 198 followed by 22.0 g/tex in hybrid CSHG 9.

Performance of CSHH 238 in Br-05 (a) –1 Zonal trial : The hybrid CSHH 238 was tested under irrigated conditions in North Zone. It recorded the mean seed cotton yield of 2523 kg/ha against 2357 kg/ha of LHH 144 Zonal check hybrid. The hybrid was characterized by medium staple (27.8 mm), good micronaire (4.6) and moderate strength (22.4 g/tex) and was recommended for agronomy trial.

Performance of *G. hirsutum* hybrids CSHH 243 in Br-05 (a) –1CHT (Zonal trial) : The hybrid CSHH 243 was tested in North Zone and recorded mean seed cotton yield of 2431 kg/ha (ranked fifth) against 2357 kg/ha of LHH 144, zonal check. It was characterized by medium staple (27.1 mm), good micronaire (4.9) and moderate strength (23.1 g/tex).

CSH 2563 was found with high yield and better fibre quality character in common TMC1.2 trial under North Zone conditions and was recommended for advance trials in AICCIP. Two high yielding and good

fibre quality genotypes CSH 2575 and CSH 2580 were sponsored in 2005-06 TMC common trials.

Development of hybrids (MS based) of medium staple length in *Gossypium arboreum* L.

F_1 crosses: Under this trial 111 F_1 hybrids were tested. The five top yielding hybrids are CINA-316 X RG-8 (3268.0 kg/ha), CISA-65 x PAIG-8/1 (3050.0 kg/ha), RG-341 x PA-304 (2723.3 kg/ha), CISA-310 x CINA-323B (1960.8 kg/ha), RG-342 x DLSA-202 (1742.9 kg/ha) and five top GMS based hybrids are DS-5 (GMS) x G-27 (2941.16 kg/ha), DS-5 (GMS) x HD-123 (2832.04 kg/ha), DS-5 (GMS) x PAIG-8/1 (2614.4 kg/ha), DS-5(GMS) x DLSA-9 (2614.4 kg/ha) and DS-5(GMS) x RG-286 (2510.0 kg/ha).

GMS lines: One CISA 2 line with yellow flower has been identified and confirmed by genetic analysis as GMS line.

Diversification and utilization of male sterility system

Evaluation of GMS based hybrids: Two different trials were conducted. In the first trial 60 GMS based hybrids were evaluated and the highest seed cotton yield was recorded in MCU-5 x CIRB-71 (1972 kg/ha), K 34007 x M 45 (1886 kg/ha) and CSHG 1858 x LRK 516 (1886 kg/ha) as against 1680 kg/ha and 1715 kg/ha recorded in local check hybrids LHH 144 and Om Shankar respectively. Maximum ginning out turn of 36.8 % was recorded in the cross combinations K 34007 x M 45 followed by 36.6 % in CSHG 09 x F 4105.

In the second trial 61 GMS based hybrids were tested and the highest seed cotton yield was recorded in GMS based hybrids MCU-5 x PHP-2 (3086 kg/ha) and CSHG 1250 x VCHM (2538 kg/ha) as against 1715 kg/ha in local check hybrid Om Shankar. Maximum ginning out turn of 38.5 % was recorded in the cross combination K 34007 x PHP 3 followed by 38.0% (K 34007 x PHP-11) and 37.8 % (K 34007 x PIL 8).

Evaluation of CMS based hybrids: Three different trials were conducted. In the first trial 52 CMS based hybrids were evaluated along with local check hybrids Om Shankar and LHH 144. The highest seed cotton yield was recorded in F 505 x CIR 119 P1 (3611 kg/ha) followed by 3409 kg/ha in K 34007 x CIR 526, P3 H 777 x CIR 97 P2 and F 1183 x CIR 97 P3. The highest ginning out turn of 38.5 % was recorded by the cross SH 2379 x CIR 526 P1 followed by 37.8 % in H 777 x CIR 526 P2. The hybrid SH 2379 x CIR 920 P1 has shown the highest 2.5 % span length of 29.1 mm in comparison to local check LHH 144 (28.5 mm). The hybrid F 505 x CIR 920 P1 had bundle strength of 24.5 g/tex.

In second trial 55 hybrids were evaluated and the highest seed cotton yield of 3545 kg/ha was recorded in K 34007 x CIR 926 P2 and SH 2379 x CIR 526 P3. Maximum ginning out turn of 38.3 % was recorded by SH 2379 M x CIR 926 P2 as compared to 33.3% in Om Shankar.

In the third trial 42 hybrids were evaluated along with conventional check hybrids Om Shankar and LHH 144. Highest seed cotton yield of 306 g/plant was recorded in cross Jhorar x CIR 526 P3 followed by 237 g/plant in RB 281 x CIR 526 P3 and 235 g/plant in Pusa 31 x CIR 119 P3. Ginning out turn was found to be maximum in LH 1134 x CIR 1169 P1 (37.7 %) followed by 37.5 % in RB 281 x CIR 97 P3 as compared to 33.3 % in Om Shankar.

Maintenance of CMS lines: The local adapted cultivars and parents of promising hybrids viz. CMS LRA 5166, CMS Jhorar, CMS RB 281, CMS LH 1134, CMS Pusa 31, CMS HS 6, CMS K 34007, CMS F 505, CMS F 1183, CMS CSH 25 M, and CMS SH 2379 have been converted into cytoplasmic male sterile having cytoplasm of *G. harknessii* and these CMS lines are being maintained through sib mating.

Identification and maintenance of restorer lines The new restorer lines *viz.* CIR 8, CIR 12, CIR 15, CIR 23, CIR 26, CIR 32, CIR 38, CIR 47, CIR 70, CIR 72, CIR97P1, CIR 97P3, CIR 119P1, CIR 119P3, CIR 126P1, CIR 526P1, CIR 526P, CIR 920 P1, CIR 926 P2, CIR 926 P3, CIR 1169 P1 and CIR 1169 P2 have been identified based on four year

studies. These restorer lines are able to restore the fertility upto 80-100 per cent.

Performance of CSHG 26 in Br-05 (a) –1 : The hybrid CSHG 26 tested under irrigated conditions in North Zone recorded mean seed cotton yield of 2333 kg/ha (ranked third) against 2158 kg/ha of LHH 144, zonal check. The hybrid was characterized by superior medium staple (30.5 mm), good micronaire (4.7) and moderate strength (23.2 g/tex).

Male Sterile strain in American cotton with red pigmented plant body and petal spots was identified.

4.3 Genetic Improvement

G. arboreum improvement

Fifty nine new crosses involving elite genotypes of *Gossypium arboreum* and *Gossypium herbaceum* were affected for further evaluation.

Five advance promising cultures namely CINA-333, CINA-334, CINA-335, CINA-336 and CINA-337 were identified and evaluated for fibre properties.

Two new cultures CINA-333 and CINA-334 were identified for high seed cotton yield (1800-1900 kg/ha), boll weight (3.2 g to 3.5 g), fibre length (26.2 mm to 29.2 mm) and fibre strength 18.7 to 20.4 g/tex, SFC 3.6%-5.45%, maturity days 160 and GOT 37.8% –38.3%.

Thirteen single plant selections were made based on high yield, earliness, high fibre strength and long fibre with high locule retentivity. Twenty three progenies of segregating populations were evaluated for MHL, seed cotton yield, boll weight and locule opening pattern.

The unique culture of *Gossypium arboreum* named as CINA 316 possessing high locule retentivity (17-23 days) and low short fibre content (11.75 %) has been developed. The culture CINA 316 has been registered with National Bureau of Plant Genetic Resources, New Delhi as INGR No. 04079 and IC No. 296596.

G. hirsutum improvement

24 F_2 populations of *G. hirsutum* were evaluated.

128 *G. hirsutum* F_1s involving male parents as donors from germplasm for major fiber quality traits viz., staple length, fibre strength and fibre fineness and elite cultivars as female parents were evaluated for yield and other important quantitative traits. 10 intermating of F_1s and 7 BC_1s were effected in *G. hirsutum* with elite cultivars as recurrent female parents.

32 inter specific crosses (F_1) with *G. hirsutum* varieties as female parents were evaluated. 12 inter specific crosses proved fertile and 2.5% span length was observed to be a maximum of 37 mm. Five elite crosses identified having MHL 30 and above were identified and six crosses involving three wild species and two *arboreum* races were effected.

Maintenance breeding in CNH 120 MB was done and negative mass selection was effected and 200 plants were selected and selfed.

Station Trials

The following two station trials were conducted during the reported period.

G. arboreum: In this trial, four genotypes were evaluated against two check varieties namely AKA 8401 and AKH 4. It was found that none of the genotype gave higher seed cotton yield than the check varieties i.e. 1141 kg/ha in AKA 8401 and 1091 kg/ha AKH 4.

G. hirsutum: Seven genotypes were evaluated. The highest seed cotton yield of 1187 kg/ha was recorded by entry DTS 23 followed by 1129 kg/ha of CNHO 23 as compared to 562 kg/ha of check LRA 5166. The maximum ginning outturn was shown by CNHO 23 (39.04 %) compared to 33.23 % of LRA 5166. DTS 23 had highest value for boll weight (3.7 g) against 2.5 of LRA 5166.

Abiotic Stress

Under anatomical studies on drought tolerance, 115 single plant selections were evaluated in two different sets of experiments. The single plant selections were made for fibre strength, earliness and yield. In 28 single plant selections, fibre strength

ranged from 21.1 g/tex to 25.2 g/tex at 3.2 mm gauge, while fibre length ranged from 23.8 to 33.3 mm and micronaire value from 2.8 to 4.6. SPS 109 recorded 25.2 g/tex while SPS 106 and SPS 482 recorded 24 g/tex fibre strength at 3.2 mm gauge. Three advance cultures viz. P1 x AV 3469, P3 x A 72-62 and P3 x EL 500 recorded higher yield than checks. Culture P1 x AV 3469 was found to be drought tolerant.

Three promising cultures viz. CNH 32, DTS 2 and DTS 23 were sponsored for testing in the institute common trial. DTS 23 ranked first. It recorded 1187 kg/ha seed cotton yield against check CNH 36 (660 kg/ha) and CNH 120 MB (706 kg/ha). CNH 32 ranked fifth with 839 kg/ha seed cotton yield. Two cultures viz. CNDTS 23 and CNDTS 32 have been sponsored for testing in AICCIP trials Br 02 (a) and Br 02 (b).

In total, 32 *G. arboreum* genotypes developed under NATP were evaluated and compared with popular upland varieties viz. LRK 516 and PKV 081 and hybrids viz. NHH 44, Bunny and MECH 162 - a Bt hybrid. Three genotypes were identified, which showed consistency in successive years of testing and average seed cotton yield was above 1000 kg/ha. The genotypes are - MDL 2463 (1134.8 kg/ha), DLSA-17 (1223 kg/ha) and PA 255 (1074 kg/ha). Ten on-farm trials were conducted covering about 61 ha area and 60 farmers in 15 villages of two districts (Nagpur and Wardha of Maharashtra). The performance of the identified genotypes was excellent on farmers' fields also (995 kg/ha).

In 2004-05, two on-farm trials covering an area of 19.0 ha were conducted that involved 15 farmers from four villages in Nagpur and Wardha districts. In a totally rainfed situation, *G. arboreum* genotype PA 255 performed well recording 760 kg/ha against 570 kg/ha LRK 516 (check).

Nineteen promising new cultures were evaluated in a replicated trial using LRK 516 and PKV 081 as local checks. Four genotypes were found moderately tolerant to Jassids (CSH-2545, CSH 2563, SGNR 6 and KH (SH) 153), two tolerant to aphids (F 2086 and H 1250), three genotypes moderately resistant to bacterial blight and eight moderately resistant to *Alternaria* leaf spots. The genotype H 1250 was found to be promising that produced highest seed cotton yield of 1130 kg/ha followed by CSH 2563 (1057 kg/ha) and F 2052 (1013 kg/ha) in totally rainfed situation. Six genotypes have been identified for ginning outturn above 39% (GISV 248, 39.91%; LAS 6-2-1, 39.89%; and F 2086, 39.37%). Range for the fibre quality traits was; fibre length 23.3 to 27.0 mm, bundle strength 16.7 to 21.6, micronaire 2.9 to 4.0, uniformity ratio 46.5 to 52.5 and fibre elongation 4.65 to 6.8%.

A total of 104 F_1 combinations were evaluated for seed cotton yield, ginning outturn and insect pest incidence. The range of seed cotton yield was 260 to 2366 kg/ha and ginning outturn 30.6 to 42.8%.

By population improvement approaches, 20 upland *G. hirsutum* genotypes representing most genetic diversity have been identified. Suvin *G. barbadense* representing extra-long fine quality cotton has also been identified and used as one of the male parent. The identified genotypes were maintained by selfing for last 2-3 years. In the crop season 2004-05, the selfed seeds of each identified genotype grown in three rows with 10 dibbles per row were subjected to random intermating. The crossed seeds from each genotype were bulk harvested, and shall be maintained as half sibs.

Coimbatore

Breeding of *G. hirsutum* varieties with new plant types – Development of medium staple varieties

In the coordinated varietal trial of Central Zone, culture CCH 4 recorded the second highest yields of 1494 kg/ha and ginning outturn of 39 %, was superior to both the check varieties. The culture was resistant to alternaria leaf spot, but the fibre strength was found to be lower than the check varieties.

Culture 510-4 was tested under AICCIP – irrigated trials in Central and South Zone. It was found superior to the zonal check in both the zones in yield and ginning out turn. Quality wise also, it was on par with the local checks.

In the station trials, culture BRS (L x BRS) 355 recorded the highest yield of 2032 kg/ha with a ginning out turn of 36.3 per cent, as against 1513 kg/ha and 34.0 per cent of LRA 5166 (check). Culture (Pusa x M9ROK) 132 recorded the highest strength of 24.8 g/tex.

Development of high yielding and high spinning extra long staple cotton

Of the thirteen cultures evaluated in a replicated trial, culture L (RCH x T13) 52116 recorded the highest yield of 2227 kg/ha, 2.5% span length of 31.8 mm, micronaire of 4.5 and fibre strength of 22.9 g/tex. Culture CCH 526612 recorded the highest strength of 26.0 g/tex.

In a second trial twelve high strength cultures were evaluated in a replicated trial. Cultures (M5 x Z2) 1335 (2204 kg/ha) and 72 (M5 x Z2) 7132 (2185 kg/ha) recorded significantly higher seed cotton yield than the check variety MCU5 VT (1583 kg/ha). Culture 72 (M5 x Z2) 7122116 recorded the highest fibre strength of 25.1 g/tex.

In the multilocation evaluation of 27 promising cultures from various centers, CCH 226 recorded the highest yield of 2263 kg/ha at Coimbatore, as against 1435 kg/ha of Surabhi (C). It also recorded a fibre strength of 24.1 g/tex. On a Zonal basis, its performance was best in South Zone with a mean seed cotton yield of 1904 kg/ha, ginning out turn of 36.8 % and a fibre strength of 23.3 g/tex.

Sirsa

Development of cultivars with high productivity and superior quality

Demonstration of promising varietal cultures

The demonstration trial consisted of six varietal cultures and check variety H 1098. The variety CSH 7016 gave the highest yield of 3139 kg/ha followed by CSH 1 (2981 kg/ha) and CSH 17 (2978 kg/ha). The highest ginning outturn (33.9 %) and 2.5 % span length (27.8 mm) was recorded by the variety CSH 17, whereas the highest bundle strength of 22 g/tex was recorded by the variety CSH 1.

Development of varieties of medium staple length in *Gossypium arboreum* L.

Sixty promising entries were evaluated for fibre and quality traits. The culture CISA 8 (1909.0 kg/ha) gave significantly higher seed cotton yield over local check. The highest boll weight (2.3 gm) was recorded by CISA 11.The maximum GOT % (39.9%) was recorded by CISA 33. The highest 2.5 % span length (25.1 mm) was exhibited by CISA 64.

Generation of segregating material: A number of crosses attempted between long linted strains received from Parbhani and Dharwad and the local cultivars, which are short staple but high yielding were evaluated. The F_1s obtained were evaluated for staple length as well as for seed cotton yield. Single plant selections were made from F_2, F_3, F_4 etc. generations.

Single plant selections from F_2 : The single plants from crosses LD 327 x PA 304, RG 8 x CINA 323B and LD 327 x CINA 323B gave higher seed cotton yield over local check. The single plants from LD-327 x PAIG-8/1 recorded maximum GOT % (46.9).

Single plant selections from F_3, F_4, F_5: The 17 single plants were selected out of which 8 plants have promised for good fibre properties (2.5% span length 25.0-30.0 mm, tenacity 20.1-23.0 and MIC between 4.6-5.0) along with yield.

Genetic improvement for seed oil

Nagpur

Advance cultures of *G. hirsutum*

Seed cotton yield of promising cultures were F 1861 (1700 kg/ha), F-1985 (1661 kg/ha), F 1982 (1660 kg/ha) as compared to check LRK 516 (1322 kg/ha).

Seed oil content ranged from 22.70 - 26.70% as compared to check LRK 516 (24.33%).

Advance cultures of *G. arboreum*

Seed cotton yield of promising cultures were CINA 329 (1927 kg/ha), CINA 306 (1503 kg/ha), as

compared to check AKH-4 (1293 kg/ha).

Seed oil content ranged from 19.10-21.93%. Culture LD 694 (21.93%), LD 838(21.56%) and CINA 306 (21.26%) recorded high oil content as compared to the check AKH-4 (20.53%).

Evaluation of advance cultures

A set of 26 advanced cultures of G. *hirsutum* including check LRK 516 were evaluated. Among the cultures, 9DC (1123 kg/ha) recorded the highest seed cotton yield followed by 3K (1005 kg/ha) as compared to the check LRK 516 (970 kg/ha).

Station trial

The culture CNHO 23 ranked second with yield level of 1129 (kg/ha) and seed oil content 26.5%. CNHO 12 has been promoted to Br 03 (a) in all the three zones in AICCIP. The following are the features of the entry:

Seed cotton yield of Central zone – 1568 kg/ha; North zone – 2050 kg/ha; South zone – 1668 kg/ha and 2.5% span length of 23.8 mm, 20.7 g/tex and micronaire value is 5.3 and ginning percent 36.0 and it is also found to be jassid tolerant and leaf curl resistant.

CNHO 3 has been promoted to Br 03 (b) in south zone under AICCIP this year. The major salient features are:

South zone – 1130 kg/ha with 2.5% span length of 25.4 mm, 21.0 g/tex and micronaire value is 4.5 and ginning percent 35.8 and boll weight is 3.2 g.

Oil content estimated in 40 single plant selections from 2003-04 trial also showed some promise as it ranged from 22-24% and in one or two cases it was 26% and above.

Besides, 48 samples were hydrolyzed and esterification completed for determining fatty acid profile. PAGE analysis has been carried out for protein profile in 15 seed protein samples, which showed a large number of bands.

Coimbatore

Biochemical and biometrical observations were recorded at regular intervals to assess the metabolic status of the F_3 generation materials from specific crosses viz., Sumangala x F 776, M5KD 933 x F 776, CBR 3 x F 776, Anjali x F 776, Surabhi x F 776, Supriya x F 776, Sumangala x F1861, CBR 3 x F 1861 along with the segregating populations. The yield levels ranged between 100 to 180 g per plant with oil content in the range of 23 – 25%. Among these selections, Anjali x (A x F 1861) - 3 - (2), Anjali x (A x F 1861) - 3 - (5) were found superior with better morpho-physiological attributes.

Similarly, the single plant selections from the F_2 segregating populations were evaluated for seed oil content. Among the segregating materials, TMSGH 21 – (3), TMSGH 15 – (3) possessed seed oil content of 25%, whereas TMSGH20 – (2), TMSGH 20 – (7), TMSGH 18 – (5), TMSGH 18 – (7) had 27% seed oil content.

NR activity ranging between 4 to 7 µmoles/h/g fr.wt., revealed better nitrogen assimilation. Similarly, reducing sugar, protein and peroxidase activity were found gradually increasing up to 120 days after sowing stage, indicating better metabolic status.

Sirsa

Screening of available gene pool and breeding material for high oil content

Fifty-five CMS, 11 GMS and 13 Restorer lines of *G. hirsutum* were evaluated for estimation of oil content. Seventeen lines viz., CISV 4, SPC 11 x CIR 9-1-1, CMS LRA 5166, CMS F 846, CMS 39 Jhorar, CMS 55 LRA 5166, CMS 101 Jhorar, CMS 101 SH 2379, CMS 16, CMS 114 CB 9, CMS 144 CB 9, CMS 148 PIL 8, CMS 27 Jhorar, CMS 18, CMS 23-16, CMS 19-CB 25 and CMS 24 Jhorar were found to contain more than 26 % seed oil.

4.4 Genetic Diversity Through Introgression

Nagpur

Interspecific Crosses - *G. arboreum* long staple genotypes PA 402, PA 183 and PA 255 were crossed with wild species *G. thurberii, G. trilobum, G. anomalum, G. aridum* and one cv LRA 5166 of *hirsutum* cotton. Enlargement of ovary after pollination was used as the test criteria for boll setting. Likewise other *G. arboreum* genotypes such as AKH 4, AKA 8401, AKA 5 and G 27 were crossed with *G.trilobum, G. anomalum, G.aridum, G. capitis-viridis* and MCU 5.

Cross PA183 x *G. trilobum* has recorded highest boll setting of 18.2 % followed by AKH 4 x *G. raimondii* (10 %) and AKH 4 x *G. aridum* (9.0). The seed setting percentage was however low. In cross PA 183 x *G. trilobum* out of 18.2 boll set; only two small seeds could be collected. In cross G 27 x *G. anomalum* three bolls could set out of 35 pollination.

Embryo Rescue: - For *in vitro* culture, two media combinations were tested. They were 2,4 -D (0.1 mg/l) + kin (0.1 mg/l), NAA (2 mg/l) + kin (1 mg/l). In both the media 1mg /l GA3 was added .The ovules after 10, 12 and 15 days interval were removed from five crosses namely PA 402 x *G. anomalum*, PA 255 x *G. trilobum*, G 27 x *G. anomalum*, PA 183 *x G. trilobum* and AKH 4 x MCU 5. It has been observed that ovules excised from 12 and 15 DAP responded most towards callusing, enlargement of ovules and formation of embryo axis.

A total of 25 wild species, 20 perennial species, six races of *G. arboreum*, seven races of *G. hirsutum*, one race each of *G. herbaceum* and *G. barbadense* and 26 interspecific hybrids were maintained. A number of crosses between wild and cultivated species were attempted. Among the successful crosses, a sterile interspecific cross between tetraploid and diploid species *viz. G. hirsutum* and *G. aridum* was found to bear protruding stigma. If this character breeds true, it would open up avenues in cotton breeding research enhancing hybrid seed production without emasculation/ male sterility. Interspecific hybrid between two diploid species *viz. G. arboreum* and *G. triphyllum* was observed to be partial sterile, apart from bearing undeveloped bolls with motes, a few bolls developed with fertile seeds.

More than 400 cytologically stable and morphologically uniform lines developed through introgressive hybridization programme were screened and evaluated for biotic and abiotic stresses and yield. Among these, 273 plants were selected based on morphological characters. These lines showed resistance and tolerance of various degrees to sucking pests, bollworms and diseases. One of the promising line Rai 11-3 possessed high yield potential coupled with early flowering and synchronous maturity which in turn rendered escape mechanism against bollworm. Another line MSH 345, a multispecies hybrid derivative bearing cleistogamous flowers is characterized by big, round bolls with 4-5 locules and boll weight ranging from 3.5 – 4.9 g.

Out of 173 introgressed advance generation derivatives of *Gossypium* in both diploid and tetraploid backgrounds,

51 superior single plants were selected based on morphological characters and tolerance/resistance to pest and disease complex. The extent of damage in *G. arboreum* population was less than the other two due to escape mechanism associated with early maturity. The comparative yield performance for three consecutive cropping seasons of the introgressed lines received from various centres along with those developed at Nagpur. In general, the yield of the introgressed lines has increased over the years.

Among the established F_1 hybrids obtained during crop season 2003-04, 34 F_1 hybrids appeared promising and exhibited heterosis for yield.

Coimbatore

The highest seed cotton yield was recorded in CWS 50-2 (1700 kg/ha) as compared to 1100 kg/ha recorded in best check variety LRA 5166. However, with regard to the quality parameters, CWS 74-2 and

CWS-80-1 recorded the 2.5% span length and fibre strength as 25.4 and 26 mm and 19.6 and 20.5 g/tex, respectively.

None of, selected progenies of the six cultures tested for their yield and fibre quality performed better than the check varieties.

In the third trial, 10 progenies of advanced cultures (ACT) were tested for their yield performance along with check varieties Sumangala and Surabhi. Among them, ACT-7-1 (1470 kg/ha) out yielded the check variety Sumangala (1240 kg/ha) and (Surabhi 1030 kg/ha). However, with regard to fibre quality, ACT-8-2-4 had better fibre strength (20.4) as compared to the check variety Sumangala (19.0 g/tex) (Table 7).

Forty-one segregating lines were obtained from different cooperating centres following introgression breeding methods and evaluated. Several superior single plants were selected based on morphological characters for further evaluation.

The F_1s produced during the previous year between cultivated and wild species were raised and morphological characterization was carried out. Few F_1s produced during the last year between selected introgressed lines with agronomically superior varieties were raised during the current season and back crosses were affected.

Varieties of *G. hirsutum, G. arboreum* and *G. herbaceum* were crossed with wild species, in different combinations and two advanced stabilized derivatives viz., CCH 05-1 and CCH 05-2 have been entered in the initial evaluation trial of AICCIP during the year 2005-06, respectively in the irrigated and rainfed trials.

Sirsa

Sixty five crosses attempted between introgressed lines and local adapted cultivars were evaluated for yield and its component traits. The cross combination RS 2013 x TCH 1652 (2161 kg/ha) recorded significantly higher seed cotton yield over check hybrids. The crosses LH 900 x IH 35, RS 2013 x TCH 1652 VHM x TCH 1648 recorded more than 35.0% ginning out turn. The 2.5 % span length was found to be highest in cross combinations BM x TCH 1653 (33.3 mm) and PF x TCH 1648 (30.8 mm). The uniformity ratio ranged between 44 (BM x TCH 1648) and 54 per cent (PM x TCH 1652). Fifteen crosses had fibre strength more than 24.0 g/tex.

Table 7: Performance of select advance culture for yield and quality

Genotypes	Seed Cotton Yield (kg/ha)	Boll Wt. (g)	LI (g)	SI (g)	GOT (%)	2.5% SL (mm)	Strength (g/tex)
ACT-7-1	1470	6.0	7.1	8.3	39	20.3	19.6
ACT-8-2-4	1290	5.7	8.2	7.5	41	21.9	20.4
Sumangala (C)	1070	5.0	5.5	7.3	30	28.0	19.0
Surabhi (C)	1010	4.5	7.1	7.0	31	32.6	23.3

4.5 Development of Transgenics

Callus induction and somatic embryogenesis

G. arboreum cultivar PA 405, PA 255 and PA 402 were used in regeneration studies by somatic embryogenesis. *In-vitro* grown 3-4 days old germinated seedlings were used as the source of explants. Hypocotyl explants cultured in MS medium supplimented with 2,4-D + kinetin (0.1 mg/L each), NAA + kinetin (2:1 mg/L) and IAA + kinetin (2:1 mg/L) lead to the callusing. The callusing efficiency, morphological pattern and colouration of calli, besides texture were variable in different growth regulator combination. The entire hypocotyl segment at the time of culture was sub-divided into small pieces and cultured serially from top to bottom in the petriplates. The callusing efficiency and friability was higher from second and third piece of hypocotyl segment. The differentiation of embryogenic cells was higher in callus obtained from these pieces of hypocotyls.

Biochemical analysis of callus

Hypocotyl derived callus of regenerating Coker-312 and callus induced from cv. PA 255 was analyzed for protein banding pattern and total nucleic acid profile. It was observed that nucleic acids and proteins decreased with the increase in age of the callus. Like wise calli of cv. PA 255 were subjected to different concentration of salt like 25 mM, 50 mM, 75 mM and 100 mM NaCl. Two salt tolerant callus lines growing on 25 mM and 75 mM NaCl were isolated. These lines are being further utilized for somatic embryogenesis.

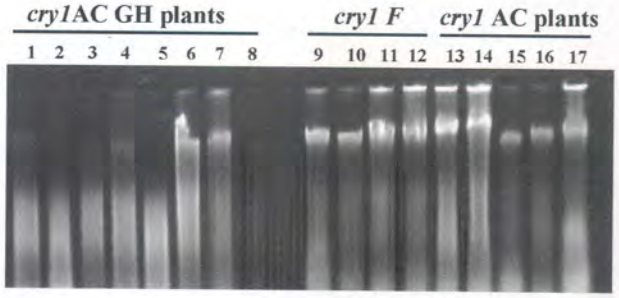
The diploid cultivars PA 402, PA 183 and PA 255 were used in gene transfer by Agrobacterium containing *cry* genes. Embryo axis and shoot tip explants isolated from 3-6 days old *in-vitro* germinated seedlings were used for Agrobacterium infection.

Transformation of cv PA 402 with *cry* 1F gene

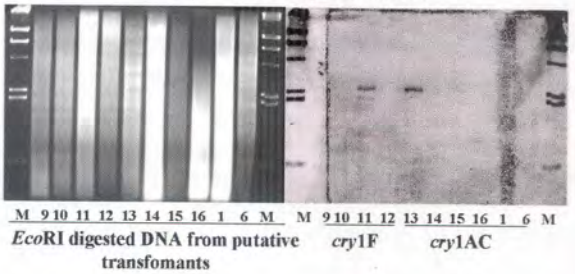
For transformation, *Agrobacterium* strain LB 4404 containing *cry* I F gene and *cry* 1 Aa3 gene was used. In all 977 explants were co-cultivated containing *cry* 1F gene and 197 explants were isolated growing on kanamycin medium. In all 15 transformation events were carried out. The response of transformation was quite favorable in event no. 4 and 8 respectively. Nearly 154 kanamycin selected explants were subculture on regeneration medium and 37 elongated shoots were obtained which included four albino shoots.

Test for gene integration

The leaf samples of *in-vitro* grown plantlets of cv. PA 402 were collected and DNA isolation was carried out for PCR and southern blot analysis. Four plantlets were PCR and southern positive (Fig. 2).



Confirmation of transgenes in putative cotton transformanats by Southern hybridization



Confirmation of transgenes in putative cotton transformanats

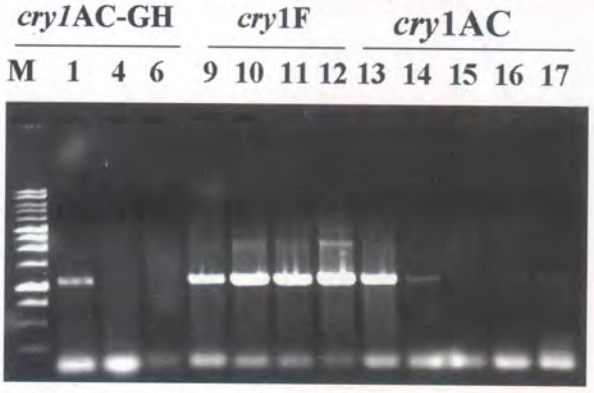


Fig. 2 : Confirmation of Gene integration

Transformation of hypocotyl

Three hundred and ninety eight hypocotyl segments were co-cultivated with *Agrobacterium* containing *cry* 1 F gene and only 26 explants showed callusing on kanamycin containing medium. It was observed that callusing in the infected hypocotyl explants was quite slow.

Transformation of cv PA 402 with *cry* 1 Aa3 gene

In another set of experiment transformation of shoot tip of cv PA 402 was carried out with *cry* 1 Aa3 gene. Critical observation of individual lot of embryonic axis explants indicated that event no.1, 19 and 20 showed promising result. Out of 82 explants in event no.1, 46 were transferred on selection medium and 42 shoots were selected on kanamycin containing medium. Likewise in event no.19, out of 78 explants, 66 growing explants were isolated on selection medium. In event no.20, however, the results were very different.

Transformation of cultivar Suvin and PA 183

Transformation and Co-cultivation

Transformation was carried out in the two genotypes using *Agrobacterium* strain containing *cry* 1 Ac gene. In case of Suvin, however, out of 129 explants infected with *Agrobacterium* only four could survive on selection medium. Among the rest, though many explants were infected by *Agrobacterium*, they either dried completely or got contaminated. The surviving explants were further transferred to regenerate in to complete plant.

In diploid cotton cv, PA183, out of 384 explants infected, 20 could survived on medium containing kanamycin. The time period for *Agrobacterium* infection was not much variable. The transformation frequency in both the events was nearly similar.

In transformation carried out with two genotypes listed above, the period of infection though kept variable in most of the experiments, infection for 1 and 1:30 hour was favourable for many of the explants of the genotypes. The transformation frequency with embryo axis/shoot tip explants is based on size of the explants and use of fresh overnight grown log-phase culture of *Agrobacterium*.

Transformation of hypocotyls

Hypocotyl explants excised from 3-5 day old germinating seedlings were used for transformation studies. Hypocotyl explants of cultivar, Suvin and PA 183 were used. For *Agrobacterium* infection, hypocotyl pieces were sub-divided into smaller segments and infected with overnight grown log-phase *Agrobacterium* suspension for 1-2 hours.

In Suvin, 115 hypocotyl explants were co-cultivated for 1½ to 2 hrs. But there was no response towards callusing.

Development of Bt - transgenic for insect resistance

The Indian elite cotton cultivar Anjali (LRK 516) was transformed with Bt *cry* 1 A (c) and the seeds of transgenic plants (T_0 - generation) were collected and T_1- generation was raised in polyhouse. ELISA test carried out with these plants, showed 6 plants having CRY protein expression ranging from 0.070 – 0.155 mg / g of total protein. Indigenous new gene construct *viz.*, *cry* 1 Aa3 and *cry* 1F were used for transformation of *G. hirsutum* genotypes. The cultivar Anjali (LRK 516) was responding well for transformation and direct shoot organogenesis. The explants embryonic axes showed high transformation frequency (1.0 - 0.5%) than meristem explants (0.01 - 0.2%). Transformed plants were regenerated in MS medium containing 2.0 mg/l of BAP and 0.5 mg /l of kinetin. In total, 12-15 putative transformants were regenerated by direct shoot organogenesis. All the putative transformants were subjected to confirmation of gene integration by PCR analysis and all the plants showed positive and the expected 0.7 kb gene was amplified.

Seeds of *G. hirsutum* varieties *viz.* LRA 5166 and LRK 516 were used for genetic transformation utilizing the *Agrobacterium* strain EHA 105 harbouring binary plasmid as vector system.

Two *G. hirsutum* varieties *viz.* LRA 5166 and LRK 516 were taken for co-cultivation with three

indigenously synthesized genes. Of the 367 LRA 5166, explants used for transformation with *cry* 1 Aa3. Three explants are in rooting medium and four hardened plants in pot-house. In LRK 516 variety of the 100 explants with *cry*1 Ia5 and 912 explants with *cry* 1 *F* co-cultivated for transformation, only four putative transformants of *cry* 1 *F* are in rooting medium. The selfed seeds of hardened plants were collected for further analysis.

The respective tally for *cry* 1 Ia5 was two and three out of 125, while only two of the 563 explants with *cry*1 F were in rooting medium.

Transformation by microinjection for agronomic traits (Drought resistant and defense genes)

Proteinase inhibitor genes were isolated by PCR amplification from cotton genome. To amplify the targeted genes forward and reverse primers were designed on the basis of published sequences. (Marchetti *et al*., 2000).

The intact DNA was isolated from *G. hirsutum* – cultivars *viz*., Anjali (LRK 516) LRA 5166, MCU 5, and *G. arboreum* – cultivar AKA 8401. Touch down principle was used for amplification of expected genes, for which annealing temperatures reduced gradually from 64 to 50 to enrich the targeted sequence. The amplified product was resolved on 1.5 % agarose gel indicated that the expected fragment of the same size as full-length genes of 650 bp for Kti3 and 250 bp for PI - IV primers. The fragments were cloned into pDrive vectors (Qiagen) and transformed into host bacteria. The transformed bacterial plasmid was isolated and reamplified the cloned PI genes and the results showed the identical fragment length. The fragment amplified with Kti3 was sent for the sequence analysis to M/s. Tech Dragon Limited, Calcutta. The sequence information is as follows.

Isolation and characterization of drought resistant genes – Dehydrins

In the present study, a partial fragment of dehydrin gene from two cotton cultivars of G. *hirsutum viz* LRK 516 and MHL 685 and one *G. arboretum* cultivar AHK 4 was isolated. Specific forward and reverse primers were designed on the basis of the dehydrin gene sequences already published and available in the public domain in the Gene Bank. Primer specific PCR amplification was carried out in EPPENDORF thermal. The amplified products were resolved on 1.5 % agarose by gel electrophoresis and eluted the amplified fragments. With the primer (Dhn Lea3D147), MHL 685 (*G. hirsutum*) amplified three fragments viz, 0.5, 0.4 and 0.35 kb. The partial amplification of fragments confirmed the presence of dehydrin genes in cotton genomes. The 0.5 kb fragment was cloned into pDrive vector and pushed in to *E.coli* strain DH5á cells.

4.6 Molecular Breeding

Nagpur

Gene tagging for leaf curl virus resistance with molecular marker

CNH 123, CNH 1012 (resistant lines) and CNH 1020, CNH 120 (susceptible lines) were collected and grown in the pothouse. The F_2 mapping population was developed from the crosses (i) CNH 123 (resistant line) x CNH 1020 (susceptible line) (ii) CNH 1012 (resistant line) x CNH 120 (susceptible line). The progenies of F_2 were forwarded to F_3 and subjected to RAPD, SSR analysis to tag the recessive gene. Sixty random primers were used to establish the polymorphic fragments. Out of 792 fragments produced, 26% were polymorphic. Ten resistant and susceptible F_2 DNA were pooled for bulk segregant analysis.

The polymorphic fragment of 1.4 bp size was present in the resistant parent and resistant pool was developed as SCAR marker for marker-assisted selection. The primer pair designed 5' GTGAGGCGTCAGAGGGAT-3' (forward) and 5'-GTTGCCGTGCACTAGGCT-3' (reverse) of the SCAR marker segregated in a Mendelian fashion in the F_2 segregating population. (GATA)n, (GA)n,(CA)n ,(GCAT)n the SSR primers were used to identify closely linked marker to the CLCuV

resistant gene. Polymorphisms were found among the parents and the F_3 lines. The genetics of resistance for recessive gene was studied with the F_2 derived F_3 population and the SCAR marker segregated in Mendelian fashion.

DNA fingerprinting of germplasm lines

Gossypium hirsutum genotypes with good fibre length viz. MHL-711, (2) MHL-685, (3) MHL-743, (4) MHL-690, (5) MHL-728, (6) MHL-150, (7) MHL-681 (8) MHL-1843, (9) MHL-557, (10) MHL-703 were subjected to genomic DNA isolation and then RAPD analysis. Thirty five percent polymorphism was obtained and diversity among them was obtained by analyzing the RAPD data. Drought tolerant lines of G. *arboreum viz.* (1) ACC 6779 (2) ACC 6783 (3) ACC – 6828 (4) ACC 6834 (5) ACC 6831) (6) ACC 6788. *G.hirsutum* viz. (1) BOSS-III (2) EL 613 (3) Ewing x Tidewater (4) P-15 (5) 150-3-1-1 (6) JK 97 286D. *G. herbaceum* (1) E-2-13 x D 133-12-6 (2) DM 110-İ0 x SM 06 (3) Sm 28 (4) KFT12 -2-5 (5) MDS 56 (6) RUSSIAN 5 were subjected to RAPD analysis. Twenty primers produced 26% polymorphism. Grey mildew immune lines of *Gossypium arboreum* genotypes are (1) 30805, (2) G 135- 49, (3) AKA 8401, (4) 30814, (5) SP 3956, (6) SM 150 B, (7) EC 176147, (8) 30826, (9) 30856, (10) 30838. All these genotypes were subjected to genomic DNA isolation and then RAPD analysis. Twenty primers have produced 18% polymorphism.

Genetic purity testing of hybrids and their parents

G Cot Hy-10, LHH 144, Phule-492, G Cot MDH 11, NSPHH 7, G.Cot.Hy 8, NHH 44 and AAH 1 were evaluated for the identification of the F_1 hybrids and their parents using DNA markers. The RAPD polymorphic primer OPA 1 led to the confirmation of hybridity of G Cot MDH-11 while OPA 20 for Phule-492 and hence can be used as a discriminating marker for testing. The ISSR primer IS 7 led to the conformation of hybridity of LHH 44 while IS 9 for Phule-492 (Fig. 3) and hence can be used as a discriminating marker for testing. Thus, the perfect discriminating markers were detected for the three hybrids i.e. G Cot MDH-11, LHH 144 and Phule-492.

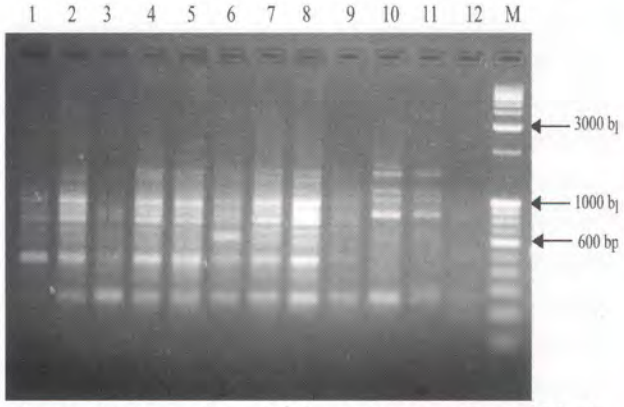


Fig. 3: ISSR profile of IS9, perfect marker of Phule-492 M= 1kb + 100 bp DNA ladder.

The RAPD polymorphic primer OPA 19 and OPB 3 led to the confirmation of hybridity of NSPHH 7 (Fig. 4) while OPB 1 for NHH 44 and hence can be used as a discriminating marker for testing. The ISSR primer IS 7 led to the confirmation of hybridity of G.Cot.Hy 8 while IS 4 for NHH 44 and hence can be used as a discriminating marker for testing. Thus, the perfect discriminating markers were detected for the three hybrids i.e. NSPHH 7, NHH 44 and G.Cot.Hy 8.

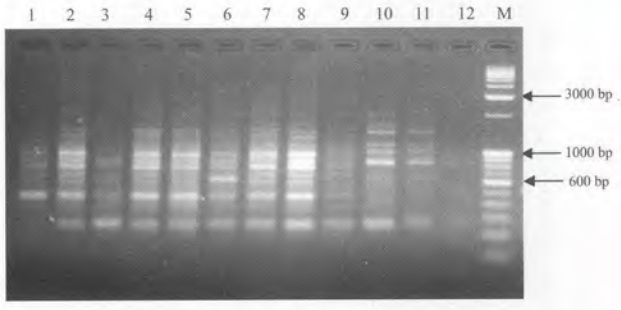


Fig. 4: RAPD profile of OPB 3, perfect marker of NSPHH 7, M= 1kb + 100 bp DNA ladder.

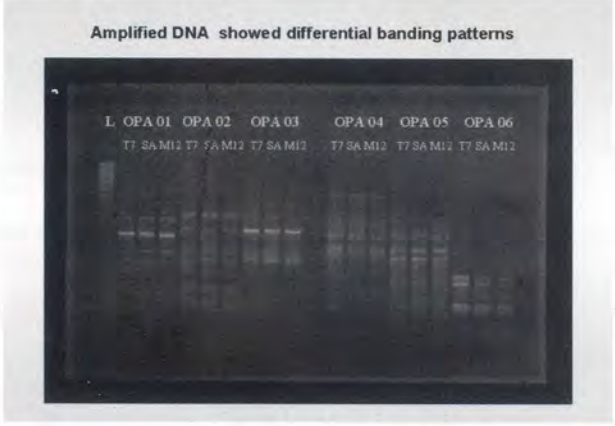
Assessment of genetic diversity of cultivars (*Gossypium Spp.*)

Micro satellite and ISSR markers were used to generate DNA profile of 25 genotypes of cotton, and each amplified DNA marker fragment was recorded. The results of cluster analysis indicated not only the separation of genotypes of the species (*G. hirsutum*) in to separate groups, but also the separation of the genotypes among each group. The similarity coefficient based on ISSR and micro satellite markers analyses, ranged from 0.57 to 0.10 and 0.72 to 0.92, respectively, suggesting considerable genetic variation between the cotton species studied.

Coimbatore

Genetic marker using molecular techniques

The DNA was isolated from single seed of hybrid Savita and its parents T7 (female) and M 12 (male). Different primers were used for detection of polymorphic bands among the parents and hybrid Savita. RAPD analysis revealed the utility of this molecular technique with further refinement for identification of female seeds in the hybrid seed lot.



T7- Female parent of Savita hybrid, SA-Savita hybrid, M12- Male parent of Savita

4.7 Seed Production and Seed Quality Improvement

Nagpur

Among seven *arboreum* genotypes, variety AKA 7 gave significantly high yield in deep and medium soils (1000 kg/ha and 5500 kg/ha respectively) closely followed by AKA 8401 (972 kg/ha). Seed index was observed to differ significantly among genotypes at different soil depths. The number of bolls / plant was significantly high for AKA 7 in deep soils (14 / plant). Slight variation in initial germination and vigour was noticed in different soil depths and genotypes. Among the 16 genotypes assessed for physiological seed vigor traits, total seed reserve depletion was highest for hybrids followed by *hirsutum* and *arboreum* genotypes. Sensitivity to methanol stress (30% solution) was higher for NHH 44 (65-70% reduction in germination than control compared to Hybrid-8 (4% reduction) which also correlated well with more amount of aldehydes released during lipid peroxidation in NHH 44. The *arboreum* genotypes uniformly had lower values for lipid peroxidation. Among the seedling vigour traits studied in the field, seed size showed significant correlation with cotyledonary leaf area.

Seed Pathology

Cotyledonary leaves and boll infection isolations in the varieties, hybrids and germplasm lines revealed presence of various fungi viz., *Alternaria macrospora* (AKA 5, AKA 8401, AKH 4, Chandrolla, DB 3-12, G1, G 27, Jayadhar, LD 327, NAS 5),Fusarium pallidoroseum (AKA 8307), *Macrophomina phaseolina* (G 27, Maljari, NHH 44, RG 8), *Myrothecium roridum* (AKA 53, Chandrolla, DH 7, G.Cot.Hy.8, JKHy1, MCU-5) and the bacterial blight pathogen *X.a. pv. malvacearum* (F 414, G.Ageti, G. Cot. Hy.8, H6, H10, H 777, Laxmi, LRA 5166, LRK 516, MCU 9, NHH 44). Besides the isolations of cotton pathogenic fungi and bacteria, the repeatedly frequent association of other parasitic fungi viz., *Alternaria tenuis, Chaetophoma* sp., *Curvularia lunata, Drechslera tetramera, Fusarium*

moniliforme, F. equiseti, Phoma exigua and the antagonistic fungus *Trichoderma viride* was observed.

Cotton seed samples belonging to germplasm lines/varieties/hybrids (F_2) of the previous crop season (2003-04), which were separated, graded, acid delinted and examined for seed discoloration, fungus fructifications and yellow slime of bacteria, were tested by Blotter method and on Nutritional agar media. The leaf and boll spot pathogen *macrospora* was detected in the range of 1-3%, leaf spot pathogen *roridum* 2-4%, stem.break/root rot pathogen *Macrophomina phaseolina* (= *Rhizoctonia bataticola*) 1-2 %, leaf spot pathogen *Phomopsis malvacearum* and seed rot pathogen *Phoma biguttulata* 1-3%, and the bacterial blight pathogen *X.a. pv. malvacearum* 1-3%. Besides the above detection of cotton pathogenic fungi and bacteria, presence of other fungi *viz., Alternaria tenuis, Aspergillus flavus, A. niger, Curvularia pallescens, Drechslera tetramera, D. hawaiiensis, Fusarium moniliforme, F. equiseti, Phoma exigua, Trichothecium roseum* and *Verticillium nigrescens* was observed.

Commonly used cotton seed dressing fungicides viz., Thiram, Captan, Bavistin (carbendazim) and Vitavax (carboxin) were evaluated in the laboratory on leaf and boll spot pathogen *Alternaria macrospora* as test pathogen. Of the two commonly used seed dressing insecticides in cotton i.e. Gaucho (Imidacloprid) and Cruiser (Thiamethoxam), the Gaucho was used for compatibility studies. It was observed in *in- vitro* studies that the Gaucho was compatible with all the four fungicides tested, even upto a concentration of 500 ppm.

Coimbatore

Estimation of storability of seeds stored at different temperatures

Delinted cotton seeds of cultivar LRA 5166 were treated with *Pseudomonas fluorescens* @ 4 g/kg, *Trichoderma viride* @ 4 g/kg, Carbendazim @ 2 g/kg stored in aluminium foil pouch under -32 °C, 5 °C, 20°C and ambient storage environments for 16 months. The seeds treated with bioinoculant, *P. fluorescens,* had better seed viability and vigour.

Assessment of storability of polymer and pesticides-coated cottonseeds

Polymer coating of cotton seed along with fungicide and insecticides and kept under long term storage revealed that coating seeds with Imidachloprid 5 g/kg or polymer @ 5 ml/kg + Carbendazim @ 2 g/kg + Thiamethoxam @ 5 ml/kg or polymer @ 5 ml/kg+Carbendazim@2 g/kg + Clothianidine @ 5ml/kg are equally effective in maintaining the seed viability, vigour and seed health.

Correlation of physical properties of seeds with viability in *G. hirsutum* germplasm lines

The physical properties of seed such as seed index (g/100 seed), embryo weight, seed coat weight, % embryo, % seed coat, ginning percent, electrical conductivity of seed leachate, dehydrogenase enzyme activity, area of seed, perimeter, Centroid X, Centroid Y, length, width, are radial, radial variance, CMRV, circularity, elongation, S. Factor, width in X, height in Y were measured. The correlation coefficient matrix indicated the positive and negative influence of physical properties on seed vigour. There were positive correlations of seed index, embryo weight, seed coat weight, and ginning percent and centroid X, ave radial, circularity, elongation, width in X, of seed with dehydrogenase enzyme activity. Negative correlations of dehydrogenase enzyme activity with % embryo, electrical conductivity of seed leachate, area of seed, perimeter, centroid Y, length and width of seed, radial variance, CMRV, S. factor, width in x and height in Y of seed were recorded.

Evaluation of progenies for fibre traits, biotic stress etc

During 2003-04, 90 plants were initially selected from cv. Sumangala and from these, 23 superior plants were identified based on bolls/plant, yield/plant (g), lint index, seed index and ginning outturn. This was restricted to 10 numbers based on the fibre properties and the selected progenies were multiplied. Similarly

with cv. Supriya, out of 42 plants initially identified, 17 were short listed based on the fibre properties and multiplied.

Morphological marker

The morphological characters of cotton cv. LRA 5166 and Sumangala (*G. hirsutum*) were studied for easy identification. All the visible morphological characters such as growth habit, leaf shape, colour, boll shape, size, seed size, shape and seedling pigmentation etc., were recorded from initial germination to harvest.

Effect of supplemental foliar nutrients on seed yield and quality of seed

Supplemental nutrition DAP @ 2 % + Boron @ 0.6 kg/ha + Zinc @ 0.5% significantly improved the seed quality in Anjali and recorded higher values for all the parameters *viz.*, seed index, lint index, germination %, germination quotient; root and shoot length, dry matter of seedlings, vigour index, seedling height (21 DAS) and seedling dry wt. (21 DAS). One additional irrigation after first harvest improved seed yield and quality of subsequent harvests.

Sirsa

Hybrid seed production

Crosses were made from beginning flower to completion of flowering i.e. 18th August to 15th October in hybrids CSHH 198, Om Shankar, LHH 144 and CISAA 2. The highest crossed boll setting percentage was noticed during Aug.18th to Sep. 7th and it was 32.2% in hybrid Om Shankar, 35.1% in CSHH 198, 35.5 % in LHH 144 and 38.5 % in CISAA 2. The seed setting percentage was observed higher (above 75 %) up to 23rd September in all the hybrids. The germination and vigour index was also higher in seed received from crossing period up to 23rd Sept.

The seed soaking in succinic acid for six hours before sowing and foliar spray of 0.1% boron at 60, 75, 90 DAS increased the seed yield in all the hybrids. The germination percentage and vigour index were also higher in the seeds of this treatment.

The highest number of seed per boll was above 35 in Om Shankar, 32 in CSHH 198, 25 in CISAA 2 and 31 in LHH 144 . The seed/ boll declined if more than four female flowers were pollinated in hybrid Om Shankar, five in CSHH 198, three in CISAA 2 and three in LHH 144.

The setting percentage of crossed boll is almost negligible during entire crossing period in case of ovary injury.

Varietal seed production

Study was carried out to know the effect of different spacing and foliar application of DAP, $MgSO_4$, Boron and $ZnSO_4$ at different stages of crop growth to improve the seed production in RS 2013 a *G. hirsutum* variety. The boll weight and boll number increased significantly with increase in the spacing and the seed cotton per plant was maximum in wider spacing 120 x 90 cm but due to higher plant population the per acre seed cotton yield was higher in 90 x 60 spacing followed by 120 x 60. With increase in spacing, slight increase in GOT, seed index, seed germination percentage and vigour index was also observed . Although foliar application of each nutrient showed beneficial effects, the significant and maximum increase in boll number (48.0) and boll weight (3.40) was observed when boron 0.1 % was applied followed by combination of all the nutrients. This treatment also showed maximum seed cotton yield.

In H 1098 (*G. hirsutum*) and LD 327 (*G. arboreum*) higher boll number, boll weight, seed index, yield per plant, germination percentage and vigour index was noticed when topping was done at 60 DAS and defoliant sprayed at 140 DAS . Among the various pickings, the seed index, germination percentage and vigour index was highest in second picking followed by first picking and least in third picking during this year.

Maintenance breeding

The selected progenies (5 female and 5 male) of hybrid Om Shankar and their 25 crosses, and the newly released hybrids CSHH 198 and CISAA 2 were evaluated based on desirable gca effects and per se performance for yield, boll number, boll weight, 2.5% span length, uniformity ratio, fibre maturity and fibre strength in three replications. During first year several female and male parent progenies of these hybrids were selected based on morphological parameters from large plant population. Data on yield, boll number, boll weight, seed index and GOT was recorded from each progeny.

Breeder seed production

Breeder seed production of the following varieties has been taken up and would be commercially sold to the Seed Producers as per the Government of India allotment.

No.	Name of Variety/ Parent of Hybrid	2004-05	
		Indent (q)	Production (q)
1.	Savita T 7	0.22	0.09
	M 12	0.01	0.12
2.	LRA 5166	0.74	1.99
3.	Surabhi	1.02	2.50
4.	MCU 5VT	1.12	1.50
5.	Anjali	0.47	1.50
6.	Supriya	1.02	1.50
7.	Sumangala	0.15	0.50
8.	LRK 516	-	0.30

Nucleus seed production

Twenty kilogram seeds each of CNH 120 MB (Pratima) and CNH 36 were produced.

4.8 Integrated Water Management

Nagpur

Significant mean maximum (23.30 q ha^{-1}) seed cotton yield was recorded with two irrigations @ 4 ha cm of water, first at flowering and second at boll development stage closely followed by (22.64 q ha^{-1}) three irrigation at the same rate first at flowering, second at early boll development and third at peak boll development stage. One protective irrigation @ 4 ha cm of water at peak boll development stage enhanced seed cotton yield > 1 q and found superior over *in-situ* moisture conservation.

Seed cotton yield due to moisture conservation practices increased from 0.61 – 2.4 q ha^{-1} over control. Ridge and furrow system was best over others adopted in different topo-sequences.

The influence of intercrops on moisture conservation and seed cotton yield showed that one row of green gram with cotton has given maximum (15.91 q ha^{-1}) seed cotton yield followed by (15.52 q ha^{-1}) cotton + blackgram. Seed cotton yield under one protective irrigation at peak boll development stage has also produced almost similar (15.50 q ha^{-1}) quantity of seed cotton and found economical.

Water use efficiency

The influence of protective irrigations in relation to water use efficiency (WUE) on seed cotton yield was maximum (3.20 q ha^{-1} mm^{-1}) when applied one irrigation at peak boll development stage and the minimum (2.20 kg ha^{-1} mm^{-1}) under control.

While evaluating the impact of intercrops on seed cotton yield maximum (2.46 kg ha^{-1} mm^{-1}) WUE was recorded in the treatments where green gram was intercropped with cotton closely followed by (2.40 kg ha^{-1} mm^{-1}) cotton intercropped with black gram and the minimum (2.01 kg $ha^{-1}mm^{-1}$) under control.

Rain water management in cotton

Ridge and furrow system across the slope at the end of August was best and effective in reducing maximum runoff, increasing percolation, conserving

Maintenance breeding

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Rain water management in cotton

Ridge and furrow system across the slope at the end of August was best and effective in reducing maximum runoff, increasing percolation, conserving

maximum rainwater and improving the recharge capacity of irrigation wells.

Recycling of harvested rain water enhanced seed cotton yield by 3-5 q ha^{-1} due to application of life saving irrigation while *in-situ* moisture conservation was able to improve seed cotton yield by 2-3 q ha^{-1} in upper to lower topo-sequences.

Coimbatore

Integrated water management system for quality fibre production

Highest seed cotton yield (1210 kg/ha) was recorded with protective irrigation at par with soil moisture conservation treatments of opening of the furrow at each row (1025 kg/ha) and alternate row (1015 kg/ha) after last interculture and compartmental bunding combined with straw mulching along with spraying of anti-transpirant (Kaolin 1%) at 30 days after rain (971 kg/ha). The highest seed cotton equivalent yield (1421 kg/ha) and highest rainfall use efficiency (4.54 kg/ha mm) were with intercropping of one row black gram between cotton rows which was closely followed by cotton + green gram intercropping system.

Response of different critical growth stages of cotton to protective irrigation

Significantly higher seed cotton yield (1950 kg/ha) was obtained with the application of irrigation scheduled at 0.8 IW/CPE ratio and was at par with other protective irrigation treatments, including application of irrigation at flowering and boll development and single irrigation at boll development and flowering stage. None of the irrigation treatments significantly influenced the quality parameters. Application of irrigation at boll development stage gave the highest irrigation water use efficiency (36.5 kg/ha mm).

Developing and testing of economical method of drip irrigation system in cotton

Linear Low Density Polyethylene lateral with dripper, with microtube and different thicknesses (200, 300 and 600 gauge) were compared with control (ridges and furrow method of irrigation) showed no significant improvement in seed cotton yield and ginning percentage of RCH 2. Seed index (10.9) and lint index (5.9) were significantly higher and net return (Rs. 17,151/ha) and cost benefit ratio (1: 1.56) were seen maximum in drip system.

4.9 Integrated Nutrient Management

Nagpur

Sorghum straw and grain yield are greater in the plots where FYM was applied with NPK. Least yield of sorghum was recorded in control plot and single nutrient applied plots. The results indicate beneficial effects of long-term FYM application persist.

A long term study was initiated to understand the effects of fertilizer and manure on the cotton + pigeon pea strip intercropping system. Results of the first year indicated that higher seed cotton yield was obtained with treatment $N_{60} P_{30} K_{30}$ + 2 t FYM + 2 t green manure (15.7 q/ha) followed by RDF treatment (14.1 q/ha) and farmers' practice (13.29 q/ha). Significant higher boll numbers were recorded with combined application of inorganic and organic fertilizer treatments over control.

A significant effect of nutrient management practices was observed in a field experiment conducted for the second consecutive year. Response to Zn and B was not observed. Yield in the plots with partial supplementation through organics (25 % and 50 %) was at par with the NPK plots. On the other hand, site specific nutrient management for a targetted yield was found to be the best treatment. None of the treatments affected the fibre quality parameters.

Response of both G. *arboreum* (cv. AKA 8401) and *G. hirsutum* (cv. Rajat) was noticed to foliar application of potassium at early and peak boll formation stages compared to K applied basally as soil application. Furthermore, soil applied K resulted in significant yield increase over the NP plots. However, K application did not impact any of the fibre quality traits. GOT of *G. arboreum* was significantly better in the + K compared to (-) K plots.

Cotton crop on ridges and furrows

Inter cropping in cotton with radish and amaranthus

Poly mulched cotton crop

In an organic farming and INM demonstration trial, results indicated that there was no significant difference in seed cotton yields obtained in organic manure treated plots and inorganic fertilizer applied plots. Higher root length and low dry matter accumulation was recorded in organic farming plots as compared to inorganic nutrients fertilized plots.

Under the NATP project, 40 on-farm trials on INM technology were laid out in two villages each in Yavatmal and Wardha districts. Data on soil moisture content indicated that soil moisture conservation treatment (ridges and furrow) with INM treatment had higher moisture contents as compared to flat bed system, and in an increased seed cotton yield by 2 to 3 q/ha more over farmers' practice.

The influence of major and micronutrients under protective irrigation on the yield of hybrid (Ankur 651) was evaluated. Results showed that the significant maximum (8.49 q ha^{-1}) seed cotton yield was recorded with 120 kg N + 60 kg P_2O_5 + 60 kg K_2O ha^{-1} + micronutrient (10 kg $ZnSO_4$ ha^{-1}) + growth retardant pix @ 50 ppm at 60 and 120 DAS followed by 120 kg N + 60 kg P_2O_5 + 60 kg K_2O ha^{-1} + 1.5 t ha^{-1} FYM every year and the minimum (4.48 q ha^{-1}) under control.

Response of Bt. cotton to application of micronutrients through soil and foliar at different growth stages studied showed improvement in seed cotton yield and staple length of Bt. hybrids *viz.* MECH 184 and MECH 162 as compared to recommended dose of fertilizer alone (N_{90} P_{45} K_{45}). Increase in Zn and Mn contents in soil (surface soil) was observed in the plots where micronutrients were given as compared to RDF plot. Higher incidence of bollworm was noticed on NHH 44.

Three years studies confirmed the benefit of supplemental irrigations from harvested rain water at peak flowering and early boll development stage of intra G. *hirsutum* hybrid NHH 44 in medium deep soils. This supplemental irrigations significantly improved the seed cotton yield by 24% i.e. 264 kg ha^{-1} over rainfed cotton. Pooled analysis of 2002-2004 results confirmed the need for micro nutrients application under supplemental irrigations to meet the higher nutrients demand at seed cotton yield levels of more than one ton per hectare. Application of micronutrients with supplemental irrigations such as B 3 kg ha^{-1} and Mn 10 kg ha^{-1} singly or together at soil + foliar application in 3:1 together Zn, Mn and Boron @ 10, 10 and 3 kg ha^{-1} every year significantly improved the seed cotton yield by 25, 20 and 18% or 372, 335 and 332 kg ha^{-1} over rainfed conditions.

Coimbatore

Testing of promising bio inoculants for potential utilization in cotton

Cotton crop responded significantly to fertilizers, bio inoculants and their interaction. Crop response was observed up to 100% N (60 kg/ha) and P (30 kg/ha) under uninoculated condition in the low N and medium P Vertisol. Fertilizer x bioinoculants interaction, revealed that highest (3327 kg/ha) seed cotton yield could be achieved with Azospirillum (HAU) + PSB + PPFM at 75% N and P level, which was 412 kg higher than 100% NP without bioinoculants. Seed index and lint index were influenced significantly due to level of N and P numerically due to bionoculants.

The yield level with either HAU or Surat culture of Azospirillum + PSB + PPFM at 50% NP is on par with 100% NP without bio inoculants, thereby a saving of 50% NP could be seen due to combined inoculation of Azospirillum + PSB + PPFM.

Individual effect of bio inoculants

Combined application of Azospirillum + PSB + PPFM at 75% N and P level produced an additional seed cotton yield of 642 and 496 kg/ha respectively than at 75% and 100% NP alone without bioinoculants resulting in 25% saving of N and P fertilizers is addition to increased yield of 496 kg/ha.

PPFM and Pesticide interaction

The phyllosphere population of PPFM, in the fully expanded third leaf of cotton on 45 DAS reveal that application of chemical fertilizers alone without

bioinoculants recorded significant reduction in PPFM colonies/cm2 of leaf. The phyllosphere population of PPFM recorded immediately after foliar spraying of PPFM has shown an increase of 57.3 to 94.7% population of PPFM in the treated plants over uninoculated check. However, pesticidal spray drastically reduced the PPFM colonies in the leaf. The reduction was only about 16.5% in the native PPFM (recorded in uninoculated plants), while the reduction in population of inoculated plants ranged from 27.6 to 59.6 % indicating that introduced PPFM is more susceptible to pesticides than native strain.

Assessment of organic residues along with *in situ* incorporation of green manure on soil fertility dynamics and cotton productivity

An integration of organics *viz.*, combined application of FYM @ 5 t/ha (15 days before sowing, DBS), cotton whole residues @ 2.5 t/ha (60 DBS) and sun hemp seeded @ 15 kg/ha simultaneously in inter-rows of cotton as GM and buried at 45 DAS produced significantly higher SCY (1904 kg/ha) over both control i.e., no NPK and RD-NPK.

Higher net return with less cost of cultivation was realized following application of crop residues/ GM over that in control.

The most revealing aspect of the present study is that application of cost effective organics available locally may act as an effective substitute for inorganic fertilization in sustaining the yield and restoring soil fertility.

Studies on changes in the soil physico-chemical properties and crop productivity under various soil cover/incorporation of *ex-situ* plant wastes in a freshly/ under-reclaimed sodic soil

Trianthema or *Parthenium* weed residues were equally effective in influencing seed cotton yield (with yields of 1791 and 1675 kg/ha) with that in FYM (1728 kg/ha); and all the above led to significantly higher seed cotton yield (over the treatments *viz.*, absolute control (no NPK & no residues), cotton crop residues, leaf litter and neem twigs etc.

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

Significantly higher seed cotton yield (1047 kg/ha) under cotton-jowar rotation compared to cotton-fallow (732 kg/ha) at the end of two years with additional jowar grain and straw yield to the tune of 6.5 and 17.5 t/ha, respectively because of higher crop growth and development. Application of FYM alone @ 15 t/ha, FYM @ 5 t/ha + RD-NPK or RD-NPK + crop residues had a beneficial effect on the cotton productivity in both the years.

4.10 Conservation Tillage

Nagpur

Effects of tillage management practices on *G. arboreum* and *G. hirsutum* were assessed for the third year. Tillage x genotype interaction was significant. Yield of the *G. arboreum* did not differ significantly between tillage systems. On the other hand, yield of the *G. hirsutum* was significantly better in the reduced tillage systems compared to the conventional tillage system (Table 8).

Table 8 : Effect of tillage systems on yield of *G. arboreum* and *G. hirsutum*

	G. arboreum	*G. hirsutum*	Mean
Conventional tillage	1089	1006	1047
Reduced tillage-1	1066	1163	1114
Reduced tillage-2	1136	1243	1189
LSD (0.05)	102		

A tillage x N or genotype x N interactions were not significant. Regardless of tillage systems, yield was significantly greater in the plots supplied with 75 kg N ha^{-1} compared to plots supplied with recommended N rate (60 kg ha^{-1}).

None of the fibre properties (staple length, strength, micronnaire and uniformity), 100 seed weight and GOT were affected by the tillage systems.

Expectedly, differences between genotypes were highly significant. Fibre length and strength were greater in the *G. arboreum* (cv. AKA 8401) than *G. hirsutum* (cv. Rajat). The fibre of the *G. arboreum* was coarser (mic. 5.0) as compared to *G. hirsutum* (4.5).

Coimbatore

Polyethylene mulch for Cotton-Maize cropping system

All the poly films, irrespective of the thickness and colour, promoted growth and enhanced the seed cotton yield ranging from 2769 to 3473 kg/ha as compared to 1846 kg/ha under non-mulching. The white coloured polymulch, out yielded all other colours with the highest seed cotton yield of 3473 kg/ha. The sucking pest incidence was very less in white colour (due to reflective action) and higher under yellow films (attractive action). In general, the stem weevil damage was very less under poly mulching and the infected plants produced galls but did not break due to higher stem girth and sturdy plants due to poly mulching.

The rate of mineralization was very high under poly mulching as evidenced from 1.33 and 2.18 fold enhancement in ammonical nitrogen (112 kg/ha) and nitrate nitrogen (244.3 kg/ha) respectively under poly mulching as compared to 84 kg/ha and 112 kg/ha recorded under non mulched soil. Due to favourable microclimate, the poly mulched cotton fixed higher CO_2 of 90.25 μ mol/cm^2/sec. as compared to 79μ mol/cm^2/sec recorded under non mulching and thus, the ploy mulched plants could assimilate higher biomass and resulted in better partitioning of assimilates. The rate of growth as measured by crop growth rate (CGR) revealed that poly mulched cotton grew faster.

Water use efficiency was heighest with 42.72 to 53.59 kg seed cotton/ha cm of water applied as against 23.12 kg seed cotton / ha cm under non mulching. Poly mulched plant could accumulate higher biomass and resulted in better partitioning of assimilates as evidenced from higher (38) number of heavier bolls (4.04 g) as compared to 22 bolls and 3.58 g/boll under non mulching. The ginning percent (34.9), lint index (3.99) and seed index (9.3) were favourably influenced by poly mulching as compared to 32%, 3.67 and 8.2, respectively for non mulching.

The intercrop also produced better nodulation and growth and recorded on an average 490 kg/ha grains as compared to 258 kg/ha under non mulching.

After harvest of cotton, fresh punching were made at 5 cm away from cotton holes and maize hybrid CORH M 4 was sown under zero tilled condition. The maize crop also benefited favourably due to poly mulching and the white coloured poly mulch recorded the highest grain yield of 8229 kg/ha, followed by yellow mulch (8044 kg/ha) as against 2864 kg/ha recorded under non mulching.

4.11 Cotton based Cropping Systems

Nagpur

Improving the efficiency of cotton+pigeon pea strip cropping in Vertisols

The studies on the competition and production efficiencies as influenced by 12, 8, 6 rows of cotton showed statistically non significant differences and reduced the seed cotton yield of adjacent cotton row by 36, 31 and 33% compared to middle rows. The single pigeon pea row produced 95 kg ha^{-1} more grain yield over two rows in *desi* cotton AKA 8401 + pigeon pea strip cropping. Hybrid cotton NHH 44 with single row of pigeon pea produced 42, 60 and 93% higher yields at 8, 6 and 12 rows of cotton respectively over two rows of pigeon pea and no significant differences were observed for 12, 8 and 6 rows of cotton or 1 or 2 rows of pigeon pea. Strip cropping with 1 row pigeon pea was economical at 6 and 12 rows of cotton whereas 2 rows of pigeon pea had at 8 rows marginal advantage. The pooled results of three years showed that year to year variations are significantly influencing both types of cotton and pigeon pea crop performance.

The seed treatment with bio-fertilisers in *desi* cotton AKA 8401 improved seed cotton yield by 42 kg ha^{-1} and alongwith 2% foliar application of urea improved the pigeon pea grain yields by 81 kg ha^{-1}

which is economical over farmers' practice (FP). The yield reductions were compensated by bio-fertilisers and 2% urea foliar spray by 10% over FP. In NHH 44 hybrid strip cropping with pigeon pea in 8:2 ratio, bio-fertilisers in hybrid cotton improved seed cotton yields by 153 (10%) and 93 kg ha^{-1} (7%) at 50% and 100 % recommended fertilizers respectively in 2/3 years. Two foliar sprays of 2% urea did produce 104 kg ha^{-1} (7%) improvement in seed cotton yield in 2/3 years. The pigeon pea grain yields were improved by 157 kg ha^{-1} at 50% recommended fertilizers with hybrid cotton strip cropping. The bio-fertilisers seed treatment in pigeon pea improved grain yields by 40% and RDF by 76% showing nutritional demand of legumes which needs attention. The application of recommended dose of fertilizers responded in all three years by 294 kg ha^{-1} (14%) over farmers practice. In hybrid cotton strip cropping system over all bio-fertilisers improved seed cotton yields by 166 (10%), foliar spray of urea 2% by 104 (9%) and 100% RDF by 192 kg ha^{-1} (19%) and bio-fertilisers over 100% RDF by 64 kg ha^{-1} (6%) respectively. The B:C ratio were improved from 2.78 to 3.66 by bio-fertilsers followed by RDF + bio-fertilisers 3.47 and bio-fertilisers with 2% urea as foliar spray by 3.18 in hybrid cotton +pigeon pea strip cropping.

Coimbatore

Evaluation of cotton based multi-tier vegetables intercropping system under irrigated condition

Growth characters and yield recorded in different multitier intercropping systems did not vary significantly. The highest seed cotton equivalent yield (4350 kg/ha) was registered with the multi-tier cropping of cotton with radish and amaranthus planted between cotton rows followed by cotton + radish + coriander + cotton (3806 kg/ha) as against sole cotton (2190 kg/ha).

Ginning percentage, seed index and lint index of cotton were not affected by the multi-tier intercropping systems. Radish and amaranthus planted between cotton rows registered the highest gross return (Rs.84908/ha.) and net return (Rs.55832/ha.) and cost : benefit ratio (2.9).

4.12 Organic Cotton Production

The survey conducted with organic farmers showed 50% yield reductions in 28-32 mm staple hybrids with no reduction in soybean- gram rotational crops. Farmers used *Jivamrut* (cow dung+urine, ghee and honey or jaggery paste) as seed treatment followed by 3-4 times application of *Amrutpani* (fermented liquid cow dung manure) + cow urine spray as vitalizer and NSKE 5% as insecticide. Insect management is crucial in years of heavy pest incidence under mono cropping of cotton.

One year study with extra long staple genotypes found Bunny, Abadhita, Sahana and Swati as superior to NHH 44 under organic managements. N fixing, P solubilising bacteria, *Trichoderma viride* and *Pseudomonas* application as seed treatment improved seed cotton yield by 21% over farmers' organic practice in long staple Surabhi cotton . Vermi compost improved seed cotton yield by 11%, Neem seed Kernel Powder (after spray) @ 2 kg ha^{-1} improved by 28% and EM application by 12% over organic farmers' practice.

4.13 Ergonomically Efficient Implements for Cotton Production

BCN single, Hollow cone and NMDS nozzeles were tested at 10, 20, and 30 PSI with Knapsack sprayer with single boom on dwarf compact genotype CNH 120 MB. NMDS nozzle found to deliver finer spray followed by hollow cone and BCN single nozzle with minimum ground loss of pesticide and giving maximum deposition on the site of egg laying on the top. The pressure range of 30 PSI is sufficient with backpack knapsack sprayer for NMDS nozzle and BCN nozzle provided the uniform pressure. Maximum spray was deposited at bottom leaves (36 %) followed by middle (36 %) and top leaves (23 %).

Adoption and Refinement of Cotton Picker and Cleaning Systems

Six varieties namely CNH 120 MB, CNH 911, CNH 123, CNH 2713, CNH 4736 and GSH 2 were planted at 100 x 45 cm spacing and tested in 2004

season with two row mechanical cotton picker to identify the suitable genotypes for mechanical picking. These varieties produced seed cotton yields under similar spacings as 881, 1506, 1590, 1285, 1529 and 1769 kg ha^{-1} in CNH 120 MB, CNH 911, CNH 123, CNH 2713, CNH 4736 and GSH-2 respectively. CNH 120 MB and CNH 2713 are most compact genotypes from height and spread basis. CNH 123 MB produced maximum bolls with 10-20 from main stem. CNH 911, CNH 2713 and CNH 4736 had all the bolls concentrated within 40 cm radially from the plant.

4.14 Production Physiology

Nagpur

Effect of plant growth regulators and nutrients on growth and yield of cotton

Three cotton cultivars *viz.*, LRA 5166, Bunny and AKH 8401 were grown in a replicated field experiment under rainfed condition. During flowering NAA and nutrients were sprayed singly and in combination to study the effect on growth, development and yield. The results indicated that the cultivar response remained significant, whereas the treatment differences were mostly non-significant.

Bunny hybrid was grown in pots and during flowering the treatments - Ethanol, methanol 1ml/l, Zinc 0.5 %, GA, IAA, IBA and Kinetin 100 ppm (single spray) and ethanol and methanol in combination with other nutrients and PGRs were given as foliar sprays. The results were significant with regard to plant height; inter node length, number of leaves, squares and total fruiting parts. The seed-cotton yield however, was non significant.

Foliar spray of GA 200 ppm and Ethanol 5 and 10 ml/l as single and in combination at flowering to Bunny hybrid grown in pots indicated that the treatment effects on growth and yield were non-significant.

Growth and Development of *Arboreum* in Shallow Soil

Arboreum genotypes viz CINA series 345, 346,347,348,349, AKA 8401 and AKA 7 grown in shallow and deep soil conditions were studied for growth and development during 90 to 120 days after planting. The study indicated that among the genotypes grown under shallow soil condition, CINA 348 has recorded better performance with regard to biomass production.

Yield modelling

A generic model INFOCROP has been calibrated and validated using crop, weather, soil, genotype, date of sowing, nitrogen level as basic inputs. The model has simulated the phenology more accurately and the accuracy of simulated yield was 92% and biomass 89% across the centers.

The integrated approach for yield predicting production at regional level (including RS generated data base, GIS and crop model) was further fine tuned with the use of refined model and was tested for Nagpur, Bharuch and Dharwad districts during the year. The model based integrated approach predicted the values of production and productivity lower than those reported by the Govt. in respect of Nagpur district. The productivity values were higher for Dharwad district as compared to Nagpur.

Source-Sink Relationship in Cotton

Nagpur

Under rainfed condition the contribution of early-formed squares to the yield is minimal. Mechanical removal of early-formed squares for either 10 or 20 days led to sudden spurt in fruiting activity. Some of the action specific chemicals such as ethrel at low concentration could delay the production of squares. This resulted in increased sympodial nodes on the plant and higher fruiting activity subsequently. However, increased yield could not be realized in these plants under rainfed condition mainly because the duration got extended and the late formed bolls were subjected to soil moisture depletion. Nevertheless, this technique can be made use of in effective control of insect pests.

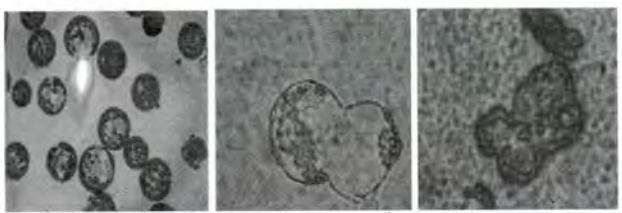
Coimbatore

Ethrel was used as foliar spray at three concentrations viz., 30, 45 and 60 ppm on 35th and 45th DAS in cotton cv. LRA 5166. At 60 ppm, there was total shedding of squares and also the vegetative growth was suppressed. The splitting of stem was observed when two sprays of ethrel were given. Two foliar sprays of ethrel at 35 and 45 DAS irrespective of the concentration brought about total change in the plant biology leaving the plants highly susceptible for sucking pests. There was synchronous flowering and boll development due to 30 and 45 ppm ethrel spray- leading to uniform boll bursting and picking could be completed in 1-2 pickings. The application of Ethrel at 45 ppm showed an increase in yield of around 40% (2340 kg/ha in LRA 5166 and 2400 kg/ha in Sumangala) over the control (1620 kg/ha).

Maleic hydrazide was applied at 90 and 100 DAS @ 500 and 1000 ppm in cotton cv. LRA 5166 and Sumangala. There was no perceptible change in the reproductive activity. The leaf area duration was prolonged by about 15-20 days. The boll size showed a marked reduction, while the boll number was enhanced by 25-30%.

Isolation and regeneration of cotton protoplasts

Hypocotyl and cotyledonary explants of cotton cv. Sumangala were exposed to three different sources of cellulolytic enzymes *viz.*, Cellulase and Macerozyme (from Yakult Biochem, Japan)- Onozuka enzymes; Celluloclast and Pectinex (Nova, Denmark); Cellulase and Pectinase (Genetix, USA), at varying levels of osmoticum and the digestion efficiency was studied. Mannitol at 9% was found optimum for maintaining the spherical shape of the protoplasts. The enzyme combination of cellulase (2%), macerozyme (0.25%) from Onozuka was found effective in release of good viable protoplasts after 12-14 hours digestion. The yield from hypocotyl explant was very low (2 x 102 protoplasts /g tissue) and released protoplasts were very fragile and could not sustain the purification process. Cotyledonary explants yielded healthy protoplasts (2 x 106 protoplasts /g tissues). MS basal medium with phytohormone combination of NAA (0.5 mgL^{-1}) + Kinetin (0.5 mgL^{-1}) and 2,4-D (1.5 mgL^{-1}) + Kinetin (0.5 mgL^{-1}) and plating density of 2 x 104 protoplasts/ml led to first cell division after three days in culture and subsequently showed quadruplet formation. The divided cells continued to survive for 15-20 days. The plating efficiency was 10-15%.



a b c

a. Freshly isolated protoplasts, b. First division
c. Quadruplet formation

Response of elevated carbon dioxide on physiology and productivity attributes of cotton genotypes

The desired level of 650 ± 50 ppm was maintained throughout the crop growth of cv. Suvin (*G. barbadense*). Right from the initial stages, the growth and vigour of the plant was significantly higher under elevated CO_2 atmosphere in terms of plant height, number of leaves and leaf size. The plant height recorded on 30th day after sowing was 9.5 cm compared to 5.2 cm in control plants under ambient condition. Leaf number was marginally more at 30 days after sowing. The leaf expansion rate was significantly faster under elevated CO_2 atmosphere with 30-40% more leaf area than the control plants. Photosynthetic activity and nitrate reductase activity in 70 days old crop was significantly higher than observed in plants grown under elevated CO_2 atmosphere. It was also seen that both photosynthetic and nitrate reductase activity got inducted earlier in the morning hours than control plants.

Sympodia number was significantly more in plants grown under elevated CO_2 atmosphere. Consequently, the boll number was also more and the boll development process was also faster. However, seed filling took 10 days more for the physiological maturity of the seeds to be attained in plants grown

under elevated CO_2 atmosphere than normal ambient grown plants. Significant increase in boll number and boll weight was recorded in plants grown under elevated CO_2 atmosphere. Consequently, the seed cotton yield was significantly more under elevated CO_2 atmosphere leading to significantly higher yield.

Nitrate reductase activity recorded 30% higher activity under elevated CO_2 atmosphere than ambient grown plants. Until 8.00 AM, the enzyme activity was at very slow rate as the leaves were quite wet on both adaxial and abaxial surface. However, this set back was compensated during the later part of the day.

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

The physiological and biochemical characterization of linted (cv. MCU 5) and lintless (cv. MCU 5LL) mutants of cotton was monitored from flowering to boll bursting. The protein content was high and ranged around 55 to 65 mg.g-1 till 15 DAA and thereafter lesser accumulation of protein was observed in both fibre (0.5-2.0 $mg.g^{-1}$) and ovules (20-50 $mg.g^{-1}$). Characteristic accumulation of reducing sugars and total free amino acids was noticed in developing seeds of lintless mutant as compared to linted MCU 5. However, such a trend could not be seen with respect to soluble proteins as it accumulated in both the genotypes. Peroxidase activity was found increasing till boll bursting in the seeds of both genotypes with a range of 40-175 units in MCU 5 and 40-200 units in MCU 5LL.

The physiological and biochemical characterization of fuzzy and fuzzless mutants (cv. AKA 98-8-1) was monitored from flowering to boll bursting. The biochemical constituents estimated are reducing sugars, proline, total soluble protein, total phenols, IAA oxidase and peroxidase. The peroxidase activity was slightly high in fuzzless (76 - 12 units in fibres and 87 - 196 units in ovules) during progressive boll development stage as compared to fuzzy genotype (68 - 10 units in fibre and 74 - 170 units in ovules).

4.15 Physiological Disorders

Nagpur

Effect of 2,4-D on plant growth

5 ppm of 2,4-D as foliar spray to Bunny hybrid during flowering indicated that appearance of typical symptoms was delayed under low temperature. The flowers showed malformation leading to reduction in size of flowers, petals and length of filaments bearing the pollen sac. Unlike in normal flowers, the petals of malformed flowers were mostly non-overlapping and stiff in texture. The pollen column has become conspicuously denser with reduction in the length of filaments. Due to the dense nature of pollen, the style appears protruded. The pollens were more brownish as compared to the normal flowers.

4.16 Stress Physiology

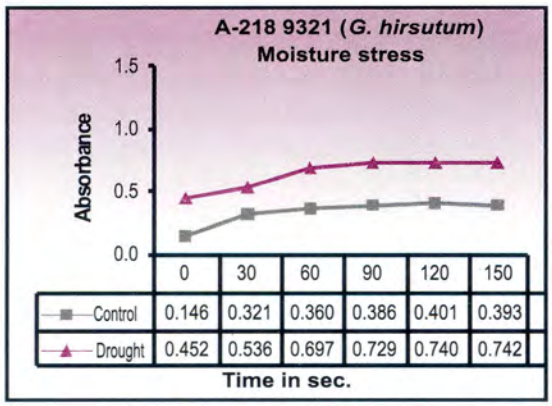
Nagpur

Screening of genotypes for drought tolerance

Nineteen genotypes *viz.* A 218, AC 19 GF, AP 18-2-1, Bunny, CAT 2107, CAT 2121, CPH 1835, LRA 5166, CAT 3260, Y 23, CAT 3656, CAT 710 , CAT 3289, CAT 1319, CAT 1934 (*G.hirsutum*) and AC 40, AS 49, CAT 6527 and CAT 3533 (*G. arboreum*) were grown in pot culture and during flowering drought stress was inducted. Leaf relative water content and leaf water potential were more prominent in *hirsutum* genotypes. On the other hand, solute concentration and root-shoot ratio were found to be relatively higher in *arboreum* lines.

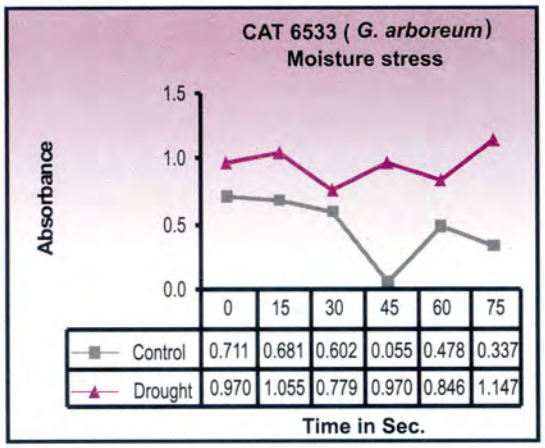
Nitrate reductase activity remained higher in eleven *hirsutum* and two *arboreum* genotypes under stress condition as compared to control. For *G.hirsutum* germplasm lines, initial catalase and peroxidase activity were found to be more under stress and after recovery phase, the difference between control and recovered set narrowed down. With time the catalase activity decreased more in stress samples than in control. In case of *G.arboreum* germplasm lines, catalase activity was found to be more in stressed leaves, but contrary to *hirsutum* lines, the catalase activity did not show decrease over a definite time period.

In case of peroxidase activity, the trend was found to be the reverse. (Figs.5 & 6).



	0	30	60	90	120	150
Control	0.146	0.321	0.360	0.386	0.401	0.393
Drought	0.452	0.536	0.697	0.729	0.740	0.742

Fig.5: Peroxidase activity in *G.hirsutum* lines



	0	15	30	45	60	75
Control	0.711	0.681	0.602	0.055	0.478	0.337
Drought	0.970	1.055	0.779	0.970	0.846	1.147

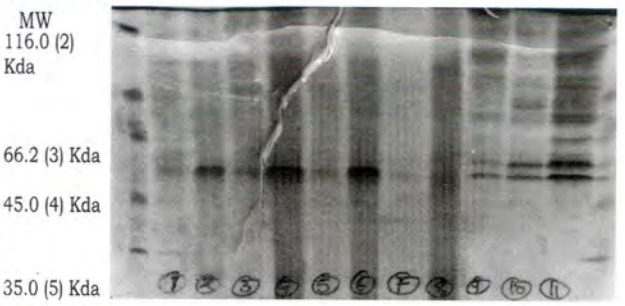
Fig.6: Catalase activity in *G.arboreum* lines

In an attempt to find out the response of cotton plants to stress proteins, leaf protein profile was determined through PAGE (Poly Acrylamide Gel Electrophoresis) for control and stress samples. Accumulation of proteins was observed under moisture stress conditions (Fig.7).

These proteins may be Heat shock proteins (HSPs), but needs further investigation.

Y 23, CAT 2107 and AC 40 had relatively higher drought tolerance.

Fig. 7 : PAGE showing bands in *G. hirsutum* and *G. arboreum* leaf samples under control and moisture stress



Genetical and anatomical studies for drought tolerance

Twenty four advance lines grown in control and moisture stress conditions were screened for leaf relative water content during flowering. The lines with higher leaf relative water content identified were - SPS 7 UR. SPS 20, SPS 28, SPS 30, SPS 39.

Salinity tolerance

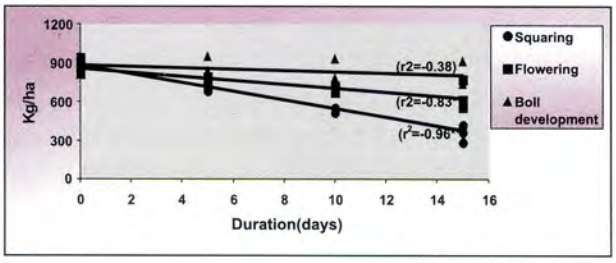
Cotton genotypes showed decline in growth and yield beyond 7 dS m^{-1}. Yield showed 10 to 20 % decline at 5 dS m^{-1} and at higher salinity, yield decreased at an increasing rate. The yield decline per unit increase in salinity was less in *G. arboreum* and *G. herbaceum* compared to *G. hirsutum* germplasm lines, hybrids and derivatives of wild species. The rate of yield decline was highest in hybrids. *G. arboreum* and *G. herbaceum* genotypes showed better tolerance for salinity. Leaf area production was very sensitive to salinity compared to decline in photosynthesis. Tolerant genotypes possessed higher accumulation of

proline and higher K/Na ratio. In cotton, the Na accumulation and K depletion was seen in roots, stems and leaves except the fruiting parts. Even at high salinity level fruiting parts maintained high K content. Decline of yield was more marked in G. *hirsutum* genotypes.

Water logging tolerance

The effect of water logging on growth, development and yield of cotton varieties and hybrids across the species was quantified in pot culture and field experiments. Depending upon the stage and duration of water logging treatment, plants response to water logging varied. Water logging for a period of 5 and 15 days at early seedling stage reduced the yield by 21% and 52% and at flowering by 11% and 37% respectively while, at later stages water logging did not show significant effect on growth and yield (Fig.8). Cotton plants at flowering and thereafter developed lenticels as an acclimatization phenomenon to withstand water logging. Wide variability was seen amongst species as well as varieties for water logging tolerance. *Hirsutum* and hybrids showed better tolerance compared to Asiatic cottons. However, prevailing weather conditions again found to influence the plants' response to water logging. Unlike yellowing, senescence, shedding of leaves and fruiting parts observed with water logging under cloudy weather, under bright light and high temperature water logging elicited wilting in cotton known as parawilt. These plants have been found to have insensitive stomata under adverse conditions.

Fig. 8. Effect of water logging duration on yield at squaring, flowering and boll development stages



Coimbatore

Identification and utilization of adaptive responses to abiotic stress in cultivated species of Cotton

Plants under water stress treatment showed significantly low rate of photosynthesis by 20 – 25% than control irrigated plants. Tolerant genotypes appeared to have better photosynthesizing capacity even under water stressed condition. Nitrate reductase activity also followed the same trend to that of photosynthetic rate. The crop maturity was delayed by 10 –12 days in plants grown under irrigated condition.

The moisture level of the soil under water stress treatment was 8-10% compared to 17 – 18% under irrigated condition as recorded on 130 days after sowing. Detopping of cotton plants at 10 cm from the tip at 90 days after sowing had a favourable impact on productivity.

Application of 2% *Kamadhenu* (cow's urine based organic fertilizer cum natural pesticide) as foliar spray brought usual change of dark green colour in the leaf. The photosynthetic rate and nitrate reductase activity was significantly higher compared to control plants. However, with repeated spray at weekly intervals, the effect of Kamadhenu on these parameters was not significant. Fresh *Komium* at the rate of 2% as foliar spray too showed the same trend.

4.17 Social Dynamics of Cotton Production

Nagpur

The panel data collected from 107 cotton growers from Mangli, Mohgaon, Kawdas and Adegaon villages in Hingna Taluka of Nagpur district during the year 2000-2005 revealed that the cotton growers whose total income is just enough to get barely on has been reduced from 35% in the year 2000 to 19% in 2005 and current financial condition of a family has become a serious problem for 46% of farmers which is increased from 26% during last five years. To supplement the income from farming, 16% more farmers have started doing off-farm jobs and womenfolk have increased their number of hours for

work on farm. Seventy per cent cotton growers are concerned about returning the loan they have taken for agriculture, which was only 9% during the year 2000.

The regression model for explanation of technology adoption behaviour of 127 cotton growers in Hingana Taluka of Nagpur district revealed that 53% of the variance in technology adoption behaviour related to adoption of hybrid cotton is explained by the variables like spatial distribution, availability of technology, marketing strategy, pricing, and promotional communications.

Impact of Technology Transfer

Analysis of the 95 FLD sample farmers from Nagpur and Coimbatore centers for showed awareness and adoption of intercropping with cotton shows that 67% respondents were aware about intercropping of cotton + soybean (1:1), cotton + Moong/Urd (1:1), cotton + cow pea (1:1). The analysis revealed that intercropping soybean, moong/urd and cowpea was adopted fully only by 7.37, 23.16 and 11.58% farmers respectively. Most of the farmers do not adopt the intercropping technology because majority of them fear that intercropping in cotton is not profitable. The other reasons for low or partial adoption of intercropping in cotton were, reduction in seed cotton yield, problems in interculture operations, fear of more pest incidence. In adoption of intercropping of cow pea with cotton, most of then expressed reasons such as them unawareness of technology, crop a competitor/ delayed growth of cotton crop. The common practice of cotton + pigeaon pea strip intercropping was adopted by more than 44% farmers.

Accessibility to Mass Media and Information Technology

Interview schedule proforma for collection of data was devised separately for extension functionaries and farmers. The sampling framework with respect of access to and use of modern mass media i.e. electronic media (radio & television), print media (newspaper and magazines) and information technologies (internet, cellular/mobile phones), etc. was finalized. Nagpur and Wardha districts in Vidarbha region of Maharashtra were identified for data collection from the respondents comprising both extension functionaries and farmers.

Coimbatore

Evaluation of cotton production technologies for yield, fibre quality and economic viability

Seven technological interventions *viz.*, Popularization of varieties (Surabhi and Sumangala), date of sowing, paired row technique (Intercropping with onion and beet root), fertilizer application based on Soil Test – Plant response correlations (INM), Integrated Weed Management (IWM), Integrated Pest Management (IPM) and Integrated Disease Management (IDM) were implemented during the year. Due to the interventions, 18 - 20 % yield increase was reported.

The farmers were motivated to take up commercial vegetables like beetroot / onion along with cowpea / blackgram under paired row technique. Water requirement was reduced by 15 per cent as compared to single row technique. The added return was appreciable to a tune of Rs. 5000/- per acre due to the intercrop.

Technology assessment and refinement of irrigated agro-eco system for coimbatore region tamil nadu through institute village linkage programme -

Various technological interventions were implemented as per the technical programme.

Sumangala was introduced to the farmers of Senthampalayam village, Coimbatore district wherein cotton is one of the major crop grown in 200 acres. In general, continuous heavy rainfall during the bursting stage of the crop coupled with low price of cotton has affected the overall profitability of the cotton crop during the present season. 'Field Day' was organized on 9th December, 2004 at the village, Allapalayam.

4.18 Cotton Economics and Marketing

Nagpur

Cotton outlook

Data were collected from 250 farm households on cotton performance during the year from Maharashtra, Andhra Pradesh, Gujarat and Madhya Pradesh. Year 2004-05 had been one of the best years from yield point of view but prices have fallen denying the accrual of benefits to the cultivator. The risk in farm income generated from prices, as the production world over has increased. Price fall also has not been production driven but by the subsidy support given by some major cotton countries.

Total factor productivity in cotton

Increase in crop production can be acreage/ input/ price or technology driven. Technology driven production is termed as total factor productivity (TFP) and measured as increase in rate of growth of output due to technical progress over rate of growth of input. The growth rates worked out over decades revealed declining productivity during 1990s in Sirsa, where as Yavatmal indicated productivity gains in post hybrid era. Time series data on agricultural inputs use since 1970-71 have been collected for Sirsa and Yavatmal districts. The information included crop acreages, production, yield, fertilizer consumption, irrigation, electricity, farm machinery, agricultural labour, animal power, prices, etc. Difficulties were encountered in collecting district-wise pesticides consumption and dis-aggregation of input use.

Bt cotton performance, constraints and risks

Data on Bt cotton performance and constraints have been collected from 300 households in the above states. This season (2004-05) too had witnessed less of the targeted pest (*Helicoverpa armigera*) menace, but there had been severe incidence of pink boll worm (*Pectinophora gossypiella*) and considerable incidence of Spodoptera (*Earias vittella*) particularly in Andhra Pradesh. Bt cotton had shown better resistance to pink bollworm and recorded higher yields with positive benefits ranging from Rs. 2200 to 20000/ ha. The partial budgeting revealed a net benefit of Rs.2200/ha in Maharashtra, Rs.4600/ha in M.P, Rs.5800/ha in Gujarat and Rs.9000-20000/ha in A.P.

The data collected from 60 cultivators in Surendranagar district (Gujarat) indicated that Bt hybrids recorded a yield of 20.46 q/ha against 16.34 q/ha in conventional hybrids. If the RCH-2 Bt alone was considered, the yields were still superior at 22.87 q/ha. The flip side of the technology was that many other non-descript and unapproved Bt hybrids too are in cultivation (few of them developed by farmers themselves) and seem to be popular among farmers.

The Andhra Pradesh survey covered 76 cultivators of Bt and conventional cotton hybrids in the intensive cotton district of Guntur. The average area under Bt was 1.58 ha against 1.53 under non-Bt cotton. Surprisingly 79 % of the sample farms Bt cotton area was totally rainfed indicating the risk capacity of the cultivators. While the 29% of the Bt cotton area was distributed between the officially approved Bt hybrids (MECH – 15% and RCH 2 – 14%), the rest 71 % of the area was under many non-descript Bt hybrids referred commonly by cultivators as Kurnool Bt (Kurnool district in A.P. is known for its cotton seed industry). The average yield performance was in the order – Kurnool Bt (33.68 q/ ha) followed by RCH-2 (30.12 q/ha) and MECH-12 (26.87 q/ha) as shown in table 9.

In cases of non-descript Bt, the seed price ranged between Rs.700 to Rs.900/packet against Rs.1600/ packet of official Bt and the concept of refuge seed supply itself was practically absent, while the adoption of the same in case of official Bt was less than 10%.

Besides there were clear benefits in terms of timely operation, crop termination, savings in yield loss and plant protection expenditure. Overcoming labour shortage ;minimizing exposure to chemicals, early termination of the crop, reduced plant protection expenditure, rejuvenating capacity of the Bt, are some of the reasons cited for preferring them. Besides, Bt particularly RCH 2 has shown resistance to pink boll-worm in Andhra Pradesh though the disadvantages

Table 9 : Performance of Bt Cotton in Guntur-2004-05

Particulars	Bt Hybrids			Conventional
	MECH -12	RCH -2	Kunrool Bt	Hybrid
Number of sprays	9.4	7.8	6.9	12.8
Cost of Plant Protection (Rs./ha)	9477.5	7936	7548	12125
Cost of cultivation (Rs./ha)	28975	26694	25185	30987
Yield (q/ha)	26.87	30.12	33.68	25.25
Gross returns (Rs/ha)	45486	51581	58064	41031
Net returns (Rs./ha)	16511	24886	32879	10044

were susceptibility to sucking pests and excessive vegetative growth.

The low seed prices of unofficial Bt ranged between Rs.700-900 per packet against the conventional hybrid seed of Rs.400-500 per packet has set off intensive competition in the industry. While the pink bollworm resistance facilitated reduction in picking cost, the relatively poorer fiber quality in case of Bt cotton fetched lesser prices compared to their non-Bt counterpart. The indiscriminate growth in unapproved Bt cotton area is courting twin dangers of hampering the monitoring of resistance break down and yield overiding quality, especially when quality cotton is the need of the hour under WTO.

Marketing of Cotton

Data on marketing were collected from 200 farmers. The information collected from these farmers who have sold to the trader, federation and CCI and were compared for price and quality relationship. Price and staple length had positive relation matching up to 70% in on farm sales and CCI procurement. But federation pricing had more element of arbitrariness. Besides, the criterion of price determination by traders were collected and analysed and was found to be bearing some relationship with HVI recorded fibre parameters and the corresponding prices. The results show the need for changing the basis of price fixation on fiber quality than mere cost of cultivation alone on the basis of varieties as is being practiced by CACP currently.

Coimbatore

Present status, constraints and future strategies of cottonseed production in Tamil Nadu

Data were collected in respect of straight variety from two seed companies, 30 growers and 20 dealers in and around Coimbatore district. The average cost of cultivation per acre was around Rs.5935/. The B:C ratio worked to 1.30.

In case of hybrid seed production, five dealers each from three districts *viz.*, Coimbatore, Erode and Salem and seventy five seed growers were selected. Cost of cultivation in Salem was greater than in Erode but cost of production was very less because average yield in Salem was to the tune of 13.12 q as compared to 11.42 q in Erode.

Marketing channel was of three types : i) Seed growers – Seed organizers – Seed firms – Distributors – Dealers – Consumers; ii) Seed growers – Seed firms – Dealers – Consumers; or iii) Seed growers – Seed firms – Consumers. Channel III was more remunerative than other channels.

Information system on cotton

All the data collected so far have been digitized and an appropriate database was created. Beta version of the Information system on cotton was developed

using Visual Basic. NET as front-end and Microsoft Access as back-end.

Information System on Cotton Cultivars (InsCOT- ver 1.1) will provide information on all the cultivars released by various agencies so far in India. The CD was created with Visual Basic. NET as front-end and Microsoft Access as back-end. Digital Cotton Photo Library (DigiCOT – ver 1.1) contains collection of around 1000 photographs with thumb view as well as full view on various features of cotton including production, protection, wild species collection, cotton disease, biotechnology, post harvest, extension activities, etc.

Package of practice for cotton production system and ITKs related to cotton production system were documented.

4.19 Pest Scenario

Nagpur

During 2004-05, jassids, thrips and mirids (*Ragmus spp.)* attained pest status during mid-August, 1st week of September and mid-September, respectively. Aphid incidence was very low. Three peaks of fruit damage during mid-September, October last and November-December caused mainly by *H. armigera* to squares, *E. vitella* and *P. gossypiella* to bolls, respectively were observed. Damage peaks in respect of bollworms occurred with the simultaneous presence of all larval instars. With the occurrence of all fruiting structures simultaneously preference by *H. armigera* to squares followed by bolls and *vice-versa* by *E. vittella* was observed. Emerging pest status of thrips and mirids among sucking pests, and pink bollworm attaining the status of key pest in cotton were established. Considering larval diapause and off season moth emergence patterns in pink bollworm it is highly essential to focus on off-season pink bollworm management.

Aphidophagous coccinellids and syrphids were meager on account of low aphid abundance. Chrysopid oviposition coincided with both the peaks of *H. armigera* oviposition. Spiders and predatory mirids were regular in occurrence between September and November. Estimated egg mortality of *H. armigera* was 47.2 %. Seasonal mean parasitisation of *Earias* by *Rogas aligarhensis* and *H. armigera* by *Campoletis chlorideae* was 16.3 and 13.9 %, respectively.

A population of reniform nematode (*Rotylenchulus reniformis*) ranged from 20-150 nematodes per 250 cc soil at the time of sowing CICR experimental farm. At mid cropping season, the population varied from 200-360 nematodes/ 250 cc soil. Reniform nematode population dipped to 10-30 nematodes/ 250 cc soil with onset of winter. Soil solarisation reduced the population of root-knot nematode (Meloidaogyne incognita significantly.

Three plant species viz. marigold, custard apple and bitter gourd were found to repel phyto-nematodes from their rhizosphere up to one meter. There was reduction in nematode population involving crops as Sorghum while in cropping systems with Soybean, there was four fold increase in population of reniform nematode.

Soil with different nutrient status was surveyed to explore the possibility of use of nematodes as indicators of soil health. It was observed that free living nematodes as Cephalobids and Rhabditids were associated with high organic matter soil. Soil with high incidence of root-rot was found to have corresponding high presence of fungal feeding nematodes as *Aphelenchus spp.* and *Aphelenchoides spp*. High population levels of plant parasitic nematodes were associated with low population levels of free living nematodes and *vice versa.*

Coimbatore

During the year 2004-05, the pest infestation was low. Aphids appeared in the month of September and persisted all through peaking during October and January. Leafhopper incidence started in the month of September and the peak activity was in the month of December and the hopper population was 5-8 per plant during this period. Infestation of white fly and spotted bollworm was very low. Incidence of

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Helicoverpa armigera was seen in the month of December. Bollworm damage to reproductive parts was highest in the month of January (13.38%).

Observation on aphid infestation on Bt cotton (RCH 2) indicated that peak infestation was in the month of December. Leafhopper on Bt cotton persisted throughout the crop period and the peak infestation was in the month of December. Natural enemy population (coccinellids and spiders) was more during November –December.

Expert System on Cotton pest/insect

Basic information on cotton pests was collated and a Network Diagram was formulated. Initially attempt was made to develop the system in Visual Basic, but it has been reoriented to develop in ASP.NET, which is useful to float the developed software online in CICR web site. Preliminary shell for the expert system was developed in visual basic and the images of pests and their symptoms of damage and control measure information were collected from entomologist.

4.20 Resistance to Insect Pests and Diseases in *Gossypium* Spp.

Insect Pests

Nagpur

Out of 229 genotypes involving 131 crosses and 98 single plant selections evaluated for genotypic tolerance using phenological trait of compensation respectively 14, 32 and 21 were susceptible, moderately tolerant and tolerant to early season bollworm damage and had higher compensation.

$BC_1 F_1$ plants of three crosses, Bikaneri Nerma x (Bikaneri Nerma x Pee Dee0695), G Cot 10 x (G Cot 10 x Pee Dee 0695) and Mahalaxmi x (Mahalaxmi x Pee Dee 0695) raised under unprotected condition in the field. Plants were screened for the identification of high protease inhibitor (PI) inducible lines in the seedling and boll formation stages. Out of 17, ten plants of the cross G Cot 10 x (G Cot 10 x Pee Dee 0695) produced protease inhibitors. Of the 10 plants, six were tagged and have been used in the generation of $BC_2 F_1$ plants. Out of the 17 plants of the cross Bikaneri Nerma x (Bikaneri Nerma x Pee Dee 0695), seven plant demonstrated the presence of PI in the seedling stage. Of these, three demonstrating the highest PI activity were carried forward for the generation of $BC_2 F_1$. Of the thirty-three plants of G Cot 10 x (G Cot 10 x Pee Dee 0695) screened, 9 demonstrated the presence of inducible PIs. Of the 25 plants screened of Bikaneri Nerma x (Bikaneri Nerma x Pee Dee 0695) 14 demonstrated the presence of inducible PI and their inhibitory activity ranged from 28- 67%. The same plants of both crosses demonstrated the presence of PI in the seedling as well as boll stage and their PI values are presented in Table 10.

Table 10 : Protease inhibitory properties of $BC_1 F_1$

	G Cot 10 x (G Cot 10 x Pee Dee 0695)		Bikaneri Nerma x (Bikaneri Nerma x Pee Dee 0695)		
Plant no	**% PI activity in seedling stage**	**% PI activity in the boll stage**	**Plant no**	**% PI activity in seedling stage**	**% PI activity in the boll stage**
P2	57.14	33.33	P1	13.33	28.06
P4	42.85	0.00	P2	33.33	43.00
P8	16.66	40.00	P4	40.00	40.00
P9	25.00	40.00	P5	72.22	60.00
P10	25.00	60.00	P7	53.33	60.00
P11	16.66	-	P 17	11.11	37.05
P13	41.66	-	-	-	-

The donor parent (Pee Dee 0695) demonstrated an inducible seedling protein PI activity of 60 % and the boll protein demonstrated an inhibitory activity of 55 %.

Three MDR cultures CNH 911, CNH 2713 and CNH 4736 were maintained and two alternaria resistant cultures were evaluated.

Coimbatore

Screening of genotypes and advanced cultures of breeders' materials to bollworms

Of the 110 genotypes field screened against bollworms with Abadhita (bollworm tolerant variety) and Surabhi as check variety, four *viz.*, (VRS x V112) 3-2-4, 5 (1x2) 724-2, (V22 x V112) (LxM55)-443 and LS 3 were found to be resistant to pink bollworm and had less loculi damage, ranging from 8.5 to 10.9 per cent as against 8.8 per cent in Abadhita and 25.0 per cent in Surabhi. Six others *viz.*, (VRS x V112) 3-2-4, (VRS x V113) 6-3-4, Sumangala, LS 1, TK 32, TK 43 were found tolerant to pink bollworm and recorded loculi damage ranging from 10.9 to 18.3 per cent as against 25.0 per cent in Surabhi. They also recorded higher seed cotton yield than Surabhi. Only one entry, BRS 5 (L x BRS) 355 was found to be tolerant to all the three bollworms. It had 18.3 and 15.7 per cent damage in bolls and loculi, respectively as against 42.4 and 25.0 per cent damage in Surabhi. It also recorded significantly higher number of good opened bolls per plant and higher seed cotton yield over Surabhi.

Performance of selected genotypes with field tolerance against bollworms

Five selected genotypes *viz.*, 5 (1 x 2) 714-7, 5 (1 x 2) 718 -2, BRS-5 (L x BRS 3-3), IRH-1-10 and L (Paiyur x RCH 2-5-2) were screened for bollworm resistance in the field for the second year. The damage caused by *H. armigera* in squares, bolls and loculi were relatively less in all the five entries as compared to IC-472, which is a susceptible check. Three out of five entries recorded significantly higher seed cotton yield as compared to the susceptible check. From the two years study, the two entries, 5 (2x2) 714-7 and (1x2) 718-29 were seen consistently tolerant against pink bollworm.

Identification of resistant lines against jassids

Among 120 cultures screened for their reaction to jassid under unprotected condition, three *viz.*, L (RCH x T13) 5-2-11, L (RCH x T13) 74- 4, L (RCH x T13) HS 52-116 were found to possess resistance to while, twenty six recorded moderate resistance.

Evaluation of germplasm and AICCIP entries for resistance to foliar diseases

All *Gossypium arboreum* germplasm lines (100) and AICCIP entries (159) screened following inoculation separately in pot culture under polyhouse conditions against alternaria leaf spot, grey mildew and bacterial blight diseases were found to be susceptible to grey mildew.

Development of resistant lines to foliar diseases

Fifty-three single plant selections having resistance to grey mildew (27), alternaria leaf spot (3) and MAR lines (23) with resistance to more than one disease were advanced for further testing. Thirteen advanced lines having resistance to grey mildew (4), alternaria leaf spot (5) and MAR (4) were evaluated for yield in comparison with LRA 5166 and Sumangala. Seven lines had a yield potential on par with the test line Sumangala and significantly better than LRA 5166. Forty-one progenies involving 101-102 B, Badnawar-1, CBR 1 and CBR 3 were screened for bacterial blight disease.

Studies on soil borne diseases of cotton

There was no serious out break of Verticillium wilt. Under artificial conditions, 34 selected Verticillium wilt resistant progenies were once again screened and the resistance was confirmed. Ninety-four single plants involving six crosses were selected based on yield and ginning out turn.

Studies on biochemical mechanisms of resistance to bollworms of cotton

Advanced genotypes such as BRS 3, BRS 5,

BRS 22, and BRS 23 were noticed to possess higher levels of defensive biochemical constituents *viz.*, gossypol, tannin and phenols with higher bollworm tolerance as compared to susceptible genotypes. The yielding ability was seen in the range of 37 to 50g / plant under protected conditions, while it ranged between 34 and 45 g/plant under unprotected conditions (Fig. 9).

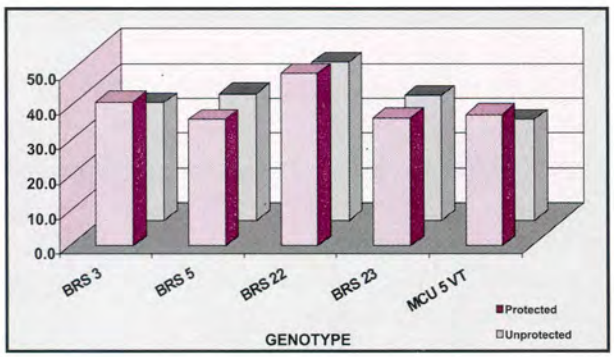


Fig. 9 : Yield of bollworm tolerant cotton genotypes under unprotected and protected conditions

Molecular evaluation through RAPD profiling revealed polymorphism between tolerant and susceptible cultivars (Fig. 10 a&b). Derivatives of tolerant introgressed lines possessing elevated levels of metabolic process intermediates have also been subjected to RAPD analysis and found to be polymorphic.

Fig. 10a.

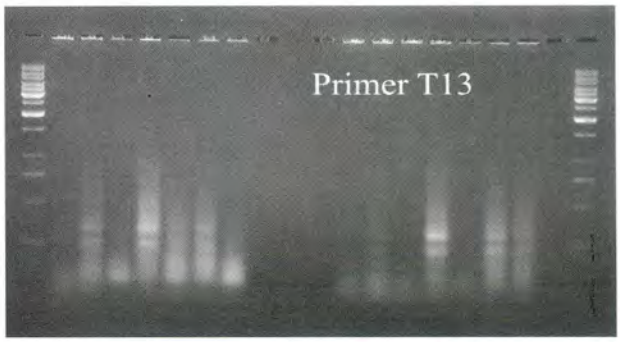
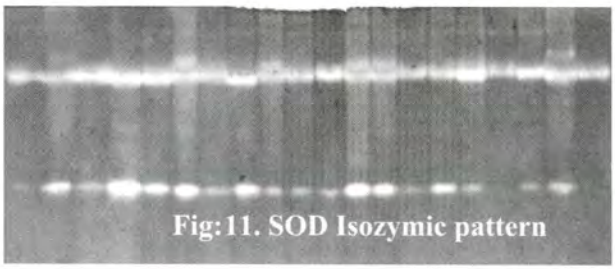
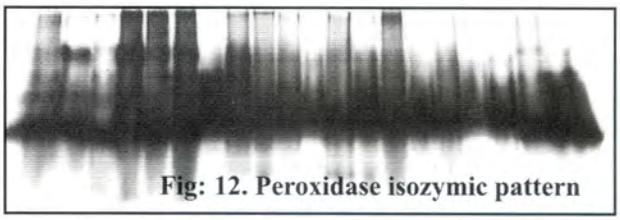


Fig. 10 a & b : RAPD profile of BRS Cultures studies on developmental biochemistry of cotton – pest / disease interaction

The effect of *Pseudomonas fluorescens* pf1 application was found superior with enhanced peroxidase activity of 102 -115 units, while the control plants possessed activity between 36-51 units. Similarly, enhanced superoxide dismutase (SOD) activity could be seen following *P. fluorescens* application in cotton. Characteristic isozymic variation could be noticed during host plant – *R. areola* interaction (Fig. 11 & 12).





Biochemical metabolic status due to interaction of pesticides was studied in field in Sumangala using Clothianidine, Methyl–o–dementon and four dosage levels of Imidacloprid. Imidacloprid @75ml/ha resulted in maximum peroxidase activity of 250 units, followed by Clothianidine, while control plants

exhibited 181 units of activity. A similar trend could be seen regarding accumulation of soluble protein (53, 54 & 44 mg/g) and nitrate reductase activity (5.2, 4.5 & 3.5 µmol NO_2 released/hr/g fr.wt), respectively.

Significant enhancement in photosynthetic rate and nitrate reductase activity could be observed following initial application of *Kamdhenu kitniyantrak* (natural insect repellent). However, subsequent rounds of application did not bring about changes in photosynthetic rate and nitrate reductase activity.

Sirsa

Studies on resistance to insect pest and diseases

On two years evaluation; genotypes CSH 3047, CSH 3051, CSH 3088 and CSH 3123 were found free from jassids and bollworms and CSH 3047 was free from jassids, bollworms and CLCuV disease. Study indicated that CSH 3047 had good fibre quality traits and yield also.

Screening of around 2000 lines of *G. hirsutum* against cotton leaf curl virus disease has led to the identification of forty resistant lines which are being used by the plant breeders.

4.21 Variability in Insect Pests and Pathogens

Nagpur

Helicoverpa

In India two species of *Helicoverpa* and one species of *Heliothis* have been recorded, viz: *Helicoverpa armigera* (Hubner), *Helicoverpa assulta* Guenee and *Heliothis peltigera* (Denis and Schiffermuller).

The primers used in the study were designed to amplify a 598 bp fragment corresponding to mid to near terminal region of CO I. Sequence of the amplified fragment was subjected to multiple sequence alignment using Clustal X. Nucleotide sequence and translated amino acid sequences, with the invertebrate mitochondrial genetic code in each of the strains resulted in high level of consensus between the two *Helicoverpa* species.

The region sequenced in this study was capable of being selectively restricted in *H. armigera* with eight restriction enzymes of which *Rsa* I was one. Its recognition site is masked by a mutation- GT¯AC in *H. armigera* that is replaced with GT¯TC in *H. assulta*, which is responsible for the absence of restriction digestion (Fig. 13).

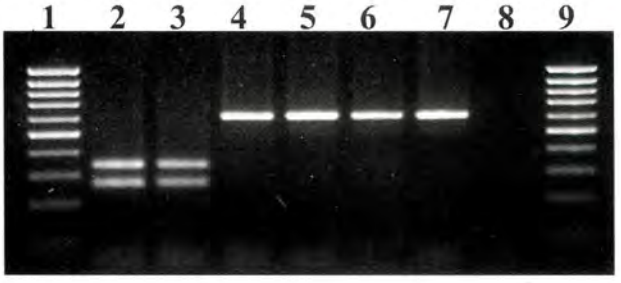


Fig. 13: Restriction digestion of PCR amplified partial COI region of *H. armigera* and *H. assulta* with *Rsa I.* L1&L9: 100 bp MW ladder, L2, L3: *H. armigera* PCR product, digested with *Rsa I*, L4: *H. armigera* PCR product undigested control, L5, L6: *H. assulta* PCR product digested with *Rsa I*, L7: *H. assulta* PCR product undigested control, L8: negative control

Molecular tools for distinguishing two haplotypes of *Helicoverpa* that differ in their ability to utilize cotton squares for the growth

PCR – RFLP using enzymes *Nci*1 for the cotton strain and *Bst* 2 UI for the non- cotton strain is proposed for the identification of the two haplotypes of *H. armigera*. Point mutations (Table 11) observed in the CO1 region have been exploited for designing this tool.

Reproductive compatibility and feeding preferences of interstrain crosses

Of the 109 single pair crosses made 48 were inter strain crosses and 61 were intra strain crosses. From the table it is clearly evident that the two strains mate and inter breed freely under laboratory conditions. Of the 109 crosses, fertile crosses ranged between 22-38% .

Table 11: Mutations in partial nucleotide sequences and the deduced amino acid sequences of Cytochrome Oxidase I (COI) gene of cotton and Non-cotton strains of *Helicoverpa armigera*

	Nucleotide sequence	Corresponding amino acid sequence
Ha Cotton	(2206)5'-ATTTTACC***G***GGA-3' (2217)	(245)ILPG (248)
Ha Non-Cotton	(2206)5'-ATTTTACC***A***GGA-3' (2217)	(245)ILPG (248)
Ha Cotton	(2377)5'-TATTT***T***ACATCAGCT-3' (2392)	(302)YFTSA (306)
Ha Non-Cotton	(2377)5'-TATTT***C***ACATCAGCT-3' (2392)	(302)YFTSA (306)

It was amply clear from this study that progeny of cotton strain feed on both cotton squares and redgram pods while progeny of non- cotton strains prefer to feed more on redgram pods than on cotton squares. In inter strain crosses where the mother was a cotton strain female, the progeny preferred to feed on both redgram pods and cotton squares. In inter strain crosses where the mother was non- cotton female the progeny preferred to feed on redgram pods when compared to cotton squares

Values in brackets indicate position of nucleotides with reference to *Drosophila yakuba* mitochondrial genome and that of amino acids in the deduced protein sequence. Letters in bold and italics indicate base substitutions.

Temporal variation in the cornutal spine numbers of pheromone trapped male moths (Fig.14).

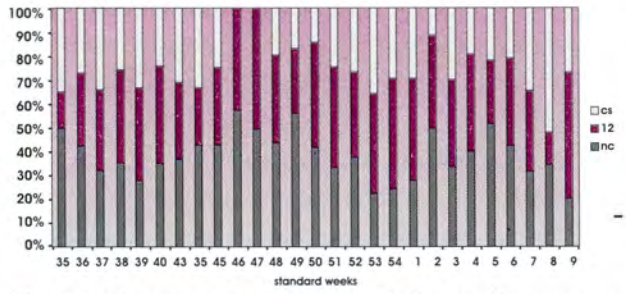


Fig. 14 : Cotton and non cotton strains in pheromone trapped male moths

Xanthomonas axonopodis pv malvacearum (Xam)

For knowing the pathogenic variability, 150 isolates were made from the bacterial blight infected leaf samples of five susceptible cultivars *viz.* Ganganagar ageti, LRA 5166, LRK 516, PKV 081 and Rajat having varying degree of susceptibility. Five races viz. 3, 7, 10, 15 and 18 were identified of which race 18 was predominant and 66.67 – 83.33 per cent isolates belonged to this race.

Races 3 and 18 were able to maintain their specific virulent nature when re-isolated from susceptible reactions of Stoneville 20 inoculated with race 3 and from hypersensitive reactions of S 295 inoculated with race 18. Inoculation of resistant host with race 3 was able to improve its virulence from single gene (B_{In}) to two genes (B_{In}, B_N) of race 5. However, dilution of virulence from five genes to three genes (B_2, B_{In}, B_N) of race 7 was observed in inoculation of resistant host with race 18. Association of susceptible or resistant hosts appeared to be responsible for dilution or increase of virulence.

Seventy one isolates made from the bacterial blight infected leaves collected from Marathwada and Vidarbha cotton growing areas of Maharashtra revealed the presence of five races *viz.* 4,7,10,15 and 18. Race 18 was most predominant and 81.69 per cent isolates belonged to this race.

Susceptible Stoneville 20 and resistant S 295 were inoculated with races 3 and 18 of *Xam* having virulence against one major gene B_{In} and five major genes B_7, B_2, B_{In}, B_N, B_4, respectively for knowing their virulence specificity after passing through

resistant and susceptible hosts. Races 3 and 18 were able to maintain their specific virulent nature when re-isolated from susceptible reactions of Stoneville 20 inoculated with race 3 and hypersensitive reactions of S 295 inoculated with race 18. Inoculation of resistant host with race 3 could be able to improve its virulence from single gene (B_{In}) to two genes (B_{In}, B_n).of race 5. However, dilution of virulence from five genes to three genes (B_2, B_{In}, B_N) of race 7 was observed with race 18 inoculation of susceptible host.

Biotypes variability in race 18 of *Xam*

Thirty new isolates of *Xam* collected from farmers' fields in districts of Wardha, Nagpur and Amravati were found to belong to race 18. Genomic and plasmid DNA were extracted from all 30 isolates in order to delineate biotype variability based on their native plasmid profiles, RAPD, Rep-PCR and RFLP. Based on the BOX-PCR fingerprinting pattern 30 isolates were grouped in 10 major groups with group V, accommodating 13 isolates. Six groups were unique having one isolate each. However, ERIC-PCR was more sensitive as it further delineated variability within three isolates that were accommodated within group V, based on BOX-PCR. Based on ERIC PCR, the isolates formed 11 groups. The isolates 19, 20 and 35 grouped together based on BOX-PCR fingerprinting formed separate groups on the basis of ERIC-PCR. RAPD analysis with OPA 13 primer further found variabilities among some group members that were grouped together based on Rep-PCR. Based on RAPD fingerprinting, 30 isolates were grouped in 16 groups. The primer generated amplicons ranging in size from 0.25 to 4.0 kb with minimum number of amplicons of one and maximum 10. Plasmid profiles of *Xam* isolates categorised 30 isolates in 12 groups with numbers ranging 1-3.

RFLP analysis of 30 isolates of *Xam* showed scorable hybridising bands in 15 isolates. These 15 isolates formed 7 groups based on their RFLP patterns. Most of the race 18 isolates possessed 2 pthN hybridising fragments. Accordingly group I is the biggest and is comprised of 5 isolates each having two hybridising bands of ca. 14 and 5 kb. Maximum of 6 hybridising bands were present in a lone isolate that belonged to group VI.

rDNA PCR analysis

In order to differentiate biotypes of race 18 based on rDNA sequence, PCR analysis of 6 representative isolates, one from each RFLP group, was done with conserved primers. The primers amplified approximately 0.65 kb DNA fragment from 5 out of 6 isolates. The rDNA fragment amplified from isolate 6 was slightly bigger compared to rest of the 5 isolates.

Ramularia areola

New synthetic media alone or in combination with either of cotton leaf decoction of carrot juice or combination of these was observed to be better for the growth of *R. areola*. The pathogen was successfully cultured with well method, inoculation of healthy leaf tissue and inoculation of conidia in broth. The method of inoculation of healthy leaf tissue was found more advantageous for isolation.

The growth pattern and mycelial dry weight of 30 isolates of *R. areola* grown on new synthetic media/ broth indicated that the isolates from the cultivars of *G. arboreum* and *G. herbaceum* were fast in growth as compared to the isolates from the varieties/hybrids of *G. hirsutum*.

The size of conidiophores of *R. areola* from freshly infected leaves of cultivars/germplasm lines of *G. herbaceum* and *G. arboreum* was comparatively smaller than the conidiophores from the varieties/ hybrids of *G. hirsutum*.

Thirteen isolates, four from the cultivars of *G. herbaceum*, six from *G. arboreum* and three from *G. hirsutum* were inoculated on 26 different cultivars belonging to four cultivated species of cotton. The isolates from *G. arboreum*, *G. herbaceum* and *G. hirsutum* were able to easily infect the cultivars/lines of these species respectively. However, the lines of *G. barbadense* were almost free to all thirteen isolates. The variability in host reaction of thirteen isolates to

26 different cultivars of four species indicate the existence of races/biotypes in *R areola*.

Twenty arbitrary primers from kit OPA were tested for their RAPD pattern by using genomic DNA from isolates of *R. areola*. Primer OPA-3 successfully amplified most of the isolates. RAPD-PCR pattern of amplification with primer OPA-3 from the isolates of *G. arboreum*, *G. herbaceum* and *G. hirsutum* gives clear indication of variation among the isolates at species level.

Fusarium oxysporum f.* sp. *vasinfectum

Thirteen cultures of *F. o.* f. sp. *vasinfectum* were isolated from different cotton growing areas of Maharashtra. Growth pattern, influence of salt concentration on growth and pigmentation of 13 isolates indicated the variability among the isolates. Pathogenic variability of these cultures was tested on susceptible cultivar G-27. The mortality varied between 30 to 100 per cent within 30 days of germination indicating the variability among the isolates.

The protocol for isolation of DNA from *F. o.* f. sp. *vasinfectum* was standardized. A PCR assay was developed for the detection of *F. o.* f. sp. *vasinfectum*. Twenty arbitrary primers OPF (Operon Technologies) were tested for RAPD pattern. Out of these, primer OPA-5 successfully amplified most of the isolates.

Coimbatore

Development of diagnostic tools for differentiation of biotypes/races of pathogens and insect pests

Insect pests: *Helicoverpa armigera*

Larvae were collected from cotton, bengal gram and pigeon pea from different locations and were reared in 12 well multicell well plates, on semi synthetic diet at 27±1°C and 75% RH. The larvae were kept for starvation for 14-18 h to avoid the interference of host DNA and used for isolation of genomic DNA of the larvae. A total number of 19 samples of DNA were isolated for subsequent PCR studies.

Morphological markers

Cornutal spine numbers varied from 9-14 in cotton and from 10-12 in pigeon pea and 12-13 in chickpea. Maximum number of individuals collected from cotton recorded a spine number of 12 followed by 11. Differentiation of cotton and non cotton strains was also attempted by measuring the weight gain after feeding for seven days with 10 day old squares of cotton cv. LRA 5166.

Pathogens

***Ramularia areola* Atk**

During 2004 - 05, heavy incidence of Grey mildew was noticed on all four cultivated *Gossypium* spp. For the first time, many germplasm lines of *G. barbadense* were found affected by this disease. However, the damage to the foliage was not to the extent as on other three cultivated species. In addition, Grey mildew like symptoms were also observed extensively on the common weed (*Euphorbia heterophylla*) found near the cotton fields.

Diagnosis through disease symptoms and morphology

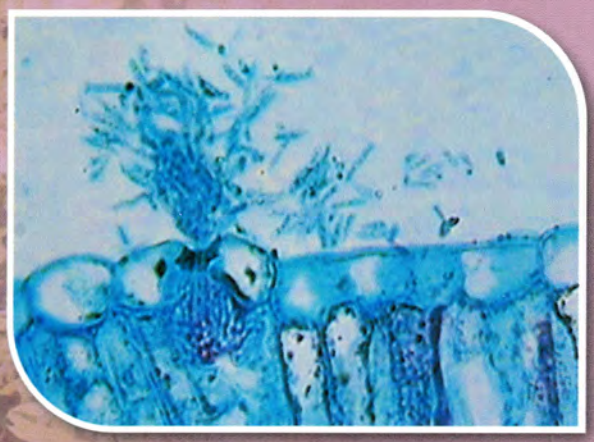
The *R. areola* isolates have been categorized into four groups based on the disease symptoms and the morphology of the fungus on the hosts.

***Arboreum and Herbaceum* isolate:** Irregular, angular/areolate spots with powdery growth appear on the under surface of the leaves with corresponding yellowish green lesions on the upper surface. In severe cases, the mildew also appears on the upper surface. The conidiophores short, emerging through epidermal layer in clusters from the sub-epidermal stroma bearing 0 – 3 septate, cylindrical/ oblong conidia singly on each conidiophore.

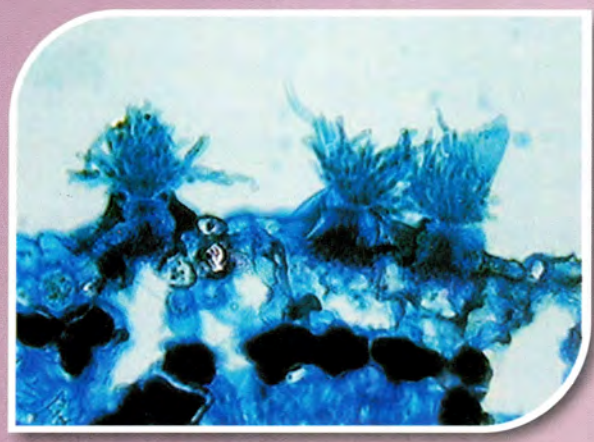
***Hirsutum* isolate:** Initially scattered greyish white powdery growth on the under surface of older leaves at the base of the plant with corresponding yellowish green spots on the upper surface. As the disease develops, the powdery growth spreads on the entire leaf and also on the upper surface. The conidiophores long, emerging through the epidermis in clusters from

Ramularia areola on different hosts

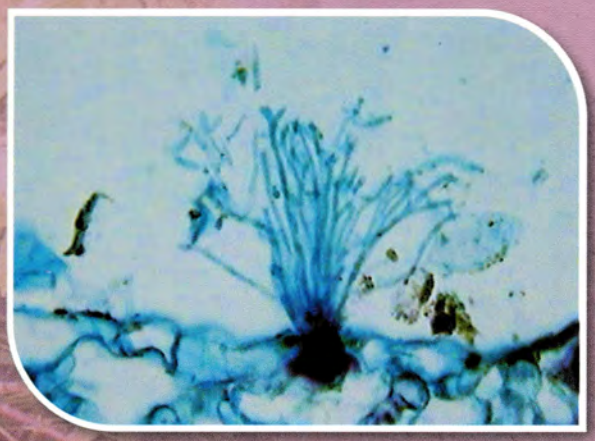
G. arboreum



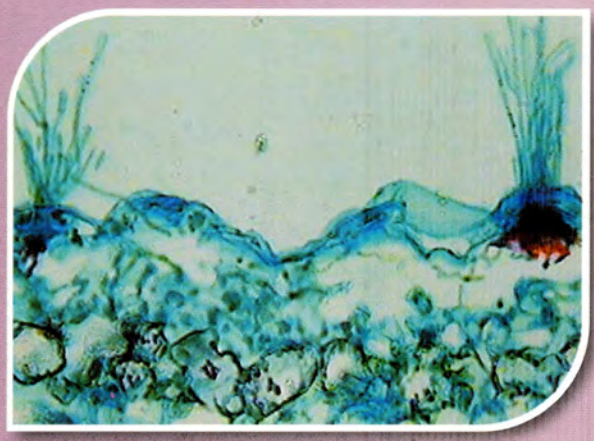
G. herbaceum



G. hirsutum

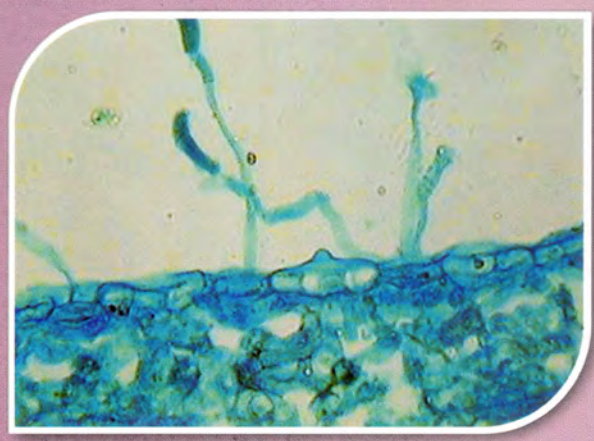


G. barbadense



E. heterophylla

E. heterophylla



a sub-epidermal stroma-bearing single 0 – 3 septate cylindrical/ oblong conidium on each conidiophore.

***Barbadense* isolate:** Scattered greyish powdery growth mainly on the under surface of the leaves with yellowish/brownish spots seen on the upper surface necrotic spots are also seen on the upper side of leaves. Hyaline long conidiophores borne singly or in bunches emerging through epidermis from a sub-epidermal stroma bearing single celled or multi-septate, cylindrical or oblong conidia singly on each conidiophore.

***Euphorbia* isolate:** Large areolate powdery spots seen on the under surface of the leaves with visible chlorotic (yellowish green discolouration) on the upper surface. Under severe disease development, powdery growth seen on the upper surface also. The conidiophores hyaline, single, long and flexuous; emerging through epidermal layer and bearing a single cylindrical, club or spear shaped conidia; the conidia are single celled.

Pathogenic variability on different hosts

Six genotypes of *G. hirsutum*, nine of *G. arboreum*, four of *G. herbaceum*, five of *G. barbadense* (identified from earlier studies) and the weed host (*E. heterophylla*) were raised in pots in polyhouse condition and inoculated with spore suspensions of *R. areola* collected from the various hosts.

The weed (*Euphorbia heterophylla*) has been identified as an alternate host for *R. areola*. The isolate from *G. barbadense* was the most virulent followed by the isolate from *G. herbaceum*. Similarly the lines LRA 5166 (*G. hirsutum*), Cernuum, Chandrolla and G. 27 (*G. arboreum*) and Jayadhar (*G. herbaceum*) and the weed host have been identified as the universal suscepts. All *G. arboreum* lines except AC 36 and *G. herbaceum* lines have been found highly susceptible to all isolates of *R. areola*. There was only hypersensitive reaction or few spots to the weed isolate on IC 629 (*G. hirsutum*), AC 36 (*G. arboreum*), GB 119 and ERB 3758 (*G. barbadense*). Similarly among the *G. barbadense* lines, GB 119 expressed hypersensitive reaction to all isolates; GB 124 resistant (no symptoms) to both *hirsutum* and *arboreum* isolates and ERB 3758 resistant to the *arboreum* isolate and hypersensitive or few spots to *hirsutum*, *herbaceum* and weed isolates. Suvin was resistant to the *arboreum* isolate.

Biochemical basis of variation

Eventhough there were minor differences among the cotton leaf constituents estimated (phenol, protein, proline and gossypol contents), these might not serve as a tool for differentiation of *R. areola* isolates. However, there were differences in the defense enzyme activities.

- The *barbadense* isolate when inoculated on the four *Gossypium* spp. exhibited higher catalase activity and low super oxide dismutase (SOD) and Ascorbic acid oxidase (AAO) activities except on LRA 5166 (*G. hirsutum*).
- The *herbaceum* isolate when inoculated showed lower catalase activity (except on Cernuum – *G. arboreum*) and very high AAO activity (except on Suvin – *G. barbadense*)
- The *hirsutum* isolate led to high SOD activity upon interaction with all hosts.
- The *arboreum* isolate had exhibited high polyphenol oxidase (PPO) activity on RAHS 14 (*G. herbaceum*) and LRA 5166 and low PPO activity on Cernuum and Suvin.

The results indicate that host defensive enzymes can be used for the differentiation of various isolates of *R. areola*.

4.22 Development of Molecular Tools

Rapid, PCR protocol was deployed for detection of CLCuV infection in *G. hirsutum* cotton, weed hosts as well as from diploid cotton grown in the vicinity of CLCuV infected *G. hirsutum*. Besides, detecting infection in plants showing typical symptoms of disease, primers also detected infection in several asymptomatic cotton by amplification of a 0.7 kb D.

Three genomes of 0.7, 1.2 and 2.7 kb were amplified and cloned. These were used to detect leaf curl virus from symptomless cotton and weed plants using dot blot method.

NA fragment.

Diploid cotton also generated some non-specific amplicons of size less than 0.7 kb. Southern hybridisation of these PCR amplicons with CP gene as DNA probe showed that the probe did not hybridise to the amplified fragments ruling out any possibility of diploid cotton serving the collateral host to the pathogen.

The conditions for expression of CLCuV coat protein in *E. coli* were standardized. Protein expression and western blotting of several recombinant clones were done to evaluate the level of coat protein expression. In an effort to further improve expression of recombinant coat protein in *E. coli*, the gene was swapped from pCaln (Stratagene) expression vector. The new vector pET 27b (Novagen) was transformed in *E.coli* and prepared for cloning the gene for expression.

Sirsa

Development of diagnostic tools for differentiation of isolates of root rot of cotton

The isolates of *R. bataticola* and *R. solani* were amplified using different OPM and OPN series primers. On the basis of dendrogram, the *R. solani* isolates were classified into four and *R. bataticola* isolates into two broad groups. The Group II was further subdivided into five sub groups. The mortality in case of group I in *R. solani* isolates was maximum and it was minimum in group IV. Groups II and III showed mortality in between group I and IV. In case of *R bataticola* isolates, no clear cut trend with respect to mortality and molecular groupings was noted (Table 12).

Table 12 : Grouping of isolates on the basis of RAPD data and pathogenicity

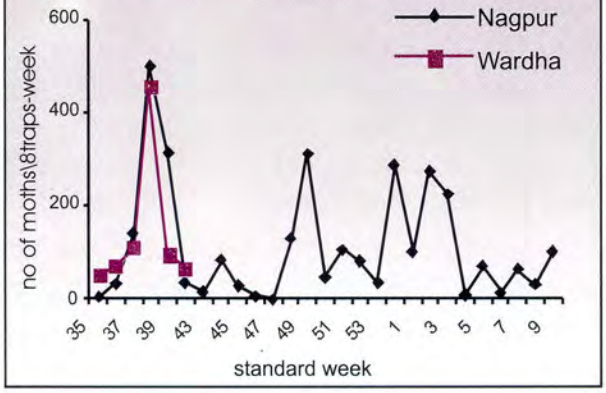
Group	*R. solani* isolates	Mortality (%)	Group	Mortality (%)	*R. bataticola* isolates
I	2, 3, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15 & 16	75.0-100.0	I	41.6	16
II	19, 20, 22 & 23	41.6-100	II IIa	25.0,58.3	1 & 11
III	17, 18 & 21	58.3-91.6	IIb	16.6-58.3	2, 3, 4, 5, 6, 7, 8, 9 & 19
IV	1, 4 & 11	15.8-75.0	IIc	16.6-75.0	10, 13, 17, 18, 20, 21, 23, 24 & 25
			IId	33.3,83.3	14 & 15
			IIe	58.3,66.6	12 & 22

4.23 Epidemiology

Analytical approaches were developed to arrive at forecast models predicting pest abundance as well as their outbreaks. During the season, the oviposition *H.armigera* on cotton occurred at 2450.5 degree/days from the calendar year. The rainy days of more than two in each of 35 & 41 standard weeks (SW) led to higher incidence of *H.armigera* in cotton ecosystem. The critical periods of weather influence were SWs 35, 41, 45 & 47 corresponding to rainy days, maximum temperature and rainfall, respectively. Higher levels of humidity (> 70%) throughout the day during August-September months, with high rainfall during the season distributed on many rainy days, and rainfall amount more than 50 mm during October resulted in outbreak of *H.armigera*. Greater than 33 °C maximum temperature, less than 70 % morning relative humidity, greater than 40 % evening relative humidity and less than 12 °C minimum temperature during standard weeks of 40, 41, 43 onwards, 48 and 49, respectively were evolved as criteria for *P. gossypiella* severity in Central zone. At South zone greater than 50 mm total rainfall during 43rd and 44th standard weeks, fall in evening relative humidity from 43rd SW with < 65% during 45th standard week would result in *P. gossypiella* severity.

The distribution of male moths that differ in their cornutal spine numbers caught in pheromone traps was studied across the season in both Nagpur and Wardha (Fig.15).

Fig. 15 : Pheromone trap catches of *H.armigera*



The 39th week, and the 3rd week comprised of *H. armigera* peaks on cotton and chickpea respectively. The 49th week corresponded to a peak on cotton overlapping with tur and it comprised of more numbers of non-cotton individuals. The 46th and 47th week did not record moth trap catches on cotton.

Coimbatore

Survey for the incidence of grey mildew and alternaria leaf spot

Severe incidence of *Alternaria* leaf spot was observed on cotton at all places in Tamil Nadu during late September and early October when there was continuous wet spell due to southwest as well as northeast monsoons. Further spread was restricted due to dry spell that prevailed after October 2004. During winter season of 2004-05, grey mildew incidence was severe at all places in Tamil Nadu as well as at Dharwad and Siruguppa in Karnataka. Earliest incidence of the disease was noticed during the first week of October, 2004.

Yield loss assessment due to *Ramularia areola*

Spore inoculum of *Ramularia areola* was applied on cotton cv. LRA 5166 in the field on 35 and 50 DAS followed by continuous spray through sprinkler to create epiphytotic conditions. The fungicide carbendazim 50 WP @ 0.1% was sprayed as per schedule at 35, 50, 65, 80 and 95 DAS depending on the treatments which reduced the grey mildew incidence and also increased the seed cotton yield to an extent of 25 % over the check (water sprayed).

Yield loss assessment due to bollworms

Sumangala followed by LRA 5166, Anjali and Surabhi recorded 8.9, 15.5, 16.3 and 44.2 per cent yield loss in varieties while Bunny followed by DCH-32 and NHH 44 recorded 6.9, 18.7 and 21.1 per cent yield loss among hybrids.

Sirsa

Epidemiological studies of cotton leaf curl virus disease

In epidemiological studies of cotton leaf curl

virus disease, ordinary runs, doublet and corrected doublet analysis was carried out for determining the pattern of CLCuV infected plants in two one acre fields selected at CICR farm and village Khairekan. The pooled data suggested mostly clustering of infected plants showing that a part of inoculum comes from outside and then the disease is spreading from plant to plant within a field.

Based on the incidence of cotton leaf curl disease (CLCuD) in different years, the data of two years i.e. years with maximum (Season 2001-Disease incidence- 98%) and minimum (Season 2004-Disease incidence- 19%) disease incidence on *G. hirsutum* variety HS-6 grown in screening nursery was compared with respect to weather parameters to pin point the role of weather factors on disease development. It was observed that higher maximum temperature (41.54°C 2004 & 36.11°C 2001), lower maximum (68.57% 2004 & 81.71% 2001) and minimum (51.00% 2004 & 61.88% 2001) relative humidities and lower rainfall (0.0 mm 2004 & 17.88 mm 2001) upto 30th meteorological week (23rd-29th July) led to lower incidence of cotton leaf curl virus disease during 2004 crop season as compared to 2001 season.

Further data on the incidence of CLCuD for six years (1999-2004) from 27th to 33rd meteorological week (MW) was regressed using step down regression procedure against six weather factors (maximum and minimum temperature, morning and evening RH, rainfall and sunshine hours) for one to three lag weeks to develop prediction equations. Based on the equations it was found that the incidence was mainly influenced by minimum temperature, evening RH and sunshine hours. It was also noted that these weather factors of two lag weeks are having maximum influence on the disease incidence, as they were represented in many of the equations. However, on 28th and 31st MW the minimum temperature and sunshine hours respectively of 3rd lag week influenced the disease incidence.

4.24 Management of Pests

Studies on the role of insecticides in cotton ecosystem

Nagpur

Testing of S1812, individually and in combination with Meothrin

S 1812 (Pyradyl) was tested in three doses, 50 g, 75 g and 100 g a.i per hectare, individually. It was also tested in combination with Meothrin (fenpropathrin) in 3 combinations (S1812 + Meothrin 50+50, 50+ 75, 75 +75 g a.i./ha). Indoxacarb, Endosulfan and Metasystox were also included as treatments at the recommended doses in the replicated experiment.

S 1812 (100 g a.i/ha was the most effective against aphids followed by S 1812 (50 g a.i/ha) and S 1812+ Meothrin (75+75 g a.i/ha), especially during the first spray. S 1812+ meothrin was on par with indoxacarb against jassids. S 1812 at the three doses tested and S 1812+ meothrin at the 3 combinations tested were effective against thrips. The least square damage was recorded in S 1812 + Meothrin (75 +75 g a.i./ha) followed by S 1812 + meothrin (50 + 75 g a.i/ha). The new molecules at the doses tested were on par with Indoxacarb against damage by bollworm both during the first and second sprays. There were no significant differences between the treatments against the whiteflies. No phytotoxic symptoms were observed at the doses tested. There were no significant differences between the yields obtained from different treatments

Testing of Servo Agrospray oil S

Servo Agrospray oil S, a product of the Indian Oil Corporation Limited is being used as foliar sprays in orchard crops. It was tested for the first time on cotton at CICR, Nagpur in the year 2004-05.

Servo Agrospray oil S was superior to control i.e. a plot wherein no chemical intervention was resorted to after the first and second spray. Servo Agrospray oil S at the lowest concentration of 0.5%

was effective against aphids and jassids, thrips especially during the first spray and was on par with the insecticidal treatment endosulfan. No square damage was recorded in the aforesaid Servo oil treatments as was observed with endosulfan. Indian Oil's Servo Agrospray oil S was effective against the sucking pest complex, especially, aphids, jassids and thrips and was found to be on par with the recommended dose of endosulfan on CNH 120MB.

Coimbatore

Efficacy of newer insecticide molecules against cotton pests and their natural enemies

Effect on fruiting body damage: Spinosad (50, 75, 100 g), NNI 0001(48, 60 g) and RIL 038 (50, 60 g) were effective in reducting the fruiting body damage during 93 to 123 DAS.

Larval incidence of Bollworms: (a) ***H. armigera***: Spinosad 45 SC all the three doses, NNI 0001 @ 48 and 60 g, KN 128 and RIL 038 @ 50 and 60 g and Spinosad 45 SC (Standard) were found effective in reducing the *H. armigera* larval incidence during 93 to 110 DAS. (b) ***Earias* spp.**: Occurrence of spotted bollworm was very low and ranged from 0.0 to 3.0 larvae per 5 plants in the various treatments. There was no significant difference among the treatments. (c) **Pink bollworm:** Pink bollworm incidence was significantly low in Spinosad at 100 g, Karate Zion @ 20 and 25 g, Karate 5 EC @ 25 g and Endosulfan @ 700 g treated plots as compared to control. The larval population ranged from 0.7 to 2.7 per 20 green bolls in the above treatments as against 6.3 in control.

Pink bollworm damage in green bolls: Spinosad @ 100 g alone was most effective in reducing green boll damage. Karate Zion 5 CS @ 25 g and Karate 5 EC @ 25 g were also effective in significantly reducing the loculi damage in green bolls.

Boll damage and seed cotton yield: There was no significant difference among the treatments in reducing the damage to bolls and loculi and seed cotton yield.

Impact on sucking pests and natural enemies: There was no much difference among the treatments in recording the sucking pests (aphids, jassids and whitefly) and predators (coccinellids and spiders). However, pyrethroid treatments Karate Zion 5 CS @ 20, 25 g and Karate 5 EC @ 25 g treatments harboured higher number of aphid population as compared to other treatments including control.

Control of Sucking Pests

Imidacloprid 350 SC 60 ml/ha, 75 ml/ha and imidacloprid 70 WG @ 40 g/ha and 35 g/ha and Clothianidin 50 WG @ 40 g/ha were sprayed on 35, 55 and 70 days after sowing. Clothianidin had the minimum incidence of 0.24 aphids per plant and remained on par with other insecticides, but superior to methyl-o-demeton and untreated check. With regard to jassid also, Clothianidin recorded the minimum incidence of 0.58 and remained on par with other insecticides and superior to methyl-o-demeton. Imidacloprid 70WG @ 30 g/ha recorded the maximum seed cotton yield of 2174 kg/ha and was superior to methyl-o-demeton and untreated check.

Carbosulfan 25 EC was tested against aphid and jassid at two dosages (1 lit/ha and 1.2 lit/ha) and compared with imidacloprid 200SL @ 100 ml/ha. Among the insecticides tested, imidacloprid recorded the minimum aphid population of 0.68/plant as compared to 6.41 in untreated check and 2.11/plant in Carbosulfan @ 1.2 lit/ha. With regard to jassid, imidacloprid 100 ml/ha recorded the minimum population of 2.33/plant as compared to 4.38 and 4.69 recorded in untreated check and carbosulfan 1.2 lit/ha, indicating the ineffectiveness of carbosulfan against jassid. There was no significant difference with regard to seed cotton yield.

Studies on bio ecology and management of cotton stem weevil *Pempherulus affinis* Faust

Evaluation of new neem products and insecticides

Three dose of Neemazal granules namely 7.5, 10 and 12.5 kgs /ha, carbofuran 33.33 kgs/ha and phorate 10 kgs/ha were evaluated against stem weevil. The treatments Phorate, carbofuran and Neemazal 12.5 kgs

/ha recorded significantly minimum percentage of incidence on par with each other and superior than the control.

Impact of organic manures

To study the impact of organic manures on the incidence of stem weevil *P. affinis*, five organic manures namely farmyard manure 12.5 t/ha, farm boon 1.25 t/ha, cell rich 1.25 t/ha, vermi-compost 1.25 t/ha and neem cake 150 kg/ha were applied twice at 30 DAS and 45 DAS. The different treatments were replicated four times in RBD design. Neem cake recorded significantly minimum percentage of incidence and on par with Farm boon.

Field trial against stem weevil at farmers' field

Two field trials were conducted against stem weevil with the variety Surabhi at Kanjapalli and Allapalayam villages of Annur block, Coimbatore Among the treatments, application of Neemcake (150 kgs/ha) + Carbofuran (1.0 kg a.i/ha) and application of neem cake (150 kgs/ha) +carbofuran (1.0 kg ai /ha), followed by stem drenching with neem seed kernel extract 5% were on par with each other and superior than the other treatments. There was no incidence of grubs when treated with above insecticides; however in control more numbers of grubs were recorded.(Table 13).

In another trial, it was seen that Carbofuran (1.0 kg a.i/ha) + chlorpyriphos (0.08%) recorded significantly minimum percentage of infestation and superior than the other treatments.

Bio Control Studies

Nagpur

Characterization of biocontrol agents

Antagonist

Soil samples were collected from cotton rhizosphere and CICR microbes were isolated by serial dilution method. Morphological and biochemical studies showed that eight out of nine microbes were the members of fluorescent *Pseudomonas* while one was identified as a strain of *Bacillus firmus*. All strains produced inhibition zone ranging between 10-50 mm in dense lawn of *Xanthomonas* grown in YGCA. The microbes were analysed for their ability to liquify gelatin and produce antimicrobial biochemicals like H_2S, levan, protease, siderophore, fluorescin and pyocyanin. Although all of them effectively inhibited the growth of *Xam*, the bacterial strains exhibited variability in their mode of antagonism. *P.fluorescens* strain CICR which caused highest inhibition of *Xam in vitro* was also the most efficient to liquify gelatin and produced highest concentrations of levan and protease but was poor in siderophore production. *Pseudomonas* strain H1a and *Bacillus firmus* strain CD1 were efficient in production of H_2S. Strains P1a, P1b and H1a efficiently produced H_2S, which was at par with CICR strain. Protease production was highest in *B. firmus* strain CD1 and *Pseudomonas* strains H1a and CICR. Strain K1a produced highest concentration of

Table 13 :Evaluation of neem cake with insecticides against stem weevil – Field trial at Farmers' fields

Treatments	Stem Weevil incidence (%)	Grubs (%)
Neem cake (150 kg/ha) + Carbofuran (1.0 kg a.i ha)	7.00 (15.15)	0.00 (2.87)
Neem cake (150 kg/ha) + Carbofuran (1.0 kg a.i ha) + NSKE 5%	8.80 (17.18)	0.00 (2.87)
Neem cake + Carbofuran (1.0 kg ai ha) + Confidor (0.04%)	17.40 (24.62)	0.00 (2.87)
Control	59.40 (50.49)	47.80 (43.74)
CD (p=0.05)	3.67	4.32

siderophore, an iron chelator while F1b and P1a produced highest concentration of fluorescin. P1a also produced highest concentration of pyocyanin.

The presence of genes governing production of DAPG was detected in strains K1a, CICR, H1a and CHAO by amplification of a 0.7 kb DNA fragment using primers conserved to phloroglucinol gene. The PCR amplified fragment was cloned. PCR and RFLP based DNA fingerprinting showed patterns unique to each strain of antagonists.

Out of 148 phylloplane rhigosphere bacterial cultures, 17 were observed to be promising inhibitors showing the inhibition zones ranging from 9-15 mm against the virulent race 18 of *Xam.*

Coimbatore

Biological control for management of grey mildew

Talc formulations of three fungal bioagents *viz., Trichoderma viride, T. harzianum* and *T. virens* and two bacterial bioagents *viz., Pseudomonas fluorescens* strains Pf1 and CHAO and combinations of the above fungal bioagents with *P. fluorescens* Pf1 strain and the standard fungicide propiconazole were sprayed four times in the field at 10 and 15 days intervals following the appearance of grey mildew on cv. Sumangala. The fungicide propiconazole (6.04 PDI) gave the best control. However, spraying of talc preparations of *Trichoderma harzianum* (26.39 PDI) and *Pseudomonas fluorescens* CHAO (27.42 PDI) at 10 day intervals greatly reduced the grey mildew incidence, when compared to the check (41.16 PDI).

Entomopathogenic nematodes (EPN)

Nagpur

Modification of media for *Metarhizium* and *Nomurea* culture.

Protocol was standardized using soaked grains of rice and jowar fortified with 1% yeast granules for development of *N. rileyi* mycelia and sporulation and metarhizium.

Results indicated that sufficient variability exists in temperature tolerance of different EPNs. Isolates of EPN from hot cotton growing areas were better adapted to higher temperature regimes whereas those isolated from comparatively cooler areas were better suited for lower temperature regimes. *S.glaseri* was better adapted for searching the host. The isolates, which showed better vertical host finding ability, were also better at horizontal host searching ability.

Induction of tolerance to high temperature and moisture stress in EPNs

The results indicated that HI5 isolate of *H.indica* was more amenable to selection for all *viz.*, the three attributes temperature stress, moisture stress and host finding ability recording maximum percent increase in tolerance for these factors. One isolate of indica isolated from cotton field of CICR, Nagpur could be made to tolerate high temperatures. Besides *H. armigera*, this isolate was found to be effective against other cotton insect pests.

Two Photorhabdus isolates symbiont of Entomopathogenic nematode which were earlier recorded to be antagonistic towards sucking insect pests of cotton, were tested in preliminary field trials at Sirsa, Nagpur and Nanded for control of sucking pests of cotton. During preliminary laboratory work, the bacterial symbiont Photorhabdus sp. broth when sprayed was found to cause mortality of nymphs of sucking pests, *Aphis gossypii, Amrasca devastans, Bemisia tabaci* and *Thrips tabaci*. Field studies indicated that spray of *Photorhabdus* sp. broth as well as toxin extracted is effective against sucking pests. Repeating the spray after three days was found to substantially further enhance mortality of sucking pests.

An experiment set up to evaluate parameters influencing storage viability of *H.indica* isolates and evaluate anti-desiccants to see if they can enhance viability of EPN under storage conditions, indicated that *H.indica* having origin from hot dry cotton ecosystem store better at higher temperature of 28°C. Of the various anti-desiccants tested, A.V.gel at 1 and 10% was found to enhance storage viability.

Integrated Pest Management

Nagpur

Implementation of two pest management approaches viz., IPM with biocontrol options including ETL based insecticidal sprays and need based chemical sprays were undertaken in the farmers fields in addition to IPM on Bt cotton. The differences for incidence of sucking pests, bollworms, native predators and bollworm damage between IPM and NBC farms were non significant. Sucking insects had increased pest status on Bt-cotton. The IPM practices had higher CB ratio over NBC in all the three villages.

Field experiment was conducted to quantify the efficacy of individual components of IPM at research station using cotton cultivar NHH 44. Based on crop phenology and seasonal occurrence of insect pests in relation to pest management options the scheme of measures ideal under rainfed IPM system are: avoidance of prophylactic measure of seed treatment, early season sucking pest management fully based on host plant resistance, avoidance of insecticidal application during the first peak of *H. armigera* occurring on first flush when more than 90 % of fruiting structures are squares, use of boll damage based ETLs, *Trichogramma* release coinciding with second peak of *H. armigera* oviposition alone, focusing bollworm management during October to November months and proper selection of insecticide considering the gain threshold. Rainfed cotton IPM proved to be cost effective and profitable with focus on conservation of native natural enemies and strict adherence to judicious application of insecticides.

Coimbatore

Integrated pest management (IPM) at village level to produce cost effective quality fibre

The success of the location specific IPM developed at this centre has been evaluated in five villages in Annur block of Coimbatore District. Encouraging results were obtained in terms of reduction in the quantity of insecticides applied from 2607 to 1086 g a.i./ ha, savings on plant protection cost by Rs. 688/ha and increase in yield by 350 kg/ ha. Efficient pest management including resistant pest *H. armigera* led to higher income of Rs.9003/ha to the project farmers as against Rs. 2482/ha to the control farmers (Fig.16).

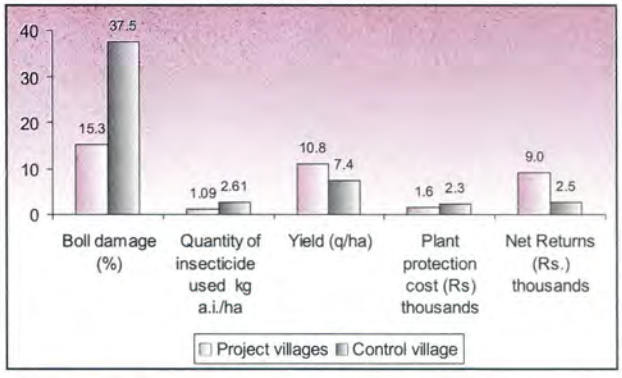


Fig. 16 : Economics and other attributes in IPM and Control Villages (2004-05)

Sirsa

The village Rangri in Sirsa district was selected for demonstrating and refining the following IPM tool kits.

- Farm yard manure application was done in the preceeding wheat crop. Emphasis was made to reduce the synthetic fertilizers.
- Emphasis was given for the selection of released varieties / hybrids.
- Bird perches were erected @ 3-5 sticks / acre.
- The pheromone traps for American, spotted and pink bollworms were installed.
- Sprays of NSKE 5 % and neem oil 1% in alternation with synthetic insecticides to scare away bollworm adults.
- Besides, the insecticides such as profenophos, and spinosad were sprayed. In general the total number of insecticidal sprays amounted to two in IPM fields

Among all the entries the maximum yield of 30.8 q / ha was noted in *desi* cotton in IPM plot followed by 29.73 q/ha in hybrids and 27.30 q/ha in American

cotton. In *desi*, the cost : benefit ratio was more in IPM (1 : 3.61) than non IPM (1 : 2.65). The C : B ratio of 1 : 3.60 was obtained in IPM plots of American cotton followed by 1 : 3.42 in the hybrids IPM. The increase in C : B ratio was mainly obtained because of 14.28 % reduction in spray and that too 4 out of 6 sprays consisted of low cost neem products.

The yield in RCH 134 Bt was 33 % more than its non Bt counterpart, and in MRC 6301 and 6304 it was 17 and 7 % respectively than non Bt LHH 144. However, the yield was slightly less in RCH 317 Bt cotton than its counterpart, which may be because of poor plant stand in this Bt cotton plot. The cost : benefit ratio in Bt cotton ranged from 1 : 3.52 to 1:2.11 and in non Bt it was from 1 : 2.64 to 2.08.

Insecticide Resistance Management

Nagpur

Dissemination of Insecticide Resistance Management programme

The IRM strategies were implemented in an area of 59,233 ha in fields of 20,525 farmers of 444 villages in 30 districts of 10 cotton growing states.

Studies on toxicity of Bt (*cry*) toxins to cotton pests, assessment of impact of Bt transgenic cotton plants on the ecosystem and development of resistance to Bt toxins in cotton bollworm *Helicoverpa armigera.*

Monitoring resistance in *H. armigera* to *cry*1Ac

Field populations of the cotton bollworm *Helicoverpa armigera* were collected from 22 locations. Log dose probit assays with *cry*1Ac showed that there has been a slight shift in the baseline toxicity values in Vadodara and Surendranagar of Gujarat and Abohar district of Punjab.

A novel bioassay on *H. armigera* utilizing Bt-cotton seed

A simple bioassay on *Helicoverpa armigera*, utilizing Bt-cotton seed as a source of *cry*1Ac toxin is described. The *cry*1Ac content in seeds was found to be 1.77 + 0.23 µg/g and the variability between individual seeds and seed lots was minimal. Bioassays on *H. armigera* using Bt-seeds stored at room temperature for two years showed that there was no significant reduction in bioactivity of the toxin present in the seeds. A discrimination dose assay utilizing 160 g Bt seeds in 1.3 L diet is proposed for detection and monitoring of *H. armigera* resistance to *cry*1Ac based Bt-cotton.

Inheritance of *H. armigera* resistance to *cry*1Ac

The mode of inheritance of the cotton bollworm, *Helicoverpa armigera* (Hübner) resistance to *cry*1Ac toxin of *Bacillus thuringiensis*, was elucidated through bioassay analysis of the response of resistant, susceptible, F_1 hybrid and backcross *H. armigera* progeny to *cry*1Ac in semisynthetic diet and transgenic Bt-cotton plants. The values of estimates of dominance were found to range between 0.40 – 0.57. Resistance was found to be monogenic, autosomal and inherited as a semi-dominant trait. The genetic studies of response of *H. armigera* to transgenic Bt-cotton showed that the effective dominance was also inherited as a semi-dominant trait.

Development of a SCAR marker to detect the frequency of *cry*1Ac resistant alleles in field populations of *Helicoverpa armigera*

A Cry1Ac near-isogenic *H. armigera* line was developed and subjected to RAPD analysis using recurrent parent as control. A total of 120 primers were used. Nine primers were found to clearly distinguish the isogenic line from the parent strain. The primers were tested with resistant individuals of *cry*1Ac resistant and susceptible populations. Four bands, which co-segregated with resistance were isolated, cloned and sequenced. Based on the unique sequences obtained four pairs of SCAR markers were designed. The markers are being validated with field populations.

Estimation of *cry*1Ac and its toxicity to *H. armigera* in Bt-cotton

The survival of *H. armigera* was correlated to the variable expression of *cry*1Ac in leaves and other

fruiting structures. Increasing levels of *H. armigera* survival were correlated with the toxin levels decreasing below 1.8 µg/g in the plant parts. Genotype independent seasonal decline of the *cry*1Ac toxin levels was observed in all the hybrids. *cry*1Ac expression decreased consistently as the plant aged. The choice of parental background appeared to be crucial for sustainable expression of the *cry*1Ac transgene.

*cry*1Ac Resistant allele frequency in *H. armigera*

The initial frequency of resistant alleles was estimated using an F_2 screen test on 180,195 and 210 isofemale lines of *H. armigera* collected from north, central and southern parts of the country. A Bayesian analysis of the data indicated the respective frequency of resistance alleles as 0.0023, 0.0025 and 0.0013 with 95% probability, and a detection probability of >80%.

Coimbatore

Dissemination of IRM strategies in Coimbatore and Theni Districts of Tamil Nadu

Through farmers participatory approach, IRM strategy was successfully disseminated in 16 villages in Avinashi block of Coimbatore District. The project covered 448 farmers and an area of 385 ha. The pest damage, number of sprays and cost on plant protection was reduced substantially in the project villages as compared to control villages. Further, seed cotton yield increased by 22.9 per cent over control villages. The project farmers obtained higher net return of Rs. 8289 / ha (Figure 17) over control farmers (Rs. 1117 / ha).

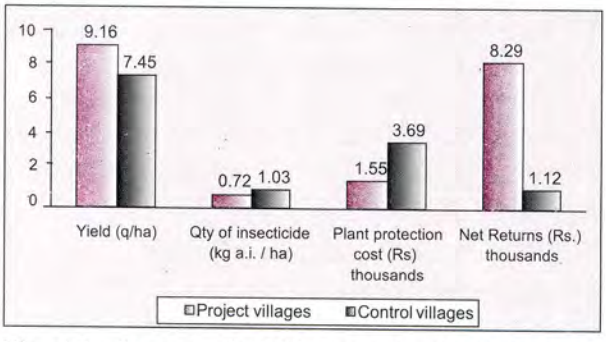


Fig. 17 : Impact of IRM Strategies in Coimbatore District (2004-05)

Discriminating dose bio-assay tests were carried out for assessing the resistance levels to different insecticides viz., synthetic pyrethroids (fenvalerate), organophosphorus compound (quinalphos) and cyclodine compound (endosulfan). The resistance levels were very high to fenvalerate (82.88), moderate level to endosulfan (40.59 %) and low level to quinalphos (21.57 %) (Table 14).

Table 14 : Resistance level of *H. armigera* to different insecticides (2004-05)

Insecticide	Dose (µg /µl)	Percent survival + standard error
Quinalphos	0.75	21.57 ± 4.09
Endosulfan	10.0	40.59±4.91
Fenvalerate	0.2	82.88±3.59

Sirsa

Basic studies on insecticide resistance

The insecticide resistance in general was slightly low in *Helicoverpa armigera* collected from IRM villages than non-IRM villages for all the six insecticide doses tested. The maximum resistance of 81.14% was observed for cypermethrin 0.1µg/µl in non-IRM villages compared to 77.64% in IRM villages, however at higher doses of cypermethrin (1.0 µg/µl) also the resistance was more in both non-IRM (70.39%)and IRM (65.88%). This was followed by methomyl 1.2 µg/µl (55.0 and 57.1% in IRM and Non-IRM villages respectively). The resistance was very low (18.18 and 20.13%) against endosulfan 10.0 µg/µl in IRM and non-IRM villages respectively. The resistance against organophosphate insecticide (Chlorpyriphos and Quinalphos) was ranging from 25 to 30 % in Sirsa district. In Hisar and Fatehabad districts also the same trend of insecticide resistance was observed in both the doses of cypermethrin. However the resistance was low in methomyl (20.83 to 34.66%) compared to Sirsa. In Hisar the resistance

to organophosphate insecticide such as Chlorpyriphos (50.66 and 52.00%) and Quinalphos (38.66 and 42.66%) in IRM and non-IRM villages respectively was more than Sirsa district. In Fatehabad the resistance against endosulfan (33.33 and 41.67%) was more than methomyl (20.83 and 26.67%), Chlorpyriphos (10.00 and 13.33%) and Quinalphos (33.33 and 40.00%) in IRM and non-IRM villages respectively.

Based on three years data of implementation of IRM strategies in Haryana, 32.80 to 47.98% reduction in number of sprays was achieved in IRM villages. The number of sprays in IRM villages was 4.39 to 5.10 as compared to 7.64 to 8.44 sprays in non IRM villages. Accordingly the cost of plant protection ranged between Rs. 1944 to 2686 in IRM villages as compared to that of Rs. 4420 to 4906 in non IRM villages.The average seed cotton yield ranged from 17.25 to 21.65 q / ha in IRM villages compared to that of 16.43 to 19.84 q / ha in non-IRM villages. The percent increase in yield ranged from 4.75 to 8.36 percent over non-IRM villages. This has led to increase in B:C ratio (1:2.93-4.14 in IRM village then 1:2.39-3.14 in non –IRM village) which subsequently yielded Rs.3760.0 to 6073.20 more net profit in IRM villages over non-IRM villages in the districts of Sirsa, Fatehabad and Hisar in Haryana.

5 Technology Assessed and Transferred

5.1 Balanced fertilization of cotton + pigeonpea strip cropping

On-farm trials were conducted to assess the impact of balanced fertilization on the cotton + pigeonpea strip cropping.

Significant yield increases of seed cotton and pigeonpea were recorded in the intervention plots compared to the farmers' practice. With recommended dose of fertilizers, seed cotton yield increased by 246 kg ha^{-1} over the farmers' practice. An increase of 145 kg ha^{-1} of pigeonpea was recorded with recommended NP. Presently farmers do not fertilize the pigeonpea crop.

5.2 Demonstration of resistant /tolerant hybrids i.e. CSHH 198 and CISAA 2

Intra *hirsutum* high fibre quality hybrid (CSHH 198 (Shresth)

CICR, Regional Station, Sirsa has developed and released an intra *hirsutum* hybrid CSHH 198 *(Shresth)* in 2004 for the entire North Zone. The hybrid possesses medium maturity of 162 days and fits well in cotton – wheat rotation of the zone. This superior medium staple hybrid has high fibre strength of 23.5 g / tex and can spin on 50s counts. Yield potential of CSHH 198 has been obtained 32 quintals per hectare which is 20% higher than LHH 144. Its lint yield has been recorded as 21% and 15.8% increase over zonal checks, LH 144 and Om Shankar respectively. The hybrid developed by the station is leaf curl resistant and tolerant to bollworms and jassids.

GMS based *desi* cotton hybrid CISAA 2

Another hybrid developed and released by this station in 2004 is a first ever GMS based *desi* hybrid CISAA 2 for the entire North Zone. This is an early maturing hybrid (160-170 days) suitable for cotton – wheat rotation of the zone. In the zonal performance this hybrid recorded up to 18.85% increase in yield over the ruling check hybrid (AAH 1). The zonal mean increase in yield more than 4 quintals/ha was recorded over existing predominant hybrid in AICCIP trials and more than 6 quintals/ha in station agronomic trials. It is moderately resistant to Fusarium wilt and at par in fibre quality properties with AAH 1. Being GMS based hybrid it has low seed production cost and therefore has a potential for wide spread among farmers.

5.3 Impact of the Technology

Farmers were convinced about the IPM, IRM and conventional hybrid seed production interventions. Moreover they also realized the benefit to delay first spray and use Endosulfan as first spray. The participatory farmers also reduced the use of pyrethroids and the earlier trend in the area of tank mixing synthetic pyrethroids in each spray was broken. All the IPM farmers and their community were influenced by the IPM techniques like Pheromone trap, Trichocard, NPV, Neem Seed Kernel Extract seed treatment and resistant/tolerant varieties/hybrids. In addition, the pollution caused due to excessive spraying was also reduced.

Some of the non-participatory farmers also took interest in the interventions. The net profit gained by participatory farmers was much higher as compared to non-participatory farmers. The hybrid seed producer/project farmer decided to adopt this technology on commercial basis so, as to get superior hybrid seed, easily available with low cost.

Success story

A Front Line Demonstration was conducted in the field of Sh.Charan Jeet Singh at village Nezia Khera. He obtained 1.5 q of hybrid seed of CSHH 198 and the approximate rate of the hybrid was Rs. 700/- and the total income he received was Rs. 90,000 from one acre. Many farmers were keen to adopt this technology. Six-kisan mela/kapas divas/field day have organized for demonstration of technologies.

6 Education and Training

6.1 Training received

Nagpur

- Dr. P K Chakrabarty, Sr. Scientist attended training on "Bio-control strategies for management of plant pathogens" at Centre for Advanced Studies in Plant Pathology, Division of Plant Pathology, IARI, New Delhi on Nov.16 – Dec. 06, 2004.
- Dr. SN Rokde, Sr. Scientist (Dairying LPM) attended 21 days winter course on "Sustainable Livestock Production" at MPKV, Rahuri during Nov. 24 to Dec. 14, 2004.
- Dr. Vinita Gotmare attended training of FAO sponsored project "Establishment of information sharing mechanism for monitoring the implementation of Global Plan of Action (GPA) for conservation and sustainable utilization of Plant Genetic Resources for food and Agriculture" at NBPGR, New Delhi on 22nd Nov. 2004 and 24-25 January, 2005.
- Dr. SM Wasnik, Senior Scientist (Extension) attended 21 days winter course on "Monitoring and evaluation of extension programme" at Centre of Advanced Studies, Division of Extension Education, IARI, New Delhi during December 10-30, 2004.
- Dr.V. Santhy, Scientist (Seed Technology) attended one week training on "Statistical Techniques Useful for DUS Testing" during January, 2005 at NBPGR, New Delhi.
- Dr. Punit Mohan, Sr. Scientist attended the Regional training of FAO sponsored project on "Establishment of Global Plan of Action (GPA) for Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture", 28th Feb. to 1st March, 2005 organized by NBPGR, New Delhi at CICR, Nagpur.

Coimbatore:

- Dr. S Manickam, Scientist (SS) attended training on "Advances in Testing, Processing and By-products Utilization of Cotton" at CIRCOT, Mumbai from 30.08.2004 to 10.09.2004.
- Dr. K. Rathinavel, Sr. Scientist attended ICAR short course on, "Application of recent Methodologies on Statistics and Computers in Agriculture Research" at Sugarcan Breeding Institute from 15-24 Sept. 2004.
- Dr. AH Prakash, Sr. Scientist participated in the training on "Photosynthesis and Bio productivity" held at Plant Physiology Division, IARI, New Delhi from 02.12.2004 to 22.12.2004.
- Sh. M Sabesh, Scientist participated in the training course on "Introduction to Networking" held at NAARM, Hyderabad from 20.02.2005 to 24.02.2005.
- Dr. S Manickam. Scientist (SS) attended training programme on "National Information Sharing Mechanism of Global Plan and Action (GPA)" held at NBPGR, Hyderabad from 07.03.2005 to 08.03.2005.

6.2 Training Imparted

Training on Cotton Production Technology

Three short state level training programmes were organized on Cotton Production Technology under implementation of action plan of ICDP Mini-Mission-II of TMC. The training programmes were organized on March 18-20, March 25-27 and April 19-21, 2004. A Capsule training schedule for fourteen lectures i.e. seven for crop improvement, two for crop production and five for crop protection was prepared.

Training Course on Bt-Cotton

A short course on Bt-Cotton was organized by Cotton Research & Development Association in collaboration with CICR, at CICR, Nagpur from Aug. 30th to Sept. 4, 2004. It was inaugurated by Dr. Sharad Nimbalkar, Vice-Chancellor, Dr. PDKV, Akola. The course also focused on PCR and ELISA based detection methods of Bt cotton that were developed at CICR. Dr. CD Mayee, Commissioner of Agriculture, Govt. of India, Dr. PD Sharma and Dr. KC Jain, Assistant Director General, ICAR

distributed the certificates to the participants in the valedictory function.

Training programme on DUS testing

A National Training Programme on DUS testing in cotton with reference to the PPV & FR legislation 2001 was organized by AICCIP at CICR, Regional Station, Coimbatore from 19-25 January, 2005. The prime objective of the training programme was to make an awareness of PPV & FR Act 2001 and DUS test procedures for cotton among the cotton scientists. There were 12 participants from DUS test centres of Cotton and AICCIP Centres. It was inaugurated on January 19, 2005 with the inaugural address of Dr. TS Raveendran, Director, CPBG, TNAU and presidential address by Dr. RK Chowdhary, Officer on Special Duty, Directorate of Seed Research, IARI, New Delhi.

A Series of lectures were also organized on various aspects of PPV & FR legislation 2001, DUS test in Cotton, Perspectives of Seed Industry and National Seed Policy 2002. There were 15 resource persons for this training programme. The participants were given training manual alongwith certificate at the end of this training programme.

Training on Organic Cotton Cultivation

A Six days training was given to forty-two trainees from four different non-governmental organization of Warangal district of Andhra Pradesh on organic cotton cultivation from 28th March to 3rd April, 04. The training syllabus included scope, merits and status of organic cotton, organic way of nutrient management, non chemical method of weed control, plant protection in organic cotton, different organic preparation, implication of organic cotton cultivation, premium and export potential of organic cotton and certification procedure of organic cotton.

7 Awards and Recognitions

- Dr. KR Kranthi, Sr. scientist (Entomology) has been awarded Vasant Rao Naik Smriti Pratishsthan Sanman 2004.
- Dr. KB Hebbar, Sr. Scientist (Plant Physiology) has received best oral presentation award for the paper entitled "Effect of water logging on growth and yield of cotton: Genotypes vs environment interaction" in Crop Production category of International Symposium on " Strategies for Sustainable Cotton Production – A Global Vision" held at UAS, Dharwad from 23-25 November, 2004.
- Dr. Nandini Gokte-Narkhedkar, Sr. Scientist (Nematology) has received best poster paper award for the paper entitled "Role of nematodes in biological control of cotton insect-pests" in National Symposium on "Changing World Order-Cotton Research, Development and Policy in Context" held at ANGRAU, Hyderabad on 10-12 August, 2004.
- Dr. P Nalayani, Sr. Scientist (Agronomy) has received poster paper presentation award for her paper entitled "Isolation of Pink Pigmented Facultative Methylotrophic Bacteria (PPFMB) from phyllosphere of cotton, its compatibility with bioinoculants/bio agents and scope for cotton nutrition in crop production" at National Symposium on Changing World Order-Cotton Research, Development and Policy in Context held at ANGRAU, Hyderabad on 10-12 August, 2004.
- Dr. T Surulivelu, Principal Scientist (Entomology) has received best oral paper presentation award for his paper entitled "Temporal distribution of pink bollworm in Bt-cotton hybrids" in crop at the International Symposium on "Strategies of Sustainable Cotton Production : A Global Vision" held at UAS, Dharwad from 23-25 Nov., 2004.
- Dr. N Gopalkrishnan, Principal Scientist (Bio-Chemistry) has received best oral paper presentation award for his paper entitled "Biotechnological approaches for cotton fibre quality improvement" in crop improvement category at the International symposium on "Strategies for Sustainable Cotton Production – A Global Vision" held at UAS, Dharwad from 23-25th November 2004.
- Dr. V V Singh, Principal Scientist (Plant Breeding) has received poster paper presentation award for the paper entitled "Collection and evaluation of genetic diversity in cotton" at the National Symposium on "Changing World Order-Cotton Research, Development and Policy in Context" held at ANGRAU, Hyderabad on 10-12 August, 2004.
- Dr. S Vennila, Sr. Scientist (Entomology) has received poster paper presentation award for the paper entitled "Interaction effect of fertilizer levels and pest management methods on cotton crop phenology and bollworms damage" at the National Symposium on "Changing World Order-Cotton Research, Development and Policy in Context" held at ANGRAU, Hyderabad on 10-12 August, 2004.
- Shri M. K. Meshram, Principal Scientist (Pathology) has received poster paper presentation award for the paper entitled "Morphological, cultural, pathogenic and molecular variation in *R. areola* atk, the causal organism of grey mildew disease of cotton" at the National Symposium on "Changing World Order-Cotton Research, Development and Policy in Context" held at ANGRAU, Hyderabad on 10-12 August, 2004.

8 Linkages and Collaborations in India and abroad including externally funded projects

National

Areas of Linkages	Institution
Fibre testing and quality evaluation	CIRCOT
Multilocation testing of promising cultures	AICCIP centers
Germplasm collection and maintenance	NBPGR
Seed technological research and breeder seed production	NSP
Evaluation of advanced cultures and germplasm for resistance to soil salinity	CSSRI (RS) Anand
Evaluation of suitable plant type for mechanical harvesting	CIAE, Bhopal
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
Testing of indigenous cotton bollworms pheromones	BARC

International

Areas of Linkages	Institution
Germplasm collection, conservation and documentation	IPGRI, Rome, Italy
Sustainable control of the cotton bollworm *Helicoverpa armigera* in small scale production system	Central Cotton Research Institute, Pakistan, Narjing Agricultural University, China, Rothamstead Agricultural Experimental Station, UK, Natural Resources Institute, UK

9 All India Coordinated Cotton Improvement Project

9.1 Crop Improvement

- During the year 2004-05, two hybrids *viz*., CSHH 198 (intra-*hirsutum* hybrid) and CISAA 2 (intra-*arboreum* hybrid) have been identified for commercial cultivation in North zone.
- Two intra-*hirsutum* hybrids *viz*., Navkar 5 (for North Zone) and Ajeet 90-2 (for Central Zone) and one intra-*arboreum* hybrid *viz*., NACH 6 (for both Central and South Zone) have been identified for release.
- In total, 39 breeding trials (both national and zonal) were conducted during the current year at 376 locations.
- The conventional hybrids were superior to the male sterile based hybrids during the past several years of testing.
- Six Bt hybrids were tested in north and south zones, whereas in central zone eight hybrids were evaluated. Based on the performance of these hybrids, the GEAC recommended the following hybrids for commercial cultivation :

North Zone MRC 6301 Bt, MRC 6304 Bt, RCH 134 Bt, RCH 317 Bt, Ankur 651 Bt, Ankur 2534 Bt

Central Zone MRC 6301 Bt, RCH 118 Bt, RCH 138 Bt, RCH 144 Bt, Ankur 651 Bt, Ankur 09 Bt, Bunny Bt, Mallika Bt

South Zone MRC 6918 Bt, MRC 6322 Bt, RCH 20 Bt, RCH 368 Bt, Bunny Bt, Mallika Bt

9.2 Crop Production

- At Sriganganagar, conventional practice adopted by farmers gave significantly higher seed cotton yield (2424 kg/ha) followed by combined application of pendimethalin @ 1.5 or 1 kg a.i./ha along with one hoeing at 35 DAS was recorded over that of control.
- At Hisar, *hirsutum* variety H 1242 gave significantly higher seed cotton yield over H 1236 with 80 kg N/ha.
- In Integrated nutrient management, 50% recommended dose of NPK + 10 t FYM + foliar spray of nutrients gave significantly higher seed cotton yield at Ludhiana, Faridkot, Nanded and Junagadh. Application of RD of NPK + 5 to 10 t FYM/ha seems to be better at Kanpur, Khandwa, Rahuri, Indore, Akola, Bhawanipatna, Lam, Nandyal, Coimbatore and Srivilliputhur and 50 % RDF + sun hemp *in-situ* incorporation + foliar spray of 2% DAP or urea were found optimum in sustaining higher cotton productivity at Dharwad.
- At Indore, foliar nutrition gave significantly higher seed cotton yield over control to the tune of 15 to 25% over control. The net income was found more remunerative (Rs. 10864/ha) against control (Rs. 8523/ha).
- At Lam use of organics only FYM, crop residue and *in-situ* green manuring alone or in combination does not substitute the use of 100% chemical fertilizers. However, among the organic combinations the FYM @ 5 t/ha + crop residues @ 2.5 t/ha + IGM of sun hemp followed by crop residue @ 2.5 t/ha + IGM and FYM alone were found superior over the rest combination. FYM + vermicompost at Nandyal and FYM @ 10 t/ha has produced significantly higher seed cotton yield at Dharwad.
- Split application of N and K produced significantly higher seed cotton yield as compared to other treatments, further among the time of application of nutrients at basal 25%, 30 DAS (50%) and 60 DAS (25%) produced significantly higher seed cotton yield as compared to rest of the top dressing at Siruguppa.
- Studies on the effect of macro and micronutrients on cotton revealed that application of recommended NPK dose is useful at various locations of North zone although soil application of sulphur at Kanpur and Zn application at Sriganganagar were beneficial for higher yield realization.
- Integrated nutrient management in cotton under cotton-chickpea crop sequence at Rahuri shows

that maximum seed cotton yield, maximum net monetary returns Rs. 15668 /ha and highest B:C ratio 1.59 was recorded with FYM @ 5 t/ha + GM of *dhaincha in-situ* + Azotobacter + Azospirillum + PSB (seed treatment) closely followed by FYM @ 5 t/ha + GM *dhaincha in-situ*.

- Intercropping of oil seeds in cotton shows that intercropping of sunflower in cotton with 2:1 or 3:1 ratio increases the net returns under assured rainfall condition of Dharwad whereas cotton + Sesame (3:1 ratio) produced significantly higher total yield than other intercropping system at Siruguppa.
- Cotton + clusterbean 1:1 ratio fertilized with 125% of RDF produced maximum seed cotton yield and also benefit cost ratio at Rahuri.
- Foliar application of 0.5% KNO_3 after 25 days of last rainfall increased seed cotton yield by 20% or more at Surat and Parbhani whereas foliar spray $CaCl_2$ and KCL resulted in increased seed cotton yield under rainfed condition of Dharwad compared to other osmoprotectants used.
- Screening for water stress tolerance indicated that nine genotypes gave significantly higher yield than national check LRA-5166, Indam-178, GK-147, L-761 and 761 were high yielding under stress as well as at par compared to respective irrigated control at Surat.
- GJHV-370, L-761 and Pusa 9217 genotypes registered higher growth rate/LAI accompanied by greater biomass and/or HI and the yield at Surat.
- *Arboreum* hybrid RAJDH 9 should be planted as 67.5 x 60 cm spacing with 40 kg P_2O_5 at Sriganganagar.

9.3 Crop Protection

Entomology

- Jassid population was above ETL level from 1st week of August to 1st week of October and Whitefly was at low level in north zone except Sriganganagar where it was above ETL level from 3rd week of August to 1st week of October. In the Central Zone, Jassid population was above ETL in August-September months in Akola, during November in Bhawanipatna and low to moderate level in rest of the regions. Whitefly was below ETL in all the centers. In Southern region, Jassid population was above ETL level from mid September to early November in Dharwad and during the first 3 weeks of October in Lam, Guntur, while it was low to moderate level in Raichur and Coimbatore. Thrips and whitefly were at low level in all the centers of south zone.
- All the three bollworms were at low level in all the centers except in IARI, New Delhi where Pink bollworm was at higher level from 1st week of September to 1st week of November. Pink bollworm was at very high level in Akola (up to 2.86/boll), Surat (12 to 16/20 plants) and Khandwa from November to mid-January. At Hisar, incidence of *Spodoptera litura* was high during October. American bollworm was at moderate level in all the centres. However, it crossed ETL in September at Akola. *Earias* bollworm peak was observed in November at Akola and Surat, and in September at Khandwa. Moderate to high level of American bollworm incidence was observed from late August to mid-November at Dharwad, from September to December in Raichur, from mid October to mid December in Lam and from late October to mid December in Coimbatore. *Earias* bollworm was at moderate level in Coimbatore and Raichur during November and December months. Pink bollworm was at higher level almost in all the centres from November to January. It was 11.5 to 43.5 per 20 bolls in Dharwad, 5 to 10/5 plants in Coimbatore, 0.9 to 2.0 per boll in Raichur and 0.3 to 1.6 per boll in Lam.
- Polo 50 SC (diafenthiuron) and clothianidin 50 WDG were found effective in reducing the

whitefly population. Foliar application of Confidor 350 SC, Confidor 70 WG and clothianidin 50 WDG were found effective against jassid, whitefly, and aphid.

- Spinosad (75 &100 g), NNI 0001, E 237, KN 128, RIL 038 and Karate Zion 5 CS were found effective against bollworm complex in all the centres except Khandwa, Nagpur and Nandyal where Spinosad alone was effective.
- IPM modules were tested with Bt. hybrid, conventional hybrid and open pollinated varieties in all the centers and were found effective in reducing the pest infestation and in increasing the seed cotton yield.
- Many cultures tolerant to jassid and moderately tolerant to bollworms were identified.

Plant Pathology

- Cotton leaf curl disease recorded a maximum incidence of 90.0% in Sriganganagar area and to a less extent in Faridkot.
- The losses in seed cotton yield due to CLCuV infection at 2-4 grades ranged between 35 to 54 per cent. Similarly, early onset of the disease at 45 DAS caused 59-65 per cent loss in susceptible genotypes.
- Several H x H hybrids and *G. hirsutum* lines showing resistance to CLCuD (grade 0 and 1) have been identified through field screening.
- Grey mildew followed by Alternaria leaf spot and Bacterial blight were the major diseases of central and south zones.
- The Pune centre has identified 16 *G. herbaceum* lines received from different centres of Gujarat having resistance to Fusarium wilt.
- Use of dust formulations of *Pseudomonas fluorescens* Pf-1 and CHAO strains as seed treatment @ 10 g/kg seed followed by foliar spray @ 0.2% at 30, 60 and 90 DAS gave good control of Alternaria leaf spot, Grey mildew and Bacterial blight diseases in Central and South zones.
- The per cent incidence of foliar diseases namely Grey mildew, Alternaria leaf spot and Bacterial blight were almost identical on both Bt and Non-Bt cotton hybrids in the Central and South zone trials.

9.4 Front Line Demonstrations

During the year, six centres each in North and Central zones and three in South zone conducted 855 Front Line Demonstrations. The major technologies demonstrated include popularization of varieties / hybrids, Integrated crop management practices incorporating IPM technology under irrigated and rainfed conditions. Introduction of long linted *arboreum* cotton such as Jawahar Tapti from Khandwa (Madhya Pradesh) and Parbhani Turab (PA 255) from Parbhani (Maharashtra) to southern dryland districts of Tamil Nadu were some of the important technologies accepted by the farmers. These varieties produced long staple, good quality cotton and the farmers got the same price as *G. hirsutum* varieties and hybrids. The average yield of cotton under Front Line Demonstrations was 521 kg/ha as compared to the National mean yield of 438 kg/ha.

10 Krishi Vigyan Kendra

10.1 Training Achievements

Eighty four short duration (1 to 3 days) training courses were conducted for 2694 practicing farmers, 689 rural youths and 135 extension functionaries:

Discipline	No. of courses	No of participants Total			
		Practicing farmers	Rural youths	Extension functionaries	
Agronomy	6	701	19	-	720
Horticulture	20	527	178	28	733
Veterinary Science	21	639	171	40	850
Extension	15	633	128	61	822
Home Science	10	149	82	-	231
Plant Protection	12	45	111	6	162
Total	**84**	**2694**	**689**	**135**	**3518**

Similarly, 33 sponsored training courses were organized in different disciplines like horticulture, plant protection, veterinary science, home science and extension deputed by State Agriculture Department, Cotton Corporation of India, Maharashtra Centre for Entrepreneurship Development, Nagpur. In all 2237 participants attended the course.

Discipline	No. of courses	No. of participants	No. of SC/ST	Sponsoring Agency
Horticulture	5	292	68	State Agril. Dept.
Veterinary Science	5	170	25	MCED & State Agril. Dept
Extension	8	810	249	State Agril. Dept.
*Home Science	5	381	137	State Agrl. Dept & LAP & SRP College Nagpur
Plant Protection	10	584	99	CCI & State Agril. Dept
Total	**33**	**2237**	**578**	

* One vocational training course on "Women participation in diversified agriculture" for four weeks duration was organized for P.G. students of Home Science Extension of LAD and Smt. R.P College of Home Science and Home Science Technology, Nagpur and 19 P.G. Home Science Extension students attended the course.

10.2 Front Line Demonstrations

Front line demonstrations (FLD's) on soybean variety TAMS-38, Pigeon pea variety AKT-8811 and chickpea variety ICCV-2 in *kharif* were conducted including 25, 13 and 13 farm families respectively with 0.4 ha area each. An average increase of 31.83%, 27.64% and 15.5% in yield of soybean, pigeon pea and chick pea was recorded respectively.

FLD on cotton PKV-Hy 4 on 4.0 ha irrigated area was conducted on fields of ten farm families in Wakeshwar and Waranga villages. An average increase in yield to the tune of 42.1% was recorded.

10.3 On Campus Crop Demonstrations

Fifty-crop demonstrations on cotton, pigeon-pea fodder crop lucerne, vegetables, fruits and flowers were undertaken. The production and protection technologies of these crops were demonstrated on area ranging from 0.4 to 1 ha.

10.4 Adaptive trials and client oriented trials

Six adaptive trials demonstrating innovative technologies on production and protection of chickpea vishal and livestock were undertaken on the farmers' fields by providing critical inputs.

10.5 Extension activities

Five field days were organized, in which 357 farmers' farmwomen and rural youth participated. During the year KVK has participated in two Kisan melas and eight national and State level agriculture and animal exhibitions organized by the different organizations throughout the country and displayed CICR production and protection technologies. Two camps were organized for livestock vaccination, ectoparasite control and treatment at Waranga and Wakeshwar village wherein more than 100 animals were vaccinated, treated and sprayed with ectoparasiticide. Health camp for children was also organized at KVK campus.

10.6 Farmers exposure visit

A team of KVK experts conducted an exposure visit of 13 progressive farmers of Banwadi, Kaldongari, Ghorad and Sawangi villages of Nagpur district to North India. During this visit, the farmers were exposed to experimental as well as demonstration of crops and animal units of various ICAR institutions and SAU's in North India. The team visited IARI, New Delhi, NDRI, Karnal and CIRG, Makhdoom during February 14 to 21, 2005.

10.7 Diagnostic Survey

Twenty six diagnostic surveys in adopted villages and other villages of Nagpur district were undertaken to suggest the remedies to overcome specific problems in crops, animals and mushroom production units covering more than 50 ha cropping area and 150 animals.

10.8 Santra Gyan Diwas

Santra Gyan Diwas was organized on 7.12.2004 at KVK, CICR, Nagpur in which 40 farmers participated and benefited.

10.9 Women in Agriculture Day

Women in agriculture day was celebrated on 14 December 2004 at KVK. Nineteen M.Sc. extension students and 29 lady staff of CICR participated in this programme.

10.10 Resource generation

Resource generated through the training, demonstration and sales was Rs.33723/-. In addition Rs.8000/- worth goat manure and vermi-compost was utilized in the farm.

11 General

11.1 LIST OF PUBLICATIONS

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11.2 LIST OF ON-GOING PROJECTS

11.2.1 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 cotton genetic resources of cultivated species of *Gossypium* (*G. hirsutum* & *G. arboreum*)	PI-VV Singh Asso. - Punit Mohan
2.	Genetical and anatomical studies on drought tolerance in cotton *G.hirsutum.*	PI-SB Singh Asso. - NK Perumal
3.	Conservation of wild species of *Gossypium* and introgressive hybridization for the improvement of cultivated species of cotton.	PI-Vinita Gotmare Asso.- MK Meshram, S Vennila, KB Hebbar, G. Balasubramani
4.	Breeding for high yielding and long staple genotypes of *arboreum* cotton with high fibre strength.	PI-Punit Mohan Asso. - P Singh
5.	Studies of genetic enhancement of upland cotton (*G. hirsutum*).	PI-TR Loknathan Asso. - P Singh,Vinita Gotmare, S Vennila, MK Meshram
6.	Studies on genetic base of upland cotton varieties in India.	PI-TR Loknathan
7.	Improvement of upland cotton for GOT and fibre properties through population improvement approaches.	Asso. - V Santhy, P Singh PI-VN Waghmare Asso. - P Singh, Vinita Gotmare
8.	Improvement of seed yield and quality in *G. arboreum* culture with low input management under different soil depths.	PI-RK Deshmukh Asso. - V Santhy, Punit Mohan, P Singh
9.	Assessment of seed vigour traits in cotton.	PI-V Santhy Asso. - RK Deshmukh, KB Hebbar, PR Vijayakumari
10.	Genetical studies on cotton seed with particular reference to germination and dormancy.	PI-PR Vijayakumari Asso. - P Singh, V Santhy
	Biotechnology	
11.	Evaluation of cotton germplasm through molecular techniques.	PI-AB Dongre Asso. - J Amudha,SB Nandeshwar,VV Singh
12.	Development of tissue culture protocol for use in breeding and genetic transformation.	PI-SB Nandeshwar Asso. - AB Dongre
13.	Molecular mapping of leaf curl virus resistance gene in cotton genome.	PI-J Amudha Asso. - D Monga, G Balasubramani

Crop Production

14.	Studies on the efficacy of micro-nutrients application and moisture management in improving yield and fibre quality of rainfed cotton.	PI -AR Raju Asso. - JV Singh, MRK Rao
15.	Improving the efficiency of cotton+pigeon pea strip cropping in vertisols.	PI -AR Raju
16.	Studies on long term effect of nutrient management practices on the productivity, nutrient balance and sustainability of cotton based cropping systems.	PI -JV Singh Asso. - D Blaise
17.	Tillage and crop residue effects on soil, nutrient and cotton crop behaviour.	PI -D Blaise
18.	Studies on water use efficiency of harvested rainwater, through drip irrigation in cotton.	PI -KS Bhasker Asso. - JV Singh, AR Raju
19.	Evaluation of suitable moisture management practices for rainfed cotton in shallow soil.	PI -KS Bhasker

Crop Protection

20.	Identification and characterisation of elite germplasm lines against key pests of cotton.	PI -S Kranthi Asso. - VV Singh
21.	Biochemical basis of induction of defense related proteins in cotton against the Gram pod borer *Helicoverpa armigera.*	PI -S Kranthi Asso. - SB Nandeshwar
22.	Interaction effects of cultivars, agrotechniques, insect pests and entomophages in cotton ecosystem.	PI -S Vennila
23.	Studies on multiple disease resistance in upland cotton.	PI -Sheo Raj - NK Taneja, VV Singh
24.	Studies on seed transmitted pathogenic infections and other seed microflora of cotton.	PI -PM Mukewar
25.	Studies on evolution of races of *Xanthomonas axonopodis* pv. *malvacearum* (*Xam*) and utilization of HVS in identification of resistant sources .	PI -MK Meshram Asso. - Sheo Raj
26.	Evaluation of cotton germplasm against Alternaria and Myrothecium leaf spot diseases.	PI -NK Taneja
27.	Efficacy of antagonist fungal microflora from rhizosphere of cotton, its growth and development including disease control.	PI -RC Ukey
28.	Studies on plant parasitic nematodes associated with cotton.	PI -N G-Narkhedkar
29.	Molecular basis of pathogenicity and race specificity of *Xanthomonas axonopodis* pv *malvacearu (Xam)* and characterization of its antagonists.	PI -PK Chakrabarty Asso. - MK Meshram, Sheo Raj

Plant Physiology and Biochemistry

30.	Physiological evaluation of cotton germplasm under rainfed conditions.	PI -MRK Rao Asso. - NK Perumal
31.	Physiological and biochemical studies on abiotic stress with particular reference to heat and drought in cotton.	PI -NK Perumal Asso. - M Chakrabarty
32.	Physiological and biochemical basis of salinity tolerance in cotton.	PI -KB Hebbar
33.	Physiological and Biochemical basis of waterlogging tolerance in cotton.	PI -KB Hebbar
34.	Source-sink alteration with reference to flower induction as a tool to improve physiological efficiency and productivity in cotton.	PI -KB Hebbar
35.	Assessment of gossypol content in working collection of cotton germplasm.	

Extension & Economics

36.	A study on structure of agriculture and social dynamics of cotton production	PI -HL Gajbhiye
37.	A study on technology adoption behaviour of cotton growers : Structural perspective.	PI -HL Gajbhiye
38.	Impact of cotton front-line demonstrations on technological advancement of cotton growers.	PI -SM Wasnik Asso. - HL Gajbhiye
39.	Estimation of total factor productivity in cotton.	PI -P Ramasundaram Asso. - M SabeshHL Gajbhiye
40.	Study on accessibility to mass media and information technology of potential users in cotton based production system.	PI -SM Wasnik Asso. - PR Deoghare

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41.	Development of early high yielding intra *hirsutum* hybrids	PI -KN Gururajan- S Manickam
42.	Breeding *G.hirsutum* cotton varieties with new plant types – development of medium staple varieties.	PI -KN Gururajan Asso. - S Manickam
43.	Development of extra long staple high spinning hybrids of interspecific origin with wider adaptability.	PI -KPM Dhamayanthi Asso. - S Manickam
44.	Development of high yielding and high spinning extra long staple cotton	PI -S Manickam- Asso. - KN Gururajan
45.	Maintenance and evaluation of cotton germplasm	PI -S Manickam
46.	Inter-specific and inter-racial hybridization and gene transfer in *Gossypium*	PI -KPM Dhamayanthi Asso. - S Manickam

47.	Development, maintenance and utilization of cytoplasmic and genetic male sterility for hybrid cotton seed production and fertility restoration in cotton	PI - S Manickam
48.	Studies on viability, vigour and longevity of cotton seeds.	PI - K Rathinavel Asso. - K Natarajan, P Chidambaram
49.	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	PI - CS Praharaj Asso. - TP Rajendran, K Sankarnarayanan, A Kannan
50.	Influence and secondary and micronutrients on qualitative and quantitative parameters of cotton	PI - K Sankarnarayanan
51.	Polymulch for water, weed and nutrient management in cotton based cropping system.	PI - P Nalayini Asso.-T P Rajendran, K Sankarnarayanan
52.	Studies on changes in the soil physico-chemical properties and crop productivity under various soil cover/ incorporation of *ex-situ* plant wastes on a freshly/under reclaimed sodic soil.	PI - CS Praharaj
53.	Studies on population dynamics of cotton pests and their enemies in the cotton ecosystem	PI - K Natarajan Asso. - B Dhara Jothi
54.	Studies on the host plant relationship and development of resistant /tolerant varieties to insect pests of cotton	PI - K Natarajan Asso. - T Surulivelu, S Manickam
55.	Studies on the role and effect of insecticides in cotton ecosystem	PI - T Surulivelu Asso. - K Natarajan
56.	Studies on bioecology and management of cotton stem weevil *Pempherulus affinis* Faust	PI - B Dhara Jothi Asso. - T Surulivelu
57.	Bio-ecological studies in pink bollworm	PI - B Dhara Jothi Asso. - K Natarajan
58.	Studies on the epidemiology and management of fungal foliar diseases of cotton.	PI - P Chidambaram Asso. - A Kannan KN Gururajan, N Gopalakrishnan
59.	Studies on soil borne diseases of cotton.	PI - A Kannan Asso.-KN Gururajan, N Gopalakrishnan
60.	Studies on bacterial blight of cotton.	PI - A Kannan Asso.-P Chidambaram, K N Gururajan
61.	Physiology of fibre growth and development.	PI - AH Prakash Asso.-SESA Khader, N Gopalakrishnan, VN Waghmare
62.	Identification and utilization of adaptive responses to abiotic stress in cultivated species of cotton.	PI - SESA Khader Asso. - N Gopalakrishnan, KN Gururajan

63.	Studies on the response of elevated carbon –di-oxide on physiology and productivity.	PI - SESA Khader Asso. - N Gopalakrishnan
64.	Studies on biochemical mechanisms of resistance to bollworm of cotton.	PI - N Gopalakrishnan Asso. - T Surulivelu
65.	Studies on development biochemistry of cotton pest/ disease interaction.	PI - N Gopalakrishnan Asso. - T Surulivelu, K Natarajan, P Chidambaram
66.	Present status, constraints and future strategies of cotton seed production in Tamil Nadu.	PI - Isabella Agarwal
67.	Impact assessment of IPM/IRM technology adaption by cotton farmers.	PI - Isabella Agarwal
68.	Farm level economic benefits of Bt cotton in Tamil Nadu.	PI - Isabella Agarwal
69.	Expert system on cotton pest/insect.	PI - M Sabesh, S Vennila, B Dhara Jothi
	Regional Station, Sirsa	
70.	Evaluation of parents in *Gossypium hirsutum* for heterotic potential and useful heterosis for replacement of existing cultivars under north Indian conditions.	PI - OP Tuteja
71.	Development of varieties and hybrids (MS based) of medium staple length in *Gossypium arboreum L.*	PI - SK Verma Asso. - OP Tuteja, SL Ahuja RA Meena, P Jeyakumar, D Monga
72.	Development of male sterility based hybrids of *G.hirsutum* for north India.	PI - OP Tuteja Asso. - D Monga, P Jeyakumar
73.	Development of *G.hirsutum* cultivars with high fibre strength suitable for high speed spinning.	PI - SL Ahuja Asso. - OP Tuteja, SK Verma, D Monga P Jeyakumar, VV Singh, KN Gururajan
74.	Genetic enhancement in diploid cotton	PI - SL Ahuja Asso.- SK Verma, Punit Mohan, Vinita Gotmare, TR Loknathan P Jeyakumar, D Monga
75.	Collection, conservation, evaluation and maintenance of genetic resources.	PI - RA Meena
76.	Studies on seed technological aspects of hybrids and varietal seed production in north zone.	PI - RA Meena Asso. - OP Tuteja, D Monga
77.	Evaluation and refinement of IPM module for irrigated cotton in north zone.	PI - P Jeyakumar Asso. - D Monga, SK Banerjee
78.	Studies on cotton leaf curl virus disease and development of resistant varieties and hybrids for its management.	PI - D Monga Asso. - OP Tuteja, RA Meena SK Verma, P Jeyakumar

Externally Funded Projects

79.	**CFC/ICAC :** Sustainable control of the cotton bollworm *Helicoverpa armigera* in small scale production systems.	PI - KR Kranthi Asso. - S Kranthi

DBT Projects

80.	Genetic improvement of strains of entomopathogenic nematodes for tolerance to environment and enhanced efficacy against *Helicoverpa armigera*, cotton bollworm.	PI - N G-Narkhedkar
81.	Studies on toxicity of Bt (Cry) toxins to cotton pests, assessment of impact of Bt transgenic cotton plant on the ecosystem and development of resistance to Bt toxins in cotton bollworm *Helicoverpa armigera*.	PI - KR Kranthi Asso. - S Kranthi

AP Cess Fund

82.	Identification and quantification of constraints, risks and policy impacts in cotton cultivation.	P Ramasundaram Asso. - HL Gajbhiye

Aventis Funded

83.	Studies on resistance breaking properties of Triazophos in combination with deltamethrin on pyrethroid resistant *Helicoverpa armigera*.	PI - KR Kranthi

Indofil funded

84.	Biochemical and ecological factors influencing the toxicity of Novaluron on the cotton bollworm *Helicoverpa armigera*.	PI - KR Kranthi

Mahyco Funded

85.	Monitoring for shifts in baseline susceptibility (development of tolerance/resistance) in the cotton bollworms toxin in various cotton growing regions of the country.	PI - S Kranthi Asso. - KR Kranthi

11.2.2 National Agricultural Technology Project (NATP)

I. Mission Mode

1.	CP-MM 1 : Development of hybrid crop-cotton -	PI: P Singh Co PI : SB Singh, Asso.: Vinita Gotmare, S Vennila, NK Taneja, MK Meshram,S Manickam
2.	MM3: Sustainable management of plant biodiversity-cotton.	CCPI: VV Singh
3.	MM4: Development of Bt. Transgenic for insect resistance-Cotton.	PI: AB Dongre CoPI : SB Nandeshwar G Balasubramani, KR Kranthi

II. Irrigated Agro-Ecosystem

4.	PSR 36: Adoption and refinement of cotton picker and cleaning system.	CCPI: AR Raju
5.	IVLP TAR 18: Technology assessment and refinement (TAR) of irrigated Agro Ecosystem for Coimbatore Region TN	CCPI : Isabella Agarwal

III. Rainfed Cotton Production System (RCPS)

6.	RCPS-2: Optimising nutrient supply in relation to moisture availability for enhanced productivity and stability of rainfed cotton based production system	PI: JV Singh CoPI:D Blaise
7.	RCPS-5: Rainwater conservation, harvesting and recycling/ recharging techniques for enhanced productivity of cotton based cropping system.	CCPI : KS Bhasker Asso.: AR Raju, MK Meshram, G Majumdar, SM Wasnik
8.	RCPS-7:Promotion of productive high quality *G. arboreum* cotton to meet the needs of marginal cultivators of rainfed ecosystem vis-à-vis textile industry.	CCPI: VN Waghmare
9.	RCPS-8: Characterisation and identification of productive and high quality cotton species/genotypes including *G. herbaceum* for different rainfed agro-ecological situations adopting suitable approaches through farmers participatory programmes.	CCPI: Vinita Gotmare
10.	RCPS-10: Development of Bt. transgenic diploid cotton against bollworm.	CCPI: SB Nandeshwar, AB Dongre
11.	IVLP-TAR 15: Technology assessment and refinement of rainfed cotton based production system in Nagpur district through institute village linkage programme under rainfed Agro Eco-system.	HL Gajbhiye, MK Meshram, P Ramasundaram, Gulbir Singh, SS Patil, UV Galkate

IV. Agro Ecosystem (Coastal)

12.	PSR 16: Exploitation of *G. herbaceum* cotton for improving agricultural output and economy of the coastal agro ecosystem.	N Gopalakrishnan

11.2.3 Technology Mission on Cotton (TMC)

Project No.	Title	CICR (N)	CICR (C)	CICR (S)
MM 1.1	Development of diploid cotton cultivars with high fibre quality	Punit Mohan CCPI	-	SK Verma CCPI
MM 1.2	Development of tetraploid cotton cultivars with high fibre quality and resistance to drought & biotic stresses	VN Waghmare CCPI	KN Gururajan PI	SL Ahuja CCPI
MM 1.3	Genetic diversity through introgression of useful genes in cultivated species of cotton	V Gotmare SB Nandeshwar G Balasubramani CCPIs	S Manickam CCPI	OP Tuteja CCPI
MM 1.4	Improvement of cotton seed oil	T R Loknathan PI M Chakrabarty Co-PI	N Gopala-krishanan, KPM Damayanthy CCPIs	OP Tuteja CCPI
MM 1.5	Maintenance breeding, seed production and marker based purity evaluation	TR Loknathan V Shanthy AB Dongre CCPIs	K Rathinavel CCPI	RA Meena CCPI
MM 2.1	Integrated nutrient management for high quality fibre and yield	Blaise PI	-	-
MM 2.2	Integrated water management system for quality fibre production	KS Bhaskar CCPI	K Shankarna rayan CCPI	-
MM 2.3	Bioinoculants for sustainable & cost effective production of high quality fibre	-	P Nalayini	-
MM 2.4	Refining regional-level prediction of yield	MRK Rao PI KB Hebber Co-PI	AH Prakash CCPI	-
MM 2.5	Ergonomically efficient implements for cotton production	AR Raju PI	-	-
MM 3.1	Integrated pest management (IPM) at village level for cost effective, quality production	S Vennila CCPI	T Surulivelu A Kannan CCPIs	P Jeyakumar D Monga CCPIs
MM 3.2	Development of diagnostic tools for differentiation and detection of biotypes/races of insect pests and pathogens of cotton	PK Chakrabarty PI S Kranthi MK Meshram Co-PIs	P Chidambaram B Dhara jyothi CCPIs	D Monga CCPI

MM 3.3	Commercialisation of bioagent mass-production technologies in intensive cotton districts	N Gokte Narkhedkar CCPI	-	-
MM 5.1	Evaluation of cotton production technologies for yield, fibre quality and economic viability	HL Gajbhiye PI P Ramasunderam Co-PI	Isabella Agrawal CCPI	SK Verma CCPI
MM 5.2	Information, cotton website and documentation	AR Raju CCPI	M SabeshPI	-
MM 5.3	TMC-MMI Coordination and Monitoring cell	M. Chakrabarty	-	-

(N) - nagpur (C) - Coimbatore (S) - Sirsa

11.3 CONSULTANCY, PATENTS, COMMERCIALISATION OF TECHNOLOGY

Two hybrids viz CSHH 198 and CISAA 2 developed by CICR RS, Sirsa were released and notified by Central Varietal Release Committee for commercial cultivation in the northern cotton zone.

Intra - *hirsutum* high fibre quality hybrid (CSHH 198 *Shresth*)

CICR, Regional Station, Sirsa has developed and released an intra-*hirsutum* hybrid CSHH 198 (Shresth) in 2004 for the entire North Zone. The hybrid possesses medium maturity of 162 days and fits well in cotton – wheat rotation of the zone. This superior medium staple hybrid has high fibre strength of 23.5 g / tex and can spin on 50s counts. Yield potential of CSHH 198 has been obtained 32 quintals per hectare. The hybrid developed by the station is leaf curl resistant and tolerant to bollworms and jassids.

GMS based *desi* cotton hybrid CISAA 2

Another hybrid developed and released by this station in 2004 is a first ever GMS based *desi* hybrid CISAA 2 for the entire North Zone. This is an early maturing hybrid (160-170 days) suitable for cotton – wheat rotation of the zone. In the zonal performance this hybrid recorded up to 18.85% increase in yield over the ruling check hybrid (AAH-1). It is moderately resistant to Fusarium wilt and at par in fibre quality properties with AAH-1. Being a GMS based hybrid it has low seed production cost and therefore, potential of wide spread among farmers.

Breeder seed production of the following varieties has been taken up and would be commercially sold to the seed producers as per the government of India allotment.

No	Name of Variety/ Parent of Hybrid	2004-05	
		Indent (q)	Production (q)
1.	Savita T 7	0.22	0.09
	M 12	0.01	0.12
2.	LRA 5166	0.74	1.99
3.	Surabhi	1.02	2.50
4.	MCU 5VT	1.12	1.50
5.	Anjali	0.47	1.50
6.	Supriya	1.02	1.50
7.	Sumangala	0.15	0.50
8.	LRK 516	-	0.30

11.4 SIGNIFICANT DECISIONS OF SRC, IMC MEETINGS

11.4.1 Staff Research Council (SRC)

The annual meeting of Staff Research Council was held under chairmanship of Dr. P. Singh, Director (Acting) on 3-4 June, 2004 to discuss the results of the work carried out during 2003-04 and to finalize the research programme for the year 2004-05. All Scientists of CICR, Nagpur, Project Coordinator, AICCIP and Head, CICR, Regional Station, Coimbatore and Dr. S. L. Ahuja from CICR, Regional Station, Sirsa participated in the meeting. Results of each project carried out during 2003-04 were presented by the individual Scientist and discussed. Technical plan of work for next year for each project was also discussed and finalized. Six new projects from CICR, Nagpur and one from CICR, Regional Station, Sirsa were presented and approved after discussion.

Chairman in his introductory remarks emphasized need for analyzing impact of new technologies in increasing income of farmers and awareness and gain of knowledge to farmers about such techniques. He emphasized that the constraint analysis in the implementation of technology and achievement of targets should also be indicated.

11.4.2 Institute Management Committee (IMC)

The Institute Management Committee meeting was held on 10th December, 2004 during the year 2004-05 at CICR, Regional Station, Coimbatore under the Chairmanship of Dr. P. Singh, Director (Acting). The proceedings of 43rd Institute Management Committee meeting were approved by the ICAR.

Major recommendations:

- The approved budget of Plan and Non-Plan of the current financial year and expenditure upto November 2004 was seen by the committee members and they expressed their satisfaction.
- The members expressed satisfaction on the progress of works and recommended that such review may be taken up by IMC periodically.
- The committee expressed their satisfaction and agreed for continuation of farm development work.
- The members discussed the various research programmes at length expressed satisfaction on the progress.
- The activities of KVK were also presented before the committee. The members expressed their satisfaction on the work carried out by the KVK.

11.5 WORKSHOPS/SEMINARS/ SUMMER INSTITUTES/ FARMER'S DAY ORGANIZED

11.5.1 Group discussion on Mechanization of Cotton Production

Group discussion Mechanization of cotton production was organized at CICR, Nagpur on 16 August 2004 under the TMC-Mini Mission-I programme.

Dr. Nawab Ali in his presidential address emphasized the need for low cost implements in a country like India where majority of farmers are marginal and small land holders. He cited the example of some developing countries where mechanized farming is practiced on a co-operative basis to facilitate the poor farmers to use costly implements. Dr. P. Singh, Chaired the session and presented in brief the genesis of the seminar. He mentioned that for mechanization in farming to succeed, the machines need to be of high quality and affordable.

The participants from CIAE, Bhopal, CIRCOT, Mumbai and Nagpur, CICR, Nagpur and Dr. PDKV, Akola were attended the group discussion.

Major recommendations are:

- Appropriate cotton varieties need to be developed for synchronous maturity to facilitate use of mechanical picker.
- Good designs of cleaning devices need to be developed to go with the mechanical picking.
- Testing of important design of the cotton picker undertaken at the different locations (PAU, Ludhiana, Dr. PDKV, Akola and CICR, Nagpur) under NATP should be carried out with the objective of identifying the design parameters and criteria suitable for mechanical cotton picker for Indian conditions.
- Animal drawn and tractor mounted planters, self propelled and tractor mounted weeders and air carrier sprays developed under AICRP on FIM scheme hold promise for adoption for cotton cultivation. These equipments should be taken up for their feasibility testing on cotton crop at different locations.
- Cotton stalk puller need to be redesigned, refined and commercialized.
- Cotton shredder should be developed.
- Suitable designs of tillage equipment should be developed/adopted for primary tillage in black cotton soil under dry land conditions.

11.5.2 Group discussion on Cotton Seed Oil Improvement:

Group discussion on Cottonseed Oil Improvement was organized at CICR, Nagpur on 15th Oct., 2004. Dr. PV Patil. Ex Director of Laxminarayan Institute of Technology was the chief guest. Dr. Phundan Singh, Director (Acting) CICR, Nagpur chaired the inaugural session. Dr. Patil in his address emphasized the importance of cotton byproducts in the industry. Dr. Phundan Singh in his address mentioned the importance of lint and seed in cotton industry. He also emphasized the need to improve the crushing and processing techniques, which presently limit the cottonseed oil production to 20% as against the potential of 45%. In the seminar a film prepared by NDDB, Anand, Gujarat on success story of a village named Narphede in Kaira District of Gujarat about cotton seed by product utilization was also screened.

The Group discussion was attended by the scientists from different institutes *viz.* CIRCOT,

NDRI, IARI, Cottonseed Crusher's organization and CICR, Nagpur.

Major Recommendations are:

- Improving the oil percentage of cottonseed by using high oil content germplasm lines i.e. 27% oil content.
- Improving oleic acid content of cottonseed oil and improving the fatty acid profile.
- Development of glandless cultivars with Bt gene to be prioritized.
- Increasing the kernal content compared to the hull.
- Contractual farming should be encouraged for making farmers grow specific materials especially high yielding and high oil content lines.
- Marketing of cottonseed oil should be emphasized
- Seed oil content as measured by NMR should be recorded in two different laboratories.
- There is a need to identify gene governing oil quantity and quality through molecular approach.
- Wastage of oil during hydrogenation should be minimized.
- Losses to be minimized by improving the technology of cottonseed oil extraction.
- Studies on anatomy of seed gossypol glands and precise localization of oil granules in the cottonseed.
- Emphasis should be made to improve the scientific processing of cottonseed oil resulting in a better oil recovery.

11.5.3 Group discussion on Cotton Leaf Curl Virus Disease

One day Group discussion on Cotton Leaf Curl Virus Disease: Present Status and Future Strategies for Management" was organized at CICR, Regional Station, Sirsa. The Group discussion was chaired by Dr. Phundan Singh, Director (Acting), CICR, Nagpur and Dr. Anupam Verma, National Professor, IARI, New Delhi was the Chief Guest. Fifteen lectures in two sessions (I – Molecular and Genetic Aspects of CLCuV and II - Management of CLCuV) were presented by the experts.

11.5.4 Group discussion on Genetic Improvement of Fibre Quality Traits in Cotton

Group discussion on "Genetic Improvement of Fibre Quality Traits in Cotton" was organized at CICR, Nagpur on 15 February, 2005. Dr. S. Sreenivasan, Director, CIRCOT, Mumbai was the Chief Gust.

Dr. Sreenivasan, in his inaugural address, quantified cotton production as per staple length, gaps in the quality cotton production, requirement of textile industries and future requirement of the quality cotton in view of the changing world scenario. Dr. Phundan Singh, in his address, mentioned the importance of fibre quality parameters and stressed on need to attain quality standards in cotton production.

In all, thirteen presentations covering different aspects of fibre quality improvement were made. A compilation of full length research papers contributed by eminent cotton scientists was released at the hands of Dr. Sreenivasan.

The major recommendations are

- Unutilized germplasm and wild genetic resources should be utilized to create gene pool governing fibre quality traits.
- Use of un adopted germplasm to improve the existing cultivars for fibre quality traits.
- The fibre quality standards may be upgraded in accordance with the newly fixed norms such as fibre length and strength ratio should be equivalent to one and the micronaire value should range between 3.5 to 4.5.
- Transgenics with improved fibre quality need to be developed.

- Molecular marker techniques need to be employed for mapping fibre trait QTLs. Marker Assisted Selection should be followed to bring faster improvement and facilitate conventional breeding.

11.5.5 Annual Review Workshop of TMC MM I

The Annual Review Workshop of all the PIs of TMC-MM I projects was held on June 25, 2004 at CICR, Nagpur under the Chairmanship of Dr. CD Mayee, Agriculture Commissioner, Govt. of India and Mission Director, TMC – Mini Mission I and II. Dr. Phundan Singh, Director, (Acting), CICR and Member Secretary (Acting), ICAR Standing Committee for TMC-MM I and Dr. TP Rajendran, Project Coordinator, AICCIP and Head, CICR, Regional Station, Coimbatore were the prominent dignitaries present.

Director & Member Secretary, in his introductory remarks, emphasized some major issues related to cotton research. The primary challenge is to achieve a breakthrough in cotton yield. The production figure for the year 2003-04 of 167.5 lakh bales, which indicates a significant increase of 28.5 lakh bales over the year 2002-03 in spite of a reduction in cotton area, indicating rise in productivity. He appreciated that it is quite encouraging that through Mission Mode approach, pesticide consumption in cotton has been drastically reduced from 50% to 35%. Mechanization in cotton cultivation has also been boosted up through proper modification of different implements.

The respective PI's very briefly presented the results of 2003-04 across all the cooperating centers and focussed on the outcome which can be implemented immediately.

The major findings and some implementable technologies are

- Two *G.arboreum* strains *viz*, CINA-316 from Nagpur and PA 402 from Parbhani have been proposed for 'Fast Track Release' and PA 402 has already been released by MAU, Parbhani during 2003-04 with the name 'Vinayak'. These two strains have better 2.5% span length (above 25 mm) and fibre strength (>20 g/tex).
- Culture CCH4 after multilocation testing at 5 centres in Central Zone and at 6 centers in South Zone, has been identified as superior to local and zonal checks and has been entered in AICCIP Agronomy trial for South Zone.
- DLSA-17, first introgressed derivative from *G. arboreum X G. hirsutum* has been released for cultivation in Karnataka.
- The culture CHNO12 with oil percent 21.77 and 1600 kg/ha seed cotton yield has been sponsored for AICCIP multilocation trial Br 02 (a) in 2004-05 season and another culture CHNO 3 with 26.68% seed oil and seed cotton yield on 1395 kg/ha has been entered in Br 02 (b) trial.
- A self propelled power weeder has been developed for small holding situation which results in a cost and time saving of 78% and 94% respectively over conventional manual weeding. Power tiller opeated boom sprayer has been developed to enhance efficiency of spraying, wider coverage and safety of operators.
- There was almost 50% reduction in insecticide sprays in IPM block as compared to farmers practice (FP). There was a two to four fold increase in the population of coccinellid and *Crysoperla* adults.
- A rapid and simple PCR Protocol has been developed for detection of bacterial blight of cotton caused by the pathogen *Xanthomonas axonopodis* pv. *malvacearum*.
- A new twig imprint method has been developed for detection of CLCuV infection in cotton.
- Fermented culture methodology was found suitable for mass production of *Trichoderma*.

- Commercial trial on preparation of hard board from cotton stalks showed that the process is technically feasible and good quality hard boards conforming to BIS specification can be prepared from cotton stalks.
- Planting of cotton on flat beds and opening of ridges and furrows at 1st intercultural operation has increased the productivity to the tune of 18% over farmers practice of sowing of cotton in flat beds without opening of ridges and furrows.

The Chairman Dr. CD Mayee appreciated the research efforts being attempted under TMC-MM I programme and emphasized that the results of practical importance should now be tried on a larger scale in collaboration with Mini-Mission-II for benefiting the cotton farmers.

11.5.6 5th meeting of ICAR Standing Committee for TMC MM I

The 5th meeting of ICAR Standing Committee for TMC-MM I was held on September 30, 2004 in Directorate of Maize Research, IARI campus, New Delhi, under the Chairmanship of Dr. Mangala Rai, Secretary, DARE and DG, ICAR. Distinguished members of the Standing Committee – Dr. G. Kalloo, DDG (CS), Dr. KC Jain, ADG (CC), Dr. SK Tandon, ADG (Engg.), representatives of Plant Protection Advisor, Govt. of India graced the meeting and from CICR, Nagpur, Dr. P Singh, Director and Member Secretary, ICAR Standing Committee for TMC-MM I, Dr. Sheo Raj, Head, Crop Protection Division, Dr. MRK Rao, Head Crop Production Division and M. Chakrabarty, Scientist In-charge TMC-MM I Cell participated in the meeting.

Dr. P Singh welcomed the members and briefly presented an overview of the progress under TMC-MM I programme with an emphasis on Genetic Improvement, Seed Technology and Technology Intervention aspects. Dr. MRK Rao and Dr. Sheo Raj made an elaborate presentation on Natural Resource Management, Mechanisation and Biotic Stress Management. Chairman desired that a review meeting of all the PIs should be organized and the PIs will apprise him of the progress made in the projects since inception.

Accordingly the review meeting was held on November 02, 2004 in NATP Conference Hall, KAB-II, Pusa, New Delhi. All the Principal Investigators were present in the meeting. The meeting was graced by Dr. Mangala Rai, DG, ICAR, Dr. Kalloo, DDG (CS), Dr. KC Jain, ADG (CC), Dr. SK Tandon, ADG (Engg.), Dr. Gurbachan Singh, ADG (Agronomy), Dr. S P Tiwari, ADG (Seeds), Dr. Amerika Singh, Director, NCIPM, New Delhi and Dr. TP Rajendran, PC and Head, CICR, Regional Station, Coimbatore.

Dr. P Singh, Director (Acting), CICR & Member Secretary, ICAR Standing Committee welcomed the delegates. The individual PIs presented the progress made against the targets assigned. Discussions were held and suggestions were made in some cases to achieve the targets in a more effective way. The significant findings were appreciated, but it was reiterated by DG, DDG (CS) and experts that the work done must be presented in monitorable and targeted output mode so that achievements will be easily understandable by all.

11.5.7 Rashtriya Kisan Mela

A one day Rashtriya Kisan Mela 2004 was jointly organized by four Nagpur based ICAR Institutes *viz*. CICR, NBSS & LUP, NRCC and Ginning & Training Centre, CIRCOT at NBSS & LUP on 20.12.2004. The Mela was inaugurated by Dr. CD Mayee, Chairman, Agricultural Scientists Recruitment Board, New Delhi. Dr. Mayee exhorted the farmers and Agricultural Research Institutes to gear up to face challenges posed by opening up of agriculture to international trade. He also released an extension bulletin. Dr. Phundan Singh, Director (Acting) informed that CICR has developed kits for

detecting substandard and contaminated seeds. In his presidential address, Dr. AK Sinha, Director, Remote Sensing Centre mentioned that information available through satellites be employed for Integrated Crop Management.

Dr. KS Gajbhiye, Director, NBSS & LUP and Dr. Shyam Singh, Director, NRCC also spoke on this occasion. The Mela was attended by large number of farmers.

11.5.8 IRM Mela

An IRM mela was organized by CICR, Regional Station, Sirsa at Fatehpuria village on October 18, 2004. Dr. DS Barar, Regional Director of PAU Research Station, Bhatinda was the chief guest. He congratulated the scientists and farmers of the village for achieving successful cotton production by adopting IRM strategies.

11.5.9 FLD Mela

FLD Mela on cotton stalk utilization was conducted by CICR, Regional Station, Sirsa at Jodhpuria village on November 4, 2004. Dr. Phundan Singh, Director (Acting), CICR, Nagpur was the Chief Guest. This mela was also attended by Dr. S Sreenivasan, Director, CIRCOT, Dr. TP Rajendran, PC and Head, CICR, Regional Station, Coimbatore, Dr. D Monga, Head I/c, CICR, Regional Station, Sirsa, Dr. Banwarilal, Joint Director Agriculture (Cotton) Haryana as well as scientists from CICR and CIRCOT. In this programme farmers were apprised about various products that can be developed from cotton stalk and its use for different purposes.

11.5.10 Kisan Mela under Cotton FLD programme

Kisan Mela was organized on 22 January 2005 at Tumgaon FLD village in Warora Tahsil of Chandrapur dist. Dr. P. Singh, Director (Acting), CICR presided over function. Other scientists Dr. MRK Rao, Dr. NK Perumal, Sh. MK Meshram, Dr. SM Wasnik of CICR and S Sakhare of State Agril. Dept. participated in this programme. More than 300 villagers comprising of farmers, rural youths, and farmwomen attended this mela.

Dr. CD Mayee, Commissioner of Agriculture, Govt. of India, addressing the participants

Dr. M. R. K. Rao addressing the Trainees

Dr. P. Singh, Director (Acting), CICR addressing the Farmers

11.6 PARTICIPATION OF SCIENTISTS IN SEMINARS / SYMPOSIA / WORKSHOPS

Sr. No.	Seminars/ Conferences/ Symposia/ Workshops	Place and Date	Participants
1.	Annual Group Meeting of AICCIP, 2004	MPKV, Rahuri 5-7 April, 2004	Sheo Raj, V.V. Singh, A. Kannan, P Chidambaram, T Surulivelu, KNGururajan, N Gopalakrishnan, D.Monga, S.L.Ahuja, O.P.Tuteja, S.K.Verma, P. Jeyakumar
2.	15th International Plant Protection Congress	Beijing, China, May 11-16, 2004,	Nandini Gokte-Narkhedkar
3.	Seminar on Networking and Internet Security	Coimbatore 4 August, 2004	M. Sabesh A.R.Raju,
4.	Group discussion cum workshop on "Mechanization of cotton"	Nagpur 6 Aug., 2004	S. N. Rokade, G. Majumdar, Nandini-G-Narkhedkar P Ramasundaram
5.	National Symposium on Changing World Order - Cotton Research Development and Policy in Context	Hyderabad 10-12 August, 2004	P. Singh, V.V. Singh, V.N. Waghmare, Vinita Gotmare, R.K. Deshmukh, V. Santhy, Punit Mohan, S.B. Singh, P.R. Vijayakumari,M.R.K. Rao, K.S.Bhaskar,Jagvir Singh, Blaise, Sheo Raj, M. K. Meshram, K. R. Kranthi, S.Kranthi, S.Vennila, N.Narkhedkar, D.Monga, S.L.Ahuja, R.A.Meena, O.P.Tuteja, P.Jeyakumar, A. Kannan, A. H. Prakash, K. Sanakaranarayanan, P. Nalayini, S. M. Wasnik.
6.	Inter-Regional Network on Cotton in Asia and North Africa (INCANA) meeting	Tashkent, Uzbekistan 6-8 Sept, 2004	Punit Mohan D Blaise M K Meshram
7.	Annual Workshop for KVK (Zone – V)	Jalna September 26-29, 2004	PR Deoghare, Smt. S N Chauhan
8.	International Cotton Genome Initiative Workshop – 2004	Hyderabad 10-13 October, 2004.	P. Singh, V. V. Singh, V. N. Waghmare, Vinita Gotmare, J.Amudha, G. Balasubramani, S. B. Nandeshwar, Sheo Raj, P. M. Mukewar, N. Gopalakrishnan, A. H. Prakash, S. Manickam,

9.	Group discussion on Genetic Improvement of Seed Cotton Oil	Nagpur 15 Oct, 2004	P. Singh, V. V. Singh, V. N. Waghmare, Vinita Gotmare, R. K. Deshmukh, S. M. Palve, Punit Mohan, S. B. Singh, N. Gopalakrishnan, O. P. Tuteja
10.	International Conference on Bioconvergence 2004	Patiala 18-20 November, 2004	S.L.Ahuja
11.	International Symposium on Strategies for Sustainable Cotton Production - a Global Vision	UAS Dharwad 23-25 November, 2004	P. Singh, V. V. Singh, R. K. Deshmukh, S. M. Palve, T. R. Loknathan, V. Santhy, Sheo Raj, M. K. Meshram, K. R. Kranthi, S. Kranthi, N. Gopalakrishnan, K. P. M. Dhamayanthi, S. Manickam, B. Dhara Jothi, S. E. S. A. Khader, P. Chidambaram, K. N. Gururajan, T. Surulivelu, C. S. Praharaj, K. Sankaranarayanan, P. Nalayini, D. Monga, S. L.Ahuja, M. R. K. Rao, K. S. Bhaskar, D. Blaise, KB Hebbar.
12.	Group discussion on Cotton Leaf Curl Virus Disease– Present Status and Future Strategies for its Management	Sirsa 15 December 2004	P. Singh, V.N.Waghmare, J.Amudha, D.Monga, S.L.Ahuja, R.A.Meena, O.P.Tuteja, S.K.Verma, P.Jeyakumar.
13.	Workshop on Biosafety issues related to transgenic crops with focus on Bt cotton	Nagpur 23 January, 2005	Punit Mohan, S.B. Singh
14.	International Conference on Soil, Water and Environmental Quality – Issues and Strategies	New Delhi 28 January–1 Feb. 2005	K.S.Bhaskar
15.	DBT Task Force meeting on 'Biopesticides and Crop Management'.	New Delhi 2 February, 2005	Nandini Gokte-Narkhedkar
16.	International Symposium on Plant Introduction - Achievements and Opportunities in South Asia	New Delhi 15-17 February, 2005	Punit Mohan

17.	Group discussion on Genetic Improvement of Fibre Quality Traits	Nagpur 15th February, 2005	P. Singh, V.N.Waghmare, S.B.Singh, T.R.Loknathan, S.M.Palve, R.K.Deshmukh, PR Vijayakumari, V. Santhy, Vinita Gotmare, S.B.Nandeshwar, S.B.Singh.
18.	International Conference on "Modern Trends in Plant Sciences with Special Reference to the Role of Biodiversity in Conservation"	Amravati. 17-20 February, 2005	K.S.Bhaskar Jagvir Singh, S. B. Nandeshwar.
19.	National Symposium on *Helicoverpa* Management – A National Challenge	Kanpur 27-28 February, 2005.	K.S.Bhaskar
20.	Workshop on Breeding for WUE, root traits and other related traits to mitigate drought	Bangalore 25-26, March 2005.	V.N.Waghmare

11.7 DISTINGUISHED VISITORS

Name & Designation	Organisation	Date
Nagpur		
Dr. C D Mayee Agriculture Commissioner,	Govt. of India, New Delhi	26/06/2004
Dr. Nawab Ali Director	CIAE, Bhopal	16/08/2004
Dr. Sharad Nimbalkar Vice Chancellor	Dr. PDKV, Akola	30/08/2004
Dr. C D Mayee Agriculture Commissioner,	Govt. of India, New Delhi	04/09/2004
Dr. S Ayyappan Deputy Director General (Fy.)	Indian Council of Agricultural Research, New Delhi	09/09/2004
Dr. S Sreenivasan Director	CIRCOT, Mumbai	15/02/2005
Coimbatore		
Dr. C. D. Mayee, Agriculture Commissioner	Govt. of India, New Delhi	18-11-2004
Shri. Nanabhau Embedwar, Member, IMC	Former Minister of Maharashtra State	10-12-2004
Shri. Ankushraoji Tope, Member, IMC	Former Member of Parliament	10-12-2004
Dr. G. Kalloo, DDG (H&CS)	Indian Council of Agricultural Research, New Delhi	18-02-2005
Sirsa		
Dr. Anupam Barik, Director,	DOCD, Mumbai	11-09-2004
Dr. Swaran Singh, Director,	DOWD, Ghaziabad	11-09-2004
Dr. Amerika Singh, Director,	NCIPM, New Delhi	15/16-10-2004
Dr. D. S. Brar, Regional Director,	PAU, RS, Bhatinda	18-10-2004
Dr. S. Sreenivasan, Director,	CIRCOT, Mumbai	04-11-2004
Dr. Anupam Verma, National Professor,	IARI, New Delhi	15-12-2004

11.8 PERSONNEL

Name of Officers/Scientists		Designations
DIRECTOR		
Phundan Singh		Director (Acting)
PROJECTOR COORDINATOR (Cotton)		
Coimbatore		
T P Rajendran		Project Coordinator (Cotton) & Head, CICR, RS, Coimbatore
PLANT BREEDING		
Nagpur		
Phundan Singh		Head, Crop Improvement Division
V V Singh		Principal Scientist
T R Loknathan		Senior Scientist
Smt. S B Singh		Senior Scientist
V N Waghmare		Senior Scientist
D K Agarwal	(on study leave)	Scientist (SS)
Coimbatore		
KN Gururajan		Principal Scientist
Sirsa		
S L Ahuja		Senior Scientist
O P Tuteja		Senior Scientist
S K Verma		Senior Scientist
GENETICS & CYTOGENETICS		
Nagpur		
S B Nandeshwar		Senior Scientist
Smt. V Gotmare		Scientist (SS)
Coimbatore		
Smt. K P M Damayanthi		Senior Scientist
S Manickam		Scientist (Sr. Scale)
SEED TECHNOLOGY		
Nagpur		
R K Deshmukh		Principal Scientist
Smt. P R V Kumari		Senior Scientist
Smt. V Santhy		Scientist
Coimbatore		
K Rathinavel		Senior Scientist
Sirsa		
R A Meena		Senior Scientist
ECONOMIC BOTANY		
Nagpur		
Punit Mohan		Senior Scientist

AGRONOMY	
Nagpur	
K S Bhaskar	Principal Scientist
Blaise	Senior Scientist
A R Raju	Scientist
Coimbatore	
C S Praharaj	Senior Scientist
K Shankaranarayanan	Senior Scientist
P Nalayani	Senior Scientist
SOIL SCIENCE	
Nagpur	
Jagvir Singh	Senior Scientist
AGRICULTURAL ENGINEERING	
G Majumdar (on study leave)	Scientist (Sr. Scale)
PLANT PATHOLOGY	
Nagpur	
Sheo Raj	Head, Crop Protection Division
P M Mukewar	Principal Scientist
N K Taneja	Principal Scientist
M K Meshram	Principal Scientist
R C Ukey	Senior Scientist
P K Chakrabarty	Senior Scientist
Coimbatore	
P Chidambaram	Principal Scientist
A Kannan	Principal Scientist
Sirsa	
Dilip Monga	Senior Scientist
ENTOMOLOGY	
Nagpur	
S K Banerjee (Vol. Retd. on 1-2-05)	Principal Scientist
K R Kranthi	Senior Scientist
Smt. S Kranthi	Senior Scientist
Smt. S Vennila	Senior Scientist
Coimbatore	
T Surulivellu	Principal Scientist
K Natarajan	Principal Scientist
Smt. B Dhara Jothi	Senior Scientist
Sirsa	
P Jeyakumar	Scientist (SS)
NEMATOLOGY	
Nagpur	
Smt. Nandini Narkhedkar	Senior Scientist

PLANT PHYSIOLOGY	
Nagpur	
M R K Rao	Head, Crop Production Division
N K Perumal	Principal Scientist
K B Hebbar	Senior Scientist
Coimbatore	
S E S A Khader	Senior Scientist
A H Prakash	Senior Scientist
BIOCHEMISTRY	
Nagpur	
A B Dongre	Principal Scientist
Smt. M. Chakrabarty	Scientist (SG)
Coimbatore	
N Gopalakrishnan	Principal Scientist
BIOTECHNOLOGY	
G Balasubramani	Senior Scientist
Smt. J Amudha	Scientist (SS)
AGRICULTURE EXTENSION	
Nagpur	
H L Gajbhiye	Principal Scientist
S M Wasnik	Senior Scientist
Coimbatore	
Usha Rani (on study leave)	Scientist
AGRICULTURAL ECONOMICS	
Nagpur	
P R Deoghare (Joined on 19-7-04)	Principal Scientist
P Ramasundaram	Senior Scientist
Coimbatore	
Smt. Isabella Agarwal	Senior Scientist
COMPUTER APPLICATION	
Coimbatore	
M Sabesh	Scientist
KVK	
S N Rokade	Senior Scientist
Administrative Officer	
Kumar Rajesh	
Finance and Accounts Officer	
Prashant Kumar	

11.9 OTHER INFORMATION

11.9.1 Library

Additions : The library procured 371 books, 56 scientific reports and bulletins, 36 reprints on cotton and subscribed 40 Indian and 22 foreign journals and CD-ROM database.

Documentation Service

Bibliographic database on cotton

Library has developed computerized bibliographic database on cotton to provide comprehensive and update information on cotton. About 2671 bibliographic references along with abstract have been stored in it.

Documentation Service such as Current Awareness Service, SDI service, Specific subject search service have been provided by sorting out the database. Using the database also brings out 'Cotton Research Abstracts' a documentation bulletin "Cotton Research Absracts Vol. 18 (1-3) 2004.

Current Title Service

Library has provided current title service by subscribing current contents with abstracts on disk from I.S.I. Philadelphia.

CD ROM database Retrieval Service

Bibliographic information on cotton and other crops on various aspects are being retrieved and downloaded as per the demand. The following CD-ROM database were used to retrieve the information:

1) CABCD 1972-2002 2) CROPCD 1973-2004. 3) AGRICOLA 1975-2000

4. AGRIS 1975-2001 5) Biotechnology Abstracts 1975-2004.

Newspaper Clipping Service

Clippings on various aspects related to cotton from local and national newspapers have been compiled and made available for references.

Library Automation

Using library application software Slim^{++}, 1918 books have been computerized and barcodes assigned for the same.

11.9.2 Participation in National Exhibition at New Delhi

CICR participated in a weeklong festival-cum exhibition on 'Biodiversity through Organic Products' at Delhi. The varied products originated from diverse cultures from various artisans were promoted for eco-friendly consumption. CICR depicted its exhibits through photographs on various cotton technologies of the institute for the benefits of students, professionals and farmers. The main attraction for the most of visitors was live samples of the cotton plants with full bursting, brought from CICR, Regional Station, Sirsa. More than 1000 visitors visited the exhibition site each day.

CICR participated in Science Expo – 2005 on the occasion of 92 Indian Science Congress held at Nirma University of Agriculture and Technology, Ahmadabad form 3-1-2005 to 7-1-2005 and in Agro-industry Exhibition organized at Pune on the occasion of 7th Agricluture Science Congress from 16-20th February 2005.

11.9.3 World Food Day

CICR celebrated World Food Day programme on the theme 'Biodiversity for food security' at its KVK adopted village Wakeshwar in Nagpur Tahsil of Nagpur district. Dr. Phnndan Singh, Director (Acting), CICR, chaired the function while Dr. Shyam Singh, Director, NRC for Citrus, Nagpur was the Chief Guest. More than 200 farmers, farm women and rural youths of Wakeshwar, Waranga and nearby villages covered under KVK attended the function.

11.9.4 Cotton Front-line Demonstrations

Cotton Front-Line Demonstration programme (FLDs) was carried out at farmers field of three villages Umari, Tumgaon and Rampur in Warora Tahsil of Chandrapur district. Based on the preliminary technical knowledge of farmers, cotton FLDs were planned involving 50 farmers with the technological interventions *viz*, integrated nutrient management in cotton, cotton based intercropping system (cotton + soybean), integrated pest and disease

management, foliar application of DAP and detopping for yield improvement, opening of ridges and furrows for moisture conservation, varietal trial of surabhi (*G. hirsutum*) and verietal trial of MB 120 (*G. hirsutum*). The inputs such as cotton seed, soybean for intercropping, rhizobium and azotobactor, sufala and zinc sulphate and other insecticides were made available to farmers and the crop was raised under supervision of FLD team members. Monitored cotton FLD interventions regularly and provided timely guidance. Under INM demonstration with reduced dose of fertilizers supplemented with the use of bio-fertilizer, the average seed cotton yield of 997 kg/ha was registered with the average increase of 19.54 percent seed cotton yield as against the farmers practice. The technological intervention cotton + soybean intercropping in comparison with sole cotton crop as well as soybean sole crop, an increase of profitability of 21.76 percent was observed with an average monetary returns of Rs.5250/ha. With application of complete IPM module an average increase of 14.46 percent was obtained as compared to sole dependence on insecticides, the average seed cotton yield of surabhi introduced for the first time in the area ranged between 625-1125 kg/ha with average seed cotton yield of 870 kg/ha.

11.9.5 Progressive Use of Hindi

- Official Language Implementation Committee of CICR working under the Chairmanship of the Director, CICR met regularly. The meetings of the committee were held on 25.10.2004, 15.01.2005 and 29.03.2005 at CICR, Nagpur and 24.08.2004 at CICR, Regional Station, Sirsa and 10.12.2004 at CICR, Regional Station, Coimbatore. Proceedings of the Official Language Implementation Committee meetings held at Institute and quarterly progress reports regarding use of Official Language Hindi were sent to the Council regularly.
- CICR was notified in the Gazette of the Government of India under rule 10 (4) of the Official Language Rule 1976.
- Two video films in Hindi Language viz. IPM in cotton and commercial production of HNPV were produced by the Institute with the financial assistance rendered by the Govt. of India. A video film in Hindi language namely 'multiple uses of cotton' was produced by the institute under NATP.
- CICR celebrated Hind fortnight and organized various programmes and competitions during this fortnight and winners were awarded during the prize distribution function held on 14th September 2004.
- CICR Regional Station, Sirsa celebrated Hindi Week from 14.09.2004 to 18.09.2004 and CICR, Regional Station, Coimbatore celebrated Hindi Day on 10th December, 2004.
- *Kapas Samachar* (Quarterly Newsletters), *Kapas Pragati* (Annual) and *Shwet Swarnima* (Annual) were published.
- Official language Implementation Committee of Nagpur city awarded CICR, Nagpur for '*Shwet Swarnima*', magzine in Hindi with citation and consolation prize for the year 2004-05.

11.9.6 Visits Abroad

- Dr. KR Kranthi, Sr. Scientist (Entomology) visited Australia (Centre for Environmental Stress Adoptation Research and Development of Genetics, La Trobe University) from 10th Feb. to 6th May 2004 for work on the molecular and biochemical aspects of insecticide resistance.
- Dr. Nandini Gokte-Narkhedkar, Sr. Scientist (Nematology) visited Beijing, China to participate in XV International Plant Protection Congress held at Beijing, China on May 11-16, 2004 and presented two-research papers.
- Sh. MK Meshram, Principal Scientist (Plant Pathology), Dr. Punit Mohan, Sr. Scientist (Economic Botony) and Dr. D Blaise, Sr. Scientist (Agronomy) were deputed to visit Uzbekistan on September 6-12, 2004 under the implementation of work plan for 2004 between India and Uzbekistan.

11.9.7 Technical Bulletins published

Title of the Technical Bulletin	Bulletin No.	Author (s)
Physiological disorders in cotton.	28	Dr. N.K.Perumal, Dr. K.B.Hebbar, Dr. M.R.K. Rao and Dr. P. Singh
Micro irrigation management in cotton	29	Dr. K.S.Bhaskar, Dr. M.R.K.Rao, Sh. P.N. Mendhe and M.R.Suryawanshi
Kapus utpadan wadisathi panlot v koradwahu tantragyan	30	Dr. S.M.Wasnik, Dr. K.S.Bhaskar, Sh.P.N. Mendhe and Sh. N.P.Barabde

11.10 Weather

Nagpur

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
June, 2004	38.1	26.7	64.0	41.0	151	11
July, 2004	34.1	25.1	81.2	57.9	136	10
August, 2004	29.8	23.4	89.0	73.8	322	12
September, 2004	33.7	23.8	87.0	58.5	38	4
October, 2004	33.4	18.6	76.3	31.3	4	1
November, 2004	31.7	15.1	69.9	30.8	-	-
December, 2004	29.7	12.0	67.4	29.2	-	-
January, 2005	28.1	13.3	74.9	42.7	113	4
February, 2005	31.7	15.8	63.0	29.3	8	2

Coimbatore

Month	Temperature (°C)		Relative Humidity (%)	Rainfall (mm)	No. of Rainy days
	Max.	Min.	Max.		
August, 2004	31.5	22.1	85	27.0	3
September, 2004	31.6	22.3	88	96.9	7
October, 2004	29.9	21.7	91	288.8	15
November, 2004	28.3	20.8	91	155.8	9
December, 2004	29.5	18.3	89	0.4	-
January, 2005	30.6	19.0	88	9.8	1
February, 2005	32.6	18.8	84	0.5	-
March, 2005	34.4	22.2	86	46.2	3

Sirsa

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	Rainy days
	Max.	Min.	Max.	Min.		
April, 2004	39.2	19.4	41.8	29.4	-	-
May, 2004	39.7	24.3	50.3	32.5	37.1	2
June, 2004	37.8	22.0	61.8	45.6	27.2	3
July, 2004	39.6	29.4	61.5	45.8	-	-
August, 2004	34.3	26.5	80.8	64.6	50.6	3
September, 2004	35.8	24.7	73.5	57.5	-	-
October, 2004	31.8	18.7	73.0	46.3	4.6	1
November, 2004	29.0	10.9	65.8	28.2	-	-
December, 2004	23.1	7.4	77.3	36.5	8.6	1

11.11 National Cotton Scenario

State-wise area, production and productivity figures for the year of report and the preceding year are presented below:

Zone/State	2003-2004			2004-2005		
	Ar.ea (Lakh ha)	Prod. (Lakh bales)	P (kg/ha)	Area (Lakh ha)	Prod. (Lakh bales)	P (kg/ha)
North Zone						
Punjab	04.52	11.00	414	05.09	16.50	551
Haryana	05.26	11.50	372	06.21	15.50	424
Rajasthan	03.35	08.50	431	04.38	11.00	427
Central Zone						
Gujarat	16.47	50.00	516	19.06	73.00	651
Madhya Pradesh	05.75	19.50	577	5.76	16.00	472
Maharashtra	27.66	31.00	191	29.80	52.00	297
South Zone						
Andhra Pradesh	08.25	26.00	536	11.74	32.50	471
Karnataka	05.00	04.00	136	05.12	08.00	266
Tamil Nadu	01.03	03.50	578	01.42	05.50	658
Others	00.56	01.00	304	00.62	01.00	274
Loose cotton consumed but not counted for in State-wise prod.		11.00			12.00	
Total	**76.30**	**177**	**387**	**89.20**	**243.00**	**463**

Prod. = Production

P = Productivity

1 bale= 170 kg.

Source : Office of the Textile Commissioner, Mumbai.