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ANNUAL REPORT
2005-06

केन्द्रीय कपास अनुसंधान संस्थान, नागपुर

CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

M. SABESH

CICR
ANNUAL
REPORT
2005-06

M.SABESH
SCIENTI;T
(Computer ApplicationS)
Central Instltute for ~otton Research
COIMBATORE - 64l 003.

ANNUAL REPORT 2005-06

CENTRAL INSTITUTE FOR COTTON RESEARCH

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CICR ANNUAL REPORT 2005-06

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PREFACE

Cotton production in the country has touched a new record of244lakh bales during the year 2005-06 with a productivity of 467 kg lint/ha. The attainment and maintenance of higher production and productivity profile during the last few years inspite of climatic aberrations in certain cotton growing regions of the country is primarily due to the adoption of improved production and protection technologies including highly productive and quality cottons. The area under transgenic cotton hybrids showed aphenomenal increase during the year.

The cultures CfNA 316 (G. arboreum), CfSA 310 (G. arboreum) and CSHH 238 (intra-hirsutum) hybrid have been identified by the AfCC1P. fn the transgenic research,four genotypes viz. LRA 5166, LRK 516, RG8 andPA 255 have been transformed.. In the male sterility programme, hybrid CfNHH 127 has been ident(fied for AICCfP trial. The TGMS system in G. arboreum is being promoted as alternative source of male sterility system. Considerable progress has been made in the development of multitier cropping system under irrigated condition and refinement of the micro irrigation system and integrated nutrient management for enhancing water and nutrient use efficiency respectively.. Rapid molecular diagnostic kit has been developed for detection of Xanthomonas axonopodis pv. malvacearum (Xam) a pathogen of quarantine significance on cotton. fRM technology for the management of pests was effectively demonstrated in 28 major cotton growing districts of the country with good success. The Bt Referral Lab played a pivotal role in analyzing the samples received from different parts of the country and in identifYing spurious lots. Development of new diagnostic kits has enhanced the precision screening for major pests and diseases. Research programmes with major emphasis on new frontiers of cotton biotechnology are being conceptualized for targeting higher in productivity and better fibre quality. Renovation activity executed in the institute has brought in enhanced and modern infrastructural facilities. All these were successfully accomplished due to the systematic and concerted efforts of my colleagues and support from Indian Council of Agricultural Research,, New Delhi.

[acknowledge with gratitude, the guidance and leadership provided by Dr. Mangala Rai, Secretary DARE and Director General, fCAR and Dr. Gautam Kalloo, Deputy Director General (Crop Sciences), fCAR, New Delhi in encouraging new research programmes backed up with excellent infrastructural facilities.

I am placing the Annual Report (2005-06) with a sense of satisfaction for public scrutiny.

(B.MKhadi)
Director.

EXECUTIVE SUMMARY

Crop Improvement

Nagpur

- One hundred accessions each of *G. hirsutum* and *G. arboreum* were evaluated in multilocation trial at Nagpur. In *G. hirsutum* 1000, in *G. arboreum* 630 and in *G. herbaceum* 90 accessions were grown for rejuvenation. New germplasm lines viz., *G. arboreum* (2) and *G. herbaceum* (1) were collected from Andaman, Nicobar and Neil Islands. A close wild relative of *Gossypium* collected from Bhavanipur was grown for seed increase and evaluation.
- 1000 accessions of *G. hirsutum* and 492 accessions of *G. arboreum* and 102 accessions of *G. herbaceum* were supplied for use in breeding programmes.
- CINA 316 (*G. arboreum*) has been identified for pre-release agronomic trial. Four advance promising cultures of *G. arboreum* viz., CINA 343, CINA 344, CINA 345 and CINA 346 were sponsored for evaluation in AICCIP trials Br 22 a/b. CINA 333 was promoted in south zone for further evaluation. Long linted CINA 343 has been retained in central zone for 2006-07.
- In male sterility programme, 137 *G. harknessii* based CMS, 11 *G. aridum* based CMS, 49 *harknessii* based restorer, 10 *aridum* based and 29 GMS lines were maintained. Hybrid CINHH 127 has been sponsored in AICCIP trial. In 18 thermo-sensitive male sterile lines, the boll setting ranged from 3% to 33%.
- Two drought tolerant cultures viz. CNDTS 52 and CNDTS 51 were sponsored for testing in AICCIP trial Br 02 (a) and (b).
- Four genotypes viz. CSH 2545, CSH 2563, SGNR 6 and KH (SH) 153 were found moderately tolerant to jassids, two tolerant to aphids (F 2086 and H 1250), three moderately resistant to bacterial blight and 8 moderately resistant to Alternaria leaf spot.
- Established 11 cuttings of interspecific hybrids brought from Surat.
- In the cross AKH 8401 x LRA 5166, ovules were harvested. 6 DAP recorded the highest callusing response of 78.0% in 2,4-D (0.1 mg/L + kin mg/L).
- Four germplasm lines viz. EC 359854, EC 357788, BN Red and RACH 16 moderately resistant to bollworm, two germplasm lines EC 356630 and Selection 47 tolerant to jassids and EC 128334, EC 356630 and EC 356864 resistant to bacterial blight were identified in breeding upland cotton for bollworm and jassid resistance.
- Cultivars F 1861, Laxmi (*G. hirsutum*) and AKA 7 (*G. arboreum*) exhibited highest values for SRUE (Seed Reserve Utilization Efficiency). Seed dormancy / hard seed ranged from 10% (G.Cot 15, G. 824) to 30% (G 67). Foliar spray of boric acid @ 0.6 kg/ha and DAP @ 2% twice at 75 DAS and 90 DAS significantly increased the boll numbers, seed cotton yield and germination.
- Four genotypes viz. LRA 5166, LRK 516, RG 8 and PA 255 have been transformed. RCGM field trials are in progress.
- Two SCAR markers for CLCuV resistance were developed and are under revalidation.
- Diagnostic kit for *Xanthomonas oxonopodis* pv. *malvacearum* is developed.

Coimbatore

- In the AICCIP multi-location testing, 7 varieties and 5 hybrids have been sponsored during the year 2006-07.
- Under network project with 100 germplasm accessions of *G. hirsutum*, seed cotton yield ranged from 5.1 to 98.2 g/plant with the

mean seed cotton yield being 42.5 g/plant.

- GMS based intra-*hirsutum* hybrids viz., J 34 x Khandwa 3, J 34 x Suman and J 34 x TK 15 have shown better performance in respect of seed cotton yield as compared to check hybrids.
- CMS based intra-*hirsutum* hybrids viz., RKR 4145 x AK 1, RKR 4145 x A, 22-29 HS x AK 1, Abadhita x DR 4, IRH 1-4 x DR 2 and Suman x GSRH 24 were found to be better than the check hybrids in seed cotton yield. CMS based interspecific hybrids viz., 70 G x PR, IRH 1-4 x PR and IRH 1-4 x SR out-yielded the check hybrids viz., Sruthi and DCH 32.
- Several single plant selections having resistance to grey mildew (112 nos.), alternaria leaf spot (8 nos.), bacterial blight (41 nos.) and MAR lines (53 nos.) with resistance to more than one disease have been developed and advanced for further evaluation.
- Out of 427 entries received from all AICCIP centres and breeders were screened against grey mildew and six entries were found resistant.
- Screening of 16 selected genotypes for multiple resistance to insect pests revealed that two genotypes viz., BTS 5 and BTS 7 were resistant to American and Pink bollworm and on par with Abadhita in respect of jassid and stem weevil infestation.
- To develop stem weevil resistant lines, the popular cotton cultivars viz., Sumangala, LRA 5166, MCU-3, MCU-5, Anjali were crossed with Moco and Exotica and the hybrids were backcrossed with the cultivars. The cross derivatives with Moco background recorded 0-3 % stemweevil incidence as compared to Exotica derivatives (3 - 8.0 %).
- About 120 genotypes were screened for jassid reaction and 13 of them showed resistant reaction.
- Foliar applications of DAP @ 2 % + Boron @ 0.6 kg/ha + Zinc @ 0.5% twice during boll maturation phase of seed crop and one additional irrigation after the first picking were found beneficial for the harvest of quality cotton seed with additional increment on yield.

Sirsa

- The intra *hirsutum* hybrid CSHH 238 and *G. arboreum* variety CISA 310 produced significantly higher seed cotton yield at all the locations in Agronomy trials. These cultures were identified during the Annual Group Meeting of All India Coordinated Cotton Improvement Project during 2006. The intra- *hirsutum* CSHH 243 hybrid was identified for Agronomy trial to be conducted in North zone.
- Six entries (CSH-3118, CISA-2R, CISAA-7, CISA 410, CSHG-2459, CSHG-960) were promoted during AICCIP workshop and three entries (CSH-7106, CISA-614, CISAA-6) were retained.
- BN-ARB-16: A Bollworms and Jassid tolerant cytoplasmic diverse strain of *G. hirsutum* Cotton, BN (Bikaneri Nerma) with *Gossypium arboreum* cytoplasm (INGRNo.05020;IC 471864) was registered with NBPGR.
- BN-TOM-277: A Bollworms and Jassid tolerant cytoplasmic diverse strain of *G. hirsutum* cotton, BN (Bikaneri Nerma) with Gossypium tomentosum cytoplasm (INGRNo.05019;IC471863) was registered with NBPGR.
- Cross boll setting percentage was higher up to 5th October in all the hybrids.
- Significant improvement in cross boll setting percentage during entire crossing period was

observed when foliar spray of Boron (0.1 %) at 60, 75, and 90 DAS was made.

- In cotton variety RS 2013, significant and maximum increase in boll number (52.0) and boll weight (3.20) were observed when DAP (2%) at 45 DAS + $ZnSO_4$ (1%) at 50 DAS + Boron (0.1%) at 60 DAS + $ZnSO_4$ at 75 DAS were applied combined.
- In the variety H 1098 and LD 327, the boll weight, seeds/ boll, yield/ plant, germination percentage and vigour index were higher when topping was made at 60 DAS.

Crop Production

Nagpur

- One hundred *G. hirsutum* germplasm lines and fifty *G. arboreum* lines (new set) were evaluated under rainfed conditions. The top ten lines for each of the characters were categorized and only very few lines had more than three characters in the top ten range.
- At the micro level and even with Bt hybrids, the performance of the INFOCROP-Cotton model in terms of different parameters, phenology and yield was found to be quite satisfactory at Nagpur and Dharwad. The area, production and productivity estimates through integrated approach (remote sensed data, GIS and crop model) for the year 2005-06 were found to be quite satisfactory in respect of Sirsa, Bharuch and Dharwad districts with a variation ranging from 5-13%.
- Split application of recommended dose of fertilizer (50 % NPK as basal and 50 % NPK through fertigation), alongwith $ZnSO_4$, Biofertilizer and 1500 kg ha^{-1} enhanced the seed cotton yield under drip in shallow soil. *In-situ* moisture conservation practice such as opening of alternate furrow was able to enhance seed cotton yield by about 220 kg ha^{-1}.
- Maximum effect of intercrops on seed cotton yield was recorded in case of greengram (224 kg) followed by blackgram (75 kg) and least by soybean (15 kg). High (1.91 kg ha^{-1} mm^{-1}) water use efficiency was recorded where greengram was intercropped with cotton followed by opening of alternate furrow after last interculture.
- Significantly higher seed cotton yield of Bt MECH 184 and non-Bt NHH 44 was recorded with foliar application of potassium nitrate alongwith Boron and Zinc (B @ 10 kg & Zn @ 2.25 kg /ha) over recommended dose of NPK.
- Among the tillage treatments, reduced tillage with two inter-culture operations (1874 kg seed cotton/ha) was at par with the reduced tillage without any interculture operations (2054 kg/ha) and both were significantly superior to conventional tillage treatment.
- Among the nutrient management practices, yield was the highest in the site-specific nutrient management treatment (1278 kg/ha) and was significantly greater than the application of recommended dose (90-19-37 kg NPK/ha) of fertilizers (886 kg/ha).
- Hybrids H 10 and PKV Hy 2 were found to be superior while among varieties Surabhi, Abadhita, Sahana, AKA 5 and 7 were statistically similar but superior over PKV Rajat, AKA 8 and CINA 316 under organic production system.
- Battery operated knapsack sprayer was developed and the prototype was evaluated. It was found that it can spray maximum 22 spray tanks each having 16 litres spray liquid can spray in single stroke of

battery charge.

- Transpiration rate and transpiration coefficient were found to be higher in *arboreum* lines indicating relatively higher leaf cooling tendencies in *arboreum*.
- Seed-cotton yield remained higher in *G.hirsutum* genotypes and yield reduction occurred due to drought. However, yield stability was relatively higher in *arboreum* genotypes grown under stress condition.
- Out of 100 *G.hirsutum* lines evaluated, 50% of the genotypes possessed more than 1% gossypol which is towards higher range. In case of *G. arboreum* lines, high range of gossypol (> 1%) has been observed in 37 out of 50 genotypes estimated.
- Salinity levels corresponding to 8 and 12 d S m^{-1} NaCl showed a significant decline in yield. From the hydroponically grown plants it is clear that amongst the different plant parts roots are the most sensitive followed by leaves and the stem is the least sensitive. Proline accumulation was more in tolerant genotypes compared to susceptible genotypes.
- Unlike yellowing, senescence, shedding of leaves and fruiting parts observed with waterlogging under cloudy weather, under bright light and high temperature waterlogging elicited wilting in cotton.

Coimbatore

- Soil moisture conservation by opening of furrow at each row of cotton after sowing registered the highest seed cotton yield (2688 kg/ha).
- Highest seed cotton equivalent yield (2800 kg/ha) and rainfall use efficiency (7.0 kg/ha-mm) was recorded when the cotton was intercropped with black gram.
- The highest seed cotton yield of 2387 kg/ha was harvested with the application of irrigation water as per the climatic needs (0.8 = IW/CPE) of the crop.
- Highest water use efficiency of 5.1 kg/ha-mm of water was calculated with the application of irrigation water at boll development stage.
- Drip irrigation system produced statistically comparable yield to conventional method of irrigation (ridges and furrow method) with higher irrigation use efficiency (85%) and 51.5 percent of water saving. Polytube lateral drips as compared to existing LLDPE dripper can reduce 80 percent of cost of the system.
- Highest seed cotton yield was harvested with the intercropping of radish + beetroot + coriander between the cotton rows. Highest gross return of Rs. 167614/ha, net return of Rs. 118217/ha and benefit cost ratio 3.4 was calculated with cotton intercropped with radish + cluster bean + beetroot system.
- Cotton-jowar cropping system was better than the monocropping of cotton for the 3rd consecutive year with an additional jowar yield of 6470 kg/ha. NP alone produced significantly higher cotton yield and is comparable with INM (CR) both in cotton and jowar. Potassium at higher dose (along with higher NP) depressed the SCY over the RDF and INM (CR). FYM @ 5 t/ha with *in situ* GM recorded the highest SCY (1615 kg/ha) although it was on par with that of RDF (1450 kg/ha).
- Application of bio inoculants consortia such as Azophosmet @ 1800 g/ha (Azospirillum 600 g, PSB 600 g and PPFM 600 g) for seed treatment and Azophosmet @ 6 kg/ha for soil application with two foliar sprayings of PPFM at flowering and boll development along with 75 % recommended N and P fertilizers recorded the highest seed cotton yield of 2755 kg/h in cotton cv LRA5166.

- Irrespective of the colours, the poly ethylene mulching improved the growth and yield of cotton cv. LRA 5166 significantly. The yield enhancement in poly mulching ranged from 840 kg to 1168 kg /ha than non mulched cotton.
- Cotton genotypes grown under elevated CO_2 atmosphere were characterized with favourable and desirable morpho-physiological features, early flowering, higher photosynthetic activity, higher Nitrate Reductase Activity with early induction, more boll number, boll weight, more dry matter production, better Harvest Index and increase in yield.
- Using 10 physiological indices, the following genotypes were identified as tolerant to drought: H 777, LRK Kgl 931, RBC 39, Nor. Okra, Anjali, AC 241, IC 79, K 34007 and K 3475.
- Application of ethrel @ 30 ppm resulted in synchronous flowering and boll development, leading to uniform boll bursting
- The nutrient and hormonal changes brought about perceptible change in seed and fibre developmental pattern. With application of GA @ 0.5 ppm there was fibre initiation in fibre less mutants of MCU 5.
- Cellulase (2.0%) + Macerozymes (0.5%) was found effective for digestion and release of healthy protoplast from leaves. The osmolarity of 9.0% mannitol was ideal for protoplast isolation.
- Lines with high tannin in leaves and squares have been identified. Fifteen superior single plant selections from these lines exhibiting fair tolerance to bollworms have been made.
- Repeated application of cypermethrin led to the reduction of Nitrate reductase activity and secondary metabolites.
- Seed dressing insecticides induced ATPase activity at a higher level as compared to control. Efficient metabolic status by way of acid Phosphatase and alkaline Phosphatase activity in addition to higher peroxidase activity could be maintained in young seedlings due to seed dressing chemicals.
- Moisture stress tolerant genotypes were seen to withstand moisture stress by way of better photosynthesizing capacity and efficient nitrate reductase activity as compared to susceptible genotypes.
- Single plant selections from the high seed oil segregating populations was obtained with seed cotton yield of 120 - 140 g/plant. Among 200 progenies evaluated, CBR 3 x F 1861-2-(2) and Anjali x F 1861-1-(2) possessed 24-26% seed oil content.
- Cost of cultivation was higher in Salem district than in Erode but cost of seed production was very less because of higher average yield realized in Salem (1312 kg as compared to 1142 kg in Erode).
- In Tamil Nadu, the B:C ratio between Bt cotton and other ruling varieties like Surabhi and LRA 5166 was found to be 1:1.32 and 1:1.81, respectively.
- Beta version of the Information system on cotton was developed using Visual Basic. Net as front-end and Microsoft Access as back-end.
- Around 60 Indigenous Technical Knowledge (ITK) in cotton production and protection adopted by the farmers were collected and incorporated in the CICR web site.

Crop Protection

Nagpur

- Insecticide resistance development was monitored regularly for most commonly

used insecticides (Cypermethrin, Fenvalerate, endosulfan, chlorpyriphos, quinalphos, methomyl, thiodicarb, indoxacarb, spinosad, emamectin benzoate) and two Bt toxins, Cry1Ac and Cry2Ab, on 20 *H. armigera* populations. Resistance levels were found to have declined significantly to all the insecticides tested. However, bollworm populations collected from some parts of Andhra Pradesh still exhibited higher levels of pyrethroid resistance.

- A Cry1Ac resistant *H. armigera* strain RES-Bt-a (82-fold) was found to susceptible to Cry2Ab and Cry1F. Cry1Ac + Cry2Ab bioassay results showed that the combination was highly potent with a capability to cause high levels of mortality in Cry1Ac resistant *H. armigera*. Thus, the dual gene technology can be considered not just as an improvised pest management method but also as technology with a strong potential to delay resistance as well.
- ELISA tests were conducted at fortnightly intervals to estimate the in-season changes in Cry2Ab expression in Bollgard-II. The seasonal expression levels of Cry2Ab2 in Bollgard-II range between 14.0 to 83.0 µg/g in leaves, and 5.5 to 62.0 µg/g in various fruiting parts. Thus compared with the Cry1Ac expression levels, which range between 0.01 to 8.0 µg/g in various plant parts, the Cry2Ab2 levels are at least 10 fold higher than Cry1Ac at any given point of time in any of the plant parts during the season.
- Insecticide resistance kits were validated independently at various locations in the country. The results showed that the kits were stable for at least six months at 4°C, and identified resistant *H. armigera* larvae unambiguously in field populations. Based on field validation results a patent application was filed in India for 'Rapid detection of insecticide resistant insects'. A novel format was also devised to detect resistant insects based on more than 2-3 mechanisms of resistance. The kit will be ideally suited to detect complex resistance traits such as against the pyrethroids.
- A stochastic model Bt-Adapt-II was developed to enable the integration of ecological and genetic variables representing factors influencing *H. armigera* resistance to Bollgard-II. The model showed that a simultaneous introduction on BG-II along with BG-1 was more beneficial to delay resistance as compared to a sequential release.
- Insecticide resistance management strategies were disseminated and implemented in 565 villages in 46,431 farmer fields covering 1,70,816 hectares. Insecticide use was reduced by 20-80% across various districts, associated with significant yield and ecological benefits. The net increase in profits over the non-participating farmers was estimated to be about 48 crores on account of yield increase and savings on pesticide usage.
- G 21-17-619, ND 63 and AR 27 were genetic stocks found tolerant to bollworm, *H. armigera*, good yielding with good fibre properties under unprotected rainfed situation and can be exploited further to suit the low input regions of Vidarbha.
- Regions of the *H. armigera* mitochondrial genome that are most likely to demonstrate evolutionary changes during speciation have been sequenced. Specific mutations have been observed to reflect the existence of haplotypes rather than host races. Three PCR- RFLP tools to detect haplotype variations.

- Seed-borne pathogenic infection of major fungus and bacterial diseases was observed. Seed dressing fungicides Sixer 75% (Mancozeb + Carboxin) and Vitavax Powaer (Carboxin + Thiram) were found compatible with seed dressing insecticide Gaucho against leaf spot fungus *Myrothecium roridum* in relation to disease-free seed production.
- Five races viz. 4, 5, 7,10 and 18 of *Xam* were identified and race18 was most predominant. Three lines B 161 (ST 904), BP 52 MB 2 and KW 61 - 240 of *G. hirsutum* have exhibited resistant reactions against virulent race 18 of *Xam* under glass house conditions. One hundred and thirty seven single plant selections with resistance to bacterial blight were made from different crosses involving resistant donor parents.
- 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*. Variable host reactions were observed in cross inoculation of seven isolates of *R. areola* on 26 cultivars of four cultivated species.
- Variability in growth pattern, influence of salt concentration on growth, pigmentation pathogenicity and RAPD-PCR pattern was observed in the isolates of *F. o. f.* sp. *vasinfectum*.
- One isolate of Entomopathogenic nematode *Heterorhabditis indica* could be made to tolerate high temperatures by selection and crossing studies. This isolate could infect *H. armigera* larvae at high temperature of 40°C. This isolate was recorded infective at ten to fifteen *H. indica* infective juveniles (IJ) per host larva. A new substrate for mass multiplication was standardized by modification of Wouts' medium .
- Entomopathogenic nematode bacterial symbionts were recorded as a new management option for management of aphids. Entomopathogenic nematodes could be reared on field collected insect larvae. The results suggest feasibility of setting up of cottage industry scale production systems for EPN. *Nomurea* and *Metarhizium* could be mass cultured on broken rice grains.
- During mapping of Central Institute for Cotton Research, Nagpur fields spread over about 258 acres, reniform nematode, *Rotylenchulus reniformis* was found as the most dominant and frequent nematode species.
- Jassids and mirids among sucking pests, and *Earias* among bollworms attained pest status during 2005-06 season. Changing pest scenario over the last five years indicated increasing mirid incidence and reducing bollworm damage.
- Calendar year based degree-day accumulation of 2492 DDs during 2005, predicted onset of *H. armigera* oviposition on cotton.
- A genetic stock, Raj 2006 having high tolerance to jassid has been developed.
- Rainfed IPM strategies incorporating no protection of *H. armigera* on the first flush of squares (September) and bollworm management during October-November months. Yield levels indicated compensatory response of NHH 44 overriding the bollworm onslaught during the season.
- During the season Bt hybrids out yielded the conventional hybrids in general, although variations among farms were high. Means of CB ratios of the Bt and conventional hybrids under IPM and NIPM situations were of the order: BtIPM (2.10) > BtNIPM (1.90) > CIPM (1.84) > CNIPM (1.13).

Coimbatore

- Two insecticides viz., Spinosad new A:D, E2Y 45, NNI 0001 and RIL 038 were effective upto 123 days after sowing (DAS) in reducing the fruiting bodies' damage. Spinosad new A:D and Beta cyfluthrin were effective in reducing boll and locule damage significantly over control and recorded higher yield.
- Thiodicarb followed by Lambda cyhalothrin, Quinalphos and Profenofos were effective against pink bollworm and recorded significantly higher yield over control (by 31.9 to 47.6 %).
- Neemcake (150 kgs/ha) + Carbofuran (1.0 kg a.i/ha), neem cake (150 kgs/ha) + carbofuran (1.0 kg ai /ha)+ stem drenching with neem seed kernel extract 5%, were on par with each other and superior than the other treatments in controlling stem weevil damage. Carbofuran (1.0 kg a.i/ha) + chlorpyriphos recorded significantly minimum percentage of infestation due to stem weevil.
- Plant clinic centre was established at Kanurpudur village with photographic displays as well as live specimen of cotton pests, natural enemies and diseases of cotton.
- An impact analysis of the implementation of IRM strategies indicated the reduction in number of insecticidal sprays as well as cost of cultivation and increase in the Cost: Benefit ratio.
- Seed treatment with thiamethoxam 500 FS @ 5 ml and 7.5 ml per kg of seed was effective in reducing the aphid and jassid population upto 40 days.
- Spraying of *Trichoderma harzianum* + *Pseudomonas fluorescens* Pf1 talc formulations at 0.2 per cent was effective against grey mildew when sprayed at 10 day intervals. An yield loss upto 33 per cent due to grey mildew disease can be averted by spraying Carbendazim 50 WP @ 0.1 per cent at 80, 95 and 110 days after sowing. Under intense disease pressure, spraying of the broad spectrum fungicide Propiconazole @ 0.1 per cent was effective in reducing grey mildew disease incidence.
- Five *barbadense* genotypes viz., GB 119, GB 124, GB 23, ERB 13758 and Suvin have been identified as differentials for the identification and differentiation of *Ramularia areola* isolates.

Sirsa

- A polyclinic has been established at Rangri village along with prototype IPM farm demonstrating the pheromone trap, light trap, neem products and others.
- The neem oil exposed to UV light for 1 hour or more than that was less effective against the larvae of *H. armigera*.
- Insecticide resistance management strategies were disseminated in 120 villages in three districts of Haryana covering an area of 41944 ha and 13073 farmers and reduction in insecticidal spray upto 46% and net profit per hectare upto 4855/- was observed.
- Six lines resistant to CLCuD were identified out of around 2000 lines tested over the years. The techniques for artificial screening through grafting and white fly inoculation were standardized and put to use.
- Four *R. solani* isolates (one each belonging to four identified groups of *R. solani*) and six R. bataticola isolates (one each belonging to six identified groups of *R. bataticola*) were amplified using ITS primers, cloned sequenced and aligned. Based on alignment data of six Rb isolates a primer was synthesized which could amplify all Rb

isolates but did not amplify any of the Rs isolate tested.

- In front line demonstration program, the hybrid CSHH 198 recorded 23.07 % higher yield, CICR 2 recorded 33.42 % higher yield over the farmers' practice. Under IPM and IRM strategy 21.33 % and 5 % higher yield was recorded over the farmers' practice respectively. A net return of Rs. 24535 was obtained by adopting the conventional seed production of CSHH 198. A net return of Rs. 60830 was obtained by adopting the GMS seed production of CICR 2.

INTRODUCTION

Brief history

Nagpur

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

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

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.***

Financial Statement

The budget grant and actual expenditure for the year 2005-06 are furnished below:

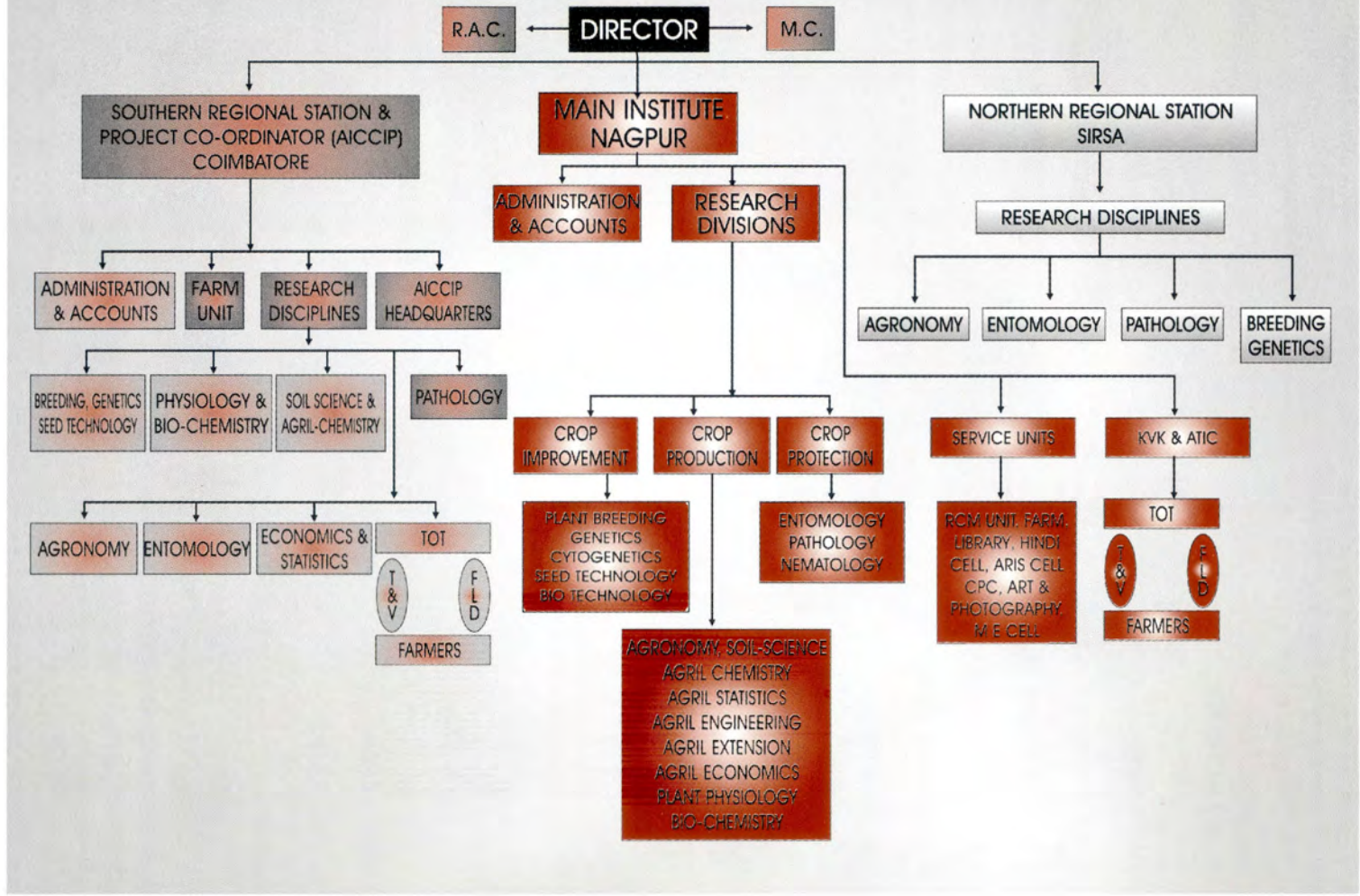
Budget Sanctioned and Expenditure		(Rs. in Lakhs)
Scheme	**Sanctioned**	**Expenditure**
Plan	133.00	132.89
Non-Plan	963.00	953.62
PLAN SCHEME		
NSP Crop	000.00	000.04
AICCIP	400.00	400.00
KVK Scheme	42.90	32.15
TMC MMI	146.11	146.11
NATP Schemes	86.00	0.17
AP CESS FUND		
IQRC&P Scheme	3.36	2.64
Bt. Resistance	-	1.86
Ent. Eno Helicoverpa	0.58	0.47
RCM	-	2.34
R DEPOSIT SCHEME		
NRI (ICAC/CFC/14)	-	0.51
DBT Scheme (DST)	3.05	1.43
DST Scheme (Race-18)	-	7.04
EPS & C (De Nocil)	-	0.38
FLD in Cotton	1.71	4.16
TMC MMI (DAC)	1.79	1.72
FLD KVK	0.18	0.43
DUS Scheme	4.60	9.95
Maintenance of Breeder Seed	6.10	10.50
DBT (QTLS)	3.27	1.23
TMC MM II	59.16	51.96
Toxicity of Bt (CRY)	-	0.35
Bt. Resistance Monitoring (Mahyco) I	3.00	1.40
Bt. Resistance Monitoring (Mahyco) II	-	1.27
Indofil	2.50	2.55
Bt. Tech	21.71	-
Potash Test	1.80	1.65
Transgenic Crops	64.21	22.35

Staff Position (As on 31 March 2006)

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**	-	-	-	**-**
Scientific	54	26	5	**85**	37	19	6	**62**
Technical	47	24	10	**81**	46	24	10	**80**
Administrative	32	10	7	**49**	27	10	7	**44**
Supporting	63	34	14	**111**	63	34	14	**111**
KRISHI VIGYAN KENDRA								
Training Organiser	1	-	-	**1**	1	-	-	**1**
Technical	8	-	-	**8**	8	-	-	**8**
Administrative	2	-	-	**2**	2	-	-	**2**
Supporting	2	-	-	**2**	1	-	-	**1**

NGP - Nagpur; CBE - Coimbatore

ORGANOGRAM OF CICR



RESEARCH ACHIEVEMENTS

Cotton Genetic Resources

Nagpur

New collections

Two hundred and fifty exotics and fifty indigenous lines were added to the germplasm. A wide range of variability was observed for seed cotton yield per plant (6.1 to 134.4 g), boll weight (1.5 to 5.8 g), ginning outturn (22.8 to 43.1%), bolls per plant (5.0 to 36.6), plant height (56 to 286 cm) and seed index (4.3 to 11.5 g).

Two germplasm lines of *G.arboreum* and one line of *G.herbaceum* were collected from Andaman, Nicobar and Neil Island Carnicobar (Andaman & Nicobar Islands) region by the NBPGR regional station, Vellanikkara, Thissur, Kerala.

Another germplasm line wild *kapas* (a close wild relative of *Gossypium*) was collected from Bhavanipur, Purnea region of Bihar state by the NBPGR regional station Harp campus, Palandu, Ranchi.

Conserved collections

A total of 5705 accessions were grown. This material consisted of base collections (1305), core collections (600), exotics (2100) lines for regeneration (1000), NATP collections (500) and genotypes multilocation (200).

Germplasm rejuvenation

One thousand genotypes were planted for rejuvenation. A set of 630 accessions of *G.arboreum* and 90 accessions of *G.herbaceum* were grown for seed multiplication and rejuvenation.

Evaluation of germplasm for fibre quality

One thousand and one hundred germplasm lines (*G.hirsutum*) were evaluated for fibre quality parameters viz. fibre length, fibre strength, fibre fineness, fibre maturity and uniformity. Superior genotypes for these traits were identified. A set of 310 accessions of *G.arboreum* was evaluated for fibre properties. Fifteen accessions of *G.arboreum* of long fibre coupled with high fibre strength were selected for utilization in breeding programme.

Evaluation of germplasm for seed oil

G. hirsutum : Fifteen germplasm lines including check LRK 516 were evaluated. Seed cotton yield ranged from 805 to 1156 kg/ha, while oil % varied from 17.29 % to 21.08 % . Line F 2138 recorded 1156 kg/ha seed cotton yield followed by F 2180 (1141 kg/ha) and DCI 108 (1131 kg/ha). For seed oil line B 4 Empire performed the best (21.08%) followed by DCI 108 (20.84 %). For fibre properties, line F 2153 recorded the highest 2.5 % span length of 24.7 mm followed by F 2180 with 23.9 mm. Line F 2156 (18.1 g/tex at 3.2 mm guage) recorded the highest bundle strength.

***G. arboreum*:** A total of eleven lines including a check were evaluated. The seed cotton yield varied from 720-1686 kg/ha. Line 6707 recorded 1686 kg/ha seed cotton yield followed by 6704 (1587 kg/ha). Line 7326 (22.62 %) recorded highest oil percentage followed by 6694 (21.68 %). LD 790 recorded the best values for fibre length (24.7 mm 2.5 % span length) and bundle strength (23.5 g/tex 3.2 mm guage).

Qualitative and quantitative improvement of cottonseed oil

Oil was extracted from 81 seed samples received from the Germplasm unit and field trial on genetic improvement of cotton of 2004-05, 199 estimations were carried. The details are presented in Table 1.

Table 1: Details of cotton seed oil estimates

Sl. No.	Nature of sample	No. of samples	Replications/ Sets of observations	Range of oil (%)
1	Germplasm accessions	20	3	14.71 -21.38
2	*G. hirsutum* cultures from Nagpur trial	17	3	17.62 - 21.61
3	*G. hirsutum* cultures from Sirsa trial	18	2	18.52 - 24.19
4	Single plant selections	26	2	17.49 - 24.51
	Total =	81	199	

Assessment of gossypol content

During the year analysis for gossypol content was carried out for 150 samples (in replicates). In addition to 550 samples already analysed in NATP project. The details are presented in Table 2.

Table 2 : Nature of samples & range of gossypol content

Sl. No.	Nature of sample	No. of genotypes	Replications	Total no. of Samples	Range of gossypol (%)
1	*G. hirsutum* seeds	100	2	200	0.320 to 2.631
2	*G. arboreum* seeds	50	2	100	0.304 to 2.785

Out of 100 *G.hirsutum* lines, 50% of the genotypes possessed more than 1% gossypol which is towards higher range. In case of *G.arboreum* lines, high range of gossypol (> 1%) has been observed in 37 out of 50 genotypes evaluated.

Evaluation of germplasm

Two hundred accessions were evaluated under multilocation evaluation trial of germplasm at three locations viz. Nagpur (rainfed), Sirsa and Coimbatore (irrigated). 104 new collections were evaluated for major economic characteristics. In addition, 300 new collections were evaluated for yield and fibre quality parameters. 1100 accessions were evaluated for technological properties. Ten best accessions for individual traits viz., seed cotton yield, boll weight, ginning outturn, mean halo length were identified both in old as well as new set for Nagpur, Coimbatore and Sirsa.

Nagpur

In Old Set

One hundred accessions of *G.arboreum* were evaluated under Br 01 trial in three zones (North- Sirsa, Central-Nagpur and South-Coimbatore) for seed cotton yield, boll weight, GOT (%) and MHL. Five best genotypes were identified for distribution among breeders and researchers (Table 3).

In New Set

Two hundred accessions of *G. arboreum* with 2 checks were evaluated under Br 01 trial in three zones (North-Sirsa, Central-Nagpur and South-Coimbatore) for seed cotton yield, boll weight, GOT % and MHL. Ten best genotypes for individual traits were identified for distribution among breeders and researchers (Table 4).

Table 3: Ten best *G. arboreum* genotypes for seed cotton yield, boll weight, ginning out turn (%) and mean halo length (Old Set)

Rank	Name of Accession	Seed Cotton Yield / plant (g)	Name of Accession	Boll weight (g)	Name of Accession	GOT (%)	Name of Accession	MHL (mm)
1	AC 3379	72.8	AC 3132	3.5	AC 3014	38.7	AC 3405	24.0
2	AC 3188	72.5	AC 3204	3.4	AC 3086	38.7	AC 3021	23.0
3	AC 3030	61.5	AC 3277	3.4	AC 3385	38.4	AC 3265	22.3
4	AC 3312	56.7	AC 3075	3.3	AC 3658	38.0	AC 3658	22.0
5	AC 3671	53.3	AC 3546	3.3	AC 3422 A	38.0	AC 3169	21.7
6	AC 3033	47.5	AC 3326	3.3	AC 3349	38.0	AC 3062	21.3
7	AC 3312	47.2	AC 3185	3.2	AC 3075	37.8	AC 3328	21.3
8	AC 3201	46.4	AC 3270	3.2	AC 3045	37.8	AC 3539	21.3
9	AC 3745	46.4	AC 3379	3.2	AC 3428	37.8	AC 3742	21.3
10	AC 3240	46.3	AC 3169	3.2	AC 3474	37.8	AC 3671	21.0
11	AKA-8401 (Check)	33.4	AKA-8401 (Check)	2.6	AKA-8401 (Check)	36.0	AKA-8401 (Check)	25.3

Coimbatore

One hundred germplasm accessions of each *G. hirsutum* and *G. arboreum* were evaluated for various morphological and agronomic characters. Substantial variability was noticed for all the characters evaluated. Germplasm lines with superior performance over the check variety have been selected for utilization. The working collection of *G. hirsutum*, the registered accessions of cotton and some exotic collections maintained under long term storage at NBPGR, New Delhi were grown under field condition for seed multiplication and future storage. Morphological purification of 266 germplasm lines of *G. barbadense* was done and characterization of 175 amongst them have been completed.

Sirsa

One hundred lines each of *G. hirsutum* and *G. arboreum* under Br 01 trial, 610 lines of *G. hirsutum* and 400 line of *G. arboreum* germplasm maintained at the Sirsa station were evaluated for yield/plant, boll weight, boll number/ plant,

Table 4: Ten best genotypes of *G.arboreum* for seed cotton yield, boll weight, ginning out turn (%) and mean halo length (New Set)

Rank	Name of Accession	Seed Cotton Yield/ plant (g)	Name of Accession	Boll wt (g)	Name of Accession	GOT (%)	Name of Accession	MHL (mm)
1	AC 3552	95.6	AC 3324	3.7	AC 3445	39.8	AC 3149	23.0
2	AC 3366	87.2	AC 3581 BLL	3.6	AC 3503	39.2	AC 3120	22.3
3	AC 3581 BLL	86.5	AC 3537	3.6	AC 3470	39.2	AC 3025	22.0
4	AC 3537	66.9	AC 3251	3.4	AC 3551	39.0	AC 3332	22.0
5	AC 3336	63.3	AC 3216	3.4	AC 3650B	38.8	AC 3324	21.7
6	AC 3189	60.6	AC 3111	3.4	AC 3104	38.6	AC 3666	21.7
7	AC 3001	57.5	AC 3025	3.3	AC 3396	38.6	AC 3206	21.7
8	AC 3637	56.5	AC 3206	3.3	AC 3516	38.4	AC 3153 B	21.3
9	AC 3324	55.0	AC 3685	3.3	AC 3146	38.4	AC 3322	21.0
10	AC 3101	53.3	AC 3373 A	3.3	AC 3001	38.4	AC 3540	21.0
11	AKA-8401 (Check)	33.4	AKA-8401 (Check)	2.6	AKA-8401 (Check)	36.0	AKA-8401 (Check)	25.3

GOT, seed index, lint index, symodia/plant, fibre length, shattering %, CLCuV incidence and bollworm infestation. Working collection in *G. arboreum* for yield/plant (32 entries), boll weight (10 entries), boll number/ plant (31 entries), earliness (24 entries), GOT (35 entries), fibre length (41 entries), shattering resistant (12 entries) and Red plant colour (11 entries) were identified. In *G. hirsutum* working collection for yield/plant (62 entries), boll weight (25 entries), boll number/ plant (36 entries), earlyness (11 entries), compact (26 entries), fibre length (15 entries), monopods (24 entries), sympods (24 entries), spot on petal (4 entries), coloured cotton (3 entries), red plant colour (6 entries), naked seed (3 entries), jassid susceptibility (14 entries), okra type leaf (6 entries) were identified.

145 *G.hirsutum* germplasm lines were evaluated for fibre strength and GOT%. The following cultures were identified for superior fibre strength (>23.0 g/tex) and GOT (>38%).

i) The cultures, CSH-3003, 3005, 3031, 3047, 3097, 3118, 3119, 3132, 3167, 3185, 3090, 3127, 3181 and 3114 had superior fibre strength >23.0 g/tex.

ii) The cultures CSH-3015, 3073, 3160, 3169 and 3175 had high GOT >38%.

Screening for Diseases

Nagpur

G.hirsutum

Screened 200 germplasm lines for three major diseases, out of which 38 were disease free, 87 moderately resistant, 48 moderately susceptible and 27 susceptible to Alternaria leaf spot, whereas, 20 were free, one resistant, 32 moderately resistant, 33 moderately susceptible

and 114 susceptible to Myrothecium leaf spot. As regard grey mildew, one line was disease free, 11 moderately resistant, 32 moderately susceptible and 156 lines were susceptible.

G. arboreum

Out of 199 germplasm lines screened for disease reaction, 46 were disease free, 100 moderately resistant, 21 moderately susceptible and 32 susceptible to Alternaria leaf spot whereas 157 were free, 32 moderately susceptible, one moderately susceptible and 9 susceptible to Myrothecium leaf spot. For grey mildew, one line was disease free, one resistant, 31 moderately resistant, 44 moderately susceptible and 122 lines were susceptible.

***G. hirsutum* (New collections)**

Amongst 421 newly collected germplasm lines, 44 were resistant, 181 moderately resistant, 41 moderately susceptible and 155 susceptible to Alternaria leaf spot. As regard Myrothecium leaf spot, 21 were spot free, 45 resistant, 23 moderately resistant, 10 moderately susceptible and 133 susceptible, whereas 33 lines were resistant, 41 moderately resistant, 59 moderately susceptible and 288 susceptible to grey mildew.

***G. hirsutum* (Exotics)**

Out of 245 exotic germplasm lines, 2 were moderately resistant, 10 moderately susceptible and 233 susceptible to Alternaria leaf spot whereas, 106 were resistant, 32 moderately resistant, 27 moderately susceptible and 80 susceptible to Myrothecium leaf spot. One line was resistant, 2 moderately resistant, 1 moderately susceptible and 241 susceptible to grey mildew.

One hundred and twelve germplasm lines were grown in augmented randomized complete block design. Accessions EC 359854, EC 357788, BN Red and RACH 16 were identified as moderately resistant to bollworms. Accession EC 356630 and selection-47 were identified as moderately tolerant to jassids. Accessions EC 128334, EC 356630, EC 356649 and EC 356864 were identified as resistant to bacterial blight.

Identification of resistant sources:

One hundred and forty seven germplasm lines of *G. hirsutum* were evaluated in pot culture for their reaction against the virulent race 18 of bacterial blight. Out of these, three lines viz. B 161 (ST 904), BP 52 MB 2 and KW 61 - 240 were observed to be resistant, 17 moderately resistant, 68 moderately susceptible and 59 lines susceptible.

Six hundred and forty five lines of *G. hirsutum* were evaluated for bacterial blight reaction under field conditions. Out of these, 54 lines were observed to be free from the incidence of bacterial blight, 47 lines were resistant. 76 lines were moderately resistant, 225 lines moderately susceptible and 243 lines susceptible.

Out of 198 *G. hirsutum* lines of Br 01 trial evaluated under natural incidence of field conditions, five lines (NCAC - 3, PUSA 109/10, VCA 4, A 02 N 67 and A 02 N 86) were free from bacterial blight whereas 20 lines (A 02 N 76, A 02 N 92, A 02 N 100, A 03 N 119, A 03 N 123, A 03 N 135, A 03 N 136, A 03 N 152, A 23, 02 A 015, DH 34, GC 11, NCAC-14, MC 127, VCA - 2, VCA - 5, VCA - 7, VCA - 22, VCA - 24, and MC- 127) exhibited resistance. Of the remaining, 25 lines were moderately resistant, 68 lines moderately susceptible and 80 were susceptible.

Physiological evaluation

During the year, one hundred *G. hirsutum* germplasm lines and fifty *G. arboreum* lines (new set) were evaluated under rainfed conditions. Amongst the parameters tested, plant height, biomass and leaf area in that order were found to have positive association with

seed cotton yield in both the species. The top ten lines for each of the characters were categorized for physiological traits. Inspite of the aberrant monsoon activity, seed cotton yield ranging from 40-50 gms was recorded in both the species in the top ten lines.

Sirsa

Screening against insects and diseases

A total of 1799 germplasm lines were planted during 1997-2005 crop seasons to screen against cotton leaf curl virus disease under natural field conditions and screening nursery. Thirteen lines showing resistant reaction over the years were screened through whitefly inoculations during 2005 season and six lines free from leaf curl disease i.e. B-59-16-79-2, BP 52-16-MB-LYYH, JBWR-21, CNH-2773, Super Okra VIRESCENT, 59-CCD were identified.

Evaluation of germplasm through molecular technique

Nagpur

Fifty germplasm lines of cotton including *G.hirsutum* (tetraploid) and *G.arboreum* (diploid) were subjected for molecular evaluation by using DNA based markers such as RAPD, ISSR and Microsatellite.

The clustering pattern of 50 accessions based on the RAPD, ISSR and SSR revealed an appreciable degree of variation among them. The cluster analysis showed considerable variability amongst the genotypes at DNA level, though phenotypically variation was not distinct. The genotypes showing extreme variation and falling in different clusters can be selected for hybridization programme and creating variability for desired traits.

Twenty four accession of *G. hirsutum* (12 Bacterial Blight resistant and 12 Jassid and Bollworm resistant) were studied for genetic diversity analysis. Three marker systems viz. 40 RAPD, 30 SSR (Microsatellite) and 19 ISSR primers, were used to assess the genetic diversity. 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 found to be most distant among all the 24 cultivars. The dendograms generated by RAPD (Fig. 1), ISSR (Fig. 2) and SSR (Fig.3) data analysis clearly formed two clusters.

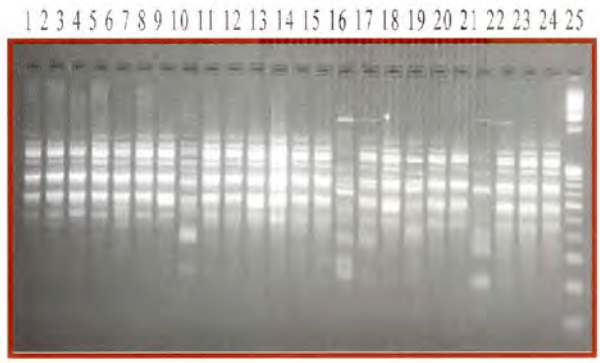


Fig. 1: RAPD profile of 24 cotton cultivars obtained (Agarose 1.5%) with primer OPA 10, Lane 1-24 corresponds to the cultivars listed as BBR and JBWR. Lane: 25 = 1kb + 100bp ladder.

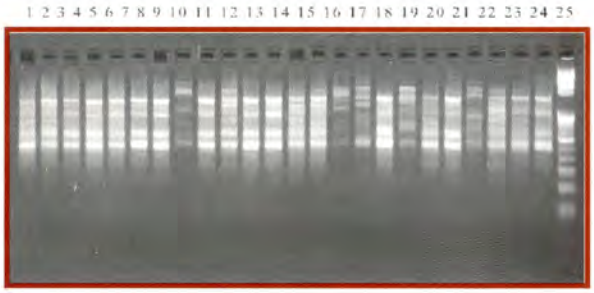


Fig. 2: ISSR profile of 24 cotton cultivars obtained (Agarose 1.5%) with primer IS 4, Lane 1-24 corresponds to the cultivars listed as BBR and JBWR. Lane: 25 = 1kb + 100bp ladder.

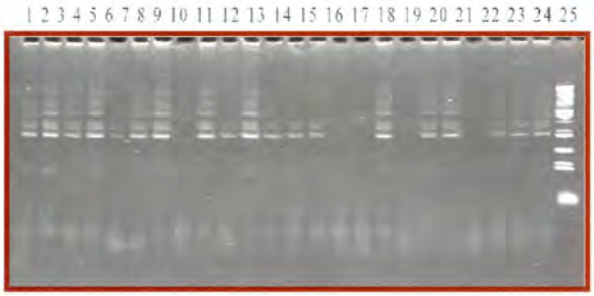


Fig. 3: SSR profile of 24 cotton cultivars obtained on (PAGE 5%) with primer JESPR-92, Lane 1-24 corresponds to the cultivars listed as BBR and JBWR. Lane: 25 = 100bp ladder.

Utilization of germplasm

Twenty genotypes possessing high ginning percent, high fibre strength and big boll size were utilized in the hybridization programme. Out of these, seven lines (CNH 120 MB, G.Cot 10, Senegal, PKV 081, D 40, 320 F and Buri 0394) were used as females and 13 lines viz. Deltapine (CJ), 70 IH 452, 6472, UPA (62) 32-2, S 6 J 20-3, 6472, Unknown Merrut, DHY 286, 2833, SV 213, GC 110, AKG 3/59 and G.Cot 10 (Bt) as male.

Seventeen long linted accessions of *G. arboreum* and five 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 spinning.

From the population involving four bacterial blight immune lines Tamcot SP 21, Tamcot SP 23, Tx ORHU 1-78 and Tx Bonham as resistant donors with susceptible cultivars Ganganagar Ageti, LRA 5166, LRK 516, PKV 081and SRT-1, 137 single plant selections have been identified for bacterial blight resistance and quality parameters. The seed-cotton yield of these selected plants varied from 37.4 - 70.8 gm/plant with an average of 14.5 21.6 bolls/plant and boll weight of 2.71 - 3.59 gm/boll.

Fourteen resistant selections have been identified for their plant quality parameters. The average boll number of these selections varied from 15.47 - 26.72 per plant with an average boll weight of 2.82 - 3.72 gm/boll. The average yield of seed-cotton varied from 48.1 - 67.5 gm/plant with the plant height of 80.7-137.5 cm/plant. The average monopodia and sympodia varied from 0.7-3.5 and 15.2 - 22.3 per plant, respectively.

Distribution

Seeds of 1000 accessions of *G. hirsutum*, 492 of *G. arboreum*, 102 *G. herbaceum* and some F_2 seeds of 10 crosses were distributed to the AICCIP centres and other Government organizations.

Seed of 492 accessions of *Gossypium arboreum* and 102 accessions of *Gossypium herbaceum* were supplied to various indenters of ICAR Institutes, Agricultural Universities and Government Institutions for research purpose only.

Registration of germplasm

(1) Following germplasm with distinguishing characters have been registered with NBPGR

(a) BN-ARB-16: A Bollworms and Jassid

tolerant cytoplasmic diverse strain of *G. hirsutum* cotton, BN (Bikaneri Nerma) with *Gossypium arboreum* cytoplasm *(INGRNo.05020;IC 471864)*

(b) BN-TOM-277: A bollworms and jassid tolerant cytoplasmic diverse strain of *G. hirsutum* cotton, BN (Bikaneri Nerma) with *Gossypium tomentosum* cytoplasm (INGRNo. 05019;IC 471863).

(2) Following germplasm with distinguishing characters have been submitted for registration with NBPGR

a) B N-Red: A bollworms and jassid tolerant morphological diverse strain of *G. hirsutum* cotton, BN (Bikaneri Nerma) with red plant body characteristics of line Mec Namara Wine sap.

b) BN-Okra: A bollworms and jassid tolerant morphological diverse strain of *G. hirsutum* cotton BN (Bikaneri Nerma) with lanceolate (super okra) leaf shape of Reba okra isogenic line-3 (ROIL-3).

c) CISA 2 (GMS): Yellow flower with petal spot, green plant body.

Hybrid Cotton

Nagpur

Maintenance of CMS, GMS and restorer lines

- 137 G. *harknessii* based CMS, 11 *G. aridum* based CMS, 49 *harknessii* based restorer, 10 *aridum* based restorer and 29 GMS lines were maintained through crossing, selfing and sibmating respectively.

Conversion into CMS, GMS and restorer background

- 31, 24 and 10 genotypes are under conversion into CMS, restorer and GMS background. Thirteen genotypes are in single plant progeny stage for restorer line development. These progenies have to be tested for fertility restoration in CMS lines. 51 single plant progenies were raised for R x R and (A x R) x P crosses. The progenies were selfed and will be tested for fertility restoration in the ensuing crop season. 17, 42, 76 and 48 SPP for C 1412, Suman, Sharda and MCU 10 were raised for GMS line development. Progenies showing 1:1 segregation were identified.
- Six progenies of Khandwa 2 and five progenies of Laxmi (with GMS base) were tested for fibre properties. SPS 10 and SPS 16 in case of Khandwa 2 and SPS 14 and SPS 20 in case of Laxmi retained the fibre quality of their parental lines. The plants for these lines were maintained through sibmating.
- The seed for SPS 10 of Khandwa 2 has been multiplied (2000 number of seeds produced) for registration.

Testing of GMS based hybrid

- A GMS hybrid CINHH 121 was sponsored for Br 05 (b)-2-PHT trial. It has been promoted for testing in Br 05 (b) trial in both central and south zone.
- One new GMS hybrid CINHH 127 has been sponsored for testing in Br 05 (b)-2 national trial.
- 130 GMS and 20 CMS hybrids have been produced for testing in station trial. Hybrid seeds for three GMS hybrids were produced for sponsoring in AICCIP trials (4 kg for CINHH 121, 3 kg for CINGH 2006 and 3 kg for CINHH 127 respectively).

Evaluation of MS lines received from NBPGR

- Six GMS and four CMS lines registred with NBPGR were evaluated. Out of six GMS

lines, IC 296576 did not show 1:1 segregation for male sterility and fertility. All the CMS lines were stable and maintained by crossing to the fertile couter part except VCM S2 and LRA 5166 as the fertile maintainer lines were not recieved .

Genetic studies for the newly developed GMS lines

- A GMS lines was developed through induced mutation. Seven single plant selections were raised and maintained through sibmating.

Generation of crosses between CMS and apomictic plants

15 CMS lines and 10 single plant progenies of apomictic plants were crossed.

Twenty seven apomictic lines were selfed and bulked seed was collected.

Development of TGMS lines

Eighteen male sterile lines of *G.arboreum* were found to be thermosensitive sterile showing fertility at low minimum temperature. These were selfed during November- early February to study the (%) fertility. The boll setting in these lines ranged from 3% to 33% . The maximum setting (%) was correlated with a minimum temperature of 14^{0}C to 16^{0}C.

Coimbatore

Development of high yielding conventional intra *hirsutum* hybrids

Twenty-seven promising intra *hirsutum* hybrids were evaluated in a replicated trial. Four hybrids were significantly superior to the best check hybrid Bunny. Hybrid LS 3 x LS 4 recorded the highest yield of 3612 kg/ha followed by LS 3 x LS 22 (3527 kg/ha). In addition to highe yield potential, the hybrid LS-3 x LS 22 possesses superior ginning outturn (38.0%), longer fibre length (31.0 mm), and good micronaire (4.4) at par with check bunny.

Development of conventional extra long staple interspecific hybrids

Seven interspecific hybrids having high fibre traits were tested in PVT. Performance of hybrids have been depicted in Table 5.

Table 5.: Performance of extra long staple interspecific hybrids

Hybrids	Yield (kg/ha)	GOT (%)	Seed oil content (%)	2.5% SL (mm)	Micro-naire	BS (g/tex)
ISC/56	3128	32.0	16.8	33.1	4.1	24.2
ISC/48	2910	33.0	21.8	33.5	3.9	24.3
ISC/32	2725	31.6	19.1	34.8	3.8	25.8
ISC/52	2237	31.3	17.9	35.1	3.9	24.4
ISC/4	2131	33.6	23.5	35.0	3.8	26.5
ISC/49	2116	34.0	19.8	33.9	3.9	25.9
ISC/24	2032	33.0	20.0	33.5	3.8	25.3
Sruthi (C)	2022	32.6	19.1	35.7	3.8	25.6
DCH 32 (C)	1301	33.3	23.7	35.6	3.7	26.3
CD 5%	634					

The hybrid ISC/4 showed promising performance in respect of yield (2131 kg/ha), 2.5% span length (35.00 m), micronaire (3.8) and fibre strength (26.5 g/tex) than check, DCH-32. The hybrid also had very high oil content to the extent of 23.5%.

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

The *G. barbadense* restorer lines *viz.*, Suvin Restorer (SR) and Pima Restorer (PR) have

been successfully developed and maintained. Utilizing these restorer lines, 18 CMS based interspecific hybrids were produced and evaluated in a station trial along with Sruthi, DCH 32 and DHB 105 as check hybrids. The highest seed cotton yield was recorded in the test hybrid 70 G X PR with 2460 kg/ha as compared to 2020 kg/ha recorded in DHB 105, the best check hybrid.

The GMS based interspecific hybrid CCHB 727 which is under testing in coordinated hybrid trial of South Zone in AICCIP have been retained for one more year of testing, since it recorded higher yield over the zonal check hybrid DCH 32. Similarly, another GMS based interspecific hybrid CCHB 125 has also been retained for one more year of testing in coordinated hybrid trial of central zone. In addition, the CMS based interspecific hybrid CCCHB 05-1 has been promoted to CHT in central zone.

Sirsa

Development of *G. hirsutum* hybrid CSHH 243

The hybrid CSHH 243 suitable for irrigated conditions in North Zone have been identified. It recorded the mean seed cotton yield of 1969 kg/ha against 1699 kg/ha of hybrid CSHH 198 zonal check. The hybrid CSHH 243 characterized by medium staple length (26.4 mm) had good micronaire (4.8) and moderate strength (22.7 g/tex). This hybrid performed well in AICCIP trials.

Development of GMS based G. *hirsutum* hybrids

The hybrids CSHG 960 and CSHG 2459 were tested in national trial Br 05a-2 in central zone. The hybrids CSHG 960 and CSHG 2459 recorded the mean seed cotton yield of 1848 kg/ha and 1867 kg/ha respectively in central zone and ranked at 3rd and 4th position respectively in central zone. Both the hybrids were promoted to Br 05a-2 zonal trials.

Development of male sterility based hybrids of *G. hirsutum*

Two different trials were conducted to evaluate the performance of GMS hybrids. In the first trial 54 GMS based hybrids were evaluated in randomized block design with three replications. The highest seed cotton yield was recorded in GMS-31 x CNH 911 (2629 kg/ha) followed by GMS1 x PHP 1 (2606 kg/ha), GMS1 x Ratna (2515 kg/ha) and GMS 3 x PHP 1 (2401 kg/ha) as against 2332 kg/ha in conventional check hybrid CSHH 198. Maximum ginning out turn of 37.9 % was recorded in the cross combinations GMS-3 x CISCB 25 followed by 37.6 % in GMS-16A x PHP 1. The highest 2.5 % span length (29.4 mm) and tenacity (23.8 g/tex) was recorded by the cross combinations GMS-16A x BM and GMS 31 x Ratna, respectively.

In the second trial 24 GMS based hybrids were tested against conventional check hybrid CSHH 198 in randomized block design with three replications. The GMS based hybrids viz. GMS 16A x PHP-3 (1235 kg/ha) and GMS 14 x PHP-1 (1193 kg/ha) recorded the highest seed cotton yield in comparison to local check CSHH 198 (1031 kg/ha). Maximum ginning out turn of 37.2 % was recorded in the cross combination GMS 28 x PHP-9 and 36.8 % in GMS 3 x CISV-1. The highest 2.5 % span length (29.5 mm) and tenacity (24.5 g/tex) was recorded by the cross GMS 16A x PHP-3 and GMS 31 x PHP-3, respectively.

Performance of GMS based *G. arboreum* hybrids

The hybrid CISAA-7 was tested in national trial Br 25a. The hybrid CISAA-7 recorded the mean seed cotton yield of 1862 kg/ha and ranked 3rd in north zone while it ranked 2nd in Central zone and 1st in south zone. The hybrid was promoted to Br 25 zonal trial.

The hybrid CISAA-6 was tested in zonal trial Br 25 (Z) in north zone. The hybrid CISAA-6 recorded the mean seed cotton yield of 1907 kg/ha and ranked 8th in north zone. It is having length of 22.9 mm with strength of 18.6 g/tex. The hybrid was retained in Br 25 zonal trial.

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

Evaluation of F_1 hybrids (GMS based)

Under this trial ten GMS based F_1 hybrids were tested against CISAA-2 in three replications. The highest yielding hybrids are DS-5 (GMS) x AKA-9136 (2674.90 kg/ha) followed by DS-5 (GMS) x CINA-318 (2572.02 kg/ha). The maximum GOT% and high span length were recorded by DS-5 (GMS) x GAM-93 (42.6% & 24.8) respectively. The highest boll number (35.9) and boll weight (2.6 gm) were recorded by DS-5 (GMS) x CINA-318 and DS-5 (GMS) x AKA-9136 respectively. The high strength was recorded by DS-5 (GMS) x MDL-2463 (20.3 g/tex).

Effect of male sterility on seed cotton yield and fibre quality traits

To study the effect of male sterility on seed cotton yield and fibre quality traits, material for the study comprised of male sterile line K 34007 (A), maintainer line K 34007 (B), GMS lines K 34007 and six restorer lines (CIR 23 A, CIR 26, CIR 28 A, CIR 32, CIR 70 and CIR 72). The restorer lines were crossed with male sterile line (A) maintainer line (B) and GMS line to produce three types of hybrids. These 18 hybrids, along with conventional check hybrids CSHH 198 and Om Shankar were grown in randomized block design with three replications. To study the effect of male sterility mean performance with sterile cytoplasm (A x R), hybrids with normal cytoplasm (B x R) and hybrids with GMS x R were compared. The mean seed cotton yield of B x R hybrids (2556 kg/ha) was highest followed by GMS based hybrids (2238 kg/ha). The CMS based hybrids (AxR) recorded the lowest mean seed cotton yield of 2139 kg/ha. This indicated that sterility has negative effect on seed cotton yield in cotton. However, no significant differences were observed on fibre quality traits viz, 2.5% span length, micronaire, uniformity ratio and tenacity.

Effect of sterile cytoplasm on yield and fibre quality traits

To compare the effect of male sterility on seed cotton yield and fibre quality traits, the material for the study comprised of five cytoplasmic male sterile lines (LRA 5166A, SH 2379A, Johrar A, Bikaneri Narma A and F 505 A), their respective maintainer lines and six restorers (CIR 23 A, CIR 26, CIR 28 A, CIR 32, CIR 70 and CIR 72). The crosses were attempted between A x R, and BxR lines to produce two types of combinations, i.e. A x R and B x R. These 60 crosses were evaluated against the conventional check hybrid CSHH 198. To study the effect of male sterile cytoplasm, mean performance of hybrids with sterile cytoplasm (A x R) and hybrids with normal cytoplasm (B x R) were compared. The mean seed cotton yields of all the B x R hybrids were higher than A x R hybrids except with LRA 5166 A x R lines. It was interesting to note that fibre quality traits in all the A x R hybrids were found to be better as compared to B x R hybrids. This revealed that, sterile cytoplasm has negative effect on yield and not on the fibre quality traits in cotton.

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 sterility lines 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, 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 based on four years studies. These restorer lines are able to restore the fertility up to 80-100 per cent.

Genetic Improvement

Nagpur

G. arboreum cotton improvement

On the basis of fibre traits, yield, GOT, boll weight and earliness, 37 genotypes were identified for crossing programme. 106 new cross combinations involving above elite genotypes of *arboreum* and *herbaceum* were made for further evaluation. Two advance promising cultures namely CINA-345 and CINA-346 were identified and evaluated for yield and fibre properties. Twenty-seven progenies of segregating population were planted in unreplicated plots and evaluated for mean halo length, seed cotton yield, boll weight and locule opening pattern. Nineteen single plant selections based on high yield, earliness, high fibre strength and long fibre with high locule retentivity were made.

Seven grey mildew immune accessions of *G.arboreum* were used in crossing programme 2001 for development of grey mildew (*Ramularia areola*) disease resistant *arboreum* cultures. Now three strains namely CINA-357 (Narrow Leaf Lobe), CINA-358 (Broad Leaf Lobe) and CINA-359 (Narrow Leaf Lobe) were identified for resistance to grey mildew disease under field conditions.

Two advance promising cultures of *G.arboreum* namely CINA-343 and CINA-344 were sponsored for evaluation in TMC trials 2006-07 North, Central and South zones at 19 locations.

Two new cultures namely CINA-345 and CINA-346 were identified for high seed cotton yield (1370 to 1520 kg/ha), boll weight (3.4 g), fibre length (27.5 to 28.6 mm), fibre strength (20.2 g/tex to 21.4 g/tex), maturity days (160 days) and GOT (35.3% to 35.8%). These cultures have been sponsored for evaluation in National Elite Varietal Trial (NEVT) of AICCIP Br 22 a/b.

Under south zone conditions *G.arboreum* culture CINA-333 recorded highest seed cotton yield and ranked 1st in South zone in 2005-06 and promoted for further evaluation.

However, another long linted *arboreum* culture CINA-343 ranked 3rd in Central zone in 2005-06 was retained in Central zone.

High locule retentive culture CINA-316 has been identified for Agronomy Trial in Central Zone, at two locations.

G. hirsutum improvement

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

21 *G. hirsutum* F_1' s involving male parents as donors from germplasm for major fibre quality traits viz., staple length, fibre strength and fibre fineness and elite cultivars as female parents were evaluated for yield and fibre quality traits. In F_2, 30 populations were raised and evaluated for yield and fibre quality traits. Based on the above characters, 35 single plant selections were made. In F_3, 23 populations were evaluated and 30 single plant selections were made. In interspecific crosses, 14 F_2 populations were evaluated and selections were made for boll wt, fibre length, fibre strength and yield. Seven Backcrosses (BC_2) were effected for further evaluation and also reciprocal crosses were made. Under intermating, six F_1 populations

were involved. Fifteen F_1 crosses involving wild species and *G. hirsutum* (LRA 5166, LRK 516, Rajat and G.Cot 10) were effected.

Maintenance breeding was taken up with CNH 120 MB using breeder seed.

Abiotic Stress

Under genetical an anatomical studies on drought tolerance, 18 cultures showed significant difference among themselves under rainfed condition but were non-significant under irrigated condition for seed cotton yield. P3 x EL 500, P6 x EL 500, P6 x A 72-62, P9 x EL 500 and P10 x EL 500 performed well under both rainfed and irrigated condition. The cultures recorded more than 50% increase over the check LRA 5166 (1129 kg/ha seed cotton yield). In the second set, 23 advance cultures were tested. Statistical analysis revealed non-significant difference among the treatments under both rainfed and irrigated condition. However, cultures M7 x P3, Texas 1050 x P2, B 58-1290 x P3 LL 56 x P1, Texas 1050 x P1 and Txmarroon x P2 were among the top ten cultures under both rainfed and irrigated conditions. In the third set, 25 F_4 crosses were evaluated and genotypes showed significant difference among themselves under both the conditions. Crosses P3 x AV 3469, P7 x SP 3892 CC, P8 x Arogya, P3 x SP 3895 and LL 56 x SP 3892 cc were some of the crosses which were among the top ten under both rainfed and irrigated conditions.

Thirty-three single plant selections were evaluated in replicated trial. In the first set, 25 SPS were tested statistical analysis revealed significant differences among the selections. SPS 32, SPS 39, SPS 56, SPS 30 and SPS 28 were some of the promising SPS. They recorded more than 80% increase over the check LRK 516 which recorded 1180.54 kg/ha seed cotton yield.

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 (F2086 and H 1250), 3 genotypes moderately resistant to bacterial blight and 8 moderately resistant to *Alternaria* leaf spots. The genotype H 1250 was found to be promising with 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 insects pest incidence. The range of seed cotton yield was 260 to 2366 kg/ha and ginning outturn 30.6 to 42.8%.

Population improvement

In improvement of upland cotton for GOT and fibre properties through population improvement approaches, twenty half sib progenies obtained through composit pollen were grown in 4-5 rows and subjected to random mating. Pollen of all the half sib progenies were bulked and used for pollination. About 200 or more female flowers of each half sib were pollinated so as to get enough number of crossed seeds of each combination. The crossed seeds from each half sib family has been bulk harvested and again maintained as half sibs. Thus, the second cycle of random mating has been completed . In addition, a programme on developing random mating population through conventional crossing and using GMS in diploid was initiated. About 20 parents have already been identified and crosses have been attempted. Second cycle of conventional intermating have also been completed in

diploids and GMS based 20 F_1s were extensively selfed.

In 26 advanced lines belonging to *G.hirsutum* subjected to drought stress, the 3rd leaf relative water content was determined during flowering. The advanced lines with relatively higher leaf relative water content were identified. The lines are- P3 x SP 3895, P3 x SP 3892 cc, P1 x AV 3469, P1 x Arogya, Tashkant x SP 3894.

Coimbatore

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

In the station trial, two cultures CCH 724 and (V 22 x V 112) (L x M55) 4436 were superior to the check in seed cotton yield. Culture (V 22 x V 112) (L x M55) 4436 was superior to LRA 5166 in yield and fibre quality also (Table 6).

Table 6 : Performance of CCH 724

Culture	Seed cotton yield (kg/ha)	GOT (%)	2.5% Span length (mm)	Micro-naire	Fibre Strength (g/tex)
CCH 724	2658*	35.0	26.5	5.0	22.2
(V 22 x V 112) (L x M55) 4436	2566*	37.0	28.1	4.6	24.4
V 112 (Pusa x M 56) 2311	2378	38.6	26.6	5.7	21.6
(L x 9030) 2133	2324	36.0	30.2	4.5	23.4
(L x 9030) 2136	2275	35.3	28.0	4.5	23.3
(Pusa x M 58) 3262	2265	34.0	28.6	4.3	24.5
LRA 5166 (c)	2276	35.0	28.6	4.8	22.5
CD @5%	382				

Performance of CCH 1831

Culture CCH 1831 was tested in the National trial under AICCIP. It performed better than the zonal check in central and south zones. Culture CCH 1831 has been promoted to Zone trials in both central and south zone,(Table 7 a & b).

Table 7 a : Performance of CCH 1831

Genotype	North Zone			Central Zone			South Zone		
	Yield	Rank	GOT	Yield	Rank	GOT	Yield	Rank	GOT
CCH 1831	976	21	33.2	1643	18	33.7	1671	14	35.2
Zonal check	1895	7	33.3	1559	24	34.1	1412	31	33.7
Zonal check	RS 2013			LRA 5166			Surabhi		

Yield = Mean seed cotton yield (kg/ha)

Table 7 b : Quality performance of CCH 1831

Genotype	Central Zone			South Zone		
	2.5% SL (mm)	Micro-naire	BS (g/tex)	2.5% SL (mm)	Micro-naire	BS (g/tex)
CCH 1831	26.2	4.2	22.5	27.1	4.1	24.3
Zonal check	28.3	4.5	22.0	31.3	3.6	22.1

CCH 226 was tested in the national trial under rainfed conditions. It recorded higher yield over the zonal check (1164 kg/ha) in the central zone with better quality performance.

Culture CCH 724 was tested in the AICCIP central zone rainfed coordinated trials. Culture CCH 724 (1660 kg/ha) recorded higher yield over LRA 5166 (1337 kg/ha) at all the locations it was tested. It was on par with LRA 5166 in ginning out turn. Quality wise, LRA 5166 was better.

Development of high yielding and high spinning extra long staple cotton

Twenty cultures were evaluated with LRA 5166 and Surabhi as check. Three cultures were significantly superior to LRA 5166 in seed cotton yield. Culture (T 7 x LSC 8)-18 recorded the highest yield of 2454 kg/ha, while the culture (Bunny x M 5-Z 2) 4-4 recorded the highest fibre strength of 27.3 g/tex.

Culture CCH 510 was tested in both central and south zone under irrigated conditions in AICCIP. Culture CCH 510-4 recorded better yield than LRA 5166 at all the locations it was tested and was also on par with it in quality. The culture CCH 510-4 has recorded higher ginning out turn and fibre strength under south zone conditions (Table 8 a & b).

Table 8 a : Performance of culture CCH 510-4 in central zone

Culture	Mean seed cotton yield (kg/ha)	GOT (%)	Fibre Properties		
			2.5% SL (mm)	Micro-naire	BS (g/tex)
CCH 510-4	1771	34.8	29.5	4.3	23.1
LRA 5166 (C)	1362	33.3	28.2	4.4	22.8

Table 8 b : Performance of culture CCH 510-4 in South Zone

Culture	Mean seed cotton yield (kg/ha)	GOT (%)	Fibre Properties		
			2.5% SL (mm)	Micro-naire	BS (g/tex)
CCH 510-4	1716	36.5	30.1	4.5	24.0
Surabhi (C)	1504	33.6	31.5	3.9	22.0

Three early generation crosses were evaluated for yield and fibre quality. Fibre quality of progeny 4 and 5 were promising with fibre strength of 25 to 28 g/tex as against 24 g/tex in Surabhi. The ginning out turn of these progenies was also good. They were on par with Surabhi in yield.

Among the 24 cultures of *G. barbadense* tested, SN (B2 X B10) 54-2 was on par with Suvin in quality with 55 percent increased yield over Suvin. It also recorded a higher ginning outturn (35%) (Table 9).

Table 9 : Performance of *G. barbadense* cultures

Culture	Seed Cotton Yield (kg/ha)	% inc over Suvin	GOT %	2.5% SL (mm)	Micro-naire	BS (g/tex)
SN(B2 X B10) 311-8	1291	190	33.0	33.4	4.3	27.8
(SN X ICB 30)132-14-1-1	889	100	**35.0**	32.3	4.0	28.1
(SN X ICB 30)132-14-1-7	717	61	**36.0**	32.6	4.3	26.2
SN(B2 X B10) 54-2	689	55	**35.0**	36.0	3.3	**30.5**
(SN X ICB 30)-132-14-1-5	602	35	**35.0**	31.3	4.4	26.4
SN(B4 X B5) 78-1	588	32	**35.0**	33.1	3.6	29.6
SN(B2 X B10) 43-4	559	26	33.5	33.3	3.7	**30.5**
SN(SN X ICB 30)132-424-1	545	23	**35.0**	33.4	4.3	29.4
Suvin- (C)	445		30.0	37.5	3.8	**30.8**
CD @5%	119					

Sirsa

Development of cultivars with high productivity and superior quality

Performance of CSH 7106

In the AICCIP North zone trials, culture CSH 7106 with 2038 kg/ha recorded the highest yield as compared to 2005 kg/ha and 2010 kg/ha in zonal check and local check respectively. The culture CSH 7106 showed superiority in fibre strength (21.0 g/tex) over both the checks viz., RS 2013 (20.3 g/tex) and H 1098 (19.9 g/tex).

Performance of *G. arboreum* culture.

The culture CISA-614 was tested in Zonal trial Br 24 (Z) in north zone. The culture CISA-614 recorded the mean seed cotton yield of 2024 kg/ha and ranked 5th in north zone. It is having length of 21.5 mm with strength of 17.1 g/tex. The culture was retained in Br 24 zonal trial.

Performance of G. arboreum culture

The culture CISA-410 was tested in National trial Br 22a (N) in north zone. The culture CISA-410 recorded the mean seed cotton yield of 1841 kg/ha and ranked 8th in north zone. It is having length of 23.2 mm with strength of 18.1 g/tex. The culture was promoted in Br 24 zonal trial.

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

(a) **Development of variety CISA 310**

The variety CISA 310 is an early maturing variety. In Zonal performance, the proposed variety over five years of testing recorded 29.0% higher yield over the zonal check RG 8. It also possesses considerably higher (41.7%) lint yield kg/ha than the zonal check in addition to its tolerance to bollworms and root rot. The variety CISA - 310 superior in both seed cotton yield and lint yield is identified for general cultivation under irrigated conditions in the north zone (Table 10).

Table 10: Over all performance of proposed variety CISA 310 in AICCIP trials (irrigated)

Item	Year of testing	No. of trials	Proposed Variety CISA 310	Zonal Check RG 8	Qualifying Variety 1 CISA 311	Qual. Var.2 CISA 318	Qual. Var.3 LD 805	CD kg/ha.
Zonal mean yield (kg/ha.)	2000-01	7	2584.4 (1)	337.3	-	-	-	441.50
	2001-02	7	2325.9 (4)	2345.1	-	-	-	351.14
	2002-03	7	1790	1872	1807	1879	1920	154.86
	2003-04	8	2134 (2)	1972	1897	2051	1842	269.45
	2004-05	7	2072 (1)	1927	1943	1977	1994	228.43
Overall mean		**36**	**2181.2 (1)**	**1690.7**	**1882.3**	**1894.3**	**1832.9**	**251.0**
% Increase or decrease over the check & qual.var.	2000-.01		-	+666.20	-	-	-	
	2001-02		-	-0.82	-	-	-	
	2002-03		-	-4.38	-0.94	-4.74	-6.77	
	2003-04		-	+8.22	+12.49	+4.05	+15.85	
	2004-05		-	+7.53	+6.64	+4.81	+3.91	
Overall Mean			**-**	**+29.0**	**+15.9**	**+10. 8**	**+13.7**	
Freq. in top five group			**23/36**	**12/36**	**6/36**	**9/36**	**12/36**	

(Figures in parenthesis indicate rank)

(b) Twenty- one entries were tested against local *arboreum* check PA 255, RG 8 and *hirsutum* check RS 2013 in three replications. Culture CISA 64 (1851.9 kg/ha) gave significantly higher seed cotton yield over *arboreum* check PA 255.

Generation of segregating material identification of mutants

Pink Petal colour mutant obtained from F_3 population of cross T-7 x LSC-5 procured from CICR, R. S., Coimbatore in 2003-04 was crossed as male and female with light yellow

petal commercial cultivar RS-2013 to understand the nature of gene action and maternal effect. The pink petal flower mutant was given the experimental designation CSPF-1. The F_1 population of crosses (CSPF-1 x RS-2013 and RS-2013 x CSPF-1) had pink flowers indicating dominant nature of the trait over yellow petal colour and ruled out the possibility of maternal effect.

Pink stamen filament mutations identified in the genotype AKH-0308 in a population during 2003 *Kharif* season were crossed with RS 2013, a creamy stamen filament with creamy yellow petal commercial cultivar to study the dominance and allelic relationship among various alleles of the characters. The pink filament stamen mutant was given the experimental designation CPF-1D (dark filament and CPF-1L (light filament). The phenotypic expression of F_1 plants suggested the dominance of pink stamen filament and pink petal margin over the cream stamen filament and yellow/creamy petal margin.

Petal spotted spontaneous mutants were identified in four genotypes, MCU 5-2, CSH-2501, AKH-0308 and AKH-9618. These mutants resembled respective parent genotypes for majority of the morphological traits but possessed in addition to the petal spot marker character some desirable morphological and fibre technological characters. The mutants were crossed with RS 2013, a creamy stamen filament with creamy yellow petal without petal spot. Dominant gene control with no maternal effect was noticed for the trait. The four mutations were allelic to each other. Back crosses were made to study the inheritance pattern of above mutants.

A red plant body male sterile plant obtained from the progeny of red *kapas* (popularly called by farmers) were crossed with CSH-3090, CISV-24, RS-2013 and CSH-3046 to know its type of male sterility. It was also maintained by crossing with red body fertile plant.

Evaluation of advance *G.arboreum* cultures

112 advance cultures were tested in one replication. The five top high yielding cultures are CISA-290-3 (173.4 g), CISA-300-2 (153.3 g), CISA-316-1 (147.0 g), CISA-318-1 (143.2 g) and CISA-324-9 (116.9 g). The cultures CISA-263-10, CISA-296-1 and CISA-327-1 recorded highest 2.5% span length (28.9 mm), micronaire (3.9) and bundle strength (26.4 g/tex) respectively.

Seed Oil

Nagpur

Entry CNHO 12 has been promoted to Br 04 (a) for Central Zone while the same entry has been retained for Br 03 (a) for South Zone. Entry CNHO 23 with seed cotton yield (SCY) of 1129 kg/ha, oil (23.50 %), 2.5 % span length (23.4 mm), bundle strength (19.4 g/tex) having resistance to jassids has been sponsored for Br 02 (a). Other entry CNHO 40 with SCY 1140 kg/ha, oil (24.20 %), 2.5 % span length (24.2 mm), bundle strength (19.5 g/tex) has been sponsored for Br 02 (b).

Five multilocation trials were conducted under TMC programme at five locations viz. Nagpur, Sirsa, Faridkot, Khandwa and Coimbatore. Trial wise research highlights of Nagpur centre are mentioned below ;

***G.hirsutum*- advance cultures :** 13 advance cultures including one check were evaluated under three replications. Seed cotton yield ranged from 663-1268 kg/ha. Culture 26 B performed best with seed cotton yield of 1268 kg/ha closely followed by 13 HS (1225 kg/ha). Oil % varied from 18.60 % to 22.29 %. For oil trait also culture 26 b recorded the highest value. For fibre properties culture F 2152 recorded the highest 2.5 % span length of 26.5 mm followed

by CSH 1 with 25.9 mm. Culture 13 HS (21.1 g/tex at 3.2 mm guage) recorded the highest bundle strength followed by F 1861 (20.9 g/tex).

***G. arboreum*- advance cultures :** Eight cultures were evaluated along with one check under three replications. Seed cotton yield ranged from 761-1348 kg/ha, while Oil % varied from 15.84 % to 20.62 % . Culture CINA 329 performed best with seed cotton yield of 1348 kg/ha closely followed by FDK 159 (1338 kg/ha). CINA 329 (20.62 %) recorded the highest oil % also. Culture CINA 323 A recorded the highest 2.5 % span length of 27.1 mm followed by CINA 329 with 26.9 mm. For fibre strength culture CINA 323 A (22.0 g/tex at 3.2 mm guage) recorded the highest bundle strength followed by CINA 306 (21.0 g/tex).

***G. hirsutum* segregating lines :** Fifteen lines were evaluated under this trial. In this trial single plants selections were made on the basis of their seed cotton yield. Seed cotton yield ranged from 944-1620 kg/ha, while Oil % varied from 15.25 % to 22.04% . Line BM X TCH 1648 performed best with seed cotton yield of 1620 kg/ha closely followed by PF X TCH 1652 (1578 kg/ha). For seed oil line 2 R SP_2 performed the best followed by 8 R SP_1 (21.08 %). For fibre length and strength, line BM x TCH 1648 performed the best with the values 27.3 mm and 22.1 g/tex respectively.

Attempting new crosses in conversion programme

A total of 120 back cross combinations were aimed at converting good productive quality lines into ones with high seed oil content. Ten parents were used for crossing. 33 new cross combinations were attempted to study the genetics of seed oil content, while 30 cross combinations and 12 cross combinations were attempted to study the genetics of Linoleic and Oleic Acid profile respectively. A total of 21 cross combinations along with 20 parents were raised for attempting back crossing as well as for generation advancement in order to build up the populations for studying genetics of seed oil content and quality.

Evaluation of breeding material and new single plant selections

A total of 220 lines of *G. hirsutum* in various filial generations were evaluated. 116 new SPSs were initiated among crosses made earlier for seed oil content and fibre productivity and quality. 13R-SP2 recorded the SCY of 2261 kg/ha followed by 8R-SP1 (1969 kg/ha). Oil % varied from 17.56 % to 24.01 %. For Oil trait SPS 9 M SP_1 (24.01 %) recorded the highest value followed by 1 M SP_2 (22.5 %). In a trial of 24 newly developed cultures, seed cotton yield ranged from 927-1591 kg/ha, while Oil % varied from 17.56 % to 24.00 % . Culture 9 DC recorded the highest values for both these traits. For fibre technological properties 16 DC (27.4 mm) recorded highest 2.5 % span length followed by 26 DC (27.0 mm), while for bundle strength 25 K (21.7 g/tex) recorded the highest strength followed by 14 K (21.6 g/tex).

Among the crosses made among elite varieties. 70 F_2 generation were raised this year. Among these F_2 generation, 73 single plant selections were made . Some of the selections namely GV 23 recorded the seed cotton yield of 2434 kg/ha. Among the other promising selections GV 30 (2018 kg/ha) followed by GV 28 (1969 kg/ha) and GV 34 (1934 kg/ha) performed better. For oil trait line GV 19 SP_1 (21.90 %) recorded the highest oil percentage followed by GV 4 SP_2 (21.09 %).

Coimbatore

Evaluation for cottonseed oil and biochemical traits in 200 lines revealed that CBR 3 x F 1861-2-(2) and Anjali X F 1861-1-(2) possessed 24-26% seed oil content. Among the single plant selections that were made from the segregating

populations, Anjali x (A x F 1861) - 1 1- 1, Anjali x (Ax F 1861) - 2 1-2, Anjali x (Ax F 1861) -4-1-3, CBR 3 X F 1861 - 2 -2-1 recorded seed cotton yield of 120 - 140 g/plant. Wide variability could be seen for Nitrate Reductase activity and other biochemical constituents like reducing sugars, soluble protein and specific enzymatic activities. Among the genotypes analyzed, NR activity ranged between 1.9 3.2 μmoles NO_2^- formed per h per g fr.wt. at 25 days after sowing stage and 2.3 3.8 μmoles NO_2^- formed per h per g fr.wt at 40 days after sowing stage in leaves of high oil content genotypes.

Genetic Diversity through Introgression

Nagpur

Interspecific Crosses

Twenty-three wild species, 15 races and 20 perennials, sterile interspecific hybrids and synthetic polyploids are maintained in the species garden and 2 species in the pots. Pollen viability study of 18 wild species and sterile F_1 interspecific hybrid was done. Pollen viability in the species of B genome group was highest *i.e* upto 88.88%. Hence, seed setting when species of B genome group were crossed with cultivated species (66.67%) was more as compared to any other genome species (34.38%). On the other hand, the pollen size also plays an important role in the setting of crosses. Though the pollen viability of *G.aridum* was 72.56 % , the percent success of crosses set ranged from 37.50-46.38 due to comparatively large size of the pollen (106.5μ). About 280 cytologically stable and morphologically uniform lines developed through introgressive hybridization programme were screened and evaluated for biotic and abiotic stresses. Superior single plants were selected based on morphological characters. These lines show resistance and tolerance of various degrees to sucking pests, bollworms and diseases. Crosses were affected between 11 wild, 6 races (as pollinators) and 12 cultivated species. Derivatives of *(G. arboreum* × *G. australe)* 2 are screened for gossypol gland density in the fertilized ovule to identify plants with glandless seed. Interspecific F_1 hybrid *G. herbaceum* × *G. anomalum* was studied as it is highly heterotic bears broad, shiny, hairy leaves with big flowers (larger than both the parents, bears 250 small fruits and has exceptionally high fibre strength i.e. 36.7g/tex at 3.2mm gauge. To transfer this high strength character to the cultivated species, F_2 and backcross generations are under study. Two interspecific derivative lines MSH 45 and MSH 53 possess brown lint, average fibre length with fine fibre, good bundle strength and good uniformity. Established 11 cuttings of interspecific hybrids brought from Surat in the pots. Obtained seeds of 17 substitution lines from Dr Sukumar Saha, USA.

Out of the F_1 of 2004-05, 11 F_1 crosses involving various cultivars/ entries attempted at CICR, Nagpur were advanced to F_2 generation for further agronomic evaluation. One hundred seventy six segregating lines intervarietal crosses-102, Rai lines-208 MSH lines-108. Segregating material from different crosses for yield, fibre properties, biotic stress and abiotic stress was screened. Advance generation introgressed entries were evaluated for biotic and abiotic stresses.

Embryo Rescue

Ovules were harvested after 5-6 DAP and cultured on MS medium containing NAA, IAA and 2, 4-D coupled with kinetin combinations. In cross PA 255 x *G.anomalum*, 220 ovules of 6 DAP were cultured on different media combination. The response of ovules was mainly towards callus induction. In most of the

cultures containing NAA, IAA (2 mg/L) and 2,4-D and kinetin (0.1mg/L) the callusing of the ovules was accompanied by browning. In 2,4-D (0.5 mg/L) and kin (0.1 mg/L) the ovules were enlarged with callusing. In another cross AKA 8401 x LRA 5166 ovules harvested 6 DAP recorded highest callusing response of 78.0 % in 2,4-D (0.1 mg/L) + kin (0.1 mg/L).

Coimbatore

In a common trial, 19 stable introgressed lines obtained from various cooperating centres were evaluated for yield and other characters. The genotype TCHH 10235 from TNAU, Coimbatore ranked first with a mean seed cotton yield of 2200 kg/ha as compared with the best check variety Surabhi with a mean yield of 1970 kg/ha. Five other genotypes also showed numerical yield superiority over Surabhi.

Several superior single plants were selected in segregating lines obtained from different cooperating centres based on morphological characters. F_1's produced during the previous year between cultivated and wild species were raised and back crosses were effected with their cultivated parental species.

The BC_1F_1 seeds obtained by crossing the cultivated diploid hybrids of *G. arboreum* viz., K 10, K11 and G 27 with wild diploid*G. triphyllum* and back crossed with their corresponding *G. arboreum* cultivars were raised and back crossing was continued. The introgressed F_3 lines of the hybrid between the cultivated diploid *G. arboreum* cultivars and wild diploid *G. triphyllum* were raised and F_4 seeds were obtained.

Development of Transgenics

a) Development of transgenic cotton for insect resistance

G. hirsutum

Good progress has been made to develop transgenic cotton with Bt *cry* 1 A c in the elite cotton cv. Anjali (LRK516). The plants are now RCGM trial. First, T_1- generation transgenic plants were advanced T_2 generation. Total 403 plants were raised in the RCGM field trial and the population was maintained. Germination percentage was found to be 96%. Total 349 plants were tested, among these 39 plants showed CRY protein expression ranging from 0.55 1.24 ppm. However, the protein concentration was found to be less. The elite cultivar *G. hirsutum* Anjali (LRK 516) was transformed with Bt *cry* I Aa3 gene by *Agrobacterium* mediation. Five healthy transformed plants showed positive amplification of 0.7kb *npt-II* gene.

An attempt was made to isolate and characterize the presence of osmotin gene(s) in our cultivars which have already been characterized as drought tolerant. In the present investigation, two (0.2 and 0.4 kb) Osmotin gene fragments were amplified with specific primer from two cotton cultivars *viz* G. *hirsutum* cv. LRA - 5166 and MHL- 685 thus confirming the presence of osmotin genes in cotton genomes.

b) Development of transgenic cotton for CLCuV resistance

The gene constructs, viz, CaMV35S::Sense CP (700 bp), CaMV35S:: antisense CP(700 bp) and CaMV35S::Antisense Rep protein (340 bp) were received from IARI. The gene constructs were restricted at the Eco RI site and they were cloned in the binary vector EHA 101. The recombinant plasmid was then mobilized into *Agrobacterium tumefaciens* carrying the vir helper plasmid by freeze and thaw method. The presence of the plasmid was confirmed by isolation of the plasmid DNA from the *Agrobacterium tumefaciens* and amplification of the gene with specific primers. Three elite

genotypes H 777, F 846 and HS 6 were selected for transgenic development.

Two G. *hirsutum* varieties viz. LRK 516 and LRA 5166 were chosen for transformation with indigenously synthesized gene constructs of Cry I Aa 3, Cry1 Ia5 and Cry I F. Transformed LRA 5166 plants was subjected to PCR analysis using a pair of cry I Aa3 primers and npt II primers for the detection of cry IAa3 gene integration (Fig. 4 a & b).

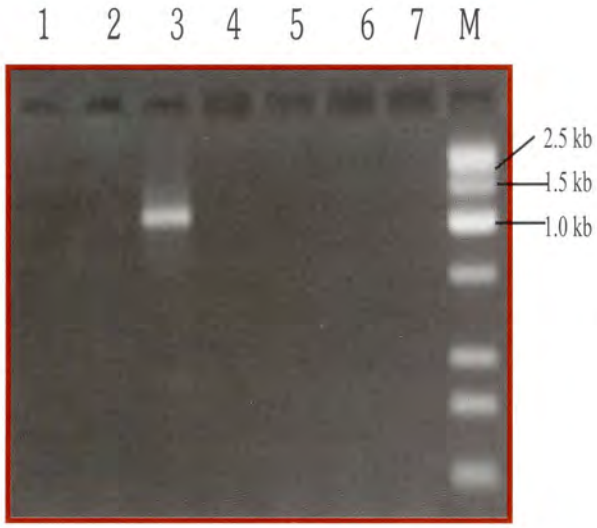


Fig. 4 (a): PCR analysis of T_0 transformed plants using a pair of *cry I Aa3* primers for the detection of *cry IAa3* gene, 1 to 6 - DNA of transformed plants, 7 - Control DNA sample of untransformed cotton plant, M- DNA ladder.

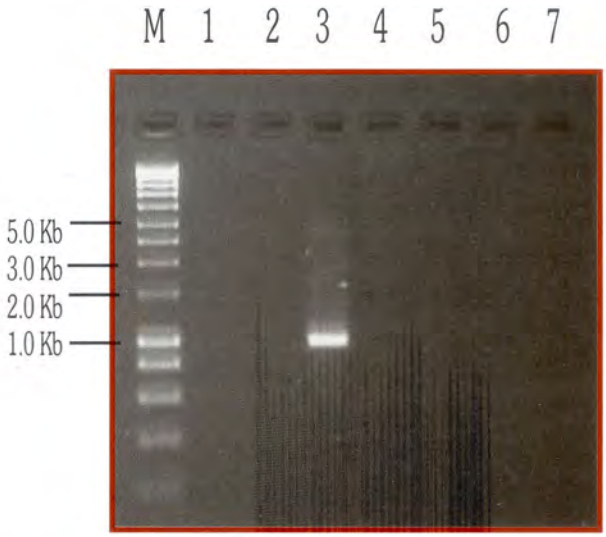


Fig. 4 (b): PCR analysis using *npt II* primers, 1 to 6 DNA of transformed plants, 7 - Control DNA sample of untransformed cotton plant, M-DNA ladder

LRA 5166 with *Cry I Ac* in T_3 generation were evaluated under RCGM field trial in the institute farm. Expression levels using ELISA were performed and seeds of the plant with higher expression of cry proteins were collected for next generation.

Seeds of T_2 generation of LRA 5166 with cry I Ac, cry I Aa3 and cry I A5 were subjected to limited field trial along with the commercial Bt. cotton such as MECH-12 and MECH-184 for comparative studies. Studies reveal that LRA 5166 with cry I Aa3 performed better in the field during limited field trial.

Twenty T_1 plants of cv PA 255 were raised in the glass house and were tested by ELISA. Two plants were identified as positive. The seeds of these plants have been collected and sown in the field this year.

Putative transformed shoots of cv PA 402 have been obtained by *Agrobacterium* mediated gene transfer containing cry I Aa3 gene and two plants were established in the soil in glasshouse.

RCGM trial : The transformed T_2 RG 8 seeds were sown in the field. The range of Bt protein in positives plants was 1.27 - 3.11 ug/g fresh leaf.

Molecular Breeding

Nagpur

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

Two SCAR markers (primer pairs designed 5' GTGAGGCGTCAGAGGGAT-3' (forward) and 5'- GTTGCCGTGCACTAGGCT-3' (reverse)), 5' AACTTAGCCGTCGCCACTTC-3' (forward) and 5'GGGCCTTAGCTGGCGGTCATC-3' (reverse) were developed to detect leaf curl virus resistance conferring genes in cotton. The markers were validated on F_5 mapping populations.

DNA Fingerprinting

60 RAPD primers, 08 ISSR and 31 SSR primers were used for the identification of the JKHy 1 and their parents and varieties viz. J.Tapti (*G.arboreum*), JK4 (*G. hirsutum*) RS 810, RS 875, RS 2013, HS 6, H 117 and HD 123.

The RAPD polymorphic primer OPC 1 led to the conformation of hybridity of JKHy 1 (Fig. 5) and hence can be used as a discriminating marker for testing.

Legends for Fig. 5, Fig. 6 and Fig. 7: Lane 1, 2 and 3 are Male, Hybrid and Female respectively of JKHy 1, Lane 4 is J. Tapti (*G. arboreum*), Lane 5 is JK4 (*G. hirshutum*), Lane 6 is RS 810, Lane 7 is For RS 875, Lane 8 is RS 2013, Lane 9 is HS 6, Lane 10 is H 117, Lane 11 is HD 123, Lane M - Low range DNA ruler

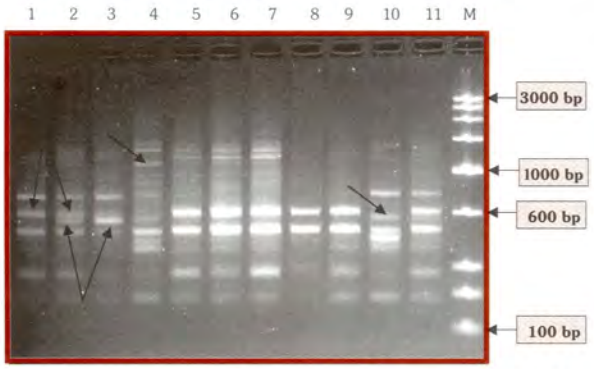


Fig. 5: RAPD profile of OPC 1 was found to be the perfect marker of JKHy 1 in which 275 bp, 500 bp and 600 bp band was present in hybrid and male but absent in female. 550 bp band of same primer present in female and hybrid but absent in male.

- The ISSR primer IS 11 led to the conformation of hybridity of JKHy 1 and hence can be used as a discriminating marker for testing.
- 37 RAPD polymorphic primers can be used as the discriminating and identifiable markers for the molecular analysis of the varieties.
- 8 ISSR polymorphic primers can be used as the discriminating and identifiable markers for the molecular analysis of the varieties (Fig. 6).

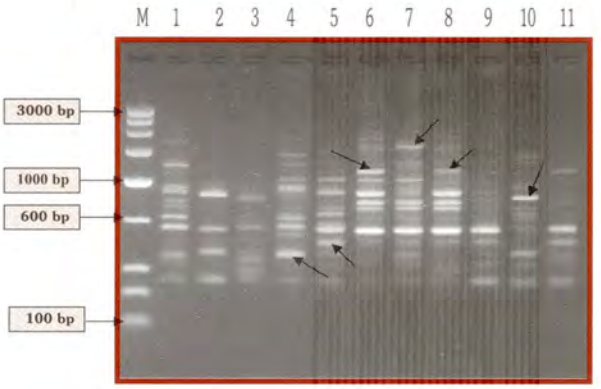


Fig 6: ISSR profile of IS 5, perfect polymorphic marker of varieties.

- 20 SSR polymorphic primers can be used as the discriminating and identifiable markers for the molecular analysis of the varieties (Fig. 7).
- 7 SSR polymorphic primers can be used as a discriminating marker for testing of JKHy 1 and their parent.

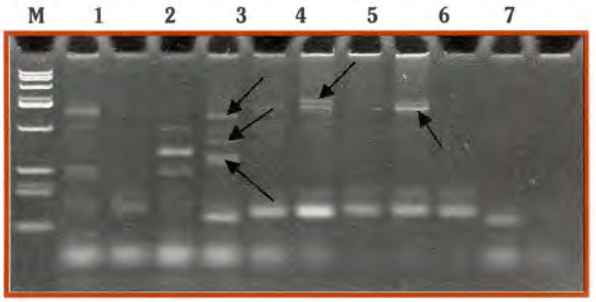


Fig 7: SSR profile of S 22, perfect polymorphic marker of varieties.

Seed Production and Seed Quality Improvement

Nagpur

Eighty two genotypes including 12 varieties, 22 hybrids and their 48 parents were tested for 41 morphological characters. Among *G. arboreum*, variety AKA 8401 (1266 kg/ha) gave highest yield in shallow soil. In medium soil, PA 402 (1275 kg/ha) gave the highest yield. In deep soil, AKA 7 (1464 kg/ha) gave the highest yield followed by PA 402 (1303 kg/ha). Variety `Veena' gave more than 90% germination in all three types of soil.

Dormancy/hard seed was found as 10% in G.Cot 15, G 824 and 30% in G 67 samples.

Different seed sizes (varied for seed index) with in two varieties viz. Surabhi and LRA 5166 were studied for germination% and seed reserve parameters (seed reserve depletion, seed reserve depletion ratio and seed reserve utilization efficiency). All parameters except seed reserve utilization efficiency varied among different sizes of seeds from 5 g to 11g, with bigger seeds giving superior values for above parameters in both the varieties. SRUE (Seed Reserve Utilization Efficiency), a trait found to be useful in faster seedling emergence did not vary significantly among the various seed sizes in both the varieties. This parameter also showed significant variation among 13 genotypes of *hirsutum* and *arboreum* as well as among 10 lines studied under drought tolerance. Among *hirsutums* F-1861 and among *arboreums*, AKA7 and among drought tolerant genotypes Laxmi had the highest values for SRUE.

A field study using LRA 5166 and Surabhi along with 3 different seed sizes and two different seed placements in each variety revealed bigger seed size to be significantly superior in better field emergence compared to other sizes and placements. Significant difference was observed for cotyledonary leaf area between genotypes as well as seed sizes. Bigger seeds of Surabhi had the highest cotyledonary leaf area, No. of bolls/plant and seed cotton yield/plant was significantly higher for bigger sized seeds emerged early from deeper placement compared to shallow placement.

The effect of foliar sprays of micronutrients on seed cotton yield and resultant seed quality improvement was studied in variety Anjali. Foliar spray of Boric acid @ 0.6 kg/ha. and DAP @ 2% twice at 75 DAS and 90 DAS gave significantly higher no: of bolls/plant (23) as well as SCY/plant (70.30 g) followed by DAP alone and DAP + Boric acid+ Zn sulphate respectively. The seed index and germination% was highest (8.3 g and 74% respectively) on the seeds picked from the treatment consisting DAP and Boric acid spray followed by DAP sprayed alone and DAP+Boric acid + Zn respectively.

Coimbatore

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

One additional irrigation led to higher germination quotient of the harvested seed. Foliar application of DAP @ 2 % + Boron @ 0.6 kg/ha + Zinc @ 0.5% significantly improved the seed quality and recorded higher values for all the parameters in the seeds of first and second picking. Application of DAP @ 2 %, Boron @

0.6 kg/ha and Zinc @ 0.5% individually had marginal effect on seed quality improvement. However, combined application of DAP @ 2 % + Boron @ 0.6 kg/ha + Zinc @ 0.5% thrice during flowering and boll maturation resulted in the harvest of quality cotton seed with an increase in seed yield.

Standardization of Seed Pelleting/ Coating with Polymers

Seeds treated with Polykote @ 3 ml kg^{-1} + Thiram 75% WDP @ 2.5 g kg^{-1} + Super red @ 5 ml kg^{-1} + Cruiser 75% WP @ 5 g kg^{-1} coating improved viability from 91% to 95% and from 90% to 95% in case of polyloc. Coating seeds either with polykote or polyloc have shown improved field emergence.

At sixteen months of storage seeds coated with Polykote @ 3 ml kg^{-1} + Thiram 75% WDP @ 2.5 g kg^{-1} + Super red @ 5 ml kg^{-1} + Cruiser 75% WP @ 5 g kg^{-1} have registered germination of 86% and 83% which were significantly higher than in untreated seeds stored in (70% and 71%) cloth bag and poly bag, respectively. Similar observations were noticed for other parameters recorded in this experiment.

Sirsa

1. Hybrid seed production: The suitable crossing period was noticed up to 25 September and the cross boll setting percentage was above 30 % in Om Shankar and CSHH 198 and 52 % in CISAA 2. After this period the cross boll setting percentage declined gradually and after 7th October was negligible. The foliar spray of Boron at 60, 75, and 90 DAS showed significant improvement in cross boll setting percentage during entire crossing period. The yield and seed quality was superior in this treatment than the other treatments.

2. Varietal seed production: Significant increase in boll number, yield, seed quality and boll weight was observed when combination of DAP 2% at 45 DAS, $MgSO_4$ 1 % at 50 DAS, Boron 0.1% at 60 DAS and $ZnSO_4$ 2% at 75 DAS were applied. In varieties the yield was higher when topping was made at 60 DAS. The seed quality was superior in second picking followed by first picking and least in third picking during this year. Maximum improvement in germination percentage, vigour index and field emergence (%) was noticed when seed was treated with polyloc along with thiram and vitavax.

Maintenance breeding: The selected 5 female, male progenies of each of hybrid Om Shankar, CSHH 198 and CISAA 2 were evaluated based on *sca, gca,* per se performance and biotic stress condition and in Om Shankar female progeny P24, P153 and male P28, P32; in CSHH 198 P1, P3, P4 of female and P3, P4 of male and in CISAA 2 P10, P 6 of female and P3, P6 of male parent were noticed good combiners for yield contributing characters and fibre properties.

Standardization of seed pelleting/ coating with polymers

The polymer coating experiment in combination with fungicide and insecticide was conducted under national seed project. Among the various treatments the polyloc along with thiram and vitavax were found with respect to germination percentage, vigour index and field emergence.

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.

Nucleus seed production

20 kg seeds each of the two cultivars viz. CNH 120 MB (Pratima) and CNH 36 were produced.

Name of Variety/ hybrids		2005-06	
		Indent (q)	Production (q)
LRA 5166		3.81	4.80
LRK 516 (Anjali)		1.96	2.98
Surabhi		0.99	1.00
Supriya		0.80	1.00
Sumangala		0.15	0.50
CSHH 198			
	Female		0.50
	Male		0.20
CISAA2			
	Female		0.20
	Male		0.20

Integrated Water Management

Nagpur

Results showed that maximum (1904 kg ha^{-1}) seed cotton yield was recorded in the treatment where 50 % NPK (120 : 60 : 60 kg ha^{-1}) was applied as basal and rest 50 % through fertigation alongwith micronutrient (10 kg $ZnSO_4$ ha^{-1}) closely followed by 1773 kg ha^{-1} by the treatment with 50 % NPK as basal and 50 % through fertigation + micronutrient @ 10 kg $ZnSO_4$ ha^{-1}) and the mean minimum (1294 kg ha^{-1}) under control. Higher seed cotton yield in this treatment was supported significantly by yield contributing characters like number of bolls, boll weight (g) and yield per plant (g). Overall, the seed cotton yield improvement in all the treatments was > 372 kg ha^{-1}) over control.

However, split application of recommended dose of fertilizer (50 % NPK as basal and 50 % NPK through fertigation), with integration of $ZnSO_4$ + Biofertilizer + 1.5 t ha^{-1} FYM was found essential and economically suitable for cotton under drip in shallow soil.

In-situ moisture conservation

In-situ moisture conservation practice such as opening of alternate furrow was able to enhance seed cotton yield by about 220 kg ha^{-1}, while opening of furrow in each row after last interculture lead to enhancement by 55 kg ha^{-1} and almost similar increase in yield was recorded due to tied hoeing over control.

Water use efficiency

The impact of different moisture conservation practices on water use efficiency was evaluated. Maximum (1.91 kg ha^{-1} mm^{-1}) water use efficiency was recorded where greengram was intercropped with cotton followed by opening of alternate furrow after last interculture and the minimum (1.61 kg ha^{-1} mm^{-1}) under control.

Coimbatore

Poly mulching in cotton based cropping system

Irrespective of colour, all the poly films enhanced the growth and development of cotton significantly due to favourable microclimate like optimum soil moisture (nearer to field capacity) and higher temperature. The

Low cost drip system

Multi-tier inter cropping

Cotton crop under
drip + polymulching

PCR kit for
Xanthomonas detection

root CEC of poly mulched cotton ranged from 16.12 to 17.68 (m.eq/100 g) as against 13.0 m.eq in non mulching. Among the treatments, silver colour poly film accumulated the highest DMP of 215.1 g/plant at 90 DAS. The enhancement in seed cotton yield due to polymulching was to the tune of 2.10, 2.01, 1.98, 1.80 and 1.69 fold respectively in silver, red, blue, black and yellow colours than conventional method (Table 11).

Table 11: Root cation exchange capacity and growth attributes of cotton cv LRA 5166 as influenced by coloured poly mulching on 90 DAS

Treatments	Root CEC m.eq/100g	Plant Height (cm)	No. Leaves / Plant	Leaf Area (cm) / leaf	DMP g/plant
Control – T_1	13.00	96.3	114.0	96.4	96.8
Black – T_2	17.42	106.7	183.3	144.1	191.9
Red – T_3	16.90	107.3	163.0	155.5	179.1
Blue – T_4	16.12	104.3	162.7	157.4	205.8
Silver – T_5	17.68	114.0	173.7	162.0	215.6
Yellow – T_6	16.38	109.0	177.7	152.8	190.3
SEd	1.13	7.21	12.36	18.2	11.8
CD 5 %	2.51	16.07	27.53	40.6	25.2

Drip and polymulch in cotton maize cropping system

The growth of cotton cv. LRA 5166 was influenced favourably due to polymulching and drip + polymulching and found better than drip irrigated cotton. The polymulched cotton with drip irrigation scheduled at 0.4 ETC were taller by 27 cm than drip-irrigated cotton at 0.8 ETC. The growth attributes like number of leaves/plant, leaf area, node no. and dry matter accumulation were higher under polymulch + Drip at 0.4 ETC than Drip at 0.8 ETC. The polymulch + Drip at 0.4 ETC recorded the highest number of harvestable bolls/plant. The total water requirement for various treatments ranged from 57.3 to 92.7 ha cm and scheduling of irrigation at 0.4 ETC + polymulching recorded the highest (42.7 kg/ha cm) water use efficiency as against (16.10 kg/ha cm) recorded under conventional method.

Rain water management through agro techniques

Opening of furrow at each row at sowing registered the highest seed cotton yield (2690 kg/ha). The highest seed cotton equivalent yield (2800 kg/ha) and rainfall use efficiency (RUE - 7.0 kg/ha-mm) were calculated with cotton intercropped with black gram. Cotton +black gram system in addition to intercrop yield (203 kg/ha), produced moderately higher seed cotton yield (2480 kg/ha) which resulted in higher seed cotton equivalent yield and rainfall use efficiency.

Response of different growth stages of cotton to protective irrigation

The highest seed cotton yield of 2390 kg/ha was obtained with the application of irrigation water as per the climatic needs (0.8 = IW/CPE) of the crop (three irrigations were given). The least seed cotton yield (1970 kg/ha) was recorded in rainfed control. The results proved the necessity of supplemental irrigation in addition to rainfall

to realize higher growth and yield.

Water management in *G. hirsutum* cotton

Seed cotton yield was not influenced by different drip layouts. Polytube lateral drip system was found to be much cheaper than the LLDPE with dripper system. Higher irrigation use efficiency (85%) and water saving (51.5 %) were calculated with drip irrigation system treatments as compared to control (ridges and furrow method) (Table 12).

Table 12 : Seed cotton yield, water use efficiency (kg/ha-mm), irrigation use efficiency and economics of low cost drip irrigation system.

Particulars	LLDPE with		Polytube thickness			Control
	Dripper	Micro-tube	150 gauge	300 gauge	450 gauge	Ridges & Furrows
Seed cotton yield (kg/ha)	3020	2680	2650	2890	2870	3150
Irrigation use efficiency (kg/ha-mm)	41.5	36.9	36.5	39.8	39.5	21.0
Total cost of irrigation system (Rs/ha)	69025	35338	11990	12430	13310	-
Per annum cost of irrigation (Rs/ha)	13112	6710	3410	3905	4505	2200
Total cost of cultivation (Rs/ha)	41305	34903	31383	32098	32698	28193
Total gross returns (Rs/ha)	63420	56280	55650	60690	60270	66150
Total net return (Rs/ha)	22115	21377	24267	28592	27572	37957
Benefit cost ratio	1.5	1.6	1.8	1.9	1.8	2.3

Integrated Nutrient Management

Nagpur

Studies conducted on the effect of manurial treatments on yield of cotton and pigeonpea grown in strip cropping system indicate significantly higher seed cotton yield in the treatment N60 P30 K30 + 2t FYM + 2t goat manure (904 kg/ha) and N 90 P 45 K 45 + S 20 + Zn 20 (881 kg/ha) over farmers' practice (622 kg/ha) and FYM treated plots (736 kg/ha) applied in the same plots in the second successive year. Least seed cotton yield was recorded in control plot. Higher yield in pigeon pea was obtained in FYM applied plots. No significant difference in biological yields in the manurial treatments was observed although it was significantly higher over lower dose of NPK and control plots. An increase in staple length in NHH 44 hybrid (1.5 mm) in FYM plots over lower dose of NPK was observed.

Effect of nutrients on yield and fibre quality of rainfed Bt hybrids

Significantly higher seed cotton yield of Bt MECH 184 and non-Bt NHH 44 was recorded with foliar application of potassium nitrate alongwith Boron and Zinc (B @ 10 kg and Zn @ 2.25 kg /ha) over recommended dose of NPK. No significant difference in yield with Zn and B treatments was observed. MECH 184 Bt responded to foliar application of nutrients.

However, higher boll weight of MECH 184 Bt was recorded with Boron application. Combined foliar application of potassium nitrate with Zn and B increased bundle strength significantly over other fertilizer treatments. Among the hybrids, significant differences were observed.

Agronomical evaluation of Bt NCS 138 and NCS 913 (Bunny) under rainfed conditions

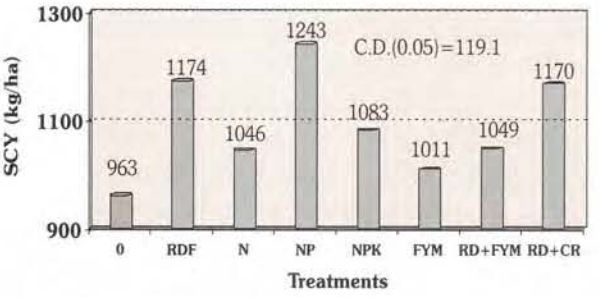
Data on Bt NCS 138, NCS 913, Bunny and NHH 44 (check) with different fertilizer and spacings indicate significantly higher seed cotton yield in Bt hybrids (ranging from 2080 to 2652 kg/ha) over non Bt hybrids Bunny (1000 kg/ha) and NHH 44 (1650 kg/ha). Among the spacings, all the hybrids (Bt and non-Bt) at 90 x 45 spacing gave an additional seed cotton yield of 250 kg/ha over 90 x 60 cm and 330 kg/ha over 90 x 30 cm. Boll weight in both the Bt hybrids was in the range of 4.2 4.8 gm where as in NHH44 it was 3-3.2 gm. Good fibre values viz. staple length and bundle strength in both the Bt hybrids were recorded. Significant varietal differences for fibre values were observed while fertilizer treatments (NPK 100:60:80 and 150:80:100) did not have any significant impact.

Coimbatore

Long term effect of nutrients in cotton based cropping system

Cotton-jowar out yielded (seed cotton yield of 1081 kg/ha) significantly cotton-fallow (834 kg/ha) with additional jowar grain and straw yield of 6480 and 1680 kg/ha respectively. Highest seed cotton yield (1243 kg/ha) was realized following application of N:P:K @ 90:19:0 kg/ha and was on par with RDF (60:13:25 kg/ha) and RD plus 2.5 t/ha of crop residues (RD+CR) at the end of 3 years of cropping (Fig. 8) in this K enriched mixed black calcareous clay loam soil PERIYANAICKAN-PALAYAM series-vertic ustropept) with medium fertility status.

Fig.8: Effect of long term nutrient supply on cotton



Conservation Tillage

Nagpur

Tillage and green manure effects on growth and yield of cotton and soil properties

Studies were conducted for the 10th consecutive year with a fixed layout for the tillage treatments. Bt (RCH-2) was the cultivar grown during the year. Among the tillage treatments, reduced tillage with two interculture operations (1874 kg seed cotton/ha) was at par with the reduced tillage without any interculture operations (2054 kg/ha). Both the reduced tillage treatments yielded significantly more than the conventional tillage treatment (1526 kg/ha). Improvements in the reduced tillage treatments were due to an effective weed control.

Green manure was grown *in situ* (in between crop rows) to evaluate the possibility of N saving. Yield with 80 kg N + GM (1864 kg/ha) was on par with 100 kg N plots (1791 kg/ha). A further reduction of fertilizer N to 60% of recommended N (1479 kg/ha) reduced seed cotton yield significantly. The results of this first year of study, indicate a potential saving of 20% N with an *in situ* green manure. Furthermore, *in situ* green manure plots had a lower weed

density and consequently lesser weed biomass (6.25 $\pm$ 1.5 g/m^2) as compared to the non-mulched plots (14.6 $\pm$ 4.2 g/m^2). The mulch also provides a better soil hydrothermal regime.

The results of the third year and pooled analysis indicate the benefits of rotation. Seed cotton yield in 2005-06 was significantly greater in the cotton-soybean rotation plots (1058 kg/ha) than the cotton-cotton monoculture treatment (750 kg/ha). Among the nutrient management practices, yield was the highest in the site-specific nutrient management treatment (1278 kg/ha) and was significantly greater than the application of recommended dose (90-19-37 kg NPK/ha) of fertilizers (886 kg/ha). Interestingly, no significant response was observed to application of Zinc or Boron, especially considering that the soils are low in Zinc (<0.6 ppm Zn). However, these results do not mean that Zinc or Boron is not needed. It is probable that the cultivar NHH-44 has a better capacity to grow under low Zn soils. A small addition of organic manure (25% of N) on a regular basis was found to improve yields (1074 kg/ha) as compared to application of mineral fertilizers alone (886 kg/ha).

In a second experiment, application of K to Bt transgenic hybrid resulted in a significantly greater seed cotton yield (1546 kg/ha) than the treatment NP (1301 kg/ha). However, there was no effect of foliar application over the soil application. Similar results were observed in on-farm trials conducted in Wardha district. Average of eight farms, yield in the farmers' practice, NP and NPK treatments was 710, 778 and 875 kg seed cotton/ha.

There was no significant difference among the various organic sources (crop residue compost, farmyard manure, vermicompost) in the first year of the study. Yield in the organic manure alone was the least and was at par with the control treatment.

Coimbatore

In situ green manuring

Application of FYM @ 5 t/ha along with RDF was found to be equally effective as that of RDF + dried grass @ 5 t/ha over only RDF, neem and cotton stalks applied on soil surface @ 5t/ha and control. Maximum yield was obtained with easily decomposable biowastes. Soft plant tissues such as dried leaves, Parthenium weeds and Trianthema were equally effective in realizing yield similar to that of FYM or RDF.

Cotton Based Cropping Systems

Nagpur

Cotton + soybean + pigeonpea and Soybean-wheat/sunflower were studied for additional micronutrient requirement, without changing randomization in order to improve profitability of cotton and cotton based cropping system. The excess rainfall and its distribution nullified the influence of soil depth from shallow to medium soils under similar nutrient supply. The foliar spray of micro nutrients brought about 8 % improvement in medium soil grain yield. Chelated and non chelated micronutrients foliar sprays brought about 35 and 30 % higher grain yield of pure soybean in shallow soils.

The intercrop biomass and yield of soybean with cotton were 50 % of pure crop yield i.e. proportion to its plant stand and was not significantly effected by soil depth, moisture management and micronutrient treatments. The biomass of cotton intercropped with soybean was significantly influenced by soil depth increasing from shallow to medium soils and also with soil and or foliar application of Zn, Mn and B together. The chelated micronutrients

found an edge over non chelated. The pure soybean biomass was significantly higher in medium deep soil but positively higher with soil and or foliar application of micronutrients. The intercropped pigeonpea responded well to micronutrients in medium soils (both chelated and non chelated micronutrient sprays).

The profitability of the system was analysed which was giving a minimum of 1.48, 1.59, 1.63, 1.85, 2.03, 1.91, 1.89, LER and BCR 4.65, 4.81, 4.62, 4.82, 4.84, 5.02, 5.44 in control, Zn 10, Mn 10, B3 kg ha^{-1} yr, Zn + Mn + Bo (75% soil + 2.5% foliar) chealated and non chelated foliar application of micronutrients. The best is soil and foliar application followed by chelated foliar sprays.

Cotton + pigeonpea 8: 2 seed treatment with bio-inoculants *Azotobacter, Azospirillum/ Rhizobium, Pseudomonas, Basillus subtilis* together at the time of sowing with soil moisture conservation through ridges and furrows and 2% urea alongwith micronutrients in chelated form two foliar sprays prior to flowering was found to be yield 32% over non chelated form, 39% over bio-inoculants and conservation measures and 49% over 50% RDF. Similar trend was also observed in *desi* cotton.

Impact of intercropping on seed cotton yield

The impact assessment of intercrops in cotton was conducted. It was found that maximum effect of intercrops on seed cotton yield was recorded in case of greengram (224 kg) followed by blackgram (75 kg) and least by soybean (15 kg). This showed that greengram being the short duration crop has no adverse effect on cotton crop performance over other crops. Not only this, greengram residue also improved organic matter content in the soil, alongwith soil moisture.

Gross yield and gross return (Rs ha^{-1})

Mean maximum (2466 kg ha^{-1}) gross yield was recorded in the treatment where soybean was intercropped with cotton followed by blackgram and greengram and the lowest (1278 kg ha^{-1}) under sole cotton. Similarly, the mean maximum (4811 kg ha^{-1}) gross return was recorded in the treatment where greengram was intercropped with cotton. Higher gross return in cotton with greengram as intercrop was mainly due to high produce value in the market, with the added advantage of higher water use efficiency also.

Significant mean maximum (1380 kg ha^{-1}) seed cotton yield was recorded with 3 irrigaitions; first at flowering, second at early boll and third at peak boll development stage, closely followed by (1257 kg ha^{-1}) two irrigations first at early boll and second at peak boll development stage.

Coimbatore

Cotton based multi-tier vegetables intercropping system for higher production and economic return

The highest seed cotton yield (2480 kg/ha) was obtained with the intercropping of radish + beetroot + coriander between the cotton rows. Periodical harvest of intercrops coriander (25 DAS), radish (45 DAS), and beetroot (75 DAS), lead to less competition within the component crops which ultimately resulted in significantly higher seed cotton yield with cotton + radish + beetroot + coriander system. The least seed cotton yield (2080 kg/ha) was harvested in control plot. The highest gross return of Rs. 167614/ha, net return of Rs. 118217/ha and benefit cost ratio 3.4 were realised with cotton intercropped with radish + cluster bean + beetroot system in Table 13.

Table 13: Seed cotton yield and economics of multitier cropping system

Treatments	Seed Cotton Yield (kg/ha)	Net profit (Rs/ha)	Benefit cost ratio	Seed cotton equivalent yield (kg/ha)
T1. Sole cotton	2080	15487	1.5	2080
T2. Cotton + radish + Veg.cowpea + beetroot	2430	90339	3.1	6300
T3. Cotton + radish + cluster bean + beetroot	2180	118217	3.4	7980
T4. Cotton + radish + dolichos + beet root	2310	90012	3.3	6190
T5. Cotton + Coriander + veg.cowpea + cluster bean	2340	98904	3.0	7080
T6. Cotton + coriander + dolichos + cluster bean	2110	75157	2.6	5880
T7. Cotton + beet root + veg.cowpea + cluster bean	2420	91430	2.8	6810
T8. Cotton + cluster bean + veg.cowpea + dolichos	2240	66212	2.3	5540
T9. Cotton + radish + beet root + coriander	2480	95025	3.4	6340
SED	110	-	-	-
CD (5%)	240	-	-	-

Organic Cotton Production

Nagpur

The field experiment was conducted in organic management with fermented cow dung + urine water four times and bioinoculants + Rockphosphate as RDF and inorganic as per recommended package. American hybrids, varieties and green gram (intercrop) were found significant with 50, 68 % and 37 % higher yield respectively under organic management (11th year). The superior hybrids were H 10 and PKV Hy2 confirming last year trial results. Among varieties Surabhi, Abadhita, Sahana, AKA 5 and 7 were statistically similar but superior over PKV Rajat, AKA 8 and CINA 316.

Ergonomically Efficient Implements for Cotton Production

Battery operated knapsack sprayer was evaluated in the laboratory, field condition as well as in the farmers' fields. It was found that it can spray maximum 22 spray tanks each having 16 litres spray liquid in single stroke of battery charge. The field capacity, comfort, convenience and other feed backs were analysed for fine tuning. Spray droplet analysis was done by using lever operated knapsack sprayer.

Multipurpose tool bar having an attachment for sowing of cotton with soybean and fertilizer placement was developed and is under field testing. Local and improved implements were studied. Wooden interculture hoes were designed for square planting, paired row planting and intercropping with adjustable spacing which can save man power with limited maintenance.

Production Physiology

Nagpur

Effect of plant growth regulators and nutrients on the growth and yield of cotton under rainfed condition

In a field experiment, MECH Bt 184, Bunny and NHH 44 were given foliar sprays of Naphthalene acetic acid 20 ppm, suphala 1% and, copper sulphate 0.3% during flowering. Detopping was included as one of the treatments. The results indicated that the treatment and interaction effects were non-significant, whereas significant genotype differences were noticed with regard to root length, leaf production and seed-cotton yield. Among the various treatments imposed during flowering, Suphala 1% foliar spray improved yield in all the cultivars.

Genotypes suitable for cultivation in shallow soil

Seven *G.arboreum* genotypes (AKA 7, AKA 8401, DLSA 17, G.Cot 19, PA 255, PA 402, Veena) and one *G.hirsutum* genotype (LRK 516) grown under deep and shallow soil conditions were sampled for growth in terms of root length, shoot length, production of nodes, leaves and squares, relative water content and biomass production of root, shoot, leaf and fruiting parts. Soil moisture status was recorded for both deep and shallow soils on two occasions.

The results point out that leaf production remained higher in G.Cot 19 followed by DLSA 17 under shallow soil. The genotypes DLSA 17 and AKA 7 had maintained higher square production. The performance of AKA 7 is also better under deep soil condition. The soil moisture content was found to be higher in deep soil as compared to shallow soil

Coimbatore

Physiological and molecular elucidation of fibre development process

Wide variability in amylase activity was seen during crop growth period in different cultivars. The biochemical changes from the date of anthesis to maturity has been analysed from seed and fibre of lint (MCU 5) and lintless mutant (MCU 5 LL) as well as in fuzz and fuzziless mutants (AKH 98-8-1). The biochemical constituents *viz.*, reducing sugars, proline, total soluble protein, total phenols, IAA oxidase and peroxidase were estimated. Significant polymorphism has been noticed between linted and lintless mutant for three primers studied. Ovule culture studies showed that the nutrient and hormonal changes brought about perceptible change in seed and fibre developmental pattern. With the application of GA @ 0.5 ppm, there was fibre initiation in fibre less mutants of MCU 5 LL.

Isolation and regeneration from cotton protoplasts

Effective digestion protocol for protoplast isolation from leaf tissues of cotton genotype Sumangala has been standardised. Cellulase (2.0%) + Macerozymes (0.5%) from Onozuka was found effective for digestion and release of healthy protoplast from leaves. The osmolarity was maintained by 9.0% mannitol. Cell wall formation and cell division was observed when protoplasts were cultured in liquid medium with 1 $mg.^{-1}$ L 2,4-D + 0.5 $mg.^{-1}$ L Kin.

Crop and yield modelling

Nagpur

Refinement of regional level prediction of cotton production

A field experiment was conducted involving Bt and non-Bt hybrids and varieties and date of sowing as treatments at CICR, Nagpur. The soil, crop and weather data of the experimental site

was calculated in Infocrop format for model calibration. The model, which was calibrated and validated earlier for the simulation of growth and yield of hybrids and varieties of cotton, was iterated to simulate the duration required for flowering and maturity. Adjusting the phenology related parameters in the model had correctly simulated the biomass and yield of MECH 184, RCH 2, Bunny and Suarbhi except in the case of late sown RCH2 hybrids. This requires further fine-tuning in the model.

At the macro level, the integrated approach for yield assessment at district level was undertaken in four cotton growing districts viz. Nagpur, Bharuch, Dharwad and Sirsa. The area, production and productivity estimates through integrated approach (remote sensed data, GIS and crop model) for the year 2005-06 were found to be quite satisfactory in respect of Sirsa, Bharuch and Dharwad districts with a variation ranging from 5-13 %. For Nagpur district, however, the figures derived from integrated approach in respect of production and productivity were found to be much higher than the observed values. Attempts are underway to refine the crop model as well as the approach and incorporate the pest factor in arriving at production and productivity estimates.

Coimbatore

Interaction effect of genotypes, nitrogen and date of sowing on cotton growth and development

Nitrogen had no significant influence on seedling emergence and germination. Delayed sowing showed greater root growth for the first 60-90 days. Plant height, root length, leaf area and other physiological parameters were significantly higher in delayed sowing (D2) compared to early sowing (D1) in cotton cv. Suvin, but was not partitioned to the kapas at harvest. The partitioning of photosyntahtes to boll development in cv. Surabhi was better in D1 than in D2.

Phenological variations between Bt and non-Bt versions of cotton

It was observed that the Bunny Bt showed a higher seedling vigor over non- Bt. The plant height, root length and leaf area was higher in Bt over its non- Bt counterpart, till 60-75 days, while the total fresh weight was higher till 135 days. The *kapas* yield was higher in Bt (115.1 g/plant) over the non Bt Bunny (55 g/plant). The plant growth characteristics like plant height, root length ceased to grow after 90 days, while the active growth of stem and root was observed till 120-135 days in non Bt variant. Hence, the partitioning to the economic part was not effective in non Bt Bunny. Similar trend was observed in Mallika Bt and non-Bt

Source-sink Relationship in Cotton

Nagpur

Plant mapping

Temporal and spatial distribution of fruiting forms, retention and their fate on the plant, shedding pattern and plants ability to compensate for the early loss of fruiting forms were recorded in 32 field grown plants. The above observations were recorded every alternate day both in Bt and non-Bt plants in order to analyze the genotypic and environmental interaction on fruiting forms. Genotypic as well as environmental influence was seen on the retention of fruiting forms at different positions on the canopy. Bt plants had lost fruiting forms more by physiological factors and less by entomological factors while it was vice versa in non-Bt plants.

Coimbatore

Foliar application of ethrel at 40 DAS brought about shedding of already produced squares and also delayed further square initiation by 15-20 days. Irrespective of the concentration, ethrel application brought about change in the plant biology leading to robust plant growth. There

was a significant change in the biochemical constituents with increase in NR activity, enhanced accumulation of reducing sugars, proline and protein.

The partitioning of the biomass was initially more to the vegetative part like stem and root. The stem girth doubled over the control plant. With the delayed initiation of reproductive growth, the shift in partitioning changed. There was total shift and more than 80% went to the fruiting part and very little to the stem and root. There was synchronous flowering and boll development with ethrel application leading to uniform boll bursting and picking was completed in 1-2 pickings. Application of ethrel @ 60 ppm brought about total shedding of squares transiting suppression of growth followed by total recovery alongwith higher seed cotton yield as compared to control (Table 14).

Table 14: Effect of ethrel on physiology and yield of cotton cultivars

Treatments	Plant height (cm)	Number of sympodia	Leaf area	Boll number	Boll weight (g)	Yield (kg/ha)
V1T1	79.4	21.0	943	26.6	3.00	1620
V1T2	136.2	27.0	6830	44.2	2.80	2490
V1T3	115.0	23.0	6831	36.6	2.80	2070
V2T1	107.0	20.4	1746	23.4	3.00	1418
V2T2	121.2	22.6	11524	50.0	2.80	2828
V2T3	131.2	25.8	10159	47.0	2.80	2658
CV (%)	17.1	13.8	33.8	34.4		
LSD -V	NS	NS	2194**	7.1*		
LSD-T	22.9**	3.8**	2687*	8.7**		
LSD- V X T	23.7*	3.9*	NS	12.2**		

V1 LRA 5166; V2 Sumangala; T1- Control; T2 - Ethrel @ 30 ppm; T3 ethrel @ 60 ppm

Response of elevated carbon dioxide on physiology and productivity of cotton

Suvin was raised under elevated CO_2 atmosphere of 650 ± 50 ppm throughout the cropping period under field conditions. At harvest, improvement in plant height, number of nodes, leaf area, boll number, boll weight, total dry matter production was noticed. Thus, the yielding ability of the plants under elevated CO_2 atmosphere was very apparent and significant. Plants grown under elevated CO_2 atmosphere always maintained a higher level of photosynthetic activity right from the initial stages until harvest. The lint index, seed index and seed oil content also showed an increase under elevated CO_2 atmosphere.

Physiological Disorders

Nagpur

Effect of 2,4-D on plant growth

2, 4-D spray (5 ppm) enhanced boll drying indicating involvement of hormonal action. The results reveal that pre-soaking of seeds with 2,4-D resulted with delay in germination, stunted growth and reduction in number of nodes and leaves. However, typical 2,4-D symptoms like leaf modification with prominent veins and tubular floral structures did not appear even after a prolonged period after sowing of the pre-soaked seeds. On the other hand, foliar application of 2,4-D (5 ppm) instantly brought out the typical 2,4-D symptoms within a week time. This indicates the differential mode of action of 2,4-D in the plant system. It is possible that in the pre-soaking treatment, seed constituents possibly reduced the deleterious effects of 2,4-D to a greater extent. The study needs further confirmation.

Stress Physiology

Nagpur

Screening cotton genotypes belonging to *G.hirsutum* and *G. aboreum* for drought tolerance

19 genotypes were screened for drought tolerance during flowering in a pot experiment. The genotypes are *G.hir* 4, CAT-385, 3556, 1058, 3815, 379, 1285, 3845, 848, 3796, MECH Bt 184, Bunny, LRA 5166, NHH 44 (*G.hirsutum*) CAT 7396, CAT 7861, AC 1, AC 3 (A), CAT 6962 (*G.arboreum*). Observations were recorded on leaf water potential, relative water content, solute concentration, stomatal resistance, transpiration rate, transpiration coefficient, biomass production, recovery of leaf relative water content, root-shoot ratio and yield. Nitrate reductase activity, anti-oxidant enzymes (Catalase and peroxidase) and protein profile were determined. The data were statistically analyzed. The treatment and genotype effects are mostly significant. The relatively tolerant lines identified ar -CAT 1058, CAT 848, CAT 385, CAT 3796, CAT 379, CAT 3596, CAT 7861, CAT 6962, AC 3 (A).

Drought stress imposed during flowering decreased leaf water status in all genotypes. Leaf solute concentration remained higher in *arboreum* genotypes indicating a trend towards higher osmotic adjustment. Stomatal resistance was found to be relatively higher in *hirsutum* genotypes due to the drought treatment. Transpiration rate and transpiration coefficient were found to be higher in *arboreum* lines indicating relatively higher leaf cooling tendencies in *arboreum*.

Root and shoot biomass production trends showed a tendency of increase under drought stress while the leaf and fruiting parts biomass

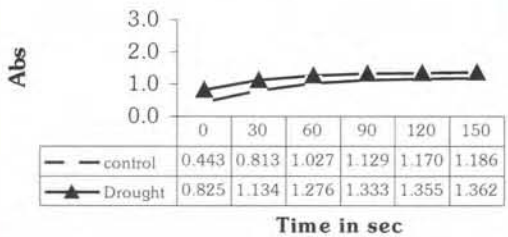
production tended to decrease under stress condition. The total biomass production decreased under drought environment and it remained higher in genotypes belonging to *G.hirsutum*. Root-shoot ratio increased under drought stress and remained higher in *arboreum* lines, on a comparative basis, root-shoot ratio both in micro-plots and pots remained mostly on par except differences in quantitative terms. The associative trends among important plant traits pertaining to stomatal and non-stomatal parameters remained higher under drought environment as compared to control. Seed-cotton yield remained higher in *G.hirsutum* genotypes and yield reduction occurred due to drought. However, yield stability was relatively higher in *arboreum* genotypes grown under stress condition.

Biochemical and molecular aspects

- Nitrate reductase activity (NRA) : The activity has been estimated in the leaves during 4th day of moisture stress. All the genotypes except 2 *hirsutum* lines showed more NR activity under stress as compared to control.

Anti-oxidant enzymes: Catalase activity measured during moisture stress did not show any definite trend in genotypes belonging to both the species. Peroxidase activity was mostly found to be more during stress in case of *hirsutum* (Figs 9 & 10) whereas no consistent trend was observed in *arboreum* genotypes.

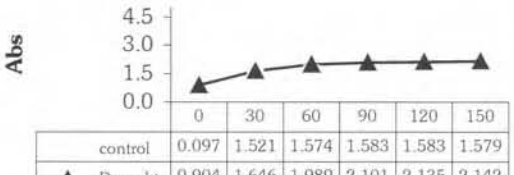
Fig 9 : Peroxidase enzyme G.hirsutum Leaf



	0	30	60	90	120	150
control	0.443	0.813	1.027	1.129	1.170	1.186
Drought	0.825	1.134	1.276	1.333	1.355	1.362

Time in sec

Fig 10 : Peroxidase enzyme G.hirsutum Leaf



	0	30	60	90	120	150
control	0.097	1.521	1.574	1.583	1.583	1.579
Drought	0.904	1.646	1.989	2.101	2.135	2.142

Time in sec

Protein profile: Protein profile determination through PAGE (polyacrylamide gel electrophoresis) banding pattern revealed accumulation of proteins during moisture stress in few genotypes (Fig. 11), which may correspond to heat shock proteins. In most of these cases, the strong protein band has been found to occur at 40 Kda and a number of bands have also been observed between 70 and 100 Kda (Figs 11& 12). Quantitative estimation of these leaf proteins by Lowry's method showed increase in leaf protein content during stress in those lines which also had protein accumulation in stress environment.

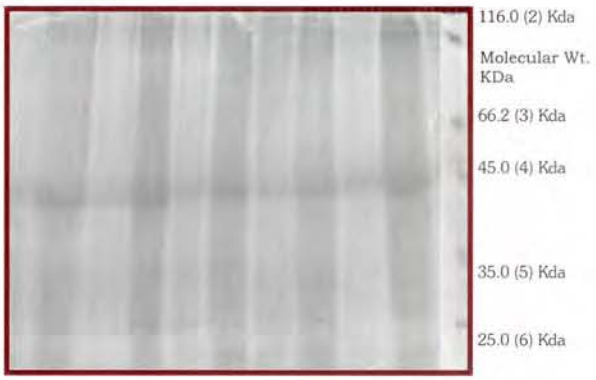
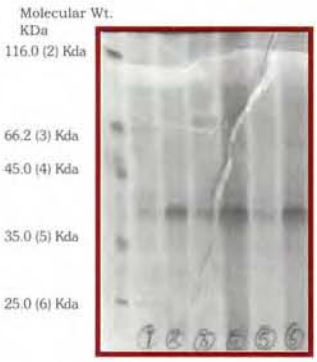


Fig. 11: PAGE showing response of cotton plants to moisture stress

C_{11}- C_{15} *G.hirsutum control*

D_{11}-D_{15} *G.hirsutum stress*



Sample No	Sample Name (genotypes of 2004-05 repeated)
1	*G. hirsutum* Leaf (Control)
2	*G. hirsutum* Leaf (Drought)
3	*G. arboreum* Leaf (Control)
4	*G. arboreum* Leaf (Drought)
5	*G. hirsutum* Leaf (Control
6	*G. arboreum* Leaf (Control)

Fig. 12: PAGE showing accumulation of more number of bands under stress conditions

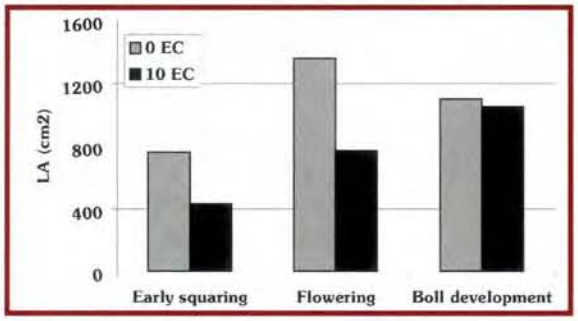
Salinity tolerance

The salinity tolerant genotypes selected from the previous experiments were grown in hydroponics (0, 5, and 10 d S m^{-1} NaCl), potculture (0, 5, 10, 15 and 20 d S m^{-1} NaCl) and in microplots (0 and 10 d S m^{-1} NaCl). The microplots had a dimension of 4m x 3m x 2m length x width x height respectively. At regular interval the salinity levels of pots and the microplots were monitored. The salinity levels of pots corresponded to 0.3, 3, 6.5, 8.5 and 12 corresponding to 0, 5, 10, 15 and 20 d S m^{-1} NaCl application respectively. Growth and yield of salinity treated plants was on par with the control plants up to 5 d S m^{-1} beyond that it started declining. Salinity levels corresponding to 8 and 12 d S m^{-1} NaCl showed a significant decline in yield. From the hydroponically grown plants it is clear that amongst the different plant parts roots are the most sensitive followed by leaves and the stem is the least sensitive. The salinity treated plants maintained higher relative water content and chlorophyll and thus the stomatal conductance and photosynthesis did not decrease significantly (Table 15). However, the decline in the leaf area (Fig.13) reduced the total biomass production and yield at higher salinity levels. Plants regulated their osmotic potential by the accumulation of proline. Proline accumulation was more in tolerant genotypes compared to susceptible genotypes.

Table 15: Photosynthesis (micro moles/m^2/s), transpiration (moles/m^2/s) and stomatal conductance (moles/m^2/s) of salinity treated plants

Genotype	Transpiration			Stomatal conductance			Photosynthesis		
	10 EC	0EC	Mean	10 EC	0EC	Mean	10 EC	0EC	Mean
G27	4.15	4.15	4.15	331.00	312.00	321.50	19.40	17.80	18.60
DHY 286	4.43	4.49	4.46	336.50	349.00	342.75	18.95	21.75	20.35
AK 32	4.84	5.09	4.96	394.00	471.00	432.50	19.85	22.55	21.20
320 F	5.24	4.56	4.90	485.00	369.00	427.00	23.25	20.10	21.68
PKV 081	5.11	4.81	4.96	433.00	410.00	421.50	22.45	20.55	21.50
BURI 0394	4.43	4.38	4.40	311.50	332.00	321.75	20.05	16.65	18.35
LRK 516	4.51	5.16	4.83	328.50	376.50	352.50	19.35	23.65	21.50
PKV HY 2	4.58	5.14	4.86	341.50	405.00	373.25	17.65	24.00	20.83
LRA 5166	4.41	5.37	4.89	317.50	495.50	406.50	17.15	22.45	19.80
Mean	4.63	4.79		364.28	391.11		19.79	21.06	
C.D at 5%	Gen 0.38	Salt NS	G x S NS	50	NS	NS	NS	NS	NS

Fig.13 Leaf area of control and 10 EC salinity treated plants at different growth stages



Water logging tolerance

The effect of waterlogging on growth, development and yield of cotton varieties and hybrids across the species was quantified in field experiments. Depending upon the stage and duration of waterlogging treatment, plants response to waterlogging varies. Waterlogging for a period of 16 days at 100 DAS reduced the growth and yield by more than 50 %. Similar decrease was seen in stomatal conductance and photosynthesis of waterlogged plants. The, prevailing weather conditions again found to influence the plants response to waterlogging. Unlike yellowing, senescence, shedding of leaves and fruiting parts observed with waterlogging under cloudy weather, under bright light and high temperature waterlogging elicited wilting in cotton known as parawilt. *Hirsutum* varieties and hybrids were more prone to wilting while it was not seen in Asiatic cotton. In a pot grown plants under bright sunlight and high temperature wilting could be observed within 2 hours of waterlogging treatment. Wilting was not elicited in pot grown shaded plants suggesting that high stomatal conductance of the plants under bright light in anaerobic condition elicited wilting. Chemicals, which inhibit the stomatal conductance, partially delayed the occurrence of wilting symptoms.

Effect of shade (left) and bright sunlight (right) on waterloggd plants grown in pots

Social Dynamics of Cotton Production

Nagpur

To characterize the diffusion rate of Bt cotton among the farmers in four selected villages in Hingna taluka of Nagpur district, a panel study was conducted involving 100 cotton growers and it was observed that 12 per cent cotton growers have gone for Bt cotton in very first year of introduction of this technology. During second year it was reduced to 11 per cent. During third year it was increased to 15 per cent and fourth year it was 20 per cent. Adoption behaviour was also affected by spatial distribution. Attempt was also made to explore the comparative adoption behaviour in relation to hybrid cotton, Integrated Pest Management (IPM) and Bt cotton, three most significant innovations in cotton crop to strengthen the prediction equation. It was observed that the adoption rate of hybrid cotton is much higher as compared to Bt cotton and IPM over the period of four years of their launching. However, during the first year of introduction of these technologies, Bt cotton had highest rate of adoption as compared to remaining two

technologies. From second year onwards the spread of hybrid cotton was much faster than Bt cotton.

Evaluation of technologies and economic viability

Nagpur

More than 100 farmers from three villages *viz.* Tishti, Dadhera, and Lohgadh in Kalmeshwar taluka of Nagpur district were involved in Lead Center of this project. Due to failure of the initial sowing of cotton, 30 client farmers could not continue the experiments. The technological interventions carried out on the fields of cotton growers reveal that dry sowing has increased the yield up to 3.2 per cent and large number of farmers are convinced that this simple technology can bring significant increase in yield. Soybean was found to be most profitable crop in intercropping system with cotton. Integrated Nutrient Management seems to make some difference in fiber quality also particularly in staple length. However, the difference is non-significant. On economic viability it was observed that BC ratio was higher for Bt cotton (2.15) as compared to farmers practice of growing another popular hybrid (1.60). Adoption of IPM technology leads to reduction in cost of production up to Rs.200/- per quintal of seed cotton.

Coimbatore

Seven technological interventions have been implemented in Keeranatham and Vellamadai villages of S. S. Kulam block of Coimbatore district *viz.*, Popularisation of Varieties (Surabhi and Sumangala), Introduction of Bt cotton, Date of sowing, Paired row technique in cotton, Fertilizer Application Based on Soil Test Plant response correlations (INM), Integrated Pest Management (IPM) and Integrated Disease Management (IDM). Intercropping with vegetables like radish, coriander, lablab and beetroot in cotton proved to be a successful technology with B:C ratio of 1:2.1 as against farmers' practice (1:1.42).

Nagpur

Accessibility to mass media and information technology

During the period the data were collected from randomly selected 55 extension functionaries from Nagpur and Wardha district through personal interview in a interview schedule proforma. Tabulated and analysed the data for the samples in respect of general profile of mass media/information technology, access to and use of modern mass medias (Electronic media-radio & television, Print media-newspaper/ magazines/printed literature and Information technologies- Internet, cellular/mobile phones). The perusal of data for general profile of extension workers including age, education, position/post held, experience, monthly income and training received in mass media/IT as well as possession of various mass media and It tools reveals that majority of the respondents i.e.60% belonged to middle age groups of 41-55 years, possessing diploma in agriculture and educated up to higher secondary, most of them (49%) holds posts of agril supervisors and had service experience more than 21 years, 36 % drawing monthly pay / income in the range of Rs.10,000 to 15000 and 29 % of them received training 'once' in IT sector. Further 89,87 and 62 percent extension workers possessed mass media and information technology sets like TV, radio, and fixed/mobile phone, respectively. 18% extension workers have possessed computers. In case of print media 75 % extension workers were subscriber of more than two news papers while 67 % of them were subscriber of farm magazines like Baliraja, shetkari, etc. It was also recorded that quite good numbers (63%) extension workers had cable TV connections.

Further, the data analyses for access and use of mass media revealed that 76 % extension

workers had access to and used newspapers viz Hitavada, Lokmat and Sakal for seeking cotton related information, 42 % of them have used 'often' the printed materials primarily Shetkari Masik and Baliraja and also other magazines/bn folders/leaflets and other extension bulletins produced by State Agril. Department/ICAR Institutes. Similarly, majority of 45% extension workers used to listen/hear cotton and other agril related programmes broadcasted in 'Mazhe Ghar Mazhe Wawar' by AIR and 45% watched 'occasionally' Doordarshan programme 'Amchi Mati Amchi Manse' and Cable TV 'Annadata' transmitted on use of Bio-pesticides in cotton, market information and price trend in various crops .The Kisan Call Center a toll free facilities established recently by Govt of India at ICAR Institutes and SAUs have been 'often' used by 15 percent extension functionaries for getting scientific information from scientists or experts on Bt cotton and organic cotton production. Mobile/Cellular Phones though quite expensive but are being used in a communication nowadays and it was observed that 15 % highly educated and younger officials have 'often' used it for seeking solutions from the scientists during drought situation and outburst of pests and diseases on cotton crop. Internet/Web a vast global information resource or library, which has been emerged recently as a powerful communication technology, have 'often' been used by 5 % extension workers from the private Internet services of cyber café and availed latest information in cotton production technologies.

Coimbatore

FLD on cotton

Front line.demonstration (20) on Introduction of Bt cotton, Intercropping with vegetables, Application of neem cake, foliar application of DAP & Potash and seed, soil and foliar application of bio inoculants have been conducted at S.S.Kulam and Thondamuthur blocks. IPM was demonstrated in an area covering 48 ha in the same village. In general, heavy rains have drastically reduced the yield and quality of cotton in most of the project farmers' fields.

Cotton Economics and Marketing

Coimbatore

Cottonseed production in Tamil Nadu

The contract seed growers were selected from Erode (55) and Salem (20) districts. Cost of cultivation was more in Salem than in Erode but the cost of production was very less because of higher average yield in Salem (1312 kg/ha) as compared to Erode (1142 kg/ha). Marketing channel in Salem was of three types. Seed growers-Seed organizers-Seed firms-Distributors-Dealers -Consumers; Seed growers -Seed firms-Dealers-Consumers; Seed growers -Seed firms -Consumers.

Economic analysis of contract farming in Tamil Nadu

Majority of non contract farmers felt lack of knowledge about improved technologies of cotton production. Few contract farmers faced rejection of their produce due to poor quality. Few contract farmers, in spite of enjoying higher price, were not satisfied with the stipulated contract price by the sponsor. It could be seen that the contract farmers were more benefited than the non contract farmers. To make this venture a success, contract farmers and sponsoring firms should strictly adhere to the contract procedures.

Information system on cotton

Nagpur

The website is given new look with more linkages and new data sets. Interactive website

is being made. Appropriate data bases were collected for the information system on cotton.

Coimbatore

Information on cotton was collected from different government as well as authentic private sources. The information includes primary data from area production productivity to tertiary data like cloth/yarn production/export/import. The collected data were checked for consistency and the transformation of scale of the data was done, wherever necessary. Appropriate databases were created with the provision to update the database, with new datasets and corrected datasets, in the future. So far around 30 datasets were collected on different aspect on cotton production and post-production components. The collected datasets were categorized as districtwise as well as statewise domain time series data.

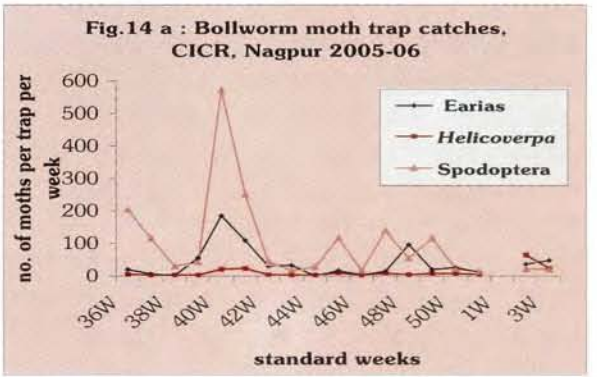
Beta version of the Information retrieval system was developed with advanced tool using Visual Basic.NET. The developed system is menu driven with embedded user friendly tools like drop down menus, list boxes, combo box, and radio buttons. The system also has the facility to report and take print out the queried results using Crystal Reports.

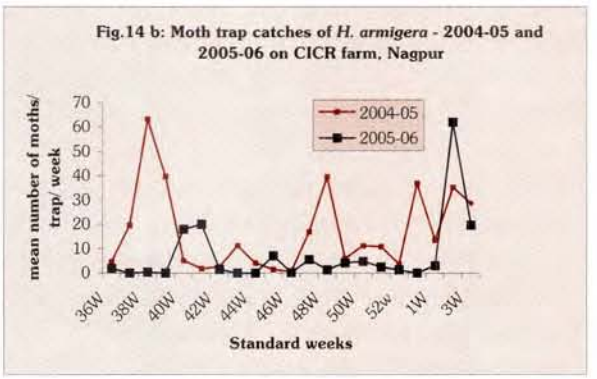
Pest Scenario

Nagpur

Temporal variation of cotton bollworms

Helicoverpa armigera moth activity was significantly lower in the year 2005-06 as compared to 2004-05. Of the four bollworms *Spodoptera litura* moth activity was the highest although there was no significant damage due to *Spodoptera* on CICR, Nagpur farm (Fig.14 a & b). *Earias vittella* was the major bollworm that caused significant damage in mid reproductive stage of the crop this season. Incidence of *Earias insulana* in moth trap catches of Central India was also seen. Off-season pheromone trap catches of *P. gossypiella* indicated contribution from the diapausing population into the ensuing crop season.





Increasing population of jassids in three successive generations during the vegetative crop growth phase that continued development till the crop harvest was observed. The season had damaging population of jassids during 3rd week of August and 2nd week of September. Peak population of thrips was seen during mid-September. Build-up of mirids commenced with the squaring of the crop and peaked during the last week of September. Aphid infestation occurred at low levels during August and September months with peak infestation during first week of September, but with no visible

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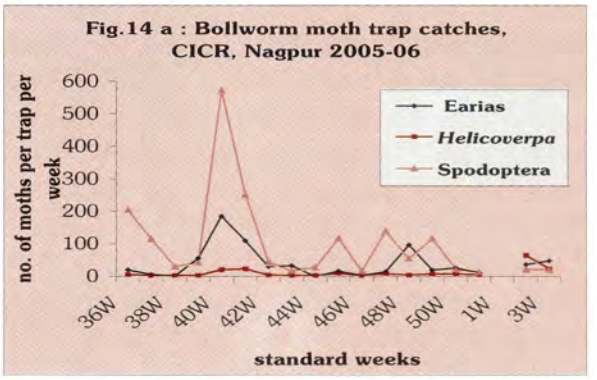

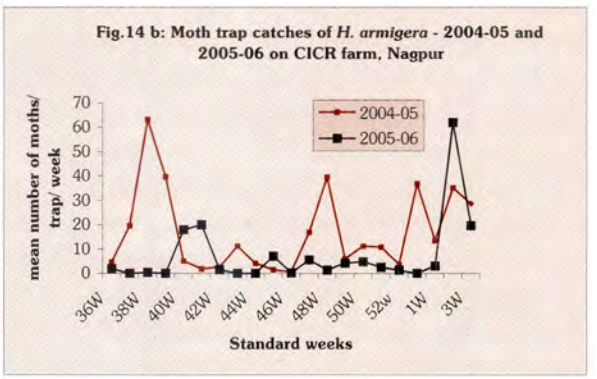

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symptoms. However, incidence reappeared from mid-November and persisted till harvest.

Helicoverpa armigera oviposition commenced during the last week of July on cotton crop with its grand peak during the second week of September. Oviposition and larval development continued through the months of August, September, October and November with more number of generations on cotton but at very low levels; *Earias vittella*, infestation started from mid-August. Population build up was high and continuous from mid-October till December. *Pectinophora gossypiella* established on the crop only from the last week of November, with its effective build up from January. Highest pink incidence was noticed on the developing green bolls of February.

Initial square damage was exclusively by *E. vittella* during mid-August. Damage to squares by *H. armigera* had commenced from 1st week of September with the maximum damage during the 2nd fortnight of September. *Earias* damage to squares was simultaneous with *H. armigera* during September but at reduced levels. *E. vittella* caused maximum damage to squares during 2nd and 3rd weeks of October. It also caused damage to green bolls continuously from mid-October. *P. gossypiella* damage to green bolls started from mid-December and overtook the boll damage by *Earias* from mid-January.

Natural enemy scenario

Coccinellid predators were seen only during first weeks of August and September. The aphid parasitoids *Aphidius* and *Aphilinus* spp. were abundant and regulated the late season aphid population effectively. Chrysopid oviposition peaked with the jassid nymphal population during September and continued at low level during mid and late seasons. Abundance of spiders was high from September to mid-October.

Host plant resistance to insect pests

A total of 725 entries comprising working collections, single plant selections, hybrids and advanced generations were field evaluated for reaction to jassids and tolerance to bollworms under unprotected conditions. 285 selections and 440 rejections were made. Six of the working collections and 16 of first generations (F_1) were identified to possess higher compensation to bollworm damage. Seed production for two hybrids that had higher genotypic resistance ratios were undertaken for further testing. In addition, 117 working collections were field screened wherein 13 moderately tolerant, 82 susceptible and 22 highly susceptible entries for jassids and 108 tolerant and nine susceptible entries for bollworms were identified.

Coimbatore

Population dynamics of cotton pests and their natural enemies

The incidence of aphid and whitefly was very low during the crop season. However, jassid occurrence was observed throughout the year. A maximum jassid population of 9-10 / plant was recorded under unprotected condition in the month of November.

In general bollworm incidence was low during this year due to high rainfall. Under protected condition Bt cotton recorded only 1.7% bollworm incidence in the month of December. In non Bt cotton raised under unprotected condition a maximum of 6.8 % was recorded. *Helicoverpa armigera* incidence was negligible. Among the natural enemies the predators coccinellids and spiders were recorded during October and December both in Bt and non Bt cotton.

Occurrence of *P. affinis* on the alternate host *Althea rosea*

As *Althea rosea* (Holly Hock) was recorded as

alternate host for *P. affinis*, the plants were raised around the experimental field to record the incidence. The level of incidence was recorded as 20 % in *A. rosea*.

Impact of the age of the boll on the Pink bollworm incidence

Bolls of 30, 45 and 60 days old were collected from the variety Surabhi at weekly intervals and individual bolls were dissected out and observed for the incidence, number of larvae of pink bollworm. Minimum pink bollworm incidence was recorded in 30 days old bolls (DOB) (29.20) followed by 45 DOB (44.01). However, the percentage of incidence of PBW in 45 and 60 days old bolls (DOB) were on par with each other.

Reaction of Bt hybrids against pest and diseases

Studies on the growth indices of *Helicoverpa armigera* on Bt and NBt hybrids

Significant differences were observed in the feeding indices on Bt cotton hybrids. Feeding on Bt cotton hybrids was minimum as compared to non Bt hybrids. Consequently *H. armigera* larvae failed to gain the weight on Bt hybrids. Relative growth rate (RGR), Relative consumption rate (RCR), Efficacy of conversion of ingested food to body substance (ECI) and Approximate digestibility (AD) were recorded as minimum in Bt hybrids than NBt hybrids, except in NCS 145 Bt the RCR and AD were higher than the NCS 145 NBt. Among all the Bt hybrids RCH 2 Bt recorded the lowest values of all the growth indices (Table 16).

Table 16 :Consumption and utilization of Bt cotton hybrids by *H. armigera*

Treatments	Food Ingested (g)	Excreta (g)	Wt. gain (g)	RCR	RGR	AD	ECI	ECD
1. NCS 145 Bt	0.085	0.011	0.005	2.69	0.70	39.01	10.72	13.40
2. NCS 145 NBt	0.203	0.098	0.045	1.75	0.81	34.27	17.77	36.88
3. NCS 207Bt	0.020	0.003	0.002	1.15	0.24	18.38	17.42	0.92
4. NCS 145 NBt	0.154	0.060	0.038	2.77	0.79	47.63	19.58	27.92
5. RCH 20 Bt	0.056	0.004	0.003	0.65	0.18	25.00	3.10	2.23
6. RCH 20 NBt	0.176	0.082	0.046	2.49	0.86	38.11	23.71	33.40
7. RCH 2 Bt	0.022	0.003	0.000	0.27	0.05	0.00	0.00	0.00
8. RCH 2 NBt	0.125	0.051	0.035	1.53	0.58	67.78	16.40	16.72

Incidence of stem weevil and shoot weevil in different Bt and Non Bt cotton hybrids

Bt and NBt versions of different hybrids namely NCS 145 Bt, NCS 145 NBT, NCS 207 Bt, NCS 207 NBT, RCH 20 Bt, RCH 20 NBt, RCH 2 Bt, RCH 2 NBt and RCH-368 Bt were observed for stem weevil and shoot weevil incidence. All the Bt hybrids recorded minimum percentage of incidence than their corresponding NBt hybrids. Among the Bt hybrids RCH-2 Bt recorded minimum percentage of 4.72 than the other hybrids. In all the Bt and NBt hybrids, except RCH 368 Bt, the percentage of incidence ranged from 13.75% - 29.73% which were on par with each other. Maximum incidence of 46.16% was recorded in RCH 368 Bt.

Incidence of Pink bollworm on different Bt & NBt hybrids

Bt hybrids recorded minimum percentage of incidence of PBW when compared to the NBt hybrids and the incidence ranged from 15.91% to 21.15% and 44.10% to 51.71% in Bt and NBt hybrids, respectively (Fig.15). Weekly observation indicated that maximum incidence was recorded during IInd week of February invariably in all the Bt & NBt hybrids during the month of March.

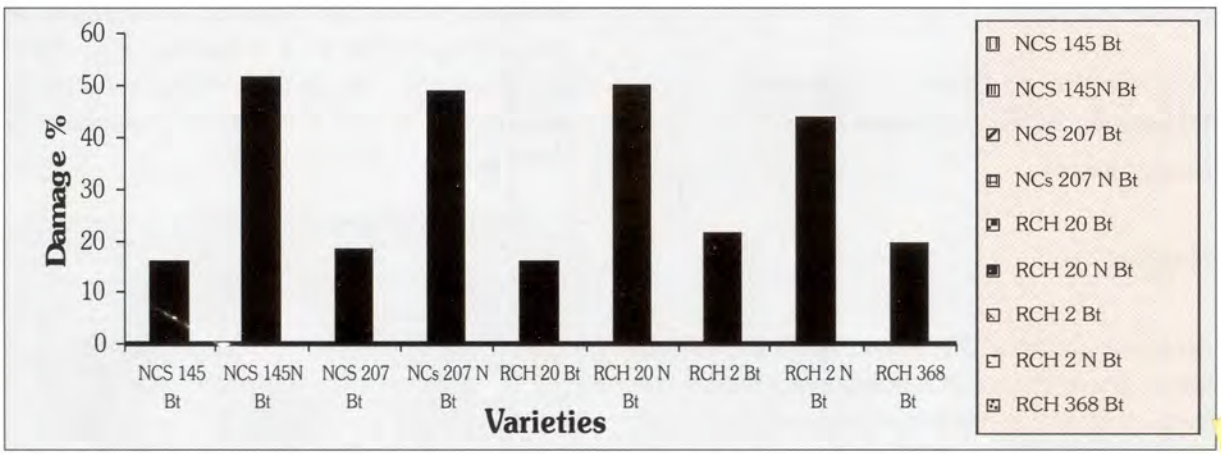


Fig. 15 : Incidence of Pink bollworm on different Bt. & Non Bt. hybrids

Incidence of grey mildew in different Bt and Non Bt cotton hybrids

In order to find out the possible existence of variation in the reaction of Bt hybrids to grey mildew, Bt hybrids *viz.*, RCH 2 Bt, RCH 20 Bt, RCH 118 Bt, RCH 138 Bt, RCH 144 Bt, RCH 335 Bt, RCH 344 Bt, RCH 359 Bt, RCH 362 Bt, RCH 368 Bt, RCH 702 Bt, RCHB 708 Bt, NCS 145 Bt and NCH 207 Bt were screened under artificial inoculation in poly house along with their non-Bt counter parts. The results revealed that there was no difference in susceptibility of Bt and the corresponding non-Bt hybrids to grey mildew.

Sirsa

The incidence of jassid and spotted bollworm was observed during the end of July and continued throughout August and beginning of September. However, American bollworm population was noted in traces randomly. At isolated localities the incidence of *Spodoptera* was observed. Natural enemies such as spider, coccinellids, *Chrysoperla* were rarely observed.

Severe incidence of CLCuV was noticed in many of the non-descript varieties such as Raja Sikander, Baadsha, etc. However, very less incidence of 1-2% was noted in H-1117 and in some non-descript Bt cotton entries. The incidence of other foliar diseases was not observed.

Expert System on Cotton pest/insect

Coimbatore

Adequate information to diagnose the pest and insect were collected and related photographs were also collected. Information on control measures including chemical, biological, natural were collected for all the pests. Basic network algorithm using the technique artificial neural network (ANN) was created. In this expert system instead of using any ready made shells

codes are created using visual basic. The system under development uses both forward and backward chain reasoning to achieve diagnoses as well as recommendations. While creating codes, provision is made to alter and update the codes and network of the system in future.

Resistance to Insect Pests and Diseases in *Gossypium* Spp

Insect Pests

Nagpur

Protease inhibitor (PI) from Pee Dee 0695, (a jassid susceptible line) is being introgressed into jassid tolerant genotypes with good agronomic background, Bikaneri Nerma and G cot 10. High PI plants were identified through *in vitro* enzyme inhibitory assays in BC_2F_1 progeny of the two crosses Bikaneri Nerma x Pee Dee 0695 and G Cot 10 x Pee Dee 0695. Out of 15 plants tested for protease inhibitors in the bolls, 8 demonstrated to have high PI activity in BC_2F_1 G cot 10 x Pee Dee 0695 while of 20 plants tested 12 demonstrated high PI activity in the bolls of BC_2F_1 Bikaneri Nerma x Pee Dee 0695. High PI lines were advanced to the BC_3F_1 and BC_2F_2 generations.

BC_2F_1 Bikaneri Nerma 54 bolls/ plant

BC_2F_1 G Cot 10 X Pee Dee 0695 60 bolls/ plant

Pee Dee 0695 (10 bolls/ plant)

Coimbatore

Screening of genotypes for resistance to Bollworms

Bollworm tolerant selection BTS 5 and BTS 7 showed less population of *Helicoverpa armigera* (1.7 to 2.0 / 5 plants) as compared to other entries (3.7 to 19.7 / 5 plants). BTS-7 and BTS-8 recorded significantly higher seed cotton yield (1370 to 1583 kg/ha) as compared to Abadhita (1152 kg/ha) (Fig.16).

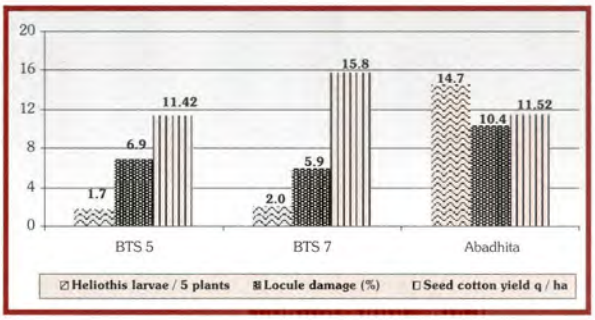


Fig.16 : Performance of bollworm tolerant selections

Among 11 long staple and high ginning percentage genotypes tested, CCH 510-3411, L (RCH x T13) 521111 & L(RCH x T13) 551822 had significantly low population of *Helicoverpa armigera* larva (4 to 6 per 5 plants) as against 10.5 per 5 plants in Abadhita. However, Abadhita recorded higher yield (1630 kg/ ha) over all other entries (1110 to 1560 kg/ha).

Identification of resistant lines against jassids

About 120 genotypes were screened for their reaction to jassid. Among these, (VRS x 115) 6341, (M5 x Z2)-1389-2, L (RCH x T13) - 521111, L (RCH x T13) 521163, L (RCH x T13) 521192, L(RCH x T13)551822, VRS19 x LS(3)-334, VRS 19 x LSC4-76, H 4-557-36, LSC-332, Ento-2-6, BRS -5 (L x BRS 5) 2211, (PUSA x M58) 511E, LS.1, PUSA x C1998-2241 registered resistant reaction to jassid under

field condition. Of the fourteen long staple and high strength genotypes tested, only six genotypes ((M5 x Z 2) M 9 ROK 18319, (M5 x Z 2) M 9 ROK 12137, CCH 526612, CCH 510-4, (M 5 x Z 2) 1389-2 & (LSDC 2 x LSDC 3) 3322) were found tolerant to jassid.

Resistance breeding for stem weevil

Sumangala, LRA 5166, MCU-5, Anjali were crossed with Moco and Exotica and backcrossed with the parents. The progenies crossed and backcrossed with Moco had 0 - 2.94% stem weevil infestation as compared to Exotica (2.94 - 8.0%)

Screening of germplasm and AICCIP entries for resistance to foliar diseases

The AICCIP entries (357 nos.) from National and zonal breeding trials were screened under poly house for their resistance to bacterial blight, alternaria leaf spot and grey mildew. Among these, only seven entries showed resistance to grey mildew and the rest were susceptible.

Development of resistant lines to foliar diseases

Forty six single plant selections having resistance to grey mildew (18 nos.), alternaria leaf spot (two nos.), bacterial blight (15 nos.) and MAR lines (11 nos.) were planted in the field and assessed through further evaluation and selection. Based on this field evaluation during this year, 214 single plant selections were advanced for fibre quality tests and further selection. Based on boll number, ginning outturn and lint index these were reduced to 57 single plants and advanced for fibre test.

Eighteen advanced lines having resistance to grey mildew (7 lines), alternaria leaf spot (8 lines), bacterial blight (one line) and MAR lines (two lines) were evaluated in field trials for yield in comparison with LRA 5166 and Sumangala. Out of these, two lines viz. ALR 4 and GMR 13 gave better seed cotton yield than LRA 5166 and Sumangala and six were better than LRA 5166.

Studies on biochemical mechanisms of resistance to bollworms of cotton

Among the germplasm lines, SOCC 17, SOCC 171, F 2007, F 2009, RS 2097, GTHV 4190, F 1861, HGIPS 542 showed promise with higher levels of condensed tannin during growth periods and also phenols in squares in the range of 15-26 mg/g . Fifteen superior single plant selections exhibiting fair amount of tolerance to bollworms were made.

Biochemical characterization of bollworm tolerant genotypes viz., BRS cultures- BRS 3, BRS 5 and BRS 22 revealed higher levels of constituents such as gossypol, tannin and phenols with moderately higher bollworm tolerance in these genotypes as compared to popular cultivars like LRA 5166 and MCU 5 VT under unprotected conditions. Yield per plant was in the range of 32 - 46 g/plant under protected conditions, while the corresponding values under unprotected conditions ranged between 35 - 45 g/plant. Derivatives of tolerant introgressed lines were again noticed to possess higher levels of terpenoid metabolites and phenols in locules and were found less susceptible to bollworms.

Developmental biochemistry of host plant-pest/disease interaction

Repeated application of cypermethrin led to the reduction of Nitrate reductase activity and also secondary metabolites. Seed dressing insecticides were found to induce ATPase activity at a higher level as compared to control. Efficient metabolic status through acid phosphatase and alkaline phosphatase activity in addition to higher peroxidase activity could be maintained in young seedlings due to seed dressing chemicals. Enhanced nitrate reductase and ATPase activities were seen in initial stage due to *Kamadhenu Kitniyantrak* spray (a natural

organic insect repellent) but subsequently, no perceptible changes were noticed.

Biochemical aspects of variation in isolates of *R. areola*

The induction of peroxidase activity in response to specific isolates of *R. areola* revealed consistent trend that could be used towards differentiation of the isolates. The induction of Superoxide dismutase and catalase in representative genotypes was studied using various isolates of *R. areola*. Except for *arboreum* isolate interaction with *G. barbadense* (Suvin), characteristic trend was discernible regarding induction of catalase activity. However, such a noticeable pattern could not be observed in case of Superoxide dismutase enzymatic activity spectrum. The *hirsutum* isolate led to characteristically higher level of activity in all the hosts studied.

As regards defensive enzyme Ascorbic acid oxidase induction in host-pathogen interaction, only *herbaceum* isolate led to expression of higher levels of activity, a trend nearly similar to previous year and indicative of usefulness as a diagnostic tool.

Nagpur

Evaluation and characterization of host plant resistance to key insect pests

Three elite (high yielding with good fibre quality) genetic stocks, AR 27, G 21-17-619 and ND 63 performed consistently well in an unprotected field trial carried out for 3 years at CICR, Nagpur. They were found to be tolerant to *Helicoverpa armigera* under field as well as artificial screening conditions. Tolerance was measured in terms of larval mortality of 2-day-old larvae released on detached squares over a seven-day screening period. Reduction in larval weight gain by the 7th day as compared to check was the second parameter for measurement of tolerance. One of the factors contributing to bollworm tolerance in these lines was traced to flavonols- high rutin (>33 ug/g fresh weight) and chlorogenic acid (> 18 ug/g fresh weight) in the ovary of fully formed squares which were positively correlated to high larval mortality under artificial screening.

Utilization of these stocks is being made through single plant selections, seed multiplication and location specific trials for evaluating adaptability.

G 21-17-619

Obtained from Africa

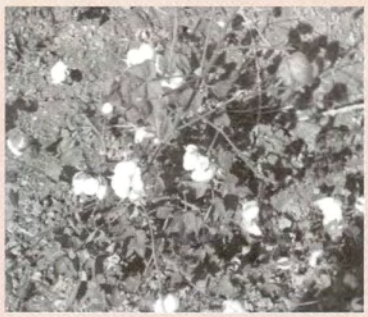
Mean yield per plant was 40-60 g synchronous boll opening, early (150-160 days)

Tolerant to jassids (Grade I: leaves free from crinkling, no bronzing or drying).

Jassids and bollworm *Helicoverpa armigera* did not cross ETL in the three years of field-testing.

Fibre strength: length ratio is 0.76

Suitable for rainfed IRM.



ND 63

Obtained from Nanded (MS) 30-35 g/plant

Big boll 4.8 g

Tolerant to jassids (Grade I: leaves free from crinkling, no bronzing or drying).

Fibre strength: length ratio 0.8

Suitable for rainfed IRM

Suitable as a sucking pest and bollworm tolerant parent in breeding programs.

Morphological features

Leaf hairy, normal shape, petal bright yellow, pollen yellow and petal spot absent, leaves and floral nectar-ies present, big bracted

AR 27

Obtained from Nandiyal (AP)

40-60 g/plant

Boll weight 4-4.5 g

Susceptible to jassids 60 DAS showing Grade II damage (leaves show curling, crinkling, and slight yellowing on lower portions of the plant).

Tolerant to bollworm, *H. armigera* that did not cross ETL in the three-year unprotected trial.

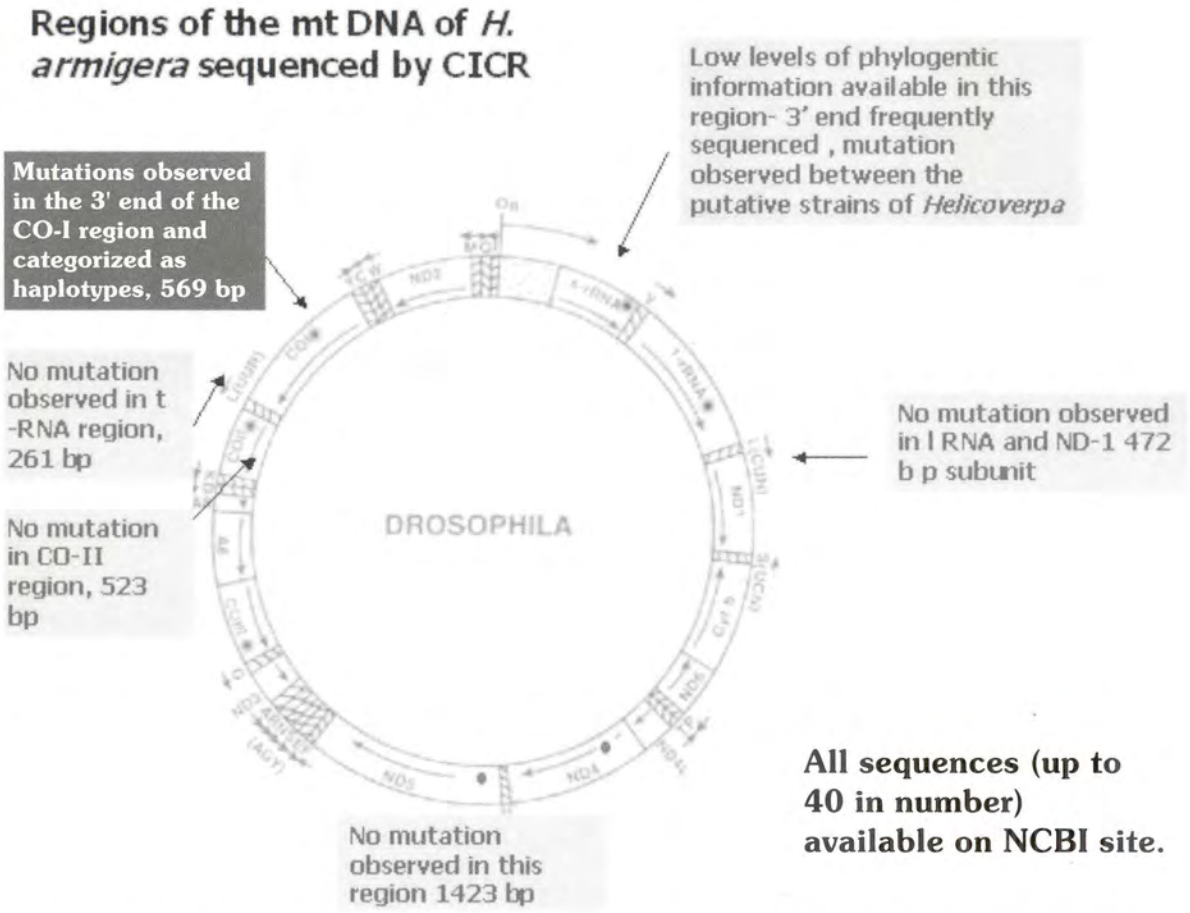
Fibre strength: length ratio 0.8

Morphological features

Leaf glabrous, very broad, petal colour light yellow, pollen dark yellow, petal spot absent, nectaried, and bracts appear smaller on flowers than on squares.

Variability in Insect Pests and Pathogens

Nagpur



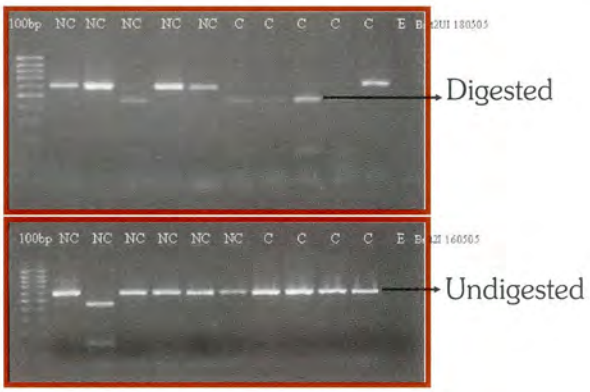
PCR- RFLP tools to identify intra-specific haplotype variation in *H. armigera*

a) Based on CO-1 mutation

At least two major haplotypes occur in Indian populations of *H. armigera* as determined by two mutations in the partial CO- I region, CO-1 being important in coding for cytochrome oxidase. This was determined by sequencing more than 100 moths collected from different geographic regions of the country. Identification of these haplotypes can be made using PCR-RFLP tools that have been designed and validated. Eleven samples of non- cotton strain and 9 samples of the cotton strain were subjected to PCR- RFLP using Bcn1 and Bst 2UI in separate reactions. PCR- RFLP, a molecular diagnostic tool detects haplotype based on the specific mutation that may or may not be associated with its feeding preference as seen below.

PCR RFLP to detect mutation in the partial CO- 1 region using Bcn1 (CC SGG where S is C/G)(2206) 5' ATTTTACC ***G/A*** GGAA 3' (2217).

PCR RFLP to confirm mutation in the partial CO-1 region using Bst 2UI (CC WGG where W is A/T)



PCR

b) Based on 12s r RNA mutation

Multiplex PCR designed to detect mutation in the 12s r RNA region of the mitochondrial genome of *H. armigera*.

A mutation was detected in strains differing in their feeding preference in the 12s rRNA region that may represent a haplotype. A multiplex PCR was designed to detect the mutation.

Two primer sets, representing forward and reverse primers, were designed so that the 3' end carried the mutation of interest. The primers were the following-

Cotton Forward primer:

5' ATTTAAATCCACCCTCAATTAATTG 3'

Cotton Reverse Primer:

5' ATTTATACCAATATTAATTTGTAAC 3'

Non-Cotton Forward Primer:

5' ATTTAAATCCACCCTCAATTAATTA 3'

Non Cotton Reverse Primer:

5' ATTTATACCAATATTAATTTGTAAT 3'

Cotton reverse primer when used in combination with SR-J-14199 and SR-N-14594 detected the mutation in the 12s r RNA region giving two bands of 400bp and 200bp with the putative cotton strain and only a 400bp band with the putative non- cotton strain.

Multiplex PCR to detect mutation in 12s r RNA region of the mitochondrial genome of *Helicoverpa*

3: Cotton strain (oligo22$^+$oligo23$^+$cot RP).; 4: cotton strain (oligo22$^+$oligo23); 5: 100 bp ladder; 6: Non-cotton strain (oligo22$^+$oligo23$^+$cot RP); 7: Non-cotton strain (oligo22$^+$oligo23).

Pathotypes:

One hundred and fifty isolates of *Xam* 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 to identify pathogenic variability; if any. Five races viz. 4, 5, 7, 10 and 18 were identified of which race 18 was predominant and, 70.00-86.67 per cent isolates belonged to this race.

Sixty seven isolates made from the bacterial blight infected leaves collected from cotton

growing areas of Maharashtra revealed the presence of five races viz. 3,7,10,15 and 18. Race 18 was most predominant and 89.55 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 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 with race 18 inoculation of susceptible host. Association with susceptible or resistant hosts appeared to be responsible for dilution or increase of virulence of races.

Survey of cotton leaf curl virus infected cotton in North India

A survey was conducted in different places of Punjab, Haryana and Rajasthan during June 2005 with an objective to characterize the strains of CLCuV. Most of the fields of these regions were found infected with whitefly spread of Geminivirus disease. Studies were also done with the aim to ascertain if different symptoms characterizing cotton leaf curl syndrome (viz., upward or downward cupping of lamina, severe and mild vein thickening, enation etc.) were caused by different strains of CLCuV. Forty-six infected leaf samples showing different symptoms or severity of infection were collected from different places of the three states. These included 20 samples from Sirsa, 11 from Punjab and 15 from Rajasthan. The presence of virus in infected samples was confirmed by rapid PCR protocol developed by us (Fig. 17 a-c).

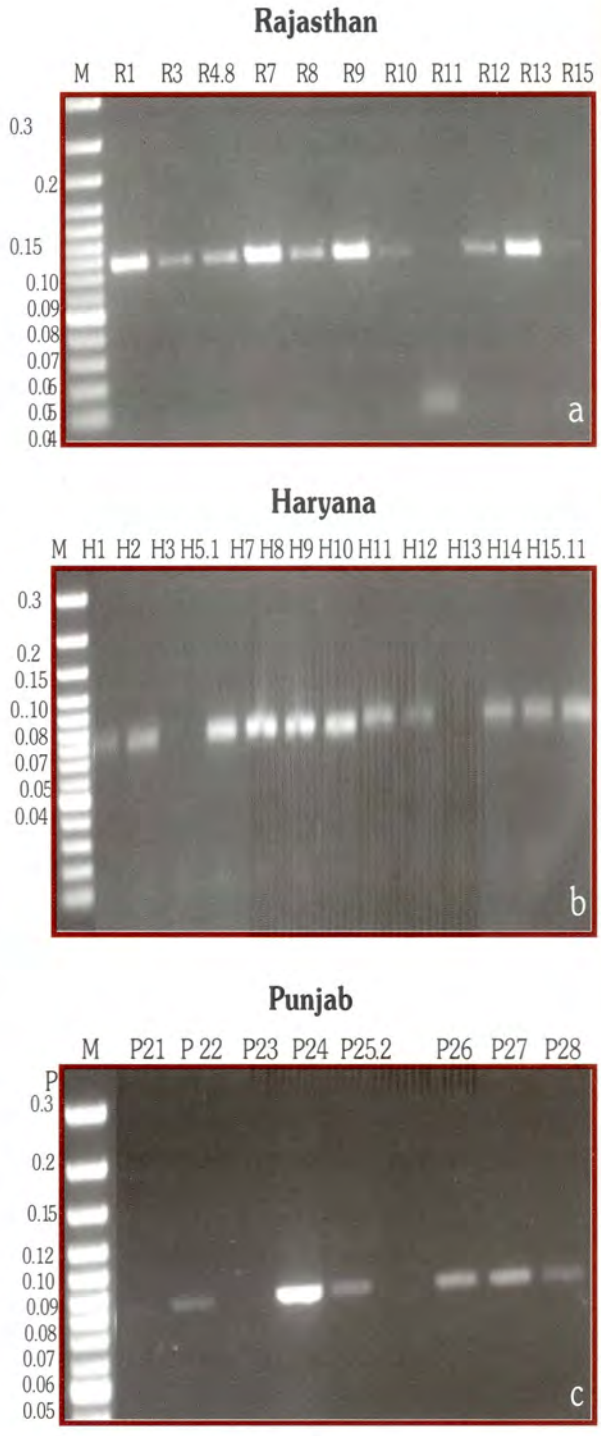


Fig.17 (a,b,c). Detection of CLCuV in infected cotton collected from North India

Cloning and sequencing of coat protein gene

The CP gene of 771 bp amplified from CLCuV infected plants using specific primers showing different symptoms were cloned. Surprisingly the CP gene sequences of CLCuV associated with different symptom types did not reveal significant variability to justify association of different strains. Significance of few nucleotide variations observed among different CP genes is being ascertained.

Expression of coat protein in *E. coli* cells

The optimum conditions for maximum expression of the coat protein in E. *coli* cells were standardized. To check for higher expression if any, the coat protein gene amplified from Sirsa strain of CLCuV was also cloned in pET27b protein expression vector besides in pCaln plasmid (Stratagene, USA) that was done previously. Greater fraction of fusion protein expressed in *E. coli* appeared to get localized in the inclusion bodies. Comparatively higher expression was observed when the gene was expressed from pCaln vector.

Molecular diagnosis of fungal pathogens of cotton

An attempt was made to develop molecular diagnostic tests that could enable rapid detection of major fungal pathogens of cotton. With this objective the rDNA regions of *A. macrospora* and *Ramularia areola* strains isolated from four cultivated species of cotton were cloned and sequenced.

The sequences of rDNA comprising of partial sequences of 28s and 18s rRNA genes and complete sequences of ITS1, ITS2 and 5.8s rRNA genes of the two pathogens were compared. Variable sequences were used to design primers specific to each pathogen species. The specific PCR amplification protocols for each set of primers and pathogens were developed. Primers helped in precise detection *A. macrospora* and *R. areola* strains (Fig.18). Differentiation among four *R. areola* strains was further done with unique restriction sites that are present in one but not the other (Fig. 19, Table 17).

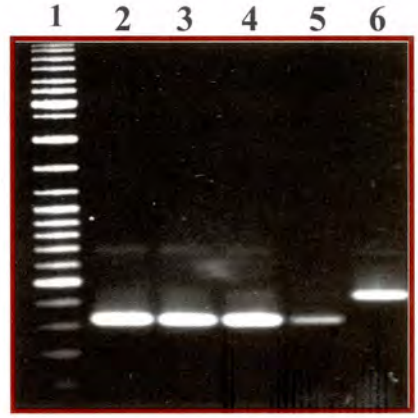


Fig. 18. Detection of cotton pathogens using species-specific primers. Lanes 1-4, *arboreum, herbaceum, barbadense* and *hirsutum* isolates. Lane 5, *A. macrospora*, M, 100 bp ladder.

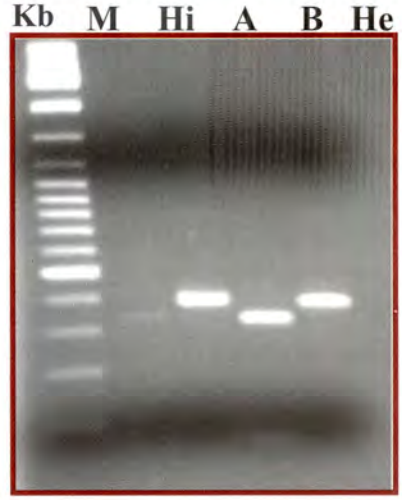


Fig. 19. Restriction enzyme digestion of PCR product amplified using *R. areola* specific primers with *Pvu*II to differentiate tetraploid from diploid isolates. Lanes 1-4, *hirsutum*,

Table 17: Restriction enzymes capable of differentiating four different strains of *R. areola*

Enzyme	*G. arboreum*	*G. barbadense*	*G. herbaceum*	*G. hirsutum*
*Bpu*10I	+	-	-	-
*Bss*KI	-	+	-	-
*Bsa*WI	-	-	+	-
*Xma*I	-	-	-	+

DNA based diagnostic approaches to identify biotype diversity in race 18 of *Xanthomonas axonopodis* pv. *malvacearum* and commercialization of a PCR detection kit

Survey, collection and identification of races of *Xanthomonas axonopodis* pv. *malvacearum*

Bacterial blight (*Xanthomonas axonopodis* pv. *malvacearum*, *Xam*) infected cotton fields were surveyed in different regions of Maharashtra and Madhya Pradesh. Thirty infected leaf samples were collected and brought to CICR for identification. The pathogen was isolated from bacterial blight infected cotton leaves and grown on YGCA medium. Identity of the pathogen was confirmed by diagnostic PCR protocol developed at CICR, Nagpur. Based on their reaction on cotton all differentials were found to belong to race 18. Race 18 isolates were also confirmed by RFLP markers developed by CICR.

Restriction Fragment Length Polymorphism (RFLP) RFLP analysis was done with 30 race 18 isolates of *Xam* to study the genetic variability. RFLP analysis exhibited distinct polymorphism between race 18 isolates of *Xam* showing scorable hybridising bands. Based on the analysis of RFLP patterns 30 race 18 isolates were clustered in seven groups. Most of the race 18 isolates possessed two pthN hybridising fragments (Fig.20).

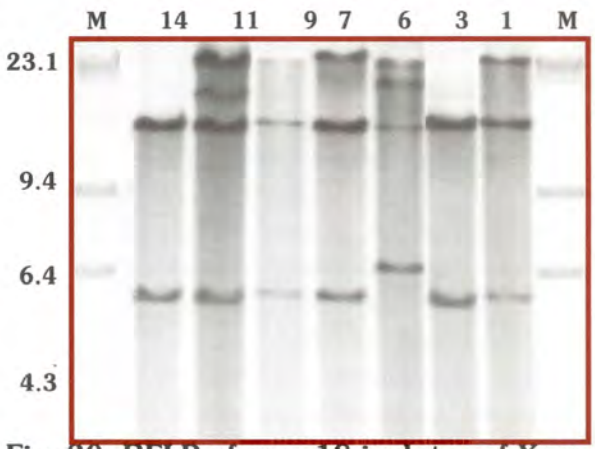


Fig. 20: RFLP of race 18 isolates of *Xam*. Lance 1-7, isolates of *Xam*: M, λ / *Hind*III marker

rDNA PCR analysis

In order to differentiate variants of race 18 based on rDNA sequences, PCR analysis of seven representatives isolates, one from each RFLP groups, was done with conserved ITS primers G1 and L1. The primers amplified ~0.6kb DNA fragments from all the representative RFLP groups. The amplified rDNA fragments of all variants of race 18 were cloned and one of the sequences was deposited in Gene Bank (DQ 414745). Multiple alignment and analysis of seven RFLP variants of *Xam* did not reveal any variation based on rRNA gene sequence.

Standardization of PCR protocol for IS112 insertional element in *Xam*

Thirty isolates of race 18 of *Xam* were amplified using primers JEL 1 and JEL 2. All the isolates generated PCR fragments from 6 to 18 in number with size ranging between 0.25 to 10 kb. IS112 based repetitive DNA fingerprinting of 30 isolates showed significant genetic variability based on the amplification of sequences between the dispersed IS112 elements. Based on IS112 repeat fingerprinting, isolates were clustered in 9 major groups (Fig. 21 a & b).

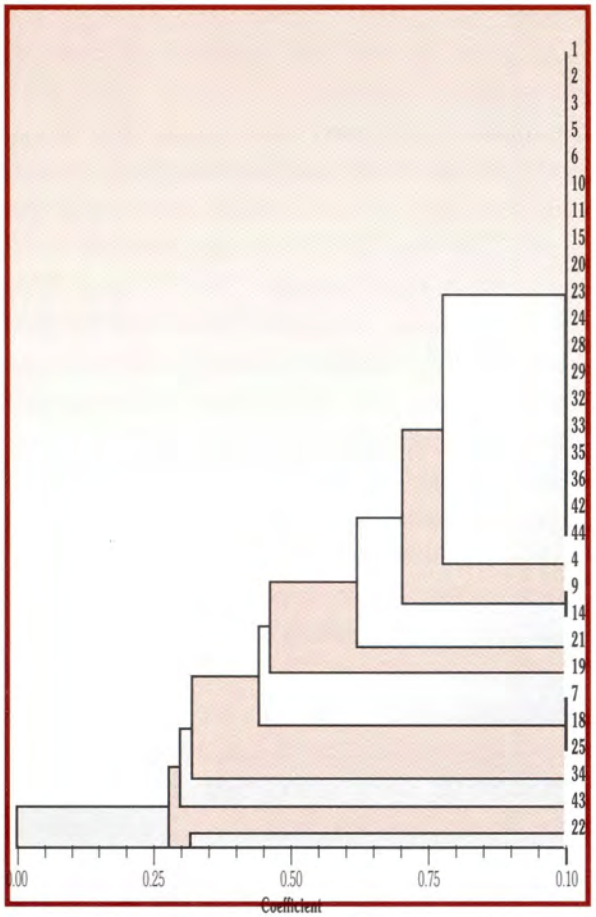


Fig. 21 a: Cluster analysis using UPGMA grouped 30 race 18 isolates into 9 groups based IS element PCR

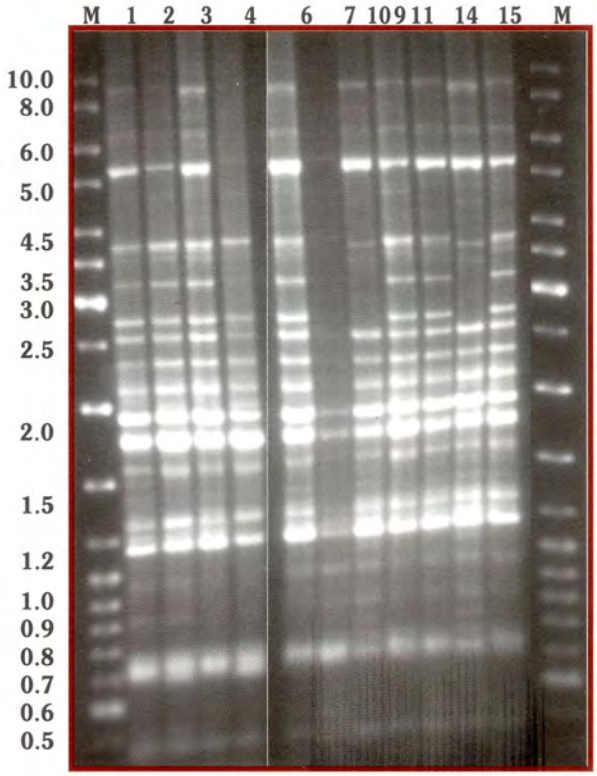


Fig. 21b: DNA fingerprinting based on IS112 repetitive element PCR of race 18 isolates of *Xam*. Lance 1-11, isolates of *Xam*: M, 1KB DNA ladder

Optimisation of "*Xanthomonas* detect" PCR kit protocol for commercialisation

Diagnostic PCR method, developed for detection of *Xam* in infected cotton tissues and seeds was further optimised with regard to various components of the PCR kit.

PCR reactions were performed with different concentrations of bacterial cells/DNA keeping all other conditions and components uniform. With whole bacterial cells as PCR template, successful amplification was observed in all the cases from 20 to 10^3 cells.

A set of thirteen different PCR buffers (Fail safe A to M, Epicentre, USA) were evaluated for their

efficiency in PCR amplification of target organism. Better amplification was obtained in buffers H, I and L. Further optimisation and standardization showed buffer I to be the highly sensitive and efficient in detecting the presence of pathogen in reaction.

Taq polymerase enzymes from Biolene and Epicentre were found to be the best. The two enzymes were utilised for further standardization with Fail-safe buffer and the sytem was found to be highly efficient for detection *Xam*.

When stored at 20^{0}C the kit continued to be active at least for 6 months.

Coimbatore

Anatomy of the stem galls caused by stem weevil

Anatomical studies revealed that in the galled stems of all the varieties except Exotica and Moco, periderm and phloem cells were affected and dilated. Cortex region was modified by tangential expansion. Secondary phloem had maximum changes of necroses, crushing of tissues and sieve elements, fragmentation of fiber bands, distortion of phloem fibers and diffuse hypertrophy and hyperplasia of the ground tissue. Secondary xylem exhibits reduction in pore diameter, pore frequency poor lignification of vessels and fibers, diffuse dilation of the xylem rays. Xylem parenchyma rendered meristematic producing wound parenchyma which forms one of the primary sources of tissue for feeding of the grub. In Exotica, vessels near the wounded parenchyma had an amorphous gummy substance deposited all along the near walls. In Surabhi, a distinct growth ring is evident in the Xylem. In MCU-5 secondary Xylem vessels were filled with gummy substance.

Variability among the population of *H. armigera* for SSR markers

Studies conducted to evaluate the variations among *H. armigera* collected from four different hosts and locations by using SSR markers showed sufficient variation among the genomic DNA isolated.

Diseases

Interaction between various genotypes of *Gossypium* and isolates of *Ramularia areola*

Two year studies on reaction of various genotypes belonging to four cultivated *Gossypium* spp and the weed, *Euphorbia heterophylla* to different isolates of *R. areola*, clearly indicate the differential response of the hosts. The line GB 124 is fairly resistant to all the isolates of *R. areola*. GB 119 and ERB 13758 showed susceptible reactions to only *barbadense* isolate whereas Suvin was susceptible to both *barbadense* and *hirsutum* isolates. The *G. hirsutum* line IC 629 showed resistant reaction to the weed isolate and moderate resistant reaction to the *hirsutum* isolate and susceptibility to other three isolates, where as the *G. arboreum* line AC 36 showed resistance to the weed isolate and susceptibility to other four isolates. The *G. hirsutum* cv. LRA 5166, the *G. herbaceum* and *G. arboreum* lines tested as well as the weed host *Euphorbia heterophylla* were susceptible to all isolates. The results indicate that the *G. barbadense* hosts along with the selected lines of other three *Gossypium* spp may be used for detection and differentiation of *R. areola* isolates.

Development of Molecular Tools

Nagpur

***Ramularia areola* (Grey mildew)**

The pathogen was successfully cultured with Well method by 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. New synthetic media alone or in combination along with either of cotton leaf decoction or carrot juice or combination of these was observed to be better for the growth of *R. areola*.

The growth pattern and mycelial dry weight of 12 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*.

A total number of seven isolates of the pathogen, two isolates from the cultivars of *G. herbaceum*, three from the cultivars of *G. arboreum* and two from *G. hirsutum* were inoculated on 26 different cotton cultivars belonging to four cultivated species. Pathogen isolates from *G. arboreum*, *G. herbaceum* and *G. hirsutum* cotton were able to infect the lines of the same species. However, initiation of infection was observed with the isolates of *G. arboreum* and *G. herbaceum* on lines of *G. barbadense* but there was no profuse sporulation. The lines of *G. barbadense* were almost immune to the isolates from *G. hirsutum*. The variability in host reaction of seven isolates to 26 different cultivars of four cultivated species indicated the existence of races/biotypes in *R areola*.

Twenty arbitrary primers (Operon Technologies, Alameda, CA) 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 three cultivated species of *G. arboreum*, *G. herbaceum* and *G. hirsutum* gave a clear indication of variation among the isolates at species level.

***Fusarium oxysporum* f. sp. *vasinfectum* (Fusarium wilt)**

Nine cultures of *Fusarium oxysporum* f sp. *vasinfectum* were isolated from different cotton growing areas of Maharashtra. Growth pattern, influence of salt concentration on growth and pigmentation of nine isolates indicate the variability among the different isolates. Pathogenic variability of these cultures was tested on susceptible cultivar G-27. The mortality varied between 40.00 to 95.65 per cent within 30 days of germination indicating the variability among the isolates.

Protocol for DNA isolation of *Fusarium oxysporum* f sp. *vasinfectum* was standardized. PCR was developed for the detection of *Fusarium oxysporum* 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. The isolates of *Fusarium oxysporum* f sp. *vasinfectum* were clearly assigned to two distinct groups indicating the variation in the pathogen.

Cultural characteristic such as growth rate, colony appearance and pigmentation, salt tolerance capacity, pathogenicity and RAPD pattern gave clear indication of variation in the pathogen *Fusarium oxysporum* f. sp. *vasinfectum*.

Sirsa

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

Root rot caused by *Rhizoctonia solani* and *R. bataticola* is an important disease affecting cotton grown in northern region. Two species-specific primers were developed for quick identification of *Rhizoctonia bataticola* species. These primers, ITS-Rb-F and ITS-Rb-R were designed by comparing the aligned sequences of internal transcribed spacer regions (ITS) of *R. bataticola* species isolates. The primer showed good specificity for the species R *bataticola*, and the product ranging 410-462 bp was amplified exclusively when tested with isolates of *Rhizoctonia bataticola*. PCR sensitivity ranged from 1 pg to 10 ng for DNA extracted from *R. bataticola* mycelium. No amplification products were detected from isolates of *Rhizoctonia solani* using these primers. The assay is useful for rapid identification of *R. bataticola* species cultures and their differentiation from *R. solani* (Fig. 22).

Fig. 22: Specificity of PCR assay with genomic DNA from different isolates of *Rhizoctonia* sps.Lane 1-6 isolates of *R. bataticola*; Lane 7-10 isolates of *R. solani*.

A coat protein primer designed earlier for detection of cotton leaf curl virus which amplifies the entire coat protein gene of 771 bp was validated for its use for detection of virus in cotton plants, weeds and whitefly during 2005-06 crop season (Fig.23).

Fig. 23: Validation of coat protein primer for detection of CLCuV from cotton (A), whitefly (B) and weeds (C) - Amplification of coat protein gene of 771bp.

Epidemiology

Nagpur

Prediction of onset and severity of *H. armigera*

Calendar year based degree-day accumulation of 2492 DDs during 2005, predicted onset of *H. armigera* oviposition on cotton. Low male moth catches in pheromone traps (< five/week) during September, less than one egg per plant before the 1st week of September and less larval incidence (< one) between end of September and mid-October did not fulfill the *H. armigera* severity prediction criteria and negated its outbreak. The criteria of severity of *H. armigera* during *rabi* season in relation to that of cotton was validated.

Prediction of *P. gossypiella* severity

During 2005, the severity of pink bollworm was less with the morning relative humidity and minimum temperature conditions not congenial for the population development.

Weather variables & Standard week	Criteria predicting severity	Goodness of fit during 2005	Observed severity
Maximum temperature (40)	> 33 °C	33.9	
Morning relative humidity (41)	**< 70 %**	**75.7**	
Evening relative humidity (43)	> 40 %	56.3	Less
Minimum Temperature (48)		14.2	
Minimum Temperature (49)	< 12 °C	**12.3**	

Coimbatore

Survey for the incidence of grey mildew and alternaria leaf spot

During 2005-06 winter cotton season, there was severe incidence of grey mildew throughout Tamil Nadu on all four cultivated *Gossypium* spp. The heavy and frequent rains from September to December '05 helped in the development of the disease as well as further spread. Alternaria leaf spot was seen only during the early part of the season and the incidence was also low and localized.

Yield loss assessment due to fungal foliar diseases

Spraying of Carbendazim 0.1% @ 80, 95 and 110 DAS greatly reduced the disease when compared with spraying on 95 and 110 DAS and Check (water spray) and averted 33% yield loss. The same trend was noted during 2004-05.

Management of Pests

Nagpur

Testing of new molecules

Sumitomo molecule S-1812 was evaluated singly and in combination with Meothrin (Fenpropathrin), S 1812 was tested at 3 doses of 50 g a.i./ ha, 75 g ai/ha and 100 g ai/ha. S1812 was tested at two doses of 50 g a.i/ha in combination with 50 and 75 g a.i/ha of Meothrin. S 1812 was effective against jassid nymphs at the three doses tested singly and in combination up to 10 days after spray on par with endosulfan, metasystox and meothrin on CNH 120 MB. Significant reduction in square damage was observed in all the combination treatments as compared to S 1812 (50,75,100 g ai/ ha) and was comparable to meothrin or indoxacarb when used alone.

S-1812 was apparently safer to coccinellid nymphal population as compared to meothrin and the combination too was safer at lower concentrations with no reduction in nymphal population compared to control.

A new molecule β-cyfluthrin was tested at 3 doses, 12.5 g ai/ha, 18 g ai/ha and 25 g ai/ha. The single year trial has demonstrated that β-cyfluthrin at the doses tested contributes significantly to increased seed cotton yield of the first pick, although there was no significant differences within the doses tested. It is effective against jassids by demonstrating a dose dependant reduction of its population up to 3 days after spray. It demonstrates a dose dependent reduction of *Helicoverpa* damage, 3

days after spray and continues to offer protection up to 5 days after spray.

The Energy Resources Institute, New Delhi tested its new botanicals, in 6 treatments, Teri I, Teri II, Teri III a, Teri III b, Teri V a, Teri V b. Formulations were sprayed 4 times during the season. Teri IIIb and Teri Va appear to be the most promising molecules in terms of pest control. Use of Teri formulations or neem did not contribute to significant yield advantage this season although they demonstrated significant advantage in conserving beneficials in the field.

Studies on seed transmitted pathogenic infections in relation to disease-free seed production

Diseases incidence during seedling and boll development stage

Cotyledonary leaves and boll infection isolations in the varieties/hybrids/germplasm lines revealed the presence of pathogenic fungi viz. *Alternaria macrospora* (G1, AKA-53, Chandrolla, DB 3-12, MDCH-201) *Cercospora gossypii* (AKA-8307, AKA 8401, AKA 5, LD 327, DB 3-12, DH 9, Laxmi, LRA 5166, LRK 516, DHY 286, Suman, Surabhi, H6), *Phoma exigua* (G1, Maljari, AKA 8307, AKH 4, G 27, Chandrolla, MDCH 201, Laxmi), *Macrophomina phaseolina* (G 27, AKA 5, AKA 53, AKA 8401, PKV 081, Laxmi, LRK 516, G.Cot. Hyb.8) and the *Myrothecium roridum* and bacterial blight pathogen *X.a.* pv. *malvacearum* with moderate to severe incidence on majority of the *G. hirsutum* varieties and intra-*hirsutum* hybrids.

Detection of pathogenic infections in 2004-05 seed samples

Cotton seed samples belonging to fifty germplasm lines/varieties/hybrids (F 2) of the previous crop season (2004-05), which were separated, graded, acid delinted, were examined for seed discoloration, fungus fructifications and yellow slime of bacteria. These were tested by Blotter method and on Nutritional agar media. Infection ranging between 1 to 3% was observed that of *Alternaria macrospora*, *Myrothecium roridum*, *Phoma exigua*, *Macrophomina phaseolina* and the bacterial blight pathogen *X.a.* pv. *malvacearum*. Association of other fungi viz., *Alternaria tenuis*, *Curvularia* spp., *Drechslera tetramera*, *Fusarium spp. and Trichothecium roseum* was also observed.

Compatibility of seed dressing fungicides with seed dressing insecticides

Seed dressing fungicides Sixer 75% (Mancozeb 63% + Carbendazim 12%) and Vitavax Power (Carboxin 37.5% + Thiram 37.5%) were found compatible, with seed dressing insecticide Gaucho (Imidacloprid) even upto a concentration of 500 ppm under *in vitro* studies when leaf spot fungus *Myrothecium roridum* was used as test pathogen.

Coimbatore

Evaluation of newer insecticides against key pests of cotton

Three new insecticides (E2Y 45, Spinosad new A:D & Beta cyfluthrin) as first year trial and two new insecticides (NNI 0001 & RIL 038) as second year trial evaluated for the control of key pests of cotton, along with Spinosad as standard. Critical observation on key sucking pest - jassid revealed that none of the treatment was effective during the high intensity period i.e. 108 to 123 days after sowing (DAS). With regard to bollworms, all the treatments except Beta cyfluthrin were effective upto 123 DAS in reducing the fruiting bodies damage which ranged mostly from 0.4 to 4.8 % in the treatments and 4.5 to 6.5 % in control. The treatments Spinosad new A:D, at 100 g and Beta cyfluthrin at 18 & 25 g were effective in reducing the boll and locule damage significantly over control. They also recorded

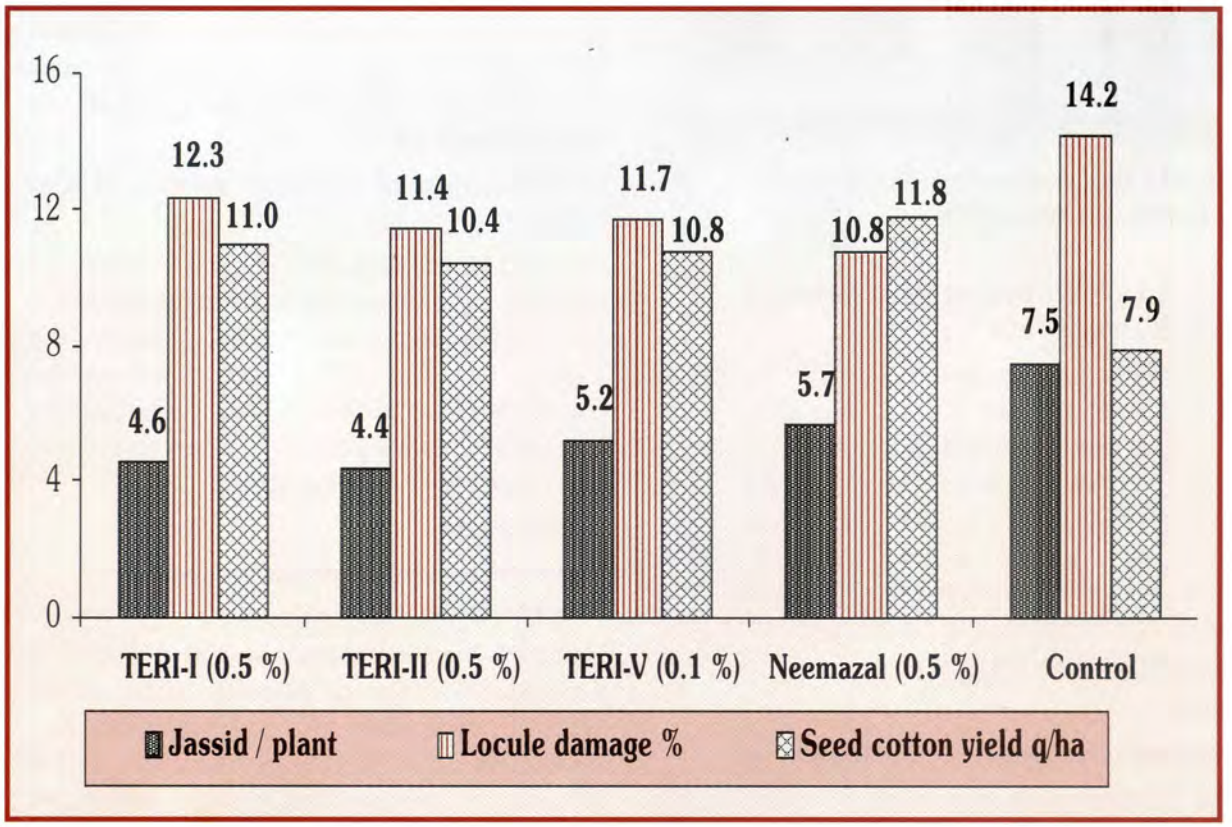
higher seed cotton yield (2543 to 2584 kg/ha) as compared to other treatments (1866 to 2386 kg/ha) and control (1571 kg/ha).

Evaluation of Botanicals (TERI formulations) against key pests of cotton

Sucking pests: TERI formulations brought out a reduction of 16.8-40.9% jassid population, while the standard commercial formulation-Neemazal effected 24.2 % reduction. Among the TERI formulations, TERI II (0.5 %) followed by TERI-I (0.5%) and TERI-V (0.1%) were promising (Fig.24). The population of other sucking pests viz., aphid, thrips and whitefly were not at appreciable level and hence were not recorded.

Bollworms: TERI formulations brought out a reduction of 11.5 to 67.2% damage by bollworms in the shed fruiting bodies. Among the TERI formulations, TERI-V (0.1%) followed by TERI-I (0.5%) were promising and recorded 67.2 and 40.0% reduction, respectively Fig.24. The reduction of retained fruiting bodies damage ranged from 8.6 to 29.6 % among the treatments. TERI-I (0.5%), TERI-V (0.1 %) brought out 29.6 and 27.2 % reduction as compared to 18.5 % reduction in Neemazal. At harvest, locule damage ranged from 11.4 to 18.6 % among the TERI formulations and 10.8 % in Neemazal. Locule damage reduction was 23.9, 19.7, 17.6 and 13.4 % in Neemazal, TERI II (0.5%), TERI-V (0.1%) and TERI-I (0.5%) treatments respectively.

Fig.24: Botanicals (TERI formulations) against key pests of cotton



Evaluation of insecticides against pink bollworm

Three Organo phosphorous insecticides (Profenofos, Chlorpyriphos & Quinalphos), two Synthetic pyrethroids (Lambda cyhalothrin & Beta cyfluthrin) and one Carbamate insecticide (Thiodicarb) were evaluated against pink bollworm in cotton. Non of the treatments were not effective in reducing damage in green bolls and loculi during 124 to 184 DAS. Further, they were also not effective in reducing the larval incidence of pink bollworm in flowers (Rosette) and green bolls. At harvest, locule damage was significantly low in Quinalphos, Chlorpyriphos and Pyrethroids over control (Fig.25).

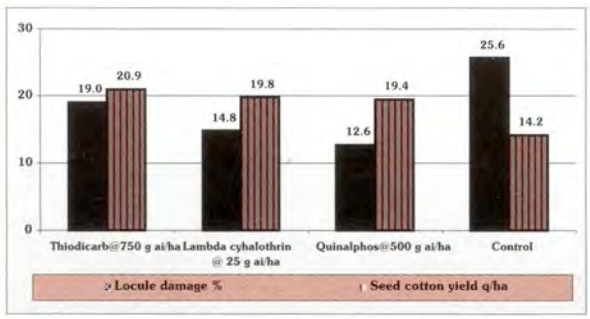


Fig.25 : Relative susceptibility of pink bollworm to insecticides

Role of seed treating insecticide in cotton ecosystem

Seed treatment of thiomethoxam 500 FS @ 5 ml and 7.5 ml per kg of seed was effective in reducing jassid and aphid infestation upto 40 days after sowing. With regard to seed cotton yield, there was no significant difference among the treatments. IOC Servo Agro spray oil was observed to be ineffective against whitefly and aphid as compared to standard check methyl-o-demeton and endosulfan.

Sirsa

New insecticide molecule screening

The chemical such as Polo 50 SC spray of 300 and 400 g ai/ha was effective against whitefly. Spinosad 45 SC A : D ratio @ 100 g ai/ha, @75 g ai/ha, EZY 45 (20SC) @ 40 and 30 g ai/ha were effective in the management of bollworms.

Bio Control Studies

Nagpur

Out of collective and individual soil antagonist microflora, *Trichoderma viride*, *Trichoderma harzianum*, *Penicillium* spp., and *Mucor racemosus* were found useful in limiting the root wilt and advance stage root rot with their pathogenicity respectively caused by *Fusarium oxysporum* f.sp. *vasinfectum* and *Rhizoctonia solani* and *R. bataticola* with bioassay in blotter, pots and field conditions. As a result of seed treatment, the foliar diseases, leaf spots and leaf blight caused by *Alternaria macrospora*, *Myrothecium roridum* and *Xanthomonas axonopodis* pv. *malvacearum* were observed to be limited initially in the pot and field conditions. In addition to control over diseases, the growth and vigour of plant was enhanced by seed treatment with *Trichoderma* spp. in diploid and tetraploid cottons.

Identification of efficient strains of bio-control

Out of 148 phylloplane bacterial cultures, 17 phylloplane / rhizosphere bacterial isolates were observed to be promising inhibitors showing the inhibition zones ranging from 9-15 mm against the virulent race 18 of *Xam*. The most promising bacteria belonged to *Pseudomonas fluorescence* and *Bacillus* spp.

Coimbatore

Field trials against stem weevil at farmers' field

Two trials were conducted in farmers' fields at Kanjappalli village of Avinashi taluk during 2005-06. In the first trial, the treatments *viz.*, Neemcake (150 kg/ha) + carbofuran (1.0 kg/a.i/ha), Neemcake (150 kg/ha) + carbofuran

(1.0 kg a.i/ha) + stem drenching with neem seed kernel extract 5%, were on par with each other and superior than the other treatments. In the second trial, the treatment Carbofuran (1.0 kg a.i/ha) + Chlorpyriphos recorded significantly minimum percentage of infestation.

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 in the field at 10 and 15 days intervals following the appearance of grey mildew on cv. Sumangala. Effectiveness of the treatments was ascertained at frequent intervals by collecting leaf samples.

During this year, there was very high incidence of grey mildew disease following heavy and continuous rains. Under these conditions, the fungicide Propiconazole was found to be the most effective treatment for the management of the disease. Among the bioagents, the combination spray of *T. harzianum* + *P. fluorescens* Pf1 was effective in reducing the disease to limited extent when sprayed at 10 day intervals.

Entomopathogenic nematodes (EPN)

Nagpur

An isolate of *Heterorhabditis indica* was developed tolerant to temperature stress by selection and crossing studies. All the isolates of entomopathogenic nematodes belonging to *Heterorhabditis spp.* and *Steinernema spp.* isolated from cotton growing ecosystems and found effective against cotton insects particularly cotton bollworms were evaluated for variation in tolerance to temperature, moisture stress and host finding ability. Variability was recorded in temperature tolerance, host finding ability and moisture tolerance of different isolates of Entomopathogenic nematode isolates.

For induction of tolerance to high temperature and moisture stress, total of ten selection cycles were carried out. One isolate of *Heterorhabditis indica* which had high temperature optima could be made to tolerate high temperatures by periodic exposure to high temperatures and selection of individuals that can tolerate it. This isolate could infect *Helicoverpa armigera* larvae at high temperature of 40°C.

Field-testing of heat tolerant isolate of *H.indica* against cotton insect pests

Heat tolerant isolate of *H.indica* in preliminary field trials was found effective against cotton insect pests. Ten to fifteen *H.indica* infective juveniles (IJ) per host larva was observed as the most effective dose for mortality of all the stages of *H.armigera* and other cotton insect pests viz. semilooper (*Anomis flava*), spodoptera (*Spodoptera litura*), pink bollworm (*Pectinophora gossypiella*), leaf roller (*Sylepta derrogata*) and spotted bollworm (*Earias sp.*). Its bacterial symbiont showed specific action against sucking pests.

Standardization of protocol for mass multiplication on artificial media

For field application of EPN, as component of Integrated Pest Management Modules, large quantity of nematode inoculums is required. In pursuance, various non-synthetic, synthetic and semi-synthetic culture media were evaluated in the laboratory. Wouts' substrate developed by Wouts (1981) was found to give maximum production of infective juveniles. However, the infectivity of inoculum produced was not satisfactory. Incorporation of Pork fat at 1 and 5 % instead of vegetable oils was found to give maximum production of nematode juveniles with high infectivity against cotton bollworm

larvae. Amongst the animal fats tried , Beef fat or Goat fat did not support good nematode population. Fat from ruminant animals as Beef and Goat are known to have slightly higher amounts of Palmitoleic acid which has antimicrobial properties and thus may be antagonistic towards nematodes. Moisture seems to be critical factor in mass production of nematodes. Temperature of 28°C and humidity above 60% were found to be suitable for nematode multiplication. (Table 18). New modified Wouts' medium can thus be used for mass multiplication and application of *H.indica* in the management of *H.armigera*.

Table 18: Production of infective juveniles of *H.indica* on modified Wouts' media under different temperature and moisture regimes. (Nematode numbers in 000)

Temperature regimes °C	Moisture regimes (% RH)			
	40	60	80	90
20	8-14 (10)	45-71 (60)	57-75 (68)	65-92 (85)
25	16-21(20)	110-156 (140)	130-182 (170)	156-210 (190)
28	19-25 (22)	125-168 (155)	156-190 (188)	190-215 (198)
30	20-25(23)	133-173 (158)	170-203 (190)	176-222 (180)

Figures in parenthesis indicate average.

Media which failed to give nematode build up are listed below.

i. Egg yolk supplemented with soya flour
ii. Dog food pellets
iii. Egg albumin with Soya flour
iv. Coconut milk and wheat germ
v. Coconut milk with dog food pellets
vi. Nutrient medium with normal peptone and beef extract
vii. Liver of pork, goat and chicken
viii. Goat kidney

Entomopathogenic nematode bacterial symbionts recorded as a new management option for management of aphids

A bacterial symbiont of entomopathogenic nematode (EPN) *Heterorhabdits indica* was found as viable management option for cotton aphids.

Laboratory evaluation

Results of laboratory evaluation indicate that raw bacterial broth, extracellular as well as intracellular fraction were effective against aphids (Table 19). The results indicate that there may be both intracellular as well as extracellular location of toxins with antagonistic effect against aphids.

Table 19: Laboratory evaluation of bacterial symbiont against cotton aphids

Treatment	Per cent Aphid mortality at hrs.	
	24 h	48 h
Bacterial broth	80	74.6
Bacterial supernatant 1	69.4	71.4
Bacterial supernatant 2	74	69.4
Pellet	61.3	68.1
Control Water	1.3	2.4
Control Sterile broth	2.8	2.8
CD 5%	4.3	5.2

Field evaluation: Besides cotton, heavy aphid infestation was reported on Chrysanthemum and Roses. On rose, initial population ranged between 75-100 aphids per plant while on Chrysanthemum population of 350-500 aphids was recorded. These ornamental plants were also treated with bacteria to evaluate effect of bacterial broth on aphid population. The results indicate confirm efficacy of bacterial broth as well as supernatant obtained indicating insecticidal nature of extracellular as well as intracellular components (Table 20).

Table 20: Per cent mortality of Aphids due to bacteria *Photorhabdus luminescens* under field conditions

Treatment	Cotton	Chrysanthemum	Rose
Bacterial broth	88	93.6	75
Bacterial supernatant 1	76	93.5	82
Bacterial supernatant 2	71.2	90.9	88
Pellet	61.3	73.5	60.7
Control Water	1.5	4.6	2.1
Control sterile nutrient broth	4.0	8.8	5
CD 1%	6.4	7.1	4.9

The results indicate potential of bacterial symbiont of EPN as management strategy for sucking pests as aphids. The strategy compares well with chemical treatment in term of economics. Cost of single treatment with bacterial symbiont works out 40-50% cheaper than chemical treatment while being ecologically safe

Mass production of EPN on field collected lepidopteran larvae

Though nematodes can be economically mass produced on artificial media for limited application, EPN can also be cultured economically *in vivo* on insect larvae. Various

insect species were evaluated for their ability to sustain and multiply populations of EPN. Except *Spodoptera* larvae, all other insect species could support nematode development and its population build up.

Application of 1 to 2 billion EPN *H.indica* infective juveniles/ ha has been reported to be effective dose against *H.armigera* on cotton. The cost of production of one billion infective juveniles (excluding cost of manpower) comes to Rs. 16 for *Galleria* larvae, Rs. 32 for *Corcyra* larvae while for different stages of *H.armigera* larvae cost ranges between Rs. 27 to 42/-. The costs compare well with the costs incurred for chemical management of cotton insect pests. The results indicate the feasibility of setting up of cottage industries using field reared lepidopteran larvae for production of EPN for use against insects especially in small land holdings as well as high value intensive cropping systems.

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

Protocol was developed using soaked grains of coarse broken rice fortified with 1% yeast granules for development of *N. rileyi* and *Metarhizium mycelia* and sporulation. On Jowar there was less sporulation while on wheat the fungi could not develop.

Soil sampling for nematode presence

Mapping of Central Institute for Cotton Research, Nagpur fields spread over about 258 acres was completed. Population dynamics of plant parasitic nematodes under different cropping sequences for complete calendar year was mapped. Reniform nematode, *Rotylenchulus reniformis* was found as the most dominant and frequent nematode species. Population of reniform nematode ranged between 80-380 nematodes /250 cc soil at sowing. At mid season, the population ranged between 425- 560 nematodes/250 cc soil. On termination of crop which also concides with onset of winter, the population was found to dip to 10-30 nematodes/250 cc soil. Other nematode species recorded were *Helicotylenchus, Pratylenchus, Tylenchorhanchus* and *Hoplolaimus spp*. Weed species associated with cotton were found to be good hosts of reniform nematode. With onset of winter , majority of nematodes were found to enter anhydobiotic state. This state was marked by coiling of nematodes with no apparent activity. Cropping systems incorporating Jowar was found to have reduced renifrom nematode ranging between 15-30 nematodes/ 250 cc soil. Incorporaton of Soybean in cropping systems which is very good host of reniform nematode was found to result in enhanced reniform nematode population which ranged between 399-430 nematodes/ 250 cc soil.

Studies indicated that nematodes could be used 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.

Integrated Pest Management

Nagpur

Insect pest management

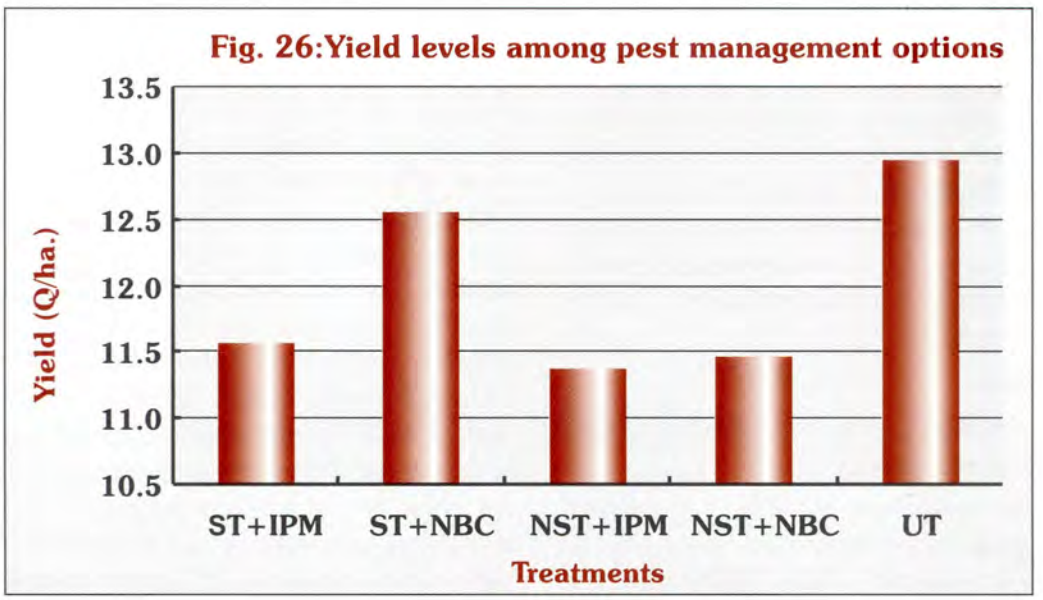
Validation of IPM measures *viz.*, avoidance of prophylactic measure of seed treatment (ST), no protection of *H. armigera* on the first flush of squares(September) and bollworm management during October-November months was done through field experiment using NHH 44. The experiment had ST, or ST + single systemic insecticide spray, or single neem seed kernel extract (NSKE) spray or two

systemic insecticide sprays for sucking pest management with or without management option against *H. armigera* on the 1st flush and similar bollworm management options during October-November, in addition to a completely unprotected crop.

Two sprays of systemic insecticides reduced jassid nymphs significantly over seed treatment with single foliar spray and no seed treatment with single NSKE spray. This indicated the efficacy of foliar treatment against jassids. On the other hand crop with seed treatment alone had nymph population on par with seed treatment + one systemic insecticidal sprayed crop, the later on par with the untreated crop. Such results indicated the non-necessity of the prophylactic measure of seed treatment.

Damage on open boll and loculi basis was higher among treatments with seed treatment on par with untreated crop. The damage was lower on the crop with need based chemical (NBC) sprays for all insect pests without prophylactic seed treatment. Yield levels indicated significant differences among treatments for the second and third pickings. In the second pick, yields of NBC treatments with or without seed treatment, but with *H. armigera* management on first flush had significantly lower yields. On the contrary, IPM treatments without *H. armigera* management on first flush had significantly higher and on par yields with untreated crop. With the bollworm protections during October and November, crop that had ST and/or sucking pest and early season bollworm management contributed to yield from the late flush formed during November. The unprotected crop had higher yield contribution to yield from October formed second flush. The strategy of NST and non-protection of *H. armigera* during September augment better quality of cotton as well. This validated the need for avoidance of *H. armigera* management occurring in first flush. Similar yields among IPM, NBC and unprotected treatments (Fig. 26) during the season confirmed the compensation factor of NHH 44 overriding the insect pest onslaught in governing the yield. These pointed to the need for redesigning cotton pest management considering crop response over the pest population and its damage.

Fig. 26:Yield levels among pest management options



Cultivar- Insect Pest interactions

Eight cotton cultivars viz., AKA-8401, MECH-162 Bt, MECH-184 Bt, RCH-2 Bt, Bunny, PKV HY-2, Surabhi and LRA-5166 studied for cultivar bollworm interactions revealed higher and also late season compensatory capacity of conventional hybrids (PKV Hy-2, Bunny) and variety (Surabhi) with significantly higher square production in response to higher loss of bolls. The varieties LRA-5166 and AKA-8401 produced lesser number of squares and lower loss of fruiting structures and had lower degree of compensation to the late season fruiting structure damage. Higher susceptibility of *arboreum* cultivar AKA-8401 to *Earias* amongst other cultivars was noticed. Higher entomological and lower physiological shedding in respect of AKA-8401, PKV Hy-2 and LRA-5166 and the reverse trend with Bt cultivars, Bunny and Surabhi was observed. Bollworm damage had been highest in *arboreum* followed by conventional *hirsutums*, while it was lowest on Bt hybrids. The yield levels indicated poor performance of AKA-8401 and LRA-5166 and on par better performance of Bt and conventional hybrids besides surabhi. While the transgenics have contributed to yield due to the input trait of Cry-1Ac, the conventional hybrids made up for yield levels due to their ability to respond for damage i.e. compensation. Since plant compensation is concerned with yields rather than fitness, and variation in compensatory response affects sampling and ETLs an optimal strategy needs to be devised to improve pesticide regimes considering fruiting pattern and fruit setting.

Coimbatore

IPM at village level to produce cost effective quality fibre

Various components of IPM have been demonstrated with farmers participation in six villages of Avinashi Taluk (Chinnakanur, Periyakanur, Oothukadu, Sengalipalayam, Thottakalampudur and Ramanathapuram) in Coimbatore district during 2005-06. This helped 196 cotton cultivators, covering an area of 226 acres of cotton. The important activities carried out in the project villages were development of a nucleus village, establishment of one plant clinic centre and several IPM model farms. It resulted in reducing number of sprays and plant protection cost by 82.6 and 69.4 per cent respectively, besides good amount of conservation and augmentation of natural enemies in the project villages. It also increased the seed cotton yield by 18.9 per cent and net returns by Rs.7640/ha (Fig.27) .

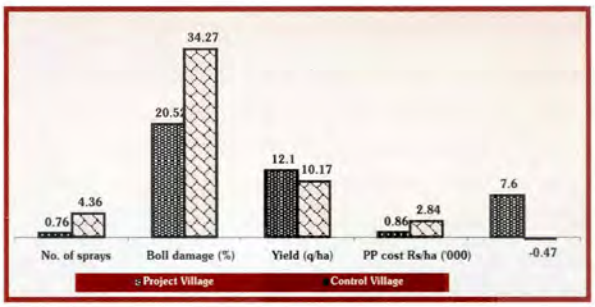


Fig. 27: Economics and other attributes in IPM and control village

IPM for Bt cotton

IPM for Bt cotton included maintenance of biodiversity (through inter crop-blackgram / bund crop-cowpea / trap crop-castor / ecofeast crop-maize, setaria), pheromone monitoring, use of neem as ovipositional deterrent, mechanical collection (eggs, grownup larvae, rosette flowers and shed squares), bird perch, topping and use of need based insecticides. Three Bt cotton hybrids (RCH20, MECH 184 and NCS 207) were evaluated and compared with the non IPM fields in the control villages. Adoption of IPM reduced the sucking pests and bollworms substantially compared to non-IPM plots. Low population of natural enemies was

observed on non-IPM cotton, which received maximum pesticidal sprays. The good impact was felt by way of reducing number of sprays, plant protection cost and increasing the seed cotton yield, net return and cost benefit ratio (Table 21).

Table 21: Impact of IPM on the performance of Bt hybrids

Particulars	RCH 20 Bt		MECH 184 Bt		NCS 207 Bt (Mallika Bt)	
	IPM	Non IPM	IPM	Non IPM	IPM	Non IPM
Jassid /plant	2.43	0.72	1.22	2.53	2.06	2.43
Predators / plant	0.45	0.41	0.37	0.26	0.39	0.28
ABW larva/ plant	0.13	0.20	0.27	0.33	0.02	0.13
PBW / 5 green bolls	0.13	0.29	0.33	0.30	0.10	0.20
Number of sprays (SW; SP; BW)	3 (1,1,1)	5 (1,3,1)	2 (0,2,0)	4 (1,3,2)	2 (1,1,0)	3 (0,2,1)
Open boll damage (%)	10.0	11.11	11.32	15.20	3.40	4.02
Locule damage (%)	6.29	7.22	5.13	8.09	3.14	2.91
Yield (q / ha)	23.75	17.50	25.00	15.00	21.25	17.50
Plant protection (Rs/ha)	1725	3315	1500	3070	1175	2190
Net Return (Rs / ha)	19628	11975	22455	10005	22613	15710
C:B ratio	1:1.67	1:1.50	1:1.77	1:1.48	1:2.07	1:1.78

SW-Stem weevil; SP - Sucking Pests; BW-Bollworms

Integrated disease management

Fungicide treatment Carbendazim 50 WP followed by the bioagent combination treatment (*Trichoderma harzianum* + *Pseudomonas fluorescens* Pf1) were the best spray schedule to manage grey mildew.

Sirsa

Integrated pest management

This year (2005-06) the area of the nucleus IPM farm has been extended to 39 acres including 6 Bt cotton entries in 18 acres as compared to 4 acres of 2003-04. This year the farmers such as Sh. Bhagwan Das, Sh. Mangat Ram, Sh. Sher Singh and Sh. Dharam Pal also joined the IPM trial along with the already existing farmers. In addition to this all the Bt cotton entries were also demonstrated in Randhawa village under farmers practice.

Among the entries in conventional IPM the maximum yield of 2500 kg/ha was noted in *desi* hybrid cotton (CICR 2) in IPM plot followed by other hybrids (2000 kg/ha) and in American cotton (1800 kg/ha). In hybrids the cost: benefit

ratio was more in IPM (1: 3.24) than non IPM (1 : 2.33). The C: B ratio of 1: 2.73 was obtained in the American cotton IPM. The increase in C : B ratio was mainly obtained because of sprays consisted of low cost neem products .

In case of Bt cotton, the maximum yield was obtained in MRC 6304 (1575 kg/ha) IPM trials than that of all the Bt cotton IPM as well as Non IPM trials. The yield in RCH 317 IPM was (1550 kg/ha) more than that of its non IPM and in RCH-134 IPM the yield was (1450 kg/ha) more than that of its Non IPM trials. Also, in case of MRC 6301 IPM the yield was (1100 kg/ha) more than that of its Non IPM (443 kg/ha). However in Ankur 651 the yield was (83 kg/ha) less than that of its Non IPM due to poor plant stand. The cost: benefit ratio in Bt cotton IPM was ranging from 1 : 1.56 to 1:0.08 But in non IPM it was negative in all the entries ranging from 1 : 0.71 to 0.28.

IPM in Cluster Villages

During the current season in addition to this nucleus village cluster of four adjoining villages *viz.*, Arniawali, Bakriawali, Choburja and Dhingtania were also selected for disseminating the IPM strategies. In total 18 farmers from these villages covering an area of around 40 hectares were adopted under IPM. The emphasis was made in selection of recommended varieties / hybrids *viz.*, H-1117, H-1226, H-1098 (American varieties), HD-123, RG-8 (desi varieties) and AAH-1 (desi hybrid).

The IPM practices such as light and pheromone traps and spray of neem based products were followed in these villages. Around 4.1 to 4.7 sprays were made in these fields, in which 40 -50 % sprays were of neem based products. The seed cotton yield in these IPM plots was ranging from 1530 to 2110 kg/ha.

Insecticide Resistance Management

Coimbatore

Dissemination of IRM strategies in Coimbatore district

Dissemination of IRM strategies had been undertaken in 16 villages of Annur and Avinashi blocks of Coimbatore district. Insecticide resistance of *Helicoverpa armigera* had been monitored in the project villages. The population dynamics of pests and natural enemies was also observed in the project villages the details are given in Table 22.

Table 22. : Summary table in plant protection, productivity and economics

S. No.	Particulars	IRM project villages	Control villages
1.	Number of project farmers	473	50
2.	Area in hectares	294.9	31.2
3.	Number of sprays	1.43	4.36
4.	Quantity of insecticide used g a.i./ha	634.70	1132
5.	Open boll damage (%)	17.38	34.27
6.	Locule damage (%)	10.34	24.55
7.	Yield (kg/ha)	1415	1017
8.	Cross Returns (Rs./ha)		
	➢ cotton	25,465.50	18306.00
	➢ Intercrop	508.00	125.00
	Total	**25,973.50**	**18431.00**
9.	Plant Protection cost (Rs./ha)	1,532.00	2,835.00
10.	Other cultivation cost (Rs./ha)	13,894.00	16070.00
11.	Total cost of cultivation (Rs./ha)	15,426.00	18,905.00
12.	Net Return (Rs./ha)	**10,547.14**	**-474**
13.	Cost Benefit Ratio	**1:1.69**	**1:0.98**

Sirsa

Forty villages in each of the three districts *viz.*, Sirsa, Fatehabad and Hisar district were selected for implementing the Insecticide Resistance Management strategies. The spray of neem was done at many places for the management of sucking pests, as well as imidacloprid, at places where severe incidence of jassids was noted. For the management of spotted bollworm, the spray of endosulfan was adopted followed by synthetic pyrethroid (in case of severe attack of spotted bollworm).

The number of sprays in IRM villages ranged from 4.13 to 4.80 compared to that of 5.74 to 8.87 sprays in non-IRM villages. The general trend of using tank mixture of insecticide was found in non-IRM villages. The spraying of tank mixture of insecticides was reduced to a great extent in IRM villages. In Haryana there was 35.57 % reduction in pesticide load and 43.8 % reduction in cost of plant protection in IRM villages compared to non-IRM villages. This reduction is due to i) application of cheaper and eco-friendly neem products, ii) spray of insecticides based on ETL, iii) avoidance of tank mixture of insecticides, iv) avoidance of unnecessary multiple spraying of costly insecticides, and other important IRM strategies.

By following the IRM strategies around 28.04 to 45.88 % reduction in number of sprays was achieved in IRM villages, which has contributed to Rs.1151 to 2875 reduction in cost of cultivation over non-IRM villages. The average seed cotton yield ranged from 1452 to 1914 kg/ha in IRM villages compared to that of 1346 to 1771 kg/ha in non-IRM villages. This has led to increase in C : B ratio which subsequently yielded Rs.3271 to 4855 more net profit in IRM villages over non-IRM villages.

Insecticide Resistance Monitoring

For detecting the resistance in *H. armigera* against five major pesticides *viz.*, endosulfan, spinosad, chlorpyriphos, fenvalerate and cypermethrin, the larvae of *H. armigera* were collected from chickpea field during April, 2006 and larvae were reared under laboratory conditions (Temperature 26±2°C and relative humidity 65±5 %). The resistance monitoring work was carried out on F_1 population. The data depict that 95% mortality was recorded in case of endosulfan 10 ug/ul i.e. 5% resistance was found and in case of spinosad 1ug/ul 4% resistance was realized. Whereas in case of fenvalerate 100% resistance was recorded, demonstrating no mortality. In case of chlorpyriphos and cypermethrin 67% and 74% resistance respectively was recorded. However, in Fatehabad the resistance level was ranged from 33.33% against Endosulfan 10 ug/ul and up to 87.5 % against Cypermethrin 0.1ug/ul as well as Fenvalerate 0.2 ug/ul.

TECHNOLOGY ASSESSED AND TRANSFERRED

- Performance of transgenic Bt cottons
- Dry sowing of cotton
- Planting on ridges and furrows
- Cotton based intercropping system (cotton + soybean)
- Integrated nutrient management in cotton
- Foliar spray of 2% DAP
- Integrated Pest Management in cotton
- Insecticide Resistance Management
- Cultivation of clean cotton

EDUCATION AND TRAINING

Training received

Nagpur

- Dr. Vinita Gotmare, Scientist (SS) (cytogenetics) attended winter school on 'Recent advances in chromosome manipulation for increasing production and transfer of inbuilt resistance to biotic and abiotic stresses' at MPKV, Rahuri from Nov. 8-28, 2005.
- Dr. S. N. Rokde, Sr. Scientist (LP & M) attended training on 'Agro-eco situation' at Vasantrao Naik State Agriculture Extension and Management Training Institute, Nagpur from 18th - 24th Nov. 2005.
- Dr. S. Vennila, Sr. Scientist (Entomology) attended training on 'Resistance breeding in crop plants' at Department of Plant Breeding, Genetics and Biotechnology, PAU, Ludhiana from Jan. 3-23, 2006.
- Dr. V. Santhy, Scientist (SS) (Seed Technology) attended training on "Molecular evaluation of cotton" at CICR Nagpur from June 1-7, 2005.
- Dr. R. K. Deshmukh attended training programme on 'DUS testing of plant varieties principles and application' at IARI from March 6-10, 2006.

Coimbatore:

- Dr. S Manickam, Scientist (SS), (Cytogenetics) attended training on 'DUS testing of plant varieties' at IARI, New Delhi from 12-17, Sept, 2005.
- Dr. K Rathinavel, Sr. Scientists (Seed Technology) attended a training programme on "DUS testing of plant varieties - principles and applications at IARI, New Delhi from March, 6-10 2006.

Training Imparted

Model Training Course on Production Technology for Bt Cotton

A Model Training Course on "Production Technology for Bt Cotton" was organized at CICR, Nagpur during Sep.21-28, 2005. The training course was sponsored by the Govt. of India, Ministry of Agriculture, Directorate of Extension, New Delhi. Dr. Tapan Chakrabarty, Dy. Director, National Environmental Engineering Research Institute(NEERI), Nagpur inaugurated the Course. Nineteen senior level extension functionaries from seven states including Punjab, Haryana, Madhya Pradesh, Maharashtra, Orissa, Andhra Pradesh, and Tamil Nadu attended the training course. Dr. B.M.Khadi, Director, CICR, distributed the certificates at the valedictory function held on

concluding day. Dr. Hemchandra Gajbhiye, Principal Scientist (Agril. Extension) was the Course Director.

Model Training Course on Integrated Pest Management in Cotton

A Model Training Course on "Integrated Pest Management in Cotton" was organized at CICR, Nagpur during Nov.17-24, 2005. The training course was sponsored by the Govt. of India, Ministry of Agriculture, Directorate of Extension, New Delhi. The meeting was organized to enhance skills of senior functionaries of Agriculture Departments of various states, so that the advances in plant protection technologies are transferred to cotton growers all across the country. Dr. R.T. Gahukar, former Technical Advisor to Food & Agriculture Organization (FAO), inaugurated the course. This eight day program was attended by nineteen participants from Punjab, Haryana, Madhya Pradesh, Maharashtra, Andhra Pradesh and Tamil Nadu. Dr. B.M.Khadi, Director, CICR, distributed the certificates at the valedictory function. Dr. Hemchandra Gajbhiye, Principal Scientist (Agril. Extension) was the Course Director.

Capacity Building Programme for Indian Agriculture Research, Extension and Development Organizations in Globalized Economy

The Indian Council of Agricultural Research in association with the Centre for International Trade in Agriculture & Agro-based Industries (CITA), New Delhi has organized a "Capacity Building Program for Indian Agriculture Research, Extension and Development Organizations in Globalized Economy" at CICR, Nagpur during Mar.3-4, 2006. This two day program included awareness seminar on such issues as challenges faced by Indian agriculture and agro-based industries under WTO regime, changes in global scenario in world livestock markets, innovations in agri-food sector, world market, ecological and social issues in agri-food trade, transparency and ethical issues in food trade. The program also included capacity building workshop which dealt with technical issues in agri-food industry, trade and economic issues in agri food industry, legal requirements, and accountability and transparency issues in food trade. The objective of organizing this program was to sensitize the scientists, university staff, entrepreneurs, state officials, farmers, media and other interest groups in inculcating trade dimensions to agricultural research in order to improve the commercial viability of the agricultural produce which will directly benefit the marginal farmers and agricultural entrepreneurs in terms of capital.

The program was attended by 86 participants from 14 organizations which included seven ICAR Institutes and seven State Agricultural Universities located in central India.

Coimbatore

Training Programme on Long Staple Cotton Production

A two day trainer's training programme on long staple cotton production in Tamil Nadu was organized by the Directorate of Cotton Development, Ministry of Agriculture and Cooperation, Government of India at CICR, Regional Station, Coimbatore on September 23-24, 2005. There were twenty five participants from the Department of Agriculture of Haryana, Madhya Pradesh, Karnataka, Andhra Pradesh and Tamil Nadu states. The training was inaugurated by Dr. T. S. Raveendran, Director, CPMG, TNAU, Coimbatore. During the training programme lectures on various topics pertaining to long staple cotton cultivation in Tamil Nadu were delivered. The trainees were also taken to the

IVLP and IPM villages for an interaction with the farmers. A booklet on long staple cotton cultivation in Tamil was released on the occasion.

Training Programme for Field Level Workers

A training programme was organized for the field level workers at CICR Regional Station, Coimbatore on August 22-23, 2005. A series of ten lectures were organized by the scientists of CICR Regional Station, Coimbatore covering various aspects of cotton cultivation.

Sirsa

Training on Cotton Production Technology

Three short state level training programmes of three days duration were organized at CICR Regional Station, Sirsa on Cotton Production Technology under implementation of Action Plan of ICDP Mini Mission II for TMC. The Training programmes have been organized on April 18-20, April, 25-27 and April 28-30, 2005. These training programmes were attended by Haryana State Agriculture, Department Officials. A capsule of fourteen lectures i.e. seven in crop improvement, two in crop production and five in crop protection technologies was prepared to impart training.

Training on Bt detection kit

The officials from State Agriculture Department and Haryana Seed Development Cooperation were trained on Bt cotton detection kit on August 10, 2005 at CICR Regional Station, Sirsa. Lectures on Bt cotton and its detection aspects and practical demonstration were organized.

National Level Training of Trainers

A National level training of trainers on advancement in cotton research was inaugurated by Dr. B. M. Khadi, Director, Central Institute for Cotton Research, Nagpur at meeting Hall of CICR, RS, Sirsa on 5th & 6th September, 2005. Trainees from states implementing MM-II scheme, KVK's, SAU's and ICAR institutes participated besides these resource persons from Ministry of Agriculture, ICAR institutes and SAU's have also taken part. The following publications were released at this occasion:

1. CICR, RS Sirsa at a Glance
2. Germplasm Bulletin I
3. Training manual of National Level Training on Advancement in Cotton Research

Dr. Mangala Rai, Secretary, DARE & Director General, ICAR visiting IRM Lab.

Dr. M. S. Swaminathan, Chairman, National Commission on Farmers visiting Molecular Pathology Lab.

Dr. B. M. Khadi, Director receiving 'Rajashree Tandon' Official Language Award of ICAR.

Dr. M V Rao, Former Vice Chancellor, ANGRAU, Hyderabad visiting IRM Lab.

AWARDS AND RECOGNITIONS

Rajarshee Tandan Award

Central Institute for Cotton Research, Nagpur has bagged the prestigious "Rajarshee Tandon " Official Language Award instituted by Indian Council of Agricultural Research for excellent execution of official work in Hindi. The award was presented to Dr. B. M. Khadi, Director, CICR Nagpur at a function held at New Delhi on 27th February, 2006 by the chief guest Dr. Ratnakar Pandey, Ex. Member of Parliament. Dr. Mangala Rai, Secretary, DARE and Director General, ICAR presided over the function. CICR received a shield and a certificate of merit

Ganesh Shankar Vidyarthi' Award

Central Institute for Cotton Research, Nagpur has got the Ganesh Shanker Vidyarthi Prize for its publication 'Swet Swarnima' (in Hindi) Ganesh Shanker Vidyarthi Prize.

Dr. Hemchandra Gajbhiye,

Principal Scientist (Agril. Extn) has received 'Gram Mitra Award' for the year 2006 instituted by Dr. Ambedkar Rural Welfare Foundation, Sakhra District Wardha (MS) in recognition of his services for rural masses in Vidarbha. The award consisting of memento and shawl was presented at the hands of Dr. NM Nimgade, eminent agricultural scientist (Retd) at village Sakhra district Wardha on Jan. 26, 2006.

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/SAUs
• Germplasm collection maintenance and plant quarantine clearance	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

INTERNATIONAL

Areas of Linkages	Institution
Germplasm collection, conservation and documentation	IPGRI, Rome, Italy

ALL INDIA COORDINATED COTTON IMPROVEMENT PROJECT

Crop Improvement

National Trials

- Ten National Trials, seven for the improvement of *G. hirsutum* varieties and tetraploid hybrids and three for the improvement of *Desi* varieties and hybrids were conducted during the year 2005-06.
- In the Initial Evaluation Trial of *G. hirsutum* varieties under irrigated conditions, entry LH 2076 was adaptable to all the three zones and came with in first three ranks in mean seed cotton yield. Entry ADL 903 recorded the highest yield in both Central and South Zones.
- Under rainfed situation in Central Zone, entries NH 630, KH 155 and GTHV 0/35 were the three best entries for seed cotton yield. In South Zone, only CPD 818 was better than the Zonal check.
- Among the conventional intra-*hirsutum* hybrids under irrigated conditions, FHH 136 was the best hybrid in North Zone. Tulasi 27 was found to be adaptable to both Central and South Zone and occupied the second rank in both the zones. Under Rainfed conditions BSSCH 29 occupied the first rank in both Central and South Zones.
- Among the male sterile based hybrids tested under irrigated conditions, six hybrids were better than the Zonal check in Central Zone. Under rainfed conditions, only one hybrid recorded higher seed cotton yield over the Zonal check in South Zone.
- In the inter specific (*G. hirsutum* x *G. barbadense*) hybrid trial, four hybrids viz., JKCHB 214, USHB 25, RAHB 170 and ARBHB 943 occupied the first four ranks in both Central and South Zones and were superior to DCH 32, the check hybrid.
- In the trial on *G. arboreum* genotypes, several high yielding genotypes have been identified in all the three zones. LD 875, CISA 2R, and LD 876 were promising in North Zone. KWA 227 and KWA 225 were suitable for both Central and South Zones. CINA 333 recorded the highest yield in South Zone.
- Several intra *arboreum* hybrids superior to AAH-1 (C) have been identified. Performance of CISSA 7 was promising in all the three zones. Hybrids LMCH 28 and AAH 22 were the best in North Zone. Hybrids GGCH 7 and JKCDH 501 were suitable for both Central and South Zones. GGCH 81 recorded the highest fibre strength in all the three zones
- Among the *G. herbaceum* cultures tested, GSHV 93/2001 and GSHV 109/2001 were better than the Zonal check variety G. Cot 23.

North Zone Trials

- Entries F 2036 and CSH 7106 among *G. hirsutum* genotypes and hybrids HHH 386, HHH 270, JKCH 1050 and USHH 11 among intra *hirsutum* hybrids were promising.
- *G. arboreum* genotypes LD 861, CISA 614, LD 866 and FDK 103 were higher yielding than the Zonal check. Intra *arboreum* hybrids superior to the Zonal check hybrid AAH -1 have been identified.

Central Zone Trials

- *G. hirsutum* genotypes GSHV 01/1338 and CCH 510-4 under irrigated conditions were superior to LRA 5166 in yield and also had better quality. Under rainfed situations, GSHV 01/26 and HAG 1009 were superior to LRA 5166 (Zonal check) in yield and were on par with it in quality.
- Eight intra *hirsutum* hybrids superior to Ankur 651 (Zonal check) in seed cotton

yield under irrigated condition have been identified. Fibre quality wise, PMCH 99 was the best.

- All the hybrids evaluated under rainfed conditions were better than the Zonal check NHH 44. Eight hybrids were superior to the local check hybrids
- Among the inter specific hybrids JKCHB 212 and PSCHB 901 showed better yield and fibre quality parameters as compared to DCH 32 (check).
- Eleven *G. arboreum* genotypes superior to both zonal and local checks have been identified.

South Zone Trials

- Fifteen *G.hirsutum* genotypes were superior to Surabhi (Zonal check) in mean seed cotton yield. Quality wise CCH 510-4 was the best.
- Sixteen intra *hirsutum* hybrids were superior to Bunny (Zonal check) in seed cotton yield. Quality wise, Tulasi 117 was superior to Bunny. Indam 178 and ARCHH 9770 were on par with Bunny in fibre quality.
- Under rainfed situations, 18 hybrids were superior to the zonal check Bunny but with variable fibre qualities.
- Even though all the inter specific hybrids evaluated were superior to DCH 32. Quality wise HAGHB 1042 and JKHB 212 were good.
- Among the *G. arboreum* genotypes tested, entry KWA 23 and ARBHA 35 were promising.

Crop Production

- Conventional practice adopted by farmers gave significantly high seed cotton yield (2167 kg/ha) over that of control and lower doses of pendimethalin (@ 0.50 and 0.75 kg a.i. /ha +one hoeing at 35 DAS) but it was statistically at par with combined application of pendimethalin @1.5 or 1 kg a.i. /ha along with one hoeing at 35 DAS at Sriganganagar. Lower number of weeds and weed dry matter was recorded in these treatments.
- 50% recommended dose of NPK +10 t FYM + foliar spray of nutrients gave significantly highest seed cotton yield (2858 kg/ha) over rest of the treatments at Ludhiana. Similar results were also recorded at Faridkot, where combined application of 10 t FYM/ha along with 50% RDF and foliar spray produced highest seed cotton yield (2824 kg/ha) and yield attributes such as number of bolls per plant, while other indices viz., boll weight and GOT were not influenced by INM treatments. In Kanpur, highest seed cotton yield was observed in RD of NPK + 10 t FYM /ha which was significantly superior over rest of the treatments.
- Combined application of recommended dose of fertilizer with FYM @ 10 t/ha produced higher seed cotton yield at Khandwa and Rahuri, whereas 50% RD of NPK + 10 t FYM/ha at Indore and FYM @ 5 t/ha + 100% RDF at Akola are recommended for higher yields.
- At Lam, Guntur, application of FYM @ 10 t/ha along with 50 % of recommended dose of chemical fertilizer was found efficient to sustain cotton yield and soil health under rainfed condition, while at Nandyal and Srivilliputtur, RD of NPK + 10 t FYM / ha gave higher seed cotton yield and RD of NPK + 5 t FYM per ha was optimum at Siruguppa

- Foliar application of urea (2 %) at flowering and DAP (2 %) at boll development phase helped in getting higher seed cotton yield at Khandwa and Rahuri.
- Four sprays of 2% KNO_3 resulted in higher seed cotton yield at Nanded and Siruguppa, whereas four sprays of 3% KNO_3 seemed beneficial at Surat.
- Different organic fertilizers did not influence seed cotton yield under rainfed condition; however, *in situ* incorporation of green manures led to higher yield at Nandyal.
- Application of 60 kg N/ha + 40 kg S/ha along with 10 t FYM /ha was found more remunerative as compared to other treatments at Indore.
- At Akola and Nanded, seed cotton yield was significantly higher with recommended plant protection measures than protection with biopesticides only; whereas reverse trend was seen at Indore. Recommended dose of fertilizer recorded higher seed cotton yield than other treatments in which organic manures were used as source of nutrient at all locations.
- Narrow spacing of 60 x 30 cm gave significantly higher seed cotton yield (2381 kg/ha) over wider row spacing.
- Maximum seed cotton yield of 2171 kg/ha was obtained due to detopping at 65 DAS and lowest (1579 kg/ha) was recorded under control at Khandwa.
- The flat surface of the soil either raised or normal had the tendency to result in more yields as could be seen in growth and yield attributing parameters, though not significantly. Among the different soil cover management, farm waste and paper cover improved the yield by reducing weed problem at Coimbatore.
- Drip irrigation at 60% ET under paired row gave higher seed cotton yield (3979 kg/ha) as compared to other planting techniques.
- Fertigation with 125% recommended dose of N & K applied as 10% basal with remaining 90% from 30 - 120 days in 9 splits recorded significantly higher seed cotton yield (3982 kg/ha) as compared to control with recommended manual fertilizer application, but was at par with other fertigation doses and splits at Nandyal.
- *Hirsutum* variety H-1226 at Hisar and RS-2013 at Kanpur gave significantly higher seed cotton yield over different *hirsutum* hybrids and *arboreum* varieties. However, RS-2013 was statistically at par with *hirsutum* hybrid LHH-144 and RG-8 at Sriganganagar.
- Nutrient application in Hisar and Sriganganagar led to significantly higher yields due to N,P,K,S and Zn over other treatments, whereas at Kanpur, application of NPK and S gave significantly higher seed cotton yield over control, NP and NPK.
- Preceding cotton varieties had no significant effect on wheat grain yield at Hisar and Sriganganagar, whereas lesser yield was recorded after Omshankar at Kanpur. Residual effect of nutrients on wheat crop were not recorded in Sriganganagar and Kanpur, whereas grain yield was affected significantly at Hisar by the application of N and P to cotton crop only. Further application of K, S and Zn in cotton did not have significant effect over N and P treatment.
- At Rahuri, highest seed cotton yield, highest B:C ratio and net monetary return were obtained from the treatment FYM @ 5 t/ha + green manuring of *dhaincha in situ* + Azotobactor + Azospirillum + PSB (seed treatment).

- Cotton + Cluster bean (1:1 ratio) fertilized with 125% of RDF produced maximum seed cotton yield and better cost benefit ratio of 1:1.90 at Rahuri.
- Intercropping of one row of sunflower with two rows of cotton or one row of castor with three rows of cotton proved remunerative (1:2.2) over sole crop (1:1.4) and other intercrop combinations at Dharwad.
- High yielding cotton genotypes were characterized physiologically by better assimilation of photosynthates and translocation efficiency.
- Genotypes have been identified for further improvement in physiological attributes with better adaptability under stress.
- Negative correlation was seen between sucking pest incidence and total phenols.
- Cotton genotypes with higher seed protein and oil content have been identified for further use in breeding programme.

Crop Protection

- Cultures tolerant to jassid and moderately tolerant to bollworms were identified from breeders' materials from the three cotton growing zones of India.
- Jassid population crossed ETL during 1st week of June to mid July in Ludhiana and on the last week of September at Hisar. It crossed ETL during 3rd week of September to 2nd week of October in Akola, and from 4th week of August to last week of September in Khandwa. Peak activity was observed during September to December in Guntur, August to October in Dharwad, October to December in Raichur and October in Nandyal.
- Whitefly was at low level in all the centres of South and North zone except at Sriganganagar where it crossed ETL during 1st to 3rd week of September. In Junagadh, it was above ETL level (31 to 37 / plant) throughout November.
- High population of thrips (28 to 64 / plant) was recorded in Junagadh from mid August to mid September and throughout September in Surat (29 to 87 / plant).
- Aphid population was at above ETL during 2nd week of October to 1st week of November at Faridkot, during August and November to end of January in Akola, October to November in Junagadh, throughout November in Khandwa, mid September to early December in Guntur, October to January in Dharwad and October in Raichur.
- Predators were at higher level in Faridkot and Dharwad (October to December), moderate level at Sriganganagar and low level at Hisar.
- *Earias* bollworm was at peak (5 to 19.5 larvae / 5 plants) during mid July to first week of October in Ludhiana, from mid November to 1st week of January in Akola (5 to 10 / 5 plants) and in Khandwa (5 to 7 / 5 plants).
- The bollworm, *Helicoverpa armigera* crossed ETL during second fortnight of August (4 to 6 larvae / 5 plants) at Ludhiana, from last week of August to mid September; October in Akola; September - October in Junagadh and Surat and October November in Khandwa. It was at higher level during October in Dharwad and Nandyal and at moderate level in Lam-Guntur and Raichur.
- Peak activity of pink bollworm was observed during December-January in Lam-Guntur, Dharwad and Raichur while it was at low

level in all the centres of North zone, Nagpur and Nandyal.

- *Spodoptera litura* was at high level (7 to 17 larvae / 5 plants) during mid August to mid September in Sriganganagar, during October-November in Nandyal and August, November and February in Lam, Guntur.
- One new insecticide, Polo 50SC at 400 and 500 g a.i. / ha was found effective against whitefly and recorded significantly higher yield over control at Sriganganagar, Khandwa and Junagadh.
- One new seed treatment chemical Thiamethoxam (Cruiser 500FS) was found effective against aphid and jassid upto 63 DAS in Khandwa and Surat. However it recorded significantly higher yield over control at Khandwa only.
- Spinosad new A:D (at 50, 75, 100 g), RIL 042 (at 500, 750, 1000 ml), NNI 001 (at 48, 60 g), E2Y 45, S1812 and E237 were found effective against bollworms and recorded significantly higher yield over control.
- Against pink bollworm, thiodicarb followed by pyrethroids (Lambda cyhalothrin, Beta cyfluthrin, Deltamethrin) were effective in reducing the larval infestation and locule damage. Quinalphos, Chlorpyriphos and Profenophos were moderately effective. Besides offering good protection against pink bollworm, Thiodicarb recorded significantly higher seed cotton yield over control in several centres viz., Guntur, Nandyal, Raichur, Srivilliputtur, Surat and Khandwa.
- Location specific IPM modules were tested with Bt-hybrid, conventional hybrid and variety in all the centres and were found effective in reducing the pest infestation, plant protection cost and in increasing the seed cotton yield. IPM fields had more natural enemies and showed high cost: benefit ratio.
- Cotton leaf curl virus disease continued to be the predominant disease of North Zone with an incidence ranging from traces to 78.0 per cent in Punjab and traces to 90.0 per cent in Rajasthan.
- All the released varieties and hybrids including the Bt cotton hybrids released during the last two years were found to be susceptible to CLCuV, though at various intensities at different locations.
- In Gujarat, bacterial blight was the major disease (PDI of 21.5), whereas, in the other states of Central and South Zones, grey mildew (maximum extent of 30 to 86 per cent) and Alternaria leaf spot (20 to 30 per cent) were the major diseases.
- Forty two entries resistant to CLCuN, 17 for Alternaria leaf spot, 18 for Myrothecium leaf spot, two for grey mildew, five for bacterial leaf blight, 20 for Fusarium wilt and one for root rot have been identified.
- Seed treatment with Vitavax 200 WP (3.0 g/kg of seed) gave the best results and seed treatment with talc formulation of *Trichoderma viride* @ 10 g/kg of seed plus soil amendment @ 2.5 kg/ha gave the next best results in the control of root rot at Sriganganagar.
- Plant protection with Carbendazim 0.1% (for grey mildew), Copper oxychloride 0.2% + Streptocycline 100 ppm (for other foliar diseases) and/or the biological agent *Pseudomonas fluorescens* (Pf1 and CHAO strains) gave effective control of grey mildew, Alternaria leaf spot, Myrothecium leaf spot and bacterial leaf blight.
- Early onset of CLCuV (before 30 DAS) caused an yield loss of 57.54 per cent.
- Spraying of Carbendazim 0.1% at 50, 65,

80 and 95 DAS gave the best control of grey mildew (7.05 PDI) compared to check (43 PDI) and prevented an yield loss of 32.5 to 44.65 per cent in Nanded and Dharwad.

- Spraying of Propiconazole between 35 and 95 DAS at fortnightly intervals reduced Alternaria leaf spot incidence significantly in Rahuri and Lam and prevented a yield loss of 26.33 to 56.25 per cent.

Front Line Demonstrations in Cotton

Two hundred and seventy seven demonstrations were conducted in the states of Punjab, Haryana and Rajasthan in North zone.

Punjab

Improved *G. hirsutum* varieties F 1861 and LH 1556 were compared against the local varieties. The yield increases in the improved varieties were of the order of 23.6 and 7.1 percent, respectively. Similarly, the improved *desi* varieties LD 694, LD 329 and Moti were also superior to the local variety LD 327 by 13.2 to 40.5 percent. Improved package of practices like timely sowing, weed control, plant population and balanced nutrition were superior to the farmers' practice by 7.1 to 55.8 percent. The advantage of timely sowing over delayed sowing was also demonstrated with varieties F 1861, LH 1556 and LD 327. Delayed sowing resulted in 7 to 21 percent reduction in yield.

Haryana

At Hisar, the male sterile based Hybrid AAH-1 recorded a mean seed cotton yield of 1670 kg/ha, as compared to 1196 kg/ha recorded in the local variety. Similarly, *G. arboreum* variety HD 324 (1731 kg/ha) was superior in seed cotton yield to the local varieties (1330 kg/ha) by 30.2 percent. The yield superiority of newly released hybrids HHH 287 and HHH 223 was also demonstrated. At Sirsa, hybrid CSHH 198 and CICR 2 were superior to the local hybrids by 18.5 and 29.7 percent, respectively.

Rajasthan

At Sriganganagar, improved varieties RS 2013 and RS 810 were superior to BN, RST 9 and F 846. On an average, improved varieties recorded 29.2 percent higher seed cotton yield over check varieties. Five hundred and eighty eight demonstrations were conducted in the Central Zone states of Gujarat, Madhya Pradesh and Maharashtra.

Gujarat

At Junagadh, RCH2 was superior to check hybrids like NHH 44, Ganga, Mallika and Nav Bharat 151 by 9 to 40 percent. The *G.arboreum* variety AKA 8 and the *G. hirsutum* variety AKH 8828 were preferred over AKA 5 and Rajat respectively due to big boll, non shedding and non lodging habit in AKA 8 and big boll, fluffy opening and high ginning outturn in AKH 8828. The new varieties were also high yielding as compared to AKA 5 and Rajat.

Madhya Pradesh

At Indore, cotton intercropping with Maize (2:1 row ratio) was found to be more remunerative as compared to sole cotton. INM practice (75% RD of NPK and 5 tonnes FYM/ha +*Azospirrilum* and PSB seed treatment and PSB soil application) recorded 22 to 37 percent higher yield over farmers' practice.

Maharashtra

Five FLDs were conducted in Nagpur with Surabhi. Anjali was the check variety. The average seed cotton yield of Surabhi ranged from 625 to 875 kg/ha with an average increase of 7 percent over Anjali. Similarly MRC 6301 Bt was demonstrated with NHH 44 as the local check hybrid. The Bt hybrid recorded a mean seed cotton yield of 965 kg/ha as against 865 kg/ha in NHH 44. Foliar application of 2 % DAP with detopping was also demonstrated with yield advantage of 150 kg per hectare.

Advantage of ridges and furrow planting as against flat bed sowing was demonstrated. The yield advantage was of the order of 10 percent. An average yield of 888 kg/ha was obtained in INM practice as against 753 kg/ha in farmer's practice. Additional monetary return of Rs.5199/ha was obtained by adopting intercropping of soybean in cotton.

At Akola, AKA 8 recorded 11.7 percent increased yield over AKA 5 in the FLD plots in farmers' fields. Similarly, the pre release variety AKH 8828 registered 9 percent increased seed cotton yield over Rajat. High ginning out turn and big bolls in AKH 8828 are the additional features in the new variety. Superior performance of AKH 081 in shallow soils was demonstrated with an average yield advantage of 7 percent. Foliar application of 2% urea or DAP resulted in 10 percent yield advantage. At Rahuri, groundnut intercropping in summer cotton gave additional returns of Rs.13620/ha as compared to sole cotton. The B:C ratio of intercrop demonstration worked out to 1.72 which was higher than non intercrop demonstration (1.22).

Two hundred and eighty five demonstrations were conducted in the South Zone states of Andhra Pradesh, Karnataka and Tamil Nadu.

Andhra Pradesh

RCH2 Bt and Bunny Bt were the main hybrids demonstrated with non Bt hybrids for comparison. The magnitude of increased yield in RCH 2 Bt was 30.5 percent with a BC ratio of 1.31. Similarly, Bunny Bt recorded 48.5 percent increased seed cotton over Bunny.

Recommended fertilizer dose, Micronutrient (Zinc, $MgSO_4$ and Borax) application and recommended spacing are some of the other technologies demonstrated with an average yield increase of 5 to 15 percent.

Karnataka

At Dharwad, DLSa17, DDhc 11, RCH2 Bt and RAHS 14 were demonstrated in the FLD plots. The technologies on INM, Micronutrient, Plant Growth Regulators and water management were also demonstrated. Participating farmers realized 15 to 18 percent increased yield over the non-adopted farmers. Eleven demonstrations were conducted with RAHS 14, a new *herbaceum* variety. These plots registered 11 to 17 percent increased yield over DB 3012. At Raichur, IPM technologies for Bt cotton hybrids were demonstrated.

Tamil Nadu

At Coimbatore, Surabhi under irrigated conditions and Sumangala under rainfed conditions performed well in comparison to check variety LRA 5166 with an yield increase of 10 to 17 percent. Intercropping of cotton with vegetables like Radish, Carrot and Beans fetched an additional return of Rs. 5000 per acre.

FLD on Integrated Pest Management

A total of 20 FLDs on IPM, encompassing six demonstrations in North zone, 10 in Central Zone and 4 in South zone were conducted during the year 2005-06. The main IPM components used were seed treatment with Imidacloprid/thiomethoxan @ 5 g/kg seed, stem application (1:4 Monocrotophos or 1:20 Imidacloprid) at 20,40 and 60 DAS, border crops viz., Sorghum/Maize, trap crops viz., Marigold for *Helicoverpa*, castor for Spodoptera, bird perches 10/acre, use of Pheromone traps for pest monitoring, use of Neem seed kernel extract (NSKE), deep ploughing in summer, clean cultivation practices like burning crop stubbles, trimming bunds and destruction of weeds. Detopping at 70-90 DAS, hand picking of grown up larvae and destruction and handpicking of larvae in rosette flowers.

At Faridkot, IPM demonstrations recorded higher seed cotton yield than the non IPM check

plots. The percent increase in seed cotton yield varied from 11 to 17 percent depending on the variety used. At Sirsa, an overall net return of Rs.5565/acre and increase in yield of 4.20% over non IPM fields were realized. At Sriganganagar, it was found that boll and locule damage were comparatively lower in IPM plots as compared to non-IPM plots. The mean population of Chrysopa/plant was higher in IPM (0.76) as compared to Non IPM crop fields (0.31). Beneficial insects like Coccinellid beetles, spiders etc., were found in abundance ranging between 0.88 to 1.45 in IPM fields as against 0.25 to 0.68 of Non IPM fields.

At Akola, Bt cotton was included as one of the IPM components. In the IPM plot, an average of 3.62 applications/ plot were taken and plant protection cost was 1.13 times less with 13.33 per cent higher seed cotton yield over farmer's practice (FP)/non-IPM plots. Considering the total income and expenditure incurred on IPM and non IPM fields, more profit (1:1.27) by using IPM technology was realized than farmer's practice (Non IPM) (1:0.64)

At Dharwad, in DHH 1, IPM interventions were effective in controlling the pest incidence, which resulted in higher yield of seed cotton over recommended insecticide schedule (RPP). Returns for every rupee of investment was more from IPM blocks due to lesser cost of protection compared to RPP blocks. In DHH 11, under IPM practice, a mean seed cotton yield of 1860 kg/ha was realized. With an overall expenditure of Rs. 10,502, the BC ratio realized was 1:4.43. As against this, the non IPM plot yielded 1757 kg/ha. With an expenditure of Rs.11,204 per hectare, the BC ratio was 1:3.92. At Coimbatore, there was an increased yield of 18% in the IPM fields as compared to Non IPM fields.

FLD on Implements

Sixteen FLDs on implements were taken up during the year. Advantage of implements like cotton planter, Disc harrow and Aeroblast sprayer were demonstrated at Faridkot. At Sirsa, deep plough and use of rotavator were demonstrated. The farmer got 1010 kg/ha while using deep plough and rotavator against farmer's practice (930 kg/ha). At Sriganganagar, the demonstration of aeroblast sprayer was conducted at farmer's field and it was compared with knapsack sprayer, commonly used by the farmers. Due to uniform spray and good control of pests, the seed cotton yield under aeroblast sprayer plots was 1980 kg/ha as against 1675 kg/ha in the plots where spray was done through knapsack sprayer.

At Akola, a new implement viz., Two row under root cutter was demonstrated in farmer's field. The new implement was compared with tractor drawn "V" pass. The new implement requires 5 litre diesel/ha and "V" pass requires 7.5 litre diesel/ha. The operation of under root cutter also requires less time than "V" pass.

At Guntur, the Thaiwan sprayer showed better efficiency of spraying without spray drift, which ultimately reduced cost and improved chemical impact on pest attack by covering more surface area with fine spray.

KRISHI VIGYAN KENDRA

Ninety one short duration (1 to 3 days) training courses were conducted in different disciplines for 1480 practicing farmers, 413 rural youths and 483 extension functionaries. In all 2376 participants benefited from the courses.

Discipline	No of Courses	No of participants			Total
		Practicing farmers	Rural youths	Extension functionaries	
Crop Production	10	232	27	25	284
Horticulture	23	386	63	97	546
Veterinary Science	14	153	120	56	329
Extension	17	254	63	113	430
Home Science	15	165	85	167	417
Plant Protection	12	290	55	25	370
Total	**91**	**1480**	**413**	**483**	**2376**

Similarly, 19 sponsored training courses were organized for 1 to 10 days duration in different disciplines like crop production, horticulture, plant protection, veterinary science, home science and extension deputed by state agriculture department Maharashtra, Orissa and Punjab, RCF Nagpur, RAEM Training Institute, Nagpur, ICDS Zilla Parishad and Santaji Mahavidyalaya, Nagpur. In all 733 participants attended the course.

Discipline	No of courses	No of participants	Sponsoring agency
Crop Production	3	76	State Agril. Deptt., Maharashtra
Horticulture	1	26	SMS Kalahandi, Orissa
Veterinary Science	2	61	State Agril. Deptt.& RCF, Nagpur
Extension	1	110	Santaji Mahavidyalaya , Nagpur.
Home Science	8	366	ICDS Zilla Parishad & RAEM, Training Institute, Nagpur.
Plant Protection	4	94	State Agril. Deptt. Orissa & Punjab and RCF, Nagpur.
Total	19	733	

Front Line Demonstration

Front line demonstration (FLD's) on soybean variety JS-335 in *kharif* and chickpea variety Vijay in *rabi* season were conducted on 25 farm families each respectively with 0.4 ha area each. An average increase of 25.51 % and 20.50 % in yield of soybean and chickpea was recorded respectively.

FLD on cotton variety CNH-120 MB and LRA-5166 in *kharif* season was conducted on field of 25 farm families in Sukli and Panjari Lodhi villages. An average increase of 16.0 % and

22.2 % in yield of CNH-120 MB and LRA-5166 was recorded respectively. Similarly, FLD on Okra variety Parbhani Kranti was conducted on 4 farm families in village Sukli. An average increase in yield to the tune of 24.2 % was recorded.

On Campus Crop Demonstrations

Forty-eight 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.

Adaptive trials / on farm testing

Nine adaptive trials / on farm testing were conducted on tomato variety Pusa Ruby under rainfed condition during *kharif* 2005-06 to examine the problem of damping of disease in nursery and field. The innovative technologies on production and protection of tomato Pusa Ruby and livestock were undertaken on the farmers fields by providing critical inputs.

Extension Activities

Four field days were organized in which 235 farmers, farm women and rural youths participated. During the year KVK has participated in one Kisan Mela and five national and state level agriculture and animal exhibitions organized by the different organizations throughout the country and displayed CICR production and protection technologies. Four camps were organized for livestock vaccination, ectoparasite control and treatment at Kaldongari, Banwadi, Sukli village wherin more than 300 animals were vaccinated, treated and sprayed with ectoparasiticide. Health camp for children was also organized at KVK campus.

Diagnostic Survey

Thirty diagnostic survey in adopted villages and other villages of Nagpur district were undertaken to suggest the remedies to overcome specific problems in crops, citrus, ber, animals and mushroom production units covering more than 60 ha cropping area and 180 animals in 25 villages of seven tehsils of Nagpur district.

Field Days

Soybean Gyan Diwas was organized on 4.10. 2005 at KVK, CICR, Nagpur in which 53 farmers and farm women participated and benefited. Similarly, Chan Gyan Diwas was organized on 28.02.006 at KVK, CICR, Nagpur in which 72 farmers, farm women and rural youths participated and got benefited.

Visitors

During this period, 312 practicing farmers, farm women, rural youths and extension functionaries visited the KVK, CICR, Nagpur.

GENERAL

List Of Publications

Papers Published in Research Journals

Ahuja S.L. (2006). Preliminary information on three novel morphological mutants detected in cotton *Gossypium hirsutum*. *Czech J. Genet. Plant Breed*, **42**(1):20

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Tuteja OP, Gopal Krishnan N, and Sunil Kumar. 2005. Evaluation of germplasm lines and different cultures of cotton (*G. hirsutum*) for identifying the sources of high oil content. *Journal of Cotton Res. Dev.*, **19** : 168-169.

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Waghmare VN, Rong J, Rogers CJ, Pierce GJ, Wendel JF. and Paterson AH. 2005. Genetic mapping of a cross between *Gossypium hirsutum* (cotton) and the Hawaiian endemic, *G. tomentosum. Theoretical and Applied Genetics* **111**(4): 665-676.

List Of On-going 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)*	PL: VV Singh Assoc: Punit Mohan
2.	Genetical and anatomical studies on drought tolerance in cotton *G.hirsutum.*	PL:SB Singh Assoc: NK Perumal
3.	Studies on development of practically usable cytoplasmic genic male sterility and restorer lines and genetic male sterility system in cotton.	PL:SB Singh
4.	Conservation of wild species of *Gossypium* and introgressive hybridization for the improvement of cultivated species of cottons.	PL: Vinita Gotmare Assoc: MK Meshram, S Vennila, KB Hebbar,G. Balasubramani
5.	Breeding for high yielding and long staple genotypes of *G.arboreum* cotton with high fibre strength.	PL: Punit Mohan Assoc: P Singh
6.	Studies of genetic enhancement of upland cotton *(G.hirsutum)*.	PL: TR Loknathan Assoc:P Singh, DK Agarwal, Vinita Gotmare,S Vennila, MK Meshram
7.	Studies on genetic base of upland cotton varieties in India.	PL: DK Agarwal Assoc: TR Loknathan V Santhy, P Singh
8.	Improvement of upland cotton for GOT and fibre properties through population improvement approaches.	PL: VN Waghmare Assoc: P Singh, Vinita Gotmare
9.	Seed yield and quality in *G.arboreum* cultures with low input management under different soil depths.	PL: RK Deshmukh Assoc: V Santhy, Punit Mohan P. Singh
10.	Assessment of seed vigour traits in cotton.	PL: V Santhy Assoc: RK Deshmukh KB Hebbar, R Vijayakumari
11.	Development of transgenic cotton for Insect Resistance through backcrossing and advancement of generation.	PL: B. M. Khadi Assoc: KR Kranthi AB Dongre, SB Singh, SB Nandeshwar G Balasubramani
12.	Genetical studies on cotton seed with particular reference to germination and dormancy.	PL: PR Vijayakumari Assoc: P Singh, DK Agarwal, V Santhy
13.	Evaluation of cotton germplasm through molecular techniques.	PL: AB Dongre Assoc: J Amudha SB Nandeshwar, VV Singh

14. Development of tissue culture protocol for use in breeding and genetic transformation.	PL: SB Nandeshwar Assoc: AB Dongre
15. Molecular mapping of leaf curl virus resistance gene in cotton genome.	PL: J Amudha Assoc: D Monga G Balasubramani
Crop Production	
16. Integrated approach for yield maximization of hybrid cotton under drip irrigation	PL: K.S.Bhaskar
17. Long term effect of fertilizer and INM on productivity, soil fertility and quality of rainfed hybrid cotton	PL: Jagvir Singh Assoc: D Blaise
18. Effect of nutrients on yield and fibre quality of rainfed Bt hybrid	PL: Jagvir Singh
19. Tillage and green manure effects on growth and yield of cotton and soil properties	PL: D Blaise
20. Improving the efficiency of cotton + arhar strip cropping in vertisols	PL: A.R.Raju
21. Studies on the efficacy of micro nutrients application and moisture management on yield and fibre properties of rainfed cotton	PL: A.R.Raju
22. Development of package of practices for organic cotton production	PL: A.R. Raju
23. Adoption and refinement of cotton picker and cleaning system	PL: A R Raju
24. Evaluation of suitable moisture management practice for rainfed cotton in shallow soil	PL: K.S.Bhaskar
25. Demonstration trial on organic farming and INM technology	PL: Jagvir Singh
26. Agronomical evaluation of Nuziveedu Bt cotton	PL: Jagvir Singh
27. Physiological evaluation of cotton germplasm under rainfied conditions.	PL: MRK Rao Assoc.: NK Perumal, K B Hebbar
28. Physiological and biochemical studies on abiotic stress with particular reference to heat and drought in cotton.	PL: NK Perumal Assoc.: M Chakrabarty
29. Assessment of gossypol content in cotton germplasm	PL: Mukta Chakrabarty
30. Physiological and biochemical basis of salinity tolerance	Assoc: K.B.Hebbar
31. Physiological and biochemical basis of waterlogging tolerance	PL: K.B.Hebbar
32. Evaluation of cotton production technologies for yield, fibre quality and economic viability	PL: H. Gajbhiye
33. A study on technology adoption behaviour of cotton growers: Structural perspective.	PL: HL Gajbhiye
34. Study on accessibility to mass media and information technology of potential users in cotton based production system.	PL: SM Wasnik Assoc.: PR Deoghare

Crop Protection	
35. Identification and characterisation of elite germplasm lines against key pests of cotton.	PL: S Kranthi Assoc: VV Singh
36. Biochemical basis of induction of defense related proteins in cotton against the Gram pod borer *Helicoverpa armigera*.	PL: S Kranthi Assoc: SB Nandeshwar
37. Interaction effects of cultivars, agro-techniques, insect pests and entomophages in cotton ecosystem.	PL: S Vennila
38. Studies on multiple disease resistance in upland cotton.	PL: Sheo Raj Assoc: NK Taneja, VV Singh
39. Studies on seed transmitted pathogenic infections and other seed microflora of cotton.	PL: PM Mukewar
40. Studies on evolution of races of *Xanthomonas axonopodis* pv. *malvacearum (Xam)* and utilization of HVS in identification of resistant sources .	PL: MK Meshram Assoc: Sheo Raj
41. Evaluation of cotton germplasm against Alternaria and Myrothecium leaf spot diseases.	PL: NK Taneja
42. Efficacy of antagonist fungal microflora from rhizosphere of cotton, its growth and development including disease control.	PL: RC Ukey
43. Studies on plant parasitic nematodes associated with cotton.	PL: N G-Narkhedkar
44. Molecular basis of pathogenicity and race specificity of *Xanthomonas axonopodis* pv *malvacearu (Xam)* and characterization of its antagonists.	PL: PK Chakrabarty Assoc: MK Meshram Sheo Raj
45. Study on accessibility to mass media and information technology of potential users in cotton based production system.	PL: SM Wasnik Assoc: PR Deoghare
Regional Station, Coimbatore	
46. Development of high yielding intra *hirsutum* hybrid	PL : K.N.Gururajan Assoc: S Manickam
47. Breeding new *G. hirsutum* cotton varieties with new plant types - Development of medium staple varieties	PL : K.N.Gururajan Assoc: S Manickam
48. Development of Extra long staple high spinning hybrids of interspecific origin with wide adaptability	PL: K.P.M.Dhamayanthi Assoc: S Manickam
49. Development of extra long staple *G. barbadense* varieties with improved fibre properties	PL: K.P.M.Dhamayanthi Assoc: K.Rathnavel
50. Development of high yielding and high spinning Extra long staple cotton	PL: S Manickam Assoc: K.N.Gururajan
51. Development, maintenance and utilization of cytoplasmic and genetic male sterility for hybrid cotton seed production and fertility restoration in cotton	PL : S Manickam
52. Maintenance and evaluation of cotton germplasm	PL: S Manickam
53. Studies on viability, vigour and longevity of cotton seeds	PL: K.Rathinavel

	Assoc: K Natarajan, P.Chidambaram
54. Studies on the long term effect of continuous application of nutrients in fixed cotton based crop rotation on the productivity, nutrient balance and sustainability of the cropping system	PL: C.S. Praharaj Assoc : K.Sankaranarayanan S. E. S . A. Khader
55. Assessment of organic residues along with *in situ* incorporation of green manures on soil fertility dynamics and cotton productivity.	PL : C.S.Praharaj Assoc: K. Sankaranarayanan S. E. S . A. Khader
56. Water management in G. hirsutum and G. barbadense cotton.	PL : K. Sankaranarayanan Assoc: P. Nalayini, C.S. Praharaj
57. Evaluation of cotton based cropping system for higher production and economic return	PL : K. Sankaranarayanan Assoc: P.Nalayini, C.S. Praharaj
58. Polymulching for water, weed and nutrient management in cotton based cropping system	PL : P. Nalayini Assoc: K. Sankaranarayanan
59. Response of elevated carbon-di-oxide on physiology and productivity.	PL: S.E.S.A Khader Assoc: N. Gopalakrishnan
60. Identification and utilization of adaptive responses to abiotic stress in cultivated species of cotton	PL: S.E.S.A Khader Assoc: N. Gopalakrishnan K.N. Gururajan
61. Physiological and molecular elucidation of fibre development process in cotton for enhancing fibre yield.	PL: A.H. Prakash Assoc: N Gopalakrishnan
62. Source-sink alteration with reference to flower induction as a tool to improve physiological efficiency and productivity in cotton.	PL: A.H. Prakash Assoc: N. Gopalakrishnan
63. Studies on biochemical mechanisms of resistance to bollworm of cotton	PL: N Gopalakrishnan Assoc: T. Surulivelu
64. Studies on developmental biochemistry of cotton pest/ Disease interaction	PL: N Gopalakrishnan Assoc: T. Surulivelu K. Natarajan, P. Chidambaram
65. Studies on the role and effect of insecticides in cotton ecosystem	PL : T. Surulivelu Assoc: K.Natarajan,
66. Studies on the host plant relationship and development of resistant/tolerant varieties to insect pests of cotton	PL: K. Natarajan Assoc:T.Surulivelu, S. Manickam
66. Studies on population dynamics of cotton pests and their natural enemies	Pl : K Natarajan Assoc: B. Dhara Jothi
67. Studies on Bioecology and management of cotton stem weevil *Pempherulus affinis*	PL: B. Dhara Jothi Assoc: T. Surulivelu
68. Bio ecological studies in Pink Bollworm	PL: B. Dhara Jothi Assoc: K Natarajan
69. Studies on the epidemiology and management of fungal foliar diseases of cotton	PL: P. Chidambaram Assoc: K. N.Gururajan N. Gopalakrishnan
70. Farm level economic benefits of Bt cotton in Tamilnadu.	PL: Isabella Agarwal

71. Adoption, impact and returns to research investment on improved cotton cultivars in Tamilnadu	PL: Isabella Agarwal
72. Economic analysis of contract farming in cotton in Tamilnadu.	PL: Isabella Agarwal
73. Expert System on Cotton pest/insect	PI: M. Sabesh Assoc.: S. Vennila B. Dhara Jothi
Regional Station, Sirsa	
74. Evaluation of parents in *Gossypium hirsutum* for heterotic potential and useful heterosis for replacement of existing cultivars under north Indian conditions.	PL: OP Tuteja
75. Development of varieties and hybrids (MS based) of medium staple length in Gossypium arboreum L.	PL: SK Verma
76. Development of male sterility based hybrids of *G.hirsutum* for north India.	PL: OP Tuteja Assoc: D Monga, P Jeyakumar
77. Development of *G.hirsutum* cultivars with high fibre strength suitable for high speed spinning.	PL: SL Ahuja Assoc: OP Tuteja, SK Verma, D Monga, P Jeyakumar, VV Singh, KN Gururajan
78. Genetic enhancement in diploid cotton	PL: SL Ahuja Assoc: SK Verma Punit Mohan, Vinita Gotmare, D Monga TR Loknathan, P Jeyakumar,
79. Collection, conservation, evaluation and maintenance of genetic resources.	PL: RA Meena
80. Studies on seed technological aspects of hybrids and varietal seed production in north zone.	PL: RA Meena Assoc: OP Tuteja, D Monga
81. Effect of light on stability and efficacy of neem in IPM	PL: P Jeyakumar Assoc: D Monga
82. Studies on cotton leaf curl virus disease and development of resistant varieties and hybrids for its management.	PL: D Monga Assoc: OP Tuteja, RA Meena, SK Verma,P Jeyakumar
Externally Funded Projects	
83. Assessing potassium requirements of cotton + pigeonpea cropping system	PL: Blaise
DBT Projects	
84. Genetic improvement of strains of entomopathogenic nematodes for tolerance to environment and enhanced efficacy against Helicoverpa armigera, cotton bollworm.	PL: N G-Narkhedkar
85. Studies on toxicity of Bt (Cry) toxins to cotton pests, assessment of impact of Bt transgenic cotton plant on	PL: KR Kranthi Assoc: S Kranthi

the ecosystem and development of resistance to Bt toxins in cotton bollworm Helicoverpa armigera.	
Network Project	
86. Development of Bt transgenic cotton with indigenously synthesized gene	PL: A.B.Dongre
Mahyco Funded	
87. Monitoring for shifts in baseline susceptibility (development of tolerance/resistance) in the cotton bollworms toxin in various cotton growing regions of the country.	PL: S Kranthi Assoc: KR Kranthi

Technology Mission On Cotton (TMC MM-I)

Project No.	Name of the Project	Name of the Project Leader and Associate(s)
MM 1.1	Development of diploid cotton cultivars with high fibre quality	CCPI : Punit Mohan, S K Verma
MM 1.2	Development of tetraploid cotton cultivars with high fibre quality and resistance to drought and biotic stresses	PI : K N Gururajan CCPI : V N Waghmare S L Ahuja
MM 1.3	Genetic diversity through introgression of useful genes in cultivated species of cotton	PI : V Gotmare CCPIs : S B Nandeshwar G Balasubramani S Manickam O P Tuteja
MM 1.4	Improvement of cotton seed oil	PI : D K Agrawal Co PI :M. Chakrabarty CCPIs : KPM Damayanthy N Gopalakrishanan,
MM 1.5	Maintenance breeding, seed production and marker based purity evaluation	CCPI : O P Tuteja, K Rathinavel A B Dongre, T R Loknathan, V Shanthy, R A Meena
MM 2.1	Integrated nutrient management for high quality fibre and yield	PI : D Blaise Co-PI : J V Singh
MM 2.2	Integrated water management system for quality fibre production	CCPI : K S Bhaskar K Shankarnarayan
MM 2.3	Bioinoculants for sustainable and cost effective production of high quality fibre	P Nalayini
MM 2.4	Refining regional -level prediction of yield	PI : M R K Rao Co-PI : K B Hebber CCPI : A H Prakash
MM 2.5	Ergonomically efficient implements for cotton production	PI : A R Raju
MM 3.1	Integrated pest management (IPM) at village level for cost effective, quality production	CCPI : S Vennila, T Surulivelu A Kannan, P Jeyakumar D Monga,
MM 3.2	Development of diagnostic tools for differentiation and detection of biotypes/races of insect pests and pathogens of cotton	PI : P K Chakrabarty Co-PIs : M K Meshram S Kranthi, P Chidambaram CCPIs : B Dharajyothi D Monga
MM 3.3	Commercialisation of bioagent mass -production technologies in intensive cotton districts	CCPI : N Gokte Narkhedkar
MM 5.1	Evaluation of cotton production technologies for yield, fibre quality and economic viability	PI: H L Gajbhiye Co-PI : P Ramasunderam CCPI : I Agrawal, S K Verma
MM 5.2	Information, cotton website and documentation	PI : M Sabesh CCPI : A R Raju
MM 5.3	TMC -MMI Coordination and Monitoring cell	M Chakrabarty,

Consultancy, Patents, Commercialisation Of Technology

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.

Name of Variety/ hybrids		2005_06	
		Indent (q)	Production (q)
LRA 5166		3.81	4.80
LRK 516 (Anjali)		1.96	2.98
Surabhi		0.99	1.0
Supriya		0.80	1.00
Sumangala		0.15	0.50
CSHH 198	Female	—	0.50
	Male	—	0.20
CISAA2	Female	—	0.20
	Male	—	0.20

Patent

Detection of insecticide resistant insects, 2006.

Significant Decisions Of Rac, Src, Imc Meetings

Research Advisory Committee (RAC)

The annual meeting of Institute's Research Advisory Committee was held on 21 April, 2005 at CICR, Nagpur under the chairmanship of Dr. S. N. Puri, Vice Chancellor, Central Agricultural University, Imphal. The following members attended the meeting.

1.	Dr. S. Sreenivasan, Director, CIRCOT, Mumbai	Member
2.	Dr. B. M. Khadi, Principal Scientist, UAS, Dharwad	Member
3.	Dr. N. K. Singh, Principal Scientist, NRC for Biotechnology, New Delhi	Member
4.	Dr. S. K. Ghosh, Principal Scientist, CRIJAF, Barrackpur	Member
5.	Dr. P. P. Tarhalkar, Ex.Head, Division of Crop Production, CICR, Nagpur	Member
6.	Shri Nanabhau Embedwar,	Member
7.	Shri Ankushrao Tope	Member
8.	Dr. P Singh, Director (Acting),CICR, Nagpur	Member
9.	Dr. N. K. Taneja, Principal Scientist, CICR, Nagpur	Member Secretary

The proceedings of the meeting were approved by the Council. The following are specific recommendations for the research work to be carried out/strengthened.

- Develop blue print for fast track development of Bt, keeping in view the quality aspects.
- Studies should be conducted to evaluate efficacy of micronutrients in improving micronaire value of Bt cotton.
- Breeding for drought tolerant varieties which will give yield even under water scarce situations.
- Breeding good fibre quality cotton
- Varieties suitable for shallow soils should be developed.
- DNA finger printing of germplasm in view of IPR
- Work on genomics should be initiated
- INFOCROP model should be fine tuned.
- Cotton mechanization projects need to be strengthened.
- CICR should develop better types of 80s and 120s counts *barbadense* cotton.
- Management of bollworms involving IPM/IRM

Staff Research Council (SRC)

The Annual Staff Research Council meeting was held on 27-28 April, 2005 at CICR, Nagpur under the chairmanship of Dr. Phundan Singh, Director (Acting), CICR to discuss the results of the research work carried out during 2004-05 and to finalise the technical programme for the year 2005-06. Besides all the scientists of CICR, Nagpur, the meeting was also attended by Dr. T.P. Rajendran, Project Coordinator & Head, CICR Regional Station, Coimbatore. Achievements made in all the Institute projects and funded projects in operation at the institute were presented by the individual scientist and progress of research critically reviewed.

The technical programme of research for the year 2005-06 was finalised after detailed discussion.

Two new project proposals were presented and approved after discussion. Publication entitled "Achievements in Cotton Research" brought out by the Project Coordinator & Head, CICR Regional Station, Coimbatore was released

during the meeting.

Dr. Nandini Gokte-Narkhedkar, Secretary and Dr. V Santhi, Jt. Secretary, SRC assisted in conducting the proceedings of the meeting.

The staff research council meeting of CICR Regional Station, Sirsa was held on 13 April, 2005 at Sirsa Station. The meeting was chaired by Dr. P. Singh, Director (Acting), CICR, Nagpur and attended by the scientists. All the scientists of this station presented the research findings of various projects and research programmes for the year 2005-06 were finalised.

The staff research council meeting of the CCR Regional Station, Coimbatore was held at Coimbatore on July 29, 2005 under the Chairmanship of Dr. B. M. Khadi, Director, CICR, Nagpur.

Shri. K N Gururajan, Project Coordinator & Head I/c, in his introductory remarks highlighted research achievements of the regional station, during 2004-05. All the scientists from regional station, Coimbatore presented achievements made in their project(s). The Director reviewed the results of thirty-two institute projects, eleven TMC projects and two NATP projects. The technical programme for next year was finalised.

Institute Management Committee (IMC)

Forty fourth Institute Management Committee meeting was held at CICR, Nagpur on 1st February, 2006 at CICR, Nagpur under the Chairmanship of Dr. B. M Khadi, Director, CICR, Nagpur. The meeting was attended by the following members.

1.	Shri Nanabhau Embadwar	Non-Official Member
2.	Shri Ankush Raoji Tope	Non-Official Member
3.	Shri P. N. Singh, Sr. F & AO, NBSS & LUP, Nagpur	Member
4.	Shri S. L. Baviskar, Divn. Supt. Agril. Officer, Nagpur	Member
5.	Shri D. K. Agarwal, Scientist	Member
6.	Dr. Dilip Monga, Head I/c, Regional Station, Sirsa	Special Invitee
7.	Shri Kumar Rajesh, Administrative Officer, CICR, Nagpur	Member Secretary

The following are the major recommendations:

- The committee expressed their satisfaction on the revenue realization during last financial year as well as in the current year. The committee also expressed that utilization of funds in HRD sub-head may be ensured.
- The committee expressed that possibilities may be explored to install a biogas unit in the farm for proper utilization of farm waste. The non-official members of the committee opined that the CICR Officers or their representatives may witness the process of tender finalization by CPWD in the respect of CICR works.
- The committee expressed its satisfaction and agreed for continuation of farm development work.
- Committee felt that cotton farmers from various districts in the vicinity of the institute may be invited to attend the KVK programme.

Dr. Mangala Rai, Secretary, DARE & Director General, ICAR addressing the Scientists of the Institute.

Dr. M. S. Swaminathan, Chairman, National Farmers Commission, addressing the Scientists

Shri Anees Ahmed, Hon'ble Minister for Animal Husbandry, Dairy Development and Fisheries, Govt. of Maharashtra delivering the inaugural address

Dr. Gautam Kalloo, DDG (H & CS), ICAR addressing the participants.

Nineteenth Meeting of ICAR Regional Committee No. VII

The Nineteenth meeting of ICAR Regional Committee No. VII was held at International Centre, Goa on November 18-19. 2005. Shri Anees Ahmed, Minister of State for Animal Husbandry, Dairy Development and Fisheries, Govt. of Maharashtra was the Chief Guest and Dr. Mangala Rai, Secretary DARE and DG, ICAR Chaired the Inaugural Session.

The meeting was attended by Vice -Chancellors of Agricultural Universities, DDGs' & ADGs of ICAR Headquarters, Directors of ICAR Institutes, Secretaries and Commissioners of various states departments, Directors of Research & Education of Universities and Project Coordinators of All India Coordinated Projects in Maharashtra, Goa and Madhya Pradesh.

Hon'ble Shri Anees Ahmed in his inaugural address mentioned the efforts of Shri Sharad Pawar, Hon'ble Minister of Agriculture, Govt. of India with regard to animal welfare in the State. He expressed the need to have livestock policy for long term as well as short term. He also informed that a consultative meeting would be held shortly to work out a micro plan for livestock production and genetic improvement of cow and buffalo.

The Hon'ble Minister has mentioned about a joint venture of Nagpur University with the private sector for the development of pocket PC based module data retrieval based system for animal performance.

Dr. Mangala Rai Chairman, Secretary, DARE and DG, ICAR, New Delhi emphasized the importance of the regional committee meeting and its role in assessing and reviewing the various issues and bringing out useful recommendations for implementation. The importance of researchable issues like floriculture for which special attention is required was emphasised. The D.G., ICAR highlighted the following issues for detailed deliberation.

Importance of soybean as a major protein (45%) crop and how its by-products could be fortified for diversified value added products and their marketing.

Development and use of appropriate farm machinery is of paramount importance in the coming years and needs more attention and the optimum plant population will be a major factor.

Enhancing the spread of horticulture in the farming community of MP on the Maharashtra pattern with emphasis on processing and packaging.

In respect of Bt-Cotton, mixed response by the farmers has brought about the need to get Bt under good agronomic background.

More emphasis on grapes for wine production especially by selecting appropriate plant materials and growing them properly alongwith much needed marketing strategies and diversification of products.

The need to enhance export potential of Banana alongwith technologies for improving water use efficiency.

Promoting the use of micro irrigation techniques for enabling judicious use of scarce water resource.

Prominent among those present were: Dr. G.Kalloo. DDG (Horticulture and Crop Sciences). Dr. S.Ayyappan, DDG (Fisheries), Dr. P Das, DDG (Extension), Dr. Nawab Ali, DDG (Engg.), Dr. Lal Krishna, ADG (AH), Dr. G C Tiwari, ADG (Edun.) and Dr. R C Maheshwari, ADG (TC) from ICAR, Shri. J. P Dange. Principal Secretary (ADF) and Dr. V.G. Ramteke, Joint Commissioner of AH, Govt. of Maharashtra, Mrs. Ranjana Choudhary, Principal Secretary, (Fy/AH/Dairy), Shri. R R Siddiqui, ADF, Shri. Rajkishor Swai, Secretary, Agriculture, Shri. L P Patel, Director, Agriculture, Govt. of Madhya Pradesh and Shri J K Dadoo, Development Commissioner, Shri R. G Joshi, Director of Agriculture, Shri A K Wahal, Chief Conservator of Forest, Dr. T T Naik, Director, Animal Husbandry & Veterinary Science, Shri S C Verenkar, Director of Fisheries,

Govt. of Goa, Dr. D.P. Singh, Vice Chancellor, JNKVV, Jabalpur, (M.P.), Dr. A T Sherikar, Vice Chancellor, MAFSU, Nagpur.

Action Points and Key Areas for Agricultural Research and Development in Region VII

1. Development plans for medicinal and Aromatic plants would be crystallized and niche area would be identified by every universities.
2. Demonstration plots of latest varieties of green peas to be grown for farmer's exposure.
3. To access all the varieties of green peas available and grow in staggered planting in M.P. and to fulfill the frozen pea demand by providing a continuous supply of peas.
4. Demonstrations, seed production and popularization of high yielding rice varieties in upland tracts. Explore the possibility of improving the local red kernel types by laying hands on some CSR series material developed by CSSRI, Karnal.
5. Study of micronutrient deficiency in soil to be accelerated
6. For tackling obnoxious weeds collaborative efforts have to be made to come out with some remedial measures
7. Life cycle of hairy caterpillar in soybean has to be studied inclusive of the biology of the pest.
8. Emphasis on dormancy in green gram and black gram has to be given by exploring the available genetic resources. Intensify efforts to induce dormancy
9. Perspective plan for the study of yellow vein mosaic virus and Rhizoctonia in soybean has to be brought out.
10. Priority attention is needed in chickpea and other pulses, especially lentil. JNKVV center has to be strengthened. ICARDA could be explored to avail lentil genetic resources.
11. Export potential of niger crop has to be promoted by increasing breeder's seed production.
12. Composites, hybrids to be promoted in other crops as in the case of maize.
13. Identify areas where in research could be accelerated especially rice hybrids could be popularized. Guidance could be obtained from ICAR.
14. ICAR may not fund for seed production; the universities should bring out some innovative ways.
15. In order to meet growing menace of pest and disease and also looking into the prevalence of uncertainty of Bt gene expression over the years, gene-pyramiding approach, and multiple resistance breeding have to be adopted.
16. Productivity could be enhanced through diversification of CMS exploring the TGMS system of male sterility.

HORTICULTURE

17. Grape genetic resources need to be augmented for wine production. Appropriate training in the areas of production and processing of wine should be organized.
18. New initiatives, research programmes in cashew processing have to be developed and niche area of excellence would be instituted.
19. Promoting export of vegetable crops viz, vegetable hybrids for bacterial resistance of tomatoes, brinjal and cucurbits
20. Improvement of local mango variety by screening the available material and genetic resources should be taken up.

NATURAL RESOURCE MANAGEMENT

21. Ridges and furrows are to be followed where in water would be harvested/ conserved to enhance productivity.
22. Creating awareness for sustainable use of fertilizers.

ANIMAL SCIENCE

23. Strategic areas have to be worked out to

initiate cattle improvement.

24. Veterinary survey/ identification of development modules.
25. Genetic upgradation of local breeds in animals in Maharashtra should be given a new facelift.
26. In order to increase the quality testing of meat and milk, it has been advocated to charge the samples for generating income. A budget line has to be there to expedite the available financial resources.
27. Improvement of local breeds- Principles and strategies have to be worked out to upgrade the existing cattle breeds.
28. Fodder banks and seed banks could be set up which could serve as a helping hand under drought situations.
29. A base paper has to be prepared on researchable and development issues relevant to genetic improvement of breeds and has to be submitted to ICAR through State Dept. of Agriculture
30. An efficient pool of animal population is to be developed in the country by adopting appropriate breeding strategies to upgrade local breeds of cattle, sheep, fish, ducks etc.

FISHERIES

31. Brood stock production, quality is important- one KVK would be earmarked for each district.
32. Renovation of Balaghat hatcheries in M.P. to be taken up.
33. Khazan lands to be explored for fish farming in Goa
34. Promote marine culture production (Mussel farming), intensify marine culture practice; diversify farming, evaluate fishes in Khazan lands and integrated farming of carp seed, ornamental fish to be grown for value addition, pearl culture - all the ICAR institutes would be involved. Promote Aqua-tourism in all the three states especially Goa.
35. Diversified products of Shrimp to be brought to Goa.
36. Optimization of fishing fleets to be taken up to cater to registration of all the vessels.
37. Fishing policy has to be harmonized.
38. For efficient fish seed transportation, research work has to be initiated for the production of canvas bags, Jute impregnated in plastics.
39. Develop models for integrated fish farming.
40. Fish rearing centers have to be set up and also studies related to wave conditions should be taken up.
41. Fishing rights from reservoirs have to be sought from the Ministry of Irrigation.
42. Techno- feasibility of setting up of hatcheries is very important aspect and need to be considered.

AGRICULTURAL ENGINEERING

43. The post harvest aspects in soybean and turmeric have to be reviewed.

EXTENSION

44. Guidance has to be given to farmers for organic farming.
45. Extension work has to be accelerated.

AGRICULTURAL EDUCATION

46. Training programme on WTO matters would be organized for all the states of Maharashtra, Madhya Pradesh and Goa and ICAR will be the nodal agency.
47. Human Resources Development has to be enhanced in Agriculture Universities through up gradation of course curricula Courses should not be duplicated in different universities
48. The State Universities would address issues relating to upgradation of course curriculum. College of Agriculture, Nagpur has to be given a new facelift being a premier institution.

Workshops / Seminars / Summer Institutes / Farmer's Day Organized

Rashtriya Kapas Mela

A one day Rashtriya Kapas Mela 2005 with the theme 'Sustainable Cotton Production' was organized on 16.10.2005 at the campus of CICR, Nagpur. The objective of the Mela was to provide a common platform for all agencies associated with cotton production, protection, harvest and marketing and also equip farmers with latest technology so that dream of sustainable cotton production can be realized.

The Mela was inaugurated by Hon'ble Union Minister for Agriculture , Shri Sharad Pawarji. In his address, Shri Pawarji exhorted scientists to work towards developing high yielding, low cost intensive, disease and pest resistant and eco-friendly varieties with good fibre quality that could suit various agro-ecological zones. He added that after the signing of multi-fibre agreement, India will have to compete in the international market. He mentioned that laws to curb menance of spurious Bt seed are in pipeline. Speaking on the occasion, Shri Dutta Meghe, Rajya Sabha, Member stressed on the need for taking latest technologies to the farmers.

Shri N. P. Hirani, Administrative Head, Maharashtra State Cotton Marketing Federation stressed on regulation of seed market and called for strict laws to protect farmers. Shri Anil Deshmukh, Minister, PWD, Shri Dharamrao Baba Atram, Minister of State for Transport and Social Justice; Shri Manohar Naik, Minister of Food and Drug Administrative, Maharashtra State; Dr. Rajendra Shingne, Minister Revenue and Rehabilitation, Maharashtra State,; Shri Nanabhau Embedwar, Former Minster, Maharashtra State and Member, Institute Management Committee, Dr. G. Kalloo, DDG (Hort. & CS), ICAR; Dr. Sharad Nimbalkar, Vice Chancellor, Dr. PDKV, Akola and Shri Sudhir Goyal, Agricultural Commissioner, Maharashtra State were also present on the occasion. Dr. Kalloo in his address presented a brief overview of cotton scenario in India. Earlier, the welcome address was delivered by Dr. B. M. Khadi, Director, CICR, Nagpur.

The significant feature of Mela was the exhibition which was organized to apprise the farmers of latest technologies of cotton production, protection, processing, product development and income generation. Latest technologies regarding Bt cotton production, Integrated Pest Management, Integrated Nutrient Management, latest cotton varieties and hybrids and Farm Machinery were demonstrated to farmers. Farmers were given information on other avenues of income generation livestock rearing, fishery, cultivation of fruit and ornamental plants, mushroom cultivation etc. More than 40 companies dealing in seed, bio-pesticides, equipments, fertilizers, sprinkler, drip irrigation and financial institutions exhibited their wares. A "Kisan Goshti' was also organized to provide technical expertise and on the spot clarification of farmers queries.

Krishi Mela

A Krishi Mela was organized by the CICR, Nagpur on 29.01.2006 under the cotton front line demonstration (FLD) programme at Zilla Parishad Primary School premises in village Rampur in Warora Tahsil of Chandrapur district. Dr. MRK Rao, Head, Division of Crop Production, CICR was the Chief Guest. On the occasion, Dr. Rao asked the farmers to adopt crop production technology like Ridges and Furrow technique, use of proper dose of NPK as per recommendations, green manuring, use of biofertilizers, vermi-compost, intercropping, organic manures, harvesting of rain water in

Shri Sharad Pawarji,
Hon'ble Minister for Agriculture,
Govt. of India,
addressing the farmers.

Shri Sharad Pawarji,
Hon'ble Minister for Agriculture,
Govt. of India,
releasing Souvenir during the
Rashtriya Kapas Mela.

Shri Sharad Pawarji,
Hon'ble Minister for Agriculture,
Govt. of India, interacting with
the Director and Scientists in
the experimental field.

Dr. M. S. Swaminathan,
Chairman,
National Commission on Farmers
discussing with the
Director and Scientists

ponds and using it during drought like situation, etc. Speaking on the occasion Dr. Phundan Singh, Head, Division of Crop Improvement stressed on use of quality seed for increasing cotton productivity. He emphasized the need for adoption of recommended varieties/hybrids and advised to purchase the seeds from reliable sources only; Dr. R. K. Deshmukh, Principal Scientist and Incharge FLD outlined about various interventions/ technologies demonstrated. Dr. S. M. Wasnik asked the farmers to help in group formation and spread of the technologies to the other and nearby farmers.

On the occasion, many FLD farmers shared their experiences of cotton FLD programme, the success stories and the benefits received due to technology adoption. Out of 93 FLD farmers, three farmers namely Shri Raju Dumare, Shri Milind Bhoyar and Shri Sanjay Nannaware were felicitated. More than 300 farmers, farmwomen and rural youth participated.

TMC-MM1 Annual Review Workshop

The Annual Review workshop of TMC MMI was held on 16-17 June, 2005 at CICR, Nagpur under the Charimanship of Dr. B. B. Khadi, Director, CICR, Nagpur and Member Secretary, ICAR Standing Committee for TMC MMI. All the Principal Investigators attended the workshop and presented the significant findings of their project work.The major findings are :

Genetic Improvement

Diploid cotton

- 97 newly developed strains were tested for their yield potential and fibre traits in five activities over 13 centres. In addition, 1622 genotypes in early generation (F_2 to F_6) were evaluated and more than 2500 single plant selections were made at various centres to create desirable variability for enhancing genetic improvement of diploid cotton.
- Nine strains, *viz.* PAIG-29, AH-65, AH-11, AH-1 (from Parbhani), CINA-318, CINA-316, CINA-343 and CINA-344 (from Nagpur) and JLA-2199 (Jalgaon) have been tested under All India Co-ordinated Cotton Improvement Project (AICCIP) during 2005-06.

Tetraploid cotton

- Two hundred and nineteen cultures were evaluated at five centres in north zone. Promising cultures with 22.0 to 24.0 g/tex fibre strength, 4.0 to 4.9 micronaire and up to 38 per cent ginning out turn have been identified.

Introgressed derivatives

- Large segregating populations have been evaluated and individual plants selected for the desirable traits viz. biotic and abiotic stress tolerance and fibre quality. Stabilized lines also were screened. AKA 01-1, AKA 01-2, IGM-28, IGM 42, MSP-345, TCH 1648, TCH 1653, LD-327, AKDH-33, RAC-023, and AKH-2053 were identified to be tolerant to bollworm complex.

Cottonseed oil

- In AICCIP Trial, a culture CNHO 12 has been promoted to Br 03 (a) in South zone, Central zone and North Zone for 2005-06. Similarly, CNHO 3 has been promoted to Br 03 (b) in South zone for 2005-06.

Molecular markers

- DNA markers for confirmation of hybrid characters of G.Cot HY-8, NHH-44 and NSPHH-7 were detected. STMS primer MGHES73, found to be polymorphic between the parents of hybrids of G cot Hy 8 and NHH-44 was used to determine seed purity of these two hybrids.

Natural Resource Management

Integrated Nutrient Management

- In the north zone of irrigated cotton-wheat

double cropping system, significant response to S was observed at Hisar and Zn at Sri Ganganagar

- For rainfed cotton based cropping system, significant response to Zn and B was noticed at Parbhani, Bhopal and Banswara.
- With Site-specific nutrient manage-ment (SSNM), target yields were achieved at Bhopal, Nagpur, and Coimbatore.

Integrated water management

- Maximum gross returns were accrued with intercropping of cotton either with black gram or green gram or soybean, followed by protective irrigation and opening of furrow in every row.

Yield prediction

- INFOCROP, a generic model has been adopted, calibrated, validated and further refined for cotton yield prediction and the model has been calibrated for prediction of soil water balance in vertisols. An integrated approach for production assessment was developed utilising remote sensing, GIS and crop model was tested Nagpur, Dharwad, Bharuch and Sirsa districts. The results are as such promising.

Implements for cotton production

- A Self-propelled air assisted boom sprayer was developed and field-tested. The cost of operation was Rs. 260 compared to Rs. 300 in conventional method of spraying. The saving in cost of operation was 10 to 20 per cent, labourer cost was 20 to 30 per cent and saving in time was 45 to 55 per cent.

Biotic stress management

Integrated pest management (IPM) at village level

- Sex pheromone polymorphism was confirmed.

Diagnostic tools for insect pests and pathogens

- The PCR protocol developed for detection of *Xanthomonas axonopodis* pv. *malvacearum* strains was further refined.
- PCR-RFLP and multiplex PCR protocols have been developed to detect intra- specific haplotype variation in *H. armigera.*
- PCR based rapid protocol developed in CICR for CLCuV detection has been validated for mapping the prevalence of virus in cotton, whitefly vectors as well as new weed species in different zones in North India.
- SCAR markers have been developed for host specific strains of whitefly.

Commercialisation of bioagent mass-production

- Two technologies - Liquid fermentation technology of *Beauveria bassiana*, *Metarhizium anisopliae*, *Trichoderma harzianum* and *T. viride* and solid state mass production of *Nomuraea rileyi* have been developed.

Commercial technology development for value addition

Some important findings are :

- Machine for Compacting Cotton Stalk Using Hydraulic System.
- Biological Softening of Lignocellulosic Material for Preparing Binderless Boards
- Preparation of Multilayer Particle Board from Cotton Plant Stalks

Technology intervention

- The full package of Integrated Pest Management in cotton produced 16 % higher yield with reduction in cost to the tune of Rs 2647/ per ha.
- The economic viability of Integrated Nutrient Management is 1.33 per cent with added returns of Rs 3388/ per ha.

Information, cotton website and documentation

All the collected data were digitized and

appropriate databases were created and Information retrieval menu were also developed using the software Visual Basic.NET. Significant progress was made in the development of information retrieval system by attempting the developed software converted to ASP.NET for online access to the database by the web users.

The following technologies have been found to be beneficial after review of the progress of work and may be tested on a large scale with the support of Mini Mission II.

- Promotion of released varieties
- Dry sowing in cotton
- Rainwater management (*in-situ* soil moisture conservation)
- Site specific nutrient management for a targeted yield
- Popularisation of bio-inoculant like Pink Pigmented Facultative Methylotroph
- Detection of seed borne infection by PCR in different cotton growing areas.
- Monitoring the spread of leaf curl virus infection in cotton and its weeds by PCR.

Small Committee Meeting of CAB

4th meeting of Small Committee of CAB (Cotton Advisory Board) was organized on Aug 26, 2005 at CICR, Nagpur under the Chairmanship of Dr. H. R. Das, Textile Commissioner, Ministry of Textiles, Govt. of India. The meeting was attended by members representing ICAR Institutes, SAUs, Textile Research Associations, User Industries, Textile Ministry and Textile Mills.

The recommendations are:

- Emphasis should be made for Extra long staple cotton cultivation under contract farming
- The promising culturs identified on the basis of fibre parameters are required to be further tested
- End uses of cotton have been diversified and the breeders need to keep in mind the requirement of end users while developing varieties and hybrids.

Cotton produced by Culture RH 021, developed at MPKV, Rahuri was claimed to absorb nearly eight times more water/moisture than the cotton from the presently available cotton cultivars. If it can be promoted, it will be quite profitable over the absorbent developed through chemical treatments. The House discussed that such cultures, which are useful for a specific purpose may be promoted under contract farming, as there may not be general buyers.

Participation of Scientists in Seminars / Symposia / Workshops/ Training

Sr. No.	Seminars/Conferences /Symposia/ Workshops	Place and Date	Participants
1.	Annual Group Meeting of All India Coordinated Cotton Improvement Project	Sri Ganganagar 7-9 April, 2005	T. P. Rajendran, A. Kannan, P. Chidambaram, T. Surulivelu, S. Manickam,
2.	National Seminar on "Cotton Fibre Quality Standards"	Coimbatore 23rd April, 2005	T. P. Rajendran K. N. Gururajan, K. Rathnavel, Sankaranarayanan, S. Manickam D. Monga,, S.L.Ahuja, R.A.Meena, O.P.Tuteja and S.K.Verma
3.	National Workshop on Planning & Management of Agricultural Extension Trainings	New Delhi 19-20 May, 2005	H.L. Gajbhiye
4.	National Seminar on Five Decades of Extension in India : Experiences and Prospects	New Delhi 21-22 July, 2005.	H.L. Gajbhiye
5.	International workshop on Field evaluation techniques on GM crops	Delhi 08-09 August,, 2005	S.L. Ahuja
6.	4th meeting of CAB, Small Committee	CICR, Nagpur 26 August, 2005	S. B.Singh V.N.Waghmare
7.	National Symposium on Recent trends in Biochemistry	TNAU, Coimbatore 17 September, 2005	N. Gopalakrishnan
8.	National Symposium on Microbial Technology for Productive Agriculture	TNAU, Coimbatore 7-8 October, 2005	P. Nalayini
9.	International Conference on Plant Genomics and Biotechnology: Challenges & Opportunities	IGAU, Raipur, 26-28 October, 2005	V.N.Waghmare Surender Kumar

10.	International Conference on Plasticulture and Precision Farming-2005	New Delhi 17-21 Nov., 2005	K.S. Bhaskar P Nalayini
11.	Special Group Meeting on Research and Development Efforts on Hybrids in Selected Crops	NBPGR, New Delhi 21-22 November, 2005	SB Singh
12.	2nd Global Conference on Plant Pathology	Udaipur. 25-29 November, 2005	D Monga, P Jeyakumar
13.	National Workshop on Recent Advancement in Improvement of Cotton Seed Quality	Surat 29 Nov., 2005	R.A Meena
14.	National symposium on Efficient water management for Eco-friendly, Sustainable and Profitable Agriculture	IARI, New Delhi, 1-3 December, 2005.	Jagvir Singh
15.	National Symposium on Recent Advances and Research Priorities in Indian Nematology	IARI, New Delhi 8-10 Dec., 2005.	Nandini Gokte-Narkhedkar
16.	National Seminar on Strategies for improved farming and ecological security of coastal region.	Thiruvananthapuram 21-24 December, 2005	K. N. Gururajan
17.	Indian Science Congress: Integrated Rural Development , Science & Technology	ANG RAU, Hyderabad 03-07 January, 2006	C. S. Praharaj
18.	Regional Workshop on Science Communication	Nagpur 7-8 Jan, 2006.	H.L. Gajbhiye
19.	International conference on Antioxidants, oxidative stress and inflammation in chronic diseases"	Nagpur 12-13 Jan., 2006	A.B. Dongre
20.	DBT Task Force meeting on Biopesticides and Crop Management.	New Delhi 18-19 Jan., 2006	Nandini Gokte-Narkhedkar
21.	National Seminar on Transgenic Crops in Indian agriculture: Status, Risks & Acceptance	Hisar 28-29 January,2006	D. Monga, , S.L.Ahuja, R.A.Meena, O.P.Tuteja S.K.Verma P.Jeyakumar

22.	National Conference on Agrobiodiversity	Chennai 12-15 February, 2006	K. N. Gururajan
23.	Breeder Seed Review Meeting	NBPGR New Delhi 13 February, 2006	R.K.Deshmukh
24.	National Workshop on Planning & Management of Agricultural Extension Trainings	New Delhi 14-15 Feb., 2006	H.L. Gajbhiye
25.	International Conference on Social Science Perspective in Agricultural Research and Development	New Delhi 16-18 Feb., 2006.	H.L. Gajbhiye
26.	National Seminar on Prosperity through Quality Seed	ANGRAU, Hyderabad 24-26 February, 2006	B.M.Khadi PR Vijayakumari V.Santhy
27.	Second National Plant Breeders Congress	TNAU, Coimbatore. 1-3 March, 2006	B.M.Khadi J. Amudha, G.Balasubramani SB.Singh P.Singh
28.	Training on Advanced Biochemical and Molecular Biology Techniques	IARI, New Delhi. 1-18 March, 2006	K.B. Hebbar
29.	Capacity Building Programme for Indian Agricultural Research, Extension and Development Organization in Globalized Agricultural Economy	CICR, Nagpur 3-4 March, 2006	PR Vijayakumari V.Santhy SB Singh
30.	Training-cum-Workshop on Plant Genomics 2006	New Delhi 16-29 March, 2006	S.K Verma
31.	Modern techniques in studies of abiotic stress response and stress inducible genes in plants	ILS, Bhubaneshwar 21-24 March, 2006	K.B. Hebbar
32.	National Convention on Knowledge - Driven Agricultural Development : Management of Change	IARI, New Delhi 24-26 March, 2006	P.M.Mukewar

Distinguished Visitors

Name & Designation	Organisation	Date
Nagpur		
Dr. C. D. Mayee, Chairman	Agricultural Scientists Recruitment Board, New Delhi	27.06.2005
Dr. Rafiq Chaudhary, Head	International Cotton Advisory Committee (ICAC), Washington, USA.	27.06.2005
Dr. Sietse Van Der Werff	Common Funds for Commodities (CFC), Netherlands	27.06.2005
Dr. Derek Russell	Natural Resources Institute (NRI)	27.06.2005
Dr. H.S. Das, Textile Commissioner	Ministry of Textile, Govt. of India, Mumbai	26.08.2005
Shri Sharad Pawarji, Hon'ble Union Minister for Agriculture	Govt. of India, Krishi Bhawan, New Delhi	16.10.2005
Shri Dutta Meghe, M.P.	Raj Sabha, New Delhi	16.10.2005
Shri Anil Deshmukh, Minister PWD	Govt. of Maharashtra, Mumbai	16.10.2005
Shri Manohar Naik, Minister – Food and Drug Administration,	Mahrashtra State, Mumbai.	16.10.2005
Shri N. P. Hirani, Administrative Head,	Maharashtra State Cotton Marketing Federation	16.10.2005
Shri Dharamrao Baba Atram Minister of State for Transport and Social Justice,	Govt. of Maharashtra, Mumbai	16.10.2005
Shri Rajendra Shingne, Minister Minister – Revenue and Rehabilitation,	Maharashtra State, Mumbai.	16.10.2005
Dr. Sharad Nimbalkar, Vice Chancellor	Dr. PDKV, Akola	16.10.2005
Dr. G. Kalloo, DDG (CS & Hort.)	Indian Council of Agricultural Research, New Delhi.	16.10.2005
Dr. M. S. Swaminathan, Chairman	National Commission on Farmers (NCF), New Delhi.	21.10.2005
Shri C. Nanda, Former Chairman	NABARD	21.10.2005
Shri Atul Sinha, Member Secretary & Former Secretary, GOI.	National Commission on Farmers (NCF), New Delhi	21.10.2005
Shri Rana Jagjitsingh Padamsingh Patil, Minister of State for Agriculture	Maharashtra State.	21.10.2005
Shri Ali Jafari Mofidabad, Head	Cotton Research Institute of Iran	22.11.2005

Mr. Hakimijon Saydaiev, Head	Cotton Germplasm Department, Uzbek Cotton Breeding Institute, Uzbekisthan.	22.11.2005
Mr. Amir Helali	Administration of Cotton Research, General Commission for Scientific Agricultural Research, Aleppo, Syria.	22.11.2005
Mr. Bayramgeldi Gurgeldiyer Principal Cotton Specialist	Ministry of Agriculture of Turkmenistan	22.11.2005
Dr. Mangala Rai, Secretary, DARE & Director General ICAR	Indian Council of Agricultural Research, New Delhi.	27.12.2005
Dr. M V Rao, Former DG (Special)	Indian Council of Agricultural Research	28.12.2005
Dr. P Das, DDG (Extn.)	Indian Council of Agricultural Research	30.12.2005
Coimbatore		
Dr. Gautam Kalloo, Deputy Director General (Crop Sciences & Horticulture)	Indian Council of Agricultural Research	18-09-2005
Dr. Ali Jafari (Iran), Head	Cotton Research Institute, Mofidabad, Iran	23-24.11.2005
Dr. Hakimjon Saydaliev, Head	Cotton Germplasm Department, Uzbek Cotton Breeding Institute, Tashkent, Uzbekistan.	23-24.11.2005
Dr. Amir Helali, M	Administration of Cotton Research, General Commission for Scientific Agricultural Research, Aleppo, Syria	23-24.11.2005
Bayramgeldi Gurtgeldiyev, Principal Cotton Specialist	Ministry of Agriculture, Turkmenistan	23-24.11.2005
Sirsa		
Dr.B.M.Khadi, Director,	CICR, Nagpur	09.07.05
Sh.Banwari Lal Joint Director	Agriculture (Cotton – Haryana)	9.3.05– 4.04.05
Dr. B. M. Khadi, Director,	CICR, Nagpur	5-6.09.2005
Shri R. P. Singh, JD,	DOCD, Mumbai	5-6.09.2005
Shri. L.C. Godara, Joint Director of Agriculture,	Govt. of Haryana, Sirsa	5-6.09.2005
Mr.R.P.Singh, Joint Director,	DOCD, Mumbai	06.10.05
Mr.Ali Jafari Mofidabad, Head,	Cotton Research Institute, Iran	22.11.05
Mr. Hakimjon Saydaiev, Head,	Cotton Germplasm Department, Uzbek Cotton Breeding Institute, Uzbekisthan	22.11.05
Mr.Amir Helali,	Administration of Cotton Research, General Commission for Scientific Agricultural Research, Aleppo, Syria	22.11.05
Mr. Bayramgeldi Gurgeldiyev, Principal Cotton Specialist	Ministry of Agriculture of Turkmenistan	22.11.05
Mr. Bhupinder Singh Hooda, Chief Minister,	Haryana	10.10.05

Personnel

NAME OF OFFICERS/SCIENTISTS	DESIGNATION
DIRECTOR	
Phundan Singh	Director (Acting) upto 05.05.05
B M Khadi	Director w.e.f. 05.05.05
PROJECT COORDINATOR (Cotton)	
Coimbatore	
T P Rajendran	Project Coordinator (Cotton) & Head - upto 31.05.05
KN Gururajan	Project Coordinator (Acting) w.e.f.1.6.2005
PLANT BREEDING	
Nagpur	
Phundan Singh	Head (Acting), Crop Improvement Division
V V Singh	Principal Scientist
T R Loknathan	Senior Scientist
Smt. S B Singh	Senior Scientist
V N Waghmare	Senior Scientist
S M Palve	Senior Scientist
D K Agarwal	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 (SS)
SEED TECHNOLOGY	
Nagpur	
R K Deshmukh	Principal Scientist
Smt. P R Vijaya Kumari	Senior Scientist
Smt. V Santhy	Scientist (SS)
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	Principal Scientist
Coimbatore	
K. K. Bandyopadhya	Senior Scientist (Joined on 19.10.2005)
AGRICULTURAL ENGINEERING	
G Majumdar (on study leave)	Scientist (SS)
PLANT PATHOLOGY	
Nagpur	
Sheo Raj (Retd. On 31.01.2006)	Head (Acting), Crop Protection Division
P M Mukewar	Principal Scientist
N K Taneja	Principal Scientist
M K Meshram	Principal Scientist
R C Ukey	Principal Scientist
P K Chakrabarty (upto 11.09.06)	Senior Scientist
Coimbatore	
P Chidambaram	Principal Scientist
A Kannan (expired on 26.02.06)	Principal Scientist
Sirsa	
Dilip Monga	Senior Scientist
ENTOMOLOGY	
Nagpur	
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
Coimbatore	
Smt. J Gulsar Banu (joined on 05.12.05)	Senior Scientist
PLANT PHYSIOLOGY	
Nagpur	
M R K Rao	Head (Acting), Crop Production Division
N K Perumal	Principal Scientist
K B Hebbar	Senior Scientist
Coimbatore	
S E S A Khader	Principal Scientist
A H Prakash	Senior Scientist
BIOCHEMISTRY	
Nagpur	
A B Dongre	Principal Scientist
Smt. M. Chakrabarty	Scientist (SG)
Coimbatore	
N Gopalakrishnan	Principal Scientist
BIOTECHNOLOGY	
P K Chakrabarty (w.e.f. 1209.2005)	Principal Scientist
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	Principal Scientist
P Ramasundaram (Releived on 05.10.05)	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	

Other Information

Library

Additions : The library procured 169 books, 90 scientific reports and bulletins and subscribed 36 Indian and 20 foreign journals.

Documentation Service

Bibliographic database on cotton

Library has developed computerized bibliographic database on cotton to provide comprehensive and updated information on cotton. About 2958 bibliographic references along with abstracts have been stored in it.

Documentation Services such as Current Awareness Service, SDI service, Specific subject search service have been provided by sorting out the database. Using the database Library has brought out a documentation bulletin "Cotton Research Absracts Vol. 19 (1-3) 2005.

Library Networking

For ready access within the Institute to databases available in the Library, a CD-ROM workstation was established in the Library. By virtue of which a server which housed all the databases was installed in the Library. All the networked terminals in the Institute can access the library Server and all the database are accessible to the CAB, ABSTRACTS, CROP-CD, BIOTECHNOLOGY ABSTRACTS, AGRIS-CD and AGRICOLA-CD

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^{++}, 2400 books have been computerized and Barcodes assigned for the same.

Cotton Front Line Demonstration

Nagpur

Cotton Front Line Demonstration programmes were carried out at 93 farmer's fields in three villages Rampur, Pachgaon and Pichdura in Warora Tahsil of Chandrapur district Initially, preliminary survey of villages the cotton FLDs were planned in 93 farmers fields involving 50 farmers selected under cotton production technologies and 43 under IPM Block/ technologies. The technological interventions viz Trials of hybrids RCH-2 Bt, MRC 6301 Bt, CICR varietal trials Surabhi , dry sowing, ridges and furrows at 30 DAS, recommended plant population, supplementing nutrient requirement with bio-fertilizer application, balance use of nutrient, intercropping of soybean with cotton, integrated pest management , use of 2%DAP as foliar spray and detopping etc. were conducted. During the year continuous rains in third and fourth week of June delayed the sowing of cotton and soyabean crop. Few farmers attempted resowing due to poor germination of soyabean because of continuous rains.

In general, under FLD trials a significant increase in the yields in various interventions was recorded as compared to farmer's practices. The seed cotton yields of 888 kg/ha were registered with INM practice as compared to 753 kg/ha from non-INM farmers practice. In intercropping of cotton + soybean an increase of 33.57% profitability was observed over sole cotton crop. Bt MRC 6301 showed its yield advantage when compared with NHH-44 and recorded seed cotton yield 965 kg/ha as compared to NHH-44. However, RCH-2 Bt suffers due to incidence of Jassids and reddening of leaves.

Polyclinic Inaugurated

Dr.B.M.Khadi, Director, CICR, Nagpur, visited the Regional Station, Sirsa on 09-07-05. During his visit he inaugurated a polyclinic at Ragnri village This polyclinic has been established at

Rangri village along with prototype IPM farm demonstrating the pheromone trap, light trap, neem products, etc. The expert advise on identification of insect pests and natural enemies and other IPM technologies are given to farmers through posters as well as training under field conditions.

Participation in National Exhibition

Indian Science Congress Exhibition

CICR participated in exhibition organized by Indian Science Congress held at Achrya N. G. Ranga Agricultural University, Rajendra Nagar, Hyderabad on Jan. 3-7, 2006. The CICR stall in the ICAR pavilion was visited among others by Dr. Mangala Rai, Director General, ICAR, New Delhi and Dr. M. S. Swaminathan, renowned agricultural scientist. CICR displayed in its stall photographs, charts and demonstration material an various cotton production and protection technologies.

National Krishi Expo. 2006

CICR Nagpur participated in National exhibition Krishi Expo 2006 on the theme Mission 'Increasing Productivity of Agriculture' organized by Ministry of Agriculture, Government of India at Pragati Maidan, New Delhi during March 8-12, 2006. CICR displayed in its stall photographs and charts on various cotton production and protection technologies. During the period more than 5000 visitors comprising of farmers, students, extension workers and other professional from various states visited CICR stall.

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 19.07.2005 and 12.01.2006 at CICR, Nagpur. Proceedings of the Official Language Implementation Committee meetings and quarterly progress reports regarding use of Official Language Hindi were sent to the Council regularly.
- CICR celebrated Hindi fortnight and organized various programmes and competitions during this fortnight and winners were awarded during the prize distribution function held on 19th September 2005. CICR, Regional Station, Coimbatore celebrated Hindi Day on 14th September, 2005.
- Kapas Samachar (Quarterly Newsletters), Shwet Swarnima (Annual), Kapas Pragati (Annual) and Rashtriya Kapas Mela Souvenir were published.

Technical Bulletins published

Title of the Technical Bulletin	Bulletin No.	Author (s)
Epitome of agro meteorology, Nagpur	32	K.S. Bhaskar
Rainwater management techniques for enhanced productivity of cotton-based cropping system	33	K.S. Bhaskar, S.M Wasnik MRK Rao, M.R Suryawansi P.N Mendhe, NP Barbade
Identification of sources of resistance to grey mildew disease (*Ramularia areola* Atk.) in Diploid cotton (*Gossypium arboreum*).	34	Punit Mohan., P.M Mukewar V.V. Singh P. Singh B.M Khadi J. Amudha V.G. Deshpande

WEATHER

Nagpur

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
June, 2005	39.4	28.8	60.5	42.2	194.00	10
July, 2005	30.2	24.3	89.1	76.6	369.00	19
August, 2005	30.2	23.8	89.5	72.3	146.00	11
September, 2005	31. 5	23.9	89.01	67.0	253.00	9
October, 2005	31.6	20.5	82.3	57.00	77.00	3
November, 2005	30.1	13.3	73.8	30.6	-	-
December, 2005	27.3	11.7	73.4	37.3	-	-
January, 2006	29. 4	11.2	64.2	28.7	-	-
February, 2006	34.3	15.2	54.3	20.6	-	-

Coimbatore

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy days
	Max	Min	Max	Min		
April 2005	33.8	23.6	89	49	**77.2**	9
May 2005	34.5	23.5	88	50	104.4	9
June –2005	32.2	23.5	78	52	11.4	3
July – 2005	31.1	22.6	79	59	40.1	6
Aug. – 2005	30.4	22.5	84	53	84.5	7
Sept. – 2005	31.2	22.6	86	55	25.4	6
Oct. – 2005	30.7	22.0	92	62	333.1	15
Nov. – 2005	28.1	20.3	92	67	196.6	10
Dec. – 2005	29.2	19.1	93	55	60.1	5
January, 2006	29.7	18.2	90	47	28.2	1
February, 2006	31.8	16.9	87	31	0.0	0
March, 2006	33.5	21.9	89	45	151.4	3

Sirsa

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy days
	Max.	Min.	Max.	Min.		
April 2005	35.3	18.7	47	24	-	-
May 2005	40.9	23.9	46	28	26.6	1
June –2005	42.8	28.6	54	37	13.2	2
July – 2005	35.9	27.5	77	55	102.0	3
Aug. – 2005	36.4	26.4	68	54	264.6	1
Sept. – 2005	32.7	24.9	79	70	178.8	7
Oct. – 2005	33.4	17.1	56	32	-	-
Nov. – 2005	27.4	9.2	56	25	-	-
Dec. – 2005	22.2	4.9	74	32	-	-

NATIONAL COTTON SCENARIO

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

State-wise cotton area, production and productivity

Zone/State	2003-2004			2004-2005			2005-2006		
	Area (Lakh ha)	Prod. (Lakh bales)	P (kg/ha)	Area (Lakh ha)	Prod. (Lakh bales)	P (kg/ha)	Area (Lakh ha)	Prod. (Lakh bales)	P (kg/ha)
Punjab	4.52	11	414	5.09	16.50	551	5.57	21.00	641
Haryana	5.26	11.5	372	6.21	15.50	424	5.83	14.00	408
Rajasthan	3.35	8.5	431	4.38	11.00	427	4.72	11.00	396
North Zone	**13.13**	**31.00**	**401**	**15.68**	**43.00**	**466**	**16.12**	**46.00**	**485**
Gujarat	16.47	50	516	19.06	73.00	651	20.77	89.00	728
Maharashtra	27.66	31	191	28.40	52.00	311	28.89	36.00	212
Madhya Pradesh	5.75	19.5	577	5.76	16.00	472	6.00	18.00	510
Central Zone	**49.88**	**100.5**	**343**	**53.22**	**141.00**	**450**	**55.66**	**143.00**	**437**
Andhra Pradesh	8.25	26	536	11.78	32.50	469	10.37	30.00	492
Karnataka	5	4	136	5.21	8.00	261	4.50	6.50	246
Tamil Nadu	1.03	3.5	578	1.29	5.50	725	1.36	5.50	688
South Zone	**14.28**	**33.5**	**399**	**18.28**	**46.00**	**428**	**16.23**	**42.00**	**440**
Others	0.56	1	304	0.68	1.00	250	0.72	1.00	236
Total	**76.30**	**166**	**370**	**87.86**	**231.00**		**88.73**	**232.00**	
Loose cotton consumed but not counted for in State-wise prod.		11			12.00			12.00	
Grand Total	**76.30**	**177**	**387**	**87.86**	**243.00**	**470**	**88.73**	**244.00**	**467**

Prod. = Production P = Productivity 1 bale= 170 kg.