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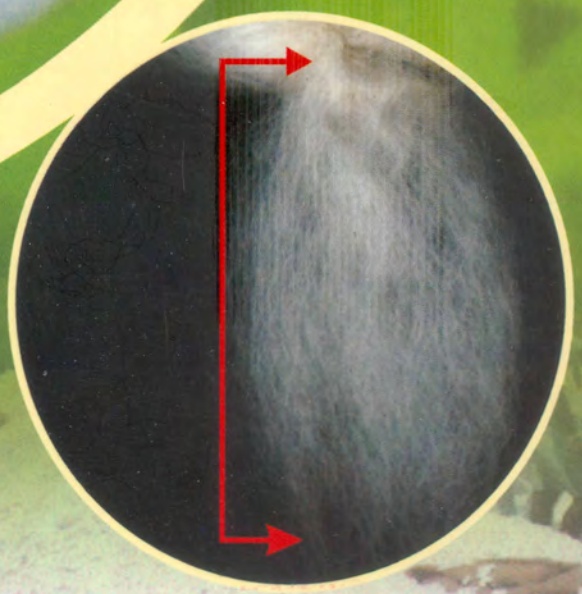
ANNUAL REPORT
2003-04



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

CICR

Annual Report 2003-04

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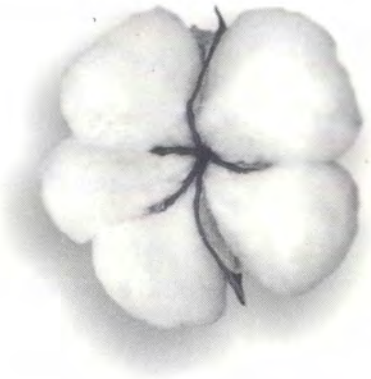

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Cover Back (Insert) :
CSHH 198 - high yielding intra-*hirsutum* hybrid identified for release in the northern cotton zone.

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भा कृ अनु प
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Preface

Cotton outlook for the year 2003-04 has been a landmark for India in terms of better productivity and prices. The season witnessed a production of 177 lakh bales and a record productivity of 387 kg lint/ha. Unusually higher productivity has been complimented by relatively remunerative prices, against the canons of practical economics. The success of the season can be attributed to an array of factors favourable ambience, involving on-farm research mode and outreach activities by NARS, developmental and Institutional efforts, growers confidence and striving, advance crop performance in major cotton economies etc. The institute has released two hybrids one intra-*hirsutum* (CSHH 198) and a MS based *desi* hybrid (CISAA 2) suitable for cotton-wheat cropping system of north zone.

Cotton season was relatively free from any catastrophic pest onslaught. However, the economic survey of cotton performance has come out with revelation of plant protection contributing more than one-third of the cost even during this season. The trends emphasise the need for cutting-down the pesticides and fertilizer bills in cotton production particularly in resource rich conditions. This underscores the need for transfer of cost cutting technologies - IPM, soil mulching, water harvesting, intercropping etc.

The imported cotton picker tested for the first time brought-out encouraging results in term of efficiency with the identified genotypes characterised by synchrony in maturity, compact, plant stature, fruiting bodies position etc.

It is a matter of pride to every one of us that the institute annual report 2002-03 has won the **Best Annual Report Award** of ICAR. The institute shall strive hard to attain further acclaims in the years ahead.

All these have been possible due to untiring efforts of my colleagues and also due to the support from ICAR, New Delhi.

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

I am presenting the annual report 2003 - 04 with pride and sense of fulfilment for public scrutiny.

(Phundan Singh)
Director (Acting)

An intra *hirsutum* hybrid, CSHH 198 developed by the CICR Regional Station, Sirsa and identified for release in the northern cotton zone.

CINA-316, a *G.arboreum* culture with high locule retentivity identified and registered with NBPGR.

Testing of an imported cotton picker at CICR, Nagpur.

Executive Summary

Crop Improvement

Nagpur

- During the year, a collection of 92 *G. hirsutum* accessions including one exotic was added to existing genetic wealth.
- An advance culture, P9 x EL 500 of *G. hirsutum* was identified as the best for drought tolerance which out yielded the check, LRA 5166 by 45%.
- Of the 54 introgressed derivatives of *Gossypium* species evaluated, some were resistant to sucking pest complex and fungal / bacterial diseases.
- Seed test weight had positive correlation with seedling height, dry weight and number of secondary roots and negative correlation with cotyledonary leaf area, days to true leaf initiation and height-node ratio.
- Among the seventy genotypes subjected to DUS testing, genotypic differences were observed for hypocotyl pigmentation, plant stem hairiness, leaf lobe number, leaf colour and leaf midrib pubescence.

Coimbatore

- Intra *hirsutum* hybrid CCHH 1836 with a mean seed cotton yield of 1860 kg/ha occupied the fifth rank as against 1640 kg/ha of zonal check in central zone.
- Cytoplasmic male sterility (CMS)-based hybrid Supriya x Mex (2320 kg/ha) was superior to the control Bunny (2190 kg/ha).
- CMS-based hybrid CCHH 03-3 recorded the highest yield of 3120 kg/ha and was significantly superior to Savitha (2770 kg/ha).
- Interspecific hybrid L2 x P27 recorded the highest yield of 2340 kg/ha, as against 1485 kg/ha of DCH 32, as check.
- CCH 4, a medium staple *G. hirsutum* variety with Alternaria leaf spot resistance occupied the third and second rank respectively, in Central and South zone AICCIP trials.
- CCH 526612 with a mean seed cotton yield of 1790 kg/ha was superior to Surabhi and the local check in the south zone trials.

Sirsa

- The hybrid CISAA 2 ranked first over the three years. An intra-*hirsutum* hybrid CSHH 198 is with medium maturity (162 days), synchronous opening and fits well in cotton wheat rotation.
- The cultures CISA-310, 311 and 318 were at 2nd, 4th and 5th position respectively under zonal trials.
- The hybrid LD 733 X LD 327 (2597.39 kg/ha) recorded the highest yield over check. The highest 2.5% span length (27.0 mm) was recorded by CISA-33 X LD-327.
- In *G. hirsutum* , the new restorer lines namely CIR 8, CIR 12, CIR 23, CIR 26, CIR 32, CIR 38, CIR 70 and CIR 72 have been identified.
- Using Gregg male sterile line governed by two recessive genes, following GMS lines (*G.hirsutum*) CSHG 4, CSHG 1253, CSHG 1251, CSHG 1257, CSHG 12519, CSHG 18516, and CSHG 12517 have been developed. Four lines with higher oil content (> 23.0 %) i.e. TMGH 5, RS 810, V3-73/355 P6 and SH 2379 have been identified from the germplasm.

Biotechnology

- Embryogenic axis and the shoot tip showed differential response in different varieties and explant preparation for co-cultivation.
- Large number of putative transformed plants of LRA 5166 and LRK 516 with Bt Cry I Ac, Bt Cry I Aa3 and Bt Cry I A5 were developed.
- Gene integration and expression have been confirmed in transgenic plants on the basis of ELISA and PCR.

Crop Production

Nagpur

- Residual effect of continuous application of fertilizer and manures was the greatest with 15 t FYM and 7.5 t FYM + 45 kg NPK ha^{-1}.
- The productivity of traditional cotton + pigeonpea strip intercropping system can be improved by supplying the crops with recommended dose of fertilizers and nutrient sprays (2% urea, DAP and micronutrients).
- Mechanised picking of cotton was evaluated with an imported picker and it was found that one hectare could be covered in two hours compared to 370 women hr/ha in case of manual picking. Peri sprayer was developed and is ergo-nomically designed to avoid operator contamination with weedicide.
- Combined application of micronutrients (50 % soil + 50 % foliar) improved the seed cotton yield in Bt. hybrids as compared to recommended dose of NPK.
- The improved INFOCROP model performed reasonably well for many attributes including yield over years, varieties, locations and management practices.

Coimbatore

- Long-term manurial trial revealed that total cotton equivalent yield of 2990 kg/ha was realized in cotton-jowar cropping system in comparison to 1020 kg/ha in cotton-fallow due to better plant growth and development.
- Application of 75 % N and P (K 100 %) + Azospirillum (HAU) + PSB + PPFM produced higher seed cotton yield to the tune of 726 kg than 100 % N and P without bio inoculants.
- A new herbicide mixture of clomazone 15 %, pendimethalin 30 % as galaxy at 2 and 2.5 litre/ha gave broad spectrum control of weeds associated with cotton and enhanced the seed cotton yield.
- IWM involving pre-emergence application of pendimethalin 1 kg/ha (3rd day) + hand weeding (35 DAS) + post emergence application of GOD H001 controlled the weeds efficiently in cotton.
- Black polythene mulch enhanced the seed cotton yield of LRA 5166 to the tune of 2.37 fold as that of non mulched bed planting besides 40 % water saving and complete control of weeds throughout the crop growth due to poly-mulching.
- Bt cotton hybrids (780 kg/ha) performed well under delayed sowing condition (1st October) as compared to corresponding non Bt check (580 kg/ha).
- Bt cotton + cowpea inter-cropping system produced higher seed cotton yield (1890 kg/ha), seed cotton equivalent yield (2180 kg/ha), LER (1.82), GR (Rs 60921/ha) NR (Rs 32071/ha) and benefit cost ratio (2:1).

Crop Protection

Nagpur

- NHH 44 compensated for the loss of fruiting structures up to 25% without yield

reduction. Square damage in relation to total fruiting structures was greater than 30% till the end of September but did not affect the yield realization.

- Absence of sucking pest control on the sucking pest tolerant cultivar allows for more compensation for bollworm damage.
- Increased biological fitness of *H. armigera* on the systemic insecticide treated plants was confirmed.
- *Hyptis suaveolens* Piot. (Lamiaceae (Labiatae): Lamiales) acted as a host plant of *H. armigera* between October and January months.
- Greater than 33^0C maximum temperature, less than 70% morning relative humidity, greater than 40 % evening relative humidity and less than 12^0C minimum temperature during standard weeks of 40, 41, 43 onwards, 48 and 49, respectively led to the severity of *P. gossypiella* attack.
- Five races viz. 4, ,5, 7, 10 and 18 of Xam were identified and race 18 was most predominant. Six lines viz Arkansas 22, Bold Rowden, Durango E-44-50, Florida 1377 T167-10 and Pandora of *G. hirsutum* exhibited resistant reaction against virulent race 18 of Xam under glass house condition.
- 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 eight isolates of *R.areola* on 21 cultivars of four cultivated species. RAPD-PCR pattern of amplification of isolates from *G.arboreum*, *G.herbaceum* and *G. hirsutum* gave indication of variability among the isolates at species level.
- A molecular marker for host resistance was identified to differentiate plants with resistance to CLCuV. A CLCuV fragment of 1.2 kb was amplified, clones and sequenced. Variability in whitefly was observed by using a molecular marker.
- Genomic finger printing based on repetitive PCR, RAPD and RFLP analysis of bacterial blight isolates revealed variability amongst different races and indicated existence of several biotypes within race 18.

Coimbatore

- Life table studies on *Earias* indicated that larval mortality was 26.3% of which the mortality due to parasitism by *Rogas sp* and *Agathis sp* was 17.0%.
- Life table studies on *H. armigera* revealed that larval mortality due to unknown reason was 13.5% and due to NPV was 38.9%.
- Average loss of seed cotton yield due to bollworms in varieties and hybrids was 45.8 and 58.3 % , respectively.
- Spinosad at 75 g a. i. / ha, Emamectin benzoate at 11.0 g. a. i./ha and KN 128 at 75 g. a.i./ha showed low *H. armigera* larval incidence.
- Neem seed extract 5% recorded minimum infestation due to stem weevil (8.81%).
- Methyl parathion 25 kg/ha recorded minimum percent infestation of 8.78 and was superior to all other treatments for stem weevil suppression.
- Studies revealed that insecticide resistance was at the highest level in the pyrethroid-fenvalerate (93.5 %) whereas it was low to moderate in endosulfan (31.3 %) and quinalphos (46.9 %).
- Two unidentified Hymenopteran parasites were recorded from stem weevil. *Althea rosea* L. (Hollyhock), an ornamental plant of family Malvaceae, has been recorded as alternative host for stem weevil.

- The *Ramularia areola* isolate obtained from *G.herbaceum* was almost identical to the *arboreum* isolate in virulence.
- The spray of talc powder formulations of the bioagents *Trichoderma viride, T. harzianum, T. virens* and *Pseudomonas fluorescens* Pf1 and CHAO isolates was able to reduce the Alternaria leaf spot incidence to an extent of 37.0 to 43.0 % especially with *P. fluorescens* compared to check (water spray).

Sirsa

- In IPM plots of H 1098 variety yielded 9q/ acre with seven sprays including 4 sprays of neem against 6 q / acre with 9 sprays of synthetic insecticides in non IPM plots.
- In light trap 100 and 115 *Helicoverpa* adults have been observed in 43rd and 44th standard week. Around 7% of beneficial insects were also attracted to light trap along with pests.
- Screening of germplasm against CLCuV has led to the identification of 32 resistant lines.

Plant Physiology and Biochemistry

Nagpur

- Foliar spray of NAA and nutrients were non-significant whereas cultivar differences were significant. Flower production remained higher in *arboreum* cultivars, whereas seed-cotton yield increase was noticed in NHH 44, particularly with NAA application along with nutrients. AKH 4 (*G.arboreum*) was found to be more promising with regard to growth and development under shallow soil.
- All phenolic components (total phenol, gossypol and flavanol) showed a decrease and amino acids and reducing sugars were found to increase as an after effect of insecticide spray irrespective of cultivars.
- A huge database has been generated for gossypol content in different plant parts of working collections of cotton germplasm lines belonging to *G.hirsutum, G. arboreum, G.herbaceum* and wild species.
- Salt tolerant genotypes possessed higher activity of antioxidant enzymes like peroxidase and catalase in their leaves and accumulated higher amount of proline and K.
- Higher loss of water through the insensitive stomata coupled with restricted flow of water movement though the roots caused wilting in some genotypes due to water-logging.

Coimbatore

- There was a significant improvement in yield with application of 45 or 60 ppm ethrel at 35 DAS.
- Ovules of cotton cultivar DCH 32 (at anthesis) cultured on BT medium with NAA (10 mg.L) + GA (0.5 mg.L) was found to be ideal for *in vitro* fibre development studies.
- The optimum date of sowing was 19th August followed by 29th August and any further delay significantly reduced the crop growth and yield.
- The yield differences between water stress conditions and normal conditions were not significant in the case of drought tolerant genotypes. On the other hand, the susceptible genotypes recorded significantly less yield under stress conditions as compared to normal conditions.
- Plants grown under elevated CO_2 atmosphere always photosynthesized significantly at a higher rate than ambient grown plants (11.4 μ mol CO_2 m^{-2} s^{1} as against 9.4 μ mol CO_2 m^{-2} s^{1}).

- Following spray of *Pseudomonas fluorescens*, two fold increase in peroxidase activity and superoxide dismutase was observed in grey mildew susceptible genotypes and these got enhanced with subsequent inoculation with the pathogen *Ramularia areola*.

Agricultural Extension and Economics

Nagpur

- The regression analysis revealed that a model incorporating explanatory variables like age, education, adequacy of income, health, indebtedness and economic condition of a family is significant and explains 43 % variance of perceived quality of life by cotton growers.
- A model tested for the adoption of IPM technology revealed that large portion of variance in adoption behaviour of cotton growers can be explained by spatial distribution, availability of technology, marketing strategy, pricing and promotional communication.
- The data compiled for 300 farmers revealed that the cotton frontline demonstrations have brought significant changes in knowledge level of cotton growers, adoption percentage and yield levels as compared to non-FLD farmers.
- The high cost characterized the technical constraints-use of non-certified seed, lack of seed treatment, proper spacing, plant protection, and fertilizer use. The extent of use of non-notified varieties was to the extent of 33% ranging from 15% in Bhatinda to 55% in Hisar. Concomitant to this was the varietal proliferation in all the sample farms.

Introduction

Brief history with summary of past achievements

Indian Central Cotton Committee used to sponsor cotton research schemes on an adhoc basis till the work of the committee was taken over by the ICAR in 1966. All India Coordinated Cotton Improvement Project (AICCIP) initiated by the Council in the year 1967 with headquarters at Coimbatore gave new fillip and direction in terms of multidisciplinary and multi-centre approaches with the active involvement of State Agricultural Universities. The project has contributed significantly in tackling location-specific problems in terms of varietal improvement and development of appropriate production and protection technologies. However, looking to the low level of productivity which is primarily due to the fact that the major cotton growing area is under rainfed conditions and the need for expanding the research efforts in the spheres of basic and fundamental research, the **Central Institute for Cotton Research** was established at Nagpur in the year 1976 by the ICAR. The erstwhile Regional Station of IARI at Coimbatore (Tamil Nadu) became a part of CICR simultaneously to cater to the needs of southern cotton zone. In the year 1985, the IARI Regional Station at Sirsa (Haryana) was transferred to CICR as a regional centre for the northern irrigated cotton zone.

Summarized Past Achievements

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

Regional Station, Sirsa

- The seed development studies showed that the cotton seed recorded highest seed index, germination percentage, vigour index and lowest moisture content after 55-60 days of anthesis.
- The crossing period between 15th August and 15th September was found suitable for hybrid seed production from yield and quality point of view under north zone.
- Insecticide resistance in *Helicoverpa armigera* in north zone was monitored and observed that the resistance to synthetic pyrethroids such as cypermethrin and fenvalerate was maximum i.e. from 25 to 83% whereas the resistance to other insecticides such as endosulfan and quinalphos ranged from 16 to 75%.
- Carbendazim, MEMC and Thiophanate methyl were highly toxic to both the root rot pathogeons showing complete inhibition at 50 ppm. In addition to this mancozeb, captan and celest showed complete inhibition of *R. solani* at 50 ppm. Captan at 100 ppm and celest and mancozeb at 1000 ppm showed complete inhibition of *R. bataticola* also.
- Two isolates of *T. harzianum* and one each of *T. viride* and *G. virens* showed promise against *R. solani*. Similarly, an isolate of *G. virens* proved effective against *R. bataticola*.
- Application of a combination of *T. harzianum, T. viride* and *G. virens* @ 0.33% of each culture W/W in pot

culture studies was effective in reducing root rot of cotton in *arboreum* variety DS-1. Experiments on coating the seeds @ 0.4% to 1.0 with bio control agents showed root rot reduction and yield improvement in field to some extent.

- Testing of nutritional requirements of bio control agents showed that nitrogen source was essential for the spore germination of *Trichoderma* and *Gliocladium* species. Culture filtrates of bio agents raised on different carbon and nitrogen sources showed significant inhibition of root rot pathogens.
- Screening of cotton varieties against root rot in sick field revealed that LH 900 showed minimum disease incidence (19.1%) as compared to (63.1%) check variety DS-1 with maximum seed cotton yield. Screening of 132 *G. hirsutum* germplasm lines (1993-2000) revealed B-1371, A72-62, Arkansas green, FS-128, Coker 200-4cy, GR 6015, Texas 34, TH 144-3-62,DL-1, SV-5B, C-1098, C-6-58, C38, Akala 56-25, SFA 243 and PH 36 A as tolerant to root rot.

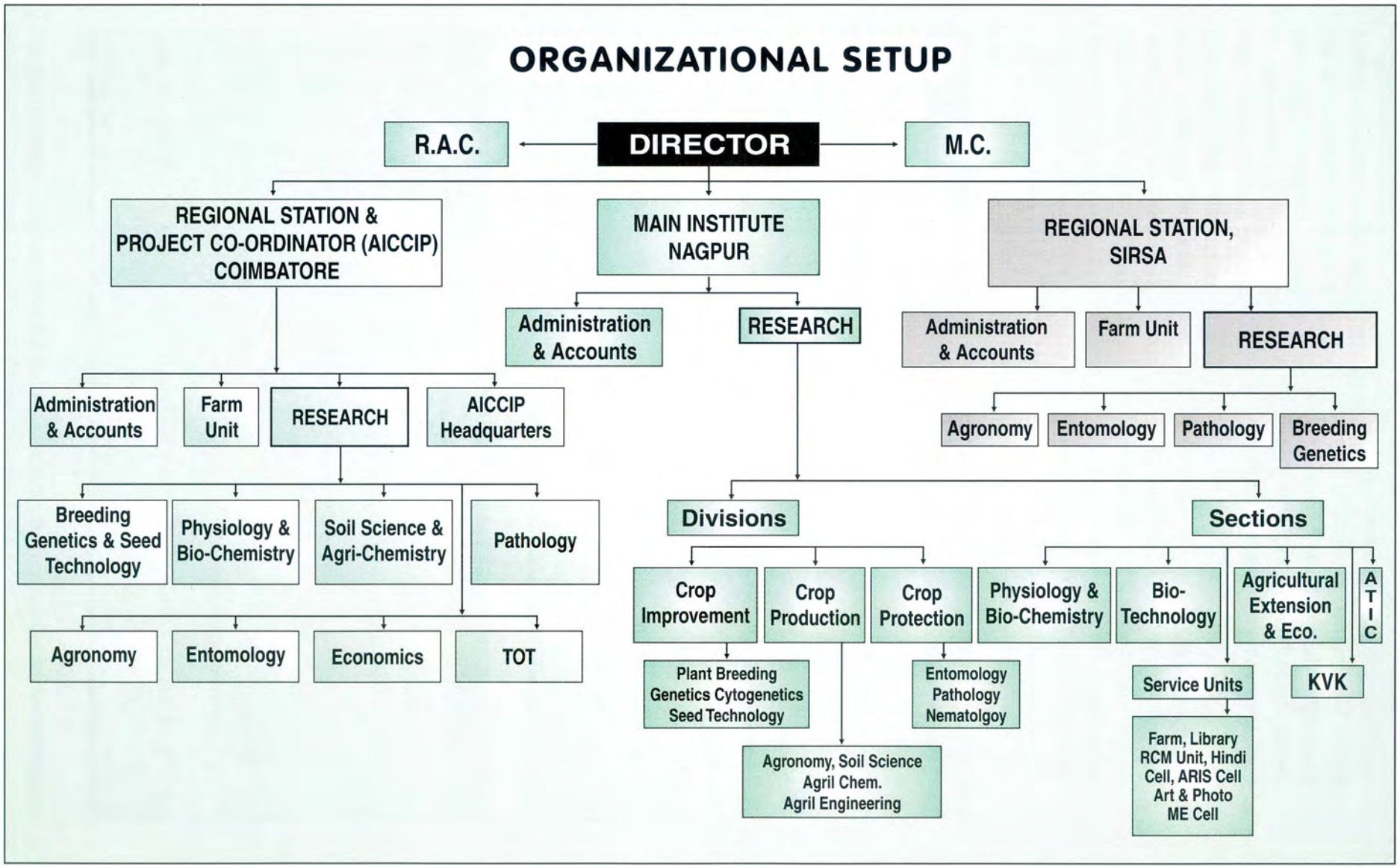
Surabhi, a long linted variety - invading new frontiers

SURABHI, is a *G.hirsutum* high yielding, long staple variety released by the Coimbatore Regional Station of the Central Institute for Cotton Research. This variety is occupying 70,000 ha area in the State of Tamil Nadu during 2004 summer season. It is now preferred to be cultivated under both rainfed and irrigated tract of Tamil Nadu. The crop suffered less pest damage and hence the farmers were able to harvest better quality cotton. Surabhi has 2.5% span length of 33 m.m., fibre strength of 23 to 25 g/tex and micronaire ranging from 3.6 to 3.8 and ideally replaces the quality of MCU 5 VT / MCU 5 as 80s cotton with 25% higher yield of seed cotton under irrigated farming of Tamil Nadu and is seen to replace LRA 5166 and DCH 32 (Jayalakshmi) area of southern zone. It met the requirements of the textile industry and fetched the highest price of Rs. 3,000 to Rs. 3,400 per quintal of seed cotton .

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.

ORGANIZATIONAL SETUP



Financial Statement

The budget grant and actual expenditure for the year 2003-2004 are furnished below :

Budget Sanctioned and Expenditure		(Rs. in Lakhs)
SCHEME	**SANCTIONED**	**EXPENDITURE**
Plan	102.00	101.99
Non-Plan	967.00	863.08
PLAN SCHEME		
NSP Crop	000.00	000.16
AICCIP	472.00	472.00
KVK Scheme	33.10	25.74
TMC Scheme	128.20	121.46
NATP Scheme	124.00	107.29
AP CESS FUND		
IQRC&P Scheme	3.48	2.88
IICBP	2.22	2.54
ENBCHABC	1.62	1.85
RCM	1.50	1.35
R DEPOSIT SCHEME		
NRI (ICAC/CFC/14)	33.22	13.25
DBT Scheme (Development of Molecular Tools)	5.89	0.56
FLD in Cotton	26.13	21.88
TMC MM I (DAC)	21.04	18.18
FLD KVK	-	0.23
DUS Scheme	1.35	-
Maintenance of Breeder Seed	16.00	16.00
Incentive for Breeder Seed production	5.10	5.06
TMC MM II	37.18	27.40
Aventis	-	0.82
Toxicity of Bt (CRY)	7.97	4.78
Bt. Resistance Monitoring (Mahyco)	9.58	8.33
Indofil	2.50	0.13
Bt. Tech	5.86	0.78

Staff Position

Name of Post	Sanctioned Cadre Strength				Post Filled Up			
	NGP	**CBE**	**Sirsa**	**Total**	**NGP**	**CBE**	**Sirsa**	**Total**
Director (RMP)	1	-	-	**1**	1	-	-	**1**
P.C. & Head	-	1	-	**1**	-	1	-	**1**
Scientific	54	26	5	**85**	38	18	6	**62**
Technical	48	32	10	**90**	44	29	10	**83**
Administrative	33	11	8	**52**	31	10	8	**49**
Supporting	78	44	15	**137**	69	42	15	**126**
KRISHI VIGYAN KENDRA								
Training Organiser	1			**1**	1			**1**
Technical	9			**8**	8			**8**
Administrative	2			**2**	2			**2**
Supporting	2			**2**	1			**1**

Research Achievements

Crop Improvement

Nagpur

P1-86/1-ICR-F30/0430 :

Collection, conservation, evaluation, documentation and utilization of genetic resources of cultivated species of *Gossypium* (V.V. Singh and Punit Mohan).

G. hirsutum

During the year a collection of 92 accessions was made including one exotic received through NBPGR, New Delhi and 37 indigenous accessions received from SAUs and NBPGR Regional stations at Akola, Cuttack and Ranchi. One exploration each was conducted in Karnataka and Andhra Pradesh. A total of 4560 accessions were grown during the crop season for regeneration, seed increase and evaluation; they included working collections (300), core collections (480), base collections (1260), exotics (1300) besides 500 accessions for regeneration. All the new exotic collections (57) of the previous year were evaluated as per Germplasm Index Card for major economic attributes and their reaction to various pests and diseases. The range of variability for a few economic characters in the exotics and Br 01 trial is given below:

Among the exotics, elite germplasm lines were identified i.e. PSB CT 8 (87 g) and UPL C 2 (69 g) for seed-cotton yield per plant; MHR 11 (4.4 g) for boll weight; PCB CT 10 (32.3 mm) and NM 970513 (31.0 mm) for mean halo length; PSB CT 8 (41 %) and PCB CT 10 (39 %) for ginning outturn.

Two hundred accessions were evaluated under AICCIP multilocation evaluation testing (Br 01). The superior accessions identified included VCC-3 (222 g), HOC-2 (202 g), SS-105 (199 g) and TAM87N-5 (166 g) for per plant seed-cotton yield; MC-73 (5.7 g), SV-413 (5.6 g), AK-32 (5.6 g) and GC-110 (5.3 g) for boll weight; VCA-5 (44 %), MC-127 (43 %), AKH-8627 (43 %) and VC-8 (43 %) for ginning outturn; NA-1375 (32.3 mm), SV-418 (31.6 mm), JKCL-702 (31.0 mm) for mean halo length. The genotypes identified for tolerance / resistance to jassids, aphids and bollworm attack included VCC-3, HOC-2, MC-73, VCA-5, AKH-8627, SGNR 7, SV 5, VC 17 whereas the genotypes identified for tolerance / resistance to *Myrothecium* leaf spot, CLCuV, bacterial blight and Alternaria leaf spot diseases included VCC-3, VCC 24, JKCL-702, MC 130, SGNR 4, VC 17, COTTON 16.

Regarding fibre quality parameters, the promising accessions identified for long staple (2.5 % span length) included JKCL 702 (34.6 mm), SR 107 (33.0 mm), NA 1375 (31.8 mm), NA 920 (31.8 mm), Pusa 109/10

Germplasm material	Seed-cotton yield per plant (g)	Boll weight (g)	Mean Halo length (mm)	Ginning outturn (%)
Core collections	35 - 170	3.2 - 4.4	23.0 - 34.0	32 - 39
Exotics	3 - 87	2.5 - 4.4	19.3 - 32.3	33 - 41
Multi-location testing- Br 01	9 - 222	1.7 - 5.7	18.3 - 32.3	27 - 44

(29.1 mm), SV 213 (29.1 mm) whereas the promising accessions identified for fibre strength (3.2 mm) were SV 213 (24.5 g/tex), GC 110 (23.9 g/tex), KDGH 231 (23.3 g/tex) and AKG 3 / 59 (22.7 g/tex).

G. arboreum

The passport data of 1870 germplasm lines of *G. arboreum* were compiled and prepared on prescribed proforma of NBPGR and have been sent to NBPGR New Delhi. A set of 910 germplasm lines of *G. arboreum* and 67 lines of *G. herbaceum* were grown for seed increase and rejuvenation.

Lint samples of 960 germplasm lines of *G. arboreum* were evaluated for fibre properties at CIRCOT, Nagpur. Seed of 167 accessions of *G. arboreum* and 43 accessions of *G. herbaceum* were supplied to various indenters for research purpose only. Seventeen accessions of *G. arboreum* and nine of *G. herbaceum* were used in crossing programme for development of diploid genotypes with high yield, high fibre strength under *Desi* Cotton Improvement Programme. Two hundred and two accessions of *G. arboreum* were evaluated under Br.01 trial in three zones for seed cotton yield, boll weight, ginning out-turn and mean halo length. Ten best genotypes were identified for distribution among breeders and researchers.

P1-86/2-ICR-F50/0430 :

Conservation of wild species of *Gossypium* and introgressive hybridization for the improvement of cultivated species of cotton (Vinita Gotmare, M.K. Meshram, S. Vennila, G. Balasubramani and K.B. Hebbar).

Twenty five species, 20 perennial species, six races of *G. arboreum*, seven races of *G. hirsutum*, one race each of *G. herbaceum* and *G. barbadense*, 26 interspecific hybrids were maintained at species garden.

Colchicine treatment to F_1 hybrids and their parents was given and the effect is morpho-logically confirmed and, cytologically to be confirmed on initiation of flower buds.

Thirteen wild species and nine races were used as pollinators in the crossing programme.

P1-2000/1-ICR-F-30/0430:

Breeding for high yielding, long staple genotypes of *G. arboreum* cotton with high fibre strength (Punit Mohan and P. Singh).

Evaluation of cultures in AICCIP: Two new cultures, CINA 343 and CINA 344 have been sponsored for evaluation in the National Elite Varietal Trial (Br 22 a and b) of AICCIP. The culture CINA 316 has been retained in Central Zone Trial (24 b) of AICCIP for further evaluation in the ensuing season 2004-05. Another culture CINA 318 of high fibre strength (22.8) has been promoted in South Zone trial 24 (b) of AICCIP for further evaluation.

Identification of promising cultures: Three new cultures namely CINA 337, CINA 338 and CINA 339 were identified on the basis of boll weight, fibre length and strength for seed multiplication and evaluation of fibre properties.

New crosses effected : One hundred and ten new crosses involving elite genotypes of *G.arboreum* and *G.herbaceum* were effected for further evaluation.

Single plant selection (SPS) : Forty seven single plant selections based on earliness, medium and superior medium fibre length, high fibre strength and high yield were made.

Evaluation of advanced promising cultures in rainfed saline black soil : Studies on salt tolerance were made with 23 promising advanced cultures of *G. arboreum* and a check under rainfed saline black soil conditions at Central Soil Salinity

Research Institute, Regional Station, Anand during *kharif* season 2003-04. The salinity level of soil was ECe 4-6 dS/m (0-30 cm). The crop was irrigated twice with saline water (ECe 7-8 dS/m). The seed cotton yield potential per plant was significantly higher in cultures CINA 313, CINA 323 A, CINA 330, CINA 324, CINA 315 and CINA 327 than check AKA 8401. Higher staple length was observed in the genotypes CINA 306, CINA 316, CINA 321, CINA 323 A and CINA 326.

Evaluation of segregating population : Eighteen progenies of segregating population (F_3-F_5) were planted in un-replicated plots and observations on ginning outturn, earliness, halo length and yield contributing characters were recorded.

P1-88/1-ICR-F30/0430 :

Genetical and anatomical studies for drought tolerance in cotton *G. hirsutum* (Suman Bala Singh and N.K. Perumal).

Twenty five combinations in F_5 generation and two sets of advance culture (18 and 23) were raised under rainfed and irrigated conditions. Since there were rains till October, no supplementary irrigation was given and the experiments were treated as normal. Among the 25 F_5 crosses tested, seed cotton yield ranged from 398.53 to 1294.51 kg/ha. Sixteen combinations were found to be at par with the check LRA 5166 which recorded 800.92 kg/ha seed cotton yield. Seven combinations recorded more than 20% increase over the check. P1 X SP 3895 was the best combination identified recording 1294.51 kg/ha seed cotton yield and 61.63% increase over the check. Some of the other superior combinations identified were P1 X Arogya, P1 X SP 3892 cy, P3 X AV 3469 and P1 X SP 3892 cc.

Among 18 advance cultures tested in the first set, eleven were at par with the check LRA 5166 that recorded 769.76 kg/ha seed cotton yield. The seed cotton yield ranged from 441.59 to 1117.29 kg/ha. P9 X EL 500 was the best culture identified recording 45% increase over the check. P3 X EL 500, P6 X A 72-62 and P10 X EL 500 were other good cultures and recorded more than 30 per cent increase over the check.

In the second set, 23 cultures were tested and seed cotton yield ranged from 491.45 to 1139.47 kg/ha. Sixteen cultures were at par with the check LRK 516 which recorded 666.66 kg/ha seed cotton yield. LL 56 X P1 recorded highest seed cotton yield of 1139.47 kg/ha with 70% increase over the check LRK 516. Texas 1050 x P2, TxMaroon x P2, Tx Maroon x P3 were some of the other good cultures identified with more than 50 per cent increase over the check.

Out of 33 single plant selections tested in replicated trial, SPS 39 UR recorded the highest yield of 1260.19 kg/ha followed by SPS 40, SPS 30, SPS 32. The seed cotton yield ranged from 414.83 to 1293.88 kg/ha. SPS 8, SPS 61, SPS 10, SPS 21 were found to be promising in preliminary evaluation trial.

Twenty advanced lines belonging to *G.hirsutum* (SPS 40 UR, SPS 52, SPS 63,SPS 22, SPS 31, SPS 35UR,SPS 43, SPS 12,SPS 56 UR, SPS 32 UR, SPS 30, SPS 51 UR, SPS 29. SPS 39, SPS18, SPS62, SPS20, SPS36, SPS64 and LRA 5166) were screened for 3rd leaf relative water content during flowering. The following lines were found to possess higher leaf relative water content under induced moisture stress condition - SPS 39,SPS 35 UR,SPS 18 (above 55 %).

P1-2000/2-ICR/F30/0430 :

Breeding cotton genotypes suitable for cultivation in shallow soils (V.N. Waghmare, Punit Mohan, K.S. Bhaskar and N.K. Perumal).

Fifty-nine upland genotypes were evaluated in a replicated trial on shallow (two replications) and medium deep soil (three

replications). Observations recorded showed seed cotton yield between 146 to 926 kg/ha in shallow soils and 185 to 1760 kg/ha in medium deep soil. Comparison in both situations revealed significantly high number of bolls (12.02 vs 19.4), seed cotton yield (426.4 vs 592.97 kg/ha) and number of monopodia (1.56 vs 1.99) in medium deep soils. No significant difference was observed for plant height (89.84 vs 89.94), number of sympodia (15.76 vs 15.60) and ginning percent (39.57 vs 38.23). Seven genotypes namely, AV 3649, Demeter III (II), DS-14303, MCU-10, TXO-RS-8, Macha and 76-IH-22 better performed under shallow soil than in medium deep soils.

Seventy-one *G. arboreum* genotypes were evaluated in two replications on shallow soils. Wide genetic variation was observed for different traits including plant height (58.66 to 169.65 cm), number of monopodia (1.0 to 3.95), number of sympodia (9.7 to 22.2), number of bolls per plant (5 to 20.3), ginning percent (30.71 to 41.41 %) and seed cotton yield (90.55 to 787.63 kg/ha). Six genotypes, which performed very well and produced seed cotton yield above 5 q/ha in shallow soil conditions have been identified.

Growth, biomass production and 3rd leaf relative water content were determined in 15 *G.hirsutum* lines (G Cot 10,G.Cot 100, H 777, HA 46-124, JBWR 25, JBWR 36, LRK 516, Laxmi, Anthens, AV 3649,MCU 10, Macha,M 18, Rajat, Reba-put 9) and 15 *G.arboreum* genotypes (A 1418,AC 26,AC 27,AKA 5, AKA 7, AKA 8401,AKH 4, Arvind,B11,B11 A,BDN 5628,BDN 5900,BDN 6498,BDN 6529,Burma C 19) grown under shallow soil condition. The study brought out that *arboreum* genotypes had relatively more root and shoot length, more number of nodes, leaves and flower production. Biomass production and leaf relative water content remained relatively higher in *hirsutum* genotypes grown under shallow soil condition. H 777, JBWR 25 (*G.hirsutum*), B 11 A,A 1418, AKH 4 (*G.arboreum*) were found to be more promising with regard to growth and development under shallow soil.

P1-2002/1-ICR-F30/0430 :

Studies on genetic enhancement of upland cotton (T. R. Loknathan, P. Singh, D. K. Agarwal, Vinita Gotmare, S. Vennila and M. K. Meshram).

This year 68 F_1s generated earlier through adapted x unadapted germplasm were evaluated for their performance in major yield components and fibre quality traits. One hundred and twenty eight new F_1 crosses were generated involving 18 female parents as recipients and nine male parents as donors selected from germplasm. Thirty one crosses excelled in MHL (>27 mm) over check varieties viz. LRA 5166 and LRK 516 ; seven crosses excelled (>36 GOT) over checks ; five crosses excelled in boll weight (> 4.5) ; thirteen crosses in seed index (> 8) ; ten crosses in lint index (> 4.5) and seven crosses in yield (> 15 q/ha). Six wild diploid species crossed with LRA 5166 were grown as F_1s. The species *G. barbosanum* introgressed very well with LRA 5166 and displayed dominance for traits viz. leaf shape, petal spot, nunber of squares, bract shape and was also found free from sucking pests indicating greater penetrance and expressivity. There was boll formation but seed setting was not there. Efforts are on to make the triploid fertile so that it could serve as a useful fertile interspecific derivative in the breeding programme. Six parents viz. LRA 5166, LRK 516, MCU 5, G.Cot 10, Rajat and Suvin were taken up as recurrent female parent and seven wild species were grown as donors viz., *G. anomalum, G. bickii, G. thurberi, G. aridum, G. capititis viridis, G. raimondii* and one cultivated tetraploid viz. Suvin *(G. barbadense)*.

P1-2003/1-ICR-F30/0430 :

Studies on genetic base of upland cotton varieties (D. K. Agarwal).

A total of 11 released varieties of upland cotton were sown and seventy new cross combinations were initiated to broaden the genetic base. Pedigree of released upland cotton varieties is also being collected, which would further be analysed to study the kinship among the varieties.

AICCIP Trial : Breeding Trial on Bt Cotton (Punit Mohan and P. Singh).

Two experiments on Bt. Cotton Bollgard I and II were conducted under rainfed conditions. In Bollgard I experiment, 26 genotypes including Bt gene and their counterparts were grown in two replications. However, in Bollgard II experiment, eight genotypes with Bt gene with their counterparts were grown in three replications.

Study of fibre properties of Bt cotton trial: Non-significant difference was observed for uniformity ratio, fineness of fibre in Bollgard I and II experiments. Seed cotton yield was recorded significantly higher in hybrids viz. 2340, 2336, 2332 and 2342 in Bollgard I experiment and 2324, 2322 and 2323 in Bollgard II experiment.

Coimbatore

P1-75/2-ICR-F-30/0430:

Development of high yielding intra *hirsutum* hybrids (K.N. Gururajan and S. Manickam).

Of the 130 hybrids evaluated with NHH 44 as the check, seven recorded more than 20 per cent increased seed cotton yield over the check. Of these, four recorded 38% and above ginning out turn. Of these, two hybrids viz., LK 22 x TK 33 (2440 kg/ha) and LK 23 x TK 43 (2420 kg/ha) recorded acceptable fibre quality of 27 mm fibre length and 22.5 g/tex fibre strength.

In the second trial, of the 63 hybrids evaluated as many as 15 were found to be statistically superior to the check hybrid Bunny (C). Six hybrids recorded more than 40% increased yield with superior fibre properties (table 1).

Hybrid CCHH 1836 was tested in the National trial. The performance was best in Central zone, where it recorded a mean seed cotton yield of 1860 kg/ha and occupied the fifth rank.

P1-89/2-ICR-F30/0430:

Breeding new *G. hirsutum* varieties with new plant types and development of and medium staple varieties (K. N. Gururajan and S. Manickam).

Culture CCH 4 was tested under irrigated conditions in both Central and South zone. In Central zone, it recorded a mean seed

Table 1: Performance of long staple hybrids in station trial

S. No.	Culture	Seed cotton yield (kg/ha)	% Increase over Bunny	Ginning (%)	2.5% SL (mm)	Micronaire	Strength (g/tex)
1	LS 2 x LS 13	1640	62	39	28.5	4.7	22.0
2	LS 1 x LS 13	1640	62	36	31.8	4.2	21.8
3	LS 1 x LS 18	1610	60	36	31.6	3.8	22.6
4	LS 1 x LS 15	1470	46	35	31.5	3.9	24.4
5	LS 1 x LS 20	1460	44	35	29.5	4.3	23.6
6	LS 1 x LS 8	1460	44	36	33.0	3.9	22.9
7	Bunny (C)	1000	-	37	31.3	3.6	22.7
	CD 5%	400					

cotton yield of 1690 kg/ha (third rank) against 1460 kg/ha of local check and 1310 kg/ha of LRA 5166 (zonal check). In south zone, it recorded 1880 kg/ha (second rank) and was superior to both zonal 1680 kg/ha and local checks , (1580 kg/ha). It recorded the highest ginning out turn of 41 per cent. The culture, CCH 4 was characterized by medium staple(26.5 mm), good micronaire (4.4) and moderate strength (20.5 g/tex).

CCH 510-4 was tested under both irrigated and rainfed conditions (table 2). Under irrigated conditions (Br 02a) in central zone, it recorded 1170 kg/ha as against 880 kg/ha of local check and 760 kg/ha of zonal check.

Sumangala and LRA 5166 as checks, three viz., 5(1x2)724-2, C.1301 and 5(1x2)18-2 recorded more than 20 per cent yield over best check Sumangala (1440 kg/ha).Quality wise, they were superior to Sumangala (C) and on par with LRA 5166 (C).

P1-89/3-ICR-F30/0430 :

Development of high yielding and high spinning extra long staple cotton (S. Manickam and K.N. Gururajan).

The culture CCH 526612 (table 3) was tested in the coordinated varietal trial of south zone under irrigated conditions and recorded 1790 kg/ha and was superior to both the local (1580 kg/ha) and common checks (1680 kg/ha).

Table 2: Performance of culture CCH 510-4 in National trial (Irrigated)

S. No	Culture	Seed cotton yield (kg/ha)			Ginning out turn (%)
		NZ	CZ	SZ	
1	CCH 510-4	1130 (14)*	1170 (4)	1710 (8)	34.4
2	Zonal check	2160 (4)	880 (15)	1710 (9)	33.4
3	Local check	2390 (1)	760 (23)	1540 (17)	34.1

* performance rank of the zone in parenthesis

In south zone, even though it recorded a mean seed cotton yield of 1710 kg/ha, it was on par with the local check (1710 kg/ha), but superior to the zonal check (1530 kg/ha).

Under rainfed conditions in central zone, CCH 510-4 recorded 840 kg/ha and was marginally superior to the zonal check LRA 5166 (829 kg/ha) with a mean 2.5 % span length of 28.0 mm, micronaire of 4.6 and fibre strength of 22.8 g/tex.

In the station trial, 17 cultures evaluated with

Culture CCH 526612 was tested under Agronomy trials to find out its fertilizer and spacing requirements. The optimum row spacing and fertilizer requirement were 75 x 30 cm and 60 : 30 : 30 kg NPK. At Lam, Guntur, seed cotton yield did not vary due to variety, spacing and nitrogen levels.

In the station trial, fourteen cultures were evaluated along with three checks. Two

Table 3: Performance of culture CCH 526612 in South zone

Sr. No.	Culture	Seed cotton yield (kg/ha)	Ginning (%)	2.5 % SL (mm)	Micro-naire	Strength (g/tex)
1.	CCH 526612	1790 (III)*	34	30.1	4.2	21.2
2.	Surabhi (ZC)	1680 (VIII)	34	32.0	3.6	22.9
3.	Local check	1580 (VI)	37	-	-	-

* performance rank of the zone in parenthesis

cultures L(RCH x T13)52-1-1 (1840 kg/ha) and L(RCH x T13) 510-4 (1770 kg/ha) were significantly superior to the best check Sumangala (1290 kg/ha).

P1-89/6-ICR-F30-0430:

Interspecific and inter-racial hybridization and gene transfer in Gossypium (K. P. M. Dhamayanthi and S. Manickam).

Five different trials were conducted to evaluate the performance of various plant progenies derived from superior plants and advanced cultures. In the first trial, 30 plant progenies were tested and the highest seed cotton yield was recorded in IRH II-1-17 with 1540 kg/ha of yield as against 1090 kg/ha recorded in the best check variety of Sumangala. When the bulk of IRH 1-4 is compared with the individual superior progenies, there was a remarkable improvement for all the quality characters evaluated so far, as furnished in table 4. Especially, the ginning outturn has been recorded upto 49.6 % (IRH 1-4-7) as compared to 42.4 % recorded in the bulk. Even the mean of six progenies was found to be 45.9%, far superior to the bulk.

In four other trials, derivatives from introgressed lines, plant progenies and progeny bulks were tested along with LRA 5166, Sumangala and Surabhi as checks. Sumangala topped in three and in the fourth trial, the highest seed cotton yield was recorded in CMT 11 with 2310 kg/ha against 1700 kg/ha of yield recorded in LRA 5166. However, several progenies were identified with better boll weight (more than 5.0 g/boll), lint index (more than 7.0 g) and superior ginning outturn (more than 40 %).

Cytological characterization of cultivated and wild species *viz.*, *G. aridum*, *G. armourianum* and *G. davidsonii* were carried out and karyomorphological and phylogenetical studies were done. Vegetative propagation of wild species using growth hormones was studied. IBA treatment @ 2000 ppm was found to be the best for inducing profuse root growth and overall vegetative development of wild species.

P1-89/1-ICR- F30/0430:

Development of extra long staple high spinning hybrids of inter-specific origin (*G. hirsutum x G. barbadense* with wide adaptability (K. P. M. Dhamayanthi and S. Manickam).

Two preliminary station trials were conducted to evaluate the performance of interspecific hybrids. In the first trial, 52 conventional hybrids were evaluated along

Table 4: Comparative performance of bulks *vis-à-vis* plant progenies of IRH 1-4

Genotype	Boll weight (g)	L.I. (g)	S.I. (g)	GOT (%)
IRH 1-4-Bk (2003-04)	5.2	8.1	**11.0**	42.4
IRH 1-4-4	5.1	8.0	8.7	47.9
IRH 1-4-7	4.3	7.5	7.6	**49.6**
IRH 1-4-10	**6.2**	**8.9**	10.9	44.9
IRH 1-4-12	5.2	8.4	9.8	46.0
IRH 1-4-17	4.9	7.7	10.2	42.8
IRH 1-4-18	5.1	7.9	10.1	43.8
Mean of above	5.1	8.0	9.5	45.9

Bold figures indicate the maximum value recorded

with TCHB 213 and DCH 32 as check hybrids. LK 14 X P 25 (2510 kg/ha) and LK 14 x P 27 (2460 kg/ha) recorded significantly higher yield over in the best check TCHB 213 (1620 kg/ha).

In the second trial, 62 MS based interspecific hybrids were evaluated along with TCHB 213 and DCH 32 as check hybrids. The test hybrid G 2 X P 30 recorded the highest yield of 1800 kg/a as against 1480 kg/ha recorded in the best check hybrid TCHB 213.

The comparative performance of both male sterile as well as conventional interspecific hybrids over the last four years indicated superiority of few test hybrids over the best check hybrid DCH 32. The hybrid L 2 x P 27 recorded the highest mean seed cotton yield of 2340 kg/ha with 57 % yield increase over DCH 32. Among the MS based hybrids, G 2 x P 30 was the best with mean seed cotton yield of 1530 kg/ha as against 1490 kg/ha recorded in DCH 32. Quality wise also, the above hybrid was superior to DCH 32.

The male sterile based hybrid CCHB 727 has been promoted from PHT to CHT of south zone in AICCIP testing. Hybrid seeds of both conventional and MS base were produced for testing them both in station trial as well as in AICCIP. National as well as South Zone AICCIP trials of interspecific hybrids were conducted. In the national trial, of the 21 entries tested, the hybrid RAHB 47 ranked first with 1940 kg/ha of yield. In the south zone trial, out of 11 hybrids tested, RAHB 37 was found to be the best with 1920 kg/ha of yield.

Maintenance and evaluation of cotton germplasm (S. Manickam).

Four hundred *G. hirsutum* accessions and 330 *G. barbadense* accessions were maintained under field condition. The fibre quality of *G. barbadense* germplasm accessions are furnished in table 5.

Two hundred accessions in each of *G. hirsutum* and *G. arboreum* were evaluated. *G. hirsutum* germplasm lines were found to have superiority over check variety (LRA 5166) for yield, agronomic characters as well as for quality characters.

P1-89/5-ICR-F30-0430 :

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

Table 5: Performance of select *G. barbadense* germplasm lines

Genotype	Boll WT (g)	LI (g)	SI (g)	GOT (%)	2.5% SL (mm)	Mat. Ratio	UR (%)	MIC	BS (g/tex)	EP (%)	BS/ SL Ratio
ICB-5	2.7	4.2	6.6	**38.9**	28.1	0.7	46.9	3.8	27.7	2.7	0.99
ICB-6	2.2	2.7	5.3	33.8	30.3	0.7	45.9	3.4	27.7	2.9	0.91
ICB-32	**3.1**	4.5	**8.9**	33.6	35.0	0.7	46.4	3.5	22.8	3.5	0.65
ICB-110	2.1	3.5	6.3	35.7	29.6	0.7	47.1	3.3	**29.8**	3.6	1.01
ICB-185	2.3	2.9	5.7	33.7	26.6	0.7	**49.7**	**4.2**	27.4	3.1	**1.03**
ICB-220	2.5	3.7	8.2	31.1	**35.2**	0.7	45.8	3.3	25.2	3.7	0.72
ICB-276	2.8	**4.9**	8.7	36.0	34.9	0.7	46.2	3.4	24.5	3.9	0.70
Suvin					34.7	0.6	42.2	2.7	24.9	**4.0**	0.72

Bold figures indicate the maximum value recorded

and fertility restoration in cotton (S. Manickam).

Two trials were conducted to evaluate the performance of 40 different CMS based intra-*hirsutum* hybrids. In the first trial, the test hybrid RKR 4145 x DS 146-3 (with 3230 kg/ha) recorded significantly higher yield over the best check Surya (with 2710 kg/ha) with 19% higher yield. In another trial, when 13 CMS based hybrids were tested, the maximum yield was recorded in the test hybrid MCU 5 X DR 1R with 2560 kg/ha.

Comparison of mean performance of CMS hybrids over the last three years (table 6) indicated superiority of test hybrid Supriya x Mex (2320 kg/ha) over check hybrid Bunny (2190 kg/ha). This hybrid was found to possess better fibre quality with strength to length ratio of 0.8 as against 0.7 recorded in the above check hybrids.

Sirsa

Development of varieties and hybrids (MS based) of medium staple length in *Gossypium arboreum* L. (S. K. Verma).

a. Development of varieties: Three cultures CISA 311, CISA 318 and CISA 310 ranked in first five in National trial and zonal trials during 2001-02, 2002-03, 2003-04 and are also being retained for further testing during the year 2004-05.

Station trials: Five AVTs were conducted. Promising entries for span length (>22 mm) are: CISA-1, CISA-6, CISA-63, CISA-16, CISA-59, CISA-60, CISA-64, CISA-65, CISA-66. Promising entries for yield (> 20 q/ha) are: CISA-1, CISA-7, CISA-25, CISA-26, CISA-52, CISA-11, CISA-15, CISA-20, CISA-24, CISA-27, CISA-34.

Table 6: Comparative performance of CMS hybrids over the last three years

CMS Hybrid	Yield (kg/ha)			Mean of three years				
	2001-02	2002-03	2003-04	Yield (kg/ ha)	2.5 % SL	MIC	BS (g/tex)	BS/ SL
Supriya x Mex	1626	3023	-	2324	28.9	4.5	23.2	0.8
Suman X AK 2	2051	1938	2661	2216	28.6	4.7	22.3	0.8
22-29-HS X AKH 1162	-	-	2199	2199	27.2	4.7	20.6	0.8
Bunny [C]	-	2587	1786	2187	31.8	4.3	22.5	0.7
PKV Hy.4 [C]	-	2141	-	2141	32.1	4.1	23.7	0.7
Savita [C]	1070	271	1775	1039	32.2	3.6	23.6	0.7

When 21 GMS based hybrids were evaluated in a replicated trial, the highest seed cotton yield was recorded in the check Bunny (2710 kg/ha) followed by the test hybrid G 67 X KH 3 with 2440 kg/ha. Several test hybrids had superior fibre quality, for instance, the test hybrid G 67 x TK 26 had a fibre length of 28.3 mm, strength of 25.4 g/tex and was characterized by high boll weight (5.8 g/boll).

Generation of segregating material: Under this a number of crosses were attempted between long linted strains received from Parbhani and Dharwad and the local cultivars which are short stapled but high yielding. Span length more than 24.5 mm was recorded in many hybrids.

New crosses attempted: Thirty five new crosses were attempted involving long linted entries and the local cultivars.

Single plant selections from F_2, F_3, F_5

etc.: One hundred and eighty six single plant selections were done having high span length.

i) AVT-1: Of the 12 entries tested against local check RG 8 and HD 123 in three replications, CISA 8 (1909.00 kg/ha.), CISA 1 (1486.04 kg/ha.), CISA 7 (1428.29 kg/ha), and CISA 6 (1383 kg/ha.) gave significantly higher seed cotton yield over local check. The highest 2.5 % span length (21.1mm) was recorded by CISA 10.

ii) AVT-2: None of the 12 entries tested yielded significantly higher over local check. The highest 2.5 % span length (20.0 mm) was recorded by CISA 18. The maximum GOT % (38.9%) and highest boll number (22.4) was recorded by CISA 12 and CISA 17 respectively. The highest boll weight (2.3 gm) was recorded by CISA 11.

iii) AVT-3: Of the 12 entries tested against local check RG 8 and CISA 310 in three replications, none yielded significantly higher over local check. The highest 2.5 % span length (23.2 mm) recorded by CISA-21. The maximum GOT % (39.9%) and highest boll number (18.8) was recorded by CISA 26 and CISA 29 respectively. The highest boll weight (2.2 gm) was recorded by CISA 24.

iv) AVT-4: Of the 16 entries tested against local check CISA 310 in three replications, CISA-35 (1268.85 kg/ha.), CISA 36 (1051.60 kg/ha.), CISA 44 (983.07 kg/ha), CISA 43 (948.78 kg/ha) and CISA 34 (891.62 kg/ha.) gave numerically higher seed cotton yield over local check. The highest 2.5 % span length (21.3 mm) was recorded by CISA 33-. The maximum GOT % (39.9%) and highest boll weight (2.0 g) was recorded by CISA 33.

v) AVT-5: When 20 entries were tested against local check CISA 310 in three replications, CISA 63 (1566.06 kg/ha), CISA 58 (1486.05 kg/ha) and CISA 56 (1394.60 kg/ha) gave significantly higher seed cotton yield over local check. The highest 2.5 % span length (25.1mm) was recorded by CISA 64. The maximum GOT % (39.0%) and highest boll number (22.2) was recorded by CISA-62. The highest boll weight (2.0 gm) was recorded by CISA 46.

b) Three hybrids having span length more than 24 mm were developed and performed well under national trial. CISAA 1 and CISAA 2 stood at first and second rank under zonal trials. **The hybrid CISAA 2 has been identified for cultivation in north zone by AICCIP varietal release committee.**

One hybrid CISAA 6 and one culture CISA 614 have been sponsored to National Trial Br 25PHT and Br 22a/b. A number of combinations have been made to test the performances of the best combiners under replicated trials.

P1-85/2-ICR-F30/0430 :

Evaluation of parents in *G. hirsutum* for heterotic potential and useful heterosis for replacement of existing cultivars under North Indian conditions (O. P. Tuteja).

Identification of new hybrid CSHH 198 for cultivation in North zone : Hybrid CSHH 198 is an intra-*hirsutum* hybrid, with medium maturity (162 days), synchronous opening and fits well in cotton wheat rotation, has recorded an overall mean seed cotton yield of 21.96 q/ha as against 18.2 q/ha of LHH 144 (cc) and 13.78 q/ha of local checks. It represents medium to superior medium staple group (26.5 mm), with micronaire value of 4.5, uniformity ratio of 49.2 % and fibre strength of 23.5 g/tex. In the full spinning test this hybrid has given the satisfactory CSP value (2345) at 50s counts and had shown the better strength/length ratio as compared to the other check hybrids. The ginning outturn of 32.5 % recorded by this hybrid was found to be better than that of check hybrids LHH 144 (31.8 %)) and Om Shankar (31.2 %). In lint yield also the hybrid CSHH 198 has

recorded an increase of 21.4 % over LHH 144 (CC) and 15.8 % over local check Om Shankar (LC).

Demonstration of promising hybrids : The demonstration trial consists of 14 hybrids and check hybrids Om Shankar and LHH 144. Each entry was sown in an area of 48.6 sq. meter and the spacing was kept at 100x 45 cm. The hybrid CSHH 238Y gave the highest yield of 3294 kg/ha followed by CSHH 238 (2739 kg/ha) and CSHH 198 (2706 kg/ha). The ginning outturn ranged from 30 to 33%. The hybrid CSHH 825 has shown the highest bundle strength of 24.7 g/ tex.

Local hybrid trial 1 : In this trial 28 hybrid combinations were evaluated against check hybrids LHH 144 and Om Shankar. The highest seed cotton yield of 2894 kg/ha was recorded by CNH 911 x PHP2 followed by 2824 kg/ha in F 505 x PHP 7 as compared to 2315 kg/ha in Om Shankar. Maximum ginning out turn of 36% was recorded by F 505 x M 62 as compared to that of 33% in Om Shankar.

Local hybrid trial 2: In this trial 83 crosses were evaluated against the local check hybrid Om Shankar. The seed cotton yield was recorded to be maximum in HS6 x RS 2013 (3366 kg/ha) followed by RST 9 x RS 875 (3152 kg/ha). Seed cotton yield of 3086 kg/ha was recorded in three crosses viz. RS 2013 x RS 810, LH 1556 x RS 2013 and PIL 8 x H S6, which is significantly higher than the yield given by LH 1556 (1852 kg/ha). Ginning out turn was found to be maximum of 36% in RS 810 x Jhorar.

Development of male sterility based hybrids of *G. hirsutum* for North India

(O. P. Tuteja).

CMS hybrid trial 1: In this trial 22 crosses were evaluated against the local check hybrid Om Shankar. The highest seed cotton yield of 1831 kg/ha was found to be in CMS 15 followed by 1821kg/ha in CMS hybrid 14 as compared to 1780 Kg/ha in local check. Ginning out turn was found to be highest in CMS hybrid 12 (39 %) followed by 36% GOT in entries CMS hybrid 10 and CMS hybrid 14 as compared to 32% in check and Om Shankar. 2.5% span length was found to be maximum in CMS hybrid 5 (31.1 mm) followed by CMS 2 (30.7 mm) in comparison with check LHH 144 (30.2 mm) and Om Shankar (28.5 mm).

Maintenance of CMS lines: The local adapted cultivars and parents of promising hybrids viz. LRA 5166, Jhorar, RB 281, Pusa 231, LH 1134, HS 6, F 505, K 34007, H 777, Bikaneri narma, F 1183, CSHH 2379, CSH 25 M, F 846, PIL 8, LH 1556, CISV 1, CISV 2, LRK 516, Laxmi, PIL 43 and LSS 1 have been converted into cytopaslmic male sterile lines having cytoplasm of *G.harkensii* and these CMS lines are being maintained through sib mating.

Identification of new restorer line: The new restorer lines namely CIR 8, CIR 12, CIR 23, CIR 26, CIR 32, CIR 38, CIR 70 and CIR 72 have been identified based on three years studies (2001-2003). These restorer lines are able to restore the fertility upto 70-100 per cent.

GMS hybrid trial 1: In this trial 38 GMS based hybrids were evaluated against conventional check hybrids i.e Om Shankar and LHH 144. The highest seed cotton yield 2469 kg/ha was found to be in GMS 26 x 59 followed by 2411 kg/ha in GMS18 x 62 as compared to 2207 and 2068 kg/ha 'Om Shankar' and LHH 144 respectively. Ginning out turn was found to be highest in GMS hybrid 22 x 56 (37.1%) followed by 35.9 % in GMS 18 x 62. as compared to 33.3% in Om Shankar.

Conversion of GMS lines: Genetic male sterile lines (GMS) of American cotton (*G.hirsutum*) were converted by using Gregg male sterile line governed by two recessive genes. By transferring these genes following GMS lines CSHG 4, CSHG 1253, CSHG 1251, CSHG 1257,

CSHG 12519, CSHG 18516, and CSHG 12517 have been developed

Development of *G.hirsutum* cultivars with high fibre strength suitable for high speed spinning (S. L. Ahuja, O. P. Tuteja, S. K. Verma, R. A. Meena, D. Monga, P. Jeyakumar, V. V. Singh and K. N. Gururajan).

A. Evaluation of genotypes for GOT and fibre quality

a. Three hundred and eighty four lines were screened for GOT % (144 germplasm under unsprayed condition + 240 germplasm lines under sprayed condition, 112 without MOP and 128 with MOP). GOT% ranged from 28.93 to 39.44% under unsprayed condition; Lines CISV-3 and CISV-4 had GOT% around 40% (39.20 and 39.4%).

Under sprayed condition (without MOP), % GOT varied from 29.94 to 42.18%. 32 lines recorded GOT more than 35%. Entries F-1946, LH-1953, LH-1950, LH-1972 and SISV-3 recorded 40% and above GOT%.

b. Some of the entries like CISV-3 and CISV 2 gave high GOT under both the conditions and there was no effect of MOP on their high GOT per cent (38.0%).

c. When 423 genotypes were tested for fibre quality, 40 were with more than 23 g/tex tenacity. CSH 3127, CSH 3033 and CSH 3181 had fibre strength more than 25 g/tex. CSH 2524 and CSH 2572 had good yield and strength and were sponsored in National trial.

B. Evaluation of genotypes for diseases and insects-pests : Jassid tolerant genotypes CSH-3047 under unsprayed condition and CSH-3106, CSH-3120, CSH-3200, CSH-3172 were high yielders under sprayed condition. CSH 3037, CSH 3047 and CSH 3060 were found to be leaf curl resistant in three experiments. Three genotypes CSH 3201, CSH 3051 and CSH 3054 were spotted bollworm tolerant and high yielding.

C. Evaluation of genotypes for earliness: KDCAKD, Raja Sikander, MMA-R-49, MMA-IRH 10, PIL-8, VIKRAM out of 144 genotypes under unprotected condition, CISV-12, CISV-31, CPD-447 out of 128 genotypes under protected condition without MOP, and SGNR-2, HISAR-2, CPD-2, CPD-447, RS-875 and M-45 out of 112 genotypes under protected condition with MOP were found early (days to flowering around 50 days and maturity between 135-145 days).

D. Evaluation of genotypes for high seed cotton yield : CISV-16, CISV-33, CNH-36, LH-1950, LH-1960 out of 144 genotypes under unprotected condition, LH-1953, RS-2098, H-777, JAIPURIA, PUSA-3216, LH-1960 out of 128 genotypes under protected condition without MOP, SGNR-1, SGNR-23, RS-810, RS-2013 and AKH-8627 out of 112 genotypes under protected condition with MOP, were found high yielder (100 g/plant) than H 117 check (53 g/plant).

1. Crosses attempted to combine genes with respect to yield, fibre quality, disease and pest resistance from the available sources : About 800 crosses attempted in line x tester and diallel fashions using high GOT, high strength, disease and pest resistance from the available sources for institute and TMC projects.

2. Study of factors affecting fibre properties: Three hundred and eighty four genotypes were evaluated (144 germplasm lines under unsprayed condition + 240 germplasm lines under sprayed condition 112 without MOP and 128 with MOP). Some of the genotypes like CSH 3036 and CSH 3035 gave high GOT under both the conditions and there was no effect of MOP on their high GOT per cent (38%). CSH 3127 genotype had high strength of 25 g/tex under protected and unprotected conditions.

Collection, conservation and

maintenance of genetic resources (R. A. Meena).

Hundred lines each of *G. hirsutum* and *G. arboreum* under Br 01 trial and 1060 lines of *G. hirsutum* and 540 lines of *G. arboreum* germplasm maintained at this station were evaluated for yield/plant, boll weight, boll number/ plant, GOT, seed index, lint index, sympodia/plant, fibre length, shattering %, CLCuV incidence and bollworm infestation. The range of variability was quantified and twenty superior genotypes were identified. In addition to that some lines with different morphological characteristics were identified i.e. in *G. hirsutum* 18 lines with broad leaf; 13 with okra type leaf; 51 with yellow petal; one with pink petal (SA 10); 67 with yellow anther; three with red colour spot (i.e VC 8, ICMF 31 and ZGG 3) at the base of petal; two with coloured lint (SA 675 with green colour and Brown lint clean with brown lint); one with red plant body (SA 10). In *G. arboreum* 57 with white; two with cream and 25 with pink flower colour; 24 with red plant body and one with coloured lint (CISA 316 (Brown lint)were observed.

Seed Technology

Nagpur

P1-2003/2 -ICR-F30/0430 :

Improvement in seed yield and quality in *arboreum* culture with low input management under different soil depths (R.K. Deshmukh, V. Santhy, P. Singh, Punit Mohan and P.R.Vijaya Kumari).

Three separate experiments were conducted in shallow, medium and deep soil (vertisol) under low input i.e. only FYM @ 2.5 tons / ha. Seven genotypes were grown in all the three soils with four replications. Culture CINA 346 has given maximum yield which was significantly superior over other cultures in shallow soil. In medium and deep soil, cultures did not differ significantly. However, in deep soil, culture CINA 345 gave nine quintals of yield, two quintals more than others.

Total dry matter was higher in deep soil though there were genotypic differences at flower initiation. At boll opening stage, dry matter was more in shallow soil than deep and medium soils.

As far as ginning outturn is concerned, there were not much differences across soil depths. However, different cultures differed significantly in all the three pickings. Culture CINA 348 had 2% higher ginning outturn in different pickings. Further, control variety AKH 7 had highest ginning percentage (>40%) against other cultures. Culture CINA 346 had lower seed index, while AKH 7 recorded lowest. This may be one of the reasons for higher ginning percentage.

P1-2003/3 -ICR-F30/0430 :

Seed yield and quality improvement in *arboreum* cultures with low input management under different soil depth (R.K. Deshmukh).

Significant higher yield in CINA 346 culture was recorded over other culture in shallow soil condition while CINA 345 gave higher yield in deep soil condition.

P1-2003/1-ICR-F30/0430:

Assessment of seed vigour traits in cotton (V. Santhy, R. K. Deshmukh, K. B. Hebbar and P. R. Vijaya Kumari).

Fourteen genotypes were characterized for eight seedling vigour traits and significant variation was observed for all the traits. Analysis revealed positive correlation for seed test weight with seedling height, seedling dry weight and number of secondary roots where as, low/negative correlation with other important traits such as cotyledonary leaf area, days to true leaf initiation and height-node ratio indicating traits other than seed weight govern the initial vigour of seedlings in the field. A laboratory study on characterization of genotypes for physiological seed vigour

traits showed significant differences for rate/speed of germination, seed reserve depletion ratio, seed reserve mobilization efficiency and response to accelerated ageing. One of the *arboreum* culture, CINA 46 was found performing better with respect to reserve mobilization efficiency, the basis for which needs to be studied.

Coimbatore

P1-97/1-ICR-F-25/0430:

Studies on viability, vigour and longevity of cotton seeds (K. Rathinavel, P. Chidambaram and K. Natarajan).

Effect of growth hormones and chemical sprays on seed storability

Enhancement of storability and vigour in both fuzzy and delinted seeds over 16 months of storage was witnessed when seeds produced with the mother seeds soaked in succinic acid @ 0.2% was sown and followed by foliar application of NAA @10 ppm on 60 and 75 days after sowing.

Estimation of storability of cottonseeds stored at different temperature

Significant differences due to storage temperature, period of storage and seed treatments for germination, seedling length, dry matter of seedling and vigour index was observed. Low temperature storage environment maintained the seed viability and vigour throughout the storage period. Among the bio inoculants *Pseudomonas fluorescens* was found effective in maintaining the viability and vigour. However, bio inoculants are on par with fungicide in protecting seed deterioration over different levels of storage temperature and period of storage. The conducive temperatures for survival or maintaining the population of *Pseudomonas fluorescens* and *Trichoderma viride* were observed to be 20°C and 10°C respectively.

Assessment of storability of polymer and insecticides coated cottonseeds

Delinted LRA5166 seeds coated with polykote, a seed coating polymer along with fungicide and insecticides and subsequently were stored for 16 months. The seed quality estimations recorded at bimonthly intervals revealed that coating seeds with Imidachloprid 5 g kg^{-1} or polymer@5ml kg^{-1}+ Carbendazim@2 g kg^{-1}+ Thiamethoxam@ 5ml kg^{-1} or polymer @ 5ml kg^{-1}+ Carbendazim@2 g kg^{-1}+ Chlothianidine @5ml kg^{-1} are equally efficacious in maintaining the seed viability, vigour and also for maintaining the seed health.

Sirsa

Studies on seed technological aspects of hybrid and varietal seed production in north zone (R. A. Meena, O. P. Tuteja and D. Monga).

Hybrid seed production:

A. Identification of suitable crossing period for higher yield and superior seed quality and seed setting potential: Crosses were made in the parents of hybrids Om Shankar and LHH 144 from beginning to completion of flowering. During this year up to 22nd Sept. average 10-15 flowers per day per plant were observed. There after, the flower number per plant gradually declined as the season progressed. The highest cross boll setting percentage was noticed up to Sept. 1st and it was 38% in hybrid Om Shankar and 32% in hybrid LHH 144.

B. Effect of seed soaking and foliar application of chemicals on seed yield, quality and crossed boll setting percentage: Considering seed treatment and foliar spray of chemicals together, the seed soaking in KH_2PO_4 (100 ppm) before sowing and foliar spray of $MgSO_4$ (1%) at 60, 75 and 90 DAS increased the seed yield, seed quality and boll setting percentage.

C. Effective pollination from one male

flower: At initial stage (up to 28th August) one male flower could pollinate up to eight female flowers in both the hybrids i.e. LHH 144 and Om Shankar resulting in seed set. The highest number of seed per boll was above 32 in LHH 144 and 35 in Om Shankar.

D. Suitable crossing time in the day: The high cross boll setting percentage was observed upto 11 AM in both the hybrids. After that it gradually declined.

Varietal seed production

Evaluation of effect of spacing, chemical spray for quality seed production of varieties: The boll number and boll weight increased significantly with increase of spacing and was maximum at 120 x 90 cm followed by 120 x 60 cm of the spacing, slight increase in GOT, seed index, seed germination percentage and vigour index was also observed. Among individual nutrients, significantly higher boll number (55.3) and boll weight (3.16) were observed when boron 0.1 % at 60 DAS was applied. It was followed by application of DAP 2% at 45 DAS.

A. Effect of crop management practices on seed quality : In variety H 1098 and LD 327 the boll weight, seeds/ boll, yield/ plant, germination percentage and vigour index were higher in the crop when topping was made at 90 DAS and defoliant sprayed at 140 DAS.

B. Seed quality at different intervals: In most of the varieties the seed index, germination percentage and vigour index was highest in second picking followed by first picking and least in third picking during this year.

C. Evaluation of different grade of seed for seed quality: In fuzzy ungraded seed, the germination percentage and vigour index were very low because of mixing of the immature and damaged seed in seed lot. Much improvement in germination and vigour index was not observed after delinting. These seeds when graded by removing immature and damaged seed (floaters) on water surface after delinting, improvement in germination and vigour index was noticed.

D. Optimization of quantity of acid and time for delinting: Maximum germination percentage was observed when one kg seed treated with 100 ml acid commercial grade of sulphuric acid for four minutes or with 120 ml acid for 3 minutes in almost all the varieties. The acid treatment for longer period harms the seed and as a result the reduction in germination percentage was noticed.

National Agricultural Technology Project

MM1 : Development of Hybrid Crops-Cotton

Nagpur - (Phundan Singh, Suman Bala Singh, Vinita Gotmare, S. Vennila, N. K. Taneja and M. K. Meshram)

Developing high yielding, medium staple and short duration hybrids with required fibre quality having resistance / tolerance to major pests, diseases and drought using available male sterile sources.

During the season, 36 *harknessii* based CMS, seven restorer and GMS lines were maintained alongwith 59 CMS, 37 restorer and 15 GMS lines received from cooperating centres. Out of the 19 CMS lines evaluated under sprayed and unsprayed conditions, six B lines viz. RCMS 5, AKH 8801, 64 D, AK 8, AK NH 258 and GSGMS 24 were at par with check LRA 5166. B-line 64 D showed 60% and 70% increase over the check LRA 5166 under both the conditions. Among the nine restorers, GSRH 26 was among the top five under both the conditions. It ranked first under sprayed condition with 67.40%

increase over LRA 5166.

Of the 126 GMS and 90 CMS hybrids evaluated in five different trials, NGMSH 26-04, NGMSH 12-04, NGMSH 81-04, NGMSH 89-04, NGMSH 99-04, NGMSH 97-04 and NGMSH 105-04 were found promising. These hybrids recorded more than 10% heterosis over the check NHH 44. A common trial was conducted for testing CMS and GMS hybrids received from nine cooperating centres. The seed cotton yield ranged from 219.90 to 1578.22 kg/ha and 419.44 to 1746.28 kg/ha under sprayed and unsprayed conditions respectively. NGMSH 121 ranked first under both the conditions with 2202.29 and 1746 kg/ha seed cotton yield. This hybrid also ranked third based on the average performance of nine locations of cotton growing zones.

Breeding for early maturity intra and interspecific *desi* cotton hybrids for different agro climatic zones

Twenty five *desi* GMS lines are being maintained. Five *desi* GMS lines were tested under common trial. GAK 35 and GAK 26 were the best lines identified based on their performance. In another trial, eleven *desi* hybrids sponsored by cooperating centres were evaluated. The highest yield of 1509.70 kg/ha was recorded by the hybrid RAJDH 144 and AAH 18 (1810.63 kg/ha) under sprayed and unsprayed conditions respectively as against the check AAH 1 which recorded 799 and 1061 kg/ha seed cotton yield respectively.

One hundred and sixty *desi* GMS hybrids were evaluated in unreplicated trial. GAK 4234 X AKH 4, GMS 1 X LS 3, GAK 4234 X LS 3, GMS 7 X LS 3 were some of the good combinations identified.

Identifying, developing and diversifying the cytoplasmic and genetic sources of male sterility and effective stable restorer genes with fertility enhancing factors in *G. hirsutum* and *desi* cotton

F_1 crosses (2002-03) were raised in pots and were backcrossed to one of the parents. There was no seed set and will be repeated during the ensuing crop season. Colchicine treatment of 0.1% was effective and has been standardized.

Several cross combinations between cultivated and wild species were obtained (22 crosses). Success percentage ranged from 11.1 to 50%. Crosses were also attempted among three cultivated species (*G. hirsutum, G. arboreum* and *G. herbaceum*) and six races (16 crosses). Percentage seed set and number of boll set ranged from 11.1% to 60% and 1.0 to 27.0 respectively.

Identification of resistant sources from germplasm and breeding material for CLCuV and other diseases to utilize them in the development of resistant hybrids

AKH 016R line showed field immunity to *Alternaria* leaf spot. However, CCMS 22-29 HS, RCMS 6A, LCMS 517A, CCMS Supriya, GSCMS 24A, CIR 59, HCMS 11A, CAK 3801A, RCMS 5, CAK 8, CAK NH 258 CMS lines and GSRH 26, CIR 6, GSRH 41, AKH 76 R restorer lines showed moderately resistant reaction.

For grey mildew, CCMS 22-29, CCMS Supriya, CMSA 18, L 389 A, CMS line and LR 103 restorer line showed field immune reaction while only DMSA 20 showed resistant reaction to *Myrothecium* leaf spot. Two CMS and R lines L 389 A, CAK 8801 A and AKH 186 R and CIR 6 recorded immune reaction to bacterial blight.

None of the tetraploid hybrids was immune to these diseases while all *desi* hybrids were susceptible to grey mildew. One hybrid viz. CAHH 301 was immune and CAHH 305 showed resistant reaction to bacterial blight. Among the hybrids tested under institute trial, NCMSH 145-04, 147-04, 149-04,

NGMSH 49-04, 96-04, 100-04, 106-04, 110-04, 111-04, 116-04, 119-04, 120-04, 121-04, 124-04 and H8 were immune to *Alternaria* leaf spot, while only NGMSH 120-04 was immune to grey mildew and NCMSH 192-04 and NGMSH 106-04 to *Myrothecium* leaf spot. Hybrids NCMSH 139-04, 149-04, 161-04, 165-04, 176-04, 194-04, 198-04, 213-04, 215-04, NGMSH 24-04, 41-04, 51-04, 77-04, 98-04, 101-04 and 125-04 showed immune reaction to bacterial blight.

Identification of resistant sources from germplasm and breeding material against bollworms and sucking pests and their utilisation in the development of resistant hybrids

A total of 319 entries were field screened for sucking pests and bollworm resistance. All the CMS lines except LCMS 517A were found to be highly susceptible to jassids. Four entries viz. CAK 880-1 A, L 389 A, RCMS 6A and CAK NH 258 were found to be tolerant to bollworms on fruiting body basis under unsprayed condition. Among the R lines only AKH 186 was found to be tolerant to jassids while DR 8 was tolerant to bollworm on fruiting bodies basis. Similarly, GMS lines HGMS 3/03, GHGMS 6 and GHGMS 1 were also found tolerant to bollworm on fruiting body basis.

All the 21 hybrids tested under common trial were found highly susceptible to aphids, while CAHH 305 and 301 were tolerant to jassids. Under Institute trial, hybrids NGMSH 16-04, 20-04, 23-04, 74-04, 80-04, NCMSH 143, 145 and 138 were found tolerant to bollworm on fruiting body basis. Among *desi* hybrids, DDah-2 was found to be tolerant while two hybrids viz. AAH 18 and RAJDH 144 were moderately tolerant on fruiting body and locule basis.

Coimbatore - S. Manickam

A common trial was conducted to evaluate 19 'A' and 'B' lines along with MCU 5 VT, Sumangala and LRA 5166 as checks and nine restorer lines. Some sterile plants were observed in restorer lines *viz.*, GSRH 41 (1 plant), CIR 6 (1 plant) and in DR 8 (2 plants). Also, the line AKH 76 segregated for leaf hairiness and AKH 186 for petal spot.

Of the five GMS lines belonging to *G. hirsutum* evaluated for their stability, HGMS 3/03 was found to segregate for petal colour and leaf shape; GHGMS 1 segregated for petal colour and leaf hairiness; GHGMS 6 segregated for petal and pollen colour.

In a common replicated trial, 21 intra-*hirsutum* hybrids including Savita, NHH 44 and Bunny were evaluated. Significant differences were noticed among the entries and the test hybrid CCCHH 03-3 recorded the highest yield of 3120 kg/ha against the best check hybrid viz. Savita with 2770 kg/ha.

It was observed that, in none of the five diploid GMS lines, the segregation for fertile and sterile was found to be in 1:1 ratio.

Ten *desi* hybrids were evaluated in a replicated common trial along with a hybrid check (AAH 1) and a varietal check (K 10). The hybrid AKDH 5 with a mean seed cotton yield of 1330 kg/ha was statistically superior to both the checks *iz.*, AAH 1 and K 10 which recorded respectively, 1100 kg/ha and 610 kg/ha.

MM3: **Sustainable Management of Plant Biodiversity Cotton** (V. V. Singh).

An exploration was conducted in Coastal and Inland Karnataka and parts of Anantpur district of Rayalseema region of Andhra Pradesh and 54 samples were collected belonging to *G. hirsutum* (25), G. *arboreum* (06), *G. herbaceum* (17), *G. barbadense* (06).

New collections (522) of the previous years were evaluated as per Germplasm Index Card for major economic attributes and their reactions to various pests and diseases and conserved in MTS and (48)

accessions having sufficient seed quantity were sent to NBPGR, New Delhi for long-term storage. The characterization data (522 accessions) and the passport data (54 accessions) were documented. The range of variability for a few economic characters in the newly collected material is given below -

Germplasm material	*Kapas* yield per plant (g)	Boll weight (g)	MHL (mm)	GOT (%)
New collections	16 - 314	1.9 - 4.8	19.0 - 33.0	32 - 43

Among the new collections elite germplasm lines identified were IC 336182 (314 g) for seed cotton yield per plant; IC 336182 (4.8 g) for boll weight; IC 336118 (33.0 mm) for mean halo length; IC 336187 (43 %) for ginning outturn. All these accessions possessed desired level of resistance / tolerance to diseases and insect pests. The promising accessions identified for long staple (2.5 % span length) included IC 336107 (31.0 mm), IC 336189 (30.8 mm), IC 336184 (30.3 mm), IC 336142 (30.1 mm) and IC 336161 (29.5 mm) whereas the promising accessions identified for fibre strength (3.2 mm) were IC 336142 (24.6 g/tex), IC 336187 (24.9 g/tex), IC 336136 (24.5 g/tex), IC 336185 (22.9 g/tex) and IC 336171 (22.7 g/tex).

RCPS-7 : **Promotion of productive high quality *Gossypium arboreum* cotton to meet the needs of marginal cultivators of rainfed ecosystem *vis-à-vis* textile industry** (V. N. Waghmare).

The quality *G. arboreum* genotypes were evaluated and extensively compared in station and on farm trials with popular varieties (*desi* and upland) of the region. Fifteen genotypes were evaluated for seed cotton yield and yield contributing characters in replicated trial. The seed cotton yield of various genotypes ranged between 212.02 to 977.45 kg/ha as against checks AKA 8404 (321.02 kg/ha) and PA 255 (450.26 kg/ha). In *arboreums*, the highest seed cotton yield of 977.45 kg/ha was recorded by MDL 2463 followed by MDL 2593 (872.38 kg/ha). *G. hirsutum* hybrid, MECH 162 (Bt) surpassed in yield i.e. 1490.26 kg/ha over all the genotypes. The superior genotype identified for yield contributing characters include MDL 2601 for number of bolls/plant (18.9) and KWA 25 for boll weight (2.87 gm.) and KWA 225 for ginning per cent (40.79 %).

Non-replicated trials were conducted on farmers' fields to evaluate comparative performance of *desi* and popular upland genotypes that include MDL 2463, PA 402, DLSA 17, PA 255, Bunny, MECH 162 (Bt.) and NHH 44. Seed cotton yield of the *G. arboreum* genotypes ranged from 215 to 580 kg/ha. PA 255 recorded the highest average yield of 429 kg/ha among *arboreum* genotypes while upland Bt hybrid MECH 162 yielded 634 kg/ha. In station trial, variety PA 402 performed better (868.45 kg/ha) among *arboreums*. Bt hybrid MECH 162 recorded the highest seed cotton yield (1605.33 kg/ha) among all entries followed by Bunny (1243.14 kg/ha). Also, MECH 162 was early in maturity compared to Bunny and NHH 44.

Under large scale testing of long stapled introgressed genotypes in station trial common control PA 255 (994.9 kg/ha.) excelled other *G. arboreum* genotypes and Bunny, an upland popular hybrid. In an on - farm trial conducted in one acre, the average seed cotton yield of PA 255 was 417 kg/ha, on par to AKA 8401 (414 kg/ha) against just 253 kg/ha of LRA 5166. 35, 41 and 60 kg seeds of identified quality *arboreum* genotypes, namely PA 255, MDL 2463 and PA 402 were respectively produced.

Technology Mission on Cotton

MM 1.2: **Development of tetraploid cotton cultivars with high fibre quality and resistance to drought and biotic stress**

Nagpur - (V. N. Waghmare).

Fifty seven upland genotypes and 72 F_1 cross combinations were evaluated during the crop season. The genotypes with least incidence of jassids (Rajat and JBWR-25), square damage (G-67 and H-52) and boll damage (TXO-RS-80, Demeter III (II) and Macha) were identified. Wide genetic variability was observed for boll weight (2.14 to 4.09 g), boll number (11.63 to 28.27), GOT (31.92 to 43.74 %) and seed cotton yield (179.17 to1760 kg/ha). The genotypes identified for yield traits included 98/L6 for bolls per plant (28.27), Saubhagya for boll weight (4.09g) and Meade-9030D for ginning percent (43.74%). Reba Pvt-9 recorded significantly higher yield (1760.0 kg/ha) than the best check variety PKV-081 (1120.3 kg/ha).

The range of fibre quality trait values were - 2.5% fibre length 20.7 to 31.6 mm; bundle strength 17.4 to 23.7 g/tex; uniformity ratio 41.4 to 51.4; micronaire 2.8 to 5.1 and elongation 5.5 to 8.1 %. The genotype EL-958 has fibre length of 31.6 mm at 2.5% SL and bundle strength of 23.7 g/tex that is highest among the tested upland genotypes. Surabhi has the similar fibre properties, i.e. fibre length of 31.2 mm and strength of 23.6 g/tex. However, yield performance of both the genotypes remained low.

The F_1 hybrids showed varied disease reaction. The lowest jassids count was recorded in G.cot-100 x Macha and Surabhi x G-67; the lowest square damage in Gcot-100 x Macha and MCU-5 x Sahana and the least boll damage in G-67 x Demeter III(I), LH-1134 x G-67 and Sahana x Surabhi. The F_1 hybrids showed wide genetic variability for boll weight (2.33 to 4.33 g), boll number (14 to 55), GOT (29.46 to 44.7 %) and seed cotton yield (32.71 to132.2 g) per plant. The range of values for quality characters were: fibre length 25.2 to 33.1 mm; bundle strength 18.9 to 25.9 g/tex; uniformity ratio 42.9 to 53.2; micronaire 2.8 to 4.7; elongation 5.8 to 8.5 % and SFC 3.7 to 17.9 %. It is to be noted that the fibre length up to 33 mm and bundle strength of 25.9 g/tex was obtained in the F1 hybrids.

Coimbatore - (K.N. Gururajan)

Two hundred *G. hirsutum* lines were evaluated in two sets. Twenty lines characterized by high yield, high ginning out turn, big bolls, fibre strength of over 24.0 g/tex have been selected for further evaluation.

Two hundred *G. barbadense* accessions were evaluated essentially for ginning out turn and fibre quality parameters. Superior lines with ginning out turn of 35 per cent, lines superior to Suvin in length, micronaire and strength have been selected for further evaluation.

In the station trial, 27 high strength *G. hirsutum* cultures were evaluated in a replicated trial. The high strength cultures recorded as much as 28 per cent increased seed cotton yield over Surabhi (C). Culture (M5 x Z-2)1322 recorded the highest fibre strength of 24.9 g/tex.

Eight *G. barbadense* cultures were evaluated in a replicated trial. None of the cultures was statistically superior to Suvin (C). Culture S(B4xB5)5 gave the highest yield of 14.6 g/ha. Quality wise Suvin (C) was the best.

Sirsa - (S. L. Ahuja)

Screening of germplasm lines of *G.hirsutum* and breeding materials for high ginning out turn and superior fibre quality characteristics: GOT ranged from

28.93 to 39.44% in 128 lines. Lines CSH-3036 and CSH-3037 had GOT% around 40% (39.20 and 39.4%) and were also good yielder. Thirty two lines recorded GOT more than 35%. Lines CSH-3127, CSH-3089 and CSH-3122 had tenacity around 25.0 g/tex.

Utilization of Suitable genotypes in crosses with good agronomic base: Crosses attempted with already available suitable genotypes having high GOT and fibre strength with good agronomic back ground like CSH 3158, CSH 3207 and other strains. More than 800 crosses attempted in Line x tester, diallel fashion.

Screening for resistance to jassids: Of the 144 lines under unprotected and 240 lines under protected conditions tested, CSH-3047 (70 g/plant) under unsprayed and CSH-3106, CSH-3120, CSH-3200, CSH 3172 under sprayed conditions performed better. Jassid population per leaf ranged from nil to 5.33 in un-sprayed and unirrigated condition and from 1.33 to 15.89 under sprayed and irrigated condition.

Screening for resistance to bollworm : The above lines when tested for bollworms, CSH-3201 was completely free from bollworm damage. The entries which recorded less than 5% spotted bollworm infestation CSH-3047, CSH-3048, CSH-3088, CSH-3160, CSH-3015, CSH-3103, CSH-3115, CSH-3093, CSH-3073, CSH 3123, CSH-3113, CSH-3203, CSH-3204, CSH-3201, CSH-3205.

Screening for leaf curl virus disease : Some of the high yielding leaf curl free lines were: CSH-3169,CSH-3178,CSH-3172, CSH-3175, CSH-3163, CSH-3047, CSH-3035, CSH-3043, CSH-3037, CSH-3059 and CSH-3143. Per cent infestation ranged from 0.00 to 53.14 at 80 days and 0.00 to 63.33 at 100 days after sowing.

Identification of suitable cultures with drought resistance: Of the 144 lines sown under no irrigation and 112 under recommended irrigation, CSH-3120 was found high yielding in irrigated as well as under unirrigated conditions. Other high yielding cultures, CSH-3044, CSH-3053, CSH-3208 and CSH 3117 were drought tolerant.

MM 1.1 : Identification and development of diploid cotton with high yield and fibre quality suitable for high speed spinning .

Nagpur - (Punit Mohan and P. Singh).

Three advanced generation cultures namely CINA 330, CINA 333 and CINA 334 were multiplied and evaluated for fibre quality.

Three new cultures based on yield, fibre strength and length were identified for further seed multiplication and evaluation. Seed of advanced and promising cultures namely CINA 323 B, CINA 329, CINA 316, CINA 305 and CINA 323 was supplied for distribution.

The Culture CINA 316 has been retained to trial 24 (b) of AICCIP for further evaluation in the ensuing season 2004-05.

The culture CINA 318 of high fibre strength has been promoted to south zone trial 24 (b) of AICCIP for further evaluation.

Twenty six cultures of various research institutions were evaluated for yield contributing characters and fibre properties at CICR, Nagpur. Higher yield was recorded in Jawahar Tapti (20.16 q/ha) and CINA 316 (19.12 q/ha) followed by AKA 8401 (18.96), CINA 323 A (18.52), DLSA 24 (18.05) and PA 402 (17.38 q/ha). However, highest fibre strength was recorded in the cultures KWA 225 (23.35), AH 65 (23.30), CINA 323 B (22.15), CINA 323 A (21.50) and Jawahar Tapti (21.75).

Sirsa - (S.K. Verma)

Under this project four trials were conducted. A total number of 383 single plants were made from segregating populations (F_2, F_3, F_4, F_5 etc.) on the basis of quality parameters (span length, strength etc.).

MM 1.1 Trial: -Under this trial 37 entries were tested against local check RG 8 and LD 327. Entry CISA-6 could gave numerically higher seed cotton yield over the check (table 7).

Single plant selections: A total number of 383 single plants were selected from segregating populations (F_2, F_3, F_4, F_5 etc.) on the basis of quality parameters (span length, strength etc.).

Table 7 : Performance of CICR cultures under this trial

Sr. No.	Entry	Yield (kg/ha)	Boll wt. (gm)	GOT (%)	2.5% S.L.	UNIF (%)	MIC Value	Strength (g/tex)
1	CISA 6	**2326.01**[1]	2.4	36.0	20.9	51	6.6	17.1
2	CISA 64	1708.73[5]	2.3	33.7	24.2	43	5.4	19.6
3	CISA 60	1960.21[3]	2.8	34.0	21.7	46	6.0	16.6
4	CISA 66	1891.62[4]	2.7	33.8	23.4	42	5.8	18.6
5	CISA 16	2303.15[2]	1.8	36.9	19.0	47	7.2	13.5
	RG 8	1314.58	2.4	36.9	20.0	45	8.3	13.5
	LD 327	1097.38	2.3	34.0	16.8	51	6.9	13.0

Highest 2.5 % span length (22.5 mm) was recorded by DLSA 17. The maximum GOT % was recorded by PA 405 (38%) and highest boll weight (3.0 g) was recorded by AKA 8404.

LHT-1 (F_2)**:** 10 F_2s were tested against local check RG 8 and HD 123 in three replications. The highest 2.5 % span length was recorded by LD 327 X PA 255 (22.1 mm).

LHT-2 (F_2): 17 F_2s were tested against local check HD-123. The highest 2.5 % span length was recorded by LD 327 X DLSA 16 (22.5 mm).

Evaluation of F_1 crosses: Of the 43 F_1 hybrids tested against RG 8, the five top yielding hybrids are namely LD 733 X LD 327 (2597.39 kg/ha), DS 5 X LD 694 (2590.83 kg/ha), CISA 33 X LD 327 (2460.21 kg/ha), LD 694 X HD 123 (2323.04 kg/ha) and HD 123 X PA 255 (2313.77 kg/ha). The highest 2.5% span length (27.0 mm) was recorded by CISA 33 X LD 327. The hybrid CISA 33 X LD 327 showed highest heterosis (43.61%) over check variety HD 123.

New Crosses attempted: 65 new crosses have been attempted using high yielding and long staple parents. Parents from Parbhani, Dharwad have been used to make crosses with DS-5 (GMS).

MM 1.3: Genetic improvement through introgression of useful genes in cultivated species of cotton.

Nagpur - (Vinita Gotmare)

Fifty four introgressed derivatives of *Gossypium* in both diploid (31) and tetraploids (23) background belonging to three commercially grown species received in 2003 from 10 cooperating centers were included in the evaluation, along with 12 introgressed entries promoted last year (2002-03) besides 14 lines developed.

Introgressed *Gossypium* material was screened against economically important sucking pests (Jassid, aphid and whitefly), bollworm damage and fungal/ bacterial diseases (Alternaria leaf spot, bacterial blight and grey mildew) under natural epiphytotic conditions, adopting recognized scales.

AKA-01-5, RAC 021, RAC 024, RAC 025, Ponduru × *arboreum* (F2-9), Sarvottam × KWA - N 4, Sarvottam × KWA 7, Hh-1, Hh-4, NHH 02, NHH 03, IS-376-4/2/21, IS 376/4/3, IS 376/4/2/26, GISV-2511699 × G. Cot 10 were found to be resistant to pest complex.

The lowest bollworm damage was in *G. arboreum* entry AKA-01-5 followed by RAC 021, RAC 025, AKDH 36 and AKA-01-3. AKA-01-10, *arboreum* × *barbadense*, Ponduru × *arboreum* were found to be resistant to bacterial blight which need to be tested at multilocations to verify consistency in performance. Agronomic evaluation of introgressed derivatives was undertaken by scoring the population for seed cotton yield (g/ plant and q//ha) and five associated traits. *G. arboreum* based derivatives, in general, gave good performance, with only AKA 01-3 (114.9 g) and RAC 021 (111.2 g) exceeding the check PA 183 (102.6 g). *G. herbaceum* based derivatives entries were not encouraging (8.0 46.2 g/plant and 0.65 4.47 q/ha). Similarly the performance of *G. hirsutum* derivatives was not satisfactory. 72 crosses were attempted involving introgressed derivatives as female and cultivars/ hybrids of *G. hirsutum* as male.

Coimbatore - (S. Manickam)

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

Few varieties of *G. hirsutum, G. arboreum* and *G. herbaceum* were crossed with wild species available in the station, in different combinations and seeds were obtained in few crosses. The details of parents used for wide crossing is furnished below:

The triploids obtained by Surabhi x *G. armourianum* and LRA 5166 x *G. raimondii* were back crossed with their corresponding female *G. hirsutum* cultivars and BC_1F_1

Female parent		Male parent
Species	**Cultivar**	**Species**
G. hirsutum	Sumangala	*G. gossypoides*
,,	LRA 5166	*G. triphyllum*
,,	Anjali	*G. davidsonii*
,,	Surabhi	*G. aridum*
G. arboreum	K 10	*G. armourianum*
,,	K 11	
,,	G 27	
G. herbaceum	G COT 13	
,,	G COT 21	
,,	RAHS 21	
G. arboreum x G. herbaceum hybrid	G COT DH 11	

seeds were harvested. The diploids obtained by crossing the cultivated diploid *G. arboreum* cultivars *viz.*, K 10, K11 and G 27 with wild diploid *G. triphyllum* were back crossed with their corresponding *G. arboreum* cultivars and BC_1F_1 seeds were harvested. These back cross progenies will be raised during the coming season for further evaluation and utilization.

In a full MS medium supplemented with hormones in specific combination, very good response was noted and white friable callus was obtained in the triploid of the cross between Sumangala x *G. aridum*. After sub culture of white friable callus embryonic cells were obtained. Few cells have grown up to globular stage and are being maintained for further differentiation.

Sirsa - (O. P. Tuteja)

Identification of wild and cultivated sources for superior fibre properties, biotic and abiotic stresses : For jassid reaction, two entries namely AKA-01-1 and IGM-27 were found to be resistant. For CLCV reaction, three entries namely AKH-8828, TCH-1653 and TCH-1648 were found to be resistant.

Evaluation of introgressed genetic material for the targeted trait and utilization of these in transferring to the superior agronomic base genotypes : Of the 35 entries/lines evaluated, eight promising entries/lines were used in crossing programme to develop the superior F_1's and for making selection in segregating generations.

Crossing wild and cultivated species advancement of the introgressed material alongwith identification of sources for desirable characters in their respective centres : 65 new crosses were made for distribution among different centres.

Twenty seven single plants were selected in F_2, 14 in F_3 and 37 in F_4 generation, on the basis of superior fibre quality and resistance to insect-pest and diseases.

MM 1.4: Genetic Improvement of Cottonseed Oil (D. K. Agarwal and Mukta Chakrabarty).

***G. hirsutum* advance cultures:** Twenty advance cultures were evaluated under three replications. The seed cotton yield varied from 6.75- 16.09 q/ha. Culture TMOH 22 recorded the highest seed cotton yield (16.09 q/ha) while the seed oil content was highest in the culture TMOH 28 (20.23 %), alongwith highest mean halo length of 27.84 mm.

***G. arboreum* advance cultures :** Twelve cultures were evaluated along with one check under three replications. The five best cultures for seed cotton yield were TMOA 1 (11.50 q/ha) followed by TMOA 4 (11.21 q/ha), TMOA 2 (10.75 q/ha), TMOA 7 (9.26 q/ha) and TMOA 6 (8.91 q/ha). TMOA 12 recorded highest seed oil content (18.60 %). The mean halo length varied from 16.44 mm to 25.25 mm, being highest in culture TMOA 7.

***G. hirsutum* germplasm lines :** Thirty four lines were evaluated. TMGH 14 recorded highest seed cotton yield (20.30 q/ha) followed by TMGH 6 (18.42 q/ha). A number of lines namely TMGH 27(21.05 %), TMGH 1 (20.90 %) and TMGH 23 (20.80%) recorded good seed oil content.

***G. arboreum* germplasm lines :** A total of fifteen lines were evaluated. TMGA 9 recorded the highest seed cotton yield (6.78 q/ha) followed by TMGA 7 (6.51 q/ha). The seed oil content ranged from 17.7 to 22.9 %.

***G. hirsutum* segregating lines :** Twenty four were evaluated under this trial. The seed cotton yield was the highest in line TMSGH 19 (25.17 q/ha) followed by TMSGH 13 (21.43 q/ha) and TMSGH 3 (21.16 q/ha).

***G. arboreum* segregating lines :** A total of 18 lines were evaluated. The seed cotton yield was highest in TMSGA 18 followed by TMSGA 3 (16.56 q/ha) and TMSGA 17 (15.97 q/ha).

A total of 145 lines of *G. hirsutum* in various filial generations were evaluated. 9 DC- SP2 recorded the seed cotton yield of 20.52 q/ha followed by 9 DC- SP3 (20.51 q/ha). In another series line 23K-SP1 recorded the highest seed cotton yield (15.17 q/ha) followed by 22K-SP3 9.11 q/ha). A number of lines recorded the seed oil % > 24 %. The line 39 R - SP 1 recorded the highest seed oil content (26.85%) followed by 62 R SP 1 (26.84%), 117 R SP 1 (25.72%) and 58 R SP 1 (24.91%).

A set of 13 advance cultures of *G. hirsutum* including one check Rajat was evaluated. Among the cultures, 12 ES recorded highest seed cotton yield (16.02 q/ha) followed by 23 ES (15.80 q/ha) and 14 EP (15.58 q/ha). Rajat recorded the seed cotton yield of 9.06 q/ha. The seed oil content among the cultures varied from 20.03 to 27.11%. 23 ES recorded the highest seed oil content of 27.11% closely followed by 3 HS (26.68%) and 1 HS (26.35%).

Oil content has been estimated by Solvent Extraction Method through Soxtec Apparatus and an overview of different samples along with the range of oil content is presented here:

Advanced *G. hirsutum* cultures (2002-03): 18.76 - 22.97% (check : 19.55%)
Advanced *G. hirsutum* cultures (2003-04): 20.06 - 27.11% (check : 24.35%)
G.arboreum germplasm lines : 20.10 - 24.73%
G.hirsutum germplasm lines : 15.78 - 24.98%

In all categories some materials have been found to be promising for oil content.

Coimbatore - (N. Gopalakrishnan and K. P. M. Dhamayanthi)

Seed oil evaluation in advanced lines:
Six genotypes among 115 lines analysed registered more than 25% seed oil content. Among the advanced *arboreum* lines, TMOA 7, TMOA 12, TMOA 14 recorded 24% seed oil content and among the *arboreum* germplasm lines, TMGA 14 registered 24%. Among *G.hirsutum* lines, TMGH 29, TMGH 30, TMOH 21 and TMOH 25 registered seed oil content of 24-25%. Among the advanced cultures, TMOH 20, TMOH 21, TMOH 22, TMOH 26 and TMOH 28 yielded around 1000 kg/ha and among the germplasm lines TMGH 25, TMGH 27,TMGH 28 and TMGH 29 yielded around 1700 kg/ha.

Evaluation of F_2 generation materials from specific crosses:
F_2 generation materials from specific crosses *viz.*, Sumangala x F776, M5KD933 X F 776, CBR3 X F 776, Anjali X F 776, Surabhi X F776, Supriya X F 776, Sumangala X F1861, and CBR 3 X F 1861 were sown along with the high oil genotypes. Single plant selections have been made from the F_2 crop; among these selections, CBR 3 x F 18613, ANJALI x F 18611 registered more than 70g per plant seed cotton yield. Anjali x (A x F1861)-3 registered 150 g per plant.

Evaluation of metabolic status of high oil content lines:
Among the genotypes analysed, NR activity ranged between 5 to 7.5 µ moles/h/g fruit wt; in cultures viz. CIR 8, CRB 12, F1861, F 776, LH 1900, SOCC 16 and SOCC 62. All the biochemical parameters such as reducing sugar, protein and peroxidase activity were found maximum up to 120 days after sowing .

Sirsa - (O. P. Tuteja)

Four entries namely TMGH 5, RS 810, V3-73/355 P6 and SH 2379 were found to

contain more than 23 % seed oil content.

Evaluation of germplasm lines of *G. hirsutum*: Higher seed cotton yield of 3310 kg/ha was recorded by CISV 40 followed by 2847 kg /ha in F 1982. Highest ginning outturn of 36 % was recorded in CSG 7. The highest bundle strength of 26.0 g/tex and 2.5% span length was recorded in B-58-1290 (29.4 mm) and M 26 (28.7 mm).

Evaluation of germplasm lines of *G. arboreum*: The highest ginning outturn of 46.3 % was recorded in LD 842 followed by 41.6 % in LD 778 and 41.5 % in LD 794. Maximum 26.0 mm of 2.5 % span length recorded by 6755 followed by 24.9 mm in 6763. These entries also recorded more than 23.0 g/tex of bundle strength .

Evaluation of segregating material of *G. hirsutum*: The highest single plant yield was recorded by P_2 of FHH 94 (200.7 g/plant) followed by P_3 of 22K (SP3) (180.4 g/plant). The plant selected from FHH 94, FHH 119 and FHH 104 recorded maximum 2.5 % span length of 29.0 mm .

Evaluation of segregating material of *G. arboreum*: P_2 of Sanjay recorded the highest single plant yield x long staple (150.4 g/plant). Maximum 2.5 % span length more than 26.0 mm was recorded by the plants selected from Sanjay x long staple, Sanjay x yield plant and AKH 4 x long staple.

Evaluation of advance cultures of *G. hirsutum*: Highest seed cotton yield of 2577 kg/ha was recorded in F 1861. The advance culture F 2030 recorded the ginning outturn of 36.3 %. The entry F 776 also recorded 2.5 % span length of 29.8 mm and bundle strength of 23.5 g/tex.

Evaluation of advance cultures of *G. arboreum*: LD 838 recorded highest seed cotton yield of 2306 kg/ha and 42.9 % ginning outturn. The entry CINA 329 (27.6 mm) and CINA 330 (26.8 mm) recorded the higher 2.5 % span length as well as desirable bundle strength.

Seed Technology

MMB 1 : Maintenance breeding, seed quality improvement and marker based purity evaluation

Nagpur - (T. R. Loknathan and V.Santhy).

CNH 36, variety of *G. hirsutum* was grown in three replications. Uniformity of population was ensured particularly at the square formation and flowering stage and 200 progeny seeds have been developed.

Micro-nutrients Borax @ 0.1%, $MgSo_4$ @ 1% and DAP @ 2% were foliar sprayed after first picking (150 DAS) and their effect on seed index, good seed %, germination % and seed vigor index studied. All the quality parameters were numerically superior for Boron spray @ 0.1% though the effect on seed index and good seed % were statistically non significant.

Coimbatore - (K.Rathinavel).

In LRA 5166, Sumangala and Suvin, 15, 10 and 9 progenies, respectively, were evaluated for genetic purity, reproductive traits and fibre qualities. Morphological markers of varieties LRA 5166 and Sumangala (*G.hirsutum*) were recorded for easy identification of varieties. Thirty three identifiable morphological markers were recorded.

In Anjali and Suvin, (seed crop) supplemental foliar application of DAP @ 2 % + Boron @ 0.6 Kg/ha + Zinc @ 0.5% significantly improved the seed quality over other treatments. An additional irrigation after first harvest improved seed yield and quality.

Sirsa - (R.A. Meena and O. P. Tuteja)

The earlier selected progenies (eight female progenies and seven male progenies) were further evaluated for heterosis, specific and general combining abilities and *per se* performance under

biotic stress condition. Finally three progenies of each parent were identified and are being used for large scale seed multiplication. The cataloguing of these progenies and hybrids based on morphological and genetic markers is in progress.

Testing of Genotypes for DUS under PVP and FR act (R.K.Deshmukh, V. Santhy and P.R.Vijayakumari).

Seventy genotypes were subjected for DUS testing based on morphological characters suggested as per the test guidelines. Ten selected uniform plants for each genotype in four replications were observed for 45 characters at seedling, vegetative plant growth, flower and boll stages as well as fibre quality traits.

The genotypes were uniform with respect to following traits such as cotyledonary leaf pigmentation (absent), plant growth habit (indeterminate), branching habit (sympodial), sympodial growth (horizontal), leaf shape (normal : palmate), leaf appearance (lobed), presence of leaf gossypol gland (present), leaf nectaries (present), bract type (normal), bract serration (serrated), stigma position (embeded) and boll opening (open). Differences were observed mainly for hypocotyl pigmentation, plant stem hairiness, leaf lobe number, leaf colour, leaf midrib pubescence, flower petal and pollen colours.

Biotechnology

P1-96/1-ICR-F-30/0430:

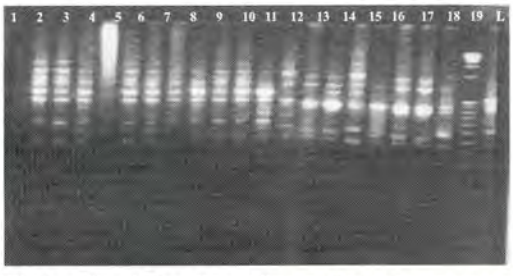
Evaluation of cotton germplasm through molecular techniques (A. B. Dongre, J Amudha, S. B. Nandeshwar and V. V. Singh).

One hundred germplasm lines of *G.hirsutum, G.arboreum* and wild species were subjected to molecular evaluation by using DNA based markers such as RAPD, ISSR and Microsatellite.

The study revealed that these accessions inspite of being morphologically similar were found to have considerable variation at the level of molecular loci. Similarities were found in the clustering of ISSR and RAPD analysis. However, all the three markers used showed separate clustering for diploid and tetraploid. No duplicates were observed in the stock analyzed.

Microsatellites and ISSR markers based molecular characterization of genetic diversity in *Gossypium spp.* (Diploid and Tetraploid)

The results of cluster analysis indicated not only the separation of genotypes of two major species (*G. arboreum* and *G. hirsutum*) into separate groups, but also the separation of the genotypes among each group. The similarity coefficient calculated by UPGMA method based on ISSR and microsatellite markers analysis, ranged from 0.59 to 0.90 and 0.59 to 0.93 respectively, suggesting a considerable genetic variation, between the cotton species studied.



ISSR profile of 19 cotton cultivars obtained with primer IS 7. Lane 1 19 corresponds to cultivars listed in Table 1. Lane 20, L = 1 kb, 100 bp ladder.

Microsatellite (SSR) profile of 19 cotton cultivars obtained with primer JESPR 25. Lane 1 19 corresponds to cultivars listed in Table 1. Lane 20, L = 1 kb, 100 bp ladder.

Molecular evaluation of grey mildew immune lines:

Grey mildew immune lines viz., G-135- 49, 03805, 30814, 30826, 30838, 30856, EC-174-092 and susceptible check AKA 8401 were subjected for RAPD analysis. OPERON kit primer OPC and OPD were used for PCR amplification. A total of 762 products were obtained out of which 28 % were polymorphic in nature. OPC 2 primer produced unique fragment of 1.5 Kb size which is present invariably in all immune lines and absent in the susceptible check. The PCR derived RAPD product $OPC02_{1500}$ can be used as diagnostic tool for identifying the grey mildew resistant line in the germplasm gene pool.

Molecular evaluation of lines with good fibre length:

Seven lines with good fibre were subjected for genomic DNA isolation and RAPD analysis. Out of 567 RAPD fragments obtained only 12 were polymorphic and mostly ranged from 1.0 Kb 2.5 Kb with different set of primers. All other fragments were found to be monomorphic. Diversity among them was obtained by analyzing the RAPD data and the dendrogram was constructed using UPGMA analysis method. The mean hallow length (MHL) ranges from 33-37mm.

P1-91/1-ICR-F30-30/0430:

Development of tissue culture protocol for use in breeding and genetic transformation (S. B. Nandeshwar and A. B. Dongre).

Regeneration protocol was standardized in *G. arboreum* viz. PA 255, PA 183 and

DLSA 24. Shoot tip and embryonic axis explants excised from three day and seven day old germinated seedlings were manipulated and induction of multiple shoots were obtained.

Both the procedures of regeneration viz. embryogenic axis and the shoot tip showed differential response in different varieties as well as for different procedures employed for explant preparation for co-cultivation.

Out of three varieties used viz. LRK 516, LRA 5166 and MCU 10, LRK 516 responded well for both explants (shoot tip and embryogenic axes).

However, it was observed that embryogenic axes respond better in comparison to shoot tip in all the three cultivars.

Amongst different procedures adopted for preparation of explants for co-cultivation, side cut method of explant preparation appears to be better. Embryogenic axes were found to respond well for root induction as compared to shoot tip.

P1-2003/1-ICR-F-30 /0430:

Molecular mapping of leaf curl virus resistance gene in cotton genome (J. Amudha, D. Monga, G. Balasubramani).

Young healthy leaves of CNH 123, CNH 1012 (resistant lines) and CNH 1020, CNH 120 (susceptible lines) were collected from the plants grower in green house and genomic DNA was isolated by Paterson method. The DNA isolated was amplified by Operon random primers. The resistant and susceptible lines were amplified and identification of molecular polymorphism among the parents (CLCuV resistant and susceptible lines) was carried out. The F_2 mapping population was developed and advanced to F_3. Ten resistant and susceptible F_2 DNA were pooled for bulk segregant analysis. The F_2 segregating RAPD loci were mapped using Mapmaker programme into ten groups. F_2 plants were tested for CLCuV incidence. Whiteflies were released after primary leaves appeared (7th day) and on 21st day the incidence was recorded. That the CLCuV resistant gene is governed by Mendelian segregation (3:1) pattern as indicated by the observed and expected frequencies.

(i) CNH 123(resistant line) X CNH 1020(susceptible line)

↓

F_2: F_3

(ii) CNH 1012 (resistant line) X CNH 120 (susceptible lines).

↓

F_2 : F_3

F_2 derived F_3 (F_2: F_3) population is suitable for mapping recessive genes as the cotton leaf curl virus resistant gene is governed by recessive gene. Out of 692 fragments produced 35% of fragments were polymorphic and SCAR marker was developed.

Young healthy leaves of F_2 segregating population were collected from Sirsa. Mapping populations are as LRA 5166 X Laxmi, PIL 8 X F 84 b, Laxmi X RS 921, LRK 516 X RST 9 , LRK 516 X RS 921

Genomic DNA was isolated and resistant and susceptible lines were amplified with the designed SCAR forward and reverse primer among the parents (CLCuV resistant and susceptible lines) for the validation of the SCAR marker developed in all the populations.

National Agricultural Technology Project

MM 4 : Development of Bt transgenic cotton for insect resistance (A. B. Dongre, S. B. Nandeshwar, G. Balasubramani and K. R. Kranthi).

G. hirsutum varieties viz. LRA 5166 and

LRK 516 were taken for co-cultivation with indigenously synthesized gene Cry I Aa 3, Cry I A 5 and Cry I F. In LRA 5166, 543, 286 and 789 explants were used for transformation with gene construct Cry I Aa 3, Cry I A 5, Cry I F respectively. With Cry I Aa 3, 11 explants are in rooting medium and six hardened plants in pot-house. With Cry I A 5 construct, 4 explants are in rooting medium and nine are hardened plants in pot-house. With Cry I F, 8 plants are on rooting medium.

In LRK 516 variety, total 100 explants with Cry I A 5 and 912 explants with Cry I F were co-cultivated for transformation. Out of that only 9 putative transformants of Cry I F are in rooting medium.

Anjali (LRK 516) explants (embryonic axes and meristematic tissues) were transformed with Bt *Cry* I A (c) gene by *Agrobacterium* mediation. Of the 31 putative transformants produced by direct shoot organogenesis. 17 plants were found positive with ELISA test (table 8). The Cry protein expression was found to be 0. 4 2. 4 μg /g of fresh leaf protein. Seeds from T_0-generation plants were collected and raised in the restricted field condition. T_1 - generation plants showed around 10 ng of Cry protein expression by ELISA test. Activation of *vir* gene present in the helper plasmid was confirmed by the acetosyringone treatment and excision of LB and RB sequence from the binary plasmid was observed.

RCPS 10: Development of Bt transgenic diploid cotton against bollworm (S. B. Nandeshwar and A. B. Dongre).

G.arboreum cultivars PA 255, PA 183 and DLSA 24 and one *G.hirsutum* cv PKV 081 were evaluated for regeneration and their embryo axes were co-cultivated with *Agrobacterium* containing Cry I Ac , Cry I F and Cry I Aa3 genes. The Cry 1F was used in PA 183 ,Cry I Aa3 in DLSA 24 and Cry I Ac in PKV 081.

In cv. PA 183 , 838 embryo axes were co-cultivated and 271 were isolated on antibiotics medium. Out of 271 explants survived on kanamycin medium, 231 responded to regeneration and 8 rooted plants were obtained.

In cv. DLSA 24, 769 embryo axis explants were co-cultivated with *Agrobacterium* containing Cry I A a3 gene and 242 explants survived on selection medium. The transformed embryo axes on transfer to regeneration medium produced 18 rooted shoots. While in case of PA 255, 793 explants were co-cultivated, 232 were selected on kanamycin medium, 64 plants were regenerated . Out of which 15 rooted plants were obtained and 8 were established in the soil.

Testing of leaf samples for gene expression in RG 8

The leaf sample of transformed RG-8 were

Table : 8. Summary of transformation and regeneration of cv Anjali in MS media with BAP and kinetin for direct shoot organogenesis

Cultivar inoculated	No. of explants transformants	No. of putative frequency	Transformation	ELISA test
Anjali				
Embryonic axes	3150	28	0.8	16
Meristomatic tissues	720	3	0.4	1
Albinism	-	6 (EA)	-	-
	0 (MT)			
Total	3870	31	0.8	17

tested for the Bt- protein by ELISA. In all 98 samples were tested and 36 were found positive.

NIC CGP 1 / 41 : Induction of para-nodules in cotton with nitrogen fixing bacterium *Azorhizobium caulinodans* (G. Balasubramani and J. Amudha).

Rhizobium fredii isolated from soybean (*G. max)* showed virulence on nodule induction in cotton. Six individual plants of Anjali and two of LRA 5166 produced nodules in their root system. Nodules were characterized but nitrogenase activity estimated by AR-method, showed no positive results.

Technology Mission on Cotton

MMA 6 : Overcoming incompatibility barrier in interspecific hybridization (S. B. Nandeshwar).

The long staple *arboreum* PA 255 and PA 183 were crossed with *G.thurberii*, *G.trilobum*, *G.anomalum*, *G.aridum*, *G.raimondii*, *G.capitis-viridis* and *G.harknesii* as pollen parents. The following results were obtained.

1. The cross PA 183 X *G.trilobum* , PA 183 X *G.harknesii* and PA 183 X *G.capitis-viridis* did not show setting of seeds and bolls.
2. In cross PA 255 X *G.trilobum*, four bolls were set containing two seeds.
3. In PA 255 X Coker 312, three bolls were set without any seeds. Similar situation was seen in crosses made with *G.anomalum*, *G capitis-viridis* and *G.harknesii* respectively.
4. In crosses PA 183 X *G.anomalum* , PA 255 X *G.aridum*, PA 255 X *G.raimondii* and PA 183 X *G. raimondii*, the seed set range was 8-56.

Embryo culture in interspecific hybridization

Four crosses were used in embryo culture studies. They are PA 183 X *G.aridum*, *G. thurberii* and PA 255 X *G.anomalum*, *G.aridum*.

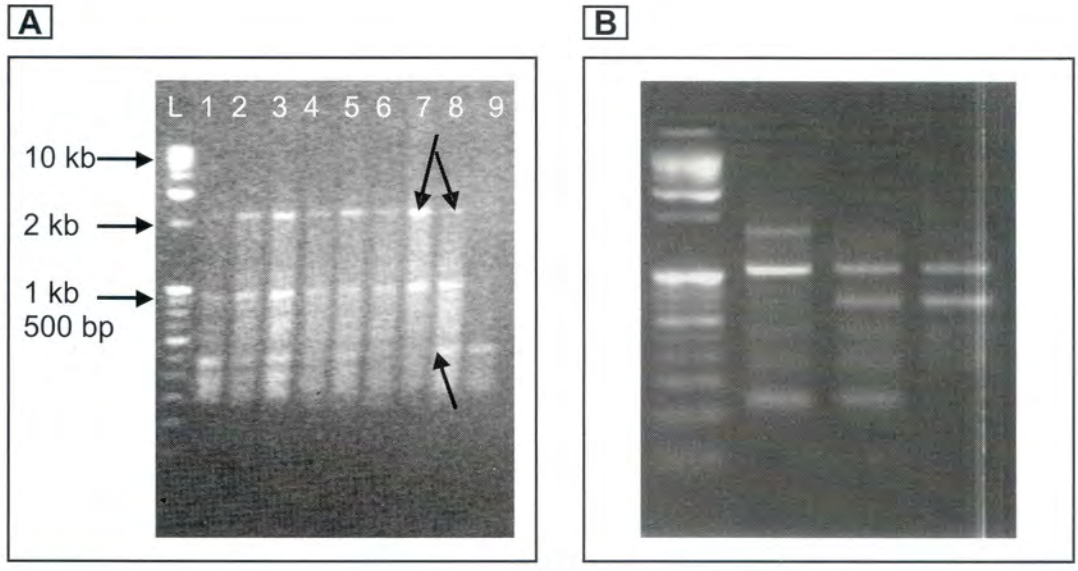
In cross PA 183 X *G.thurberii* 10,12,15 days after pollination (DAP) ovules were isolated and cultured in four media combinations. The responses of *in-vitro* culture of ovules were observed mostly in MS+ 2,4-D + Kin (0.1: 0.1 mg/L) + GA3 1mg/L .This was followed by MS+ 2,4-D + Kin (0.5:0.5 mg/L) + GA3 1 mg/L.

In second cross (PA 255 X *G.anomalum*) 12,8,10 DAP ovules were isolated and cultured for regeneration. When 52 ovules were cultured in MS+2,4 -D + Kin (1.0 :0.5 mg/L) there was response, while in 2,4 - D + Kin (0.5:0.5 mg/L) +GA3 1 mg/L 37 per cent of the ovules responded. In 2,4 -D + Kin (0.2 :0.2 mg/L) + GA3 1 mg/L medium there was 29 per cent response to ovule growth while in 2,4 -D + Kin (0.1:0.1 mg/L) +GA3 1mg/L 41 per cent response was recorded.

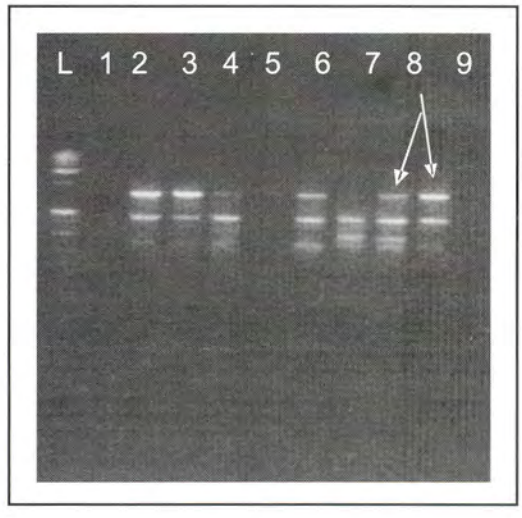
In cross PA 183 X *G.aridum* 6,10,12 DAP ovules when cultured showed 44 per cent response in 2,4-D + Kin (0.1 : 0.1 mg/L) + GA3 1 mg/L.

MM 1.5 : Maintenance breeding, seed production, enhancement of seed viability and studies on marker based purity evaluation (A. B. Dongre).

40 RAPD primers and 12 ISSR were used for the identification of the F_1 hybrids Surya, Savitha and Shruthi and their parents. The RAPD polymorphic primer OPA 13 and OPB 14 and ISSR polymorphic primer IS 2 led to the confirmation of hybridity of Shruthi and hence can be used as a discriminating marker for testing of genetic purity of hybrid. The ISSR polymorphic primer IS 10 confirms the hybridity of Surya.



RAPD profile of Shruthi by A) OPA 13 and B) OPA 14. Male, hybrid and females of Surya (Lane - 1 2 3), Savitha (4 5 6) and Shruthi (7 8 9) L- DNA ladder (1kb + 100 bp)



ISSR profile of Shruthi by IS 2. Male, hybrid and female of Surya (Lane - 1 2 3), Savitha (4 5 6) and Shruthi (7 8 9). L- DNA ladder (1kb + 100 bp), showing the hybridity of Shruthi.

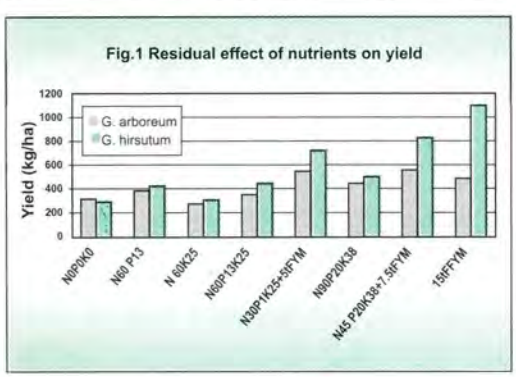
Crop Production

P1-85/1-ICR-F25/0430 :

Studies on the long term effect of nutrient management practices on the productivity, nutrient balance and sustainability of cotton based cropping system.

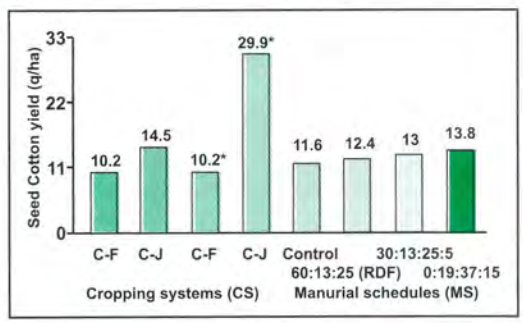
Nagpur - (Jagvir Singh and Blaise)

Residual effect of nutrients on seed cotton yield and yield attributing characters after continuous application of manures and fertilizers for 18 years were studied. Higher dry matter accumulation, number of bolls and seed cotton yield were recorded in the plots where FYM alone or with NPK was added. Highest yield of G. *hirsutum* was recorded where 15t FYM was applied. Residual effect of treatment N45P20K38+7.5t FYM on yield , number of bolls and dry weight of cotton was more pronounced in jowar-*hirsutum* cotton (C3) rotation system. Similar yield trends were observed for G. *arboreum* (mono-cropping). Seed cotton and yield attributing characters were greater in *hirsutum* - jowar rotation compared to mono-cropping *hirsutum*. Least values of seed cotton (2-3 q), number of bolls (3-5) and dry matter accumulation were recorded in the control, N and NK plots. Similarly higher N and P uptake at maturity stage was observed in treatments where FYM was continuously added with NPK (Fig.1). In general, N and P uptake was higher in G. *arboreum* than G. *hirsutum*.



Coimbatore - (C.S.Praharaj)

The results revealed that seed cotton yield increased by 43 kg/ha (Fig. 2) and additional jowar grain and straw yield to the tune of 77 and 205 kg/ha respectively following cotton-jowar (jowar grown on residual fertility after cotton) rotation over that in cotton-fallow system.



*Total *Kapas* yield based on cotton + cotton equivalent yield of jowar (with 77 kg/ha mean jowar grain yield)

Fig. 2 : *Kapas* yield under cropping systems and manurial schedules during 1993-94 to 2002-03 (pooled data for 10 years)

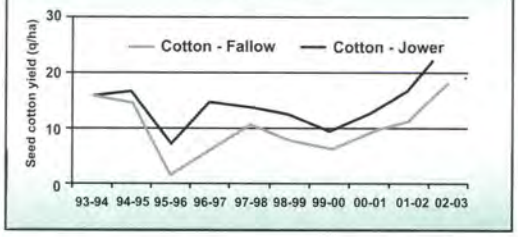
Total cotton yield of 2990 kg/ha (based on equivalent yields) was realized in cotton-jowar cropping system in comparison to 1020 kg/ha in cotton mono-cropping system. Better crop performance in cotton-jowar system was attributed to improved root growth (by 8 %), better growth and yield attributes (*kapas*/plant by 23 %, bolls by 12 % and sympodia by 6%), less weed growth (by 28%), improved soil physical and chemical condition and higher NPK uptake.

Additional profit to the extent of Rs. 12000/- accrued for the extra long staple American cotton along with Rs. 18500/- for jowar thereby making a cumulative return of Rs.30500/- per hectare in cotton-jowar over that in cotton-fallow.

Application of fertilizer-N, P and K @ 30,13 and 25 kg/ha respectively plus FYM @ 5 t/ha (30:13:25:5) could be sustainable under the existing condition although annual combined addition of P and K @ 19

and 37 kg/ha along with FYM @15 t/ha (0:19:37:15) gave higher/similar productivity in cotton jowar (Fig. 2 & 3).

Fig. 3 Yearwise trend in *kapas* yield as influenced by the cropping systems (1993-94 to 2002-03) @



@ During 1995-96, the low plant population (due to wilting) produced lower *Kapas* yield.
*** Cropping cycle is August (sowing of cotton) to July end (harvest of jowar)**

Adhoc Trial : Studies on the effect of micronutrient application on yield and quality of Bt hybrids under rainfed condition (Jagvir Singh and M. R. K. Rao).

Field experiment in medium deep soil with two Bt hybrids MECH 184 and 162 alongwith one local check NHH 44 was conducted to study the effect of micronutrients (Zn,B and Mn) on yield and fibre qualities. Results revealed that combined application of micronutrients (i.e. 30 kg $ZnSO_4$ + 10 kg Borax + 10 kg $MgSO_4$/ha) in Bt hybrids gave 3 to 3.5 quintal more yield per hectare over recommended dose of NPK (control), while no treatment difference was observed in the yield of NHH 44. Among the methods of application, 50% soil + 50% foliar gave higher yield in Bt hybrids. Micronutrient treated plots had 7-8 more bolls than untreated plots.

Studies on water use efficiency of harvested rain water through drip irrigation in cotton (K. S. Bhaskar, Jagvir Singh, A.R. Raju and G. Majumdar).

The mean maximum seed cotton yield (16.85 q ha^{-1}) was recorded in plots with two plants per hill (T_1) followed by four plants per hill spaced 15 cm apart (T_2) and the lowest in four plants per hill at 30 cm apart (T_3). Higher seed cotton yield in advance sown cotton in T_1 was due to more number of bolls per plant, more boll weight and growth parameters such as more plant height (cm) and higher sympodial branches per plant at different crop growth stages.

Evaluation of suitable moisture management practices for rainfed cotton in shallow soil (K. S. Bhaskar).

Result showed that ridge and furrow system was able to increase the moisture level by 3-5 % at various crop growth stages over flat method of sowing. Seed cotton yield also increased by about 10 % in ridge method over flat. Response of irrigation in alternate furrow was better over cotton in same system *sans* irrigation. Among all the moisture conservation practices, ridge and furrow system with or without irrigation was superior to others.

Tillage and crop residue effect on soil nutrient and cotton behaviour (Blaise, Nandini G. Narkhedkar).

Tillage systems (conventional tillage [CT] vs reduced tillage [RT]) did not affect seed cotton yield of G. *arboreum* or G. *hirsutum* cultivars. Yield of G. *hirsutum* (1421 kg ha^{-1}) was significantly greater than the G. *arboreum* plots (1063 kg ha^{-1}). Number of bolls retained per plant enhanced 1.5 times the RD of N and consequently resulted in significantly higher seed cotton yield (1361 kg ha^{-1}) than the N_{60} plots (1123 kg ha^{-1}). At the end of seven years (2002-03), soil organic C, available P and exchangeable K did not differ significantly between tillage systems.

Studies on the efficacy of micro nutrients application and moisture management in improving yield and fibre quality of rainfed cotton (A. Ravinder Raju, J. V. Singh and M. R. K. Rao).

Supplemental irrigations at peak flowering and early boll development stage improved the seed cotton yield/ha by 31% over rainfed

cotton. However, improved soil moisture did not play a significant role in improving the fibre quality parameters of rainfed hybrid cotton. Soil application of micro nutrients Zn, Mn and Boron @ 30, 30 and 10 kg ha^{-1} respectively every year improved the seed cotton yield per hectare and boll number significantly. However, their interaction with moisture supply was not significant. Soil application of these micro nutrients significantly improved the fibre quality traits such as 2.5% span length, micronaire and uniformity ratio.

Improving the efficiency of cotton + pigeon pea strip cropping in Vertisols (A. Ravinder Raju).

The studies on the competition and production efficiencies of 12, 8, 6 rows of cotton with one or two rows of pigeon pea showed no significant difference. Seed cotton yield of adjacent cotton row was reduced by 32, 33 and 36% and of pigeon pea rows by 34 and 32 % compared to middle rows of cotton. The single pigeon pea row produced significantly 97 kg ha^{-1} more seed cotton yield over two rows in cotton+ pigeon pea strip cropping. The boll weights were also reduced. The LER values varied from 1.07 to 1.09. Small increase in LER was due to more competition under replacement series with two dominant crops. Similar trial was conducted with *desi* cotton AKA 8401 and no significant differences were observed for 12 and 8 rows but both were significant over 6 rows. Similarly, single pigeon pea row did not reduce seed cotton yield compared to two pigeon pea rows in the system. The yield reduction due to pigeon pea competition was 36, 56 and 44% at 12, 8 and 6 rows respectively compared to middle cotton rows. The LER was greater with two rows of pigeon pea strip cropping compared to one and the advantage ranged from 1.42 to 2.13 from 12 to 6 rows of strip cropping respectively.

The use of bio-fertilisers as seed treatment in hybrid cotton improved seed cotton yields by 21 and 145 kg ha^{-1} at 50% and 100 % recommended doses (RD) respectively. Two foliar sprays of 2% urea produced 222 kg ha^{-1} additional seed cotton yield . The pigeon pea yield was improved by 145 and 46 kg ha^{-1} at 50% and 100 % RD. In AKA 8401 (12+2) biofertilisers improved the yield by 23 kg ha^{-1}, while foliar sprays of 2% urea by about 53 kg ha^{-1} in seed cotton yield whereas in pigeon pea grain yields were improved by 39 and 64 kg ha^{-1} respectively over 50% RD.

Adhoc trial: Evaluation of Godrej weedicide as pre and post emergence application in integrated weed management of rainfed hybrid cotton

Pre or post emergence application of Godrej weedicide interchanged with pendimethalin and early interculture and hand weedings at 35 DAS was significantly superior. Godrej weedicide as pre emergence application followed by post emergence grass weedicides supplemented with late intercultures at 60 DAS were found inferior.

Coimbatore

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 (C. S. Praharaj).

The first year result revealed that although growth and yield traits were not significantly influenced due to treatments involving crop rotations and manurial schedules yet the trend was similar i.e., maximum seed cotton yield was realized following application of FYM @ 15 t/ha (1060 kg/ha) followed by recommended NPK along with 5 t/ha of FYM (990 kg/ha). Relatively low yield was realized because of severe incidence of

stem weevil causing an average 15.3 % wilting of plants during 2003-04.

Initial soil fertility analyses reveals no significant differences observed between the experimental units with respect to fertility parameters viz., OC, OM, pH, EC, available-N, P & K and sodium (both at 0-25 cm and 26-50 cm soil depth).

Adhoc Project : **Precision farming technologies for higher productivity** (C. S. Praharaj).

A preliminary experiment conducted to compare the application of FYM @ 10 t/ha as basal + foliar feeding of DAP at 70 & 90 DAS with that in the recommended application of NPK (½N and full P & K as basal and ½N as top dressing) on the performance of *Surabhi* cotton revealed that no difference in *kapas* yield was observed although numerically higher sympodia, *kapas*, boll number per plant (and consequently lower boll wt.) were recorded under the former (FYM) treatment.

Exploring suitable agro techniques for Bt cotton hybrid (K. Sankaranarayanan, P. Nalayini and B. Dhara Jothi).

An experiment conducted to find out the optimum plant density and the response to N, P and K application to Bt cotton hybrid revealed that geometrical arrangement of plants in 75 cm between ridges and 60 cm between the plants registered significantly higher yield (1420 kg/ha) with a population of 22, 222/ha and application of 150% of RD level of fertilizer recorded significantly higher yield (1450 kg/ha). However, that was on par with the application of 125% of RD level.

An experiment conducted to find out optimum time and also to assess the performance of Bt cotton under delayed sowing conditions, revealed that there is no significant difference between the Bt and non Bt (MECH-162) hybrids. August 15th and 1st Sept. sowing found higher yield of 1490 kg/ha for both the treatments. Under delayed sowing condition (1st Oct.) Bt hybrid registered higher yield (780 kg/ha) than non Bt hybrid (580 kg/ha).

An experiment conducted to assess the status of raising inter-crops with Bt cotton hybrid, revealed that maximum seed cotton yield (1890 kg/ha) was registered with Bt cotton + cowpea inter-cropping system and the visible legume effect of cowpea on Bt cotton resulted in higher seed cotton yield. Maximum seed cotton equivalent yield (2180 kg/ha), land equivalent ratio (1.82), gross return (Rs. 60921/ha) net return (Rs. 32071/ha) and benefit cost ratio (2.1) were observed with Bt cotton + cowpea system.

Influence of secondary and micro-nutrients on qualitative and quantitative parameters of cotton (K. Sankaranarayanan).

The treatments consisted of recommended level of soil and foliar application (60, 75 and 90 DAS) of $ZnSO_4$, $FeSO_4$ (50 kg/ha for soil and 0.5% for foliar), $MgSo_4$ (10 kg/ha for soil and 0.5% for foliar), Borax (5 kg/ha for soil and 0.5% for foliar) and control. The results revealed that foliar application of $MgSO_4$ @ 0.5% recorded significantly higher seed cotton yield (1260 kg/ha), which was closely followed by foliar spray of 0.5% of $FeSO_4$ treatment (1241 kg/ha) as compared to control (1040 kg/ha).

The results revealed that Ginning percentage, lint index, 2.5% span length, uniformity ratio were affected by application of nutrients. Significantly higher ginning percentages of 40.0 and 39.1% were respectively observed with application of $FeSO_4$ (50 kg/ha) as soil and foliar spray (0.5%) on 60, 75 and 90 DAS as compared to control (36.7%); Lint index was significantly affected by soil application of $FeSO_4$ (50 kg/ha) (6.5) and foliar application (0.5%) of $MgSO_4$ and $FeSO_4$ on 60, 75 and 90 DAS (6.4 and 6.2) than control (5.3). Significantly higher staple length (28.2 mm),

numerically higher fibre strength (20.8 g/tex) and fibre quality index (283.5) were observed with foliar application of borax @ 0.5% on 60,75 and 90 DAS and corresponding values for control is 27.3 mm for length, 19.7 g/tex for strength and 265 (FQI). Soil application of $FeSO_4$ (50 kg/ha) and Borax (5 kg/ha) were observed with significantly higher uniformity ratio of 51.3 and 51.8 respectively as compared to control (49.7). Seed index, maturity ratio, micronaire value and fibre elongation were not significantly influenced by the application of the nutrients.

AICCIP Trial - **Agronomic requirements of pre-release varieties** (K. Sankaranarayanan).

The experiment is conducted with objective to find out the optimum spacing and fertilizer level to pre released culture (CCH 526612). The treatments consisted of two different spacing (75x30 and 75x45 cm) combined with three levels fertilizers (75, 100 and 125% of recommended level (60:30:30 kg of N, P&K/ha) and compared with control (LRA 5166 with 75x 45 cm spacing with 100%RD level of N, P&K). The results concluded that sowing of pre-released culture (CCH 526612) at 75X 30 cm spacing and application of 100 per cent of recommended level of fertilizers (60:30:30 kg N, P and K/ha) are optimum for higher production (2479 kg/ha) which recorded higher yield of 625 kg/ha than control (LRA 5166).

AICCIP Trial: **Testing of herbicides for bio-efficacy** (P. Nalayini).

The new herbicide mixture of clomazone 15 % + pendimethalin 30 % at 2 and 2.5 lit/ha controlled the weeds efficiently and found superior to rest of the treatments at 20 DAS. This herbicide gave a broad spectrum control of both broad leaved weeds and grass weeds as evidenced from the weed control efficiency of more than 90 % at 40 DAS and about 75 % at 60 DAS and enhanced the production of higher number of burst bolls and higher seed cotton yield. Trifloxysulfuron registered significant reduction in boll numbers and the boll weight was also reduced significantly at higher dose of 10 g/ha.

All the pre-emergence herbicides controlled the weeds effectively during early stages and were on par and found significantly superior to unweeded control. However at 60 DAS, integrated method of pre-emergence application of pendimethalin 1kg (3rd day) + hand weeding (35 DAS) + post emergence application of GOD H001 controlled the weeds efficiently and was on par with hand weeding (20 and 35 DAS). The weed control efficiency as measured by the dry matter of weeds proved that the herbicide rotation with pre and post emergence herbicides with hand weeding and/ inter culture registered more than 80% weed control Up to 60 DAS.

Ad-hoc trial: **Polyethylene mulch for Cotton-Maize cropping system** (P. Nalayini, T. P. Rajendran and K. Sankaranarayanan).

The black polyethylene mulch promoted significantly the growth and development of cotton cv LRA 5166 as evidenced from increase in root growth with increased root length, root biomass, root volume with more number of secondary roots. The most important process of nutrient mobilization by the plant through root cation exchange capacity is significantly improved by the poly mulching which recorded the root CEC of up to 26.5 milli equivalents / 100 g of roots as compared to 15.9 milli equivalents / 100 g of roots under non-mulched control. The increase in soil temperature under black poly mulch was up to 4°C from normal which enhanced the beneficial rhizospheric microbes, nutrient mineralization and mobilization. The evaporation of water from mulched soil was completely arrested and the water saving was up to 40 % due to poly mulching. Apart from moisture

conservation, the weed control was excellent.

The overall favourable microclimate under polymulching resulted in enhanced yield upto 2113 kg/ha as compared to 891 kg/ha under nonmulched bed planting (table 9).

Table 9: The growth and yield attributes of LRA 5166 due to poly-mulching

Treatments	Root CEC	Root dry wt/pl	Leaf area/ leaf (cm^2)	Leaf dry wt (g)	Bolls/ plant	Boll wt g/boll	Seed cotton yield (kg/ha)
T1-100 micron	19.4	4.39	89.2	0.76	26.9	3.92	2039
T2 - 75 micron	26.5	4.50	80.9	0.69	26.2	4.10	2113
T3 - 50 micron	25.0	4.27	83.5	0.72	25.8	4.05	2104
T4 30 micron	26.2	3.78	99.3	0.75	23.7	3.94	2010
T5 control	15.9	1.49	56.1	0.60	15.1	3.50	890.7
SEd	0.84	0.26	9.75	0.05	2.12	0.17	123.4
CD (P= 0.05)	1.92	0.61	22.49	0.11	4.89	0.40	284.4

The polythene sheets of 50, 75 and 100 micron were intact even after the harvest of cotton and a technique of growing rotation maize without disturbing the layout was attempted. Punching were made 5 cm away from cotton holes and maize crop was sown under zero tillage poly mulched condition. The growth of maize crop was excellent and weed free due to poly mulching. The cotton sticks were smeared with 2,4-D to prevent regrowth and the cotton holes were utilized for fertilizer application for maize crop.

National Agricultural Technology Project

RCPS-2: **Optimising nutrient supply in relation to moisture availability for enhanced productivity and stability of rainfed cotton based production system** (Jagvir Singh and Blaise).

Forty on-farm trials were conducted in two target districts to evaluate the impact of INM technology in ridge and furrow system over farmers practice under rainfed conditions. Two types of soil conditions viz. shallow (<30cm) and medium deep soils (45-90cm) were selected and hybrid cotton was grown with three treatments, T_1-Farmers practices with flat bed, T_2- INM treatment with flat bed and T_3- INM treatment with ridge and furrow system. Soil moisture was lower in flat bed than ridge and furrow system at 110 DAS in both soil conditions. Seed cotton yield in INM treatment with ridge and furrow system was 3-4 q more/ ha than the farmers' practice with flat bed system. Higher availability of N and P was also observed in INM technology. Mulching of green manure in *situ* and preparation of ridge furrow between 80 to 110 DAS were found useful in conserving moisture for a long period than flat bed system.

RCPS-5: **Rain water conservation, harvesting and recycling/ recharging techniques for enhanced productivity of cotton - based cropping system** (K. S. Bhaskar).

The various moisture conservation practices, tested on 40 farmers field on degraded soils in Thugaon on different toposequences indicated that ridge and furrow system across the slope was the best system and effective in conserving rain water and improving the recharging capacity of irrigation wells and subsequently the yield of cotton-based cropping systems.

Similarly, the response of recycling of harvested rainwater on cotton and cotton-based production system was above the

moisture conservation practices, which improved the yield of cotton and cotton-based cropping system significantly in upper to lower toposequences.

RCPS-9 : **Develop and evaluate production technologies for indigenous cotton in North east region** (A. Ravinder Raju, M. K. Meshram, G. Mazumdar and S. M. Wasnik).

G. arboreum varieties K 10, AKH 4, A 1418 and Khandwa are presently suitable for open end spinning and need proper agronomic package support for improving seed cotton yield performance. The economic analysis revealed that their present performance is similar to hybrids but saving in 30% external inputs reduces the risk.

The most economical package for medium deep soil at Mudhol was N fixing *Pseudomonas* along with PSB as seed treatment + 2 % urea as foliar spray + 50 % RDF. Seed bacterization with FS and PSB is recommended in medium deep soils with foliar spray of 2 % urea at 60 and 80 DAS. Moisture conservation by opening ridges and furrows after first inter-cultures with INM both in hybrid NHH 44 and *G. arboreum desi* cottons out performed farmers' practice.

Ponduru cottons had superior strength to length ratio of 0.85-0.91. In sandy clay loam soils only ratooning was found economical as sole crop. Ponduru Hill cotton is often ratooned for a year in ground nut mixed cropping. Ratooning produced 21% higher yield. Ratooning with fertilizers improved seed cotton yields 115% more than sole cotton. Under supplemental irrigations with fertilizers almost the yields were doubled with B:C ratio 1.67. Punasa cotton ratooning in black soils produced 33% more seed cotton yield with B:C ratio justifies for it.

PSR 4: **Studies on the efficacy of bio-inoculants in cotton-wheat production system** (A. Ravinder Raju and D. Monga).

The INM trial with short listed elite strains *Azotobacter HT 541, Nagpur-2* improved the seed cotton yields and were superior to 100% RDF followed by *Azosprillum Nagpur-2* and *Pseudomonas* which were similar to RDF. They had superior N, P uptake over 100% RDF when they were supplemented with only 65% RDF. The mixture of N fixing strains of different species as liquid cultures are having cumulative effect than individual species of N fixers. The commonly used agrochemicals carbendazim at recommended level for seed treatment could be tolerated by all species of N fixers followed by Mancozeb and imidachlorprid. Pendimethalin might have reduced marginally seed cotton yields due to reduced level of microbial multiplication.

PSR-36: **Adoption and refinement of cotton picker and cleaning system** (G. Majumdar).

Four varieties, namely CNH 120MB, CNH 123, GSH 2 and CNH 155, considered for their suitability for mechanized picking were sown at a spacing of 90 X 10 cm in four ha. Observation in plant characteristics, affecting mechanical harvesting system like, coordinates of bolls for their spatial distribution, plant height, population, width of plot, number of monopodia and sympodia, leaf shedding, kapas yield, height of lower most boll were recorded to correlate to the efficiency of mechanical picking and trash content etc in each of the variety. Pre and post harvest losses along with picking efficiency was worked out for each variety. The picker efficiency increased with lateral spread and number of open bolls. Spatially compact varieties resulted in better picking efficiency (table-10). The picker was able to pick 100% cotton in twice over picking. It took two hrs to pick one ha with machine whereas it took 370 women-hr/ha. On an average picker

Table-10 : Picking efficiency by mechanical picker

Sr. No.	Variety on ground (gm/m^2)	Wt. of cotton fallen (gm/ m^2)	Wt. of cotton picked by m/c (gm/ m^2)	Wt. of cotton hand picked wt. left (gm/ m^2)	Post harvest of picker (%)	Picking efficiency
1.	CNH120MB	7.7	44	58	7.5	75.9
2.	CNH123	5.5	60	63.8	14.1	94
3.	CNH155	3.9	8.38	38.7	8.5	21.6
4.	GSH2	4.2	40	65.6	14.5	61

could harvest 443 kg/ha of seed cotton.

Coimbatore

PSR-16 : **Exploitation of *G.herbaceum* cotton for improving agricultural output and economy of coastal agroecosystem** (N. Gopalakrishnan, K. N. Gururajan and S. E. S. A. Khader).

High yielding ability of *desi* cotton hybrid G.Cot. DH.7 and G.Cot.DH.9 could be demonstrated in coastal areas of Gujarat, Karnataka, and Tamil Nadu. G. Cot. DH 7 and G. Cot DH 9 registered very high yields with a mean performance of 4042 q/ha over three years in coastal areas of Karaikal (Union Territory of Pondicherry). Stability analysis over three years indicated the stability of *desi* cotton hybrids *viz.*, G. Cot DH 7 and G. Cot DH 9 for higher yields. G.Cot DH 9 with a mean fibre length of 27.4 mm and bundle strength of 20.8 g/tex may be suitable for spinning up to 30-40s counts. *G. herbaceum* genotype RAHS 14 was found saline tolerant, high yielding (600-900 kg/ha) even under very adverse conditions, early and well adapted at many locations.

The high yield potential of *G. herbaceum* cultures *viz.*, DB.3-12, G.Cot.13 and G. Cot.21 even under very adverse situations could be demonstrated with average yield of 600-800 kg/ha. Productivity of *G. herbaceum* genotypes could be further enhanced by growing under protective management situation as seen in large scale trials at Raichur and Dharwad. *G. herbaceum* genotypes exhibited steady state maintenance of metabolic status with higher levels of soluble protein, reducing sugar content and phenolics in leaves during crop growth at Coimbatore. Higher levels of metabolically important enzymes like nitrate reductase and peroxidase were noticed in *G.herbaceum* genotypes.

Technology Mission on Cotton

MM 2.1: **Integrated nutrient management for high quality fibre and yield** (Blaise and Jagvir Singh).

Field experiments were conducted to evaluate the effects of crop rotation (cotton-soybean vs cotton - cotton) and fertilizers on productivity and fibre quality. In the first year of trial, rotation effect was not observed. Application of zinc and boron resulted in significantly higher seed cotton yield than when applied singly. Response to zinc or B were not significant when compared to application of recommended dose of NPK. Foliar application of potassium also did not result in any significant improvement in seed cotton yield.

MM 2.2: **Integrated water management for quality fiber production**

Nagpur - (K. S. Bhaskar).

Studies on rain water management

through different agro - techniques in cotton

One protective irrigation through harvested rain water to cotton at peak boll development stage was effective in realizing maximum (16.13 q ha^{-1}) seed cotton yield. The effect of black-gram as inter-crop was next to protective irrigation followed by opening of alternate furrow after last inter-culture in sole cotton. Inter cropping of soybean with cotton has given maximum (Rs 55488 ha^{-1}) gross return, higher cotton equivalent and higher ginning per cent.

Response of different critical growth stages of cotton to protective irrigation

Maximum (21.04 q ha^{-1}) seed cotton yield was recorded when cotton crop was irrigated at early boll and peak boll development stage which enhanced seed cotton yield by about 8 q ha^{-1}. Protective irrigation also increased significantly the total biomass and ginning per cent in cotton. For realizing higher cotton yield potential under rainfed situation, the protective irrigation at early and peak boll development stages is essential in shallow vertisols.

Coimbatore- (K. Sankaranarayanan)

Pair row planting, single lateral for two pairs using micro tubes for water delivery was tested against the recommended one (pair row planting, single lateral for single pair with dripper delivery) under two irrigation schedules (0.8 and 1.0 ETc) and compared with control (conventional method of irrigation). The results revealed that growth character, yield parameters, yield were not significantly influenced by layouts. Maximum water use efficiency (60.4%) was calculated for 0.8 ETc irrigation schedules. Quality parameters were not affected by layouts and irrigation schedules.

Critical growth stages' response to protective irrigation

The treatments of protective irrigation consisted of irrigation at squaring, flowering, boll development, squaring + flowering, flowering + boll development, squaring + flowering + boll development, irrigation at 0.8 IW/CPE ratio and rainfed control. Higher seed cotton yield (1080 kg/ha) was realized with scheduling of irrigation at 0.8 IW/CPE which was on par with other irrigation scheduling treatment except rainfed control (579 kg/ha). Quality parameters were not influenced by irrigation schedule. The results revealed that application of single irrigation at boll development stage increased the seed cotton yield (54%) as compared to rainfed control. However, with increase in the number of irrigation, the response was reduced. Provision of one irrigation increased the yield an average 300 kg/ha and two 410 kg/ha.

MM 2.5: Ergonomically efficient implements for cotton production

(G. Majumdar).

A) Evaluation of existing nozzle

Five available pesticide sprayer nozzles namely BCN Single, BCN Triple, Hollow Cone nozzle, NMDS and Double nozzles were evaluated for droplet sizes and VMD/NMD ratios at two different pressures namely 20 and 40 psi. VMD/NMD ratio was 0.955 for NTM Hollow Cone nozzle at 20-psi pressure, which is closest to VMD/NMD ratio of one among all the nozzles, meaning that this nozzle produced droplets of uniform size, a most desirable quality from the point of efficiency and reduction in losses. The average droplet sizes are also around 100, which is the recommended droplet size for controlling the cotton insect pests.

The discharge from nozzles was observed by spraying at 20 and 40 psi for a minute in a graduated cylinder and average of three replications taken for each nozzle. Paper strips 10 cm X 200 cm were prepared and spray solution sprayed from a height of 60,

75, 90 and 105 cm to assess the swath width from each nozzle. Among the nozzles the NTM Hollow Cone nozzle at 20 psi recorded the highest per cent P deposition meaning the spray fluid retention on plant was more with this nozzle compared to others. It also resulted in 45% reduction in spray pesticide over conventional NMDS nozzle (table 11).

Table 11 : Average droplet size, droplet density and coverage of different nozzle

Nozzle	Pressure Size	Ave. Droplet	No. of Droplets	Coverage (%)
NMDS	20	59.7696	160	44.94
	40	47.7138	150	26.83
BCN Single	20	62.4298	97.5	29.75
	40	47.3742	140	24.69
BCN Triple	20	52.4682	142.5	30.74
	40	41.0916	170	22.55
Double Nozzle	20	48.7326	85	15.86
	40	47.8836	150	27.03
NTM Hollow Cone	20	97.635	135	100
	40	83.0888	157.5	85.83

b) Evaluation of Peri-sprayer

With two nozzles spaced 60 cm apart, the sprayer did not develop sufficient pressure and hence coarse droplets of spray fluids emerged from both the nozzles. However, the sprayer can very well be used for spraying pre and post emergence weedicides in cotton. Field coverage of the sprayer was found to be 3.5 hrs/ha. The sprayer is ergonomically designed to avoid operator contamination with weedicide as the operator pulls the sprayer as he walks away from the treated foliage / area

c) Evaluation of cotton stalk puller

The two-row tractor drawn cotton stalk puller designed last year and fabricated this year was put on trial. The main shaft of the puller was modified and fabricated. An additional float is being fabricated for facilitating ease of hitching to tractor.

MM 5.2 : Cotton information, website and documentation

Nagpur - (G. Majumdar).

A digital photo library of 2500 coloured as well as B/W photographs of technologies developed at CICR, Nagpur and Sirsa has been established.

CICR website maintenance: CICR website **www.cicr.nic.in** monthly updated.

Collection of data for cotton database retrieval system : Data related to all aspects of cotton being compiled, edited and sent to lead center for incorporation into the cotton database retrieval system.

Contents of cotton literature for the states of Maharashtra, Orissa, M.P., Gujarat, Rajasthan, Tamilnadu and Haryana compiled by DOCD for development of cotton software in collaboration with ECIL, were got edited and updated by subject matter specialists. The corrected volumes were then sent to ECIL for final coding in the software.

Development of production drawings and solid models of implements developed under TMC: Three dimension (3D) solid models, virtual working prototypes and production drawings of planter, time sorter, closed system of

pesticide metering and dispensing, and stalk uprooter developed under TMC, MMI, were generated and compiled to aid in the commercialization of the implements.

Coimbatore - (M. Sabesh)

Eighty per cent of the data were collected digitized and appropriate databases created. For the collected data set, information retrieval menu were developed using the software Visual Basic.

The CICR web site has been developed using latest web tools like Flash Macromedia, graphics using Adobe Photoshop, etc. The web site contents were systematically designed with following menus: Institute, Research, TMC, NATP, AICCIP, Personnel, KVK, News, Database, contacts. Each of these menus contains detailed sub menus. Periodically, contents were updated.

About 1000 photographs were collected on diverse aspects of cotton and efforts were made to develop Digital Photo Library.

MM 2.4 : Refinement of regional level yield prediction in cotton

Nagpur - (M.R.K. Rao and K. B. Hebbar)

During the year, considerable progress was achieved in fine tuning and validating the INFOCROP model for cotton. The performance of the model, across locations, sowing dates, has improved considerably in terms of nearness of simulated trends and values as compared with the observed. An experiment was laid out with recommended fertilizers with two dates of sowing under rainfed and irrigated conditions (supplemental irrigation) and NHH-44 and LRA 5166 were evaluated. Two supplementary irrigations has resulted in an additional yield of 3 to 4 q/ha in hybrid and 2 to 3 q/ha in LRA 5166. The refined INFOCROP model predicted growth leaf area and yield reasonably near to the observed values both in the irrigated and rainfed situations.

Model predicted emergence after 5 to 6 days of sowing. Model simulated phenology from sowing to emergence, sowing to flowering and sowing to maturity varied with the weather and soil data of different locations. Sowing to flowering had taken 70 to 80 days and sowing to maturity 150 to 230 days in early sown crop. LAI in most of the treatments matched with the observed values. Under irrigated condition LAI values were high whereas under rainfed model simulated a lower LAI. LAI reduced with delayed date of sowing. Model predicted slightly higher TDM and yield compared to observed yield in almost all the treatments. This is because the pest component has not been included in the model. Model simulated higher yield with normal date of planting and it reduced with delayed planting. Both biomass and yield were higher under irrigated condition. Varieties showed a lower biomass and yield compared to hybrids.

Integration with GIS is being attempted at CRIDA. Weather based (rainfall and temperature) regression model for yield prediction was worked out at NRSA, Hyderabad, which has predicted the yield quite close to the observed over years.

Coimbatore - (A. H. Prakash).

Flowering

Seedling emergence after 4-5 days of sowing irrespective of the date of sowing and N levels, there was advancement by 2-3 days in both 50% square formation and 50% flowering with delayed sowing.

Root length and dry weight

The nitrogen had no significant influence on root growth, while date of sowing had. Late sowing showed a faster growth rate till 50 DAS.

Plant height and shoot dry weight

The higher dose of nitrogen had a significant effect on seedling vigour. The plant height was highest in N_3 irrespective of the date of sowing till 45 DAS. This advantage was not

further observed. Similarly, with change in sowing schedules, the D_3 treatment was significantly higher followed by D_4, D_2 and D_1 till 60 DAS. During the later part of growth D_2 reached a maximum plant height of 83 cm by 120 DAS and was significantly higher than all other treatment. Similar trend was observed in shoot dry weight.

Number of monopodia and sympodia

There was no significant influence of date of sowing nor Nitrogen on the number of monopodia produced. There was variation in the number of sympodia produced with early sowing (D_1 & D_2) having a positive effect and the later sowing significantly lower number.

Leaf area

There was a significant influence of Nitrogen application on Leaf area. No produced significantly lower leaf area irrespective of the date of sowing. N_1, N_2 and N_3 were found to be on par and maintaining significantly higher leaf area over No. Date of sowing also influenced leaf area. The treatment D_2 produced higher leaf area and was on par with D_3, while D_4 and D_1 produced significantly lesser.

Square and boll production

There was variation in the pattern of square production. D_2, D_3 and D_4 were on par, while D_1 was found to produce significantly lower squares. Nitrogen had no significant influence on square production.

There was no significant effect of N levels on boll number, while date of sowing did. But both had no significant influence on leaf dry weight, square dry weight and burr dry weight.

Cotton yield and total biomass

The nitrogen level showed a significant variation only with respect to D_1 sowing, while in other dates the yield was non-significant. Among the dates of sowing D_2 treatment was found to produce the highest kapas yield (2633 kg/ha) and was found to be significantly higher than all other treatment. The next best treatment was D_3 (2474 kg/ha) followed by D_1 (2097 kg/ha) and D_4 (1386 kg/ha). Similar trend was observed in total dry matter production with D_2 producing the maximum dry matter (5362 kg/ha) followed by D_3 (4892 kg/ha), D_1 (4738 kg/ha) and D_4 (3044 kg/ha).

Coimbatore

MM-2.3 : **Bioinoculants for sustainable and cost effective production of high quality fibre** (P. Nalayini and P. Chidambaram).

The response of LRA 5166 to levels of fertilizers and bio-inoculants was significant. Application of 100 % N and P recorded the highest seed cotton yield of 2191 kg/ha and was on par with 75 % level. The bio inoculants also enhanced the seed cotton yield significantly. Among the treatments, Azospirillum (HAU) + PSB + PPFM recorded the highest seed cotton yield and was on par with Azospirillum (TNAU) + PSB + PPFM. Among the combinations, Azospirillum (HAU) + PSB + PPFM at 75 % N and P produced the highest seed cotton yield of 2488 kg/ha.

The levels of fertilizers decreased the rhizospheric population of total diazotrophs, PPFM, *Azospirillum* and PSB during early days. While the enumeration at harvest revealed that 75 % recommended N and P recorded higher population of PPFM and PSB. All the bio inoculated plants maintained significantly higher rhizospheric population of *Azospirillum* and PSB than un inoculated control.

Peat soil followed by lignite maintained higher viable colonies for individual and combined inoculation of *Azospirillum*, PSB and *Methylobacterium* upto 120 days. Only *Methylobacterium* isolate could tolerate temperature upto 60 ^{0}C. PSB isolate of CICR could tolerate upto 350 ppm of oxytetracycline while the PSB (TNAU)

could tolerate this antibiotic only upto 75 ppm.

From the phyllosphere and rhizosphere of various cotton genotypes, the following isolates were isolated and purified: Pink Pigmented Facultative Methylotrophs (PPFM), *Azospirillum* sp, Heterotrophic *Thiobacillus*, Phosphorus and Zn solubilizing bacteria and *Bacillus subtilis*.

Methylobacterium can be mixed with other bioinoculants and / bioagents for promoting vigour index, crop growth, N and P nutrition and for pest and disease management in cotton.

In vitro sulphur oxidation and P solubilization have been confirmed for CICR isolates of Methylobacterium. Also, one PSB isolate of CICR tentatively identified as *Pseudomonas* Spp. has been proved for solubilization of insoluble P and Zn.

Crop Protection

Nagpur

P1-93/1-ICR-F60/0430 :

Biochemical basis of induction of defense related proteins in cotton against *Helicoverpa armigera* (S. Kranthi and S.B.Nandeshwar).

In an effort to transfer the protease inhibitor gene from Pee Dee 0695 into elite genotypes, crosses were made between Bikaneri Nerma, Khandwa 2, G. Cot 10 and Co2, each, as female parent and Pee Dee 0695 as the male parent. Parents were evaluated before the initiation of the crossing programme and Pee Dee 0695 was found to be susceptible to jassids.

F_1s were backcrossed with the elite parent and the backcross progeny was obtained. F_1 progeny were evaluated for insect pests under unprotected condition in the field. There were no significant differences between jassid numbers at 45, 60, 75 and 90 DAS and the jassid damage grade or between the total and damaged squares at 75 DAS, between parents and the F_1 progenies.

P1-94-1-ICR-H10/0430 :

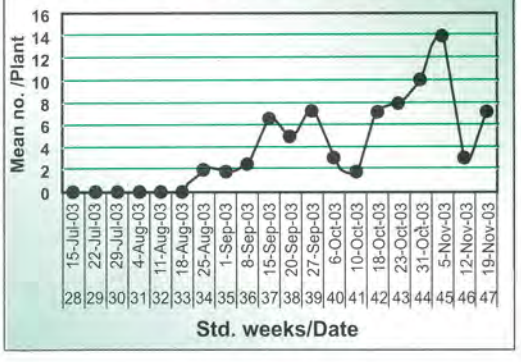
Interaction effects of cultivars, agro-techniques, insect pests and entomophages in cotton ecosystem (S. Vennila).

Jassids and aphids were not significant during the season. Thrips attack was maximum during second fortnight of August. Mirid bugs of *Ragmus* spp. had six generations between August and November (Fig.4). Among bollworms the incidence of *Helicoverpa armigera* during the second fortnight of September, *E.vittella* and *P.gossypiella* beyond mid October and mid November, respectively was high. A mean of five larvae per plant causing 35-40 per cent fruiting structure damage during third week of September was observed. Dynamics of bollworm damage indicated higher square damage due to *H.armigera* during second fortnight of September and boll damage due to *Earias* and *Pectinophora* from mid October. Predatory coccinellids were low and the chrysopids were moderate to abundance. Peak occurrence of spiders coincided with *H.armigera* larval peak.

Cotton cultivar NHH 44 did not differ for any of the phenological and morphological estimates under protected and unprotected situations but for yield. The reduction in yield under no protection by 18 % had been due to the increased boll damage due to *Earias* and *Pectinophora*. Plant compensation for the loss of fruiting structures up to 25% without yield reduction was worked out. Square damage in relation to total fruiting structures greater than 30% till the end of September did not affect the yield realization. Protected crop harboured more number of *H.armigera* larvae despite receiving less oviposition.

First to third instars of *H.armigera* contributed much of the square damage during third week of September and all the instars damaged during the subsequent weeks. The simultaneous occurrence of all instars between mid October and November and higher survival of second and third instars of *Earias* caused much of boll damage. CD RoM of ICOTIPM, an expert system on Indian Cotton Insect Pest Management was released.

Fig.4 : Seasonal dynamics of *Ragmus* spp.



P1 96 /1-ICR H 10 / 0430:

Estimation of loss due to major insect pests of cotton (S. K. Banerjee).

Variety LRA 5166 : A field experiment was laid out with seven treatments i.e. complete control of sucking pests, control of *H. armigera*, control of pink bollworm, control of bollworm complex, control of pest on the basis of ETL, complete control of major pests and untreated control, replicated thrice in randomized block design. The data revealed that the treatments where the practices for complete control of major pests were followed had minimum green boll damage (9.25%) as well as locule damage (15.56%) as against 23.65 % of green boll damage and 24.74 % of locule damage in the plots of untreated control. The avoidable yield loss due to all the major pests collectively was estimated to be as high as 55.42 % whereas, due to sucking pests and bollworm complex, the avoidable yield losses were recorded to the tune of 21.05 and 45.12 % respectively.

Hybrid NHH 44: Field experiment was carried out with seven treatments including untreated check in randomized block design with three replications. The results revealed that avoidable loss due to all the major pests was to the tune of 36.29% whereas, due to bollworm complex it was 27.86 %. The avoidable losses in the seed cotton yield due to sucking pests, *H. armigera*, and pink bollworm was estimated to be 7.84, 23.87 and 17.43 %, respectively. The locule damage of 7.97 % was recorded in the plot of complete control of major pests as against 19.25 % in untreated control. When the control measures were adopted on the basis of ETL, the loss in the yield could be avoided by 33.35 %.

AICCIP TRIALS : (S. K. Banerjee)

Chemical control of bollworm

Field experiment was laid out in the randomized block design with thirteen treatments including untreated control replicated thrice. The treatments viz., Emamectin benzoate 5 SG at different doses (i.e. @ 8 g, 9.5 g & 11 g a.i./ha), Omite (600 g a.i./ha) + Cypermethrin (60 g a.i./ha), KN 128 15% EC (@50 g & 75 g a.i./ha), RIL 038 20 WDG (@ 50 g & 100 g a.i./ha), NNI 001 480 SC (@75 ml,100 ml & 125 ml/ha), Spinosad 45 SC @ 75 g a.i./ha and untreated control were incorporated to evaluate their effectiveness against bollworms. The data on the square damage, green boll damage, locule damage, open boll damage and yield revealed that all the chemicals under testing in the trial were found to be superior to untreated control. Within the treatments RIL 038 20 WDG (@100g a.i./ha) NNI 001 480 SC (@ 100 ml/ha) and Spinosad 45 SC (@75 g a.i./ha) were found superior to other chemicals in reducing the incidence of bollworm and increasing the seed cotton yield. These treatments recorded locule damage of 11.74, 17.12 &17.19 % as well as maximum seed cotton yield to the tune of 15.0, 14.29 & 13.46 q/ha, respectively as against untreated control where the maximum locule damage (29.29%) and minimum yield of 5.79 q/ha was recorded.

Foliar application of insecticides for control of sucking pests

The treatments viz., Confidor 350 SC (@ 60 ml & 75ml/ha) Confidor 70 WG (@ 30 g & 35 g/ha, Chlothianidin 50 WDG (@ 30 g/ha) and untreated control were replicated thrice in randomized block design for the purpose of testing their effectiveness against sucking pests. The result revealed that treatment Confidor 70 WG @ 30g/ha was superior over other treatments in respect of reducing the incidence of jassids and recorded highest seed cotton yield (6.43 q/ha). It was followed by Confidor 350 SC (60 ml and 75 ml/ha). Whereas, in respect of whitefly population Confidor 350 SC (@60 ml /ha) was found better and was closely followed by Confidor 70 WG @ 30 g/ha and Chlothianidin 50 WDG @ 30g/ha. The plots

treated with Confidor 70 WG @30 g/ha recorded minimum thrips population and it was followed by Confidor 350 SC @ 75ml/ha and Confidor 70 WG @ 35 g/ha. The population of aphids was low in the plots treatment with Confidor 70 WG @ 30 g/ha and Chlothianidin 50 WDG @30 g/ha.

P1-89/1-ICR-H20/0430 :

Studies on multiple disease resistance in upland cotton (Sheo Raj, N. K. Taneja and V. V. Singh).

Seven cultures were compared for their performance. Out of them three cultures viz. CNH 911, CNH 2713 and CNH 4736 continued to perform better showing yield level of 775 to 810 Kg per ha. One new culture ALR 2208 yielded 1008 Kg per ha. Various characters of four cultures were recorded and the lint samples were sent to CIRCOT for quality assessment.

Out of 253 *G. hirsutum* lines screened in the breeder's field, five were resistant, nine moderately resistant, 21 moderately susceptible and 218 susceptible to grey mildew. Out of 432 new germplasm lines, 31 were resistant, 53 moderately resistant, 107 moderately susceptible and 241 susceptible to grey mildew in the breeder's field.

One hundred and forty two *G. hirsutum* lines were screened against grey mildew under pot culture. Seven lines namely, A 72-65, Aleppo 1 X Acala 1-1-7-7-25 PS, BP 52 NC 63, Coker 100 AWR CC, EL 415, MZ 561, V. MWR-1 CY were found to be resistant to the disease.

P1-89/3-ICR-H.20/0430 :

Studies on seed transmitted pathogenic infections and other seed microflora of cotton (P. M. Mukewar).

Disease incidence during seedling and boll development stage :

The cotyledonary leaves and boll infection isolations revealed presence of various fungi viz., *Alternaria macrospora* (AKH-4, AKA 8401, RG 8, LD 327, DB 3-12, Jayadhar), *Colletotrichum indicum* (AKH 4, AKA 27), *Myrothecium roridum* (PKV Hy 2, Surabhi, Suman, LRK 516, LRA 5166, LH 886, H6, H8, H 10), *Cercospora gossypina* (PKV Hy2, Rajat, Surabhi, Jayadhar, F 414, MCU 5, H 10), *Rhizoctonia solani* (MDCH 201) and the bacterial blight pathogen *X.a.* pv. *malvacearum* (PKV Hy2, Rajat, NHH 44, H6, H10, SIMA 1 MCU 9, PKV 081, LH 886, LRA 5166, H 777, F 414). Besides the isolations of cotton pathogenic fungi and bacteria, the repeatedly frequent association of other parasitic fungi viz., *Alternaria tenuis, Curvularia lunata, Drechslera tetramera, Fusarium semitectum* and *Phoma exigua* was noticed.

Detection of pathogenic infections in 2002-03 seed samples :

Cotton seed samples belonging to germplasm lines/varieties/hybrids of the previous crop season (2002-03), which were separated, graded and examined. The leaf and boll spot pathogen *Alternaria macrospora* was detected in the range of 1-3%, leaf spot pathogen *Myrothecium roridum* 1-3%, stem break/root rot pathogen *Macrophomina phaseolina* (= *Rhizoctonia bataticola*) 1-2 %, leaf spot/seed rot pathogen *Phomopsis malvacearum* 1-2%, bacterial blight pathogen *X.a.* pv. *malvacearum* 1-2%. Besides the detection of cotton pathogenic fungi and bacteria, the presence of other fungi viz., *Aspergillus flavus, A. niger, Drechslera tetramera, D. longirostrata, Fusarium moniliforme, F. equiseti, F. semitectum, Phoma biguttulata* and *Trichothecium roseum* was observed.

P1-92/1-ICR-H20/0430:

Studies on evolution of races of *Xanthomonas axonopodis* pv. *malvacearum* (*Xam*) and utilization of HVS in identification of resistant sources (M. K. Mehsram and Sheo Raj).

Pathotypes:

Of the 150 isolates made from five susceptible cultivars viz. Ganganagar ageti, LRA 5166, LRK 516, PKV 081 and Rajat, five races viz. 4,5,7,10 and 18 were identified of which 60 -80 % isolates belonged to race 18.

Seventy six isolates made from samples collected across Maharashtra revealed the presence of five races viz. 3,7,10,14 and 18. Race 18 was most predominant and 81.58% isolates belonged to this race.

Identification of resistant sources:

One hundred and fifty six germplasm lines of *G. hirsutum* evaluated in pot culture showed that Arkansas 22, Bold Rowden, Durango E-44-50, Florida 1377, T 167-10 and Pandora exhibited the resistant reaction. Thirteen were moderately resistant, 67 moderately susceptible and 70 susceptible.

Of the 976 lines of *G. hirsutum* evaluated under field conditions, 76 were observed to be free of bacterial blight and 43 as resistant. Remaining 127 were moderately resistant, 329 moderately susceptible and 401 susceptible.

Out of 197 lines of *G. hirsutum* of Br 01 trial evaluated, NCAC 3 and VCA 4 were free of bacterial blight whereas, 16 viz. AC-1588-4, Badnawar 1, DS-59, F 1054, GC 110, GC 160, G. Cot 18, NA 1375, Narsimha-2, NCAC-1, NCAC-14, SGNR-6, SGNR-28, VCA-2, VCA-5 and VCA-24 showed the resistant reaction. Remaining 31 were moderately resistant, 65 moderately susceptible and 83 susceptible.

Of the 237 upland cotton hybrids evaluated, 17 were free from bacterial blight and 12 exhibited resistant reaction. Remaining 23 were moderately resistant, 75 moderately susceptible and 110 susceptible.

Utilization of resistant sources:

One hundred and fifty seven single plant selections have been made with bacterial blight resistance and desirable plant parameters from the population involving four 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. The seed cotton yield of these selected plants varied from 34.7-71.4 gm/plant with an average of 13.6-21.7 bolls/plant and boll weight of 2.64-3.41 gm.

Fourteen resistant selections have been identified for their plant characters. The average boll number of these selections ranged from 15.67-27.85 per plant with an average boll weight of 2.86-3.64 gm. The average yield of seed cotton varied from 46.3-65.7 gm/plant with the plant height of 84.7-117.6 cm. The average monopodia and sympodia varied from 0.7-3.5 and 14.6-20.4 per plant, respectively.

Identification of efficient strains of bio-control bacteria:

Seventeen 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* spp. and *Bacillus* spp.

P1-93/2-ICR-H20/0430:

Evaluation of cotton germplasm against Alternaria and Myrothecium leaf spot diseases (N. K. Taneja).

One hundred and forty two *G. hirsutum* lines were screened against Alternaria and Myrothecium leaf spots under pot culture. All the lines were susceptible to Alternaria leaf spot. Eighteen lines namely, A 72-65, BM Cot 116, BM Cot 173, Changyung No 1 PS, CTI 4-25-65 CC, Dixieking, EC 132034, EC 450616, EL 120 E, EL 415, GI X CO2 X 4-4, KOP 203, N 136, N 171, RAH 53, SA 3, 418-49-45 X LSS 1-63, 5110 (Hampi) were resistant to Myrothecium leaf spot.

Out of 253 *G. hirsutum* lines grouped under working collection of cotton germplasm screened against the two leaf spots under natural incidence of diseases in the breeder

field, 16 showed resistant, 75 moderately resistant, 45 moderately susceptible and 117 susceptible reaction to Alternaria leaf spot while 69 showed resistant, 61 moderately resistant, 5 moderately susceptible and 118 susceptible reaction to Myrothecium leaf spot.

Out of 432 *G. hirsutum* lines belonging to new germplasm collection screened under natural incidence of diseases in the breeder's field, 79 showed resistant, 272 moderately resistant, 73 moderately susceptible and 8 susceptible reaction against Alternaria leaf spot.

Out of 199 entries of *G. hirsutum* included in Br 01 trial, 20 were disease free, 2 resistant, 59 moderately resistant, 38 moderately susceptible and 80 susceptible to Alternaria leaf spot. Eighty four entries were disease free, six resistant, 92 moderately resistant, eight moderately susceptible and nine susceptible to Myrothecium leaf spot.

Out of 154 entries of *G. arboreum* included in Br 01 trial, 150 were disease free and four moderately resistant to Alternaria leaf spot. Sixty three entries were disease free, 11 resistant, 75 moderately resistant, four moderately susceptible and one susceptible to Myrothecium leaf spot.

P1-93/1-ICR-H20/0430:

Molecular basis of pathogenicity and race-specificity of *Xanthomonas axonopodis pv. malvacearum (Xam)* and characterization of its antagonists (P. K. Chakrabarty and M. K. Meshram).

Repetitive PCR (Rep-PCR) genomic DNA finger-printing using REP, BOX and ERIC primers revealed wide variability within different races of *Xam*. BOX and ERIC-PCR of *Xam* isolates belonging to five different races delineated 134 and 40 amplicons respectively, between 0.25 to 6.0 kb, out of which 12 and 8 were polymorphic (Fig.5 a & b). Growth curve analysis of *Xam* isolates on susceptible and resistant cotton

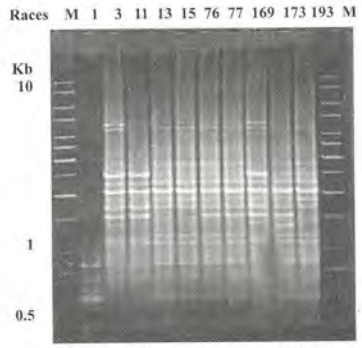


Fig 5a Box-PCR of race 18 isolates
M 1 3 11 13 15 76 77 169 173 193 M

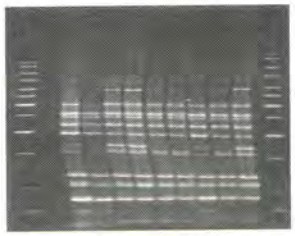


Fig 5b ERIC-PCR fingerprinting of race 18 isolates

plants showed enormous variability in *in planta* growth of race 18 isolates. Pathogenicity and molecular analysis of 30 race 18 isolates by Rep-PCR genomic finger printing, RFLP employing Southern hybridisation with pathogenicity gene *pthN* (AF016221), Random amplified polymorphic DNA (RAPD) and native plasmid profiles confirmed existence of 6-9 biotypes within race 18. BOX and ERIC primed Rep-PCR revealed existence of 6-8 variant biotypes (Fig.5 a&b), while nine biotypes were evident from Southern hybridisation and RFLP analysis (Fig. 6). Eight distinct pattern of variability was discernible within race 18 isolates based on RAPD analysis using OPA13. Number of plasmids varied from 1-3 among different race 18 isolates. Based on plasmid profiles nine variants of race 18 was evident.

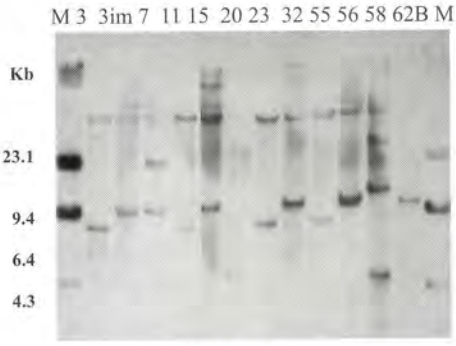


Fig.6 RFLP of race 18 isolates

P1-03/1-ICR-H20/0430:

Efficacy of antagonist fungal microflora from rhizophere of cotton, its growth and development including disease control (R.C. Ukey).

Out of 15 dominant fungal microflora from rhizosphere soil, the role of six efficient antagonists from standard suscept, LRA 5166 and G-27 against cotton pathogens, *Xanthomonas sp.*, *Rhizoctonia* sp., *Alternaria* and *Myrothecium* sp. was confirmed.

The trial was laid out *in vitro* and *vivo* for the control of root rot caused by *Rhizoctonia solani* and in normal Fusarium wilt on LRA 5166 and G-27, the standard suscept of respective diseases. *Mucor* and *Pennicillium spp.* were found supporting seed rotting and hence excluded from seed treatment. *T. viride* gave 47.55 mm, the highest inhibition zone against *R.solani*. The same strain showed 81.66% healthy germination in blotter with 6.30 cm and 10.30 cm more length of plumule and radical followed by other strains of same antagonist fungus. In pot culture, 90.83% reduction over control of root rot was observed. The increased shoot and root length by 81.14% and 76.50% was significantly better as compared to control for root rot management.

Isolates of *Trichoderma* spp. were tested for their ability to suppress by the wilt causing pathogen. *T. viride* special isolate was found superior over other isolates by forming highest inhibition zone (46.80 mm), closely followed by *T. harzianum* (43.50).

P1-96/2-ICR-H10/0430:

Studies on plant parasitic nematodes associated with cotton (Nandini Gokte-Narkhedkar and S. K. Banerjee).

Prevalence (density and frequency) of plant parasitic nematodes on cotton and cotton based cropping systems was studied. Frequency of reniform nematode *Rotylenchulus reniformis* was recorded to be 100%. Other nematode species recorded were *Pratylenchus spp.*, *Helicotylenchus spp.*, *Hoplolaimus spp.* and *Tylenchorhynchus spp.* Frequency of these nematodes ranged between 10 to 50 %. In mid crop season population of reniform nematode ranged between 180-380 nematodes/ 250 cc soil. Reniform nematode population dipped to 10-30 nematodes/ 250 cc soil with onset of winter. In February- March, population again increased to 60-100 nematodes/ 250 cc soil which may be attributed to weeds and crops as soybean serving as good hosts of reniform nematode.

One hundred cotton germplasm lines were screened against root-knot nematode. All were found susceptible. Accession no.116 TLYC Macha was found resistant to root-knot nematode as well as reniform nematode.

Coimbatore

P1-72/1-ICR-410/0430:

Studies on the population dynamics of cotton pests and their natural enemies in the cotton ecosystem (K. Natarajan and B. Dhara Jothi).

During the year 2003-04, the pest infestation was less due to drought. Aphids appeared in the middle of September and the peak infestation was during the last week of September and continued till the first week of November (4-7.6 aphids / plant) in unprotected condition. Whitefly infestation was very low. Bollworm appeared in the middle of October and *Earias spp.* were dominant in the early phase of crop growth during the last week of October-November and *Helicoverpa armigera* was in the first week of December and January. There were two peaks in the larval activity of *H. armigera*. Bollworm damage to reproductive parts was maximum (17.9%) during the first week of December.

Life table mortality studies on *Earias* indicated that larval mortality was 26.3% of while the mortality due to parasitism by *Rogas sp* and *Agathis sp* was 17.0%. The larval mortality due to unknown cause was 9.4%. The pupal mortality due to unknown reason was 24.6%. Life table studies on *H. armigera* revealed that larval mortality due to unknown reason was 13.5% and due to NPV was 38.9%. The pupal mortality was 20.0% in the month of November. In the month of December, the larval and pupal mortality were 27.2% and 24.9% respectively.

Pheromone trap catch study indicated that peak catches of 25.5 moths *Earias spp* was in the second week of January. Both the species viz., *E. insulana* and *E. vittella* were trapped together. Pheromone trap investigation on *Pectinophora gossypiella* indicated that the first catch was in the second week of November and there were two peaks of catches. Pheromone trap catches was high in the month of January and the peak was in the second week of January.

Among the natural enemies recorded, Coccinellid beetles and spiders played major role in reducing the population.

P1-89/6-ICR-H10/0430:

Studies on the host-plant relationship and identification of resistant genotypes to insect pests of cotton

(T. Surulivelu, K. Natarajan and S. Manickam).

Helicoverpa armigera - (T.Surulivelu)

i. Growth and survival of *H.armigera* in popular varieties and hybrids

Larval survival after 11 days of feeding of neonates on flower buds at controlled condition (26 ± 1 °C & 70 % RH) was 29.2, 37.5, 37.5, 41.7 and 45.8% in varieties MCU 5VT, Sumangala, Anjali, LRA 5166 and Surabhi respectively. It was 16.7, 29.2, 29.2, 41.7 and 41.7 % in the hybrids TCHB 213, NHH 44, Bunny, MECH 162 and Savita respectively. Minimum weight gain was observed in Anjali (53.3 mg / larva) and NHH 44 hybrid (84.0 mg / larva) after 11 days of feeding .

ii. Field tolerance to bollworms in popular varieties and hybrids

Field experiment was conducted with five popular varieties (LRA.5166, MCU 5VT, Surabhi, Sumangala and Anjali) and five popular hybrids (NHH 44, Bunny, Savita, TCHB 213 and MECH 162) under protected and unprotected conditions for bollworms to assess their field tolerance and loss of yield. Loss of seed cotton yield due to bollworm complex was 37.8, 43.2, 45.0, 49.3 and 53.7 % in varieties Sumangala, Anjali, Surabhi, MCU 5VT and LRA 5166 respectively. The same for hybrids was 50.1, 56.9, 57.6, 59.7 and 67.1% for MECH 162, Bunny, TCHB 213, NHH 44 and Savita respectively. Average loss of seed cotton yield in varieties and hybrids was 45.8 and 58.3 % respectively.

Eighty seven selected germplasm accessions and promising cultivars of *G.hirsutum* were screened in the field under no protection to bollworms. Boll damage due to bollworm complex ranged from 20.6 to 88.9 %. Five entries viz., 5 (1x 2) 714 7; 5 (1x2) 724 2; BRS 5 (L x BRS 5) 3-3; IRH - 1-10 and L (Paiyur x RCH) 2-5-2 were found to possess high level of tolerance against pink bollworm and recorded less than 20 % locule damage as compared to 38.3 % in the standard variety LRA 5166 and 66.7 % in the highly susceptible accession IC 472. Out of these five entries, the first two entries were also found to possess high level of tolerance to all the bollworms. They recorded 20.6 to 21.1 % boll damage as compared to 48.9 and 88.9 % in LRA. 5166 and IC 472, respectively .

Sucking pests - (K Natarajan and S Manickam).

About 150 cultures were screened for

their reaction to jassid under unprotected condition. Among these 16 cultures recorded resistant reaction. They are HSC-I 132, TCH 1649, TCH 1623, TCH 1702, BS 33, CS 1007, 5 (1 X 2) 714-9, (329 X RRM) - 103-118-2, CAT 239, 1 (RCH X T13) 52-1-1, CCH 5103, IC 126, IC 262, CAT 1261, CCH 727, HLS 79-3.

P1-89/4-ICR-H10/0430:

Studies on the role of insecticides in cotton ecosystem (T. Surulivelu and K. Natarajan).

Efficacy of newer insecticide molecules against bollworms of cotton (T. Surulivelu)

i. Field experiment was conducted in randomized block design with three replications and ten treatments, viz., Emamectin benzoate (8.0, 9.5 and 11.0 g. a. i./ha), omite (600 g. a. i. / ha) + cypermethrin (60 g. a. i. / ha), spinosad (75 g. a. i. / ha), KN,128 (50 and 75 g a. i. / ha), lambda cyhalothrin (20 and 25 g a. i. / ha) and untreated control using the variety, Surabhi. A total of four sprays were given for bollworm control on 81, 103, 120 and 134 days after sowing. Data on *Heliothis* larval incidence and per five plants was significantly low in spinosad (1.3), Emamectin benzoate at 11.0 g (2.0) and KN 128 at 75 g (2.0) as compared to 3.3 to 11.0 in other treatments. These treatments were significantly superior to all other treatments in reducing the square damage also. They also recorded significantly higher seed cotton yield ranging from 1418 to 1679 kg / ha over Emamectin benzoate 8.0 g (1324), omite + cypermethrin (891), lambda cyhalothrin (948 1248) and control (1071 kg /ha). However, all the treatments with KN 128 and Emamectin benzoate were not effective against the reduction of open boll damage and locule damage at harvest.

ii. Field experiment was conducted in randomized block design with three replications and seven treatments viz., NNI 0001 at 36, 48 and 60 g. a. i. / ha, RIL 038 at 50 and 100 g. a. i. / ha, spinosad at 75 g. a. i. / ha and untreated control using the variety Surabhi. A total of five rounds of sprays were given for control of bollworms on 73, 87, 102, 118 and 133 days after sowing (DAS). Data on *Heliothis* bollworm incidence, square damage, boll damage and seed cotton yield revealed that all the treatments were effective against bollworms and significantly superior to control. However, they were not effective on Pink bollworm.

Control of sucking pests - (K. Natarajan)

Imidacloprid 350 SC @ of 60 ml and 75 ml / ha, 70w @ 30 and 35 g / ha and Clothianidine 50 WG @ 30g / ha were sprayed on 15, 30 and 50 days after sowing cotton cultivar Sumangala. All the test insecticides recorded less population of aphid and jassid as compared to untreated check. Imidacloprid 350 SC recorded minimum aphid population of 0.1/plant and remained on par with Imidacloprid 70 WG and Clothianidine. With regard to jassid, Imidacloprid 70 WG recorded the minimum population of 0.2 / plant and remained on par with other insecticides except methyl-o-demeton which recorded 0.7 / plant. With regard to seed cotton yield the treatment recorded high yield, varying from 1960 to 2083 as compared to 1780, recorded in untreated check.

P1-2001/1-ICR-H10/0430:

Studies on bioecology and management of cotton stem weevil *Peripheroculus affinis* Faust (B. Dhara Jothi and T. Surulivelu)

Among nine different treatments evaluated, neem seed extract 5% recorded minimum infestation (8.81%) followed by Carbofuran + Neemcake (11.29%), Neemcake + Neemoil (12.50%), Chlorpyriphos (12.82%) and FYM (12.37%). All the other treatments were on par with the control.

Of the four dust formulations namely Fenvalerate 25 kg/ha, Methyl parathion

25 kg /ha, Acephate 650 g/ha, Sevin 2 kg/ha tested, Methyl parathion recorded minimum infestation of 8.78%.

Among the formulated products of neem, Neemaza1 granules @ 4 kg/acre recorded minimum percentage of infestation.

When cotton sowing was done at weekly interval during August and September, September last week sowing recorded minimum percentage of incidence when compared to the other periods of sowing.

Maximum adult emergence was recorded during the month of August. Within the month during the second week, peak emergence was recorded, females outnumbered the males in emergence.

Three different fungii were isolated from the dead adult weevil. Two unidentified Hymenopteran parasites were recorded from stem weevil. *Althea rosea L* (Hollyhock), an ornamental plant of family *Malvaceae*, has been recorded as alternative host for stem weevil.

Transverse and longitudinal sections of the normal plant exhibited normal arrangement of cell layers. In the infected plant many abnormalities namely irregular arrangement of epidermal cells, loosely arranged parenchyma cells, absence of pericycle and pith, scattered vascular bundles were recorded.

Studies on the cell structure of the normal and stem weevil infected cotton plant

Transverse and longitudinal sections of the normal plant exhibited normal arrangement of cell layer, whereas the infected cotton stem showed the following abnormalities.

Epidermis: Epidermal cells are not regularly arranged. It ruptured in many places. Cells are irregularly placed, cuticle is absent.

Cortex: It consists of irregular shaped parenchymatous cells. It lost its original oval or round shape as it looses the water content. Most of the cells are filled with granular starch grain like structures and the cells are arranged loosely, lot of intracellular spaces are seen.

Endodermis: Endodermis, a uniform horizontally rectangular cells are completely damaged and lost its original outer covering of the pericycle.

Pericycle: No pericycle is observed as the cells are highly damaged.

Vascular bundle: Vascular bundles are scattered and irregularly arranged. Xylem vessels are irregularly arranged.

Medullary rays: Original elongated cells of medullary rays are entirely distributed

Xylem: Both metaxylem and protoxylem lost their original shape, some of them are filled with some granular substance.

Phloem: Phloem cells are very few, patches of them ruptured and large vacuoles present in between few cells are filled with granules substance.

Pith: Not at all seen.

Seive tube: Original arrangement of the seive tube is disturbed.

Cambial cells: Cambial cells are irregularly arranged.

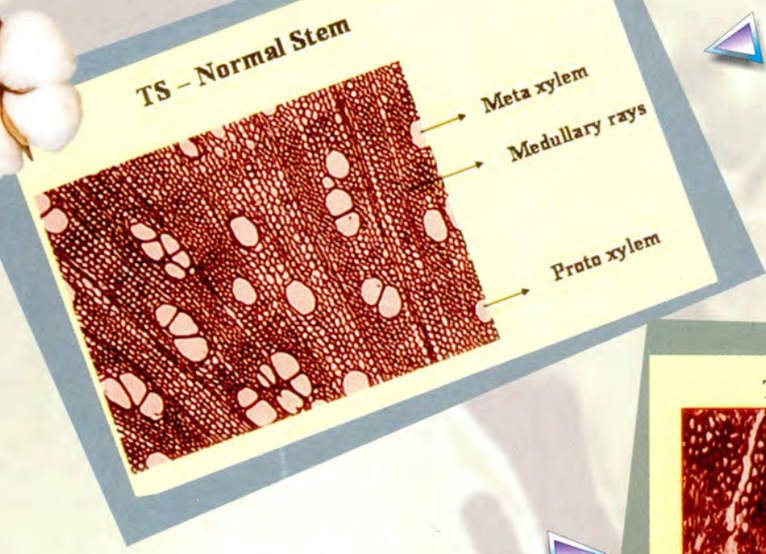
P1-89/3-ICR-H20/0430:

Studies on the epidemiology and management of fungal foliar diseases (P Chidambaram, A Kannan, K N Gururajan and N Gopalakrishnan).

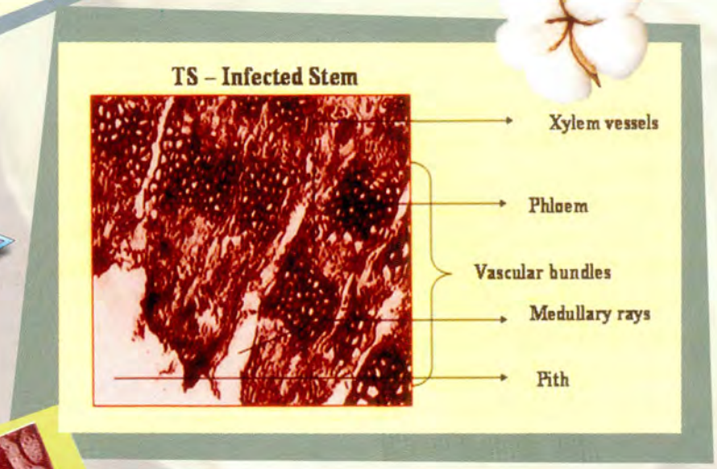
Survey for the incidence of grey mildew and Alternaria leaf spot :

Heavy incidence of *Alternaria* leaf spot was noticed on early sown hybrids *viz*., Sara 2, Bunny, TCHB 213. Similarly on early sown cv. LRA 5166 and hybrids PKV Rajat and MECH.162, very high incidence of grey mildew was observed. There was very little incidence of the two diseases on normal sown crops (i.e.) August September.

Screening of germplasm for identifying resistant lines against foliar diseases

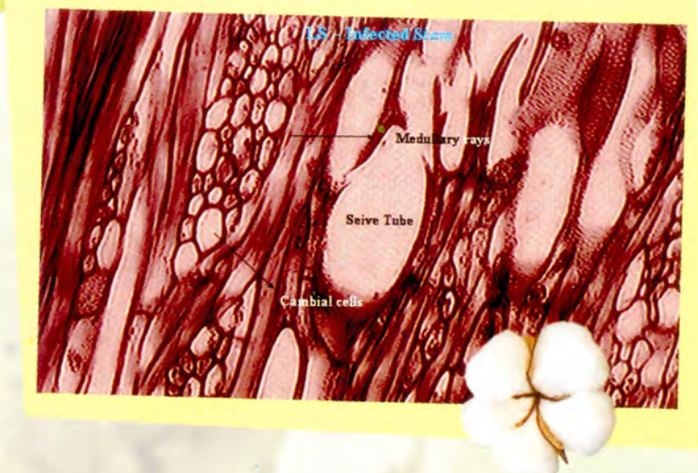


Transverse section of normal stem of cotton with intact cell.



Transverse section of stem weevil infected stem showing the derangement.

Longitudinal section of normal stem of cotton.



Longitudinal section of stem weevil infected cotton stem.

Ninety seven *G. arboreum* and 100 *G. hirsutum* lines were tested in pots under polyhouse conditions through artificial inoculation against Alternaria leaf spot and grey mildew diseases. None of the *hirsutum* lines tested showed resistance to grey mildew and in *arboreum* lines, there was no uniform disease development.

Development of resistant lines against grey mildew and Alternaria leaf spot

Several single plant selections were made for resistance to grey mildew (10) and *Alternaria* leaf spot (1). MAR lines (8) were again tested in field and advanced for further evaluation for fibre quality. Seventeen advanced lines resistant to various diseases *viz*., grey mildew (9) and *Alternaria* leaf spot (3) or having resistance to more than one disease (MAR lines - 5) were evaluated for yield. From these trials ALR.9 (an *Alternaria* leaf spot resistant line) was found to have good yield potential (2450 kg/ha) as well as desired fibre strength (22.2g/tex). This line has since been entered in AICCIP trial (Br02b) as CCH 9. CCH 4 (an *Alternaria* leaf spot resistant line) has performed very well in co-ordinated varietal trial (Br04a) of AICCIP both in central and south zones. The three lines developed under this programme namely LL 1301, CJ 1007 and CCH 5 showed resistance to both grey mildew and *Alternaria* leaf spot under artificiallyinoculated conditions.

Management of grey mildew and Alternaria leaf spot through bioagents.

In the bioassay studies with two native isolates of *P.fluorescens* (1 and 5), the isolate 5 inhibited the growth of *Alternaria macrospora* and *Fusarium* spp. However, it was not as effective as the standard Pf1 isolate. Among the five *Bacillus* spp. isolates, Ba 4 was effective in inhibiting the growth of *Rhizoctonia solani* and *Macrophomina phaseolina*.

There was gradual reduction in the incidence of *Alternaria* leaf spot in plots sprayed with *P. fluorescens* CHAO strain and at the same time there was increase in disease incidence in the control plots. However, there was no significant difference among treatments for disease incidence, yield and fibre quality.

P1- 89/1- ICR- H20/ 0430:

Studies on soil borne diseases of cotton (A Kannan, K N Gururajan and N Gopalakrishnan).

Eleven progeny derivatives involving Surabhi, Nail.85, PIL.8, VRS.16 and Suman were screened for resistance. All the progenies were found resistant. About 80 single plant selections were made. Based on economic characters and suitable fibre standards further advancement will be made.

CCH 342 (VLV.3) resistant to Verticillium wilt registered a mean seed cotton yield of 1695 kg/ha and was on par with Surabhi (CC). CCH 342 registered a mean 2.5% span length of 31.5 mm, micronaire of 3.9 and fibre strength of 22.0 g/tex.

P1-89/2-ICR-H20/0430:

Studies on bacterial blight of cotton (A. Kannan, P. Chidambaram and K. N. Gururajan).

Fourteen progenies involving 101-102B, Bandana-1, CBR.1, CBR.3, CNH.301, KH.121, TKKH.1, RHC.1694, Pisa-4515 and MCU.10 and 14 progenies having multiple disease resistance involving the parents CBR.1, IC.1301, CSH.1071, ALR.4, RR.1017 and CBR.3 were screened. Assessment for resistance could not be done even under pot house conditions as the weather was not conducive for disease expression. However, single plant population selected on the basis of boll numbers, economic characters and requisite fibre standards will be advanced.

National Agricultural Technology Project

MM III 17: Development of weather based forewarning systems for crop pests and diseases - COTTON

Nagpur - (S.Vennila)

Population dynamics of *H .armigera* as well as *P. gossypiella* through step down regression showed significance of only the lagged weather factors and hence they should be useful in forecasts. Models predicting the build up of *H. armigera* as well as *P. gossypiella* resulted in prediction of higher mean moth catches compared to that observed during the season. Standard week wise predictions for *H armigera* as well as *P. gossypiella,* signified under and over predictions for early and late seasons, respectively. During the peak period of abundance too there was under estimations for *H. armigera* and the week wise comparisons of predicted and observed moth catches could nowhere be similar indicating the inability of weekly forecasts to serve the purpose of forewarning.

Method of comparing normal and epidemic weather factors as well as moth catches for *H.armigera* to formulate criteria for its outbreak revealed greater than 70 % relative humidity during August-September months and un-seasonal rainfall with excess and / or more rainfall during the season distributed on many rainy days, and rainfall amount more than 50 mm during October as driving conditions towards outbreak. For *P.gossypiella* , greater than 33°C maximum temperature, less than 70% morning relative humidity, greater than 40 % evening relative humidity and less than 12°C minimum temperature during standard weeks of 40, 41, 43 onwards, 48 and 49, respectively led to the severity in its attack. Two locations within same geographical zone had varying scenario with different prediction equations towards build up of the monophagous *P.gossypiella* indicating the crop growth variables to be critical in population growth. The prediction for onset of *H. armigera* oviposition on cotton, based on accumulated degree-days at Nagpur indicated the calendar year accumulation to be better than that of accumulation since crop emergence. The composite representation and tracking of mean seasonal abundance of *H. armigera* and *P. gossypiella* moths over years giving rise to normal and the current abundance along side, served to forewarn the build up of the pest more effectively than the mathematically treated approaches.

Sirsa - (P.Jeyakumar and D.Monga)

Among the sucking pests, the jassid population was more as compared to whitefly and crossed ETL in the beginning of season. The spotted bollworm larval population was less than the ETL. The highest boll damage (>14%) was recorded in the first fortnight of October. Among the diseases, *Alternaria* leaf spot and bacterial leaf blight incidence was negligible. Only CLCuV incidence upto 5 to 10 % was noted. Almost the adult catches in all the three bollworm traps were higher in the month of October. In light traps 76.4 % of light trap catch consisted of *Helicoverpa* adults in the month of April and May.

The prediction equation of Sirsa for whitefly based on one lag week log equation was fitting well to the current observed value of Hisar, as chi-square value is in agreement with this. No other equation of Sirsa was fitting well with the observed value. Almost all the prediction equations of Hisar based on its log transformed value were fitting well with observed value.

The graph showing the predicted and observed population of whitefly based on decade analysis can be used effectively for prediction of whitefly population (Fig.7).

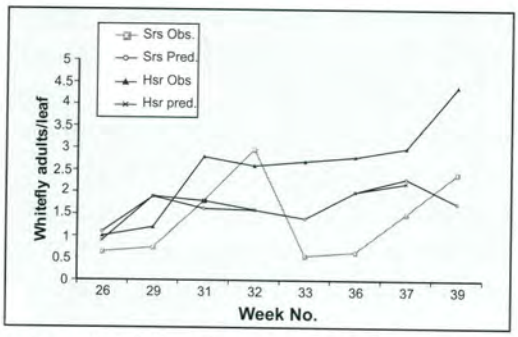


Fig. 7 : Validation of Decade analysis prediction equation of whitefly

PSR 26: Control of leaf curl viral disease in cotton and development of protocols for mass multiplication of predators, parasites and insect pathogens

Nagpur - (Sheo Raj and N. K. Taneja).

A protocol was developed to isolate DNA from cotton plants, which was used for developing molecular marker to identify resistance to CLCuV. Out of 20 primers of Operon Kit , USA, OPA 10 amplified the DNA of resistant and susceptible varieties showing different banding pattern of 0.5 to 2.3 kb.

Using the protocol standardized earlier for isolation of viral DNA during 2001-02 when 0.75 Kb DNA was amplified, another fragment of 1.2 Kb was also amplified during 12003-04. The amplified fragment (1.2 Kb) was cloned in plasmid p-Drive 322 vector (Quiagen TA cloning Kit). The fragment was sequenced by Bangalore Geni Pvt. Ltd., Bangalore and was confirmed with the help of the variable sequence as shown in Fig. 8a-e.

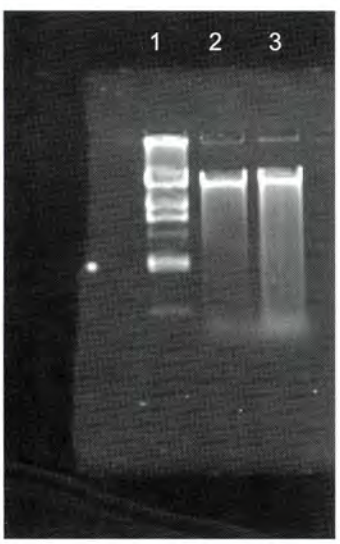


Fig. 8a: Lane 1, Lambda Hind III Marker, Lane 2 and Lane-3 Cotton Plant DNA

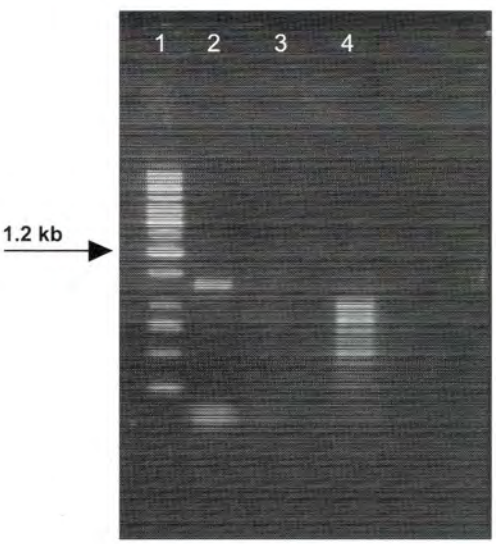


Fig. 8 b: Lane1; Marker 1kb ladder; Lane 2=Infected (HS-6) cotton; Lane 3=Healthy (HS-6) cotton; and lane 4 =100 bp ladder

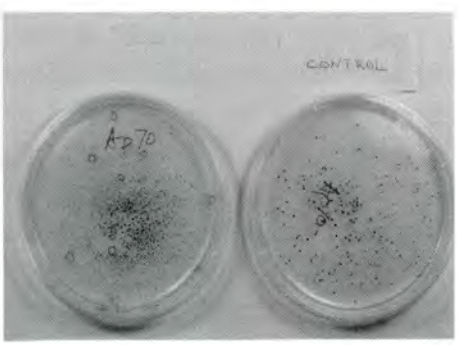


Fig. 8 c: Phage containing DNA-A clone probe from P drive 322 vector

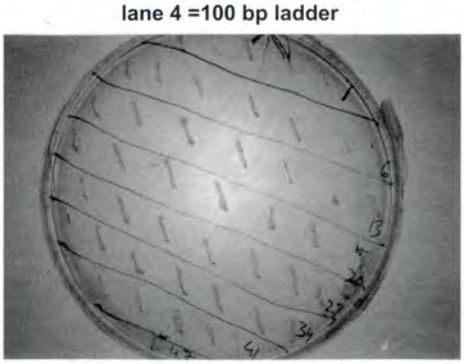


Fig. 8 d: Single colony containing DNA-A clone robe from Pdrive322 vector

Fig. 8 e: Lane: M=Marker; lane 1-19 Plasmid isolation of colony of vector DNA
Fig.8: DNA isolation, PCR amplification and cloning (1.2 kb) of CLCuV DNA

A protocol to isolate DNA from whitefly, *Bemisia tabaci* (vector of CLCuV) was standardized and PCR protocol also developed to study genetic variation in whitefly population. Studies showed that there exists variability among whitefly of different places (Fig. 9a & 9b).

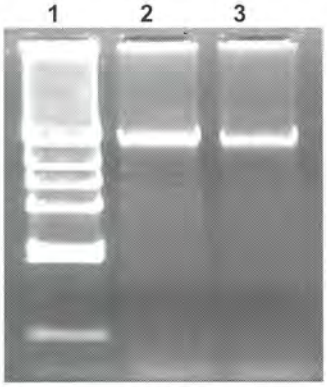


Fig.9a Isolation of DNA from Whitefly Lane 1 Lambda Hind III Marker: lane 2&3 Cotton white fly DNA

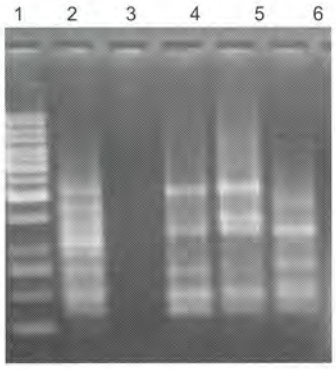


Fig.9b RAPD-PCR of white fly DNA Using molecular marker (OPA-11) showing polymorphism.
Lane 1. Lambda Hind III marker: Lane 2 to 6 white fly samples from : Nagpur : Dabawali: Sirsa: Ludhiana: Sriganganagar

Screening of more than 600 *Gossypium hirsutum* lines of different places showed 14 lines viz., Arkansas-61-28, B-57-100-CT, B-58-1372, B-59-14-14, B-59-1545, B-59-1679-2, B-61-2030, B-61-2050, BOSS-111, CC-29-2-3-20, Coker-100, CNH 911, CNH 2713 and CNH 4936 to be resistant to CLCuV and four lines namely, B-58-1372, B-59-1679-2, CB 2482-1 and DHY-286 tolerant to whitefly. However, B-58-1372 and B-59-1679-2 were tolerant to both.

Beauveria bassiana in liquid medium had a shelf life of six months maintaining the desired colony forming units. Bt production in liquid form using TYG medium and selective antibiotics was standardized. Maximum protein (92.45 gm) was realized when 18 lit. medium was inoculated with Bt (0.8 OD).

Sirsa - (D Monga and P Jeya Kumar)

Thirty one lines resistant to cotton leaf curl virus disease after screening for four years have been identified in the project. Similarly, fourteen lines were noted as tolerant (< one white fly/leaf) to white fly.

Four antisera received from UK and antiserum raised against CLCuV were tried to detect cotton leaf curl virus disease. Detection of CLCuV using coat protein primers (CPF - AATTATGTCGAAGCGAGC TGC+CPR-TAATATCAATTCGTTACAGA G, CRV-AV-TTACCGGATGGCCGCGCGATTT + CPR- TAATATCAATTCGTTACAGAG) to direct the amplification of CLCuV DNA fragments of predicted molecular sizes (750 bp and 1000 bp) was standardized.

The whitefly population was suppressed effectively by neem products (Nimbecidin and Gold Rakshak) compared to that of cotton seed oil. Among various insecticides, Acetamiprid, Difenthuron and Ethion were found effective in the management of whitefly compared to that of other synthetic insecticides. Imidacloprid seed treatment was found effective in the management of CLCuV compared to that of seed treatment with Thiomethoxam. Among the insecticides CLCuV incidence was very less (11.09 %) in Difenthuron treatment.

Technology Mission on Cotton

3.1 : Integrated pest management at village level to produce cost effective quality fibre (S. Vennila).

IPM with focus on biocontrol options was tested on hybrid Ankur-651 at Datala, Hingna tahsil, Nagpur district. The mean seasonal incidence of key insect pests and natural enemies indicated that sucking pests viz., jassids and thrips to be higher in need based chemical control (NBCC) than IPM fields. Spiders were found to be highly susceptible to insecticidal sprays and their population levels were less in NBCC fields. It was typical of *H. armigera* that its oviposition and larval incidence were higher in NBCC than IPM fields. With only three insecticidal sprays given to NBCC farms the season had less expenditure on insect control options and higher yields. As the season witnessed good production even without insecticidal sprays, IPM tools could not prove to be successful. *Hyptis suaveolens* Piot. (Lamiaceae (Labiatae): Lamiales) as a host plant of *H. armigera* between October and January months was reported for the first time, during this season.

While seed treatment with imidacloprid was found to be effective against jassids, thrips population was high. NSKE (5%) against sucking pests as well as bollworms was effective. Spider population was reduced with the use of chemical insecticides but not with NSKE. Effectiveness of *T. chilonis* against *Anomis flava* was inferred as superior over bollworms. Yield levels of need based chemical control were higher during the early picking while harvest was delayed with the use of IPM components.

Coimbatore - (T. Surulivelu).

Location specific IPM developed was further refined and implemented for production of cost effective quality fibre. It was ensured that crop diversity was maintained: cow pea as bund crop; castor / pigeon pea as trap crops; black gram / chillies as inter crop; maize and cow pea as border and eco-feast crops. Almost all the farmers erected bird perches and followed improved agronomic practices including fertilizer application based on soil testing in split doses. Use of neem and bioagents were encouraged. Cultural and mechanical measures were followed to eliminate the grown up larvae of *H. armigera* and the other bollworms. Chemical control was followed based on pest scouting and spray decisions based on economic threshold level.

Adoption of IPM measures helped to manage the major pests of cotton especially sucking pests and bollworms with reduced number of sprays from 6.8 to 1.96 and plant protection cost Rs. 6800 to Rs. 2000 /ha over control village. Besides, there was an yield increase of 20.0 % and a net profit of Rs. 12,240 /ha over control village farmers. Higher cost- benefit ratio of 1:2.3 was obtained by the project farmers as against 1:1.5 by the control village farmers. It was noted that the variety, Surabhi of CICR is well suited for this village and increased the seed cotton yield by 600 kg/ha over the existing varieties, LRA 166 and Rajat.

Sirsa - (P.Jeyakumar and D.Monga)

The village Rangri in Sirsa district was selected for developing IPM model farm in the fields of Shri Jeet Singh, selected for developing IPM nucleus farm.

IPM components adopted

- Farm yard manure application.
- Bamboo sticks (6' high) with antenna type arrangements were installed @ 3-5 sticks / acre to serve as dead bird perch
- The pheromone traps were installed for all the three bollworms for monitoring as well as mass trapping purpose.

- The neem seed powder (NSKE 5 %) and neem oil 0.3 % spray was done in alternation with synthetic insecticides to scare away bollworm adults.
- Besides, the insecticides such as Quinalphos, Alfamethrin and Rimon were sprayed.

Yield and cost : benefit ratio : Among all the entries, the maximum yield of 28 q / ha was noted in RCH 134 IPM plot. In IPM the yield of H-1098 was around 9 q / ha higher than that of corresponding non IPM. The highest C : B ratio of 1 : 4.67 was obtained in IPM plots of RCH 134 followed by 1 : 4.62 in H-1098. The increase in C : B ratio was mainly obtained because of 22 % reduction in spray and that too 4 out of 7 sprays consisted of least cost neem products.

Evaluation of different pheromone traps tied on the same bamboo: All the three pheromone traps were laid individually as well as in different combinations. All the pheromone traps performed well when they were evaluated individually as depicted in the figure. However, there was no significant difference between trap catches of same pheromone either placed individually or in combination. In case of *Helicoverpa,* the trap catch was less when tied with *Earias,* traps. For *Earias,* the traps were not performing well, when all the three traps were tied in a single bamboo, in comparison to its individual as well as their combination with any other trap. However, for pink, the difference was not much when it was laid out either individually or in combination.

3.2: Development of diagnostic tools for insect pests/ diseases

Nagpur - (M.K. Mehsram).

Ramularia areola

New synthetic media alone or in combination 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 pathogen was successfully cultured with well method, inoculation of healthy leaf tissue and inoculation of conidia in broth. The method of inoculation of healthy leaf tissue was found more advantageous for isolation.

The growth pattern and mycelial dry weight of 21 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 *G. herbaceum* cv. Jayadhar and *G. arboreum* (AKA-5) was comparatively smaller than that of *G. hirsutum* cv. SRT-1.

Eight isolates, two from the cultivars of *G. herbaceum* and three each from the cultivars of *G. arboreum* and *G. hirsutum*, were inoculated on 22 different cultivars belonging to four cultivated species of cotton. The isolates from *G. arboreum, G. herbaceum* and *G. hirsutum* were able to infect easily their respective hosts. However, *G. barbadense* lines were almost free to all the eight isolates. The variability in reaction of eight isolates to 22 different cultivars of four cultivated species indicated the existence of races/biotypes in *R areola*.

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

Fusarium oxysporum* f. sp. *vasinfectum

Seventeen cultures of *F. o.* f. sp. *vasinfectum* were isolated from different cotton growing areas of Maharashtra. Growth pattern, influence of salt concentration on growth and pigmentation of 17 isolates indicated the variability among

different isolates. Pathogenic variability of seven cultures was tested on susceptible cultivar G-27. The mortality varied between 40.00 and 100.00 per cent within 30 days of germination indicating the variability among the isolates.

Coimbatore - (P. Chidambaram, B. Dhara Jothi and N. Gopalakrishnan)

Ramularia areola* and *Alternaria macrospora

Grey mildew infected leaves were collected from Nagpur and Bellary (Karnataka) and grey mildew and alternaria infected leaves from various other places in Tamil Nadu.

Identification of variability through cultural, morphological and pathological tests

Various lines of *G. hirsutum* (6), *G. arboreum* (9), *G. herbaceum* (4) and *G. barbadense* (1) were raised in pots and inoculated with the isolates of *R.areola*. The *herbaceum* isolate was able to infect and produce typical grey mildew symptoms on the *arboreum* and *herbaceum* hosts and the susceptible *hirsutum* cv. LRA 5166 and not on *barbadense* cv. Suvin. The *hirsutum* isolate was able to infect only the susceptible *hirsutum* cv. LRA 5166.

Differential biochemical interaction for useful diagnostic tool development

Genotypes belonging to different species *viz.*, LRA 5166 (*G. hirsutum*), Suvin (*G. barbadense*), RAHS 119 (*G. herbaceum*) and Cernuum (*G. arboreum*) were inoculated with three different isolates of *R. areola*. The biochemical interaction during the post-inoculation period was monitored by measuring metabolic indicators. Differential response was seen due to effect of different isolates on the same host species as regards biochemical parameters are concerned. Notable peroxidase isozyme banding pattern differences could be observed due to virulence of specific isolates. Similar trend was observed in case of protein, phenol and proline content indicating differential response in secondary metabolism.

Nagpur - (P. K. Chakrabarty)

Xanthomonas axonopodis pv malvacearum

A simple and rapid PCR protocol was developed for quicker detection of *Xam* in axenic cultures or infected cotton by amplification of a 0.4 kb DNA fragment, without the need for extraction of DNA. Since the primer is designed to the critical region of the *pathogenicity/ avirulence* genes present in *Xam*, any strain of this pathogen, irrespective of their geographic origin or race designation can be detected. The amplification is fast and is accomplished within an hour and a half.

A pair of primer was designed to detect CLCuV in infected plants as well as symptomless host by amplification of a 0.7 kb coat protein (CP) gene of the virus. The CP gene amplified from infected plants was cloned in plasmid pDrive. The sequence of the gene is determined using primers for SP6 and T7 promoters and published in GenBank. The sequence analysis of CLCuV-Sirsa strain revealed variability in CP gene sequenced from other Indian strains of CLCuV. The CP gene is excised from pDrive plasmid and cloned in fusion protein expression plasmid pCal-n, having a calmodulin binding protein (CBP) tag. Pair of restriction enzyme sites, *Bam*HI and *Eco*RI, engineered in the primer facilitated cloning of the full-length gene at the corresponding sites in pCal-n vector resulting its translational fusion with CBP. The conditions for expression of fusion protein in *E. coli* were standardised. The CP was expressed best when induced with IPTG at 25°C. At 37°C most of the protein remain insoluble and gets localized in inclusion bodies. Expression of fusion protein is further ascertained by Western blotting of protein from polyacrylamide gel

onto the nitrocellulose membrane followed by its detection using anti-CBP antibody.

Besides PCR method, a new and simple tissue imprint blotting protocol for detection of CLCuV infection was developed. Twig imprints of the infected and healthy plants were obtained on nitrocellulose membrane. Imprinted membrane was incubated with anti-CaLCuV (Cabbage leaf curl virus) as primary antibody and goat antirabbit-AP conjugate as secondary antibody. CLCuV infected plants were detected by colour development or exposure to X-ray film by using chromogenic or chemiluminescence substrates, respectively.

Helicoverpa armigera (B. Dhara Jothi)

H.armigera larvae were collected from cotton, pigeon pea, chickpea, and tomato. from various location and maintained under laboratory conditions on artificial diet for further studies.

DNA extracted from 11 different populations was quantified by agarose gel electrophoresis using one-kb markers as standard. Polymerase Chain Reaction (PCR) technique was used to amplify the isolated DNA, using twenty random primers from Genei, Bangalore. Among the twenty primers tested amplification was observed only in A -15.

The larvae collected from different localities and crops were studied for the insecticide resistance. The larvae recorded high level of resistance for fenvalerate with 94.1 + 2.88 % survival followed by quinalphos with 51.0 + 7.22 survival. Endosulfan recorded minimum percentage of survival (50.8 + 6.56) and resistance.

Male genitalia were dissected and examined for the number of aedeagal spines to study the taxonomic differentiation between strains. The number of aedeagal cornutal spines varied from 11-14 and l0-11 in Coimbatore and Guntur population (Cotton) respectively. In tomato the number of spines varied from 10-15 and 12-13 in Nachipalayam and Bangalore populations respectively. In Bengal gram of Guntur region the number ranged between 10-11.

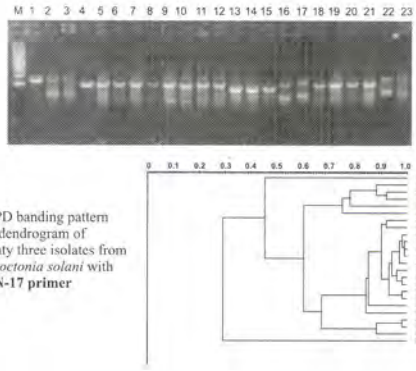
Sirsa - (D. Monga)

Rhizoctonia solani* and *Rbataticola

Morphology/Pathogenicity based differentiation of isolates :

Pathogenicity studies of *R. solani* isolates revealed that five isolates (HR-7, RJ-1, HR-3-10, RJ-3-6 and Rs Coimbatore) cutting across geographical boundaries showed 100% mortality. Minimum mortality was shown by isolate HR-4. All other isolates showed mortality in between this range. The highest pathogenicity was shown by isolate RJ-28 (83.3%) followed by HR-3-6, HR-3-10 and IHG-32 and lowest by isolates HR-15,16 and HR-3-7 (16.6%).

Molecular grouping : Based on RAPD, dendrogram and matrix, the 23 *Rhizoctonia solani* were categorized into four groups using OPN-17 primer. Similarly *R. bataticola* isolates were put in five groups with OPM-12 primer.



RAPD banding pattern and dendrogram of twenty three isolates from *Rhizoctonia solani* with **OPN-17 primer**

3.3 : Commercialization of bioagent mass-production technologies in intensive cotton districts (Nandini Gokte -Narkhedkar).

Modification of Wout's protocol with substitution of Pork fat for vegetable oil was found to give better yield of all isolates of EPN, *Heterorhabditis indicus*. Pork fat at 5% was found to give better yield of

nematodes at the rate of 5% as compared to 1%. Initial studies indicated that minimum of 60% RH is required for efficient mass production of EPN. Factors influencing change of phase of bacteria symbiotic with EPN was studied as this has bearing on success of mass production protocols. These bacteria exist in two phases. Primary phase is better producer for nematode production while secondary phase does not support good production of nematodes. Primary phase is known to change spontaneously to secondary phase. Results indicate that factors as media composition and ph was found to influence phase change. Temperature preference of bacterial symbiont was found to be in synchrony with that of host nematode. Metabolites released by nematodes were also found to serve as cue for phase change in conditions of overcrowding.

MM-II : **Dissemination of Insecticide Resistance Management** (K. R. Kranthi, S. K. Banerjee and Sheo Raj).

The IRM strategies were implemented in 331 villages of 27 districts, in an area of 13,816 hectares, with 5372 farmers. Resistance monitoring was carried out this year in all the participating states, except Gujarat. On an average there was an overall 49 % reduction in the number of sprays accounting for a 46% reduction in plant protection costs. Implementation of the technology resulted in an average net profit of Rs 8400/- per hectare. The project is being continued for the third successive year and is expected to establish IRM strategies in a sustainable form for effective cotton pest management in the country.

Coimbatore - (T. Surulivelu)

Insecticide resistance monitoring was carried out in Coimbatore during 2002-04. The study revealed that the resistance was at the highest level in the pyrethroid - fenvalerate (93.5 %) whereas it was low to moderate in endosulfan (31.3 %) and quinalphos (46.9 %).

Insecticide resistance management strategies developed and evaluated in the previous years further refined and disseminated in 363 farms in 20 villages of Coimbatore and Theni districts has resulted in effective management of cotton pests and improved profitability of cotton cultivation. Average boll damage in the farms of project villages was 8.5 as against 22.0 % in the farms of control villages. Number of sprays and quantity of insecticides used per unit area were reduced by 55.3 and 72.1 % in the farms of project villages as compared to farms in control villages. Further it also resulted in increase of seed cotton yield by 24.6 % and higher Cost : Benefit ratio, 1 : 2.2 as against 1 : 1.5 in control villages (table 12).

Table 12 : IRM impact and economics in project and control villages

Parameters	Coimbatore		Theni		Mean	
	Project villages	Control village	Project villages	Control village	Project villages	Control village
Open boll damage (%)	9.0	23.2	8.0	20.7	8.5	22.0
No. of sprays	3.0	7.2	3.8	8.0	3.4	7.6
Quantity of insecticides (g a. i. / ha)	1072	3840	-	-	1072	3840
Yield (kg / ha)	1680	1430	1820	1380	1750	1405
Net profit (Rs/ha)	24284	12850	26020	9880	25152	11365
C : B ratio	1 : 2.2	1 : 1.5	1 : 2.2	1 : 1.4	1 : 2.2	1 : 1.5

Sirsa - (D Monga and P Jeya Kumar)

One thousand and ninty five farmers from thirty villages of Sirsa, Hisar and Fatehabad districts participated in the project. There was reduction in pest population and increase in beneficial in the fields of participatory farmers' fields. A reduction of 43-53 % insecticides compared to non-IRM villages was also observed. The cost of plant protection in IRM villages was reduced by Rs. 2704-2852 over non IRM villages. The net profit of IRM farmers over non IRM farmers ranged from Rs. 3237-11327. Though , there was no drastic increase of seed cotton yield in IRM over non-IRM farmers the C: B ratio of IRM farmers ranged from 1:3.54-1: 4.63 compared to 1:2.80-1:3.73 in non participatory farmers.

Resistance monitoring : Two doses each of spinosad (1.0 and 1.5 µg/µl) and cypermethrin (0.1 and 1.0ug/ul) along with fenvalerate (0.2µg. µl), endosulphan (10.0 ug / ul), quinalphos (0.75 µg/µl) and methomyl (1.2 µg/µl) were used for bioassay studies in insecticide resistance monitoring. The maximum resistance of more than 80% was observed againt cypermethrin 0.1 µg/µl followed by cypermethrin 1.0 ug/ul and fenvalerate 0.2 µg/µl. The resistance of 1-7% was also noted against spinosad in Sirsa and Hisar districts. However, in Fatehabad it was nil. The resistance against endosulphan was nil in Sirsa district however it was 18-46 % in IRM villages in Hisar and Fatehabad districts. In the same way the resistance against quinalphos 0.75 µg/µl was 13 % in IRM villages in Sirsa, but it was 68 and 56 % in Hisar and Fatehabad districts. Insecticide resistance was 5-20 % higher in non IRM villages as compared to IRM villages.

AP Cess Fund :

Studies on the effect of insecticides on cotton plants and their interactions with American bollworm *Helicoverpa armigera* (Hubner) and its parasitoid *Campoletis chlorideae* Uchida (S.Vennila and M.Chakrabarty).

Dynamics of growth and development of NHH 44 in relation to insecticidal treatments showed that the absence of sucking pest control allow for more compensation by the crop than with sucking pest control. However, lateness in crop development results in increased exposure to late season bollworms leading to yield reduction. Variations in allelochemicals and nutritional factors in relation to insecticidal treatments over plant parts as well as age of crop growth only confirmed the findings that interactive environmental forces are dominant making it impossible to single out the effect of the insecticides.

Cultivar - insecticides and *H. armigera* interactions demonstrated that the larval mortality was the least with imidacloprid seed treated crop over all other treatments. The low mortality otherwise high survival of *H.armigera* in sucking pest control + bollworm control treatment over bollworm control clearly indicated the enhanced survival favoured by the seed treatment. The higher mean number of days to mortality among sucking pest control treatments over the bollworm and no control situations reiterated the enhanced *H.armigera* survival and presaged higher damage due to it. Increased biological fitness of *H.armigera* on the systemic insecticide treated plants was confirmed.

The parasitisation by *C. chlorideae* during the first generation of *H. armigera* was higher. However, during the peak period of larval population on cotton the parasitisation was almost absent. The availability of preferred age class of the host instars in relation to insecticidal treatments leading to differential parasitisation was inferred indicating the influence of insecticidal treatments on the host parasitoid synchrony. Host selection by the parasitoid was seemingly associated with host habitat. Diploids had higher parasitisation levels of

H. armigera than the hisutum / hybrids under laboratory conditions.

Biochemical analysis was carried out for amino acid, flavanol, total phenol, gossypol and reducing sugar content in different plant parts in five different cultivars like PKV Hy 2, NHH 44, CNH-36, LRA 5166 and AKA 8401under pot house and field and cage experiment after effect of insecticide spray.

Under pot experiment with the variety LRA 5166, each of the 30 samples were analysed for the five biochemical parameters and it has been observed that the phenol and flavanol content of all the plant parts decreases with insecticide spray at all the growth stages whereas gossypol decrease was not notice at initial stage. Amino acids and reducing sugars always showed a per cent increase after the spray.

Under field experiment, five cultivars PKV Hy 2, NHH 44, CNH 36, AKA 8401, LRA 5166 were tested and in all cases, all phenolic components (total phenol, gossypol and flavanol) showed a decrease in the insecticide treated plots as compared to untreated plots while amino acids and reducing sugars were found to increase in the former.

Under cage experiment with NHH 44, gossypol showed an increase at 30 DAS and amino acids showed a decrease.

Thus, the data showed a very uniform trend for all the cultivars, though the extent of decrease or increase vary with the variety/ hybrid and the treatment.

Use of Entomopathogenic nematodes for biological control of cotton bollworm, *Helicoverpa armigera*

(Nandini Gokte-Narkhedkar and S. K. Banerjee).

Results of field trial with EPN at the rate of 1 billion nematodes/ m2 confirmed efficacy of EPN against *H.armigera* and semilooper achieving about 55-58% reduction in population. A study on feasibility of EPN use in pesticide treated field indicated that infective juveniles were found to tolerate most of the pesticides tested. Two optical brighteners, Ujala and Ranipal, were found to offer protection against UV radiation and infectivity was not impaired. Addition of 0.1% detergent was able to keep more than 70 % larvae afloat in suspension used for field application without any impairment of viability. Of the three formulations tested for viability and infectivity of *H. indica*, viability was better in suspension with slurry close behind . Influence of environmental factors on expression of symptoms in *Corcyra cephalonica* (Rice Moth) larvae infected with *H. indica* was studied. Minimum humidity was recorded to be the critical factor in expression of symptoms. Nematode population development and build-up was very poor in a symptomatic larvae while larvae showing symptoms recorded better nematode build up and development.

DBT Projects :

Genetic improvement of strains of entomopathogenic nematodes for tolerance to environment and enhanced efficacy against *Helicoverpa armigera*, cotton bollworm

(Nandini Gokte-Narkhedkar and S. K. Banerjee).

Work was initiated on quantification of variation in tolerance to different temperature regimes in sixteen isolates of EPN isolated from cotton growing ecosystems and found effective against cotton insects particularly cotton bollworms. EPN isolates were subjected to different temperature stress regimes for 24 h and viability of infective juveniles and their infectivity to *Corcyra cephalonia* was quantified. Variability ranging from 30-34 °C was found to exist in EPN isolates with regard to temperature tolerance. Optimum temperature for most of isolates was found to range between 25-30°C, barring one isolate of EPN *Heterorhabditis indica*

which was found to be stable at 32°C. This isolate could be made to tolerate high temperatures by periodic exposure and selection of individuals that can tolerate it.

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

A model 'Bt-Adapt' was developed to simulate the rate of resistance development of *H. armigera* to Cry1Ac under Indian farming conditions. The model integrates genetic and ecological parameters of *H. armigera* in relation to its response to the Cry1Ac expressing Bt cotton. Simulation analysis showed that relative survival rate of the Cry1Ac resistant homozygous (RR), heterozygous (RS) and homozygous susceptible (SS) *H. armigera* genotypes on Bt cotton, was the most important factor influencing resistance development. Other factors those had the greatest impact on resistance development were, the relative proportion of area under Bt cotton, dominance of the resistant allele and initial frequency of resistant alleles in field populations. The extent of population reduction in Bt cotton and non-Bt crops due to pest control, was found to have a significant impact on the rate of resistance development. Simulation studies showed that cultivation of Bt cotton in 10, 20, 30 and 40% of the total area under cotton, is likely to result in resistant allele frequency reaching 0.5, which would be adequate to cause crop failure, after 54, 25, 16 and 11 years respectively if no pest control measures were adopted in both Bt cotton and non-Bt crops. With a pest control efficacy of 0.9 in Bt cotton and 0.5 in non-Bt crops, it would take 70 and 45 years for resistant allele frequency to reach 0.5 with the Bt cotton area at 30 and 40% respectively. Based on the simulation analysis, resistance management strategies are proposed with emphasis on reducing populations of *H. armigera* that survive Bt cotton and enhancement of area of alternate host crops that are as attractive as cotton to *H. armigera*, to be used as trap crop or intercrop refuges.

Externally Funded Project

NRI/ICAR/CFC/ICAC/14 :

Sustainable control of the cotton bollworm, *Helicoverpa armigera* in small scale production systems (K. R. Kranthi and Sandhya Kranthi).

Resistance monitoring was carried out for Cry1Ac, Cry2Ab, pyrethroids, methomyl, endosulfan, indoxacarb, Novaluron and quinalphos from twenty eight *H. armigera* strains collected from across the country. Six near-isogenic lines were generated through recurrent back crossing of a multiple insecticide resistant strain with insecticide susceptible as the recurrent female parent. The progenies to determine the linkage or synteny association between resistance traits. RAPD was carried out with 120 primers for each of the six near-isogenic lines and the susceptible parent to identify molecular markers. Three to seven primers were identified as being useful in amplifying DNA fragments unique to the near-isogenic lines. The markers were validated through phenotypic cosegregation of the RAPD amplicons on BC_1 progeny, and at least two RAPD bands per each near isogenic line were isolated as true co-segregating markers. PCR amplification of RAPD amplicons was carried out for parents and resistant BC_5F_2 progeny. Several unique polymorphic bands were identified in the near isogenic strains. The primers were tested on BC_1 (SS? X RS?) mapping population to validate the co-segregation of the markers with phenotypic resistance. The resistance associated amplicons were cloned and

sequenced. It was also clear that the methyl phosphorothiate or the methyl phosphate group of insecticides were not very strong inhibitors of the esterase isozymes. However, dichlorvos (methyl phosphate) and methyl parathion (methyl phosphorothiate) were the only two exceptions that inhibited five and four isozymes each respectively.

The PAGE gel studies showed that dichlorvos, methomyl, phoxim, carbaryl and bromophos were sequestered by 11, 9, 8, 7 and 6 isozymes respectively. The pattern of sequestration was very similar in methomyl, phoxim, carbaryl and bromophos with isozyme numbers 3, 5, and 9-13 sequestering them. Dichlorvos was sequestered by all isozymes except isozyme numbers 9 and 10. The information was used to identify esterase isozymes involved in resistance to the various insecticides. The unique esterases that were involved in inhibition or sequestration were used as antigens to immunize rabbits. The antisera was used to develop ELISA and dip-strips to detect resistance to various organophosphate and carbamate insecticides. A blot assay was developed to detect carbamate resistance through selective inhibition of resistance-unrelated isozymes on nitrocellulose blots. The assay was tested on field populations to correlate with bioassay data.

Esterase isozymes were characterized from each of the near isogenic lines and 13 isozymes from each strain were purified. Inhibition kinetics were worked out for all the isozymes with 14 organophosphate molecules, two carbamates, two pyrethroids and endosulfan. Two unique esterase isozymes for pyrethroid, one for methomyl and one for organophosphate were confirmed to confer resistance. Antisera were raised against four new insecticide immunogens and strips to detect spurious insecticides were designed.

An immunochromatographic strip to detect cypermethrin quality has been validated on formulations and is ready for commercial release. An Immunochromatographic strip test to detect carbamate resistance was developed and validated for its correlation with diagnostic dose data. The kit is ready for commercial release. Both kits are simple, reliable and user friendly. The tests take 10 minutes for conclusive evidence on cypermethrin quality and also to diagnose carbamate resistance.

Aventis Funded Project

Studies on resistance breaking properties of Triazophos in combination with deltamethrin on pyrethroid resistant *Helicoverpa armigera* (K. R. Kranthi).

Triazophos was found to synergize deltamethrin. The main mechanism of synergism was due to the *in-vivo* oxidative activation of triazophos to its oxon form, which is one of the most strongest inhibitors of AChE and carboxylesterases. An esterase isozyme E-6 was found to be specifically associated with deltamethrin resistance and was strongly inhibited by the oxon form of triazophos. Kinetic inhibition experiments were conducted with several pyrethroids resistant strains which had oxidases or esterases or both as the predominant mechanisms.

Indofil Funded Project

Biochemical and ecological factors influencing the toxicity of Novaluron on the cotton bollworm *Helicoverpa armigera*. (K. R. Kranthi).

Bioassays were carried out on a susceptible strain of *H. armigera*, and field strains collected from cotton fields. Log linear regression analysis was used to determine median lethal concentration (LC_{50}). There were severe growth regulating and larval mortality effects (60-90%) in control larvae of 40 and 44°C. Therefore the data were not

considered for probit analysis. The results clearly show that temperature had little role to play in altering the toxic effects of Rimon on *Helicoverpa armigera*. The data presented for LT_{90} values, cleary showed that in most of the field strains 90 % kill was observed between 3-5 days in the treatment that had the field recommended rate of 0.1% Rimon. By the end of the 7-day assay period, almost all the strains responded with a 92-100% mortality at 0.1% concentration treatment of Rimon. At concentrations of 0.01% the average range of time for 90% kill was about 5-9 days and for 0.001% it was 8-12 days. The results with third instars also indicated that the time related mortality was almost similar to that of the first instars. There was a 50% mortality response by 1.7-2.2 days and 90% mortality at 3-4 days with Rimon treatment of 0.1%. The possibility of pH having an influence on the susceptibility of *H. armigera* to Rimon, was ruled out. The results showed that mixed function oxidases can play a significant role in altering the susceptibility of *H. armigera* to Rimon and probably other related molecules.

Mahyco Funded Project

Monitoring for shifts in baseline susceptibility (development of tolerance/resistance) in the cotton bollworms (*Helicoverpa armigera, Pectinophora gossypiella* and *Earias vittella* against Cry 1A(c) toxin in various cotton growing regions of the country (Sandhya Kranthi and K. R. Kranthi).

Shifts in baseline susceptibility were monitored in a diet based bioassay method in *Earias* sps and *H.armigera* collected from 15 cotton-growing districts. Bollworm cultures from Gujarat were tested for the first time for their susceptibility to Cry1 Ac. Larvae were collected from 12 districts of northern and central regions of India during September and November 2003. Besides cultures from Warangal, Karimnagar and Khammam from A.P. were also collected. Toxicity of Cry1Ac to *Earias vittella* ranged from 0.006 to 0.105 ìg/ml of diet. The composite LC_{50} value from 19 bioassays was found to be 0.024 ìg/ml.

H. armigera larvae were collected from all over the country during the cropping season of 2003. Larvae were collected from only non-Bt-cotton fields in regions where Bt-cotton was being cultivated. The laboratory strains of *H. armigera* from Central and South India were established from the field-collected larvae. A susceptible *H. armigera*, strain was established from isofemale lines at the insectary and was used as a baseline susceptible strain for comparison.

The susceptibility of *H. armigera* to Cry1Ac does not appear to have undergone any significant changes over the previous two years of resistance monitoring. The log dose probit assays showed a consistent conformity to the baseline toxicity values established in India. The LC_{50} values ranged from 0.04 to 0.38 g Cry1Ac/mL of diet to indicate a 10-fold variability in the field strains across the country. The results showed that there have been no changes as yet in the overall susceptibility of *H. armigera* to Cry1Ac. The bioassays showed that all the strains collected from Gujarat were found to be well within the baseline susceptibility range thus far.

Plant Physiology & Biochemistry

Nagpur

Physiological evaluation of cotton germplasm under rainfed conditions

(M.R.K. Rao and N.K. Perumal).

Ninety five *G.hirsutum* and 50 *G. arboreum* lines were evaluated during the year for growth, physiological and yield attributes alongwith characterization of frame in some selected lines. Considerable variability was evident in both the species for most of the growth related traits such as height, number of sympodia, monopodia, leaf area, dry matter accumulation and apportioning and physiological characters such as relative water content, SLA, SLW, photosynthetic rate, transpiration rate, leaf temperature and stomatal difference resistance. Similarly, morpho-frame of some of the selected genotypes in both the species showed considerable variability. Top ten lines for some of the important growth, yield and physiological attributes were categorized and lines with a combination of desirable traits were culled out from amongst the top ten lines in both the species.

P1 89/ICR F.60/0430:

Physiological and biochemical studies on abiotic stresses with particular reference to heat and drought in cotton

(N. K. Perumal and M. Chakrabarty).

Seventeen cotton genotypes belonging to three species- ACC 6779, ACC 6783, ACC 6788, ACC 6828, ACC 6834, ACC 6831 (*G.arboreum*), E 2-13 X D 133-12-6, DH 110-10 X SM 06,SM 28, KFT 12-2-5, Russian 5 (*G.herbaceum*), Boss III, EL 613, E.Wing X Tide water, P 15, 150-3-1-7, JK 97 286 D (*G.hirsutum*) were screened for drought tolerance. *Hirsutum* genotypes maintained significantly higher stomatal resistance and lower transpiration rate resulting in higher leaf relative water content and leaf water potential. *Desi* genotypes possessed relatively lower stomatal resistance and leaf water potential with higher transpiration rates. Leaf epicuticular wax content remained relatively higher in *hirsutum* lines. Root/shoot ratio was found to be higher in *herbaceum* genotypes, particularly in E 2-13 X D 133-12-6. Seed cotton yield remained lower in *herbaceum* genotypes under stress environment. Yield stability was more pronounced in Asiatic genotypes. The screening of genotypes revealed that the following genotypes possessed relatively higher drought tolerance-ACC 6834, ACC 6779, ACC 6831, ACC 6828 (*G.arboreum*), DH 110-10 x SM 06, KFT 12-2-5 (*G.herbaceum*) and E.wing x Tide water, EL 613 (*G.hirsutum*).

Analysis carried out for nitrate reductase, peroxidase and catalase activity in 18 cotton germplasm lines of three different species under control and moisture stress conditions revealed that *arboreum* lines show better tolerance to drought.

Physiological and biochemical basis of salinity tolerance in cotton

(K. B. Hebbar).

Eleven cultivars of *G.hirsutum,* two each in *G.arboreum* and *G. herbaceum*, three hybrids, 23 germplasm lines and a derivative of a cross with wild species were screened for salt tolerance at 0, 5, 10, 15 and 20 d S m^{-1} NaCl concentration in pot culture. The yield decline per unit increase in salinity was more in hybrids and *G.hirsutum* compared to *G. arboreum, G. herbaceum* and germplasm lines. Thus, inspite of having higher yield under control in NHH 44 and PKV Hy2 they had a low yield under salinity.

Amongst the yield attributing characters, boll number was more sensitive to salinity than boll weight. Higher boll number in tolerant genotypes was not contributed by

higher square production but by lower square production and higher square retention. Biomass production was negatively correlated with square production in tolerant genotypes while it was positively correlated in sensitive genotypes suggesting irrespective of biomass production tolerant genotypes had better biomass partitioning towards yield. The stability in biomass production of tolerant genotypes was not contributed by leaf area of the plant but the photosynthesis rate (Fig.10). Tolerant genotypes accumulated higher amount of osmolytes like proline and K in their leaves. Stress responsive hormone ABA (abscisic acid) content had increased with salinity. Similarly, the tolerant genotypes possessed higher activity of antioxidant enzymes like peroxidase and catalase in their leaves.

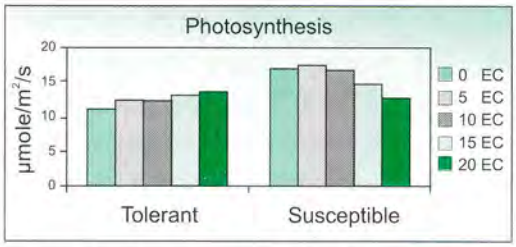


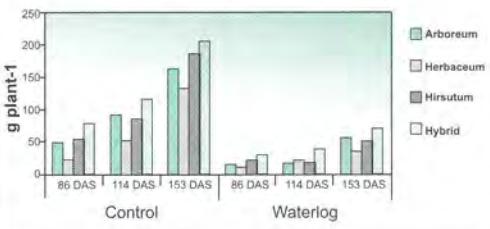
Fig.10 : Photosynthesis of a tolerant and a susceptible genotype at different salinity levels

Physiological and biochemical basis of waterlogging tolerance in cotton

(K. B. Hebbar).

Twenty four cultivars and hybrids were screened for waterlogging tolerance under field condition. When the plants were 64 days old, two strips were waterlogged due to heavy rains for a period of 21 days. Another two strips were waterlogged when the crop was 135 days old for a period of 15 days by applying irrigation water. Waterlogging at early stages (64 DAS) reduced the yield in all the cultivars and hybrids. On the other hand yield was either on par or slightly more than control when the plants were waterlogged 135 DAS. As demonstrated earlier, *arboreum* and *herbaceum* genotypes were more sensitive to waterlogging compared to hybrids and *G.hirsutum* varieties. At the end of the waterlogging treatment (86 DAS) biomass accumulation was reduced by nearly 75 % and the subsequent recovery in biomass production was rather very slow. (Fig. 11). Inspite of having low biomass in waterlogged plants, hirsutum genotypes showed less reduction in yield, suggesting better partitioning of biomass towards yield.

Fig. 11 : Total dry matter



Source-sink alteration with reference to flower induction as a tool to improve physiological efficiency and productivity in cotton

Nagpur - (K. B. Hebbar).

A field experiment was conducted during 2003-04 cropping season under rainfed condition to study the effect of sink manipulation on cotton productivity. *G.hirsutum* variety LRA 5166 and intra *hirsutum* hybrids H6 and NHH 44 were sown on 19/06/03 at a spacing of 60 x 30 cm and 60 x 60 cm respectively. Square initiation was recorded in all the plots. The incessant rains during square initiation delayed the imposition of treatment. Hence, the square removal treatment was continued for only 5 and 10 days instead of 10 and 20 days respectively. Ethrel (0.01, 0.1, 0.2%) was sprayed at square initiation (60 DAS) and 10 days after square initiation (70 DAS).

Mechanical removal of early-formed squares led to synchronized square and flower production at later stages and contributed more to yield. Delayed squaring enabled the plants to have more number of sympodia and thus higher square

production and better control of insect pests since the fruiting period was shortened.

Coimbatore -
(A. H. Prakash, N. Gopalakrishnan)

There was a significant improvement in yield with application of ethrel at 35 DAS. In LRA 5166, the highest yield of 2076 kg/ha was observed with Ethrel 45 ppm as against 1428 kg/ha obtained in the control. In Sumangala, Ethrel 60 ppm recorded the highest yield of 1112 kg/ha as against 816 kg/ha of the control.

Application of two sprays at 35 and 45 DAS irrespective of the ethrel concentration brought about total change in the crop growth and also made the plants highly susceptible for sucking pests. The NR activity was significantly higher in all the treatments compared to that of control. The enhanced activity of NR led to higher accumulation of reducing sugars and proline even after 80 DAS.

Maleic hydrazide applied in cotton genotypes LRA 5166 and Sumangala at 90 and 100 DAS @ 500 and 1000 ppm overcame apical dominance leading to sprouting of lateral buds and the plant became bushy. The LAD was enhanced by 15-20 days.

Coimbatore

P1-95/ICR-F-25/0430 :

Physiology of fibre growth and development (A. H. Prakash, S. E. S. A. Khader and N. Gopalakrishnan).

Partitioning of the photosynthates revealed that the fibre elongation is directly correlated to the ratio of reducing sugars accumulation between fibre and seed. The higher the fibre to seed ratio during the elongation period, longer will be the fibre produced. But higher the IAA oxidase and peroxidase enzymes, shorter will be the fibre produced.

Effect of different media combination and phytohormones on the biochemical constituents of *in vitro* cultured ovules of DCH 32:

From the results, it can be concluded that 0 DAA ovules of cotton cultivar DCH 32 cultured on BT medium with NAA (10 mg.L) + GA (0.5 mg.L-) was found to be ideal for *in vitro* fibre development studies. The elongation of fibre finally observed was an effect of enhanced accumulation of biochemical constituents viz., reducing sugars, amino acids and total soluble proteins and minimal activity of IAA oxidase and peroxidase. A fibre length of 8-10 mm was achieved under in vitro conditions in the present study.

P1-95/1-ICR-F60/0430 :

Identification and utilization of adaptive responses to abiotic stress in cultivated species of cotton (S. E. S. A. Khader, N. Gopalakrishnan and K. N. Gururajan).

Forty two genotypes of cotton were screened using ten physiological indices and tested. The most tolerant genotypes were Anjali, Anjali Kgl, AC.241, IC.379 and H.777, while susceptible genotypes were Khandwa, DCI.126, CNHPT.5, Supriya and Kanchana. The photosynthetic rate was significantly lower under stress condition compared to irrigated condition irrespective of the genotypes. The photosynthetic activity was relatively better in tolerant genotypes under water stressed situation when compared to susceptible genotypes. The maturation of the crop was advanced by 10-15 days in genotypes subjected to water stress than irrigated conditions. However, the tolerant genotypes were not affected significantly due to water stress in terms of yield. The mean average yield per plant across genotypes was 36.8 for irrigated control plants compared to 35.2 g/plant in water stressed situation which was statistically non significant with a cv. of 14%. On the contrary, the susceptible genotypes recorded an average yield of 41.4 g/plant under irrigated control

compared to 36.1 g/plant under water stressed treatment which was statistically significant.

In another experiment, the cotton plants were exposed to dew fall at night in water stressed and irrigated field. The photosynthetic activity increased gradually from 4.0 µ mol CO_2 m^{-2} s^{-1} at 8.00 hours and attained its peak activity between 12.00 and 14.00 hours (17.1 µ mol CO_2 $m^{-2}s^{-1}$) and declined rapidly to 5.5 µ mol CO_2 m^{-2} s^{-1} by 16.00 hours. The mean photosynthetic rate calculated over the day was on par for plants either protected or unprotected from dewfall. Interestingly, plants grown under water stressed condition benefitted significantly with dewfall. Irrespective of the dew fall, plants grown under irrigated conditions were superior in photosynthesizing capacity with an overall mean value of 12.4 µ mol CO_2 $m^{-2}s^{1}$ compared to 10 µ mol CO_2 $m^{-2}s^{1}$ in plants grown under un-irrigated condition. Dewfall helped plants grown under un-irrigated condition to increase their relative water content from 79% at 16.00 hours to 85% in the morning hours (8.00 hours). This significant increase of 6% in relative water content in the leaves help the plants to sustain their photosynthesizing capacity significantly.

P1 92 / 1-ICAR F 60 / 0430 :

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

(S. E. S. A. Khader and N. Gopalakrishnan).

Suvin raised under elevated carbon dioxide atmosphere of 650 + 50 ppm was protected from dew after 100 days of sowing and photosynthetic rate was monitored throughout the day, which in general, increased from 4.7 µ mol CO_2 $m^{-2}s^{1}$ at 8.00 hours and attained its peak activity between 12.00 and 14.00 hours and declined rapidly to 6.6 µ mol CO_2 $m^{-2}s^{1}$ by 16.00 hours . Plants grown under elevated CO_2 atmosphere always photosynthesized significantly at a higher rate than ambient grown plants (11.4 µ mol CO_2 $m^{-2}s^{1}$ as against 9.4 µ mol CO_2 $m^{-2}s^{1}$). However, with passage of time, the photosynthetic rate increased significantly over the plants that were protected from dewfall and compensated for the set back earlier during the day.

P1-89/1-ICR/F60/0430:

Studies on biochemical mechanisms of resistance to bollworms of cotton

(N. Gopalakrishnan and T.Surulivelu).

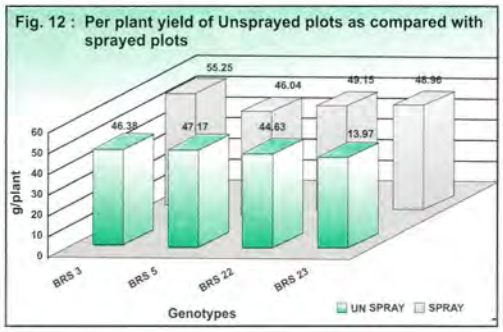
It was seen in biochemical characterization of advanced bollworm tolerant genotypes that genotypes HGIPS.542, BRS.3, BRS.5 and BRS.22 possessed higher levels of secondary metabolites as compared to checks LRA 5166 and MCU 5 VT. Five tolerant germplasm lines viz. HS.22-29, RBC.39, 70 E, JK.97, IC.481 were seen to contain higher condensed tannin and phenols (18-30 mg/g) in squares and also in seeds during reproductive phase.

Higher levels of terpenoid metabolites and phenols were seen in bolls and rinds of tolerant lines during boll development stage. Introgressed lines IRHII,12-32-HS, IRH-I-4 exhibited lesser damage by bollworms and had higher phenols, tannin in boll rinds.

The yielding ability of bollworm tolerant genotypes such as BRS.3, BRS.5, BRS.22 and BRS.23 were comparable with yield level ranging between 45 - 55 g/ plant under both protected and unprotected conditions under limited field conditions for the second year of trial, suggesting the inherent tolerance to bollworms (Fig. 12).

RAPD analysis was carried out in a set of hybrids developed using wild species and popular genotypes besides the parental genotypes. Hybridity confirmation and introgression of genomic regions from wild male parents in hybrids was

established.



P1-97/1-ICR-F60/0430:

Studies on developmentalbio-chemistry of cotton pest / disease interaction (N. Gopalakrishnan, T. Surulivelu, K. Natarajan and P. Chidambaram).

Induced systemic resistance due to application of *P. fluorescens* Pf1 was studied prior to inoculation with isolates of *Ramularia areola* in cotton genotypes. Two fold increase in peroxidase activity and superoxide dismutase could be noticed in susceptible genotypes and enhanced activity was also seen during challenge inoculation with isolates of *R. areola* in susceptible genotypes.

Seed dressing insecticides like Carbo-sulfan, Chlothianidine, Thiomethoxam and Imidacloprid led to enhanced NR activity and soluble protein content during early growth stages and higher levels of secondary metabolites as compared to water control. Repeated applications of insecticides like Endosulfan, Mono-crotophos and pyrethroids lowered NR activity and also gossypol and phenols besides increasing reducing sugar content.

Application of *Kamadhenu Kitniyantrak*, a natural insect repellent was seen to enhance peroxidase activity (10 -15%) in leaves of germplasm lines studied. The photosynthetic rate increased from 18.4 to 23.4 µmol CO_2/ m^2/s by second day and started declining gradually by sixth day given as foliar spray. There was a significant increase in the activity of photosynthesis during the first two sprays.

National Agricultural Technology Project

RCPS3 : Assessment of gossypol content in working collections of cotton germplasm (M. Chakrabarty).

A total number of 152 samples have been estimated and 350 analyses have been carried out. Results obtained during the period can be summarized as below :

- Gossypol content of four grey mildew immune *G.arboreum* lines appeared to be on the higher side compared to the local check indicating that presence of gossypol may be one of the factors imparting disease resistance.
- The CLCuV resistant culture CNH 123 has seed gossypol content close to the value of LRA 5166 (check), but lower than the check.
- Thirty five seed samples related to different advanced breeding cultures received from MAU, Parbhani showed a wide variation in their gossypol content ranging from 0.7484% to 3.4550% and it has been observed that eight cultures possess very high gossypol content in the range of 2.5-3.5% .

Extension and Economics

Nagpur

A study on structure of agriculture and social dynamics of cotton production (Hemchandra Gajbhiye).

The data collected during 2003 from 107 cotton growers from Mangli, Mohagaon, Kawadas, and Adegaon villages in Hingna taluka of Nagpur district reveal that perceived quality of life which means the degree of satisfaction with all aspects of life among cotton growers has become somewhat worse for more than 60 per cent of cotton growers. A prediction model for

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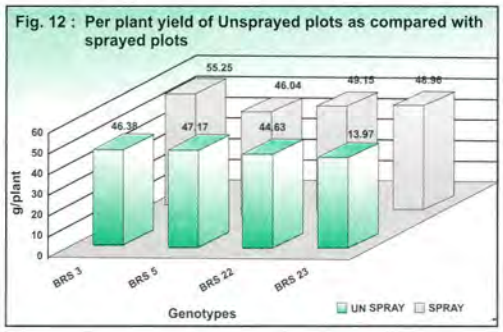

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perceived quality of life was tested and was found to be significant and explains 43 per cent variation in the explanatory variable.

A study on technology adoption behaviour of cotton growers : structural perspective (Hemchandra Gajbhiye).

This study was undertaken to understand the pattern of diffusion of some selected technologies related to cotton production through market and infrastructure perspective. Following model was tested for the explanation of adoption behaviour of cotton growers in relation to Integrated Pest Management.

$$Y = o+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+ e_i$$

Where Y = Technology adoption behavior;
X_1 = Spatial distribution;
X_2 =Availability of technology;
X_3 = Marketing strategy;
X_4 = Pricing;
X_5 = Promotional communication

This model can explain a large portion of variance in adoption behaviour of cotton growers related to IPM technology. However, there seem to be some interaction effect among independent variables. An attempt has been made to explore the complex reciprocal relationship among all of the explanatory variables that cannot be disentangled through prediction equation alone.

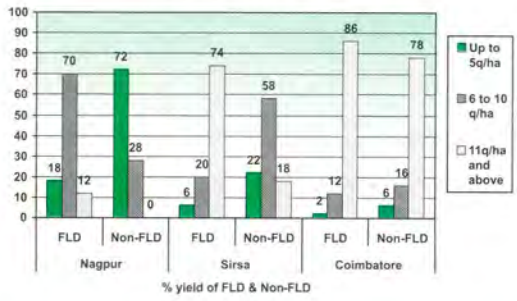
The change in R^2 indicate that the spatial distribution has a significant interaction with availability of technology and both the variables do influence the marketing strategy of the propagator of the technology. The pricing policy and promotional communication do not seem to have significant interaction effect in the prediction model.

Impact of cotton front-line demonstrations on technological advancement of cotton growers (S M Wasnik, H L Gajbhiye and S Usha Rani).

The overall data compiled for all the 300 farmers (150 FLD and 150 non-FLD) for CICR Nagpur, CICR Sirsa and CICR Coimbatore for the parameters knowledge, adoption, productivity levels, technology discontinuance, consultancy patterns followed by non-FLD cotton growers in seeking information of cotton production technologies, technological practices contributing higher yields and relationship of socio-economic and psychological characteristics and productivity levels shows that there has been tremendous increase in technological aspects of cotton growers as a result of FLD programme launched by CICR Nagpur in all the three locations of the country. It has helped greatly not only to FLD growers but non-FLD farmers also in adoption of cotton technologies and improving the yield levels in all the three districts of Nagpur, Coimbatore and Sirsa as majority of the respondents belonged to high category level (more than 11.8q/ha) to medium category (1 to 10 q/ha). The improvement in productivity levels may be attributed to increased awareness, knowledge and adoption of key technological practices by the growers realizing the potentiality in various cotton management practices.

Correlation analysis was done in order to study the nature and extent of relationship of socio-economic and psychological characteristics of farmers with productivity levels. The coefficient correlation of independent variables with productivity level analysis indicate that among the 13 variables studied knowledge, adoption, economic motivation, social participation, socio-economic status, land holding status and education established significant relationship with productivity levels in all the three districts and emerged as the potent factors affecting the productivity. The finding warrants that extension agents should consider the attributes responsible for this to induce them to match ahead in improving the productivity levels.

PRODUCTIVITY LEVELS



% yield of FLD & Non-FLD

	District	Yield (q/ha)		% increase
		FLD	Non FLD	
1	Nagpur	7.75	4.5	41.94
2	Sirsa	16.5	8.35	49.36
3	Coimbatore	21.0	17.54	16.71

P1-94/1-ICR-E10/0430 :

Economic analysis of cotton cultivation in India (P. Ramasundaram and H. L. Gajbhiye).

Data collected from 120 farms across Maharashtra (Nagpur, Wardha and Akola districts), A. P (Guntur) and North Zone revealed that 2003-04 was one of the good seasons for the crop from farmers' points of view - performing genotypes, assured rainfall/irrigation, dependable power supply, remunerative prices and less incidence of pests.

The decreased variability in terms of CV in cases of yield (18-24%) and price (16-21%) indicated lack of crop failures and the high percentage of farmers realising yield and price close to the mean, the high variability in the cost (32-35%) indicated that good or bad year, pest or no pest, cultivators have continued to incur the same expenditures on cotton. The high cost characterised the technological constraints - use of non-certified seed, lack of seed treatment, acid delinting, proper spacing, scientific plant protection and fertilizer use etc. The extent of use of non-notified varieties in vogue was to the extent of 33%, ranging from 15% in Bhatinda and 55% in Hisar. Concomitant to this was the varietal proliferation in all the sample farms.

Panel data of 60 farmers from Saoner, Hingna and Arvi Tehsils of Nagpur and Wardha district on cotton marketing revealed that no sample farmer has sold cotton to the Federation. The State Govt. decision to allow private trade has only legitimized their other wise clandestine selling to private.

Coimbatore

Present status, constraints and future strategies of cottonseed production in Tamil Nadu (Isabella Agarwal).

Collection of data from four cotton seed companies in and around Coimbatore district has been completed. Around 60 cotton seed growers and 40 cottonseed dealers have opted the data for the above said project out of which data collection has been completed from 30 cotton seed growers and 20 cotton seed dealers. Data entry and analysis of the data is under process.

Impact assessment of IPM / IRM technology adoption by cotton farmers (Isabella Agarwal)

Data collection from a total of 60 IPM farmers from surrounding villages of Annur taluk with emphasis on plant protection and 30 non IPM farmers from the distant neighboring villages where chemical pest control was the dominant approach to pest management was made to compare the technical and economic parameters of IPM. The IPM measures included were intercropping with blackgram / cowpea, trap cropping with castor/maize, use of Neem Seed Kernel extract and Trichograma egg cards, erecting bird perches, use of pheromone traps, hand picking of larvae, need based application of specific insecticides like Metasystox for sucking pests, Monocrotophos for stem weevil,

Endosulfan for American bollworm and Larvin for pink bollworm. The number of pesticides application ranged from 3 to 4 under IPM situation and from 7 to 12 under non IPM conditions. The per-hectare yield on IPM farms was around 2500 to 3000 kg/ha when compared to 1500 to 1750 kg/ha in non IPM farms. The average cost of variable inputs on IPM farms was estimated to be Rs.9054/ha when compared to non IPM farms which is marginally higher to the tune of Rs.9521/ha. The expenditure on plant protection inputs was 12 per cent less on IPM farms compared to non IPM farms but the expenditure on human labour on IPM farms was higher by 18 % than non IPM farms. Per hectare net returns on IPM farms were 41 % higher. Overall analysis on economic efficiency shows that IPM is a cost reducing strategy. The only constraint faced by the IPM farmers was the labour use. In labour scarce area, IPM is to be still thought of as per the inference derived by the sample farms in this study.

Farm level economic benefits of Bt cotton in Tamil Nadu (Isabella Agarwal)

40 Bt farmers in and around Avinashi taluk and 30 non Bt farmers from Annur taluk have been interviewed for the present study. Two years data (2002-03 & 2003-04) is to be compared as a part of the analysis. Data entry has been completed. Analysis is in process.

National Agricultural Technology Project

Nagpur

TAR-RFIVLP-15 :

Technology assessment and refinement of rainfed cotton based production system in Nagpur district (M.S.) through Institute Village Linkage Program (Hemchandra Gajbhiye, M. K. Meshram, P. Ramasundaram, G. Majumdar, Gulbir Singh, S. S. Patil, A. S. Tayade and U. V. Galkate).

This research project is executed in two villages viz. Telgaon and Tishti in Kalmeshwar Taluka of Nagpur District involving 247 farmers. During the year 24 technological interventions were administered. Twenty two were assessed and 2 technologies were refined. The interventions included crop varieites, plant nutrient, IPM, horticulture and animal science. In the crop based interventions it was revealed that Bt cotton (MECH-184) gave 25 per cent higher yield and 17 per cent more profitability over prevailing hybrid. Dry sowing of cotton one week ahead of monsoon gave 13 per cent more yield over sowing after the arrival of monsoon. Desi cotton (AKA-7) has given 14 per cent more profit to cotton growers over *Chamatkar*. Use of integrated nutrient management (INM) in cotton has increased the yield up to 16 per cent over farmers' practice. It was also observed that the yield of soybean has increased up to 20 per cent by appropriate plant population and approach. Due to early withdrawal of monsoon, two applications of 2 per cent DAP as foliar spray, first at flowering and second at boll formation stage increased the cotton yield up to 13 per cent. Productivity of cotton increased up to 16 per cent with the application of module. Pesticide Application Technology (PAT) developed by CICR may increase the profitability by 7 per cent. With the use of new approach towards Insecticide Resistance Management, the profitability in cotton production may be increased up to 24 per cent. Bacterial blight in cotton may be successfully managed with the use of delinted seed and foliar application of Copper oxychloride. *Fusarium* wilt in pigeon-pea can be managed by using wilt resistant variety (ICPL-87119) and seed treatment with *Tricoderma viride*.

Under the horticultural interventions, a new commercial crop of marigold was introduced as intercrop in orange orchards under delayed arrival of monsoon, and it was found to give higher profitability over cotton or soybean as intercrop in orange orchards.However, a crop of chilli as intercrop in orange orchard seems to be more profitable The new high yielding variety of marigold (Golden Sierra) can give 21 per higher yield than usually grown varieties like Giant Suman and also fetches better price in market. The INM approach increases the productivity upto 28 per cent in mandarins.

Under animal based interventions, it was observed that de-worming of cattle with Morantal Citrate 1 bolus/100kg body weight has increased the productivity of milch animals by 18 per cent. Milk production can also be increased up to 18 per cent by supplementing the diet of dairy cattle with mineral mixture @ 50gm/ animal/ day+ Vitablend AD3 @ 25g/100 kg feed. With the introduction of *Osmanabadi* buck in local herds of goat, the twining percentage of goats has increased by 20 per cent. Body weight of kids by *Osmanabadi* bucks was also significantly higher than kids by local bucks. Lucerne as a new leguminous fodder crop was also introduced in both the villages and it was found that milk production has increased by 13 per cent.

MM-ITK : Use of botanicals for pest and disease management in cotton, pigeon pea and sorghum (Hemchandra Gajbhiye, M. K. Meshram and S. S. Patil).

Three experiments were laid with 10 replications each involving 30 farmers in two villages of Nagpur district to validate the indigenous technical knowledge (ITK) of managing the pest and diseases in cotton, sorghum and pigeon-pea with the use of botanicals. The matrix ranking done by QuIK Screening method reveal that botanicals as eco-friendly ranked very high on efficacy in controlling pests and persistence of effect. The results of experiments revealed that mixture of garlic (mixed in kerosene), tobacco, green chilies and asafoetida provide excellent support for managing the pests like aphids, jassids, spotted bollworm and *Heliothis*. Profitability also increased up to 24 per cent in cotton, 27 per cent in sorghum and 23 per cent in pigeon-pea by resorting to the use of this ITK.

Coimbatore

TAR 18: Technology assessment and refinement of irrigated agro-eco system for Coimbatore region in Tamil Nadu) through Institute Village Linkage Programme (Isabella Agarwal)

Seven technological interventions have been taken up in the Chinnaputhur village of Dharapuram involving 40 cotton farmers. The technologies on evaluation of Bt cotton, Surabhi variety, integrated weed management, fertiliser management, proper spacing, integrated disease management and intercropping in cotton. An increase of 15 to 35 per cent yield was recorded due to the above interventions. Present adoption level is around 60 per cent in the IVLP village.

A total of 14 trainings have been imparted to the project farmers. Though the technologies are economically viable which was proved last year, the farmers could not enjoy the same potential benefit this year due to poor irrigation facility or lack of rainfall at the crucial period. Regarding the attitude and perception of farmers, they are well aware of all the technologies implemented in their fields and are keen in following the modern and refined technologies made available to them through this project.

Technology Mission on Cotton

MM-5.1 : Evaluation of cotton production technologies for yield,

fibre quality and economic viability.

Nagpur - (Hemchandra Gajbhiye and P. Ramasundaram)

More than 100 farmers from two villages (Telgaon and Tishti in Nagpur district) are involved in this project. The technological interventions carried out on the fields of cotton growers revealed that dry sowing has increased the yield up to 20 per cent and large number of farmers are convinced that this simple technology can bring significant increase in yield. Therefore, the farmers in Vidarbha region can safely go for dry sowing as soon as the monsoon reaches Mumbai. Opening of ridges and furrows at 30 days after sowing has increased the cotton yield up to 18 per cent. Integrated Pest Management has increased the productivity up to 16 per cent and B : C ratio is 1.46 as compared to farmers practice of 1.31. The B:C ratio for Integrated Nutrient Management is 1.18. On economic viability it was observed that BC ratio was higher for Bt cotton (1.12) as compared to farmers practice of growing another popular hybrid. The technological interventions like IPM, INM and IRM also made the difference in quality parameters like staple length, bundle strength and tenacity as compared to cotton produced by farmers' practices.

Coimbatore - (Isabella Agarwal)

Ten technological interventions viz., popularization of varieties Surabhi and Sumangala, cotton production technologies on IPM, INM, IRM and IDM have been taken up in Annur taluk of Coimbatore district encompassing 100 cotton farmers. The farmers could get seed cotton yield, hovering around 2000 to 3000 kg / ha due to the interventions disseminated in their fields out of this project.

APCESS : Identification and quantification of constraints, risks and policy impacts in cotton cultivation (P. Ramasundaram and H. L. Gajbhiye).

Secondary data on district-wise cotton area, production and productivity for 40 years were collected for all the nine major cotton growing states and the decomposition and stability analyses revealed that by and large the productivity during the post-hybrid era has posted significant increase (2.324 % vs 1.927 % pre-hybrid) but accompanied by high variability too (14.47 vs 10.70). The analysis done in 217 districts including 56 intensive cotton districts, showed that only 17 have recorded significantly positive growth in area, 11 in yield and 23 in both.

Three years data on varietal proliferation in irrigated (panel data of 400 farms) and rainfed conditions (700 farms with one-point data), revealed that the strategy worked during disaster years like 2001-02, with a direct linear relationship between number of varieties and yield up to four genotypes (table 13).

Table 13 : Strategizing varietal proliferation for risk aversion in cotton

Number of varieties	Average yield realised (q/ha)							
	Irrigated				Rainfed			
	% of farms	2001-02	2002-03	2003-04	% of farms	2001-02	2002-03	2003-04
One	19.5	10.75	14.5	16.5	8.75	5.34	7.14	8.63
Two	23.00	12.35	13.75	16.0	20.50	6.75	7.10	9.45
Three	36.00	13.45	15.25	17.5	27.0	7.25	8.61	8.80
Four	18.5	14.60	16.00	16.5	26.0	7.70	9.05	8.63
>Four	3.0	14.50	15.75	17.0	17.75	7.56	8.76	9.25

Bt Cotton: Data collected from 85 farm households from Hingna, Phulgaon and Arvi taluks in Maharashtra and Guntur district of A.P. and compared with last year data of 46 respondents showed that repeat adoption was less in the second year (4% in Nagpur and 12% in Guntur). MECH 184 performed better in Vidarbha and MECH-12 in A.P. The level of awareness has gone high simultaneously bringing down unrealistic expectations as reflected by a reduced risk co-efficient to 1.94 % from 2.53 % last year though the yield remained at the same level (11.73 and 11/48 q/ha vs 9.72 and 9.63 q/ha in non-Bt cotton).

Performance of contract farming in cotton:

Data of 219 participants in Integrated Cotton Cultivation Scheme promoted by M/s. Appachi Company, Coimbatore during 2002-03 in 280 ha were obtained and primary information were collected from 30 cultivators. The institutional interventions and initiatives have substantially supplemented crop productivity (by 1.48 q/ha), cost reduction by 12-15% and price premium by 8-10%. Garette scoring of respondents revealed remunerative price, reduced inputs cost, assured and high demand for quality cotton, market information and access to technical counseling as the major reasons for group cotton farming in the order. Data collected from 40 farmers in similar programme started during 2003-04 in Saoner tehsil, Nagpur district showed poor forward and backward linkage.

Performance of organic cotton

Historical data collected from 40 organic cultivators registered with two promoters in Vidarbha revealed that organic cotton production is a mode of risk aversion, cost reduction motivated by premium prices and cash payment. Though the yield after stabilization period was only 5.63 q/ha against the 7.14 q/ha in synthetic farming, the loss was more than compensated by the price premium of Rs.230-700/q and cost reduction of Rs.1900/ha. Further, the yield and price stability were high among organic farms. However, only the popular hybrids like NHH44, PKVHy-2, Ankur 651 were being cultivated in the organic mode.

Major production constraints reported:

Bt cotton:

High seed cost, poor refugia management, poor monitoring and education, lack of sucking pest tolerance, incidence of wilt, small boll size, and high rates of discontinuance.

Contract farming:

Breach of honour of contract by participants, and incomprehensive insurance cover (did not cover the drought during the year).

Organic cotton:

Lack of suitable genotypes and technologies, lack of availability of quality organic inputs, and delay in premium payment.

Coimbatore

Computer Applications

Expert System on Cotton pest/insect

(M. Sabesh, S. Vennila and B. Dhara Jothi).

Damage Symptoms of various pests and diseases including their control measures by chemical and biological means were collected and categorized and put to use in the flow diagram. Photographs of the symptoms of damage and pests were collected for visual identification by the user for selection of appropriate solution for their problem in the system to be developed. With the collected knowledge base, schematic algorithm was developed and attempt has been made to develop preliminary shell using the software Visual Basic .NET.

Technologies Assessed and Transferred

- Bt cotton has been introduced to reduce the excessive use of chemical pesticides against *Heliothis*. Hybrid Bt cotton MECH-184 was assessed on farmers fields in Telgaon and Tishti villages of Nagpur district. It was observed that MECH-184 Bt has given 234 kg more seed cotton yield per hectare over other widely grown hybrid.
- Dry sowing of cotton one week in advance of onset of monsoon has given 21 per cent more yield of seed cotton as compared to monsoon sowing. Dry sowing favours early canopy cover and the crop often escapes damage due to insect pests as well as soil erosion due to heavy rains.
- The large area under cotton has been diverted to soybean over the years in Nagpur district due to several reasons. However, it was observed that instead of sole crop of cotton or soybean cotton-soybean inter-cropping is quite remunerative. By this combination, 18 per cent profitability has increased over sole cotton and 22 per cent profitability increased over sole soybean.
- Rain water conservation is very crucial in rainfed areas. In this regard opening of ridges and furrows at the time of first inter-culture was found to be effective for improving moisture status of soil and increasing the yield up to 18 per cent.
- Integrated approach to nutrient management (INM) which includes organic manures, green manures, balance use of chemical fertilizers based on soil testing, use of bio-fertilizers and appropriate time of application seems to increase the yield up to 16 per cent with reduced spending on chemical fertilizers and higher profitability.
- The adoption rate of IPM strategy in cotton is quite slow because use of only few elements of IPM rather than the whole package. The complete package of IPM in cotton which includes chemical, biological and mechanical methods of managing pest complex was assessed at IVLP villages and it was revealed that input output ratio has increased from 1.31 (farmers practice) to 1.46.

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Education and Training

Training received

National

- Dr. Hemchandra Gajbhiye, Principal Scientist (Agril. Extension) attended the training course on Market-led-Extension, at the National Institute of Agricultural Extension Management (MANAGE), Hyderabad during Oct.14-18, 2003.
- Dr. A R Raju, Scientist (Agronomy), attended a week long course on Organic certification organized by INDOCERT, Alwaye, Kerala during December, 2003.
- Dr. Punit Mohan, Sr. Scientist , Division of Crop Improvement attended a training programme on Protection of intellectual property and agricultural research at National Academy of Agricultural Research Management, Rajendra Nagar, Hyderabad from 14-17, Oct., 2003.
- Dr. K P M Dhamayanthi, Scientist (SS), (Genetics) attended a training on Improving crop plants for enhancing quality of produce through conventional and modern plant breeding approaches organized by Tamil Nadu Agricultural University, Coimbatore from 28th Jan. to 17th Feb., 2004.
- Dr. B Dhara Jothi, Sr. Scientist (Entomology) attended a training on Pesticides and environment organized by the CAS, Department of Entomology, TNAU, Coimbaotre from 28th Jan. to 17th Feb., 2004.
- Dr. C S Praharaj, Sr. Scientists (Agronomy), participated in the advance training course in Precision farming conducted by the Center for Advance Studies, Department of Agronomy, TNAU, Coimbatore from 25th March to 14th April, 2004.
- Dr. K Rathinavel, Sr. Scientist (Seed Technology), attended winter school on Recent advances in hybrid seed production technology in agriculture and horticulture crop conducted by the Department of Seed Science and Technology UAS, Dharwad from 19.11.2003 to 09.12.2003.
- Sh. M Sabesh, Scientist (Computer Application), attended a training programme on GIS and its applications at National Remote Sensing Agencies, Department of Space, Hyderabad from 2-27 Feb., 2004.
- Dr. K Sankaranarayanan, Scientist (SS) (Agronomy) participated in the training on Integrated weed management technology - present status and future challenges conducted by the Department of Agronomy, TNAU, Coimbatore from 19.02.2004 to 10.03.2004.

International

- Dr. V N Waghmare was awarded BOYSCAST Fellowship (2002-03) by the Department of Science and Technology, Govt. of India in the area of plant biotechnology including marker assisted selection with research emphasis on molecular mapping and gene tagging in cotton at plant genome mapping laboratory, University of Georgia, Athens, USA from 26 March, 2002 to 26 Nov., 2003.
- Dr. (Mrs) Vinita Gotmare, Scientist (SS), (Genetics) attended a training programme of 'Development oriented

biotechnology' from 25th May to 27th June, 2003 in Germnay.

Training Imparted

Training on cotton production technology

CICR Regional Station, Sirsa organized a three day state level training programme on Cotton production technology under implementation of Action Plan of ICDP Mini Mission II for TMC. Two training programmes were organized, which were attended by state Agriculture Department Officials.

Training on Biotechnology and Molecular Biology

CICR, Nagpur organized four training programmes on Biotechnology and Molecular biology for students. Hundred students from various colleges participated in these training programmes. The duration of each training programme was 12 days. The course coordinator of these training programmes was Dr. A B Dongre, Head, Biotechnology Section.

Training on Bt detection

CICR organized three training programmes on Bt detection for officials of the state Department of Agriculture, Gujarat (13- 05- .03 to 15.05.03), Andhra Pradesh (27.06.2003 to 28.06.03) and Punjab (30.01.04 and 11.03.04). The course coordinator of these programmes was Dr. K R Kranthi, Sr. Scientist, Division of Crop Protection.

Training on recombinant DNA technologies in molecular plant pathology

CICR, Nagpur organized a training on Recombinant DNA techniques in molecular plant pathology from 16 to 22 December, 2003. Twelve trainees attended the training. The course coordinator was Dr. P K Chakrabarty, Sr. Scientist (Pathology), Division of Crop Protection.

Awards and Recognitions

CICR wins ICAR Best Annual Report Award - 2002-03

Central Institute for Cotton Research, Nagpur has bagged the prestigious Best Annual Report Award - 2002-03 instituted by the Indian Council of Agricultural Research (ICAR).

The award was presented to Dr. Phundan Singh, Director (Acting), CICR at a formal function held at New Delhi on the 14th July 2004 at the hands of Dr. Mangala Rai, Hon'be Director General, ICAR, New Delhi.

The Institute's report has been selected best among sixty seven institutes of ICAR. The citation of award has appreciated the pivotal role of CICR in increasing the quality and productivity of cotton in country.

The clear and lucid presentation of the report was also taken into account in the citation. CICR has recently made remarkable contribution in the form of diagnostic tool kits for detection of Bt cotton and latent infection of bacterial blight and cotton leaf curl virus and bullock drawn cotton planter for mechanization of cotton farming, a computer based expert system COT-IPM for accurate and rapid diagnosis of insect pests, appropriate insect management measures and several promising hybrids.

- **Dr. Hemchandra Gajbhiye,** Principal Scientist (Agril. Extension), CICR, Nagpur has received First Prize in Best Use of Audio-Visual Aids at the hands of Dr. A.G.Sawant, Member, A.S.R.B. in Annual Meeting of the Maharashtra Society of Extension Education held at M.P.K.V., Rahuri on Dec.13, 2003.

- **Dr. K S Bhasker,** Principal Scientist (Agronomy), CICR, Nagpur has received best poster paper presentation award on the paper entitled ' Management of degraded soils of Thugaon micro watershed for cotton based cropping system and sustainable land use : a case study' in the National seminar on Soil survey and land use planning held at NBSS & LUP, Nagpur on 20-21 January, 2004.

- **Dr. Jagvir Singh,** Senior Scientist (Soil Science), CICR, Nagpur has been awarded the second best poster paper presentation for his paper titled 'Nutrient use efficiency in rainfed cotton as influenced by moisture and integrated nutrient management in the National seminar on Resource management for sustainable agriculture held at ANGRAU, Agriculture College, Bapatla (AP) on 28-30 Jan., 2004.

- **Dr. P. K. Chakrabarty,** Senior Scientist (Plant Pathology), CICR,

Nagpur has bagged the KPS Menon Gold medal for best research paper (poster) of 2003-04 by the Indian Phytopathological Society for his paper entitled 'DNA based diagnostic tools for precise detection and differentiation of strains of *Xanthomonas axonopodis* pv. *malvacearum* and cotton leaf curl gemmini virus two economically important pathogens of cotton. The award was given at the hands of Dr. C D Mayee, Agriculture Commissioner, Govt. of India on19th Feb., 2004 in the National symposium on Crop Surveillance: Disease forecasting and management held at IARI, New Delhi.

Recognitions

- **Dr. Hemchandra Gajbhiye,** Principal Investigator Institute Village Linkage Program (NATP-TAR) and his team (M K Meshram, Gulbir Singh, S S Patil, Dr. U V Galkate and A S Tayade) were felicitated by Mrs. Rekhatai Dhawangale, Panchayat Head of the gram Panchayat Sammittee, Kalmeshwar in Nagpur district on Nov.30, 2003 for their outstanding contribution in overall agriculture development at their villages.
- The government of India has recognized the Bt laboratory at CICR, Nagpur as **"The National Bt referral laboratory'.**

Dr. Phundan Singh, Director (Acting), receiving 'Best Annual Report Award' from the Secretary, DARE & Director General, ICAR, New Delhi.

Linkages and Collaborations in India and abroad including externally funded projects

NATIONAL

Areas of Linkages	Institution
Fibre testing and quality evaluation	CIRCOT
Multilocation testing of promising cultures	AICCIP centers
Germplasm collection and maintenance	NBPGR
Seed technological research and breeder seed production	NSP
Evaluation of advanced cultures and germplasm for resistance to soil salinity	CSSRI (RS) Anand
Evaluation of suitable plant type for mechanical harvesting	CIAE, Bhopal
Development of Cry 1 A(a) gene construct	NBRI
Supply of gene construct and molecular evaluation of transgenic plant.	NRC Plant Biotechnology
DNA finger printing of cotton	NRC DNA Finger Printing
Testing of indigenous cotton bollworms pheromones	BARC

INTERNATIONAL

Areas of Linkages	Institution
Germplasm collection, conservation and documentation	IPGRI, Rome, Italy
Sustainable control of the cotton bollworm *Helicoverpa armigera* in small scale production system	Natural Resources Institute, UK

All India Coordinated Cotton Improvement Project

Salient Achievements

Crop Improvement

- During the year four genotypes viz., PKV HY 5 (intra *hirsutum*), PKV DH 1(intra *arboreum*), PA 255 (*G.arboreum*) and NH 545 (*G.hirsutum*) have been released and notified for commercial cultivation, in Maharashtra. *G.arboreum* variety, Veena has been released and notified for commercial cultivation in Andhra Pradesh. As many as 17 obsolete varieties and hybrids in Maharashtra state were removed from the seed production chain through de-notification.
- A total of 41 trials (both National and Zonal), were conducted during the year at 364 locations in the cotton growing states. In the advanced Plant Breeding trials, *G.hirsutum* cultures GSHV 97/13 and CPD 755 in Central Zone, H1250, CCH4 and RH 101 in South Zone and *G.arboreum* cultures CAD127 and CISA 310 in North Zone, JLA 794 and GAM 87 in central zone and KWA 23 and HD 424 in South zone were promising.
- In the National hybrid trial, conventional hybrids HAGHH 409 and NRCH 996 under irrigated conditions and GK147 and ARBHH 430 under rainfed conditions have recorded high yields and have been promoted to Zonal trials. Similarly *desi* hybrids VDCH-1 and KR 04 recorded significantly higher yield over the *G.arboreum* and the hybrid checks.

Agronomy and Soils

Agronomic requirements of promising pre-release/recently released cotton h*irsutum* / *arboreum* genotypes / hybrids, tillage management in cotton, integrated nutrient management (INM), integrated weed management (IWM), cropping system research and location specific research are the major areas of work during the year.

The salient findings are as under:

- Deep tillage once in two years followed by deep + conventional tillage produced significantly higher seed cotton yields and yield traits under Ludhiana condition whereas deep + conventional tillage was found optimum under Sriganganagar.
- Integrated nutrient management with combined application of 50 % of the recommended dose (RD)-NPK, FYM @ 10 t/ha along with foliar spray of recommended nutrients at Faridkot, Hisar, Sriganganagar, and Nanded ; that of RD-NPK & FYM @ 10 t/ha at Kanpur, Khandwa, Akola, Rahuri, Indore, Siruguppa, Bhawanipatna, Coimbatore and Srivilliputtur; RD-N combined with FYM @ 10 t/ha at Junagadh; and 50 % RD-NPK along with FYM @ 10 t/ha RD-NP at Lam (Guntur) were found optimum in sustaining higher cotton productivity.
- Foliar feeding of $MgSO_4$ @ 1 % along @ 1 % along with $ZnSO_4$ @ 0.5% produced higher seed cotton yield as revealed from a four years trial at Indore. At Coimbatore and Srivilliputtur, combined application of RDF along with micronutrients was also beneficial for higher productivity.
- Use of organics for production of eco-friendly cotton revealed that recommended NPK could yield superior or similar to organic treatments involving FYM, GM and crop residues etc. at Lam (Guntur) and Coimbatore.

- Studies on the effect of macro and micro-nutrition on cotton revealed that application of recommended NPK dose is useful at various locations although soil application of sulphur at Kanpur and Nanded, and Zn application at Faridkot were beneficial for higher yield realization.
- Although two manual weedings at critical stages of the crop (where crop-weed competition is maximum) combined with hoeing proved to be effective at Lam (Guntur) and Rahuri; yet trifloxysulfuron Na (Envoke) 75 WG @ 10 g/ha at Rahuri and Galaxy (ready mix of clomazone 15 % + pendimethalin 30 %) @ 2 or 2.5 l/ha at Coimbatore and Srivilliputtur were found to be as efficient as manual weeding.
- At Sriganganagar, three years research on cotton-wheat rotation conclusively proved the superiority of conventional irrigation systems over furrow irrigated raised bed (FIRB) with hand weeding or herbicide. However, on equivalent water use basis, additional 0.30 and 0.37 ha of cotton and wheat area respectively could be irrigated following FIRB practice.
- Incorporation of wheat residues was found to be superior over removal of these at Hisar and crop response to nitrogen was up to 100 kg/ha (125 % RDN) in both cotton and wheat. Higher NPK uptake was recorded in incorporation followed by burning and removal of wheat residues.
- 30th March is the optimum time of planting cotton as a relay crop in onion at Rahuri. Cotton planted after harvest of onion produced higher seed cotton yield than that of planting sole cotton and relay cropping of cotton in onion.
- Application of cotton crop residues @ 2.5 t/ha + Vermicompost @ 1.25 t/ha with 100% RDF yielded maximum *kapas* yield of 14.3 q/ha at Siruguppa.
- The highest seed cotton yield was obtained with sole cotton when compared to intercropping of oilseeds with cotton at Siruguppa. However, the significantly highest total yield of 16.2 q/ha was recorded under cotton + sesamum (3:1).
- Split application of N and K recorded significantly higher seed cotton yield over that of NPK at Siruguppa. In addition, split application of fertilizers @ 25 % at sowing, 50 % at 30 DAS and 25 % at 60 DAS was found to be beneficial for cotton.
- Early sowing of cotton during 2nd fortnight of June by supplementary irrigation from bore well water is essential for realization of significantly highest yield (compared to the rest of the methods of sowing) at Siruguppa.

Plant Physiology and Biochemistry

- Among twelve osmoprotectants tried, application of KNO_3 (0.5%) significantly increased biomass, number of bolls, yield per plant and seed cotton yield over control.
- Physiological analysis of growth and development of cotton genotypes in relation to productivity brought out the yield superiority of MECH 184 Bt (2272 kg /ha), while L 758, L 765, NSPHH 8, NSPHH 9 and NSPHH 13 closely followed with around 1800 kg/ha due to higher dry matter production associated with better harvest index and crop growth rate.
- Of the numerous secondary and micro-nutrient treatments studied, application of ferrous sulphate @ 0.25% at 65 and 75 DAS resulted in significantly superior yields followed by $MgSO_4$ (1%) and $ZnSO_4$ (0.2%). Higher boll number and boll weight are

attributed as the major reasons for enhanced yields as compared to control.

- Cotton genotypes HGIPS 542, BRS 3, BRS 5 and BRS 22 possessed higher levels of biochemical constituents like gossypol, tannin and phenols with better bollworm tolerance. The numbers of glands/sq.cm were counted and the maximum was observed in G.Cot.Hy-102 (265). The number of glands on leaves were positively correlated with phenol (+0.42), protein (+0.47), tannin content (+0.02) and gossypol content (+0.36).
- Maximum yield was obtained from *herbaceum* hybrid G.Cot.DH-7 and G.Cot.DH-9 and these varieties contained high phenols, gossypol and sugars in young bolls.
- Drought tolerant varieties LH 1968 and GSHV-97/612 contained higher amount of sugar, proline and free amino acids and they also recorded higher yield, dry matter stability index as compared to other varieties under drought condition.
- Seeds of *G.hirsutum* / *G.herbaceum* / hybrids were analysed for oil and protein content and the maximum oil content (23.39 %) and protein content (27.81 %) were obtained from the new hybrid GSHH-1877 as compared to 17-20% and 23-25%, respectively in check hybrids like GSHH-2106, GSHH-1808 and other *G.hirsutum* genotypes.
- RAPD analysis revealed hybridity confirmation and introgression of genomic regions from wild male parents in hybrids for generation of materials with better bollworm tolerance.
- Hybrids LK 18 X TK 36 and Cms LRA 5166 X AK 2 exhibited superiority with higher nitrate reductase activity and protein content during vegetative and boll development periods.
- Induced systemic resistance by way of enhanced peroxidase and superoxide dismutase enzyme activity was seen due to application of *Pseudomonas fluorescens* strain Pf1 when tested against *Ramularia areola*.
- Advanced cultures with 25% seed oil content have been identified and several single plant selections with better per plant yield have also been made.

Entomology

During 2003-04, insect pest problem in all the cotton growing regions was low due to prolonged dry weather and drought.

- Among the bollworms, the American bollworm, *Helicoverpa armigera* was less, whereas spotted and pink bollworms were moderate to high.
- There was a moderate infestation of jassid in central and south zones.
- Many cultures resistant to jassid were identified.
- Among the natural enemies the coccinellids and spiders played major role in reducing the pest problem in all the zones.
- The insecticide BSN 2060 (Oberon) and clothianidin were found effective in reducing the whitefly population.
- Imidacloprid 35 SC (Confidor) clothianidin 50 WDG recorded less aphid and jassid in all the centres.
- Emamectin benzoate and KN 128 were effective only against *H.armigera* in all the zones.
- Higher pink bollworm was recorded in Emamectin benzoate, KN 128 and spinosad treated fields in south zone.
- In all the centres IPM modules were effective in reducing the pest infestation and in increasing the seed cotton yield. IPM fields recorded more natural enemies and showed high cost benefit ratio.

Plant Pathology

- Observations on the occurrence of diseases in the farmer's fields and research farms was carried out by all centres.
- Disease progress in relation to weather factors was studied by all centres to find out the correlation between the weather parameters and disease development.
- All the lines in various breeding trials have been screened separately for their reaction under maximum disease pressure in twelve selected centres.

Management of diseases

a. Management of root rot: Two formulations of fungicide Vitavax (200 FF and WP) were tested against root rot. The bioagent *Trichoderma viride* as seed treatment as well as soil application and Carbendazim (0.1%) were also included as treatment for comparison.

b. Biological control: The efficacy of the talc powder formulations of *Pseudomonas fluorescens* strains Pf1 and CHAO as seed treatment, foliar application and soil application were tested against foliar diseases.

- Crop loss estimation: This experiment was carried out in selected centres to assess the loss in seed cotton yield due to a) Leaf Curl Virus Disease, b) Grey mildew and c) *Alternaria* leaf spot.

Significant highlights are given below:

1. CLCuV disease incidence varied from traces to 90% in the North zone states.
2. CLCuV caused a loss of 59.93 to 79.81% in seed cotton yield.
3. Root rot incidence varied from 15 to 30% at Hisar and 2.3 to 11.5% at Sirsa.
4. *Alternaria* leaf spot (maximum 35%) and bacterial leaf blight (maximum 51.9%) were the major diseases in the central zone.
5. In the Southern zone 30.53 % of *Alternaria* leaf spot and 18.05% of grey mildew were observed in Karnataka.
6. Seed treatment with Vitavax 200 WP @ 3.0 g/kg seed was highly effective against root rot at Sirsa.
7. Seed treatment @ 10 g/kg seed and soil application @ 2.5 kg/ha of *Pseudomonas fluorescens* strain Pf1 was effective against leaf curl virus disease at Sriganganagar.
8. Carbendazim @ 0.1 % was highly effective against grey mildew at Nanded and *Myrothecium* leaf spot at Khandwa.
9. Propiconazole @ 0.1% was effective against *Alternaria* leaf spot at Rahuri.

Breeder Seed Production

During the year 2003-04, thirty four varieties and four hybrids were taken up for seed production through 11 university centres and two ICAR Institutes. As against a total indent of 75.4 quintals, 261.8 quintals of Breeder seeds were produced. The breeder seed indent and production matched in respect of most of the varieties and hybrids except in the case of varieties F. 846, BN, RG 18, Pusa 8-6 and AKA 84635.

Front line demonstrations in cotton (2003-04)

During the year 2003-04, a total of 380 Front Line Demonstrations were allotted to sixteen AICCIP network centres all over the country. Only 350 demonstrations were conducted under an outlay of Rs.18.50 lakhs. The coordinating centres organized Krishi Melas during the cropping season for highlighting the major achievements, package of practices and newer technologies ready for transfer to farmers' fields. This has facilitated better feedback from the farmers to the scientists.

Krishi Vigyan Kendra

Training Achievements

Eighty nine training courses were conducted for 1086 practicing farmers, 831 rural youth and 157 extension functionaries:

Discipline	No. of Courses	No. of Participants			
		Practicing Farmers	Rural youth	Extension functionaries	Total
Agronomy	4	81	14	-	95
Horticulture	19	310	44	43	397
Veterinary Science	23	299	419	38	756
Extension	18	113	47	38	198
Home Science	11	96	154	29	279
Plant Protection	14	187	153	9	349
Total	**89**	**1086**	**831**	**157**	**2074**

Front line demonstrations

Front line demonstrations (FLDs) on soybean variety JS-335 and pigeonpea variety AKT-8811 in Kharif were conducted including 25 and 21 farm families respectively with 0.4 ha area each. An average increase of 26.05% and 14.26% in yield of soybean and pigeonpea was recorded respectively.

FLD on cotton PKV-Hy-5 and CNH 120 on 4.8 ha. irrigated area was conducted on field of six farm families in Wakeshawar and Waranga villages. An average increase in yield to the tune of 20.10% and 24.41% was recorded respectively.

FLD was conducted on field of 20 farm families of Wakeshwawr and Waranga villages on cotton PKV-Hy-4 on total eight ha area with 0.4 ha area each. An average increase in yield to the tune of 31.25% and 13.33% were recorded by adopting IPM practices and by applying 2% DAP spray respectively.

On campus crop demonstration

Forty two crop demonstration on cotton, chickpea, pigeonpea, soybean, fodder crops viz. Lucerne, jowar, 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 and client oriented trials

Six adaptive trials demonstrating innovative technologies on production and protection of crops and livestock were undertaken on the farmer's fields by providing critical inputs.

Extension activities

Five field days were organized, in which 1700 farmers participated. During this year KVK has participated in eight Kisan Melas and nine national and state level agricultural and animal exhibitions and bagged first prize for its best presentation and display of exhibits at agricultural exhibition

organized by Kurukshtra Kisan Vikas Seva Samiti held at Sakarla, dist. Nagpur. Two camps were organized for livestock vaccination, ectoparasite control and treatment at Banwadi and Waranga village wherein more than 200 animals were vaccinated, treated and sprayed with ectoparasiticide. Health camp for children was also organized at KVK campus.

Farmers exposure visit

A team of KVK experts conducted an exposure visit of 15 farmer of Telgaon and Tishit village of Nagpur district to North India. During this visit the farmers were exposed to experimental as well as demonstration of crops and animal units of various ICAR institutes and SAUs in North India. The team visited IARI, New Delhi, NDRO, Karnal, CCSHAU, Hissar and CIRG, Makdum during October 12-21, 2003.

Agricultural diversification

Nine goat units, two buffalo units, twenty vermicompost units, one NADEP compost unit and two zero energy cool chambers were established at farmers' fields. These agriculturally diversified technologies transferred by this KVK have been well received by farmers of all the villages and are now in demand. 2.04 ha area was covered by the fruit crops in adopted villages.

Resource generation

By imparting training and demonstrating the viable, economical and eco-friendly technologies to the farmers at KVK campus, through the sale of Osmanabadi goats, fruits, flowers, vegetables, mushroom, spawns and preserved products, etc., of Rs. 30531/- was generated. The FYM produce of goat unit and vermicompost unit approximately Rs.10000/- was utilized in KVK farm.

Diagnostic survey

Twenty four diagnostic surveys in adopted villages and other villages of Nagpur district were undertaken to suggest the remedies to overcome specific problems in crops, animals, mushroom production covering more than 45 ha cropping area and 160 animals.

Publications:

Thirty one popular articles in English, Hindi and Marathi were published by the KVK staff.

General

List of Publications

Research / Review papers in journals

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Cottonseed oil quality, utilization and processing	25	D.K. Agarwal Phundan Singh Mukta Chakrabarty A.J. Shaikh S.G. Gayal
Genetic enhancement in cotton	26	T.R. Loknathan P. Singh D. K. Agarwal Punit Mohan Suman Bala Singh V. Gotmare V. V. Singh
Plant parasitic nematodes of cotton farmer's hidden enemy	No. 27	Nandini Gokte-Narkhedkar P. M. Mukewar C. D. Mayee
Recent nutrient and agronomic practices for rainfed cotton	No. 27	Jagvir Singh D Blaise C. D. Mayee M. S. Deshmukh
Multi-location evaluation of cotton genetic resources (*Gossypium hirsutum*) - during a decade (1991-2002)		V. V. Singh S. J. Baitule
Sustainable management of plant bio-diversity cotton(1999 2003).		V. V. Singh

List of approved on-going projects

Institute Projects

Nagpur

Crop Improvement

1. Collection, conservation, evaluation, documentation and utilization of genetic resources of cultivation species of *Gossypium.*
2. Genetical and anatomical studies on drought tolerance in cotton *G.hirsutum.*
3. Conservation of wild species of *Gossypium* and introgressive hybridization for the improvement of cultivated species cotton.
4. Breeding for high yielding and long staple genotypes of *arboreum* cotton with high fibre strength .
5. Breeding cotton genotypes suitable for cultivation in shallow soils
6. Studies of genetic enhancement of upland cotton.
7. Studies on genetic base of upland cotton varieties.
8. Improvement of seed yield and quality in *G.arboreum* culture with low input management under different soil depths.
9. Seed yield and quality improvement in *arboretum* cultures with low input management under different soil depth.
10. Assessment of seed vigour traits in cotton.

Biotechnology

11. Evaluation of cotton germplasm through molecular techniques.
12. Development of tissue culture protocol for use in breeding and genetic transformation.
13. Molecular mapping of leaf curl virus resistance gene in cotton genome.

Crop Production

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

Crop Protection

20. Biochemical basis of induction of defense related proteins in cotton against *Helicoverpa armigera.*
21. Interaction effects of cultivars, agrotechniques, insect pests and entomophages in cotton ecosystem.
22. Estimation of losses due to major pests of cotton.
23. Studies on multiple disease resistance in upland cotton.

24. Studies on seed transmitted pathogenic infections and other seed microflora of cotton.
25. Studies on evolution of races of *Xanthomonas axonopodis* pv. *malvacearum* (*Xam*) and utilization of HVS in identification of resistant sources .
26. Evaluation of cotton germplasm against Alternaria and Myrothecium leaf spot diseases.
27. Efficacy of antagonist fungal microflora from rhizophere of cotton, its growth and development including disease control.
28. Studies on plant parasitic nematodes associated with cotton.
29. Molecular basis of pathogenicity and race specificity of *Xanthomonas axonopodis* pv *malvacearu* (Xam) and characterization of its antagonists.

Plant Physiology and Biochemistry

30. Physiological evaluation of cotton germplasm under rainfed conditions.
31. Physiological and biochemical studies on abiotic stress with particular reference to heat and drought in cotton.
32. Physiological and biochemical basis of salinity tolerance in cotton.
33. Physiological and Biochemical basis of waterlogging tolerance in cotton.
34. Source-sink alteration with reference to flower induction as a tool to improve physiological efficiency and productivity in cotton.

Extension & Economics

35. A study on structure of agriculture and social dynamics of cotton production .
36. A study on technology adoption behaviour of cotton growers : Structural perspective.
37. Impact of cotton front-line demonstrations on technological advancement of cotton growers.
38. Economic analysis of cotton cultivation in India.

Regional Station, Coimbatore

39. Development of high yielding intra *hirsutum* hybrids.
40. Breeding *G.hirsutum* cotton varieties with new plant types - Development of medium staple varieties.
41. Development of extra long staple high spinning hybrids of interspecific origin with wider adaptability.
42. Development of high yielding and high spinning extra long staple cotton.
43. Maintenance and evaluation of cotton germplasm.
44. Inter-specific and inter-racial hybridization and gene transfer in *Gossypium*.
45. Development and utilization of cytoplasmic and genetic male sterility for hybrid cotton seed production and fertility restoration in cotton.
46. Studies on viability, vigour and longevity of cotton seeds.
47. Studies on the long term effect of nutrient management practices on the productivity, nutrient balance, soil physico-chemcial properties and sustainable of cotton based cropping system.
48. 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.
49. Exploring suitable agro-techniques for Bt cotton hybrid.
50. Influence and secondary and micronutrients on qualitative and quantitative parameters of cotton.

51. Studies on population dynamics of cotton pests and their enemies in the cotton ecosystem.
52. Studies on the host plant relationship and identification of resistant / tolerant varieties to insect pests of cotton.
53. Studies on the role and effect of insecticides in cotton ecosystem.
54. Studies on bioecology and management of cotton stem weevil *Pempherulus affinis* Faust.
55. Studies on the epidemiology and management of fungal foliar diseases of cotton.
56. Studies on soil borne diseases of cotton.
57. Studies on bacterial blight of cotton.
58. Physiology of fibre growth and development.
59. Identification and utilization of adaptive responses to abiotic stress in cultivated species of cotton.
60. Studies on the response of elevated carbon di-oxide on physiology and productivity.
61. Studies on biochemical mechanisms of resistance to bollworm of cotton.
62. Studies on development biochemistry of cotton pest/ disease interaction.
63. Source sink alteration with reference to flower induction as a tool to improve physiological efficiency and productivity in cotton.
64. Present status, constraints and future strategies of cotton seed production in Tamil Nadu.
65. Impact assessment of IPM/IRM technology adaption by cotton farmers.
66. Farm level economic benefits of Bt cotton in Tamil Nadu.
67. Expert system on cotton pest/insect.

Regional Station, Sirsa

68. Evaluation of parents in *Gossypium hirsutum* for heterotic potential and useful heterosis for replacement of existing cultivars under north Indian conditions.
69. Development of varieties and hybrids (MS based) of medium staple length in *Gossypium arboreum L.*
70. Development of male sterility based hybrids of *G.hirsutum* for north India.
71. Development of *G.hirsutum* cultivars with high fibre strength suitable for high speed spinning.
72. Studies on seed technological aspects of hybrids and varietal seed production in north zone.
73. Collection, conservation, evaluation and maintenance of genetic resources
74. Evaluation and refinement of IPM module for irrigated cotton in north zone.
75. Studies on cotton leaf curl virus disease and development of resistant varieties and hybrids for its management.

Externally Funded Projects

1. **CFC/ICAR :** Sustainable control of the cotton bollworm *Helicoverpa armigera* in small scale production systems.

DBT Projects

1. Genetic improvement of strains of entomopathogenic nematodes for tolerance to environment and enhanced efficacy against *Helicoverpa armigera*, cotton bollworm.
2. Studies on toxicity of Bt (Cry) toxins to cotton pests, assessment of impact of Bt transgenic cotton plant on the ecosystem and development of resistance to Bt toxins in cotton bollworm *Helicoverpa armigera*.

AP Cess Fund

1. Use of entomopathogenic nematodes for biological control of *Helicoverpa armigera* of cotton.
2. Studies on the effect of insecticides on cotton plants and their interactions with American bollworm *Helicoverpa armigera* (Hubner) and its parasitoid *Campoletis chlorideae* Uchida.
3. Identification and quantification of constraints, risks and policy impacts in cotton cultivation.

Aventis Funded

1. Studies on reistance breaking properties of Triazophos in combination with deltamethrin on pyrethroid resistant *Helicoverpa armigera*.

Indofil funded

1. Biochemical and ecological factors influencing the toxicity of Novaluron on the cotton bollworm *Helicoverpa armigera*.

Mahyco Funded

1. Monitoring for shifts in baseline susceptibility (development of tolerance / resistance) in the cotton bollworms toxin in various cotton growing regions of the country.

National Agricultural Technology Project (NATP)

Mission Mode

CP-MM 1 : Development of Hybrid Crop-Cotton

MM3 : Sustainable management of plant biodiversity-cotton.

MM4 : Development of Bt. Transgenic for insect resistance - Cotton.

MM III 17 : Development of weather based forewarning systems for crop pests and diseases cotton.

MM ITK : Use of botanicals for pest and disease management in cotton, pigeon pea and sorghum.

II. Irrigated Agro-Ecosystem

PSR 4 : Studies on efficacy of bioinoculants in cotton-wheat based production system

PSR 26 : Control of leaf curl viral disease in cotton and development of protocol for mass multiplication of predators, parasites and insect pathogens

PSR 36 : Adoption and refinement of cotton picker and cleaning system.

IVLP TAR 18 : Technology assessment and refinement (TAR) of irrigated Agro Ecosystem for Coimbatore Region TN

III. Rainfed Cotton Production System (RCPS)

RCPS-2 : Optimising nutrient supply in relation to moisture availability for enhanced productivity and stability of rainfed cotton based production system

RCPS-3 : Assessment of Gossypol content in cotton Germplasm

RCPS-4 : Delineating the efficient productive zones for Cotton production system using GIS based crop models

RCPS-5 : Rainwater conservation, harvesting and recycling/ recharging techniques for enhanced productivity of cotton based cropping system.

RCPS-7 : Promotion of productive high quality *G. arboreum* cotton to

meet the needs of marginal cultivators of rainfed ecosystem vis-à-vis textile industry.

RCPS-8 : Characterisation and identification of productive and high quality cotton species/ genotypes including *G. herbaceum* for different rainfed agro-ecological situations adopting suitable approaches through farmers participatory programmes.

RCPS-9 : Develop and evaluate production technologies for the indigenous cotton of NE Region

RCPS-10: Development of Bt. transgenic diploid cotton against bollworm.

RCPS-11: Impact of tillage, land treatment and organic residue management on soil health, drainage and crop, productivity of rainfed cotton based system.

IVLP-TAR 15 : Technology assessment and refinement of rainfed cotton based production system in Nagpur district through institute village linkage programme under rainfed Agro Ecosystem.

IV. Agro Ecosystem (Coastal)

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

V. Competitive Grant Programme

CGP-I : Induction of para nodules in cotton with N_2 (nitrogen) fixing bacterium *Azorhizobium caulinodans*.

Technology Mission on Cotton (TMC)

Proj. Code	Project Name	Centre
MM 1.1	Development of diploid cotton cultivars with high fibre quality	Nagpur, Sirsa
MM 1.2	Development of tetraploid cotton cultivars with high fibre quality and resistance to drought and biotic stresses	Nagpur, Coimbatore Sirsa
MM 1.3	Genetic improvement through introgression of useful genes in cultivated species of cotton	Nagpur, Coimbatore Sirsa
MM 1.4	Improvement of cotton seed oil	Nagpur Coimbatore Sirsa
MM 1.5	Maintenance breeding, seed production and marker based purity evaluation	Nagpur, Coimbatore Sirsa
MM 2.1	Integrated nutrient management for high quality fibre and yield	Nagpur
MM 2.2	Integrated water management system for quality fibre production	Nagpur Coimbatore
MM 2.3	Bioinoculants for sustainable and cost effective production of high quality fibre	Coimbatore
MM 2.4	Refining regional-level prediction of yield	Nagpur Coimbatore
MM 2.5	Ergonomically efficient implements for cotton production	Nagpur
MM 3.1	Integrated pest management (IPM) at village level for cost effective quality production	Nagpur, Coimbatore Sirsa
MM 3.2	Development of diagnostic tools for biotypes/races	Nagpur, Coimbatore Sirsa
MM 3.3	Commercialisation of bioagent mass-production technologies in intensive cotton districts	Nagpur
MM 5.1	Evaluation of cotton production technologies for yield, fibre quality and economic viability	Nagpur Coimbatore Sirsa
MM 5.2	Information, cotton website and documentation	Nagpur Coimbatore
MM 5.3	Coordination and Monitoring cell	Nagpur

Significant Decisions of RAC, IMC, SRC Meetings

Research Advisory Committee (RAC)

The research advisory committee meeting for the year 2003 was held on June 3-4, 2003 at CICR, Nagpur under the chairmanship of Dr. Y S Nerkar, former Vice Chancellor, MPKV, Rahuri. The following members attended the meeting. Dr. S S Narayanan, Dr. V C Patil, Dr. K C Jain, Dr. C D Mayee and Dr. MRK Rao, Member Secretary.

The proceedings were approved by the ICAR. The following are the general recommendations:

General Recommendations

- For registration of a variety/hybrid, DUS testing as per the guidelines of ICAR should be made mandatory.
- Components of precision farming be identified for good fibre quality along with higher productivity.
- Impact of major/minor nutrients on fibre quality be worked out.
- For efficient rain water harvesting, appropriate technologies be developed in collaboration with agricultural engineers for reduction/checking evaporative losses, so as to optimize storage of harvested rain water.
- The valuable material developed by CICR through introgression should serve as a base material for increasing productivity.
- Publication on the impact of extension activities and economic/risk analysis in the form of bulletins be brought out.
- Training programme for B.Sc. (Ag.) and M.Sc. (Ag.) to set up Agr. Clinics. A course with a duration of 30 days be considered during September-October every year for enabling them to establish Agri. Clinics.
- DNA finger printing work has to be further intensified.
- Cytoplasmic genetic male sterile system has to be emphasized more in the development of hybrids. Broadening of CMS base for evolving productive CMS hybrids should be looked into.
- Basic research work has to be given more importance besides applied research.
- Gene construct to be made available through genomics research.
- Development of superior quality *arboreum* lines comparable to *hirsutum* could strengthen the productivity and adoption pattern of *desi* cotton in the country. Exclusive *arboreum* cotton growing villages should be selected and feedback should be sought upon for improving boll weight and picking quality.
- CICR should secure all the valuable genetic material in respect of cotton and store it in its gene pool with proper listing, so that it can be properly maintained and further utilized.
- Breeders of the crop improvement division should also be involved in the transfer of Bt genes to some important elite lines and also study the over all performance and fibre quality and may use them in superior hybrid development.
- Agricultural Engineer may be encouraged to develop a battery operated spindle/suction based picking unit with proper efficiency and trash free picking.

- CICR to get actively involved in genomic and proteonomics research and collaborate in the global network of International Cotton Genome initiative workshop to be held in India next year.
- A compendium based on R&D findings of CICR and AICCIP centers be prepared in an extension style publication as a guide for cotton farmers and others including cotton R&D personnel and policy planners.

Staff Research Council (SRC)

The annual meeting of Staff Research Council was held under the chairmanship of Dr. C D Mayee, Director on April 24-25, 2003 to discuss the results of the work carried out during 2002-03 and to finalise the research programme for the year 2003-04. Results of each project carried out during 2002-03 were presented by individual scientist and discussed. Plan of work for next year for each project was also discussed and finalized. Seven new project proposals were presented and approved after discussion. The meeting was conducted by Dr. Vinita Gotmare, Secretary, and Dr. N Gokte-Narkhedkar, Jt. Secretary, SRC.

Institute Management Committee (IMC)

The institute management committee was held on 18th October, 2003 during the year 2003-04 at CICR, Nagpur under the chairmanship of Dr. Phundan Singh, Director. The proceedings of the meeting was approved by the ICAR.

Major recommendations:

- The committee expressed its satisfaction and agreed for continuation of farm development work. The committee members desired that brief break-up of the farm activities of Sirsa and Coimbatore station should be furnished.
- The committee desired that activities of KVK should also be furnished in brief.

Eighteenth Meeting of ICAR Regional Committee No. VII

The eighteenth meeting of ICAR Regional Committee No. VII was held at CICR, Nagpur on September 8-9. 2003. Shri Govindrao Adik, Hon. Minister for Agriculture, Government of Maharashtra inaugurated the meeting. Dr. Mangala Rai, Secretary, DARE and Director General, ICAR presided over the meeting. The meeting was attended by Vice -Chancellors of Agricultural Universities, Directors of ICAR Institutes. Commissioners of Agriculture, Directors of Research & Education of Universities and Project Coordinators of All India Coordinated Projects in Maharashtra, Goa and Madhya Pradesh.

Delivering the inaugural address, Dr. Mangala Rai stressed that efforts should be made to attract private sector investment in Agriculture. He added that since Maharashtra and Madhya Pradesh are rainfed regions, more stress is needed on development and popularization of small and efficient water harvesting and utilization technologies.

Prominent among those present were: Dr. G.Kalloo. DDG (Horticulture and Crop Sciences). Dr. S.Ayyappan, DDG (Fisheries), Dr. P Das, DDG (Extension), Dr. J. S. Samra, DDG (Natural Resource Management), Dr. V.K.Taneja, DDG (Animal Science), Dr. S L Mehta, National Director (NATP) and Dr. R C Maheshwari, ADG (TC) from ICAR, Shri. J Dange. Principal Secretary (ADF), Govt. of Maharashtra, Shri Sudhir Goyal, Agricultural Commissioner, Maharashtra, Dr. J L Bose, IAS, Agricultural Production Commissioner, Dr. G S Kaushal, Director Agriculture, Govt. of M.P., Bhopal, Dr. V.M.Pawar, Vice-Chancellor, MAU. Parbhani, Dr. S.M.Nimbalkar, VC, Dr. PDKV, Akola. Dr. A. T.Sherikar, VC, MAFSU, Nagpur and Dr. D P. Singh, Vice Chancellor, JNKVV, Jabalpur:

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

CROP SCIENCE

- Seminar on organic farming
- Setting up of certification and inspection standards besides framing of rules for marketing organic produce
- Emphasis on crop improvement with focus on development of short duration and early crop varieties
- Identification of constraints for low productivity in Vidarbha
- Development of suitable red rice variety for Goa

HORTICULTURE

- New schemes on planting materials of medicinal and aromatic plants, spices and garlic
- New Schemes for cashew-nut apple fermentation
- Collaboration with France for grapes wine making with human resource development through foreign training
- Submission of project with clear objectives in citrus juice making

NATURAL RESOURCE MANAGEMENT

- Bench marking of major cropping systems with regular and long term monitoring of soil and water for pesticide residues and fertilizer contaminations
- Making use of soil survey reports with due emphasis on depth for recommendation of horticultural plantations
- Bio-fuel plantation in Madhya Pradesh with seed material from Chattisgarh and Andhra Pradesh
- Essentiality of better water management for salinity management
- Refinement of technologies for groundwater recharging and surface water storage

ANIMAL SCIENCE

- Increasing the production and productivity of feed and fodder
- Conservation and improvement of indigenous animal breeds for enhancing the productivity
- Appropriate action on cattle and buffalo breeding to achieve a growth rate of 4% per year
- Evolving a policy for livestock including pig and poultry in tribal areas

FISHERIES

- Setting up of hatcheries for Magur in Madhaya Pradesh
- Renovation of Balaghat hatchery
- Setting up of seed hatcheries of fish in Bhandara and Nagpur
- Preparing inventory for endangered/ threatened species of fish
- Demonstration of freshwater prawn culture in Madhya Pradesh and Maharashtra

AGRICULTURAL ENGINEERING

- Continuation of AICRP on Post harvest technology across disciplines of horticulture and engineering involving multi-locations

EXTENSION

- Emphasis on performing activities of ATIC in a way to make it a single window support system.
- Exploring the possibilities of alternative/ innovative mechanisms of extension

AGRICULTURAL EDUCATION

- Requirement of specialization in Fisheries, Forestry and Home Science as qualification for recruitment to post graduate courses and jobs
- Emphasis on institutional reforms towards common postgraduate programmes in various universities

Participation of scientists in Seminars / Symposia / Conferences / Workshops / Meetings

Sl. No.	Seminars / Symposia / Conferences / Workshops / Meetings	Place & Date	Participant (s)
1.	AICCIP Annual Group Meeting	TNAU, Coimbatore 3rd 5th April, 2003.	Mrs KPM Dhamayanthi P Chidambaram Mrs. B Dhara Jothi N Gopalakrishnan KN Gururajan A Kannan S Manickam K Natarajan CS Praharaj TP Rajendran K Rathinavel T Surulivelu
2.	Annual Review Meeting of NATP-MM Project on Development of Hybrid Crops - Cotton	NBPGR, New Delhi 5th April, 2003	Mrs Suman Bala Singh
3.	Indo-French workshop on "Research collaboration"	New- Delhi 16th & 17th April, 2003	SB Nandeshwar
4.	Annual review workshop on "Development of Bt transgenic pigeon pea, Rice and Cotton for insect resistance"	NRCPB, IARI, New Delhi on 28 29 April, 2003.	AB Dongre
5.	Cotton Advisory Board meeting for identification of suitable varieties/ hybrids from textile point of view.	CICR, Nagpur 29th Apr, 2003.	OP Tuteja
6.	Workshop on research extension linkages under NATP.	Nagpur 13-15, May, 2003	HL Gajbhiye
7.	NATP sponsored National workshop on agricultural Biotechnology.	NRCPB, IARI, New Delhi 21 and 22 May, 2003	AB Dongre
8.	Annual review workshop of indigenous technical knowledge.	Bubaneshwar 3, June, 2003	HL Gajbhiye
9.	ICAR Annual Group Meeting on Development of Hybrid Crops Cotton	Directorate of Maize, New Delhi 21-22nd July, 2003	Mrs Suman Bala Singh

10.	Review Meeting of TMC MM-1 MM 2.4 project	CICR, Nagpur, July 29 & Nov 13-14, 2003. IARI, New Delhi Feb. 23-26,2004	KB Hebbar
11.	Annual workshop on TMC MM 1.5 project.	GAU, Surat 26th August 2003.	AB Dongre
12.	International seminar on Sugarcane genomics and genetic transformation.	VSI, Pune 28-29, Aug. 2003	KR Kranthi PK Chakrabarty
13.	DBT Task Force meeting on 'Biopesticides and Crop Management'	New Delhi 11-13, Aug. 2003.	Mrs Nandini Gokte-Narkhedkar
14.	Final workshop of the CFC/ICAC 07 project on cotton geminiviruses.	ICBA, UAE 28 Sept Oct.1st 2003	D Monga
15.	Meeting of TMC MM 3.3	PDBC, Bangalore October 28, 2003.	Mrs Nandini Gokte-Narkhedkar
16.	National Symposium on Frontier areas of Entomological research	IARI, New Delhi. 5-7 Nov.,2003	P Jeyakumar
17.	Sixth International workshop on plant growth promoting bacteria,.	IISR, Calicut, 5-10, Nov. 2003	P Chidambaram
18.	Workshop-cum-review meeting on "Bt transgenic, Hybrid and CLCuV Project"	NBPGR, New Delhi 22 Nov, 2003.	AB Dongre SB Nandeshwar
19.	Review workshop of four Mini Missions of TMC	CICR, Nagpur Nov 25, 2003	NK Perumal Mrs M Chakrabarty
20.	National Symposium in Crop Production under changing environment,	BCKVV, Mohanpur, Nadia 27-29, Nov. 2003,	CS Praharaj
21.	Workshop on IPM strategies on rice, cotton, red gram and Bengal gram	RARS, Lam, Guntur 2-3 Dec.,2003.	Mrs B Dhara Jothi
22.	National seminar on Extension strategy for efficient irrigation water management and water conservation	MPKV, Rahuri 13-14 Dec., 2003	KS Bhaskar HL Gajbhiye
23.	Annual review workshop of Institute village linkage programme.	Hyderabad 22-23, Dec., 2003	HL Gajbhiye
24.	National seminar on soil survey for land use planning	Nagpur 20-21 Jan., 2004	KS Bhaskar Jagvir Singh SM Wasnik
25.	Meeting of TMC MM III & IV	CICR, Nagpur January 21, 2004	PM Mukewar
26.	National Seminar on Resource management for sustainable agriculture	ANGRAU, Bapatla 28-30 Jan., 2004	KS Bhaskar Jagvir Singh SM Wasnik

27.	Seminar on seed quality enhancement: possibilities and prospects	IARI, New Delhi 31st January, 2004	Mrs PR Vijaya Kumari
28.	National symposium on plant disease management : developments, challenges and strategies	PAU, Ludhiana. 4-5 Feb., 2004	D Monga
29.	Annual Group Meeting of National Seed Project (Crops)	PAU, Ludhiana March 1-3, 2004	PM Mukewar
30.	Annual Workshop of TMC MM5.1 project	RARS, , Guntur 4 March, 2004	SK Verma HL Gajbhiye P Ramasundaram
31.	Symposium on environmental pollution, genetic risk and impact on global health	CCS, HAU, Hisar 3-5, Mar., 2004.	SL Ahuja
32.	National Conference on Transgenic in Indian Agriculture.	IARI, New Delhi 9 - 10 March, 2004	AB Dongre G Balasubramani Mrs J Amudha
33.	Workshop on Pollution free cotton seed delinting technology	MSSCL, Akola 12 March, 2004	Mrs PR Vijaya Kumari
34.	Seminar on IPR regime	Devi Lal University, Sirsa 13th March, 2004.	D Monga, SL Ahuja, OP Tuteja P Jeyakumar
35.	National symposium on harnessing heterosis in crop plants"	IIVS, Varanasi 13th -15th March, 04	S Manickam,
36.	Annual group meeting of TMC MM1.4	Faridkot 17th March 2004	OP Tuteja
37.	National Seminar on Recent trends in Plant Biotechnology	Triuchirappalli 22 - 23 March, 2004.	AB Dongre
38.	Satellite symposium cum exhibition on enhancing productivity and sustainability in rainfed Agro ecosystem,	APAU, Hyderabad, 24-26, Mar., 2004	SB Nandeshwar HL Gajbhiye Jagvir Singh
39.	National Conference on Seed - A global perspective	New Delhi 26-28 March, 2004	RA Meena K Rathinavel Punit Mohan Mrs PR Vijaya Kumari DK Agarwal Mrs V Santhy
40.	Interactive workshop on IRM for Bt cotton	UAS, Dharward 29 30 March, 2004	T Surulivelu

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

Nagpur

Workshop of TMC MMI

The Annual review workshop of TMC MMI projects was held at CICR, Nagpur on 25-26 March, 2003. Dr. C D Mayee, Director, CICR, Nagpur and Member Secretary, ICAR Standing Committee for TMC MMI in his introductory remarks emphasized the need for better interaction among different cooperating centers for achieving tangible results which should be visible in increased cotton yield and improved fibre quality. Dr. K S Gajbhiye, Chief Guest of inaugural function also stressed the importance of Mission mode projects in the face of the emerging challenges of globalisation. Dr. Shyam Singh in his presidential address conveyed the message that Mission Mode project is always time bound and therefore the research workers must give it a priority that they can meet the targets in limited specified time.

The technical session of the workshop was conducted in three sessions. All the Principal Investigators of 22 project presented the report and future plan of work was discussed.

The results indicated that a good number of *arboreum* and *hirsutum* cultures have been developed with superior fibre quality, improved resistance to biotic and abiotic stresses and high oil content alongwith yield. Nutrient and water management strategies have been found to contribute to higher yield of cotton. Efforts were made to popularize IPM by choosing location specific modules.

Financial review was also undertaken for all the center. Dr. C D Mayee presented a brief overview of the revised technical programme and the budgetary outlay for the next four years of X plan.

Rashtriya Kisan Mela 2003

A one day Rashtriya Kisan Mela 2003 was jointly organized by four Nagpur based ICAR institutes viz. CICR, Ginning & Training Centre, CIRCOT, NBSS & LUP and NRCC alongwith Dr. PDKV, Akola, MAFSU, Nagpur and State Agriculture Department, Government of Maharashtra. The theme of RKM 2003 was 'Globalizing Indian Agriculture'. The mela brought together all agencies associated with agricultural production, protection and harvest on a single forum to equip farmers with latest technology so as to enable them to meet the challenges arising in near future due to globalisation of Indian Agriculture.

In his inaugural address, Dr. S Sreenivasan, Director, CIRCOT, Mumbai said that the Technology Mission on Cotton is playing a major role for improving quality of cotton to suit to the needs of textile industry. Dr. Phundan Singh, Director, CICR, in his address highlighted that the country is likely to witness good production of cotton. He also listed the technologies which are available to farmers to improve quality of cotton while increasing productivity. Dr. K S Gajbhiye, Director, NBSS&LUP informed farmers about concepts of contract farming and producing farm produce as per market requirement. Dr. P N Raut, Joint Director, Agriculture Department (Maharashtra) suggested that research efforts should be directed towards breeding suitable cotton varieties amenable to inter cropping. In the presidential address, Dr. Shyam Singh,

Director, NRCC, Nagpur mentioned that only high tech precision agricultural technology with assured results can transform Indian agriculture into sustainable enterprise for farmers.

Useful publications and technical bulletins were released. Ten farmers who have successfully adopted the modern technologies were also felicitated. An exhibition was organized to apprise the farmers of latest technologies of agricultural crop production, protection, processing, product development and income generation. Farmers were also given free seed samples of two cotton varieties viz CNH 36 and CNH 120 (Pratima) which have been developed by the CICR, Nagpur.

Farmers visited demonstrations field. A 'Kisan Goshthi' the interactive session between scientists and farmers was also organized.

Sirsa

IPM Mela

A farmers' mela on cotton IPM was arranged in village Parbhani on 10th July, 2003. Dr. Ashok Tamhankar from BARC, Mumbai was the Chief Guest. Dr. Tamhankar has explained about the successful use of pheromone traps in field condition. Dr. O M Bombawale and Dr. R K Tanwar from NCIPM, New Delhi and Dr. R S Punia, Deputy Director Agriculture, Sirsa also participated in this programme.

Farmers' Mela on IPM/IRM

A farmers Mela on IPM/IRM was conducted on 26th July, 2003 at CICR Regional Station, Sirsa. Dr. C D Mayee, Agriculutre Commissioner, Govt of India was the Chief Guest of this function. Dr. O P Dubey, ADG (PP), ICAR presided over the function. This mela was attended by 500 farmers.

Dr. Mangala Rai, Secretary, DARE & DG, ICAR, addressing the participants of 18th meeting of ICAR Regional Committee No. VII.

Shri. Subodh Kumar, Textile Commissioner, Govt. of India, chairing sub committee of Cotton Advisory Board held at CICR, Nagpur

Dr. Phundan Singh, Director (Acting), CICR addressing the farmers at Rashtriya Kapas Mela.

Cotton farmers participating in the Rashtriya Kapas Mela.

Distinguished Visitors

Name & Designation	Organisation	Date
Dr. G Kalloo Deputy Director General (Hort. & Crop Science)	Indian Council of Agri. Research, New Delhi.	03.04.2003
Dr. K C Jain, Asstt. Director General (CC)	Indian Council of Agri. Research, New Delhi.	03.04.2003
Shri Subodh Kumar, IAS Textile Commissioner	Ministry of Textile, Govt. of India, Mumbai.	29.04.2003
Sh. P D Patodia Chairman and Vice President, EICA	Standing Committee on Cotton, Indian Cotton Mills Federation, Mumbai.	29.04.2003
Shri Suresh Kotak Chairman & President, EICA	Kotak & Co. Ltd., Mumbai	29.04.2003
Dr. Y S Nerkar Chairman, RAC, CICR & Former Vice Chancellor	MRKP, Rahuri,	03.06.2003
Shri Govindrao Adik Hon. Minister for Agriculture.	Government of Maharashtra, Mumbai	08.09.2003
Shri Ashok Argal Member of Parliament	Governing Body Member of ICAR, New Delhi	08.09.2003
Dr. Mangala Rai Secretary, DARE & Director General, ICAR	Indian Council of Agri. Research, New Delhi.	08.09.2003
Dr. J P Dange, IAS Principal Secretary (ADF)	Government of Maharashtra, Mumbai	09.09.2003
Dr. J S Sahariya, IAS Secretary, Agriculture	Ministry of Agriculture Government of Maharashtra, Mumbai	08.09.2003
Dr. Sudhir Goel, IAS Commissioner of Agriculture	Government of Maharashtra, Pune.	08.09.2003
Dr. J L Bose, IAS Agri. Production Commissioner,	Govt. of Madhya Pradesh Bhopal	08.09.2003
Dr. G S Kaushal Director of Agriculture	Govt. of Madhya Pradesh, Bhopal	08.09.2003
Dr. P Das DDG (Agri.Extn.)	Indian Council of Agricultural Research, New Delhi.	08.09.2003
Dr. S Ayyappan DDG, (Fy. & Engg.)	Indian Council of Agricultural Research, New Delhi.	08.09.2003

Dr. G Kalloo DDG (Hort. & Crop Science)	Indian Council of Agricultural Research, New Delhi.	08.09.2003
Dr. J S Samra DDG (NRM)	Indian Council of Agricultural Research, New Delhi.	08.09.2003
Dr. J C Katyal DDG (Agri.Edu.)	Indian Council of Agricultural Research, New Delhi.	08.09.2003
Dr. V K Taneja DDG (AS)	Indian Council of Agricultural Research, New Delhi.	08.09.2003
Dr.S L Mehta National Director, NATP	Indian Council of Agricultural Research, New Delhi.	08.09.2003
Dr. R C Maheshwari ADG (TC)	Indian Council of Agricultural Research, New Delhi.	08.09.2003
Dr. S N Puri Vice Chancellor	MPKV, Rahuri	08.09.2003
Dr. V M Pawar Vice Chancellor	MAU, Parbhani	08.09.2003
Dr. S N Nimbalkar Vice Chancellor	Dr. PDKV, Akola	08.09.2003
Dr. S S Magar Vice Chancellor	Dr. BSKKV, Dapoli	08.09.2003
Dr. D P Singh Vice Chancellor	JNKVV, Jabalpur	08.09.2003
Dr. A T Sherikar Vice Chancellor	MAFSU, Nagpur	08.09.2003
Coimbatore		
Dr. M V Rao Former Special, Director General	Indian Council of Agricultural Research, New Delhi.	
Dr. G Kalloo DDG (CS & Hort.)	Indian Council of Agricultural Research, New Delhi.	
Dr. S Edison Director	Central Tuber Crops Research Institute, Thruvanathapuram.	
Sirsa		
Dr. C D Mayee Commissioner of Agriculture	Ministry of Agriculture, Govt. of India, New Delhi.	26.07.2003
Dr. O P Dube ADG (PP)	Indian Council of Agricultural Research, New Delhi.	26.07.2003

Personnel

Name of Officers/Scientists	Designations
DIRECTOR	
C D Mayee (upto 14.07.03)	Director
Phundan Singh (From 15.07.03)	Director (Acting)
PROJECT COORDINATOR	
T P Rajendran	Project Coordinator (Cotton) & Head, CICR, RS, Coimbatore
PLANT BREEDING	
Nagpur	
Phundan Singh	Head, Crop Improvement Division
V V Singh	Principal Scientist
T R Loknathan	Senior Scientist
Mrs. S B Singh	Senior Scientist
V N Waghmare	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
Mrs. V Gotmare	Scientist (SS)
Coimbatore	
Mrs. K P M Damayanthi	Senior Scientist
S Manickam	Scientist (Sr. Scale)
SEED TECHNOLOGY	
Nagpur	
R K Deshmukh	Principal Scientist
Mrs. P R V Kumari	Senior Scientist
Mrs. V Santhy	Scientist
Coimbatore	
K Rathinavel	Senior Scientist
Sirsa	
R A Meena	Senior Scientist

ECONOMIC BOTANY	
Nagpur	
Punit Mohan	Senior Scientist
AGRONOMY	
Nagpur	
K S Bhaskar	Principal Scientist
Blaise	Senior Scientist
A R Raju	Scientist
Coimbatore	
C S Praharaj	Senior Scientist
K Shankaranarayanan	Scientist (Sr. Scale)
Mrs. P Nalayani	Scientist (Sr. Scale)
SOIL SCIENCE	
Nagpur	
Jagvir Singh	Senior Scientist
AGRICULTURAL ENGINEERING	
G Majumdar	Scientist (Sr. Scale)
PLANT PATHOLOGY	
Nagpur	
Sheo Raj	Head, Crop Protection Division
P M Mukewar	Principal Scientist
N K Taneja	Principal Scientist
M K Meshram	Principal Scientist
R C Ukey	Senior Scientist
P K Chakrabarty	Senior Scientist
Coimbatore	
P Chidambaram	Principal Scientist
A Kannan	Principal Scientist
Sirsa	
Dilip Monga	Senior Scientist
ENTOMOLOGY	
Nagpur	
S K Banerjee	Principal Scientist
K R Kranthi	Senior Scientist
Mrs. S Kranthi	Senior Scientist
Mrs. S Vennila	Senior Scientist
Coimbatore	
T Surulivellu	Principal Scientist
K Natarajan	Principal Scientist
Mrs. B Dhara Jyothi	Senior Scientist
Sirsa	
P Jeykumar	Scientist

NEMATOLOGY

Nagpur

Mrs Nandini Narkhedkar	Senior Scientist

PLANT PHYSIOLOGY

Nagpur

M R K Rao	Head, Crop Production Division
N K Perumal	Principal Scientist
K B Hebbar	Senior Scientist

Coimbatore

S E S A Khader	Senior Scientist
A H Prakash	Scientist (Sr. Scale)

BIOCHEMISTRY

Nagpur

A B Dongre	Principal Scientist
Mrs M Chakrabarty	Scientist (SG)

Coimbatore

N Gopalakrishnan	Principal Scientist

BIOTECHNOLOGY

G Balasubramani	Senior Scientist
Mrs J Amudha	Scientist (SS)

AGRICULTURE EXTENSION

Nagpur

H L Gajbhiye	Principal Scientist
S M Wasnik	Senior Scientist

Coimbatore

Mrs Usha Rani	Scientist

AGRICULTURAL ECONOMICS

Nagpur

P Ramasundaram	Senior Scientist

Coimbatore

Mrs Isabella Agarwal	Scientist (Sr. Scale)

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 77 books, 40 scientific reports and bulletins, 37 reprints on cotton and subscribed 35 Indian and 30 foreign journals and CD-ROM database.

Documentation Service

Bibliographic database on cotton

Library has developed computerized bibliographic database on cotton to provide comprehensive and update information on cotton. About 2400 bibliographic references along with abstract have been stored in it.

Documentation Service such as Current Awareness Service, SDI service, Specific subject search service have been provided by sorting out the database. Using the database also brings out 'Cotton Research Abstracts' a documentation bulletin.

Current Title Service

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

CD ROM database Retrieval Service

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

1) CABCD 1972-200

2) CROPCD 1973-2004.

3) AGRICOLA 1975-2000

4. AGRIS 1975-2001

5) Biotechnology Abstracts 1975-2003.

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^{++}, 1400 books have been computerized and barcodes assigned for the same.

National Science Day

CICR celebrated 'National Science Day' on Feb. 28, 2004 on the theme 'Encouraging Scientific awareness in the community. Speaking on the occasion, Dr. Uday Mahurkar, Cardiologist, Nagpur and Chief Guest of the function narrated major risk factors associated with heart diseases and ways to prevent it. He exhorted the audience to take regular exercise, avoid smoking and mental stress to avoid heart releated ailments. Dr P Singh, Director, CICR, presided over the function. A science quiz related to human health science was also organized.

Cotton Front-line Demonstrations

The Cotton Front-Line Demonstrations programme (FLD s) has been implemented by a team of scientist consists viz. M.K.Meshram, Dr.S.M.Wasnik and Dr.R.K.Deshmukh at Tumagaon and Umari villages in Warora tashsil of Chandrapur district on 30 farmers field. Based on the preliminary technical knowledge of farmers cotton FLDs were planned with the technological interventions viz, Timely sowing of the crop, Opening of ridges and furrows at 30 DAS, Management of plant population,

Supplementing nutrient requirement with bio-fertilizer application, Balance use of nutrient, Cotton based inter-cropping system (cotton + soybean), Integrated pest and disease management, application of zinc sulphate, Use of DAP spray for controlling boll shedding. The inputs viz cotton seed, soybean for inter-cropping, rhizobium and azotobactor, sufala and zinc sulphate and other insecticides were made available to farmers and the crop was raised interventions wise. Clear-cut difference could be observed in respect of all technological interventions. The technological intervention cotton + soybean inter-cropping conducted at farmers fields was highly appreciated. The demonstration fields also were visited by a number of farmers from neighboring villages. There was a remarkable yield improvement of FLD farmers as compared to their previous practices and also as compared to non-beneficiary farmers. The yield range was recorded between 5-12 q/ha. The percentage increase in yield was recorded in the range 15-56 % in various interventions. Kisan Mela in Tumgaon FLD village was also organized to enlighten the villagers about cotton production technologies. More than 300 villagers including farmers, rural youths, farm-women, etc attended the function.

WEATHER

Nagpur

Month	Temperature (°C)		Relative Humidity (%)		Rainfal (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
June, 2003	37.8	27.1	72	51	237	11
July, 2003	30.1	24.6	92	81	339	19
August, 2003	30.0	24.2	92	80	296	18
September, 2003	30.5	23.6	90	73	137	9
October, 2003	32.2	21.0	79	49	6	1
November, 2003	31.6	16.3	79	36	-	-
December, 2003	28.4	12.6	80	35	4	1
January, 2004	28.5	12.7	83	42	24	1
February, 2004	30.0	13.7	74	40	12	2

Coimbatore

Month	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	No. of rainy days
	Max.	Min.	Max.		
August 2003	32.6	22.9	83	24.6	1
September 2003	33.3	21.9	85	13.6	1
October 2003	31.1	22.3	91	210.1	12
November 2003	29.1	21.1	90	99.2	5
December 2003	29.7	18.3	89	6.0	3
January 2004	30.7	19.0	86	10.0	1
February 2004	32.4	18.3	80	0	0
March 2004	35.8	20.8	81	0.5	0
April 2004	35.7	24.1	87	107.2	12

Sirsa

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Rainy days
	Max.	Min.	Max.	Min.		
April 2003	37.6	20.6	64	36	-	-
May 2003	41.0	25.1	52	26	-	-
June 2003	40.9	25.8	57	38	24.2	-
July 2003	34.1	26.7	83	69	188.2	-
Aug. 2003	35.3	26.6	81	60	91.8	-
Sept. 2003	34.3	24.6	79	60	97.2	-
Oct. 2003	32.5	15.2	67	35	-	-
Nov. 2003	27.7	0.7	64	29	-	-

NATIONAL COTTON SCENARIO

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

State-wise cotton area, production and productivity

Zone/State	2002-2003			2003-2004		
	Area (Lakh ha)	Prod. (Lakh bales)	P (Kg/ha)	Area (Lakh ha)	Prod. (Lakh bales)	P (Kg/ha)
North Zone						
Punjab	4.25	8.00	320	4.52	11.00	414
Haryana	5.35	8.50	270	5.26	11.50	372
Rajasthan	3.33	5.00	255	3.35	8.50	431
Central Zone						
Gujarat	14.98	31.00	352	16.47	50.00	516
Madhya Pradesh	5.50	17.00	525	5.75	19.50	577
Maharashtra	26.17	26.00	169	27.66	31.00	191
South Zone						
Andhra Pradesh	9.00	21.50	406	8.25	26.00	536
Karnataka	3.62	06.50	305	5.00	4.00	136
Tamil Nadu	1.15	04.00	591	1.03	3.50	578
Others	0.53	01.00	395	0.56	1.00	304
Total						
Loose cotton consumed but not counted for in State-wise prod.		11.50			11.00	
Grand Total	**73.88**	**140.00**	**322**	**77.85**	**177.00**	**387**

Prod. = Production

P = Productivity

1 bale= 170 kg.

Source : Office of the Textile Commissioner, Mumbai.