

EXECUTIVE SUMMARY

Crop Improvement

Nagpur

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

Coimbatore

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

mean seed cotton yield being 42.5 g/plant.

- GMS based intra-*hirsutum* hybrids viz., J 34 x Khandwa 3, J 34 x Suman and J34 x TK 15 have shown better performance in respect of seed cotton yield as compared to check hybrids.
- CMS based intra-*hirsutum* hybrids viz., RKR 4145 x AK 1, RKR 4145 x A, 22-29 HS x AK 1, Abadhita x DR 4, IRH 1-4 x DR 2 and Suman x GSRH 24 were found to be better than the check hybrids in seed cotton yield. CMS based interspecific hybrids viz., 70 G x PR, IRH 1-4 x PR and IRH 1-4 x SR out-yielded the check hybrids viz., Sruthi and DCH 32.
- Several single plant selections having resistance to grey mildew (112 nos.), alternaria leaf spot (8 nos.), bacterial blight (41 nos.) and MAR lines (53 nos.) with resistance to more than one disease have been developed and advanced for further evaluation.
- Out of 427 entries received from all AICCIP centres and breeders were screened against grey mildew and six entries were found resistant.
- Screening of 16 selected genotypes for multiple resistance to insect pests revealed that two genotypes viz., BTS 5 and BTS 7 were resistant to American and Pink bollworm and on par with Abadhita in respect of jassid and stem weevil infestation.
- To develop stem weevil resistant lines, the popular cotton cultivars viz., Sumangala, LRA 5166, MCU-3, MCU-5, Anjali were crossed with Moco and Exotica and the hybrids were backcrossed with the cultivars. The cross derivatives with Moco background recorded 0-3 % stemweevil incidence as compared to Exotica derivatives (3 - 8.0 %).
- About 120 genotypes were screened for

jassid reaction and 13 of them showed resistant reaction.

- Foliar applications of DAP @ 2 % + Boron @ 0.6 kg/ha + Zinc @ 0.5% twice during boll maturation phase of seed crop and one additional irrigation after the first picking were found beneficial for the harvest of quality cotton seed with additional increment on yield.

Sirsa

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

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

- In cotton variety RS 2013, significant and maximum increase in boll number (52.0) and boll weight (3.20) were observed when DAP (2%) at 45 DAS + ZnSO₄ (1%) at 50 DAS + Boron (0.1%) at 60 DAS + ZnSO₄ at 75 DAS were applied combined.
- In the variety H 1098 and LD 327, the boll weight, seeds/ boll, yield/ plant, germination percentage and vigour index were higher when topping was made at 60 DAS.

Crop Production

Nagpur

- One hundred *G. hirsutum* germplasm lines and fifty *G. arboreum* lines (new set) were evaluated under rainfed conditions. The top ten lines for each of the characters were categorized and only very few lines had more than three characters in the top ten range.
- At the micro level and even with Bt hybrids, the performance of the INFOCROP-Cotton model in terms of different parameters, phenology and yield was found to be quite satisfactory at Nagpur and Dharwad. The area, production and productivity estimates through integrated approach (remote sensed data, GIS and crop model) for the year 2005-06 were found to be quite satisfactory in respect of Sirsa, Bharuch and Dharwad districts with a variation ranging from 5-13%.
- Split application of recommended dose of fertilizer (50 % NPK as basal and 50 % NPK through fertigation), alongwith ZnSO₄, Biofertilizer and 1500 kg ha⁻¹ enhanced the seed cotton yield under drip in shallow soil.
- *In-situ* moisture conservation practice such as opening of alternate furrow was able to enhance seed cotton yield by about 220 kg ha⁻¹.
- Maximum effect of intercrops on seed cotton yield was recorded in case of greengram (224 kg) followed by blackgram (75 kg) and least by soybean (15 kg). High (1.91 kg ha⁻¹ mm⁻¹) water use efficiency was recorded where greengram was intercropped with cotton followed by opening of alternate furrow after last interculture.
- Significantly higher seed cotton yield of Bt MECH 184 and non-Bt NHH 44 was recorded with foliar application of potassium nitrate alongwith Boron and Zinc (B @ 10 kg & Zn @ 2.25 kg /ha) over recommended dose of NPK.
- Among the tillage treatments, reduced tillage with two inter-culture operations (1874 kg seed cotton/ha) was at par with the reduced tillage without any interculture operations (2054 kg/ha) and both were significantly superior to conventional tillage treatment.
- Among the nutrient management practices, yield was the highest in the site-specific nutrient management treatment (1278 kg/ha) and was significantly greater than the application of recommended dose (90-19-37 kg NPK/ha) of fertilizers (886 kg/ha).
- Hybrids H 10 and PKV Hy 2 were found to be superior while among varieties Surabhi, Abadhita, Sahana, AKA 5 and 7 were statistically similar but superior over PKV Rajat, AKA 8 and CINA 316 under organic production system.
- Battery operated knapsack sprayer was developed and the prototype was evaluated. It was found that it can spray maximum 22 spray tanks each having 16 litres spray liquid can spray in single stroke of

battery charge.

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

Coimbatore

- Soil moisture conservation by opening of furrow at each row of cotton after sowing registered the highest seed cotton yield (2688 kg/ha).
- Highest seed cotton equivalent yield (2800 kg/ha) and rainfall use efficiency (7.0 kg/ha-mm) was recorded when the cotton was intercropped with black gram.
- The highest seed cotton yield of 2387 kg/ha was harvested with the application of

irrigation water as per the climatic needs (0.8 = IW/CPE) of the crop.

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

- Irrespective of the colours, the poly ethylene mulching improved the growth and yield of cotton cv. LRA 5166 significantly. The yield enhancement in poly mulching ranged from 840 kg to 1168 kg /ha than non mulched cotton.
- Cotton genotypes grown under elevated CO₂ atmosphere were characterized with favourable and desirable morpho-physiological features, early flowering, higher photosynthetic activity, higher Nitrate Reductase Activity with early induction, more boll number, boll weight, more dry matter production, better Harvest Index and increase in yield.
- Using 10 physiological indices, the following genotypes were identified as tolerant to drought: H 777, LRK Kgl 931, RBC 39, Nor. Okra, Anjali, AC 241, IC 79, K 34007 and K 3475.
- Application of ethrel @ 30 ppm resulted in synchronous flowering and boll development, leading to uniform boll bursting
- The nutrient and hormonal changes brought about perceptible change in seed and fibre developmental pattern. With application of GA @ 0.5 ppm there was fibre initiation in fibre less mutants of MCU 5.
- Cellulase (2.0%) + Macerozymes (0.5%) was found effective for digestion and release of healthy protoplast from leaves. The osmolarity of 9.0% mannitol was ideal for protoplast isolation.
- Lines with high tannin in leaves and squares have been identified. Fifteen superior single plant selections from these lines exhibiting fair tolerance to bollworms have been made.
- Repeated application of cypermethrin led to the reduction of Nitrate reductase activity and secondary metabolites.
- Seed dressing insecticides induced ATPase activity at a higher level as compared to control. Efficient metabolic status by way of acid Phosphatase and alkaline Phosphatase activity in addition to higher peroxidase activity could be maintained in young seedlings due to seed dressing chemicals.
- Moisture stress tolerant genotypes were seen to withstand moisture stress by way of better photosynthesizing capacity and efficient nitrate reductase activity as compared to susceptible genotypes.
- Single plant selections from the high seed oil segregating populations was obtained with seed cotton yield of 120 - 140 g/plant. Among 200 progenies evaluated, CBR 3 x F 1861-2-(2) and Anjali x F 1861-1-(2) possessed 24-26% seed oil content.
- Cost of cultivation was higher in Salem district than in Erode but cost of seed production was very less because of higher average yield realized in Salem (1312 kg as compared to 1142 kg in Erode).
- In Tamil Nadu, the B:C ratio between Bt cotton and other ruling varieties like Surabhi and LRA 5166 was found to be 1:1.32 and 1:1.81, respectively.
- Beta version of the Information system on cotton was developed using Visual Basic. Net as front-end and Microsoft Access as back-end.
- Around 60 Indigenous Technical Knowledge (ITK) in cotton production and protection adopted by the farmers were collected and incorporated in the CICR web site.

Crop Protection

Nagpur

- Insecticide resistance development was monitored regularly for most commonly

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

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

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

Coimbatore

- Two insecticides viz., Spinosad new A:D, E2Y 45, NNI 0001 and RIL 038 were effective upto 123 days after sowing (DAS) in reducing the fruiting bodies' damage. Spinosad new A:D and Beta cyfluthrin were effective in reducing boll and locule damage significantly over control and recorded higher yield.
- Thiodicarb followed by Lambda cyhalothrin, Quinalphos and Profenofos were effective against pink bollworm and recorded significantly higher yield over control (by 31.9 to 47.6 %).
- Neemcake (150 kgs/ha) + Carbofuran (1.0 kg a.i/ha), neem cake (150 kgs/ha) + carbofuran (1.0 kg ai /ha)+ stem drenching with neem seed kernel extract 5%, were on par with each other and superior than the other treatments in controlling stem weevil damage. Carbofuran (1.0 kg a.i/ha) + chlorpyrifos recorded significantly minimum percentage of infestation due to stem weevil.
- Plant clinic centre was established at Kanurpudur village with photographic displays as well as live specimen of cotton pests, natural enemies and diseases of cotton.
- An impact analysis of the implementation of IRM strategies indicated the reduction in number of insecticidal sprays as well as cost of cultivation and increase in the Cost: Benefit ratio.
- Seed treatment with thiamethoxam 500 FS @ 5 ml and 7.5 ml per kg of seed was effective in reducing the aphid and jassid population upto 40 days.
- Spraying of *Trichoderma harzianum* + *Pseudomonas fluorescens* Pf1 talc formulations at 0.2 per cent was effective

against grey mildew when sprayed at 10 day intervals. An yield loss upto 33 per cent due to grey mildew disease can be averted by spraying Carbendazim 50 WP @ 0.1 per cent at 80, 95 and 110 days after sowing. Under intense disease pressure, spraying of the broad spectrum fungicide Propiconazole @ 0.1 per cent was effective in reducing grey mildew disease incidence.

- Five *barbadense* genotypes viz., GB 119, GB 124, GB 23, ERB 13758 and Suvin have been identified as differentials for the identification and differentiation of *Ramularia areola* isolates.

Sirsa

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

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

- In front line demonstration program, the hybrid CSHH 198 recorded 23.07 % higher yield, CICR 2 recorded 33.42 % higher yield over the farmers' practice. Under IPM and

IRM strategy 21.33 % and 5 % higher yield was recorded over the farmers' practice respectively. A net return of Rs. 24535 was obtained by adopting the conventional seed production of CSHH 198. A net return of Rs. 60830 was obtained by adopting the GMS seed production of CICR 2.

