



*Annual Report 2013-14*

CENTRAL INSTITUTE FOR

**COTTON**

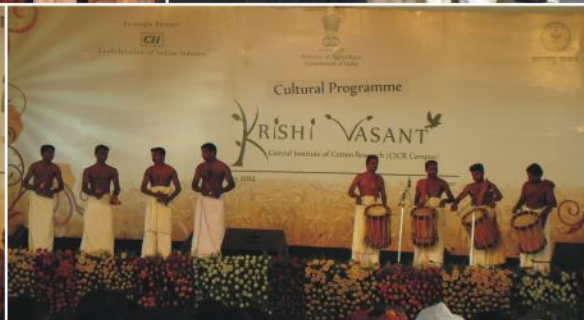
RESEARCH, NAGPUR

GLIMPSES OF KRISHI VASANT 9-13 FEB. 2014



Hon'ble President Sh. Pranab Mukherjee Inaugurating the Event

Dignitaries visit to Theme Pavilion



Theme Pavilion

Exhibition Pavilion

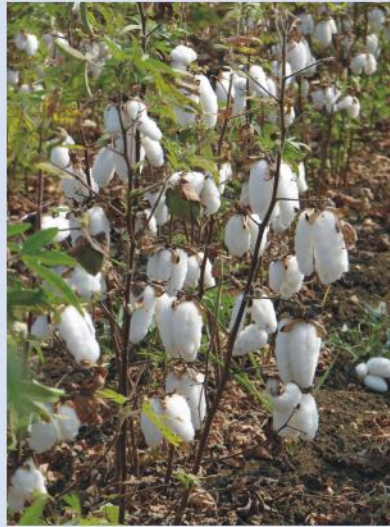


Aerial View of the Mega Event

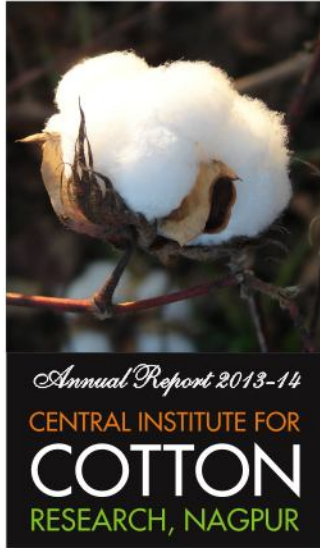




वार्षिक प्रतिवेदन  
ANNUAL REPORT  
2013-14



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



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*Cotton crop offers tremendous challenges to researchers. The 2013-14 season, was exceptionally different. Rainfall was more than double the normal in major cotton growing regions of the country. Cotton crop was damaged in several regions. Despite the abnormal conditions, yields reached an all time high record production of 375 lakh bales (170 kg lint/bale) from 115.53 lakh hectares. CICR played an important role in reaching the milestone. The institute is addressing several challenges such as the cotton leaf curl virus (CLCuV) in north India, labour shortages that mainly affect sowing operations, weeding, inter-culture and harvesting; emerging problem of insect resistance to insecticides and Bt cotton; and physiological stress caused by nutrient imbalances.*

*The cotton leaf curl virus resurfaced after a lull period of about 6 years and has starting causing concerns once again in north India. There is hardly any variety or hybrid that seems to escape the scourge of the disease. CICR scientists of the Sirsa regional station did a great job of evaluating 6000 germplasm lines for resistance to CLCuV during the past two years. Some exciting results were obtained at the Coimbatore regional station. New cotton-endophytes that have immense potential for eco-friendly pest control were discovered. A new 'hydroponic' technique was used to precisely characterize nutrient deficiency symptoms. A new concoction of bio-consortia was developed for yield enhancement. A new technique of ratooning was developed to extend the season for Bt cotton, which minimizes costs and increases yields. The scientists at CICR Nagpur head-quarters, addressed many core issues. The crop protection division did a commendable job in monitoring insecticide resistance in sap-sucking insects and Bt toxins in bollworms and discovery of new genes and design of novel gene constructs for pest management. The division initiated marker assisted breeding to convert elite varieties for resistance against the bacterial leaf blight (BLB) disease and nematodes. The main marker for BLB has been validated and the first back-cross population was characterized. New predators and parasitoids were identified from the cotton eco-system. The crop production division developed new agronomic practices for high density planting, weed management, and mitigation of leaf reddening. A new small-scale cotton harvester was developed and tested for efficiency in high density planting systems. The crop improvement division evaluated 8000 germplasm lines in three years to characterize them for fibre quality and traits for resistance to biotic and abiotic stresses. The plant breeders developed several new advanced cultures for compact plant type, drought tolerance, premium fibre quality of high strength and heavy boll weight. Interestingly, new genotypes were identified for resistance to water logging, drought and herbicide resistance. DNA fingerprinting of major elite varieties and hybrids was carried out. Biotechnologists identified new genes for fibre strength, and several economic important traits. New transgenic cotton events were generated and are being rigorously evaluated. The CICR technologies that are already making waves on farmer fields are 'High density planting technique for high yields'; 'early sowing of early maturing varieties to escape insect pests including bollworms' and 10 lakh 'e-Kapas' voice mail messages in 10 languages. CICR hosted India's largest farmers Agri-Expo 'KRISHI VASANT' during 9-13 Feb. 2014, which attracted more than 10 lakh farmers from all parts of the country.*

*While we are addressing challenges, and are highlighting the Indian record productivity of 552 kg lint /ha, it is important to note that many countries are surging ahead in yields. During 2013-14, Australia raced to the top with 2351 kg lint/ha, Mexico, Brazil and China harvested 1400-1500 kg lint/ha, and at least 32 countries were ahead of India in productivity. It is a matter of concern that India is almost completely saturated with hybrid technology. It is also important to note that out of the 80 cotton growing countries only India has adopted the hybrid technology but ranks 33<sup>rd</sup> in productivity. It is also paradoxical that a country like India, where majority farmers are not input oriented, should choose to adopt 'the hybrid technology' which is highly input-responsive, fragile and most vulnerable to biotic and abiotic stresses. It is widely acknowledged in academic circles that hybrid systems are expensive and input-intensive. They are not suited for sub-optimal conditions. At least half of the India's cotton area is not responding to hybrids for high yields. Therefore there must be a serious reconsideration to move back to varieties that can give high yields using technologies such as high density planting in marginal rain-fed soils. The institute is working on developing alternative systems of cotton cultivation for high yields with lesser inputs and are suited for marginal soils in rain-fed conditions. It is certain that good times for the cotton farmer will be round the corner with good research in the country.*

(K. R. Kranthi)



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- ◆ Thirty-five cotton germplasm materials (25 perennials of *G. barbadense*, 10 traditional cultivars of *G. arboreum* and *G. herbaceum*) were collected from Manipur, Nagaland, Meghalaya, Assam, Maharashtra and Gujarat and established in pots. The endangered land races of *desi* cotton (*G. arboreum* and *G. herbaceum*) viz. Ponduru, Mathio, Karunganni, Wagad and Uppam cotton were collected from their traditional cultivated home.
- ◆ Seven hundred and twenty three (723) exotic accessions of *Gossypium hirsutum* were added to the cotton gene pool. Trait specific 349 germplasm lines (*G. barbadense*-209, *G. hirsutum*-75, *G. arboreum*-2, *G. herbaceum*-43 and wild species-20) were selected from Germplasm Resource Information Network (GRIN).
- ◆ Fifteen long linted *G. hirsutum* accessions (staple length, 30.8-32.9 mm) and 38 high fibre strength accessions (23.0 – 24.8 g/tex) were identified and documented for utilization in breeding programme. Four cultures viz. CNA 441, CNA 443, CNA 444, CNA 445 and CNA 447 were identified suitable for absorbent and surgical purpose.
- ◆ One high yielding *G. arboreum* culture, CNA 2023 was found suitable under narrow spacing (60 x 22.5 cm). A medium maturing high yielding culture, CNH 2015 was developed.
- ◆ Two thousand *G. hirsutum* germplasm accessions were screened for waterlogging of which 200 were identified as tolerant lines.
- ◆ Two high yielding promising cultures (CNH 09-7 and CNH 09-9) tolerant to jassids were identified. Among the 200 introgressed derivatives evaluated for CLCuV resistance at Abohar, two derivatives (Rai 4B and MSH 126) showed tolerance.
- ◆ Thirteen cultures of *G. hirsutum* and four of *G. arboreum* have been sponsored for testing in AICCIP trials.
- ◆ Five cultures, four of *G. hirsutum* (CNH 7008, CSH 1110, CNH 281 and CNH 1111) and one of *G. arboreum* (CNA 1016) were promoted for further testing based on their performance in various trials of AICCIP.
- ◆ The GMS based hybrid CSHG 1862 was released by Central Varietal Release Committee vide notification No. S.O. 952(E) dated 10<sup>th</sup> April 2013. Intra-hirsutum GMS hybrid CSHG 1862 was tested in 27 locations and recorded an overall mean seed cotton yield of 21.02 q/ha as against 18.82 q/ha of CSHH 198 (Common Check) and 19.87 q/ha of local checks.
- ◆ CSH-3088 ranked fourth in Br03a trial of north zone of AICCIP during 2012-13, however it could not yield more than 10% and hence was retained in the Br03a trial of north zone for evaluation in 2013-14. Entries CSH-3175, CSH-3178, CISA-158-1 and CISA 27 (GMS based hybrids) were sponsored in Br02a, Br06a, Br22 a/b & Br 25a/b trials respectively for evaluation during 2013-14.
- ◆ CSH-3075 evaluated in Br06a compact type trial (67.5 x 10 cm) of AICCIP ranked first (zonal mean 3050 Kg/ha in comparison to local check 2625 kg/ha) and promoted for north zone trial of 2013-14.
- ◆ Three progenies cross SA-977x SA-112 viz; P-70, P-86 and P-164 were at par in seed cotton yield in comparison with check H-1226 (1876.5 kg/ha) and possessed more than 40% GOT.
- ◆ 10 compact lines with maximum 120 cm height and 20 cm width having superiority for yield and tolerance to sucking pest and CLCuV were identified.
- ◆ A set of 56 SSR primers were surveyed for polymorphism between bacterial blight susceptible and resistant lines of which 20 SSR markers were found to be polymorphic with Ganganagar ageti and S 295.
- ◆ DNA fingerprinting of 28 *desi* genotypes (3 of *G. herbaceum* and 25 of *G. arboreum*) carried out using 15 SSR markers revealed three (DPL 209, HAU 0058 and MCU 022) to be polymorphic.
- ◆ Molecular markers effectively and efficiently differentiated *G. hirsutum* varieties from *G. barbadense* varieties (Sujata and Suvin) and grouped them in separate clusters.
- ◆ Among the 14 treatments applied directly to the soil, high seed cotton yield was obtained with Vermicompost (2019 kg/ha), Cotton stalk compost (2080 kg/ha) and FYM (2015 kg/ha) in both transplanted and direct sown seeds.
- ◆ Among different seed treatments, Thiram @ 2.5 g/kg seeds gave the highest seed cotton yield (1893 kg/ha.) followed by Thiamethoxam @ 10 g/kg (1791.25 kg/ha) and Imidacloprid (Gaucho) @ 7 g/kg seeds (1711 kg/ha).
- ◆ A staining method (using Carbol fushcin) was

identified to clearly observe and manually quantify leaf and marginal hairs.

- ◆ Sufficient variability for leaf trichome density as well as stellar branching could be observed among 50 varieties studied in *G. hirsutum*. The possibility of quantifying the visual grades provided in the DUS test guidelines for leaf hairiness was confirmed.
- ◆ Breeder seed of five varieties viz., Suraj, PKV 081, NH 615, CISA 614 and AKA 7 and parents of CICR 2 hybrid were supplied for production of Foundation Seed and 136 q of Suraj and 17.3 q of NH-615 seeds (Foundation stage) were produced. Breeder seed of 1.14 q of Suraj was also produced. Resources worth 13.94 lakhs was generated through the sale of these seeds.
- ◆ To generate multigene construct, chitinase gene cassette in plant expression vector with double 35s promoter, AMV enhancer and NOS terminator was sub-cloned downstream of CICR truncated Cry 2 Ab1Ac gene cassette and confirmed through restriction analysis and transformed in *Agrobacterium*. Transformation was carried out using shoot organogenesis, somatic embryogenesis and also by *In-planta* transformation methods in cv Suraj, AKA 7 and Coker 310 respectively. In all, 136 new events were generated.
- ◆ Four new events carrying Cry I Ac and 3 events carrying Cry I F have been established for event selection trial.
- ◆ For leaf curl virus resistant cvs H 777, F 846 and HS 6 carrying ACP (Anti-sense Coat Protein) gene was confirmed by PCR with gene specific primers and were selected for event selection trial. Also for fungal resistance, *G. arboreum* cv PA 255 carrying Chitinase gene representing three events were selected for event selection trial.
- ◆ Gene expression analysis was carried out in mapping population from diverse parents with contrast fibre strength (High-25 g/tex, Medium – 22 g/tex and low 17 g/tex). Full length selected candidate gene e.g Sus A1, Ghces A1, Ghces A2 and Ghces A7 were cloned and subjected to sequencing.
- ◆ dsRNAi gene construct for silencing gossypol biosynthesis in cotton seed was developed and used in transforming *G. hirsutum* cultivars by *Agrobacterium*.
- ◆ Available EST from NCBI database for secondary wall synthesis of fibre was obtained and assembled into contigs and nucleotide blastn analysis identified 63 contigs which were uncharacterized. Four contigs that showed differential expression (18 and 25 DPA) in Suraj variety, were chosen for validation using mapping population.
- ◆ Full length nucleotide sequence of gene coding for *G. hirsutum* cobra like protein (Ghco BL 4) associated with fibre quality was isolated and cloned.
- ◆ Under High Density Planting System on shallow soils, yield under 45 x 10 cm (2.2 lakh plants/ha) and 60 x 10 cm (1.66 lakh plants/ha) was significantly higher than that at 45 x 15 cm (1.48 lakh plants/ha). Based on 38 genotypes evaluated under HDPS, Suraj, PKV 081 and NH 615 were found suitable for central India, Anjali and KC<sub>3</sub> were found suitable for south India and F 2383 for north India.
- ◆ Two new genotypes viz. CSH 3178 (*G. hirsutum*) and Phule Dhanwantary (*G. arboreum*) were identified for high density planting.
- ◆ Among *Desi* cotton varieties evaluated for surgical purpose, Yaganti, RG-8 and Phule Dhanwantary were found to be high yielders.
- ◆ 12 HDPS trials conducted in seven villages of Sirsa district increased yields by 15.63, 26.48 and 15.29% in CISA- 310, CISA 614 and F-2383 respectively as compared to normal sowing of CICR-2 and Ankur 3028 BGII.
- ◆ Twenty four advance cultures of *G. hirsutum* evaluated in randomized block design, the highest yield was recorded by CSH 2931(2494 kg/ha) followed by CSH 2932(2247 kg/ha) and CSH 2930 (2099 kg/ha) as compared to 1975 kg/ha of LH 2076 check variety. The culture CSH 2931 also recorded the highest lint yield and minimum CLCV incidence (28.17 PDI). The culture CSH 2838 recorded the highest fibre strength of 23.2 g/tex.
- ◆ 10 *G. arboreum* lines identified superior for surgical properties were evaluated for yield potential in replicated trial. The highest yield was recorded in cultivar CISA-17-93 (31.0 q/ha) followed by CISA-6-295 (30.0 q/ha) RG-540 (29.0 q/ha), CISA-504 (26.75 q/ha) and HD-432 (25.0 q/ha).
- ◆ Among the eleven cover crops evaluated for allelopathic effects and weed control efficiency, sorghum, bajra, sunflower and sunnhemp had fewer weeds and weed biomass. They were comparable to the newspaper mulch and polythene mulch treatments.
- ◆ Stale seed bed technique of weed management with residual herbicide pendimethalin (1.0 kg a.i. ha<sup>-1</sup>)+ non residual pre plant foliage herbicide (Glyphosate 0.8 kg a.i. ha<sup>-1</sup>) in 125 L water ha<sup>-1</sup> on germinated weeds before planting controlled germination of weeds up to 35-40 DAS.

- ◆ Among the cover crops evaluated for management of weeds wheat, barley, and sunn hemp suppressed the weeds efficiently and significantly enhanced the seed cotton yield.
- ◆ Sunflower produced allelopathic effect not only to weeds but also to cotton and recorded the lowest seed cotton yield and hence is not suitable.
- ◆ Weeds in cotton could be managed by integrated approach with pre emergence pendimethalin 1.0 kg on third day of cotton sowing followed by *in situ* cover crops around 35 - 40 DAS combined with one hand weeding around 70 -75 DAS .
- ◆ In Namakal district, a weed shift was observed wherever glyphosate was applied continuously. The shift was in favour of broad leaved weeds (*Cynotis culculata* and sedges (*Cyprus rotundus*) from grasses (*Echinochloa colona*). Dominance of *Trianthema portulacastrum* under continuously pendimethalin applied cotton field was observed under CICR fields at Coimbatore.
- ◆ Periodical monitoring of the reddening of cotton leaves showed that methomyl treated plants had more red leaves while plants treated with 1% potash, 0.5% lime, 1% DAP and 1% urea + 0.5% magnesium sulphate showed less incidence of leaf reddening. Leaf chlorophyll content, on an average, was found to be high (1.5 – 1.8 mg/gm fresh wt of leaf) in lime, potash, urea + magnesium sulphate treatments. Anthocyanin concentration was found to be highest in methomyl treated plants.
- ◆ Eighty four lines of the 2000 cotton germplasm lines grown were identified for earliness (drought avoidance) phenological trait. Leaf samples of 52 cotton germplasm lines had higher epicuticular wax content which is considered as a drought tolerance trait.
- ◆ A self propelled riding type cotton harvester was fabricated using a power tiller with 17 hp diesel engine. The harvester designed for narrow row cotton cultivation was tested in Suraj var. sown at 80 cm x 10 cm. The field capacity of the machine was 4.2 hrs/ha. The cost of picking was Rs 1.2 /kg for a yield of 2000 kg/ha and Rs 2403 /ha harvesting efficiency obtained was 90 % which improved to 98 % with modification of picking arrangements.
- ◆ Fourteen compact plant genotypes were evaluated along with Anjali, Supriya and Suraj as check varieties with spacing of 45 cm x 15 cm. There were significant differences among the genotypes on seed cotton yield and the highest yield was recorded in PI 36-2-4-1(3539 kg/ha) and in Surabhi x MM02-16-5-2-4 Bk. Several compact plant types with super okra leaf have been identified which will be amenable for further closer planting.
- ◆ Nine genotypes (Anjali, KC-3, NH615,MCU 7,SVPR-3, LH 900, PKV081, Suraj and Supriya) planted at 45x 15 cm (1,48,148 plant/ha) were compared with RCH 2 Bt planted at 90 x 60 cm. KC-3, highest yield (4663 kg/ha) an was on par with Anjali, NH 615 and Suraj.
- ◆ Eight *arboreum* genotypes were screened for yield performance at Coimbatore. Among them, Yaganti, a genotype from Nandyal, Andhra Pradesh recorded 2494 kg/ha, RG-8 ranked second with 1864 kg/ha and NDLA 3047 from Nandyal ranked third with the yield level of 1654 kg/ha.
- ◆ Inclined plate planter, cotton planter, cultivator mounted seed drill, pneumatic planter and animal drawn seed drill were compared with manual sowing. Manual sowing recorded the significantly highest yield (4031 kg/ha) and was on par with inclined plate planter (3843 kg/ha).
- ◆ Sowing by using inclined plate planter is economical as compared to manual sowing.
- ◆ Cotton raised under elevated CO<sub>2</sub> (650 ppm) gave significantly higher yield of 132 g/plant compared to 108 g/plant under ambient condition.
- ◆ Nutrient consortia spray increased the yield significantly by 12-15% irrespective of the atmosphere in which the plants were grown.
- ◆ Lenticel formation was found to be a good index in screening water logging tolerance. Culture nos- 2186, 2605, 2709, 2728, 2853, 3164, 3341, 4481 initiated lenticel formation within 3 days after water logging while culture no like 193, 891, 1093, 1422, 2648, 2698, 2711, 4261, initiated lenticel formation after 6 days out of the 125 cultures tried.
- ◆ Eighteen cultures developed at CICR, Nagpur was screened for drought tolerance under lab (Petri plates and pot culture) and field conditions. None of the genotypes were found to be superior over the tolerant variety LRA5166.
- ◆ Irrespective of the genotypes, pruning the crop after the harvest resulted in second fruiting cycle.
- ◆ Yield realized in Suraj crop in the second fruiting cycle due to pruning was 109 g/plant apart from the first crop yield of 170 g/plant. Quality parameters were not adversely affected, due to pruning.
- ◆ A Hydroponic method of culture was developed to study the nutritional deficiencies due to essential nutrients viz. Nitrogen, Phosphorous Potassium, Magnesium and Calcium. The deficiency symptoms were visible within seven days of culture. The pots were continuously aerated and also replenished

with nutrient solution regularly.

- Deficiency of N – Chlorosis of the leaves, particularly the older leaves.
  - Deficiency of P – Stunting; dark purple stems, purpling on upper and lower leaf surfaces; leaves small.
  - Deficiency of K – Stunting; interveinal chlorosis; leaves small, shiny, and deeply veined; some necrosis.
  - Deficiency of Mg – Stunting; leaves shiny, with a bronze cast; necrotic spots; older leaves appear normal
- ◆ Box Jenkins, a multiplicative time series model for forecasting was used to forecast the price of cotton at Karnataka and Andhra Pradesh cotton markets. The forecast was done for the first two markets in each State up to Dec'2014. Narrow variation was observed between actual and forecasted prices with an accuracy of 72%.
  - ◆ A total of 73,711 farmers were registered into a database called *e-kapas farmers' database*. Recorded noise free, short length, meaningful and timely messages were delivered through voice messages in the form of automatic phone calls to the registered farmers of Nagpur and Coimbatore.
  - ◆ Highest incidence of pink bollworm on non-Bt cotton was recorded in Junagadh (78.68 %) followed by Sirsa (61.21%) and Amreli (51.06 %) while the lowest incidence was recorded in Jalna and Nanded.
  - ◆ *Bracon lefroyi* (Dudgeon and Gough), a multiple braconid endoparasitoid causing larval mortality in pink bollworm was recorded from Nagpur.
  - ◆ In resistance monitoring of pink bollworm populations to Cry1Ac and Cry2Ab toxins during 2013-2014, Srivilliputtur, Sirsa, Junagadh and Khandwa populations recorded 2, 9, 4, and 20 fold resistances to Cry1Ac over susceptible check. Faridkot, Mansa, Sirsa, Rahuri, Akola, Junagadh and Khandwa populations recorded 25, 35, 35, 30, 40, 45, 140 and 330 fold resistances to Cry2Ab over the susceptible check.
  - ◆ Three high strength lines (CSH 3313, CSH 3047 and GTHH 032), identified as resistant source for bacterial leaf blight using CIR 246 marker were crossed with variety Suraj for incorporation of the trait through introgression breeding.
  - ◆ Among microbial inoculums, *Bacillus* sp. alone recorded highest seed cotton yield (1258 kg/ha) followed by TrichoCash alone (1255 kg/ha) and *P. fluorescens* alone (1208 kg/ha) compared to control (1035 kg/ha).
  - ◆ TrichoCash alone recorded statistically significant lowest PDI for Bacterial blight (11.38) followed by microbial consortia alone (15.51), Imidacloprid +Thiram (16.08), *Cedeceae davisae* alone (16.36) and *P. fluorescens* alone (18.32) compared to control (22.46).
  - ◆ Arogya (7.13) and CINHTi2 (8.99) recorded lowest PDI for bacterial blight, Supriya (9.25) and CINHTi2 (13.75) for myrothecium leaf spot, Suraj (6.66), Arogya (9.44) and ADB 532 (9.44) for grey mildew among 14 genotypes in HDPS under shallow soil. Spacing 45x10 cm recorded lowest average PDI for bacterial blight (32.0) and grey mildew (11.4).
  - ◆ CINHTi2 (20.75) and ADB 532 (23.93) recorded lowest PDI for bacterial blight, C1412 (12.69), Supriya (14.94) and Vikram (16.0) for Myrothecium leaf spot, Supriya (3.44), CINHTi1 (4.55) and Suraj (7.22) for grey mildew in medium soil. Spacing 60x10 cm recorded lowest average PDI for bacterial blight (30.75), 75x10 cm for Myrothecium leaf spot (19.28) and grey mildew (12.74).
  - ◆ *Anabaena laxa* + *Providencia* based formulation recorded highest seed cotton yield (1039 kg/ha), lowest Myrothecium leaf spot incidence (30.18 PDI) compared to control seed cotton yield (877 kg/ha), Myrothecium leaf spot incidence (42.11 PDI).
  - ◆ *B. subtilis* biofilm based formulation recorded highest seed cotton yield (5.03 q/ha) compared to control (3.62 q/ha) in genotype AKA7.
  - ◆ *Providencia* based formulation recorded lowest PDI for bacterial blight (7.1) followed by *Anabaena* – *P. fluorescens* biofilm based formulation (10.7) compared to control (33.3) in natural conditions in Suraj under HDPS.
  - ◆ *Anabaena* – *Bacillus* sp. biofilm based formulation, *Anabaena* - *Azotobacter* biofilm based formulation and *Providencia* based formulation recorded lowest PDI for bacterial blight of 7.1, 10.1 and 11.3 respectively and significant over control (44.0) in artificial inoculation of Suraj under HDPS.
  - ◆ PSP 8000 ppm seed treatment recorded lowest PDI for bacterial blight (20.2) followed by Agrisil 500 ppm spray (28.0), Agrisil 4000 ppm spray (28.6) and Agrisil 500 ppm seed treatment (31.5) and on par with each other and significant over control (47.60) under natural conditions in Suraj under HDPS.
  - ◆ PSP 2000 ppm seed treatment recorded lowest PDI for bacterial blight (19.64) followed by PSP 1 kg soil application (27.38) and Agrisil 4000 ppm spray (32.74) and the treatments were on par with each other and statistically significant over control (52.38) under artificial inoculation conditions in Suraj under HDPS.

- ◆ Nematode resistance and susceptibility were validated using molecular markers in genotypes Bikaneri Narma (resistant to rootknot nematode), American Nectariless and GCot-10 (resistant to Reniform nematode) and Suraj, Surabhi and NH615 (susceptible to nematodes).
- ◆ Three markers viz. CIR316, BNL3279 and NAU2152 have been validated for nematode resistance using 27 AICCIP high strength lines from Coimbatore.
- ◆ During mid season survey in Warud, Bhandara, Wardha, Katol, Kalmeshwar and Narkhed areas of Vidarbha region, lesion nematode *Pratylenchus goodeyi* was observed in samples from Warud and Bhandara districts.
- ◆ *P. goodeyi* was characterized based on 18sRNA sequence and populations and significant variations observed among populations. Molecular characterization has been done for *Rotylenchulus reniformis* and *Hoplolaimus columbus* isolated from cotton fields of Buldhana which were heavily infested with reniform nematode.
- ◆ Peak infestation of leafhoppers was observed between 38<sup>th</sup> to 41<sup>st</sup>SW, whitefly population with its peak at 39<sup>th</sup>SW (7.47 whiteflies/ 3 leaves). Two peaks of aphid incidence, first at 34<sup>th</sup> SW and second at 2<sup>nd</sup> SW (harvesting stage) were recorded. Thrips incidence was high at 3rd SW (6.23 thrips/3 leaves) and 5<sup>th</sup> SW (7.77 thrips/3 leaves).
- ◆ Pink bollworm incidence was below ETL during the entire crop season. Though large numbers of *Spodoptera* pheromone trap catches were recorded, the field damage was not correlated with trap catches.
- ◆ Life cycle of mealybug *P. solenopsis* was studied on five different constant temperatures (i.e. 12, 15, 18, 38, and 40°C) with respect to different developmental stages. Slow and lengthy growth recorded at lower temperature and fast and reduced growth recorded at higher temperature. The average total life cycle of female and overall development stage were found to be higher at 18°C.
- ◆ Biological diversity revealed five mealybug species viz. *Phenacoccus solenopsis* Tinsley, *Paracoccus marginatus* Williams and Granara de Willink, *Maconellicoccus hirsutus* (Green), *Nipaecoccus viridis* (Newstead) and *Ferrisia virgata* infesting cotton in a sporadic manner. Three mirid species viz. *Creontiades biseratense*, *Campylomma livida* and *Hyalopeplus lineifer* Walker and regular sucking pests viz. leafhoppers, thrips, whiteflies and aphids were recorded. Bollworms *H. armigera*, *E. vitella* and *P. gossypiella* were recorded from non-Bt cotton. The *Spodoptera litura*, semilooper and leaf folder damage was negligible.
- ◆ Forecasting models based on AICCIP historical data for sucking pests have been worked out. ARIMA model fitted and the goodness of fit statistics for different pests of seven years (2005-11) average data from Junagadh and Akola. Model indicated that R<sup>2</sup> values for Junagadh are 0.84, 0.93, 0.78, 0.86 and Akola are 0.73, 0.67, 0.63, and 0.60 for aphids, jasids, thrips and whiteflies respectively.
- ◆ Five parasitoids viz. *Aenasius bambawalei*, *Acerophagus papayae*, *Anagyrus kamali*, *Aprostocetus* sp., *Homalotylus* sp. found parasitizing different species of mealybugs infesting cotton in central zone. Average parasitism of *P. solenopsis* by *A. bambawalei* was 11%, *P. marginatus* by *Acerophagus papaya* was 8%, *N. viridis* by *Anagyrus kamali* was 14% and *N. viridis* by *Aprostocetus* sp. was 7.5%. The highest population of general predator *Cheilomenes sexmaculata* recorded during 1<sup>st</sup> week of august to first fortnight of September. Dipteran fly *Cacoxenus perspicax* (Knab) was found to predate on *N. viridis* (26.3%). *Hyperparasitoids Promuscidea unifasciiventris* was recorded from *N. viridis* colonies parasitized by *Anagyrus kamali* and *Aprostocetus* sp. Nine species of spiders have been identified from cotton fields during crop season 2013-14.
- ◆ Un-infested plants emit low ethylene while infested plants (Grade II to IV) emit significantly higher ethylene. The corresponding ethylene emission under protected and unprotected plants for the grades I, II, III and IV were 1.24, 1.54, 1.49 & 1.52 and 1.11, 1.44, 1.60 & 1.65 ppm respectively. A leaf hopper stressed plant at 60 DAS released up to 4 ppm ethylene while the levels were undetectable in control plants.
- ◆ Over the season, average per cent insect fauna trapped by yellow sticky trap for whiteflies were 4.90 & 6.39, leafhoppers 37.93 & 44.40, aphids 1.19 & 1.74, ladybird beetle 0.86 & 0.95, Hymenoptera 0.10 & 0.11 and Dipteran flies 0.70 & 0.74 under protected and unprotected fields respectively.
- ◆ Five cultures with elite fibre properties and comprehensive pest tolerance were developed with yield potential of 8 q/ha under unprotected conditions at normal spacing. One of these is compact with short sympodia, is highly suitable for HDPS.
- ◆ Ethylene responsive factors 1 and 2 (ERF 1 and 2) were over expressed by 2.94 and 17.4 times in leaves of leaf hopper infested plants as compared to control plants while ERF3 remained unaffected.
- ◆ Sticky trap (28.5 cm x 22 cm) was used as a mobile trapping unit for sucking pests at 65 DAS. Leaf

hopper and whitefly adults were trapped effectively while nymphal population was under estimated. Manual counting of leaf hopper adults was positively correlated (0.8) with mobile sticky trap count in 14 varieties.

- ◆ Pyridalyl recorded an LC<sub>50</sub> of 68.74 ppm while nano pyridalyl recorded an LC<sub>50</sub> of 43.88 ppm against one day old *H. armigera* in diet incorporation bioassays. The EC<sub>50</sub> of nanopyridalyl (16.74 ppm) was 3 fold higher than pyridalyl (51.26 ppm).
- ◆ Pyridalyl recorded an LC<sub>50</sub> of 13724 ppm while nano pyridalyl recorded an LC<sub>50</sub> of 9166 ppm against 3<sup>rd</sup> instar larvae of pink bollworm in diet incorporation bioassays. The EC<sub>50</sub> of nano pyridalyl was 11.8 fold higher (346 ppm) than Pyridalyl (4094 ppm).
- ◆ Topical bioassay of Thiodicarb against 2 strains of *H. armigera* (Coimbatore and Washim) at the 3<sup>rd</sup> instar larvae recorded LC<sub>50</sub> of 2.51 and 1.91 ppm, respectively. Topical bioassay of Flubendiamide (new molecule) against 3<sup>rd</sup> instar larvae of 2 strains of *H. armigera* from Sirsa and Parbhani exhibited an LC<sub>50</sub> of 0.297 and 0.117 ppm respectively.
- ◆ Cotton semilooper *Anomis flava* recorded 1000 fold more tolerant to Cry2Ab (LC<sub>50</sub>=0.212 µg/ml) as compared to Cry1Ac.
- ◆ *H. armigera* larvae were collected from Sirsa on BGII and non-Bt cotton. The non-Bt population exhibited minimal mortality for Cry1Ac at highest concentration of 1.97 µg/ml of diet and EC<sub>50</sub> of 0.469 µg/ml of diet in F<sub>1</sub> generation. Cry2Ab exhibited an EC<sub>50</sub> of 27.26 µg/ml of diet on field resistant Sirsa population. Populations generated from BGII collections exhibited LC<sub>50</sub> and EC50 values of 2.46 and 0.061 µg/ml of diet for Cry1Ac.
- ◆ F<sub>2</sub> screen study of *H. armigera* was carried out using 256 iso-females from Gujarat and 215 iso-females from Maharashtra. Resistance to Cry1Ac was detected in the F<sub>2</sub> population of Surat (A7, 2, 5) and F<sub>1</sub> population of Buldana (A10). The resistant Surat *H. armigera* (Surat A7, 2, 5, 1, 5) line exhibited no mortality at the highest concentration of 1.97µg/ml of diet of MVP11 with an EC<sub>50</sub> of 0.071 µg/ml for Cry1Ac while LC<sub>50</sub> to Cry2Ab was 2.66 µg/ml of diet and EC<sub>50</sub> was 0.712 µg/ml of diet.
- ◆ Full length cDNA sequence of Chitin synthase A (4704bp) of *Helicoverpa armigera*, and exons of alternative spliced variants (A1 and A2) was isolated based on the sequence information from BAC clone of *Helicoverpa zea*. Homology based search with nucleotide sequence (blastn) and translated nucleotide query (blastx) showed 98% and 99 % similarity with *Helicoverpa zea*.
- ◆ qPCR analysis using the primer designed for conserved region of chitin synthase A and B indicated that chitin synthases A and B remain highly expressed in the midgut tissue of all the larval stages tested.
- ◆ Maximum percent reduction in whitefly population was observed with insecticide Diafenthiuron (55.76%) and Triazophos 40EC (52.00%) treatment followed by Neemazal-T/S, 1%EC (45.51%) and Flonicamid 50%WG (33.60).
- ◆ University recommended dose of diafenthiuron @ 312.5 g/ai gave maximum percent reduction (51.36%) in whitefly population followed by its label claim dose @300gai/ha. Resurgence in whitefly population was observed at both label claimed and university recommended doses of Fipronil 5% SC.
- ◆ Overall Pink bollworm (PBW) % recovery ranged between 4.7 to 19.90 % upto 160 DAS from Non Bt bolls collected from different locations of North Zone. No larval recovery as well as damage was recorded from the collected Bt cotton fields from different locations at different intervals.
- ◆ Peak catch of PBW moths was recorded during 42<sup>nd</sup> SMW (25.62/trap/week), American bollworm (ABW) during 12<sup>th</sup> SMW (48.1/trap/week), Spotted bollworm during 39<sup>th</sup> SMW (29.29/trap/week) and Tobacco caterpillar during 18<sup>th</sup> SMW (205.7/trap/week) was observed.
- ◆ The cotton leaf curl virus disease appeared in 24<sup>th</sup> meteorological week and reached 100% at 33<sup>rd</sup> week in the screening nursery of Sirsa regional station. The incidence and severity of disease was higher compared to 2011-12 & 2012-13. The incidence of whitefly was also very high during the period with a maximum of 32 whiteflies /3 leaves in the 30<sup>th</sup> week. Flare up of whitefly population might be due to less rainfall received during June and July in north zone. The whitefly range from 4.5 to 32.0 /3leaves during the period. The range of maximum temperature between 31.5-39.9 °C and minimum temperature between 25.4-29.5 °C was recorded during the period. The morning and evening relative humidity varied from 59.4-90 and 31.9-81.3 % respectively.
- ◆ Based on station and field experiments, the minimum PDI was noted in case of Cow urine treatment (51.32) @ 6.6% followed by neem oil (51.91) @ 1% and calcium nitrate (52.95) @0.5% as compared to control (56.28). Reduction of whitefly population from 9.8 -13.3 in case of neem oil as compared to -34.5 to 37.4% in control was also noted. There was improvement in yield upto 1.1 q/ha in cow urine spray treatment.

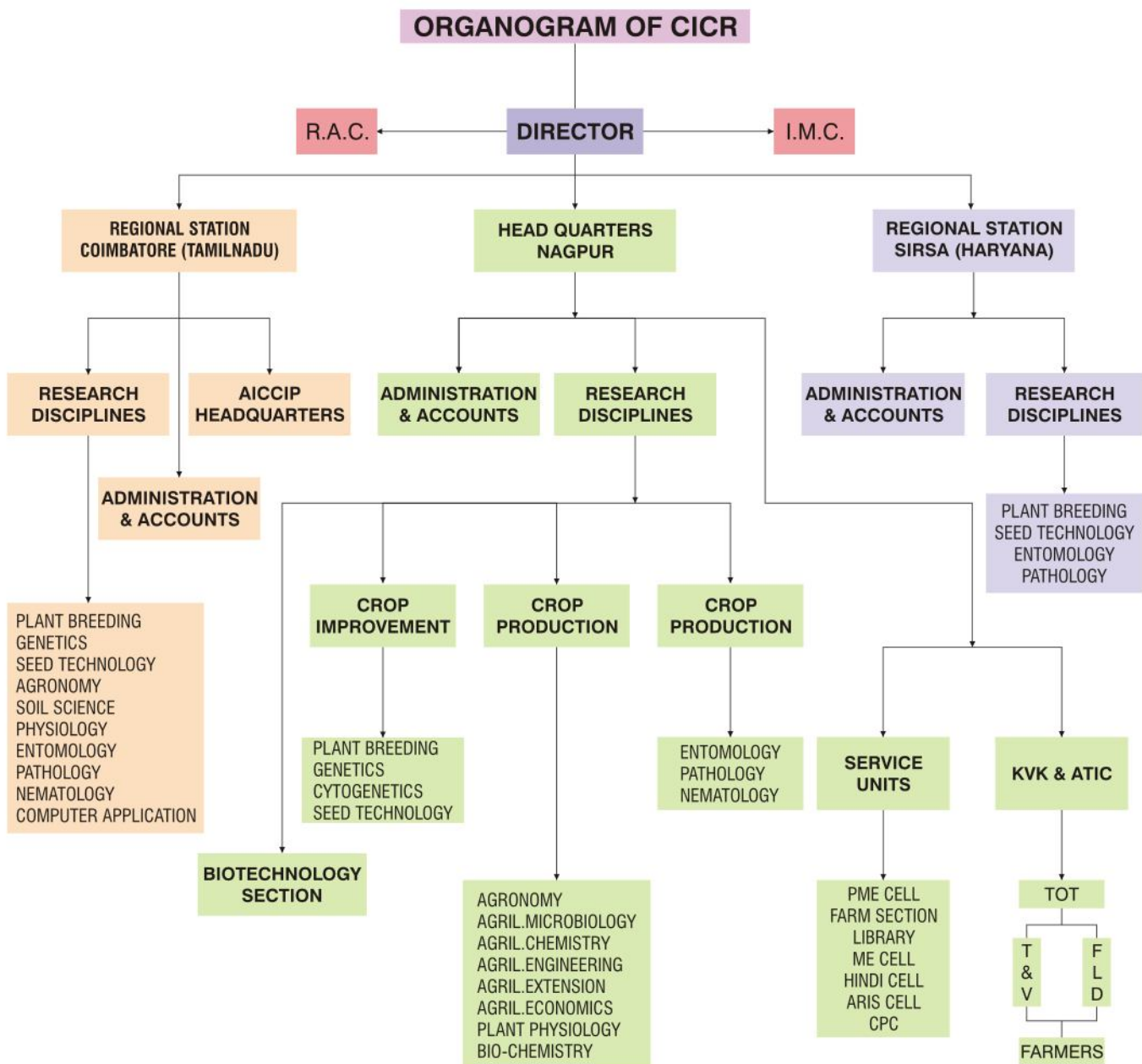


## 2.1: Brief History

- The Central Institute for Cotton Research was established at Nagpur by the ICAR, in 1976. The two regional stations of IARI at Sirsa (Haryana) and Coimbatore (Tamil Nadu) were transferred to CICR to cater to the needs of north and south India, respectively.

## 2.2: Mandate

- To conduct basic and strategic research on cotton to improve yield, fibre quality and by-products.
- To create new genetic variability for location-specific adoption in cotton-based cropping systems.
- To assist in the transfer of modern cotton production technology to various user agencies.
- To extend consultancy and linkage with international agencies to accomplish the above mandate.



### 2.3 : Staff Position (as on 31<sup>st</sup> March, 2014)

Name of the Post	Sanctioned Cadre Strength				Post Filled Up			
	NGP	CBE	Sirsa	Total	NGP	CBE	Sirsa	Total
Director (RMP)	1	--	--	1	1	--	--	1
P.C. (Cotton) & Head (RMP)	--	1	--	1	--	1	--	1
Scientific	51	20	8	79	31	13	6	50
Technical	46	16	10	72	38	8	8	54
Administrative	34	9	5	48	25	7	5	37
Supporting	43	17	10	70	30	8	8	46
<b>Krishi Vigyan Kendra</b>								
Training Organizer	1	--	--	1	1	--	--	1
Technical	11	--	--	11	10	--	--	10
Administrative	2	--	--	2	2	--	--	2
Supporting	2	--	--	2	1	--	--	1

NGP – Nagpur; CBE - Coimbatore

### 2.4 : Financial Statement

(Rs. in Lakhs)

The budget grant and actual expenditure for the year 2013-14 are furnished below:

S. No.	Scheme	Sanctioned	Expenditure
<b>CICR</b>			
1	Plan	200.00	198.23
2	Non- Plan	2741.52	2729.94
<b>Plan Schemes</b>		3593.08	1759.77
<b>NAIP Plan Schemes</b>		113.37	60.26
<b>Deposit Schemes funded by outside agencies</b>		346.91	316.32



## 3.1: Cotton Genetic Resources

### Biodiversity, characterization, conservation and utilization of cultivated and wild species

#### Nagpur

#### Exploration for perennials

Exploration and collection programmes were

undertaken in Manipur, Nagaland, Meghalaya, Assam, Maharashtra and Gujarat. Thirty five cotton germplasm materials were collected including 25 perennials of *G. barbadense* and 10 traditional cultivars belonging to *G. arboreum* and *G. herbaceum* (Table 3.1.1). All these germplasm were established in pot culture and their seeds were stored in the Gene bank. The collected cotton germplasm were characterized morphologically.

Table 3.1.1: Perennials and landraces of cotton collected from different regions of India

State	Districts	No. of Accessions	Species	Annual/ Perennial/ Landrace
Manipur	Imphal West, Senapati, Thoubal, Tamenglong, Bishnupur, Imphal East & Chandel	16	<i>G. barbadense</i>	Perennial
Maharashtra	Wardha	2	<i>G. barbadense</i>	Perennial
Gujarat	Mehsana, Patan, Banaskantha & Kachchh	5	<i>G. herbaceum</i>	Annual
		4	<i>G. arboreum</i>	Annual
		1	<i>G. barbadense</i>	Perennial
		3	<i>G. barbadense</i>	Perennial
Nagaland	Mon & Tuensang	3	<i>G. barbadense</i>	Perennial
Meghalaya	West Garo Hills	1	<i>G. arboreum</i>	Annual
Assam	Barpeta	3	<i>G. barbadense</i>	Perennial
<b>Total</b>		<b>35</b>		



Traditional Desi cotton *G. herbaceum* of Mehsana Gujarat



Perennial Cotton *Gossypium barbadense* of Bishnupur, Manipur

#### Fiber quality traits of perennial cotton

Fibre quality traits of 19 morphologically distinct germplasm materials were evaluated. Ten unique germplasm were established in perennial species garden. These included important *G. arboreum* land races like Ponduru cotton, Mathio cotton and Karunganni cotton and *G. herbaceum* land races viz. Wagad and Uppam cotton.

#### Molecular characterization of wild species and perennials

A total of 413 Simple Sequence Repeat (SSR) markers were screened using a set of 20 wild species of cotton, 15 races of cultivated species and synthetic polyploids to identify informative markers for genetic diversity assessment. Of the markers tested, 24% (103/413) showed polymorphism (Fig. 3.1.1).

## F<sub>2</sub> mapping population established

S.No	Derivative	Number of F <sub>2</sub> plants
a.	<i>G. herbaceum</i> x <i>G. longicalyx</i>	557
b.	<i>G. arboreum</i> race <i>indicum</i> x <i>G. davidsonii</i>	212
c.	<i>G. arboreum</i> x <i>G. thurberi</i>	53
d.	AK 8401 x <i>G. davidsonii</i>	34

Eleven fibre strength specific SSR primers were found to be polymorphic in the F<sub>2</sub> mapping population of *G. herbaceum* and *G. anomalum*. The F<sub>1</sub> of *G. herbaceum* and *G. anomalum* cross showed only 43% pollen fertility and >50% bolls were deformed in shape resulting in premature shedding but fibre strength was high i.e. 36.7 g/tex.



Fig. 3.1.1: Genetic diversity assessment in F<sub>2</sub> mapping population of wild species and races.

1.Africanum 2.Herbaceum 3.Digvijay 4.Indicum 5.Burmanicum 6.Bengalense 7.Cernuum 8.Sinense 9.Soudanense 10.Anomalum 11.Triphyllum 12.Capitis virides 13.Barbosanum 14.Sturtianum 15.Australe 16.Thurberi 17.Armourianum 18.Davidsonii 19.Klotzchianum 20.Aridum 21.Raimondi 22.Lobatum 23.Trilobum 24.Stocksii 25.Somalense 26.Bickii 27.Latifolium 28.Palmeri 29.Marie galente 30.Richmondii 31.Mexicanum 32.AK8401 33.Thespesia 34.Barbadense type Kuhu mandhal 35.Barbadense type Bhandara 36.IC 3981 pigmented arboreum 37.RHCW-1 kidney cotton 38.G. Barbadense collected from West Bengal 39.IC 3912 arb 40.IC 3914 arb 41.Exotic-3 42.Diu 90 43.Diu 91 44.Moco 45.Diu 92 46.Diu 93 47.Serido 48.Diu 4494

Molecular characterization was carried out for 31 perennials using 19 SSR markers. Out of nineteen, five SSR markers were polymorphic (Fig. 3.1.2)

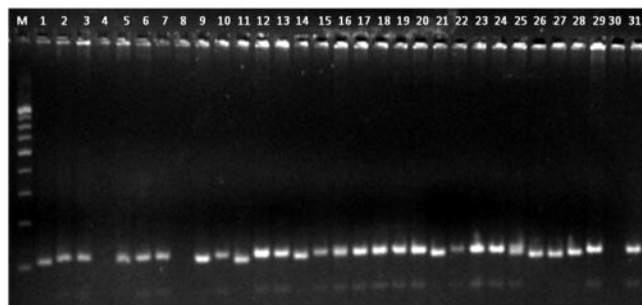


Fig. 3.1.2: SSR profile of 31 collected landraces of desi cotton and perennials from Tamil Nadu, Tripura and Gujarat with primer NAU 396

1-PLC124, 2-PLC125, 3-PLC126, 4-PLC127, 5-PLC128, 6-PLC129, 7-PLC130, 8-PLC131, 9-PLC132, 10-PLC133, 11-PLC134, 12-PLC135, 13-PLC136, 14-PLC137, 15-PLC110, 16-PLC111, 17-PLC112, 18-PLC113, 19-PLC114, 20-PLC115, 21-PLC116, 22-PLC117, 23-PLC118, 24-PLC119, 24-PLC119, 25-PLC120, 26-PLC139, 27-PLC140, 28-PLC141, 29-PLC142, 30-PLC143, 31-PLC144

### Genetic stocks identified for registration

Five genetic stocks viz. three of *G. arboreum* and two of *G. hirsutum* were identified for registration with NBP GR, New Delhi (Table 3.1.2).

#### CNH 219 - Pigmented plant body



Table 3.1.2 : Genetic stocks identified for registration

Designated material	Species	Traits
CNA-405	<i>Gossypium arboreum</i>	Narrow leaf lobe and brown linted
CNA-406	<i>Gossypium arboreum</i>	Broad leaf lobe and brown linted
CNA-407	<i>Gossypium arboreum</i>	Narrow leaf lobe, Pigmented plant body, brown linted
CNH -219	<i>Gossypium hirsutum</i>	Pigmented plant body, deeply palmate leaf lobe and brown linted
CNH CB-228	<i>Gossypium hirsutum</i>	Densely hairy bolls and cluster bolls bearing habit

### Enrichment of cotton gene bank and maintenance of germplasm

Seven hundred and twenty three (723) exotic accessions of *hirsutum* were procured through NBPGR, New Delhi for enrichment of the cotton gene bank. In addition to the above, trait specific 349 germplasm lines (*G. barbadense* - 209, *G. hirsutum* - 75, *G. arboreum* - 2,

*G. herbaceum* - 43 and wild species - 20) were selected from Germplasm Resource Information Network (GRIN). Nine import permits were issued by the NBPGR for procurement of above exotic germplasm.

### Maintenance of germplasm

The following were maintained in the wild species garden:

- 26 wild species
- 15 races cultivated species
- 40 synthetic polyploids
- One new species (EC 669583) was established in pot

### Germplasm evaluation

Two thousand and eighty-five accessions of *G. hirsutum* were evaluated for fibre quality traits. Fifteen long linted accessions (staple length, 30.8-32.9 mm) and 38 accessions for high fibre strength (23.0 – 24.8 g/tex) were identified and documented.

### Long fibre accessions

IC 292705 (32.9 mm), EC 1044 (32.9 mm), IC 292566 (32.7 mm), IC 359044 (32.7 mm), EC 344109 (32.6 mm), IC 291381 (32.4 mm), EC 344048 (32.3 mm), EC 344049 (32 mm), EC 344201 (31.4 mm), EC 1072 (31.3 mm), EC 1035 (31.2mm), IC 158943 (31.1 mm), EC 1015 (31.1 mm), IC 292478 (30.8 mm) and EC 343702 (30.8 mm).

### High fibre strength accessions

- **24.1 to 24.8 g/tex:** EC 344131 (24.8 g/tex), EC 1044 (24.7 g/tex), EC 1035 (24.6 g/tex), EC 344158 (24.4 g/tex), EC 344150 (24.4 g/tex), EC 1072 (24.4 g/tex), EC344049 (24.3 g/tex), EC 344048 (24.2 g/tex), EC 1084 (24.1 g/tex)
- **23.1 to 23.9 g/tex:** IC 358317 (23.9 g/tex), IC 359893 (23.9 g/tex), EC 343737 (23.9 g/tex), EC 1015 (23.8 g/tex), IC 291617 (23.7 g/tex), IC 150047 (23.7 g/tex), EC 343750 (23.7 g/tex), IC 158943 (23.6 g/tex), EC 1087 (23.6 g/tex), IC 292478 (23.6 g/tex), IC 358410 (23.6 g/tex), IC 358479 (23.5 g/tex), IC 358571 (23.5 g/tex), IC 359914 (23.5 g/tex), IC 358473 (23.4 g/tex), IC 357906 (23.4 g/tex), IC 358278 (23.4 g/tex), EC 343662 (23.4 g/tex), IC 357845 (23.2 g/tex), IC 359889 (23.2 g/tex), IC 291375 (23.2 g/tex), EC 344053 (23.2 g/tex), EC 343952 (23.2 g/tex), IC 292063 (23.1 g/tex), EC 343794 (23.1 g/tex), EC 1085 (23.1 g/tex)
- **23.0 g/tex:** IC 360036 (23.0 g/tex), EC 343609 (23.0 g/tex) and EC 343702 (23.0 g/tex).

### Evaluation of germplasm for salinity

Twenty-five germplasm lines including promising advanced cultures (*G. hirsutum* – 10, *G. herbaceum* – 10 and *G. arboreum* – 5) were evaluated in saline Vertisols (9.2 dS/m) at Central Soil Salinity Research Institute, Regional Research Station, Bharuch, Gujarat. The highest seed cotton yield was recorded in germplasm accessions; *G. herbaceum* : IC 371126 and IC 371099, *G. arboreum* : CNA 443, CNA 442 and CNA 447 and *G. hirsutum* : DTS 301, CNH 19 and 29 I.

### Gossypol estimation

Seed gossypol was estimated in 1994 germplasm accessions. Gossypol content ranged from 0.03 to 1.17 % and 1750 accessions showed gossypol content between 0.1 to 0.5 %.

### Distribution and utilization of germplasm in crop improvement programmes

Six thousand two hundred thirty two (6232) germplasm accessions (*G. hirsutum* - 6194, *G. barbadense* - 3, *G. arboreum* - 27, *G. herbaceum* - 1 and wild species - 7) were distributed to scientists of different State Agricultural Universities.

### Barcoding of germplasm

Barcoding of conserved germplasm accessions was undertaken and 5000 accessions of *G. hirsutum* were barcoded for easy retrieval and identification in gene bank.

### Coimbatore

In common trials of germplasm lines, 28 select *G. hirsutum* germplasm lines and 16 *G. arboreum* germplasm lines were evaluated for yield and other characteristics. Among the *G. hirsutum* germplasm lines evaluated, IC 359780 recorded the highest seed cotton yield (1805 kg/ha) followed by Sumangala (1453 kg/ha). Zero branching habit was noted in IC 291509, IC 360026, IC 356618 and IC 359992. Among *G. arboreum* germplasm lines evaluated, the highest seed cotton yield was recorded in IC 439854.

Three hundred and five *G. barbadense* germplasm lines were maintained and catalogued. Eighteen new *G. barbadense*, perennials were morphologically characterized.

### Sirsa

Out of 260 compact lines identified and evaluated at 67.5 x 10 cm, 10 lines with maximum 120 cm height and 20 cm width, with superior yield and tolerance to sucking pest and CLCuV were identified. DCI-48 (3120 kg/ ha), H-1091/99 (3000 kg ha) and GJHV-47(2970 kg/ ha) were the highest yielders. In addition, 3 lines viz. SP-3897 (2900 kg/ha), PAKISTAN-2 (3020 kg/ha) and N-78 (2900 kg/ha) with ultra narrow characteristics and earliness were observed against check RS 875 (2103 kg/ha).

### Identification of germplasm sources of resistance to insect pests

One hundred and sixty eight compact accessions were evaluated for reaction towards sucking pest. For whitefly, 36 entries were found to be moderately resistant (1-10 whitefly/3 leaves) and 29 entries susceptible (> 30whitefly/3 leaves). For thrips, only one entry was susceptible (> 45 thrips/3 leaves) and 116 entries were moderately resistant (1-15 thrips/3 leaves).

For leafhopper, 151 and 17 entries fall under highly resistant (0-3 leafhopper/3 leaves) and moderately resistant (4-10 leafhopper/3 leaves) category, respectively.

## 3.2 : Hybrid Cotton

### Nagpur

#### Development and maintenance of male sterile cotton

One hundred and thirty seven CMS (*harknessii* based), 15 CMS (*G. aridum* based), 20 GMS lines and 57 restorers were maintained through crossing with their counter B-lines, sib mating and selfing respectively. Seed multiplication for four new GMS lines developed through backcross breeding was taken up and crosses attempted to study the combining ability of these lines. Fourteen GMS *arboreum* lines were sib multiplication mated for seed and maintenance. A maximum of 26.1 g/tex fibre strength was recorded for GMS line GAK-8615(A) followed by 25.7 g/tex for GMS-4-1. These lines could be used to improve fibre quality of existing *arboreum* cultures.

Fifteen crosses were attempted to develop *Desi* hybrids (both conventional and GMS based). Two *Desi* GMS lines were crossed with five grey mildew immune lines and five promising genotypes were crossed with five grey mildew immune lines to develop grey mildew resistant *arboreum* hybrids with big bolls and high boll retentivity.

### Sirsa

#### Tetraploid cotton

#### Release of intra-*hirsutum* GMS based hybrid CSHG 1862



Intra-*hirsutum* GMS based hybrid CSHG 1862 was released by Central Varietal Release Committee for irrigated conditions of Haryana, Punjab and Rajasthan vide Gazette Notification No S.O. 952(E) dated 10 April 2013. This hybrid recorded an overall mean seed cotton yield of 2102 kg/ha as against 1882 kg/ha of CSHH 198 (Common Check) and 1980 kg/ha of local checks. Increase in seed cotton yield over the common (Zonal) check was 11.6 % and over that of local checks 5.8 %. Besides easy seed production, the GMS based hybrid CSHG 1862 is also capable of spinning at 40s counts.

#### Evaluation of intra-*hirsutum* crosses

To develop segregating population of *G. hirsutum* cotton, 16 crosses were attempted among CLCuV tolerant germplasm lines in a Line x Tester fashion. This year, crosses were evaluated against two checks CSHH 198 and CSHH 238 and the highest seed cotton yield was recorded in RS 2013 x CSH 2811 (2278 kg/ha), followed by RS 2013 x CSH 2937 (2074 kg/ha) as against 2167 kg/ha of conventional check hybrid CSHH 238. Maximum ginning out-turn of 34.1 % was recorded by the hybrid PIL8 x CSH 2937. The highest 2.5 % span length (27.5 mm) and bundle strength (23.3 g/tex) was recorded by the hybrid CB-33 x AKH 9620 respectively. The cross combination Jhorar x LRA 5166 showed the minimum CLCuV incidence of 19.5 PDI but gave the seed cotton yield of 1481 kg/ha only as compared to 2167 kg/ha of CSHH 238 with 33.3 PDI CLCuV.

#### Diploid cotton

Fifteen new crosses were attempted in line x tester fashion for hybrid development in *G. arboreum*. Four crosses using 4 GMS lines were done for large scale testing to ascertain their yield potential. All the GMS lines are maintained through sibmating. GMS based hybrid CISAA27 was sponsored in Br 25a AICCIP national trial.

## 3.3 : Genetic Improvement

### Nagpur

#### *G. arboreum* (Diploid cotton)

#### New cultures for surgical cotton

From the existing progenies, 12 short stapled cultures with high micronaire were identified. Among these, the lint samples of CNA 441, CNA 443, CNA 444, CNA 445 and CNA 447 were found suitable for absorbent and surgical purpose as per the IP 1996 standards. From another set of 13 cultures, CNA 418 and CNA 423 were found to be good in terms of liquid absorbency (1.1-1.2 second) and sulphate ash content (0.30-31%).

#### Identification of promising cultures

Twenty nine new *arboreum* cultures were evaluated under narrow spacing of 60 x 22.5 cm. Sixteen cultures

yielded more than 893 kg/ha. Eight cultures recorded boll weight > 3 g. CNA 2017 (4.1 g) recorded the highest boll weight which was superior to check AKA 8401 (3.7 g). Two entries viz., CNA 2006 and CNA 2009 have been entered in institute trial. Culture CNA 2023 was identified for high productivity with good boll number.



High yielding *G. arboreum* culture CNA 2023

Sixty six *G. arboreum* cultures identified previously for yield and fiber quality, were evaluated in replicated trial. The seed cotton yield ranged from 302 kg/ha to 1160 kg/ha. Cultures CNA 1013 and CNA 1021 were identified for sponsoring into AICCP trials.

### *G. hirsutum* (Tetraploid cotton)

#### Breeding for compactness

Three  $F_1$ s viz., N 170 ( Early maturing dwarf compact) x IC 356750, N 170 x introgressed LRA 5166 and N 170 x IC 358358 were evaluated for boll weight, boll number and plant type. Sixty three  $F_1$  plants recorded variation for number of bolls per plant (3 to 25) and boll weight ( 1 to 3.2 g) and plant height ranged from 27 to 100 cm. New  $F_1$  cross viz., N 170 x IC 356771 has been generated which is trait specific for big boll size. Fifteen dwarf  $F_1$ s were identified with plant height ranging from 25 cm to 56 cm.

Five trials were conducted with a spacing of 60 x 15 cm. The cross RS 875 x Rex recorded optimum yield levels with plant height of 77 cm, 18 cm sympodial length, 63 bolls/sq metre, small leaf size and medium boll weight (3 g). The checks grown were NH 615 and PKV 081. RS 810 x MHL 557 has been identified as having fibre length upto 29 mm.

#### Evaluation of genetically enhanced populations

Fifty-nine ( $F_8$ ), 29  $BC_3F_6$  and 22  $BC_2F_5$  genetically advanced lines were evaluated at 60 x 45 cm spacing. In  $F_9$ , the cross PKV 081 x Deltapine 66 recorded boll

number improvement (upto 36 bolls) as compared to parent (with 26 bolls) while cross G.cot 10 x Deltapine 66 recorded 45 bolls/plant as compared to parent G.cot 10 with 27 bolls/plant. In  $BC_2F_5$ , the backcross PKV 081 x (PKV 081 x PIL 8) gave the highest plot yield of 880 kg/ha with a spacing of 60 x 45 cm. However, in  $BC_3F_6$ , the same cross PKV 081 x (PKV 081 x PIL 8) had recorded 1407 kg/ha at a spacing of 60 x 45 cm. Fibre strength upto 23.8 g/tex was achieved in a unreplicated trial of advanced material. A medium duration high yielding culture, CNH 2015 was also developed.

In 29 inter-mating lines derived from 5 parental crosses (sixth cycle), 10 best lines were identified based on seed cotton yield and boll number (Table 3.3.1). Line IM 11 had the highest yield while line IM 26 had the highest boll weight (4.6 g). Many single plant selections for semi-compact and compact types were made which can serve as supportive useful material in breeding for compact types.



Table 3.3.1: Yield and yield attributes of superior inter-mating lines derived from five parental crosses

S.No.	Name of the entry	Seed cotton yield(kg/ha)	Boll wt.(g)	Boll no./plants
1	IM-1	1677.2	2.0	29
2	IM-11	1851.8	3.0	25
3	IM-12	1481.4	3.0	18
4	IM-13	1058.2	2.8	24
5	IM-14	1322.7	3.6	21
6	IM-16	1296.3	3.6	20
7	IM-19	1419.7	3.4	20
8	IM-21	1543.2	3.6	26
9	IM-22	1586.4	3.8	22
10	IM-26	1080.2	4.6	23
11	Suraj (check)	851.8	3	12

## Abiotic stress tolerance

### Nagpur

#### Drought

Four sets of experiments were conducted under rainfed and irrigated conditions to assess drought tolerance efficiency of the genotypes which are under various stages of development. Trials under irrigated conditions were vitiated due to heavy rains that persisted till October end. In the first set, eight identified drought tolerant cultures were tested along with five new genotypes for second year. All the identified cultures recorded more than 15 % increase over the check (LRA 5166). DTS 155, DTS 62, DTS 104 and DTS 44 were better performers for the second year of testing. DTS 155 recorded highest yield of 610 kg/ha with 67 % increase over the check LRA5166.

The second set comprised of 12 genotypes in F<sub>5</sub> generation, their parents and check Rajat. The seed cotton yield ranged from 401-646 kg/ha and ten genotypes were on par to the check Rajat (477 kg/ha). Pusa 56-6 x 30 I was the highest yielder followed by 29 I, 29 I x Pusa 56-4 and Pusa 56-4 x 29 I. These crosses recorded more than 20 % increase over the check.

The third set consisted of 49 single plant selections which during their preliminary evaluation had recorded high seed cotton yield, good fibre length (>28 mm) and fibre strength (> 22 g/tex). The highest yield was recorded by DTS 79 (625 kg/ha) followed by DTS 116, DTS 141, DTS 123, DTS 69 and DTS 75. Some of these selections recorded boll weight upto 4.0 g. Twelve F<sub>1</sub>s and six parents were tested in the fourth set under replicated trial. Cross PKV 081 x Suraj, 28 I x Suraj and NH 615 x Rex were some of the good performers recording 30% increase over the check LRA5166. Cross CCH 510-4 x Moco was completely fertile and showed good boll bearing with 12% increase over the check LRA 5166 (763 kg/ha). Cross LRA 5166 x N 170 was very compact and early, while 28 I x Suraj was early as well as resistant to jassid.

Eighteen intercross material were tested along with a moderately tolerant check LRA 5166 under laboratory,

pot culture and field condition. The lines were tested for germination using PEG 6000 from -0.2 to -0.9 MPa stress. Only one line 41(55)-02 could germinate at above -0.6 MPa stress. In pot culture studies, none of the lines could survive more than three days of moisture stress. In field studies, all these lines were found similar to LRA 5166 for seed cotton yield.

Five cultures were tested for salt tolerance at Central Soil Salinity Research Institute, Regional Station, Bharuch. Two of these cultures (DTS 29 I and DTS 30 I) recorded good yield (1252 and 1280 kg/ha) at salinity level as high as 9.2 dS/m. Culture CNH 28 I was promoted to Br 06 (b) trial of AICCIP in both central and south zone.

#### Screening for drought tolerance

Earliness (drought avoidance) is a phenological trait which increases the relative amount of moisture that is vital during reproductive stage to cotton grown on shallow and medium soil. Of the 2000 cotton germplasm accessions grown, 84 short duration lines were identified based on days to 50 % boll opening.

Fifty one cotton germplasm lines were identified to have high epicuticular wax content in leaves. Presence of epicuticular wax content is a water conservation strategy for drought tolerance traits. Epicuticular wax content in the okra type leaf of cotton germplasm accessions was in the range 47.1 to 473.7 µg/ cm<sup>2</sup> values for early maturing accessions with normal leaf ranged from 46.4 to 132.9 µg/ cm<sup>2</sup>.

#### Waterlogging

##### Nagpur

Two thousand - *G. hirsutum* germplasm accessions were screened against waterlogging during the cropping season 2013-14 and of these 200 accessions tolerant to waterlogging were selected. The 45 days old saplings of 150 germplasm accessions selected during 2012-13 were kept waterlogged continuously for 70 days. The maturity of the plants in waterlogged field was delayed as compared to that of the plots in normal field i.e. control field by 25 -30 days. Selected single plants (200 number) showed tolerance to waterlogging.



Field artificially waterlogged for 70 days during crop growth

## Coimbatore

Lenticel formation was found to be a good index in screening waterlogging tolerance. Out of the 125 cultures treated Culture 2186, 2605, 2709, 2728, 2853, 3164, 3341, 4481 initiated lenticel formation within 3 days after waterlogging while cultures 193, 891, 1093, 1422, 2648, 2698, 2711, 4261, initiated lenticel formation in response to water logging only after 6 days.

## Biotic stress tolerance

### Jassid

A breeding programme was initiated to develop *hirsutum* variety with improved yield, quality and tolerance to jassids. Of the 86 progenies evaluated, 19 were early (145-160 days) and tolerant to jassid. Lines CNH 09-7, CNH 09-9, CNH-09-5, CNH 09-62, CNH 09-74, CNH 09-13, CNH 09-15, CNH 09-111, CNH 2-1 and CNH 2-2 were identified for higher seed cotton yield and fibre strength. Lines CNH 09-9 recorded seed cotton yield of 2631 kg/ha followed by CNH 09-5 (2556 kg/ha) and CNH 09-7 (2025 kg/ha) with bundle strength of 23.1 g/tex, 23.4 g/tex and 25.7 g/tex, respectively.

From the segregating population  $F_2$  and  $F_3$ , 110 single plant selections were made based on earliness, boll weight, fibre strength and sympodial plant type. From inter-specific derivatives, 11  $F_5$  progenies were selected based on tolerance to jassids and yield potential from crosses NISC 261 × P 56-4, NISC 261 × AKH 081, NISC 261 × H 1252, NISC 289-4 × LRK 516, NISC 289-4 × EC 277959 and NISC 291 × EC 277959. Twelve cultures tolerant to jassids tested for seed cotton yield and fibre properties.

### Bollworm

Sixty-one promising genotypes from different agro-ecological zones were converted into Bt background through backcrossing. They are under different backcross generation (BC4F4 to BC2). Sixteen hundred individual plants were tested for presence of Bt using Elisa plates of which 428 plants were found positive.

### Testing of *G. hirsutum* cultures in AICCIP

Seven high yielding *G. hirsutum* cultures were sponsored for multi-location evaluation in All India Coordinated Cotton Improvement Project during 2013-14. Of these, four were tested in National trials and the remaining three were in advanced stage of testing in zonal trials.



## Compact plants suitable for HDPS

In two separate station trials, 14 compact plant genotypes each were evaluated along with Anjali, Supriya and Suraj as check varieties with a spacing of 45 x 15 cm. Analysis of data on seed cotton yield indicated significant differences among the genotypes and the highest yield was recorded in PI 36-2-4-1 in Trial-I with 3539 kg/ha and in Surabhi x MM02-16-5-2-4 Bk in Trial-II

Several high yielding compact plant types with super okra leaf having good fibre quality amenable to closer planting were identified.



**Surabhi X MM 02-19-1-10-1-3** 2.5 % Span length = 30.4 mm Bundle Strength = 24.2 g/tex  
**MCU-13 X VNWH-1-7-2-3** 2.5 % Span length = 30.6 mm Bundle Strength = 24.5 g/tex



**Surabhi X M5 Z2-4-2-6** 2.5 % Span length = 30.7 mm Bundle Strength = 24.2 g/tex  
**Surabhi X M5Z2-13-3-4** 2.5 % Span length = 30.4 mm Bundle Strength = 23.8 g/tex

### Good quality super okra compact genotypes

### Evaluation of long staple cultures

Thirteen superior long staple *G. hirsutum* cultures were evaluated in replicated trial along with Suraj and Surabhi as check varieties. The highest yield was recorded in MM 03 - 39-2-4-3 with 1652 kg/ha and the culture also recorded the best fibre quality parameters of 33.4 mm 2.5% span length and 24.4 g/tex of tenacity at 3.2 mm gauge.

### Evaluation of medium staple *G. hirsutum* cultures

Fifteen medium staple cultures were evaluated along with Sumangala and LRA 5166 as check varieties. Data on seed cotton yield indicated significant differences among the genotypes and the highest yield was recorded in MM02-11-7 (2464 kg/ha). The culture MM03-12-1-2-4 recorded tenacity of 24.3 g/tex with 30.3 mm length.

### Evaluation of *G. barbadense* cultures

- Nine high yielding, early maturing genotypes (CCB-30, CCB-33, CCB-36, CCB-40, CCB-52, CCB-62, CCB-63, CCB-64 and CCB-74) were identified from two advanced yield trials.

- Twenty six single plants were selected from 76 progenies based on plant type, single plant yield, earliness and ginning outturn. Of these, 11 single plants were identified as superior with respect to yield and earliness.
- Five intermated population of Suvin were raised along with the existing Suvin as control and

evaluated for yield, GP and earliness.

- Third cycle of 478 random mating population were developed from nine diversified *G. barbadense*, L. genotypes. From the segregating population, some superior single plants were selected with typical boll shape combining high boll weight.



**CCH 526612 x VNW-1**

Boll Shape: Conical with typical beak  
Seed Cotton Yield = 115 g/plant  
Boll Weight = 5.5 g



**Surabhi x M5Z2**

Boll Shape: Cylindrical  
Seed Cotton Yield = 95 g/plant  
Boll Weight = 4.8 g



**Surabhi x M5Z2**

Boll Shape: Big Conical  
Seed Cotton Yield = 95 g/plant  
Boll Weight = 6.8 g

### Fibre strength improvement

High strength genotypes evaluated earlier in All India Coordinated Cotton Improvement Project were consolidated from various centres and two separate trials, with 20 genotypes each, were conducted to evaluate their yield potential and fibre quality parameters. In the first trial, the genotype CCH 10-2 recorded the highest seed cotton yield (1482 kg/ha). Quality wise, the genotype CCH 4474 was the best (33.4 mm length and 25.0 g/tex strength). Comparative performance of these cultures over the past two years *vis-à-vis* AICCIP trial indicated consistent superiority of cultures *viz.*, CCH 4474, CCH LS 2, CCH 7122 and CCH 820 for fibre quality especially the bundle strength (Table 3.3.2).

In the second trial, the genotype SCS 1061 was the best in terms of seed cotton yield with 1672 kg/ha. The genotype also recorded the highest 2.5 % span length of 33.9 mm. The highest bundle strength of 23.7 g/tex was recorded for the genotype SH 2-4 in this trial.

### Sirsa

#### Tetraploid Cotton

#### Evaluation of CLCuV resistant cultures

##### Trial 1

In the first trial, 13 *G. hirsutum* cultures were evaluated against the check varieties RS 2013 and LH 2076 and susceptible check HS-6. The highest seed cotton yield was recorded in the culture CSH 2811 (1704 kg/ha) followed by CSH 2838 (1556 kg/ha) as against the check variety LH 2076 (1617 kg/ha). Maximum ginning out turn of 34 % was recorded in the variety CSH 2844 as compared to local check varieties 32.7 % in RS 2013 and

**Table 3.3.2 : Comparative performance of high strength genotypes for yield and quality (mean of 2012 – 13 and 2013 – 14)**

Genotype	Seed cotton yield (kg/ha)	2.5% Span length (mm)	Tenacity 3.2 mm (g/tex)
CCH 10-2	1110	29.9	21.7
CCH 4474	1008	33.5	25.5
CCH LS2	864	32.5	24.0
CCH 1831	858	29.2	22.7
Suraj (C)	807	32.4	21.9
CCH 7122	727	33.0	25.1
CCH 03-23	709	30.6	21.3
CCH 820	653	32.4	24.9
Surabhi (C)	425	33.1	23.8

33.8 % in LH 2076. *G. hirsutum* culture CSH 2908 recorded the minimum CLCuV incidence of 29 PDI and seed cotton yield of 1864 kg /ha as compared to 1617 kg/ha for LH 2076 with 37.5 PDI.

##### Trial 2

In the second trial, 11 cultures of *G. hirsutum* were evaluated against the conventional check variety RS 2013, LH 2076 and susceptible check HS-6. The highest seed cotton yield was recorded in the hybrid CSH 2931 (2494 kg/ha) followed by CSH 2932 (2247 kg/ha) as against the conventional check variety RS 2013 (1321 kg/ha). Maximum ginning out turn of 35.2 % was recorded by CSH 2924 as compared to local check varieties 32.7 % in RS 2013 and 34.0 % in LH 2076. The culture CSH 2947 had the highest 2.5 % span length (27.0 mm), and bundle strength of 21.9 g/tex having the

CLCuV incidence of 33.0 PDI as compare to 57.4 PDI recorded by HS-6 a susceptible check variety.

Out of 198 introgressed lines received from CICR, Nagpur and evaluated at RRS Abohar, a hot spot area for leaf curl virus, only two lines Rai 48 and MSH 126 showed tolerance.

### GMS based random mating population

At flowering, individual plants in the population was monitored for sterility/fertility at anthesis repeatedly at an interval of a week all 234 sterile plants watertagged. All the out-crossed bolls from the sterile plants in the population were bulk harvested and ginned to constitute the 4<sup>th</sup> cycle of GMS based random mating population.

### Fibre quality improvement

13 crosses were attempted between 5 long linted Coimbatore types with high fibre strength and 3 Sirsa cultures. F<sub>5</sub> progenies of the two crosses from these 13 crosses viz; CSH-3119-10-28-56 (3594.3 kg/ha) and MMO.3 (39-2-5)-3114-10-64 (3180.0 kg/ha) were early in maturity and gave significantly higher yield than the check H-1226 (2350.8 kg/ha). Fibre quality data indicated that CSH-3114 x MM-03-27-5-1-5 gave fibre strength more than 25 g/tex and fibre length > 30 mm. Six cultures with good fibre quality viz.; CSH-3129, 3114, 3047, 3312, 3313 and 3314 were contributed for testing under the marker assisted programme of Technology Mission on Cotton.

### Ginning outturn improvement

One hundred and forty eight F<sub>1</sub> crosses attempted between agronomically superior varieties of north zone and high GOT germplasm lines (37 to 41%) were evaluated in unreplicated trial. Sixteen F<sub>1</sub>'s of these gave GOT% > 37% and 9 crosses among these had > 75 g seed cotton yield / plant. Three F<sub>2</sub> populations of crosses RS-875 x SA-524, F-1861 x SA-668 and CSH-3129 x EC-358002 were evaluated for GOT % of individual plant in each of the cross. There were 11, 48 and 18 plants with more than 35 % GOT and 3, 4 and 1 plant(s) with > 40 % GOT in F<sub>2</sub> population of the above crosses. Thirteen F<sub>6</sub> progenies of the cross SA-977 (HG) x SA-112 (LG) were evaluated in replicated trial. Three progenies viz.; P-70, P-86 and P-164 were at par in seed cotton yield compared to check H-1226 (1876.5 kg/ha) and recorded more than 40 % GOT.

### Diploid Cotton

Under evaluation of advance culture trial, none of the genotypes could out yield the local check CISA 614 (2550 kg/ha). However, genotype CISA-6-123 (2253.1 kg/ha) gave higher yield over another local check LD 327 (2167.3 kg/ha) with 2.5% span length 19.8 mm,

micronaire 7.2 and strength 16.2 g/tex. The genotype CISA 6 had good fibre properties (2.5 % span length 25.8 mm, micronaire 5.6 and strength 18.7 g/tex). Under evaluation of varietal culture trial genotype CISA 6 (2777 kg/ha) gave numerically higher yield than CISA 310 (2600 kg/ha) and 6 genotypes gave higher seed cotton yield than the check LD 733 (1616 kg/ha). One hundred and thirty four single plant selections were made based on yield and fibre qualities from F<sub>2</sub> population.

## 3.4 : Genetic Diversity through Introgression

### Nagpur

#### Development of *Gossypium hirsutum* cultures with big bolls

One promising culture with big boll ranging from 5.9 to - 7.9 g was identified from a cross of Ganganagar Ageti x Acala B2. From the F<sub>5</sub> generation, 51 single plant progenies were raised. Twenty-three superior lines were identified for boll weight (3.70 to 5.03 g). The seed cotton yield ranged from 736 to 2717 kg/ha and GOT from 27.3 to 42.3 % in these progenies.

#### Conventional crossing based random mating population

The random mating population was constituted through conventional crossing and maintained by bulk harvesting.

#### Random mating population developed through exploitation of GMS

The seventh cycle of GMS based random mating population was completed in *G. hirsutum*. All sterile plants were tagged at flowering and allowed to open pollinate in the composite population. The out crossed bolls from all the sterile plants were bulk harvested to be raised in the next crop season.

#### Evaluation of single plant selection

Twelve hundred single plant selections from random mating population were evaluated in plant to progeny row plots. One hundred and twenty plants were selected based on manual testing for fibre quality traits. About 750 superior single plants were reselected from the segregating single plant progenies. Forty six single plant progenies were uniform and exhibited better performance for seed cotton yield.



## Development of heterotic pool for superior medium staple cotton

Heterotic population was developed for superior medium staple (25-27 mm) from parents selected on the basis of geographic diversity. Of the 37 lines developed, 21 were used in crossing programme for developing 120 F<sub>3</sub>s. Some promising lines viz. CNH 16-3-5 (31.1 mm, 23.4 g/tex), CNH 10-6-1 (27.6 mm, 23.5 g/tex), CNH 12-12-4 (29.7 mm, 23.3 g/tex), CNH 12-4-2 (30.4 mm, 24.2 g/tex), CNH 16-3-1 (28.5 mm, 23.6 g/tex) and CNH 17-2-2 (27.5 mm, 23.6 g/tex) were identified for their utilization in crossing for developing heterotic F<sub>3</sub>s.

From heterotic population 18 cultures were developed for higher seed cotton yield with better fibre properties. Promising 8 cultures viz. CNH 7008-1, CNH 7012-13, CNH 7012-11, CNH 7022-4, CNH 7023-5, CNH 7020-1, CNH 7017-3 and CNH 7018-9 were identified.

## Coimbatore

### Development of variety

CCH 2623 recorded a mean seed cotton yield of 1725 kg/ha in Central Zone with 30.5 per cent yield increase over the zonal check variety of LRA 5166. It also recorded high yield of 1798 kg/ha as against 1589 kg/ha in the zonal check variety of Surabhi with 17.0 % yield increase in south zone. The culture is characterized by 27.2 mm 2.5% span length, 4.5 10-6 g/inch micronaire and 21.3 g/tex bundle strength.



### Evaluation of advance cultures

Twenty four entries of *G. hirsutum* and seven of *G. arboreum* were evaluated in Institute trials of which eleven were identified for sponsoring in AICCIP trials during 2014-15. The cultures identified were CNH 61, CNH 7022-4, CINH 1, CINH 2, CINH 5 and CNH 118 of *G. hirsutum* and CNA 2009, CNA 449, CNA 1022 and CNA 2006 of *G. arboreum*.

### AICCIP trials

Sixteen promising entries were sponsored in various AICCIP trials during 2013-14 (Table 3.4.1). Of these 6 entries were sponsored for Initial Evaluation Trial and 6 entries for High Density Planting System (HDPS) while 4 entries were promoted to various zonal trials.

**Table 3.4.1: The list of entries sponsored for AICCIP trials 2013-14 of CICR, Nagpur**

AICCIP Trial	IET/Zone	Name of the entry
<b>G. hirsutum</b>		
Br 02 (a)	IET	CNH 1116, CNH 19
Br 02 (b)	IET	CNH 7008, C NH 2001, CSH 1115, CSH 95
<b>G. arboreum</b>		
Br 22 (a/b)	IET	CNA 375, CNA 1013, CCA 1021, CCA 3
<b>HDPS Trial</b>		
Br 06 (a)	IET	CNH 121, CNH 3
Br 06(b)	IET	CNH123, CNH 1111, CCH 7012, CCH 1102
Br 06(a) & (b)	CZ & SZ	CNH 281, CNH 1109

## 3.5: State Multi-location Varietal Trial (SMVT)

### Nagpur

A State Multi-location Varietal Trial (SMVT) consisting of 19 genotypes each of *G. arboreum* and *G. hirsutum* was conducted.

The *G. arboreum* trial was vitiated due to heavy and continuous rains throughout the crop season. The range for seed cotton yield was 357-633 kg/ha. The maximum seed cotton yield of 633 kg/ha was obtained from CNA 2009 followed by JLA 0916 (632 kg/ha) and JLA 0794 (602 kg/ha).

In *G. hirsutum*, the seed cotton yield ranged from 1385 to 2351 kg/ha. Two cultures namely; PH 1060 (2351 kg/ha) and CNH 61 (2277 kg/ha) showed significantly high seed cotton yield over the others. The seed cotton yield of control variety NH 615 was 2177 kg/ha. Culture AKH-2006-2 showed promise for fibre quality traits for the second consecutive years with fibre length of 29.7 mm and bundle strength of 22.3 g/tex.

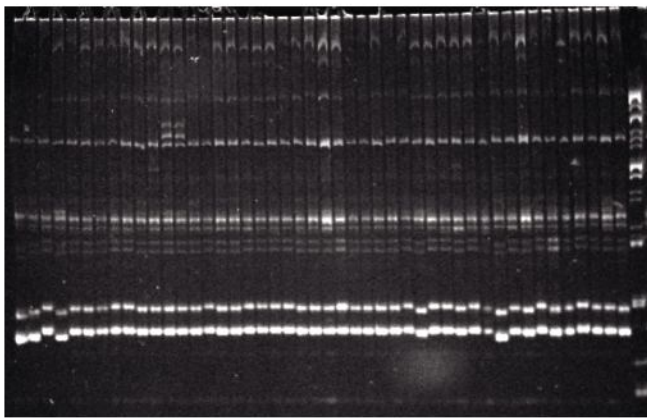
## 3.6 : Molecular Breeding

### Mapping QTLs for fibre quality traits

A cross between EL 958 and UPA 57-17 was effected and a large F<sub>2</sub> (EL 958 X UPA 57-17) population was grown. Few flowers of all the F<sub>2</sub> plants were selfed and carried forward to F<sub>3</sub> and subsequent generation following single seed decent method. At the end of F<sub>8</sub> 273 progenies of RILs were obtained; most of them were uniform for morphological traits. During 2013-14, RILs of *G. hirsutum* (248 No.) were grown in 2 row plots in two replications for fibre quality evaluation. Observations for sucking pests were also recorded.

So far, 3590 SSR markers were screened for parental polymorphism in *G. hirsutum* and 545 informative SSR markers were identified. Genomic DNA of 188 progenies has been subjected for genotyping using polymorphic SSRs (Fig. 3.6.1). Genotyping of *G. hirsutum* RILs using 59 SSR has already been completed. Genotyping of 172 RIL progenies with 2979 SNP markers was carried out by National Botanical Research Institute.

Parental polymorphism studies were also carried out in the diploid parental lines (*G. arboreum* cv. KWAN-3 x *G. herbaceum* cv. Jaydhar) used for development of RILs. A total of 1604 SSR markers were screened of which 171 SSR polymorphic markers were identified as polymorphic. So far 497 informative markers were identified after screening 3590 SSR markers.



**Fig 3.6.1: Genotyping of RILs with SSR marker CIR-203 in upland cotton**

#### Maintenance of RILs in diploid and tetraploid cotton

In *G. hirsutum*, 273 F<sub>9</sub> progenies were maintained by selfing. In *G. arboreum*, 193 progenies were selfed and maintained by single seed decent method. Both the populations are being put to use in genetic mapping of QTLs.

#### Marker Assisted Breeding

##### CLCuV resistance

From among 5000 germplasm lines screened, 30 lines were free from CLCuV under field conditions for two consecutive years. These lines were subjected for screening under epiphytotic conditions at Sirsa and also in the regular crop season at Hisar Faridkot and Abohar. None of the line was found to be resistant /immune. However, two lines with high degree of tolerance and minimum disease severity index were identified. Polymorphic survey of identified parental lines was carried out using 108 SSR markers and 54 polymorphic markers were identified.

Sufficient quantity of F<sub>2</sub> seeds was obtained at Sirsa from a F<sub>1</sub> crosses CP 15/2 x F 846 and LRA 5166 x HS-6.

Additional crosses have also been attempted among the parents selected based on minimum disease severity index and high economic yield.



**Susceptible *G. hirsutum* cotton plants affected with CLCuV**

##### Bacterial blight resistance

A set of 56 SSR primers were surveyed for polymorphism between bacterial blight susceptible and resistant lines of which 20 SSR markers were found to be polymorphic with Ganganagar Ageti and S295. Fifteen of the 20 polymorphic markers were used for genotyping the mapping population. Two hundred and thirty four germplasm lines and varieties (including AICCIP high strength lines) were screened for BLB resistance using CIR 246 marker. 27 germplasm lines including 3 high strength AICCIP lines have been identified as resistant for bacterial leaf blight using CIR 246 marker. Crossing has been made using variety Suraj as female parent and high strength lines CSH 3313, CSH 3047 and GTHH 032 as male parent. F<sub>1</sub> seeds have been harvested and sown at regional station, Coimbatore for back crossing with Suraj (BC1F1). Additional crosses have also been attempted using Suraj, Surabhi, Supriya and MCU 5-VT (long staple varieties) as recurrent parent with BLB resistant lines RKR4145 and TORSC78.

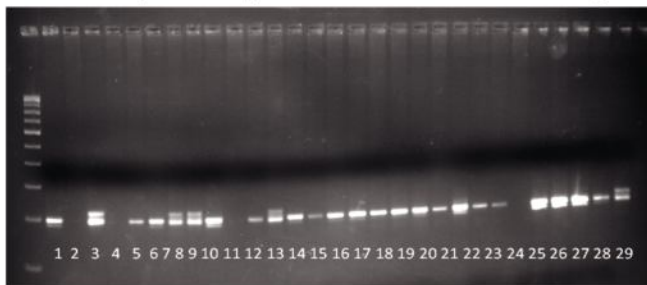
##### Nematode resistance

The identified parental lines namely Bikaneri Nerma (BN) for Root Knot Nematode (RKN) resistance; G. Cot 10 and American nectariless for Reniform Nematode (RN) resistance; and Suraj and Surabhi as susceptible parents for both RKN and RN were screened using 60 SSR markers of which 43 were polymorphic. Based on maximum divergence among the parental lines, crosses have been attempted and F<sub>1</sub>s were grown in pots for advancement of generation.

### DNA fingerprinting of public sector cotton genotypes

DNA fingerprinting of 28 *Desi* genotypes (3 of *G. herbaceum* and 25 of *G. arboreum*) was done using 15 SSR markers. Three (DPL 209, HAU 0058 and MCU 022) were found to be polymorphic (Fig. 3.6.2). DNA fingerprinting of 50 *G. hirsutum* genotypes was carried out using 80 SSR markers and 32 were found polymorphic (Fig. 3.6.3). Nine reproducible polymorphic markers were identified, which, in various combinations could be useful for differentiating varieties.

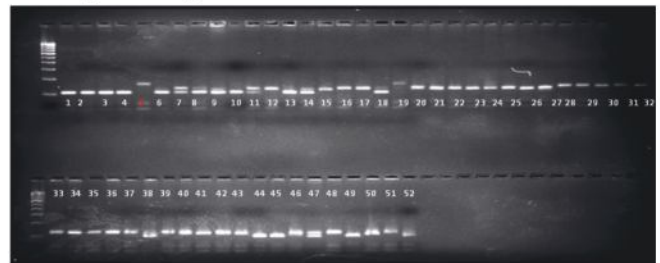
Further, genomic DNA was extracted separately from CICR released varieties viz. CHNO12, LRA5166, Pratima, Anjali, Suraj, Kanchana, Surabhi, Sumangala,



**Fig. 3.6.2: Molecular profile of released *desi* varieties by SSR markers (DPL 209)**

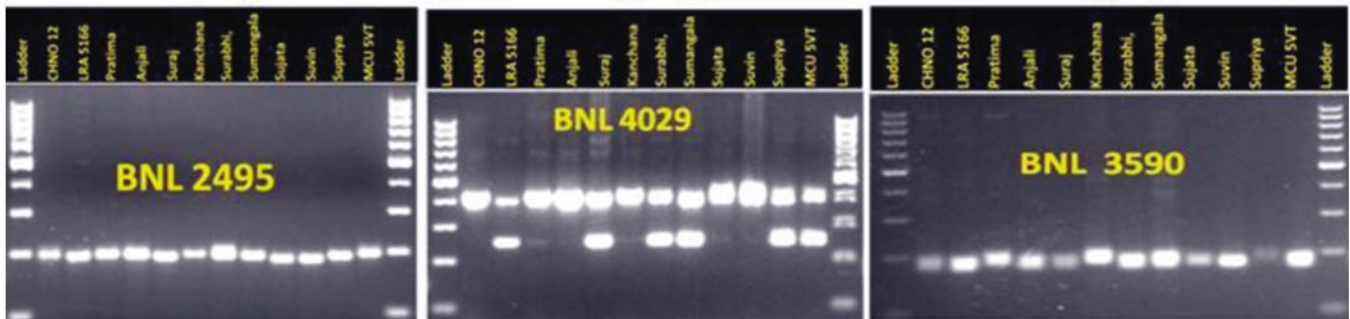
Raghavendra, JLA794, Digvijay, AKA8, AKA7, AKA8401, RG18, RG8, HD324, HD266, HD11051, HD123 G Cot 15, G Cot 19, G Cot 23, LD 210, LD 694, LD 327, LD 451, PA 183, G 27, GAK 423, C-29, Veena, Jawahar Tapti, Arvinda, Y1, Jayadhar, HD 107

Sujata, Suvin, Supriya and MCU5VT and genotyped using 330 genome-wide SSR markers reported to be polymorphic. Fifty-two distinctly polymorphic SSR markers were identified (Fig. 3.6.4) with 15.8% polymorphism. Molecular markers effectively and efficiently differentiated *G. hirsutum* varieties from *G. barbadense* varieties (Sujata and Suvin) and grouped them in separate clusters (Fig. 3.6.5). On an average, CICR varieties were found to be similar by 53%. Draft DNA fingerprint of varieties released from CICR was developed using the SSR data.

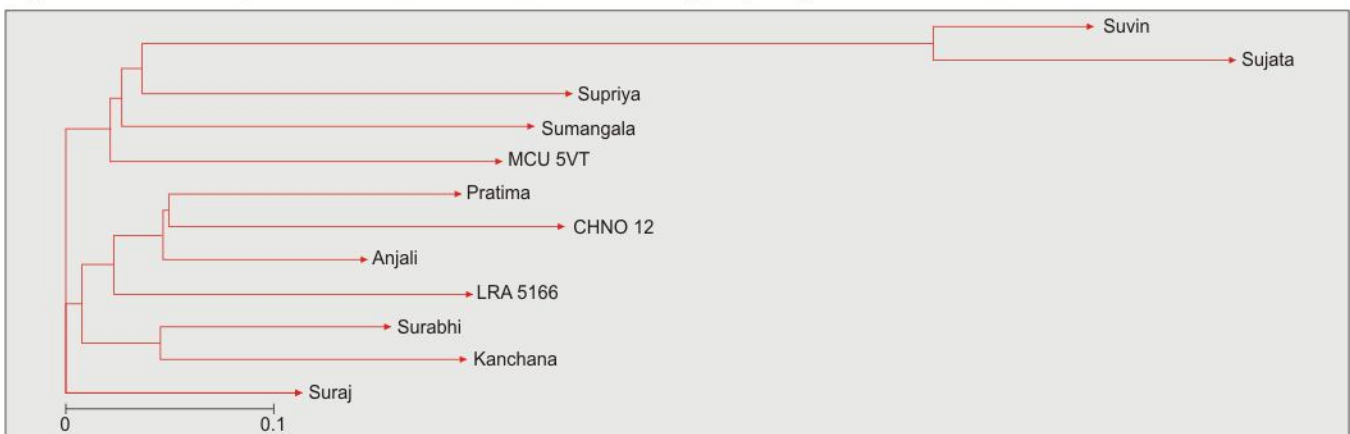


**Fig. 3.6.3: Molecular profile of public sector released varieties (*G. hirsutum*) by SSR markers (BNL 2709)**

1. Surabhi 2. Supriya 3. Sumangala 4. Suraj 5. MCU5VT 6. MCU5 7. MCU10, 8. Sahana, 9. LRA5166, 10. Anjali, 11. MCU12, 12. Arogya, 13. Sujatha, 14. Laxmi, 15. Pratima, 16. Abhadita, 17. BN1, 18. Narasimha, 19. CNHO12, 20. F1861, 21. F1054, 22. F1378, 23. F846, 24. Khandwa2, 25. Khandwa3, 26. Gcot18, 27. Gcot16, 28. Gcot20, 29. Gcot12, 30. Gcot10, 31. RS2013, 32. RS875, 33. RS810, 34. RST9, 35. HS6, 36. H1226, 37. H117, 38. AKH8828, 39. AKH081, 40. JCC1, 41. LH168, 42. NH545, 43. NH452, 44. NH615, 45. JK4, 46. Surat dwarf, 47. G-67, 48. KC-3, 49. DHY-286, 50. Deviraj, 51. G. ageti, 52. RMPBS155



**Fig. 3.6.4: Molecular profiles of CICR varieties as revealed by polymorphic SSR markers.**



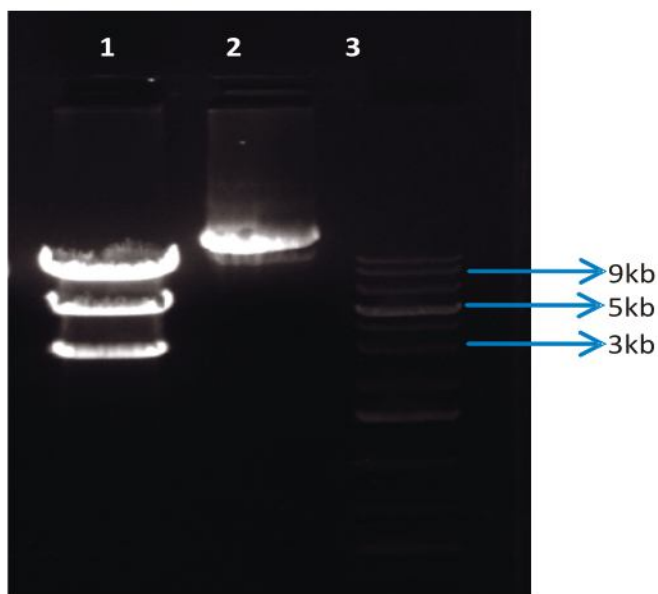
**Fig. 3.6.5: Dendrogram constructed based on genetic similarity**

### 3.7 Development of Transgenic Cotton

#### Development of multi-gene construct and Bt cotton varieties for sustainable pests management

*ChiA*, a gene for chitinase has been identified, codon-optimised and was synthesized. This gene along with cotton (*Gossypium hirsutum*) rubisco small subunit chloroplast transit peptide, fused in frame, has been cloned in plant expression vector with double 35S promoter, AMV enhancer and NOS terminator and also in *E. coli* expression vector.

To generate multigene construct (dual gene initially), chitinase gene cassette in plant expression vector with double 35S promoter, AMV enhancer and NOS terminator was sub cloned downstream of the CICR truncated *cry2Ab1Ac* gene cassette and confirmed through restriction analysis and transformed in to *Agrobacterium tumefaciens* (Fig. 3.7.1).



- EcoRI and HindIII digest of CICR truncated *cry2Ab1Ac* + Chitinase gene cassette
- Uncut CICR truncated *cry2Ab1Ac* + Chitinase gene Plasmid
- 1 Kb ladder

Fig. 3.7.1: Restriction confirmation of CICR truncated *cry2Ab1Ac* and chitinase gene cassette in plant expression vector

#### Bollworm resistant transgenic cotton

Transgenic plants carrying Bt *Cry1Ac* for insect resistance in *G. hirsutum* variety Suraj are under different stages of molecular confirmation. The presence of “transgene” with gene specific primers was confirmed and 1.8kb full length genes were amplified (Fig. 3.7.2). Presently, 4-lines of independent transgenic plants of Suraj variety were established for event selection trial

along with previous lines of ILK-Bt77 (Anjali, LRA-5166 and Suraj varieties). Concurrently, 3-lines carrying Bt *Cry1F* in Suraj variety was positive with gene specific primers were also selected for event selection trial. The new fusion genes of CICR-*Cry2Ab1Ac* were subjected to transformation and regeneration through somatic embryogenesis in Coker 310. Putative transformants were obtained via callus based somatic embryogenesis in MS media with B5 vitamins + 0.1 mg/l 2, 4-D and 1.0 mg/l 2ip + 4.0 g/l phytigel +30 g/l Maltose+ 0.1 g/l PVP. (Fig. 3.7.3).

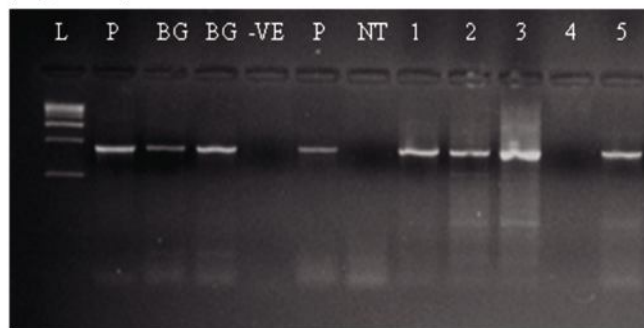


Fig. 3.7.2: L- 1kb ladder; P-Plasmid; BG-Bollguard; BGII-Bollguard-II; -VE- Negative Control; NT- No template; Sample – 1-6 Suraj-*Cry1Ac* samples.

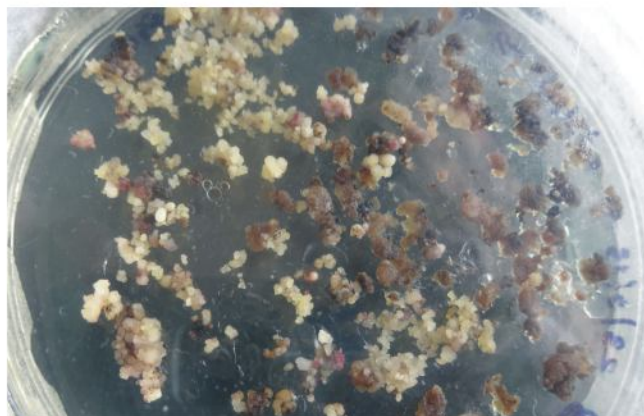


Fig. 3.7.3: Transformation of fusion gene *CICR-truncated Cry2Ab1Ac* with Coker 310/Suraj callus and regeneration through somatic embryogenesis.

#### Transformation of cry-fusion gene by direct shoot organogenesis/multiple shoot induction

Transformation of newly developed cry-fusion gene was carried out by *Agrobacterium* using shoot tip meristem cells. One hundred and eleven explants of *G. hirsutum* cv Suraj and 146 explants of *G. arboreum* on AKA 7 were selected on Kanamycin (50 mg/L) containing medium. The Kanamycin resistant explants were regenerated by direct shoot organogenesis or multiple shoot induction. The shoots that were sufficiently elongated were rooted on MS medium supplemented with 0.1 mg/L NAA and putative transformed plants were established.



**Selection of shoot explants on Kan (50 mg/L) medium**



**Multiple shoot induction from infected explants**



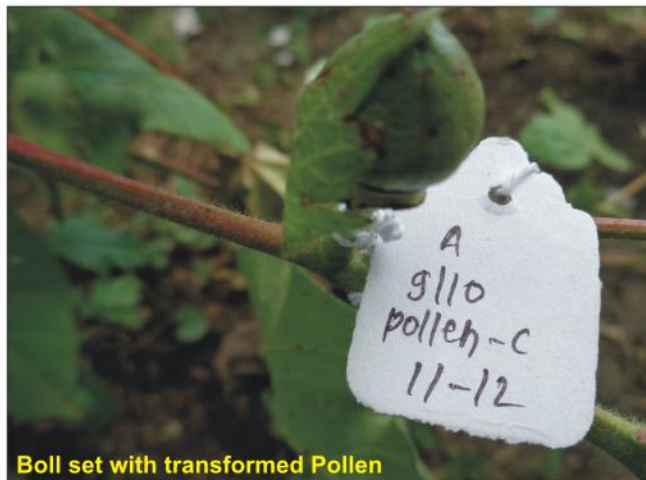
**Rooting of putative transformed shoot**

### ***In-planta* transformation**

The germ line cells from younger *in-vitro* raised seedlings were manipulated for transformation by *Agrobacterium*. In all, 359 embryo axis of Suraj were agro- inoculated and 11 T<sub>0</sub> plants were established. In another method of transformation, 328 seedling meristem were treated with *Agrobacterium* by removing one cotyledon and 105 T<sub>0</sub> plants were established. In AKA 7 however 20 plants were established from the treatment of 260 seedling meristem.



**Removal of one cotyledon**



**Boll set with transformed Pollen**



**T<sub>0</sub> Progeny**

### **Pollen and pollen tube transformation**

Freshly opened flowers were collected from field and their pollen were collected in the laboratory. The pollen was transformed by *Agrobacterium* containing cry-fusion gene. The transformed pollen were carried to field and the emasculated flowers were pollinated. In all, 444 flowers were pollinated and 30 bolls were harvested.

In pollen tube transformation, 120 flowers were injected

with *Agrobacterium* suspension and 30 bolls were harvested.

### **Leaf curl virus resistance**

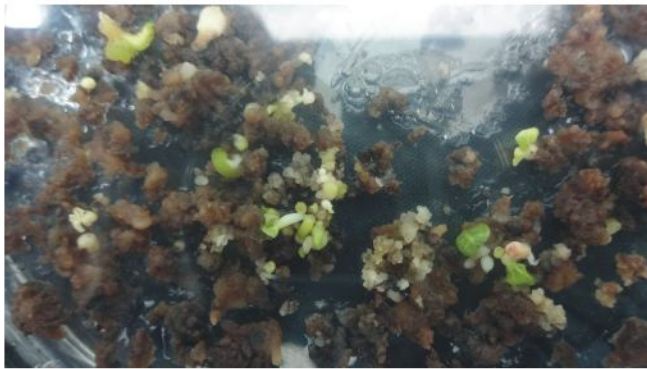
*G. hirsutum* varieties viz., H 777, F 846 and HS 6 carrying ACP (Anti-sense coat protein) gene was confirmed by PCR with gene specific primers (700 bp) and were selected for event selection trial.

### **Fungal resistance**

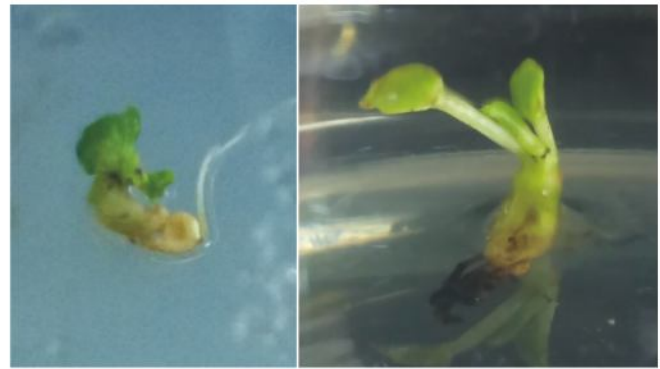
The PCR positive plants expressing chitinase gene in *G. arboreum* cv PA 255 were selected. The selfed seeds from these plants representing three events were collected for event selection trial.

### **Genomics of cotton boll and fibre development**

*Agrobacterium* – mediated transformation was carried out with embryogenic calli using 11 genes provided by consortia partner viz., Expansin, E6, RD22 like protein, Aquaporin, Galactinol-3-synthase, Arabinogalactan-3, Fatty acid chain elongase, Proline rich protein-5, Cytochrome p450 like protein, Osmotin like protein and R2R3 Myb transcription factor. Among them putative transformants were generated with Aquaporin, Expansin, Arabinogalactan 3, Galactinol- 3- synthase and RD22 like protein genes and the plants are under establishment.



Regeneration of *Aquaporin* putative transformants



Plant under establishment with *Aquaporin* putative transformants

### Molecular characterization and validation of fiber strength genes

Gene expression analyses were carried out with mapping population obtained from crossing of divergent lines with contrasting fiber strength (High fiber strength 25 g/tex, medium 22 g/tex and low 17 g/tex). The selected candidate genes such as *SusA1*, *GhcesA1*, *GhcesA2*, *GhcesA7*, *Ghcobl4*, *GhMT1* and *GhFLA3*

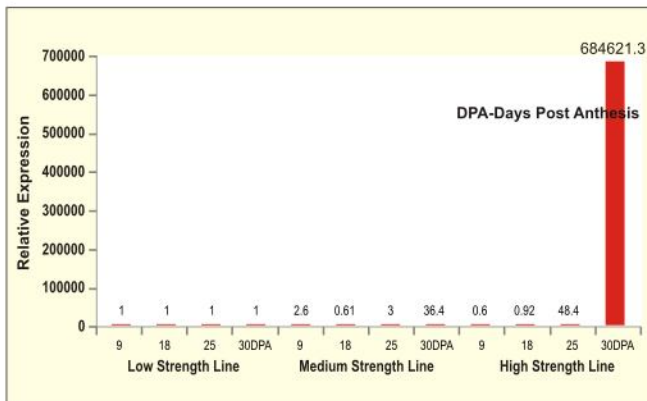


Fig. 3.7.4: Analysis of *GhCesA1* gene expression at different stages of fiber development in high, medium and low strength lines of RIL mapping population

were subjected to comparative transcriptomic analyses during mid elongation (18 DPA) to maturation phase (30 DPA) at different intervals viz, 9, 18, 25 and 30 DPA. The relative gene expression of *SusA1*, *GhcesA1*, *GhFLA3*, *GhcesA2*, and *GhcesA7* were highly expressed during secondary wall formation stage in high fiber strength lines (Fig. 3.7.4 & 3.7.5). Full length of selected candidate genes such as *SusA1*, *GhcesA1*, *GhcesA2*, and *GhcesA7* were cloned and subjected to sequencing (Fig. 3.7.6 & Fig. 3.7.7).

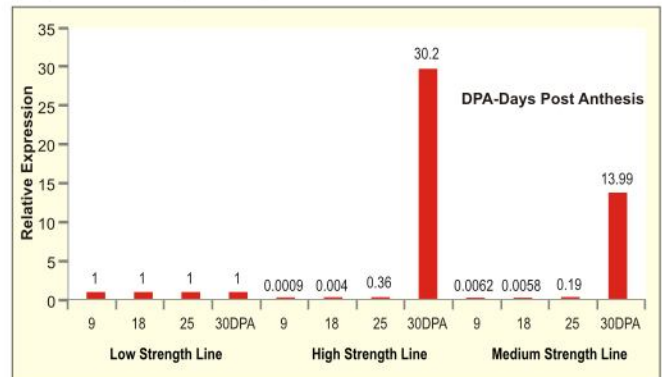
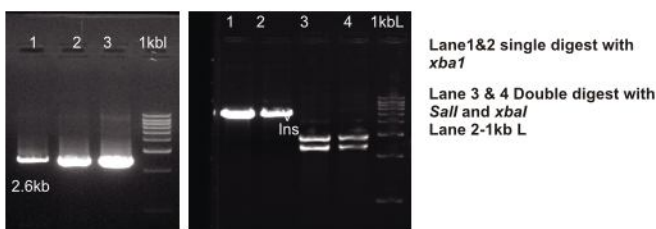


Fig. 3.7.5: Analysis of *GhCesA2* gene expression at different stages of fiber development in high, medium and low strength lines of RIL mapping population

### Cloning of *SusA1* gene from *Gossypium hirsutum* var *Suraj*



1-3 Lane *SusA1* amplicon  
1kbL- Marker

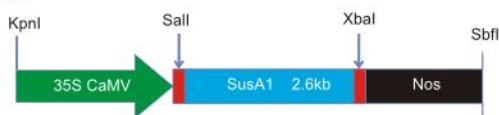
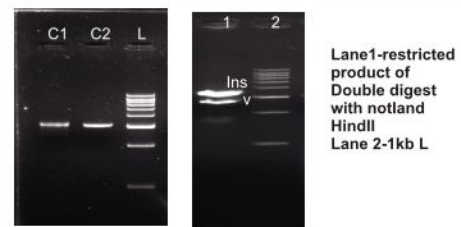


Fig. 3.7.6 : Cloning of *SusA1* gene from *Gossypium hirsutum* var *Suraj*

### Cloning of *CesA1* and *A2* gene from *Gossypium hirsutum*



Amplification of *CesA1* & 2 gene

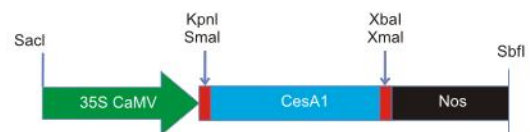
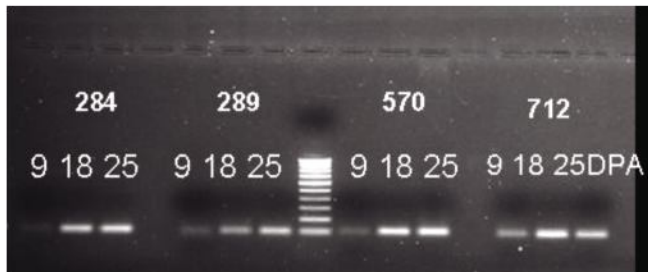


Fig. 3.7.7: Cloning of *CesA1* and *A2* gene from *Gossypium hirsutum*

### Identification of fibre strength associated candidate genes from the existing pool of genes available in public database

ESTs available for secondary cell wall synthesis stage of fibre were obtained from NCBI database, assembled into contigs and nucleotide Blastn analysis identified 63 contigs which were uncharacterized. Among them four contigs which showed differential expression during secondary wall synthesis stage (18 and 25 Days Post Anthesis (DPA) in *Gossypium hirsutum* variety Suraj were chosen for validation using mapping population.



qPCR analysis of selected genes using RIL mapping population identified a candidate gene (Contig 570), which showed 25.5 and 17.4 times higher expression at secondary wall synthesis stage at 25 and 30 DPA respectively in high strength line compared to low strength line of mapping population (Fig. 3.7.8). Protein sequence based homology search identified it as lim domain protein (actin binding family) of *Gossypium hirsutum* known to be associated with fibre strength and fineness.

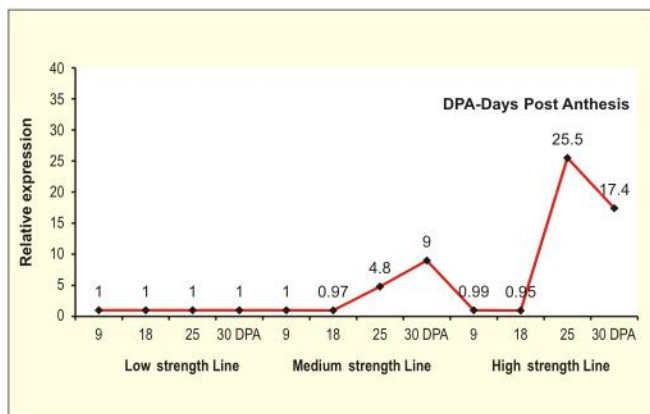
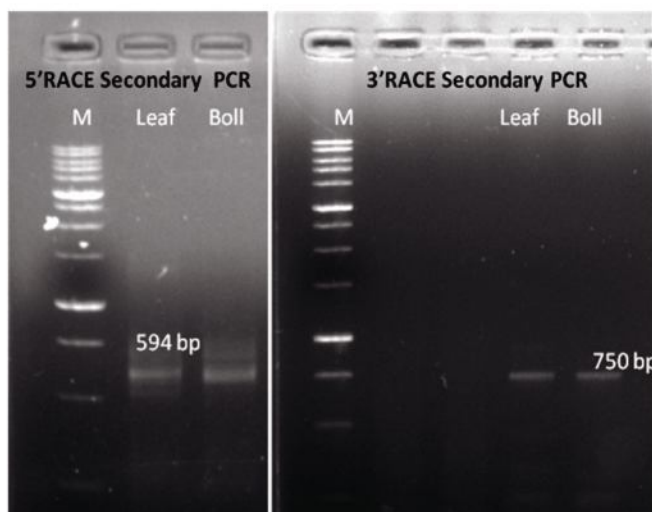


Fig. 3.7.8: Analysis of contig 570 expression at different stages of fiber development in high, medium and low strength lines of RIL mapping population

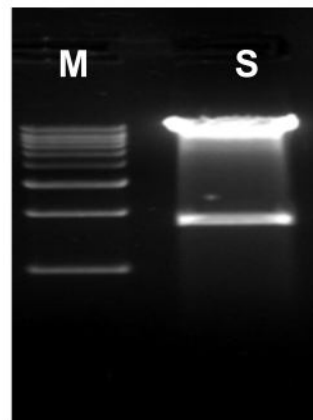
### RACE for isolation of full length nucleotide sequence of GhCOBL4

Full length nucleotide sequence of gene coding for *Gossypium hirsutum* cobra like protein (GhCOBL4) associated with fibre quality trait was isolated using 5' and 3' RACE PCR, cloned, sequenced and characterised for gene expression analysis.



### Seed specific reduction of gossypol biosynthesis

To develop RNAi construct for silencing gossypol biosynthesis in cotton seed, intron hairpin loop RNAi cassette for the target genes coding for  $\delta$  Cadinene synthase and  $\delta$  Cadinene hydroxylase under seed specific promoter in plasmid pBSK-int (3.1kb) was further successfully subcloned into plant expression vector, and transformed into *Agrobacterium tumefaciens*. *Agrobacterium* mediated transformation of *G. hirsutum* elite genotypes with dsRNAi construct for gene coding  $\delta$  Cadinene synthase driven by seed specific promoter is under progress.



M : 1.0 kb Ladder  
S : Restriction digestion with KpnI and SacI

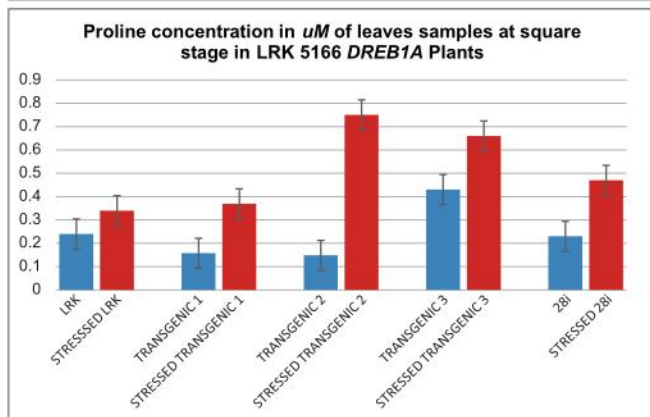
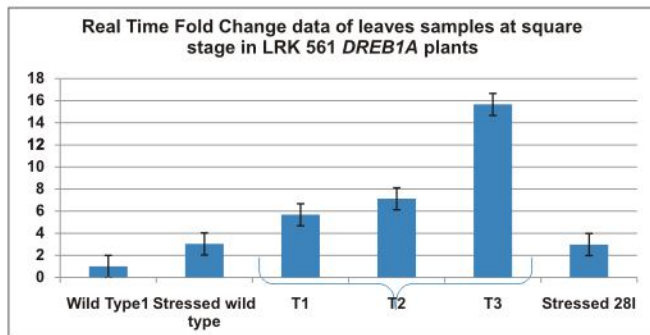
Restriction confirmation of Intron hairpinloop RNAi cassette for  $\delta$  Cadinene synthase in plant expression vector

### Development of drought resistant transgenic cotton and identification of new genes for high water use efficiency

To evaluate the gene expression of candidate genes for drought tolerance in LRK 516, transgenic ( $T_4$ ) and non transgenic plants were grown in pots and drought stress was applied to plants at square formation (55–60 days)

and boll developmental stage for 15 days. Younger leaves from the main terminal branch and root samples were taken from stressed plant at above stages and were used for RNA isolation. Cotton glyceraldehyde-3-phosphate dehydrogenase (GAPDH) a house-keeping gene was used as an internal control. Two transgenic

#### Real Time Fold Change data of leaves samples at square stage in LRK 516 DREB1A Plants



**Fig. 3.7.9: Relative fold expression of DREB1A T<sub>3</sub> progeny and transgenic cotton plants at different growth stages. Expression of DREB1A in leaves at (a) squaring stage (left) and (b) roots (right). Plants were kept under water stress for 15 days at squaring stage.**

#### Developments of new transgenic events for cotton leaf curl virus resistance

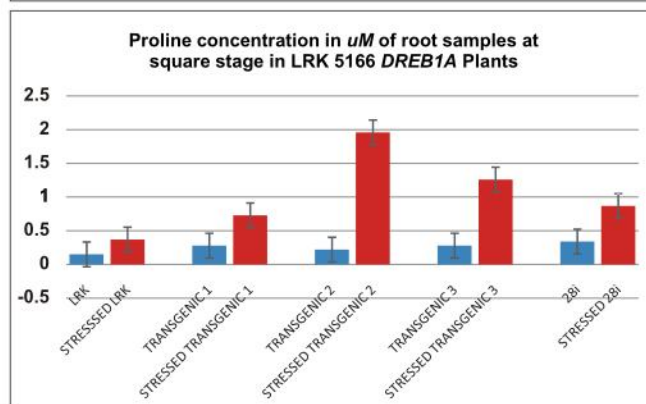
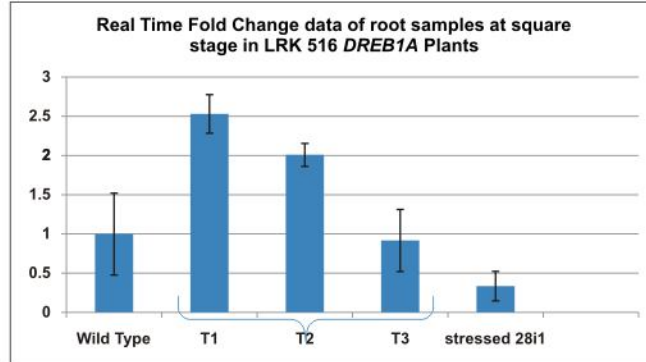
New events of transgenics for leaf curl virus resistance were developed using three genes, Sense coat protein (SCP), anti-sense coat (ACP) protein and antisense - replicase protein (ARep) in 3- genotypes viz., HS-6, H 777 and F 846. T<sub>2</sub> transgenic seedlings were raised in the polyhouse and screened for the presence of the specific gene. Seventy two plants were positive for ACP in H 777, 26 plants were positive for ACP in HS 6, 30 plants were positive for ACP in F 846.

#### Methods for screening of germplasm lines for glyphosate tolerance

Filter paper disc method for screening of glyphosate tolerance in cotton was standardized. Nine hundred and twenty one germplasm lines were screened with 2%

events were analysed for gene expression using qPCR and biochemical test for proline. The plants at square formation stage showed an average of 5 fold increase of transgene expression and 3-fold increase of proline content when compared to wild type and the drought tolerant variety 28.

#### Real Time Fold Change data of root samples at square stage in LRK 516 DREB1A Plants



glyphosate treatment. Few lines were shortlisted for molecular and biochemical characterization.

## 3.8 : Seed Production and Seed Quality Improvement

### Nagpur

#### Seed production

Under Mega Seed Project, Breeder seed of four varieties viz. Suraj, PKV 081, NH 615 and AKA 7 were supplied to 16 centres for the production of Foundation Seed and 135.96 q of Suraj and 17.34 q of NH 615 seeds (Foundation stage) were produced. Breeder seed of 1.14 q of Suraj was also produced.

TFL seeds of *G. arboreum* race *cernuum* (10 kg), Red Gram cv. BSMR-736 (2.0 q) and Certified seed of Gram cv. Vishal (7.0 q) were produced.

37 cotton varieties were sown for Stock Seed by Manual Driven Seed Drill at 60 x 15 cm spacing and about 73 kg seed was produced. Resources worth 13.94 lakhs was generated through the sale of seeds.

### Seed quality improvement

Plant vigour is better with good quality seeds. In order to enhance the seed quality, 42 different media were used for seedling nursery. Shoot, root length, stem girth and dry weight was superior with kelbrick with FYM in varying proportions as well as Kelbrick with FYM, cotton stalk compost, vermi-compost and soil mixed in equal proportion.

Higher seed cotton yield was obtained from seeds treated with H<sub>2</sub>O<sub>2</sub>, CICR Microbial Consortia individually or in combination, with and without Imidacloprid, in transplanted compared to that of direct sown seeds.

Vermi-compost (2019 kg/ha), cotton stalk compost (2080 kg/ha) and FYM (2015 kg/ha) gave best results among the 14 treatments when applied directly to the soil in the transplanted and direct sown seeds.

In root trainer experiment, 11 treatments were compared for their effect on seedling vigor. Treatment *Pseudomonas putida* and *P. flourescens* were superior in terms of root, shoot and girth of the stem.

In an attempt to revive the old seed lots of PKV 081, seed treatment with GA3 @ 40-50 mg/lit gave 30-40% germination in 2008 seed lot compared to control which was non-viable.

### Seed treatment for quality improvement

Two field trials (Trial 1: 31 seed treatments; Trial 2: 9 seed treatments) were taken up to compare their effect on seed germination, plant growth and seed cotton yield in popular cultivar, Suraj. Trial 1 consisted of 8 biologicals, 5 plant protectants, 2 growth hormones, 2 polymers, 9 reported chemical regulators and three natural products such as cow's milk, panchgavya and bio-fertilizer.

The fifth day count on seedling emergence was high with uniform seed germination for seed treatments with KNO<sub>3</sub> @ 0.5 %, Succinic acid @ 0.2 % and H<sub>2</sub>O<sub>2</sub> @ 80 mM (95 % - 100 %). The final seed emergence was above 80 % for all the treatments.

The treatment with plant protectants (thiram, thiomethoxam and imidacloprid) resulted in significantly higher seed cotton yield compared to all others. Among the microbials, seed treatment with *Pseudomonas putida* was found better. Among the other reported chemicals, succinic acid @ 0.2 % seed treatment resulted in highest seed cotton yield.

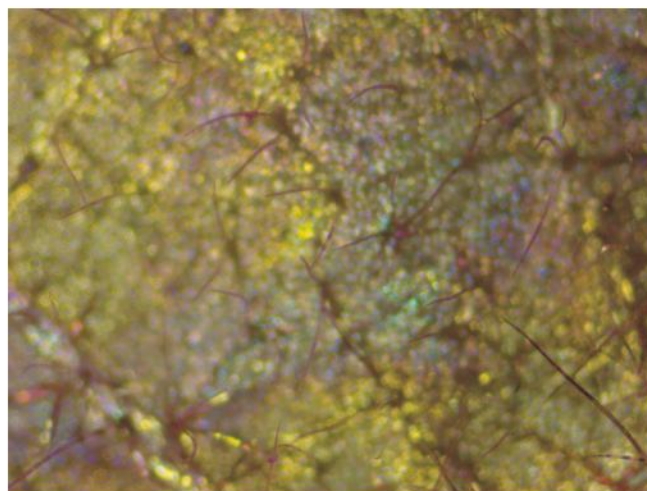
In trial II where seeds were treated with only plant protectants, the initial germination and seedling growth was uniform in seeds treated with imidacloprid and thiomethoxam. Seed treatment with thiomethoxam resulted in significantly high seed cotton yield (959

kg/ha) followed by Azoxystrobin (743 kg/ha) and untreated control (730 kg/ha).

### DUS testing

Two trials were conducted for DUS testing under "Implementation of PVP legislation, 2001" programme during the year. First year trial consisted of 40 candidate genotypes with 30 reference varieties and second year trial consisted of 15 genotypes with 7 reference varieties. Out of 37 traits to be observed, 27 characters were completed.

A method to quantify leaf hairiness and marginal bract hairiness was developed during the year. The selected leaf (fourth/fifth leaf observed at flowering stage) was observed in a unit area and stained to observe the hairs under microscope. Fifty genotypes were studied for their leaf hair density and considerable difference could be observed among the genotypes.



Leaf hairs stained for counting

The qualitative grouping provided for leaf hairiness in the National DUS test guidelines could be as follows:

Leaf Hair density	Variety
Sparse 8.5 ± SEm (0.55)	Kanchana, Sujata, Suvin
Medium 52 ±SEm (1.54)	Surabhi, MCU 5, Khandwa 2, Surat dwarf, MCU 5 VT, LRA 5166, Supriya, Anjali, Suraj, Sumanagala, F 1861, F 1054, MCU 10, Suman, Laxmi, MCU 12, PKV Rajat, Pratima, Sahana
High 119± SEm (3.073)	G Cot 12, Deviraj
Dense 190±SEm (1.75)	DHY 286

Other than leaf hair density, genotypes also showed variation in stellar branching (number of hairs originating

from one point). Suvin was unique with maximum of 8 trichomes originating from one point and F-1861 was unique with maximum of 6 branches arising from one point.

## Coimbatore

### Nucleus and breeder seed production

Nucleus seed production of Suvin, LRA 5166 and Suraj was undertaken and Breeder seed production was undertaken for Suraj, Surabhi, Supriya, Anjali and LRA 5166. In all, 129 kg of breeder seed was distributed to various seed producers.

### Seed production in agricultural crops and fisheries

Sunflower hybrid seeds (CO2) 114 kg have been produced and supplied to Department of Oilseeds, TNAU, Coimbatore.

### Implementation of PVP legislation 2001 and DUS testing of cotton under ICAR and SAU system

During 2013-14 new 82 candidate varieties of tetraploid cotton and two in diploid cotton were tested against 44 and three reference varieties, respectively. In addition to this 68 varieties of common knowledge were also tested for their Distinctiveness, Uniformity and Stability.

Registration certificate for four varieties was received. Seed multiplication and maintenance breeding was undertaken in 98 varieties of *hirsutum*, six of *barbadense* and 15 of *arboreum*.

## Sirsa

The effect of spray of various growth regulators and nutrient combinations on seed setting was not significant. The boll setting percentage was significantly higher in case of hand pollination (72%) against use of various pollinator attractants. Among the treatments it was higher in Mollases 10% (68.9 %) and Sugar 10% (68%).

During 2013-14, breeder seed of female parents (45 kg) and male parent (25 kg) of hybrid CICR 2 and variety CISA 614 (65 kg) and CISA 310 (55 kg) were produced at CICR regional station Sirsa. Three hundred and fifty quintals of certified seed of Barley (BH 393) was produced and supplied to the HSDC Sirsa.

## 3.9 : Nutrient Management

### Bio enriched compost potassium silicate

#### Nagpur

#### Evaluation of bio-enriched compost on growth and yield of cotton

A bio-enriched compost from cotton plant residues was evaluated for its performance on growth and yield of

cotton in a field experiment. Based on the two years field study, the present INM treatment (60:30:30 + 5T FYM) gave significantly higher seed cotton yield and boll weight as compared to the modified INM (M INM) treatment (60:30:30 + 5t Cotton compost). Use of cotton compost alone and the modified INM (MINM) treatments were similar to the recommended. The effect of microbial seed treatment on seed cotton yield and boll weight was not significant (Table 3.9.1).

**Table 3.9.1: Effects of cotton stalk compost with and without microbial seed treatment on cotton averaged over 2 years**

Treatments	Seed cotton yield (kg/ha)	Boll wt. (g)
<b>Main treatments</b>		
Without microbial seed treatment	2041	4.65
With microbial seed treatment	2291	4.77
<b>CD (0.05)</b>	<b>NS</b>	<b>NS</b>
<b>Sub treatments</b>		
Recommended NPK (90:45:45)	2389	4.76
Present INM (60:30:30 + 5t FYM)	2711	4.85
Modified INM (60:30:30 + 5t CC)	2252	4.65
Only FYM	1821	4.58
Only Cotton Compost	2118	4.80
Control (No nutrients)	1703	4.61
<b>CD (0.05)</b>	<b>362</b>	

### Evaluation of potassium silicate formulations on cotton production (yield and quality) and protection (pests and diseases)

Field experiments were conducted to evaluate the effects of potassium silicate formulation on cotton yield, quality, pest and disease in Suraj variety. The experiment was laid out in randomized block design with four main treatments [1. seed treatment with Agrisil (Potassium silicate solution), 2. seed treatment with potassium silicate powder, 3. Agrisil foliar Spray (Squaring), and soil application of potassium silicate powder] and 8 sub treatments [control, RDF, N & P only, 500, 1000, 2000, 4000 and 8000 ppm of potassium silicate formulations]. All the formulations were tested under natural and artificial conditions. In artificial study, Bacterial Leaf Blight (BLB) suspension @  $2 \times 10^{10}$  spores/ml was sprayed 80 DAS. Suraj (un-treated) seeds were sown at a spacing of 45 x 15 cm.

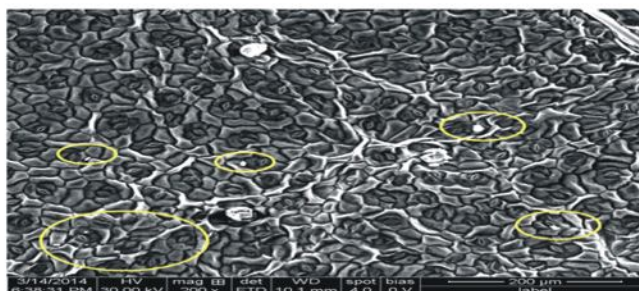
There was no significant difference in seed cotton yield between the treatments in Agrisil. Under artificial

inoculation, seed treatment with Agrisil @ 500 ppm improved boll weight significantly. Seed treatment with potassium silicate powder (PSP) had no effect on seed cotton yield. BLB incidence under natural condition was significantly influenced by seed treatment with PSP, foliar spray of Agrisil and soil application of PSP. Foliar spray of Agrisil did not show significance for seed cotton yield. Treatment differences were non-significant for sucking pests and boll worm damage.

### Coimbatore

Nano formulations of nutrients and fertilizers are expected to improve use efficiency. Therefore, nano encapsulated micronutrients like zinc fertilizer ( $ZnSO_4$ ) was synthesized using chitosan and zein polymers. Synthesized nano  $ZnSO_4$  fertilizer was characterized for size, shape and zeta potential. The average particle size i.e., intensity mean diameter was measured for zinc loaded chitosan/TPP nanoparticles. (103.2 – 234.6 nm). Mean diameter of zinc loaded CS/ TPP nanoparticle with zein coating was  $\pm 1000$  nm. Surface charge, i.e., zeta potential of zinc loaded CS/TPP nanoparticle was found to be positively charged (+34.3 to 48.6 mv). This indicated that nano encapsulated zinc fertilizer was of medium stability with slight agglomeration. After coating of zinc loaded CS/TPP nanoparticles with zein polymer, the zeta potential was also stable i.e., + 30.9 to 36.7 mv. This observation confirmed that zein was successfully coated on the surface of zinc loaded CS/TPP nanoparticles.

In a pot experiment, application of nano encapsulated zinc with chitosan and zein (0.1%) increased plant height (12.7 cm) and number of leaves (8.5) which was followed by nano encapsulated zinc with chitosan and zein (0.2 %). Nanocapsulated zinc with chitosan and without zein (plant height – 10.8 cm and number of leaves – 7.3) was similar to nano encapsulated zinc with chitosan and zein (0.3 %) treatment. The normal recommended dose of zinc fertilizer in the form of  $ZnSO_4$  recorded the lowest plant height (10.5 cm) and number of leaves (6.25) which was more or less on par with control.



Absorption of zinc loaded chitosan nanoparticles by cotton leaves

### Sirsa

#### Bio enriched compost evaluation

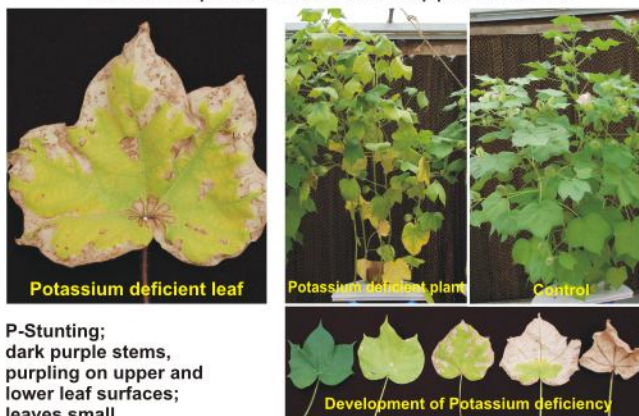
Bio-enriched cotton stalk compost prepared after chipping of cotton stalk was evaluated with JK1947 Bt hybrid *vis-a-vis* the control. Significantly higher seed cotton yield was noted in treatments with present INM practice treatment (12.5 q/ha) and enriched compost 12.7 q/ha as compared to the recommended NPK treatment (10.5 q/ha). However, yield differences amongst present INM practice, enriched compost and untreated compost were non-significant.

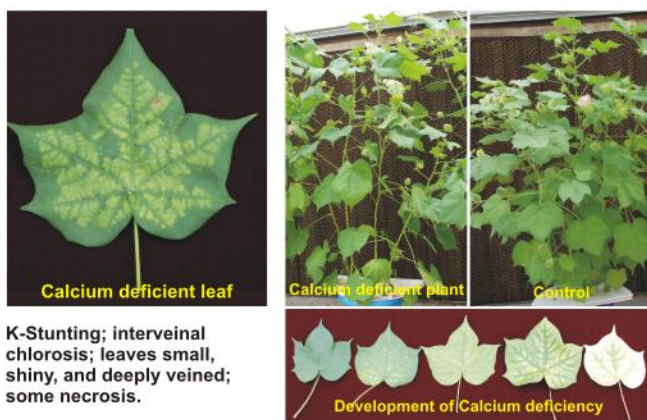
#### Documentation of nutrient deficiency

##### Coimbatore

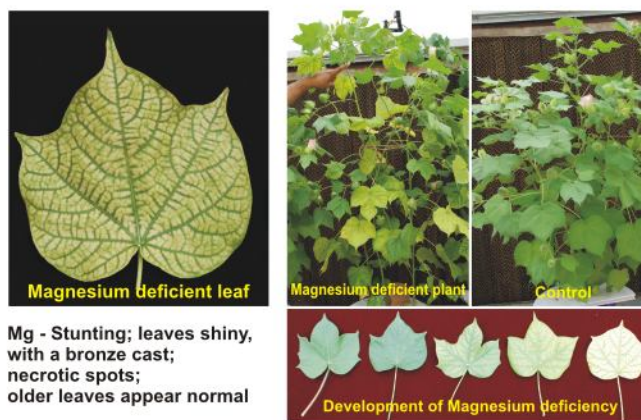
Hydroponics is a subset of hydro-culture and is a method of growing plants using mineral nutrient solutions from water without soil. A hydroponic method of culture was developed to study the nutritional deficiencies due to essential nutrients *viz.* nitrogen, potassium, magnesium and calcium. The deficiency symptoms were visible within seven days of culture.

- N - Chlorosis of the leaves, particularly the older leaves.
- P - Stunting; dark purple stems, purpling on upper and lower leaf surfaces; leaves small.
- K - Stunting; interveinal chlorosis; leaves small, shiny, and deeply veined; some necrosis.
- Mg - Stunting; leaves shiny, with a bronze cast; necrotic spots; older leaves appear normal





K-Stunting; interveinal chlorosis; leaves small, shiny, and deeply veined; some necrosis.



Mg - Stunting; leaves shiny, with a bronze cast; necrotic spots; older leaves appear normal

### 3.10 : High density planting system (HDPS) for maximizing productivity

#### Nagpur

#### Evaluation of semi-compact *G. hirsutum* genotypes

Fourteen genotypes from diverse agro-climates - NH 615 (Nanded), ADB 39, ADB 532 (Adilabad), Supriya, Suraj, LRK 516, SIMA CDRA SH-2-4 (Coimbatore), KC 3 (Kovilpatti), Vikram (Khandwa), Arogya, CINHTi1, CINHTi 2 (Nagpur), DSC 99 (Dharwar) and PKV 081 (Akola) were evaluated at 3 spacings 45 x 10 cm (220000 plants/ha), 45 x 15 cm (148000 plants/ha), 60 x 10 cm (166000 plants/ha) on a shallow (45 cm) soil under rainfed conditions. The trial was also repeated on medium deep black soils (80 cm) but the genotypes Arogya and SIMA CDRA SH-2-4 were replaced by C1412, PI-8-2-Bk (Coimbatore) and the spacings were 45 x 10 cm, 60 x 10 cm and 75 x 10 cm. On shallow soil, the effects of spacing, genotypes and spacing x genotype interaction effects were significant. Across genotypes, yield at 45 x 10 cm (2296 kg/ha) and 60x10 cm (2272 kg/ha) were at par and superior to that with 45 x 15 cm (2007 kg/ha). On medium deep soil, the spacing effect was not significant but the effects of genotype and spacing x genotype interaction were significant. The ranking of genotypes in the decreasing order of productivity at common spacings in shallow and medium deep soils is given in Table 3.10.1. A new genotype-CISH 3178 with zero monopodia and compact habit was identified for HDPS at 60 cm row spacing



**CISH 3178**

**Table 3.10.1: Ranking of genotypes on shallow and med-deep soil**

Rank	45x10 cm spacing		60x10 cm spacing	
	Shallow	Med deep	Shallow	Med deep
1	DSC-99	DSC-99	DSC-99	C1412
2	KC 3	C1412	KC -3	DSC-99
3	NH-615	AKH-081	NH-615	Vikram
4	ADB 39	Anjali	Vikram	NH-615
5	AKH-081	NH-615	Anjali	Anjali
6	Suraj	Suraj	CINHTi-1	AKH-081
7	Anjali	KC-3	AKH-081	KC-3
8	CINHTi-2	Vikram	AROGYA	Suraj
9	Vikram	ADB 39	Suraj	CINHTi-1
10	CINHTi-1	CINHTi-1	ADB 39	ADB-532
11	AROGYA	ADB-532	ADB-532	PI-8-2-Bk
12	ADB-532	PI-8-2-Bk	SIMA CDRA	CINHTi-2
13	SIMA CDRA	CINHTi-2	CINHTi-2	ADB 39
14	Supriya	Supriya	Supriya	Supriya

#### Standardization of soil moisture conservation measures

The effect of soil moisture conservation practices were evaluated in *G. hirsutum* (Suraj) planted in HDPS at 60 cm row spacing. Ridges and furrows with a bio-mulch (*sesbania* grown in the inter-row spacing and turned down at 45 DAS) was better than the flat bed method of planting. However because of heavy rainfall and excess soil moisture, the yield improvement was not significant.

#### Integrated weed management strategies

Weed control is a key issue in adoption of HDPS in narrow row spacing compared to conventional wide spaced Bt hybrid cotton. Although solutions are known, low cost technologies are the need of the day. Results indicated if there is sufficient pre monsoon rainfall (more

than 100 mm) weeds are allowed to germinate before seed bed is prepared. These weeds can be killed by glyphosate. Further, if there is sufficient soil moisture, a residual herbicide (Pendimethalin) can be applied to provide weed free period upto 40 days. Depending upon rainfall inter-cultures/ hand weedings need to be included. However, continuous extended monsoon may require post emergence weedicides like propaquizafop + pyriothobac sodium over the top application (each 0.035 kg a.i. ha<sup>-1</sup>). A low cost alternative of directed spray of glyphosate (0.75 kg a.i.ha<sup>-1</sup>) is equally effective.

### Disease and insect pest management strategies

Among the 14 genotypes evaluated on shallow soils, Arogya (7.1 PDI) and CINHTi2 (9.0 PDI) recorded lower bacterial leaf blight (BLB) incidences. Similarly on medium deep soils, CINHTi2 (20.0 PDI) and ADB 532 (23.0 PDI) recorded minimum BCB incidence. Increased plant population did not aggravate BLB incidence. The ranking of genotypes based on the incidence of foliar diseases is given in Table 3.10.2.

**Table 3.10.2 : Disease incidence in various genotypes under HDPS in Shallow and Medium deep soils (Lowest PDI is given top rank)**

Rank	Shallow soil			Medium soil		
	BLB	Myrothecium leaf spot	Grey mildew	BLB	Myrothecium leaf spot	Grey mildew
1.	Arogya	Supriya	Suraj	CINHTi2	C1412	Supriya
2.	CINHTi2	CINHTi2	ADB 532	ADB 532	Supriya	CINHTi1
3.	Supriya	CINHTi1	Arogya	PI 8-2 BK	Vikram	Suraj
4.	ADB 532	KC 3	Anjali	Supriya	CINHTi1	C1412
5.	AKH 081	Anjali	Supriya	AKH 081	CINHTi2	AKH 081

Clorantraniliprole 18.5 SC and Flubendiamide application at 60 and 80 DAS could effectively manage bollworms under HDPS system. The incidence of pests were recorded periodically on the 14 genotypes evaluated on shallow and medium deep soils. The incidence of both American and pink bollworms were

below ETL throughout the season. Based on the incidence of sucking pests the genotypes are ranked below (Table 3.10.3).

**Table 3.10.3 : Ranking of genotypes based on the severity of sucking pest incidence (Lowest incidence given top rank)**

Rank	Shallow soil				Medium deep soil			
	Jassids	Whiteflies	Aphids	Thrips	Jassids	Whiteflies	Aphids	Thrips
1	NH-615	KC-3	Anjali	CINHTi-2	NH-615	Suraj	Supriya	CINHTi-2
2	ADB-532	ADB-39	Arogya	Arogya	KC-3 & Vikram	CINHTi-2 & C-1412	PI-8-2-Bk	AKH-081
3	KC-3 & Vikram	Vikram	AKH-081	Anjali	CINHTi-2	AKH-081, CINHTi-1, ADB-39 & Anjali	DSC-99	NH-615
4	DSC-99	ADB-532, Anjali & CINHTi-2	DSC-99	Suraj	ADB-532	Supriya	KC-3 & C-1412	Anjali
5	AKH-081	DSC-99	NH-615	AKH-081	Anjali	DSC-99	CINHTi-1	ADB-532

## Coimbatore

### Evaluation of semi compact genotypes

Nine genotypes - Anjali, KC-3, NH615, MCU 7, SVPR-3, LH 900, PKV 081, Suraj and Supriya were evaluated at 45 x 15 cm (with RCH 2 Bt planted at 90 x 60 cm as check) with and without mepiquat chloride (25g ai/ha) at 45 and 60 DAS. Across genotypes, application of mepiquat chloride did not improve seed cotton yield. The number of open bolls per square meter was maximum with KC-3 (174). Significant improvement of boll weight was observed with mepiquat chloride application (3.5 g) as compared to control (3.1g). KC-3, NH 615 and PKV

081 had lower sucking pest population. The highest net return was obtained with Suraj and Anjali.

### Evaluation of machines for planting in HDPS

The inclined plate planter, cotton planter, cultivator mounted seed drill, pneumatic planter and animal drawn seed drill were compared with manual sowing and broadcast method. Among the planters, inclined plate planter was the best as it maintained row to row spacing of 45 cm and mean plant to plant spacing of 15.4 cm with (coefficient variation of 31.3 %) with a seed rate of 19.2 kg/ha. The highest yields were obtained with manual sowing and were similar to those with inclined plate planter.



### Sirsa

#### Development and evaluation of genotypes/cultures of *G. hirsutum*

Eighteen genotypes were evaluated at 67.5 x 10 cm spacing, CSH-3158 (3444 kg/ha) and RS-2525 (3726 kg/ha) gave significantly higher yield than Bt check Ankur 3028 BG II planted at recommended spacing (2521 kg/ha).

In a large plot trial, F-2383 planted at 67.5 x 10 cm spacing produced 18.7 % more seed cotton than the Bt check Ankur-3028 (1753 kg/ha). Spray of Chamatkar in F-2383 in two splits (1 ml / litre) reduced plant height, increased boll number and induced earliness.

Four varieties / cultures namely RS 875, LH 900, H 1098 and F 2383 evaluated at 67.5 x 10 cm and 67.5 x 30 cm. The yield was higher with 67.5 x 10 cm (Table 3.10.4). These cultures had plant height of less than 120 cm.

**Table 3.10.4 : Seed cotton yield (kg/ha) under HDPS and normal sowing**

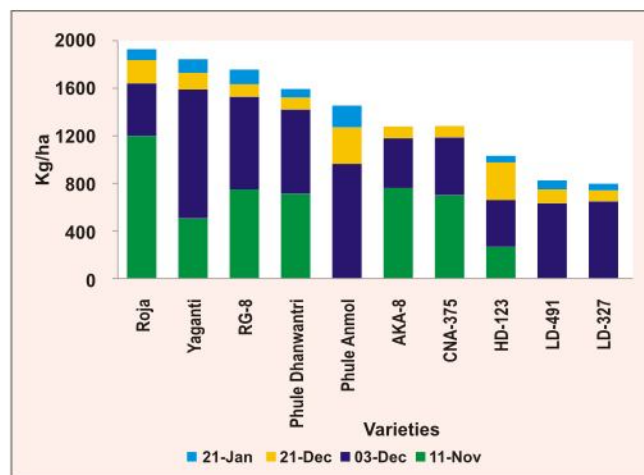
Culture/ genotype	HDPS	Normal spacing
	67.5 x 10 cm	67.5 x 30 cm
RS 875	1274	976
LH 900	2056	1566
H 1098	1995	1835
F 2383	903	678

On the basis of three years average performance in closer spacing, CSH 3178 (2356 kg/ha), CSH 3158 (2849 kg/ha) and CSH 3132 (2628 kg/ha) were promising. Other promising cultures identified were CSH 3047 (2479 kg/ha), GC 110 (2268 kg/ha), Azon 148 (2331 kg/ha) and RS 2525 (2953 kg/ha). Another compact type selection CSH 3113 gave higher yield 3086 kg/ha at 67.5 x 10 cm spacing in comparison to F 2383 (2000 kg/ha).

### Evaluation of *G. arboreum* for HDPS system and surgical cotton production

#### Nagpur

Seventeen genotypes were evaluated at 60 x 10 cm and the performance of some promising ones are depicted in Fig. 3.10.1. Roja was the highest yielder, Phule Dhanwantary was the most compact and AKA 8 and CNA 375 were early maturing. RG 8 and Phule Dhanwantary are not only high yielding but also ideally suited for surgical cotton production.



**Fig. 3.10.1: Seed cotton yield (kg/ha) of *G. arboreum* genotypes planted at 60 x 10 cm spacing**

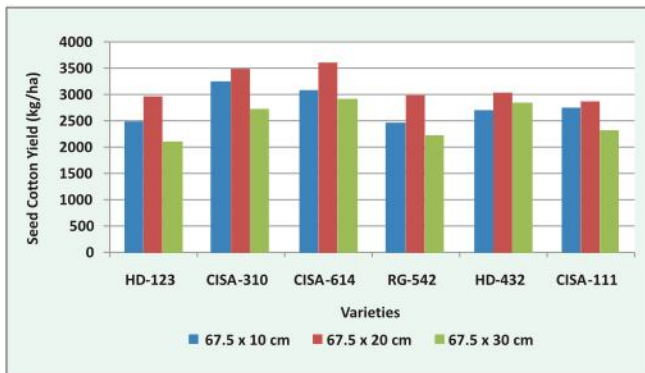
#### Coimbatore

#### Evaluation of *arboreum* genotypes for winter irrigated condition

Eight *arboreum* genotypes were evaluated at Coimbatore. Among them, Yaganti, a genotype from Nandyal, Andhra Pradesh recorded 2494 kg/ha and a genotype from Rajasthan, RG-8 ranked second with 1864 kg/ha and NDLA 3047 from Nandyal ranked third with yield of 1654 kg/ha.

#### Sirsa

Six *G. arboreum* varieties viz. HD 123, RG 542, HD 432, CISA 310, CISA 614 and CISA 111 were evaluated during 2011-12, 2012-2013 and 2013-2014. In general, higher yield was obtained with 67.5 x 20 cm spacing followed by 67.5 x 10 (Fig. 3.10.2). The increase was 500 to 700 kg/ha (9.7 to 32.7 % increase) in 67.5 x 20 cm spacing over normal spacing of 67.5 x 30 cm. The seed cotton yield ranged from 2410 kg/ha to 3652 kg/ha in 67.5 x 10 cm spacing, 2579 kg/ha to 3653 kg/ha in 67.5 x 20 cm spacing and 1392 kg/ha to 2964 kg/ha in 67.5 x 30 cm spacing.



**Fig. 3.10.2 : Seed cotton yield (kg/ha) of *G. hirsutum* varieties at different spacings (mean of 3 years – 2011 -12 to 2013 -14).**

Lint samples of 40 high yielding cultures were evaluated for surgical properties and out of these 10 cultures were identified superior for surgical properties. These lines were evaluated for yield potential and among them the highest yield was recorded in cultivar CISA-17-93 (3100 kg/ha) followed by CISA-6-295 (3000 kg/ha) RG-540 (2900 kg/ha), CISA-504 (2675 kg/ha) and HD- 432 (2500 kg/ha). Among these lines CISA 6-295 had the lowest shattering (20 %).

### 3.11: Weed Management

#### Nagpur

##### Herbicide resistant weed management

Glyphosate resistant weeds were identified from the station and onfarm trials at Nagpur and Coimbatore following repeated applications of glyphosate (Table 3.11.1). Weeds *Merremia imarginata* and *Cynotis auxillaris*, the resistance is due to waxy coating that prevents herbicide entry. *Echinochloa crusgalli* was found resistant to DNA herbicide Pendimethalin. Pyriithiobac sodium and Imzethapyr at 0.5 to 2.5 times the recommended dose had similar broad leaf control range with minor differences for grasses and both needs to be combined with graminicides and interculture operations for effective weed control. *Sorghum halepense* can be managed by over the top application of graminicides or Glyphosate at 3-4 weeks after germination where as they were not effective against *Cyperus rotundus*.

**Table 3.11.1: Weeds controlled by herbicides/ combinations**

Weeds	Glyphosate	Pyriithiobac (Pyr)	Imzethapyr	Pyr+ Quizlofop	Pyr+ Fenoxoprop	Pyr+ Propquizafop
<i>Merremia emarginata</i>						
<i>Acalypha indica</i>						
<i>Celocia argentia</i>						
<i>Digera arvensis</i>						
<i>Parthenium hysterophorous</i>						
<i>Euphorbia hirta/ microcephala</i>						
<i>Tridax procumbense</i>						
<i>Commelina benghalensis</i>						
<i>Cynotis auxillaris</i>						
<i>Phyllanthus niruri</i>						
<i>Sorghum halepense</i>						
<i>Echinochloa cerussgalli</i>						
<i>Cyperus rotundus</i>						
<i>Eriochloa Polystachia</i>						

#### Coimbatore

Weed shift occurred in same field of Namagiripatai, Namakal district where glyphosate was continuously applied. The shift was in favour of broad leaved weeds (*Cynotis culculata*) and sedges (*Cyperus rotundus*) from grasses (*Echinochloa colona*). Dominance of *Trianthema portulacastrum* under continuously pendimethalin applied cotton field was observed in the institute's farm.

##### Allelopathy as an alternate weed management strategy in cotton

#### Nagpur

Cost of herbicides is a deterrent to use of chemicals at their recommended doses. Therefore, alternative weed management strategies are needed. Allelopathic effects of crops can be utilized for weed control. However, their

use may hinder crop growth. Therefore field studies were conducted to identify cover crops with potential allelopathic effects.

Twelve cover crops were evaluated for their weed control efficiency and allelopathic effects. Among the cover crops sorghum, bajra, sunflower and sunnhemp had fewer weeds and weed biomass. These treatments were comparable to the newspaper mulch and polythene mulch treatments which had the least number of weeds and weed biomass accumulation. Seed cotton yield was adversely affected by some cover crops such as bajra and sunflower due to competitive effects. All the cover crops were tested for presence of phytochemicals (phenolics, flavonoids and alkaloids) in the above and below ground parts of the plants. Tests for the phytochemicals were negative in all the soil extracts. This could either be due to the very small amounts of the phytochemicals present or their rapid disintegration.

### Coimbatore

Cover crops with allelopathic effect to weeds such as wheat, barley, sunnhemp, sunflower, mustard, sorghum and radish were evaluated along with no cover crop control. Among them wheat, barley, and sunnhemp suppressed the weeds efficiently and significantly enhanced the seed cotton yield. Sunflower produced allelopathic effect not only to weeds but also to cotton and recorded the lowest seed cotton yield and hence was found to be unsuitable as cover crop with cotton.

Five creepers viz., cucumber, ash gourd, watermelon, musk melon and bitter gourd were evaluated as cover crops for cotton. All these creepers were sensitive to the recommended pre emergence herbicide, pendimethalin and their germination was adversely affected.

Weeds in cotton can be managed by an integrated approach with pre emergence pendimethalin 1.0 kg on third day of cotton sowing followed by *in situ* cover crops around 35 - 40 DAS combined with one hand weeding around 70 -75 DAS.

## 3.12 : Agronomy of *G. arboreum* race *cernuum*

### Nagpur

#### Agronomy of *G. arboreum* race *cernuum*

*G. arboreum* race *cernuum* was evaluated at six different spacings (45 x 15 cm, 45 x 30 cm, 45 x 45 cm, 60 x 15 cm, 60 x 30 cm and 60 x 45 cm) on a medium – deep black soil under rainfed conditions with and without mepiquat chloride (50 g a.i./ha) applied in 2 splits. Mepiquat chloride treated plants were shorter, more compact, greener and had heavier bolls. The mean seed cotton

yield was significantly higher at 45 x 15 cm followed by 60 x 15 cm spacing. Treatment combination of 45 x 15 cm + mepiquat chloride @ 50 g a.i./ha gave the highest yield (796 kg/ha) (Fig. 3.12.1). Effect of mepiquat chloride was more evident at higher plant density. Response to mepiquat chloride application was significant and across spacing the mean yield advantage was 11.3 %.

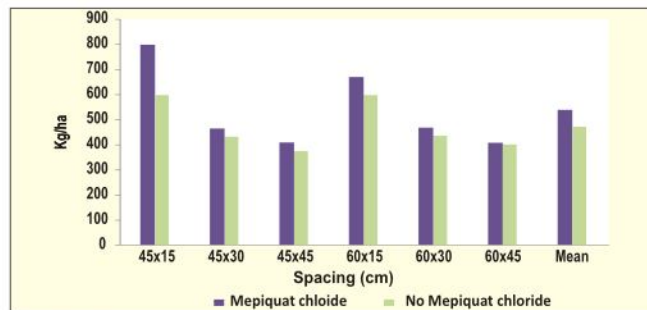


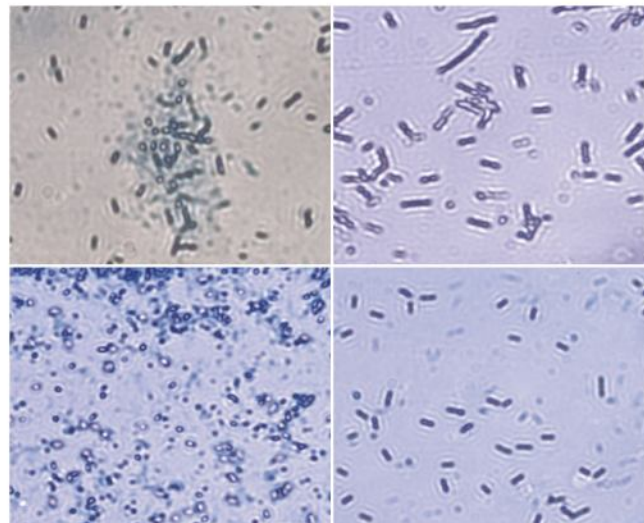
Fig. 3.12.1: Seed cotton yield (kg/ha) of *G. arboreum* race *cernuum* under different crop geometries and mepiquat chloride application

## 3.13: Soil Biology and Biochemistry

### Nagpur

#### Isolation of Bt strains

Eighty Bt strains (80 nos.) were isolated from different agro-ecological regions of India. The Bt isolates were further subjected for morphological characterization (spore staining) for confirmation. DNA isolation was done from these isolates and presently testing for the presence of *cry1Ac* gene is under progress.

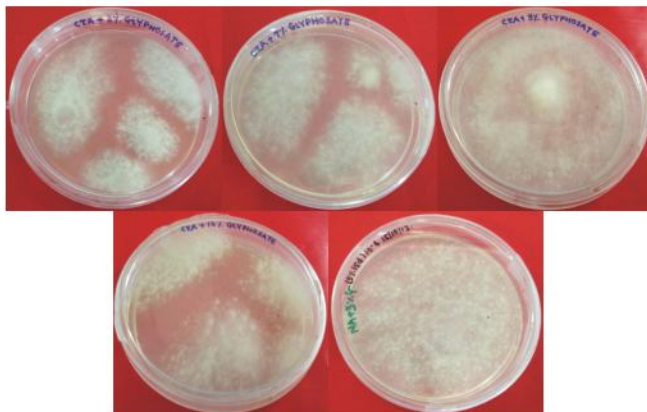


Spore staining of Bt isolates

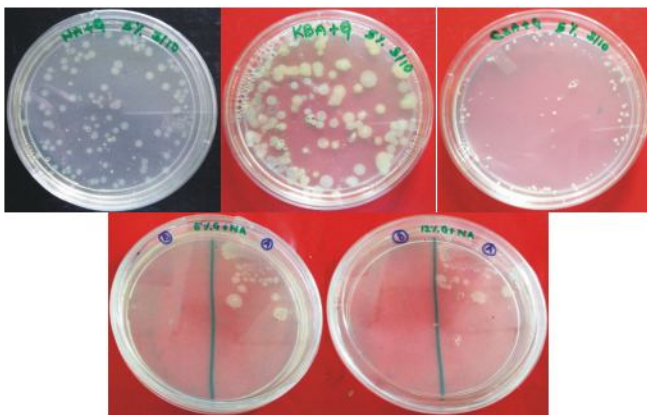
#### Isolation of glyphosate utilizing/degrading bacterial and fungal isolates

Through enrichment culture techniques, one fungal and two bacterial strains were shortlisted for utilizing glyphosate up to 12% concentration. Growth of

microbes were reconfirmed by growth on glyphosate containing minimal media. One bacterial isolate was submitted for identification through 16S rRNA.



**Fungal isolate on minimal media containing glyphosate (3-12%)**



**Bacterial isolate on minimal media containing glyphosate (3-12%)**

### Soil biological properties of black soil regions of India

All the biological properties decreased with the depth and the maximum activity was observed in 0-30 cm soil depth. The mean urease activity in different bio-climates were in the order of arid > sub-humid (moist) > sub humid (dry) > semi-arid (dry), whereas in different cropping systems, urease activity was in the decreasing order as legume > sugarcane > cereals > cotton-based cropping systems. Higher urease activities were observed in irrigated agro-systems than the rainfed regions. High management practices increased urease activities compared to corresponding low management. Significantly higher ( $p < 0.01$ ) dehydrogenase activity (DHA) was recorded in the sub- humid moist (SHm) bio-climate ( $2.45 \mu\text{g TPF g}^{-1}$ ) followed by semi-arid dry (SAd) ( $2.00 \mu\text{g TPF g}^{-1}$ ) and the least DHA was recorded in arid bio-climate ( $1.62 \mu\text{g TPF g}^{-1}$ ). Legume-based cropping system recorded significantly ( $p < 0.01$ ) higher DHA ( $2.32- 2.88 \mu\text{g TPF g}^{-1}$ ) followed by cereal-based

cropping system ( $1.29-2.82 \mu\text{g TPF g}^{-1}$ ). The pooled comparisons of DHA from irrigated ( $1.98 \mu\text{g TPF g}^{-1}$ ) and rainfed agro-system ( $1.97 \mu\text{g TPF g}^{-1}$ ) did not show any significant differences. Intensive management practices increased soil DHA ( $2.15 \mu\text{g TPF g}^{-1}$ ) than low management ( $1.78 \mu\text{g TPF g}^{-1}$ ). Significantly higher microbial biomass carbon (MBC) was recorded in sub-humid dry (SHd) bio-climate ( $267 \mu\text{g g}^{-1}$ ) followed by sub-humid moist and least in arid bio-climate ( $97.5 \mu\text{g g}^{-1}$ ). Sugarcane-based cropping system had significantly higher MBC ( $246 \mu\text{g g}^{-1}$ ) than the legume-based system ( $205 \mu\text{g g}^{-1}$ ) and lowest in cotton-based system ( $128 \mu\text{g g}^{-1}$ ). Significantly higher ( $175.7 \mu\text{g g}^{-1}$ ) MBC was recorded in high management and irrigated agro-systems ( $173.9 \mu\text{g g}^{-1}$ ) compared with low management (LM) ( $158 \mu\text{g g}^{-1}$ ) and rainfed agro-systems ( $163 \mu\text{g g}^{-1}$ ). Significantly higher microbial population was recorded in sub-humid moist bio-climate ( $6.26 \log_{10} \text{cfu g}^{-1}$ ) followed by sub-humid dry ( $6.21 \log_{10} \text{cfu g}^{-1}$ ) and the least microbial population was recorded in arid bio-climate ( $6.14 \log_{10} \text{cfu g}^{-1}$ ). Legume-based cropping system had significantly higher microbial population ( $6.23 \log_{10} \text{cfu g}^{-1}$ ) than the cereal-based cropping system ( $6.23 \log_{10} \text{cfu g}^{-1}$ ). The pooled comparison of microbial population from irrigated and rainfed agro-system showed significant difference in surface layer. Significantly ( $p < 0.01$ ) higher diversity indices was recorded in SHm, SHd and SAd bioclimates but lowest in arid bioclimates. The microbial diversity indices significantly decreased with depth in all the BM spots. The maximum diversity indices were recorded in surface soil (0-15 cm) and nearly 50% of diversity was found to be associated within 0-30 cm soil depth.

### 3.14: Management of Abiotic Stress

#### Leaf phytochemicals and their role in cotton leaf reddening

Field experiment was conducted with RCH-2 BG II Bt hybrid with 9 treatments. (CICR consortium, Potash 1%,  $\text{KNO}_3$  3%, Monocrotophos 36% SL, Lime 0.5% Methomyl 40% SP, No Fertilizer, Normal Control (1% urea and 0.5%  $\text{MgSO}_4$ ) were imposed as foliar spray at 90-100 DAS.

Light to medium leaf reddening symptoms were observed during 100-120 DAS. Periodical monitoring of the affected leaves showed that methomyl 40% SP treated plots had plants with more red leaves while plants treated with 1% potash, 0.5% lime, 1% DAP and 1% urea + 0.5% magnesium sulphate showed less incidence of leaf reddening (Table 3.14.1). Since it was late season leaf reddening, developing and matured

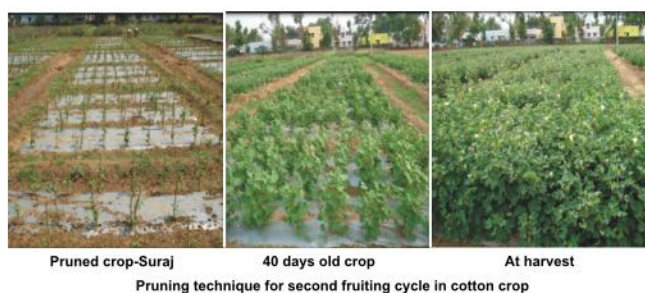
bolts were not affected. Leaf chlorophyll content, on an average, was high (1.5 - 1.8 mg/gm fresh wt of leaf) in lime, potash, urea + magnesium sulphate treatments. Anthocyanin concentration was found to be highest in methomyl treated plants. Treatments, viz. potash (1%), KNO<sub>3</sub> (3%), lime (0.5%) showed comparable seed cotton yield and higher than control.

**Table 3.14.1: Percentage of plants affected due to reddening by various treatments**

Treatment	Plants
Control	25.5
Consortia	22.2
Potash	23.3
KNO <sub>3</sub>	24.4
Monocrotophos	17.3
Lime	15.5
Methomyl	44.4
No fertilizer	21.5
Urea + MgSO <sub>4</sub>	22.2

#### Pruning of cotton for second fruiting cycle in cultivar Suraj was tried on large scale under poly mulch

Pruning of cotton for second fruiting cycle in cultivar Suraj was tried on large scale (half an acre) under poly mulched condition. Pruning was effected soon after 3<sup>rd</sup> picking and new sprouts initiated within 8-10 days. Squaring started within 40 days and boll formation within 70 days. Photosynthetic rate, nitrate reductase activity and chlorophyll content in the leaves of pruned crop was marginally lower compared to normal crop. However, nutrient consortia spray boosted the activity significantly in both normal and pruned crop. At harvest, the boll number was 31 per plant in pruned crop compared to 44 in normal crop. Boll size was significantly smaller in pruned crop and nutrient consortia spray could increase the size marginally. Irrespective of the nutrient consortia spray, seed cotton yield of 170 g per plant could be harvested from normal crop and additional yield of 109 g per plant by pruning technique. Nutrient consortia spray increased yield significantly in both normal and pruned crop. Thus, an additional yield of 60-70 % could be attained by pruning technique. The fibre span length, uniformity ratio, micronaire value, strength and elongation was not altered significantly due to pruning technique. For instance the FQI (Fibre Quality Index) calculated was 410 for pruned crop compared to 423 for normal crop. The study revealed that second fruiting cycle in cotton is possible and this technique has many advantages like no ploughing cost, less weed problem, less pesticide spray, less fertilizer requirement and irrigation schedule with less labour force throughout the



cropping season, no seed cost, advanced flowering and fruiting, faster boll development, harvest in short period with maintenance of fibre quality and is cost effective.

### 3.15 : Extra Long Staple (ELS) Cotton

#### Identification of 'crop-cycle' for extra long staple (ELS) cotton in non-conventional regions

ELS cotton is grown in southern states of India as the climatic variables prevailing during August to February in southern region is quite favorable. In Central India, temperature is comparatively more during June to October, and is lower during December to January than the southern states, due to which overall crop growth is suppressed. The kinetic thermal window of cotton crop is 23 to 32 °C where the plant metabolic activities are normal. Hence to assess the performance of ELS cotton variety Suvin, staggered sowing was done at weekly interval from 01 July to October 2013. The sowing dates were replicated four times in randomized block design. After the monsoon receded, the crop was irrigated twice.

Results indicate no significant effects for July and August sowing dates. Slight reduction (3.9%) in seed cotton yield was noticed, when sowing was delayed beyond 5 August to end of August. However, sowing dates of September and October did not yield any significant quantities of seed cotton. Since the crop is long duration (> 160 days), delayed sown crop suffered from moisture stress when the crop was in maximum boll development stages as compared to the remaining sowing dates. Similarly, during the month of December end to January, day-night low temperature suppressed physiological processes of the plant unlike other sowing dates. Total number of bolls (damaged and good quality) in all sowing dates was in the range of 39 to 41 per plant. Total harvestable bolls ranged from 15 to 17 per plant. Fibre quality parameters were comparatively good when it was compared with standard value, evaluated for southern states (Table 3.15.1). Fibre length on an average was 36.5 mm. In case of micronaire and other fibre quality parameters, all the values recorded in our experimentation are categorized as very fine and fine. There is scope for taking up ELS cotton in central India, provided it is sown during July – August and not later.

Table 3.15.1: Performance of ELS cotton under staggered sowing during *kharif* 2013-14

Date of sowing	Seed cotton yield (kg/ha)	Fibre quality parameters			
		2.5 % length (mm)	Uniformity ratio %	Micronaire	Bundle strength (g/tex)
1.7.2013	723	36.4	47.8	2.9	26.6
4.7.2013	752	36.7	49.8	3.1	26.5
5.8.2013	747	36.6	46.8	3.1	25.4
12.8.2013	720	36.6	47.3	3.1	25.4
26.8.2013	695	36.8	48.3	3.1	25.6
Table F (2.394)	0.24	0.22	1.83	1.36	1.19
SE (m)	29.4	0.20	0.53	0.06	0.33
CD (5%)	NS	NS	NS	NS	NS
CV (%)	6.35	0.84	3.53	6.36	4.43

### 3.16 : Cotton Mechanization

#### Nagpur

A self propelled riding type cotton harvester was designed and fabricated using a power tiller with 17 hp diesel engine. The harvester is especially designed for narrow row cotton cultivation as in HDPS where commercial spindle type harvester cannot operate. Because of its smaller size, and relatively simpler operations it is suitable for harvesting Indian cotton farms. Compared to spindle type pickers it has less maintenance and fewer wearable parts for replacement. The harvester was tested in Suraj variety sown at 80 x 10 cm. The crop was defoliated with Ethrel at 5000 ppm. The field capacity of the machine was found to be 4.2 hrs/ha. The cost of picking was Rs 1.2/kg for a yield of 20 q/ha and Rs.2403/ha giving equivalent amount of trash to that of commercial cotton harvester. The harvesting efficiency obtained was 90 % which improved to 98%



with modification of picking arrangements. However the average trash percentage that was 23.6 % was brought down to 19 % with process modification. The harvester includes a pre-cleaner, therefore giving the first stage of pre-cleaning on the farm. Further modifications on the pre-cleaner and grid conclave in the seed cotton-stick separator are being undertaken to further reduce the trash to acceptable limits on the farm itself. A mini stick/bur cleaner is being designed to be incorporated in the harvester giving a second stage of cleaning.



### 3.17: Socio Economic Dimensions of Cotton Farming

#### Nagpur

##### e-kapas network to connect one lakh cotton farmers for technology dissemination

'e- kapas' is an initiative for the utilization of information and communication technologies (ICTs) for delivering appropriate cotton technologies to farmers 'anywhere and anytime' to users.

##### Creation of mobile communication network system

During the period required infrastructure facilities, hardware, and software at lead centre Nagpur and at participating centres for delivering information to farmers through mobile based system were developed to implement mobile based voice message through service providers. Voice messaging service acts as an automatic voice dialler and sends the recorded messages in the form of automatic phone calls to the registered farmers. This service is provided to all farmers irrespective of telecom network.

##### Registration of cotton growers as 'e-kapas' beneficiaries

Interested farmer's were registered as beneficiary of e-kapas network. Voice messages and advisories were provided free of cost by CICR and from participating centres. The farmers can also register directly with short code services 123eworld.com (Mobi Tech Media) system. During the year 2013-14, a total of 68427 cotton farmers were registered from the seventeen participating centres from major cotton growing districts. Out of these farmers, around 30,266 farmers were registered from CICR. The growers information are being utilized to develop a database called e-kapas farmers' database.

#### Coimbatore

- A total of 4982 cotton growers in Tamil Nadu were identified and registered in e-Kapas network.
- List of FAQs (230) in cotton from the Kisan Call Centres in Tamil Nadu were collected and a total of 8277 voice SMS on Cotton technologies were sent to registered growers in Tamil language.
- Digitized and documented Technical Bulletins, CICR Annual Reports, AICCIP Annual Reports, TMC Annual Reports.
- Periodically documented reports were uploaded and existing database were updated on the CICR website.

#### Impact evaluation of Bt cotton in Maharashtra

During 2012-13, data was collected and analyzed from 1200 cotton farmers belonging to 8 cotton growing districts of Maharashtra. During reporting year data collection in ten districts from 1500 farmers namely Washim, Hingoli, Buldhana, Jalna, Jalgaon, Beed, Aurangabad, Dhule, Ahmednagar and Nandurbar was completed.

Though Bt cotton was introduced in 2002, its adoption was very slow up to 2005, afterwards Bt cotton adoption gained momentum and by the end of 2011 almost 90 percent of respondents adopted it. Currently all the respondents are growing Bt cotton. Significant changes took place after introduction of Bt cotton and the important ones are listed in Table 3.17.1.

**Table 3.17.1: Use of inputs before and after introduction of Bt cotton**

Particulars	Before Bt	After Bt
Seed (Kg/acre)	2.98	1.66
No. of insecticidal sprays	8	4
Fertilizers( Kg/acre)	325	498
Respondents used weedicides (%)	4.30	46.60
Respondents used growth regulators (%)	0.00	31.66
Yield(q/acre)	4.16	10.33

Nearly 87 % respondents felt that sucking pest problem is increasing year after year. Almost all respondents (95 %) felt that availability of pesticides is not a problem. As per the respondents there are more than 300 Bt hybrids in the market. They mainly depend on the advice of seed dealers/ private companies for the selection of hybrids. Most of the respondents (51 %) felt that selected hybrids are not giving expected yield which indicates that they are unable to appropriate decision regarding the selection of hybrids. 32 % of the respondents felt that they are unable to get their preferred hybrid at MRP rate and they need to pay more than MRP to get it. High yield, big boll size and quality of fibre are the three major traits preferred by the respondents. Paras Brahma, Mallika and Jay Bt were the top three preferred brands by the respondents. 43 % of respondents are not using non Bt seeds as refugia, 57 % of respondents use non Bt seeds as border crop and those who get red gram seed as refugia are using it as intercrop. Opinion survey revealed that Bt cotton was not responsible for suicides of cotton farmers (99 % of respondents). Almost all the respondents perceived that there were no incidence of death of animals due to Bt cotton and there were no health hazards due to Bt cotton cultivation.