

3. RESEARCH ACHIEVEMENTS

3.1: Cotton Genetic Resources

Nagpur

Exploration and collection of germplasm

ICAR-CICR has conducted National Exploration Programme in collaboration with ICAR-National Bureau of Plant Genetic Resources (NBPGR), New Delhi, Punjab Agricultural University (PAU), Ludhiana and Main Cotton Research Station, Navsari Agricultural University, Surat to collect land races of *desi* cotton and perennial cotton from Assam and Nagaland. Karbi anglong district of Assam and Dimapur, Kohima, Phek, Kiphire and Tuensang districts of Nagaland were surveyed during the exploration programme. Seventeen cotton variants including five *G. arboreum*, eleven *G. barbadense* and one *G. hirsutum* were collected. Among five *G. arboreum* accessions, two represent

G. arboreum race *cernuum* which were collected from Karbi anglong district of Assam.

ICAR-CICR in collaboration with ICAR-NBPGR, Regional Station, Cuttack, collected 41 water logging and salinity tolerant accessions of cotton germplasm from Sundarbans regions of West Bengal. Two districts namely, South 24-Parganas and North 24-Parganas, were surveyed during the exploration programme. Among forty-one, thirty-two represents *G. hirsutum* and nine represents *G. barbadense* accessions (Table 3.1.1). Out of nine, eight *G. barbadense* accessions belonged to *G. barbadense* var. *brasiliensis* and they had unique character of fused seeds (Kidney cotton). The collected seeds were conserved in the medium term storage in the Cotton Gene Bank at ICAR-CICR, Nagpur.

Table 3.1.1: List of perennials/landraces of cotton collected from different regions of India

Sl. No.	Districts	State	No. of Accessions	Species	Perennial/Landrace
1.	Karbi anglong	Assam	2	<i>G. arboreum</i> race <i>cernuum</i>	Landrace
			6	<i>G. barbadense</i>	Perennial
			1	<i>G. hirsutum</i>	Perennial
2.	Phek	Nagaland	3	<i>G. arboreum</i>	Primitive cultivar
			5	<i>G. barbadense</i>	Perennial
3.	South 24 Paraganas and North 24 parangas (Sundarbans Region)	West Bengal	8	<i>G. barbadense</i> var. <i>brasiliensis</i>	Perennial
			1	<i>G. barbadense</i>	Perennial
			32	<i>G. hirsutum</i>	Perennial

Fibre quality traits of 9 morphologically distinct *G. arboreum* and perennial of *G. barbadense* were

evaluated (Table 3.1.2).

Table 3.1.2: Fibre quality traits of collected cotton accessions from Assam and Nagaland

Name of the Species	2.5 % Span Length (mm)	Fineness Micronaire 10^{-6} g/in	Bundle Strength Tenacity (g/tex)
<i>G. arboreum</i>	20.7-25.3	3.5->7	23.7-28.5
<i>G. barbadense</i>	30.8-32.5	4.0-5.5	25.5-32.2

Characterization of perennials and land races

Morphological including DUS characterization was completed for the collected 235 landraces of *desi* cotton and perennials.

Enrichment of cotton Gene Bank

Five hundred seventy five accessions were added to cotton gene bank consisting 340 of *G. hirsutum* - (high boll weight and high ginning outturn), 26 restorer lines, 84 CMS lines, 72 maintainer B lines, 8 GMS lines, 37 elite lines of heterotic pool, and 8 *G. arboreum* accessions with high boll weight and high GOT.

Evaluation of germplasm

A set of 36 exotic accessions including 34 Coker variants and 2 accessions of CLCuD resistant were grown in pots, characterized and evaluated for economic and fibre quality traits. The superior accessions were identified for ginning outturn (%), staple length and fibre bundle strength. The



promising accessions are listed trait wise as under-

Ginning outturn : EC 882401 (34.0), EC 882398 (33.4), EC 882429 (33.4), EC 882418 (33.2), EC 881780 (33.1), EC 882406 (33.1), EC 882411 (33.1), EC 882415 (33.1), EC 882420 (32.9), EC 882399 (32.8), EC 882428 (32.8), EC 882409 (32.4).

Fibre length (>30 mm UHML) : EC 882398 (36.7), EC 882424 (33.1), EC 882408 (32.9), EC 882425 (32.9), EC 807817 (32.8), EC 882420 (31.9), EC 882422 (31.6), EC 882429 (31.5), EC 796545 (31.3), EC 882405 (31.3), EC 882417 (31.1), EC 882415 (30.9), EC 882418 (30.9), EC 882423 (30.9), EC 882431 (30.9), EC 882403 (30.6), EC 882413 (30.6), EC 882426 (30.3).

Fibre strength (>28 g/tex) : EC 882398 (32.8), EC 882424 (31.5), EC 882425 (31.3), EC 807817 (30.4), EC 882408 (30.2), EC 882423 (29.8), EC 796545 (29.7), EC 882428 (29.6), EC 882430 (29.3), EC 882431 (29.2), EC 881781 (29.1), EC 882421 (29.1), EC 882419 (29.1), EC 882406 (28.7), EC 882416 (28.5), EC 882400 (28.3), EC 882420 (28.2), EC 882399 (28.0).



Characterization & Evaluation of Exotic accessions of *G. hirsutum*

Colour linted *G. arboreum*

Full spinning test of three brown coloured linted *desi* cotton genotypes was conducted and CSPs were recorded for CNA - 405 (1987), CNA - 407 (1750) and CNA - 407 SPL (1691) while strength (lb) recorded was 141.9, 125.0 and 119.1 respectively.

G. herbaceum

A set of 582 germplasm of *G. herbaceum* were evaluated for various morpho-economic traits. Six genotypes *viz.*, IC 371582, IC 371575, IC 371587, IC

371560, IC 371602 and IC 371437 had yield level from 160 to 190 g / plant. Grouping of germplasm in open, semi-open and closed boll types, boll shape, fibre length helped to distinguish several genotypes in higher order variation than other traits. Accessions with unique traits like erect type (IC 371260), absence of extra floral nectaries on leaves (IC 371582), dwarf type (IC 371254, IC 371150, IC 371490), high boll weight (IC 371413) and more bolls (IC 371156) were identified.

Distribution of germplasm

Eight thousand twenty germplasm lines of *G. hirsutum* (7113), *G. arboreum* (330), *G. herbaceum* (565) and wild species seeds and cuttings (12) were distributed to Breeders/Scientists of ICAR-Central Institute for Cotton research and State Agricultural Universities for Cotton Improvement programme.

Germplasm Field Day

Two germplasm field days on 06 & 27 December, 2016 were organized at Main Cotton Research Farm of ICAR - Central Institute for Cotton Research, Nagpur. Breeders/Scientists of State Agricultural Universities of North Zone, Central Zone and South Zone participated in the event and identified / selected germplasm accessions in the field for their breeding programme. Nine hundred forty three elite germplasm lines of *G. hirsutum* including exotic accessions were selected by the Breeders/Scientist of ICAR and SAUs from the field and the same were later supplied to them.

Rejuvenation and seed multiplication

A set of one thousand nine hundred accessions of *G. hirsutum* were grown for rejuvenation and seed multiplication.

Coimbatore

Maintenance and evaluation of *G. barbadense* germplasm

Three hundred and ten *G. barbadense* germplasm lines were being maintained at CICR, Regional Station, Coimbatore during 2016-17 crop seasons. Accessions with superior plant types in terms of yield, quality,

earliness, hairiness and short branching were identified. Hairy germplasm accessions (11 Nos.) were evaluated for resistance to sucking pests.

Evaluation of 11 hairy germplasm accessions

Eleven hairy germplasm lines were identified as sucking pests tolerant lines. In order to understand the nature and the density of hairs present in the identified lines, pubescence studies was carried out using Scanning Electron Microscope (SEM). The density of hair was more in HAG-02 and falls under the type pilose. Among the hairy lines, CCB-85, CCB-124, CCB-264 has exhibited dense hairs but when it was subjected to SEM, it was observed that they were moderately hairy and designated as hirsute. Hairy lines were compared with the non hairy type Suvin. Yield performance trial was conducted with the 11 genotypes. However, yield was very low during 2016-17. The pooled yield data of the last 2 years indicated that CCB-124 was superior than the control Suvin.

The ginning outturn of ICB-264 and EC-13 was 35% while the check variety Suvin recorded 29%. With regards to fibre quality parameters, the span length ranged from 33-36 mm. The highest span length was observed in ICB-105 (36.1 mm) followed by HAG-02 (35.4 mm) and ICB-124 (35.1 mm).

Sirsa

G. hirsutum (730) and *G. arboreum* (760) accessions were evaluated for yield traits at ICAR-CICR, Regional Station, Sirsa. Range for trait values and promising entries for each trait were evaluated and given in Table 3.1.3.

Table 3.1.3: Trait wise promising lines

Yield traits	<i>G. hirsutum</i>		<i>G. arboreum</i>	
	Range	Promising lines	Range	Promising lines
Days to flowering	62 - 97	G4-B5 (62), Million Doller (62)	-	-
Plant height (cm)	84-130	355-E6 (84), 78/1A(84), EC 794232 (130), EC 144055 (130)	-	-
Number of monopodia	0 -11	EC 700415 (11), EC 155382 (8)	0 -11	688 (11), 89 (7)
Number of sympodia	1-17	EC 700075 (17) , EC 700073 (17)	2-13	3 (13), 562 (12)
Boll number per plant	3-50	EC692158 (50), EC 700025 (50)	3-44	253 (44),657(41)
Boll weight (g)	1-3.3	EC700472 (3.3), EC700507(3.3)	0.8- 2.95	107 (2.95), 20 (2.95)
Seed cotton yield/plant (g)	10-160	EC137595 (160), EC700247(160)	5-105	74 (105), 41 (105)

3.2: Hybrid Cotton

Sirsa

Evaluation of GMS based *G. arboreum* hybrids

Eight GMS based *G. arboreum* hybrids were evaluated for seed cotton yield with two check hybrids AAH 1 and CICR 2. GMS based hybrids CISAA 16-42 (2815 kg/ha) recorded significantly higher seed cotton yield than the highest yielder check hybrid CICR 2 (2413 kg/ha). Two hybrids CISAA 16-40 (2640 kg/ha) and CISAA 16-42 (2815 kg/ha) recorded significantly higher seed cotton yield than check hybrid AAH1 (2361 kg/ha).

Maintenance of GMS lines: Twenty-one GMS lines namely DS5, CISA 2, GAK 413A, CISG-1, CISG-2, CISG-4, CISG-8, CISG-9, CISG-10, CISG-11, CISG-13, CISG-14, CISG-15, CISG-16, CISG-17, CISG-18 (narrow leaf), CISG (broad leaf), CISG-19, CISG-21, CISG-22 (narrow leaf) and CISG-22 (broad leaf) were maintained through sibmating. Pigmented GMS line CISG 20 possess red flower colour with petal spot, robust plant type, thermo-insensitive and no pollen shedders. CISG-20 is proposed for registration as genetic stock at NBPGR, New Delhi.

Fresh crosses: Six new crosses were attempted for evaluation of performance for seed cotton yield while crossed seed of 2 hybrids CISAA 16-1 and CISAA 16-2 were produced in bulk (2 kg each) to sponsor in AICCIP trial Br 25a/b.

3.3: Genetic Improvement

G. arboreum

Nagpur

CNA-2030 has been promoted to Br 4 a/b advanced trial with an yield of >1500 kg/ha and fibre length of 28.0 mm in Central Zone. CNA-2031 is being sponsored for IET Br 22 a/b for the year 2017-18. It ranked third in Institute trial recording >3000 kg/ha. Fibre quality parameters ranged from (fibre length 22.7 mm, fibre strength-28.1 g/tex, mic value 4.6) to (fibre length 28.9 mm, fibre strength-27.6 g/tex, mic value - 4.4). A maximum of 33.3 g/tex was recorded for one culture. Quite a few lines recorded fibre strength > 30 g/tex indicating the potential for improving fibre quality traits in *G. arboreum*. Five long staple cultures upto

28 mm were multiplied. CNA-2010 recorded yield of 3259 kg/ha, with boll no. of 102 and boll wt. 2.7 g.

Coimbatore

G. arboreum accessions (1059) were evaluated in augmented block design (ABD 1) for lint yield, boll weight, seed index, ginning percentage, days to flowering, and days to boll opening. A set of 14 accessions out yielded the check varieties while 95 accessions had higher boll weight (3.5 g/boll), 41 genotypes recorded higher seed index (>7.1) and 5 genotypes had higher ginning out turn (>37%). Fourteen genotypes namely AC 3265, AKH 496, PBS 1127 - SP1, AC 3522 B, AC 3216, H 503, H 509, AC 3097, AKA 13 - SP1, N 11-54-31-32, H 173, PBN 565, 3930 A and AC 3244 were identified with single plant yield more than 37 g/pl. Five genotypes viz., AC 727, AC 515, H 502 - SP3, *arboreum* (Surat) - SP1 and O-S-217 - SP1 recorded more than 37 % ginning outturn. Six accessions namely AC 3265, AKH 496, AC 3216, AC 3097, N 11-54-31-32 and AC 3244 were identified with high seed cotton yield (>37g/pl) and early maturity (< 104 days).

Sirsa

Evaluation of Spinnable *G. arboreum* cultures

Fourteen cultures were tested in RBD along with two checks CISA 310 and CISA 614. None of the genotypes gave higher yield than the checks (Table 3.3.1). However, six genotypes CISA-6-295, CISA 33-8, CISA 33-9, CISA 64, CISA 33-2 and CISA 33-2 possess better fibre properties and yielded more than 22 q/ha. Four cultures (CISA 6-350, CISA 6-295, CISA 33-6 and CISA 33-8) recorded UHML~25 mm or more and fibre strength >24 g/tex.

Evaluation of high yielding *G. arboreum* genotypes

Sixteen genotypes were evaluated in RBD with two checks CISA 310 and CISA 614. Two genotypes CISA-6-165 (3026 kg/ha) and CISA-8 (3193 kg/ha) recorded significantly higher seed cotton yield than local check CISA 614 (2664 kg/ha). Two more genotypes namely CISA 6-2 (2963 kg/ha), and CISA 6-187 (2895 kg/ha) gave significantly higher seed cotton yield than local check CISA 310 (2535 kg/ha).

Table 3.3.1: Performance of spinnable *G. arboreum* genotypes in replicated trial

S. No.	Genotype	Seed cotton yield (kg/ha)	GOT (%)	Boll wt (g)	UHML (mm)	UI	Strength	Mic
1	CISA 6-350	2037	39.0	1.9	23.40	80	23.3	6.8
2	CISA 6-295	2320	38.2	2.0	25.2	81	23.8	6.6
3	CISA 33-6	1571	36.3	1.8	24.7	81	24.0	5.7
4	CISA 33-7	1816	39.1	1.8	23.1	80	23.3	6.6
5	CISA 33-8	2264	39.1	1.8	24.2	80	23.7	6.0
6	CISA 54-1	1482	39.7	1.9	23.2	80	23.7	6.3
7	CISA 41-1	1904	38.3	1.7	23.5	80	23.3	6.9
8	CISA 33-9	2677	40.9	1.9	20.3	77	22.2	7.3
9	CISA 6-256	1535	39.2	1.8	24.5	81	23.9	6.5
10	CISA 6-209	1915	38.2	1.8	23.8	80	23.7	6.7
11	CISA 64	2243	36.0	1.5	22.1	79	22.7	6.6
12	CISA 33-1	1952	38.0	1.8	24.6	81	24.4	6.2
13	CISA 33-2	2282	38.6	1.8	24.3	80	24.3	6.7
14	CISA 33-3	2671	38.1	1.9	24.0	80	24.3	6.7
15	CISA 614	2886	39.3	1.8	21.2	78	22.4	7.1
16	CISA 310	3609	40.2	2.0	19.7	77	22.0	7.2
	CD	325						
	CV	8.8						

Evaluation of high strength lines

Twelve cultures from ICAR-CICR, Nagpur were evaluated in replicated trial at Sirsa (Table 3.3.2). Only two cultures gave seed cotton yield >18 q/ha. Four cultures CNA-1054 (27.3 mm, 28.0 g/tex), CNA-1056 (28.1 mm, 28.6 g/tex), CNA-1057 (27.0 mm, 26.8 g/tex) and CNA-1063 (27.2 mm, 27.1 g/tex) recorded UHML >27.0 mm and better fibre strength.

Evaluation of long linted cultures

Four long linted cultures were evaluated along with quality check PA 255. All the cultures recorded higher seed cotton yield and UHML than quality check; however the yield levels were comparatively very low (577 to 1006 kg/ha).

Station Variety Trial

Under station trial, eight cultures along with two checks CISA 310 and CISA 614 were evaluated for

their yield performance (Table 3.3.3). Cultures CISA 33-5, CISA 7, CISA 6-165 and CISA 8 gave higher seed cotton yield than both the checks, CISA 310 and CISA 614. The cultures CISA 33-5 and CISA 7 recommended to be sponsored for evaluation in AICRP Br 22a/b National Trial during 2017-18.

American cotton *G. hirsutum*

Nagpur

Improvement for earliness and fibre quality

Twenty-five entries were evaluated in replicated trial for seed cotton yield and fibre properties. CNH 09-73 recorded highest seed cotton yield of 3074 kg/ha followed by CNH 09-79 (2608 kg/ha) and CNH 09-70 (2508 kg/ha). Entry CNH 09-45 recorded highest bundle strength of 35.8 g/tex followed by CNH 09-77 (34.7 g/tex) and CNH 09-72 (34.6 g/tex) with long staple of 30.4 mm, 30.0

Table 3.3.2: Evaluation of high strength lines

S.No.	Entry Name	Seed Cotton Yield (kg/ha)	GOT %	Boll Wt (g)	UHML (mm)	UI	Strength (g/tex)	Mic
1	CNA-1052	447.74	38.67	1.23	25.6	81	25.6	4.9
2	CNA -1053	1661.59	39.30	1.33	26.4	82	27.2	5.4
3	CNA -1054	1910.35	30.47	1.57	27.3	82	28.0	5.7
4	CNA -1055	1266.53	29.13	1.43	26.8	82	27.6	5.3
5	CNA -1056	1350.75	43.47	1.37	28.1	83	28.6	5.4
6	CNA -1057	1024.90	33.20	1.57	27.0	82	26.8	5.7
7	CNA -1058	1129.56	36.63	1.55	26.6	82	27.3	5.7
8	CNA -1059	1601.03	40.63	1.47	26.7	82	26.6	5.7
9	CNA -1060	1822.91	35.63	1.54	26.3	82	26.6	5.7
10	CNA -1061	1505.42	38.57	1.50	26.4	82	26.4	5.5
11	CNA -1062	1426.75	36.77	1.41	26.2	82	26.3	5.8
12	CNA -1063	1103.70	37.83	1.76	27.2	82	27.1	5.7
	CD	216.09						
	CV	7.16						

Table 3.3.3: Variety Station Trial

S.No.	Entry Name	Seed Cotton Yield (kg/ha)	GOT %	Boll wt (g)	UHML (mm)	UI	Strength (g/tex)	Mic
1	CISA 6-165	2401	41	2.0	21.6	78	22.5	6.8
2	CISA 33-6	1530	38	1.9	24.5	81	24.0	5.3
3	CISA 41-1	1956	38	1.8	24.6	81	25.0	6.2
4	CISA 33-5	2512	45	2.0	21.4	78	22.3	6.4
5	CISA 33-2	1924	40	1.7	23.7	80	23.6	6.4
6	CISA 7	2463	45	2.0	21.5	78	23.0	6.5
7	CISA 8	2362	45	1.9	22.3	79	22.8	6.6
8	CISA 405	1993	46	2.0	20.9	78	22.0	6.3
9	CISA 310	2058	45	1.9	20.9	78	22.5	6.7
10	CISA 614	2318	44	2.2	21.7	79	22.4	6.5
	CD	245						
	CV	6.60						

mm and 29.3 mm, respectively.

In another trial, CNH 09-11 recorded highest seed cotton yield of 3085 kg/ha followed by CNHIS 5 (2997 kg/ha) and CNH 8 (2746 kg/ha). Entry CNH

8 had boll weight of 5.8 g with seed cotton yield of 2746 kg/ha and fibre bundle strength of 30.2 g/tex. Entries CNH 09-11, CNH 09-32 and CNHIS-3 had recorded fibre bundle strength 31.3 g/tex, 30.9

g.tex and 30.3 g/tex, respectively. CNH 09-4, CNH 09-5 and CNH 09-62 were sponsored in Br 06 (b) -Initial Evaluation of Compact genotypes under rained condition for the year 2017-18.

Three-way and multiple crosses were attempted in order to increase genetic variability in the populations. In segregating populations of these crosses, single plant selections were made. Around 3200 single plants were selected from populations of three-way and multiple crosses for better quality, tolerance to sucking pests and early maturity of 145-165 days.

In three-way crosses, cross (NH615 × Suvin) × IC 356751 had staple length of 33.0 mm with fibre strength of 31.0 g/tex. Cross (Suraj × G-21-19-619) × NH 615 had staple length of 30.2 mm and fibre strength of 31.3 g/tex. Amongst complex crosses, cross (Suraj × G-21-19-615) × (NH615 × CCH 4474) had staple length of 32.8 mm and fibre strength of 30.7 g/tex followed by cross (NH615 × CCH 4474) × (Suraj × CCH 4474) with staple of 29.1 mm and fibre strength of 29.8 g/tex in comparison to parents NH 615 (27.5 mm, 25.2 g/tex) and Suraj (29.7 mm, 30.4).

Single plant selections (1400) were made for recombinants and transgressive segregants in F₂ population of *G. hirsutum* × *G. barbadense* crosses. Single plant selections of segregating F₂ generation of three-way and multiple crosses were affected with Suraj, NH 615 and CCH 18-5.

Entries CNH 7012-13 and CNH 09-4, CNH 09-62 sponsored in AICCIP trials Br 02 (b) and Br 06 (b), respectively during 2016-17. CNH 09-4 recorded fibre bundle strength of 29.0 g/tex and ranked first

in Central zone. Entry CNH 09-62 recorded upper half mean length of 30.1 mm (rank 4 - Central zone) and fibre bundle strength of 33.0 g/tex (rank 5 - South zone).

Seven promising advanced breeding lines CNH 12-4-2, CNH 2-2, CNH 09-7, CNH 10-6-1, CNH 09-77, CNH 18-8-3 and CNH 12-12-4 were entered in Institute Common Trial 2016-17. Of the seven, two entries CNH 12-4-2 and CNH 09-77 were promoted to multilocation Initial evaluation trial Br 02 (b) under AICRP for 2017-18.

Compact type and jassid tolerance

A total of 91 F₁ populations were evaluated for different traits including earliness, jassid tolerance and compact plant architecture. The promising F₁ populations having higher seed cotton yield and boll weight were selected for generation advancement. Six F₂ populations from these crosses developed in 2014-15, were evaluated and promising plants were selected based on earliness, jassid tolerance, compact plant architecture, boll weight and seed cotton yield. Twenty-six non-Bt and 66 Bt (*cry1Ac* gene; Mon 531 event) F₁ plants to progeny rows and individual plant selections were evaluated (Photo a & b) and most promising progeny selections were selected for further advancement. These selected progenies (Photo c) possess earliness (120 days), jassid tolerance (grade I- II), compact plant architecture (height 100 cm and horizontal width 40 cm with 0-1 monopodia), boll weight (3.5-5 gm), fibre length (23-27 mm) and fibre strength (24-27 g/tex). These promising progenies have the potential to provide higher cotton yields under HDPS.





Promising early maturing selections [a: Field View; b. progeny view, c: Individual plant selections]

Coimbatore

Long staple *G. hirsutum* with improved fibre strength

Thirteen long staple cultures were evaluated in the station trial along with long staple check varieties viz., Surabhi and Suraj. Yield data analysis indicated significant differences among the entries and six test cultures recorded significantly higher seed cotton yield over the best check variety. The highest seed cotton yield of 1566 kg/ha was recorded by the test culture YLS 21-4. The test culture YLS 19-2 combined superior yield (1315

kg/ha), upper half mean length (34.5 mm) and tenacity (33.3 g/tex).

From the segregating population, 45 single plants with big boll were identified. Thirty single plants were selected with the mean ginning outturn of 45.1%. The maximum ginning outturn recorded was 48.5%. In addition, 89 single plants with brown lint were selected for further screening.

Two big boll progenies viz., Surabhi x MM02 19-1-10-3-3-3 and CCH 526612 X VN WH-1-26-1-3-2 showed promise in yield and fibre quality parameters.



Surabhi x MM02 19-1-10-3-3-3



CCH 526612 X VN WH-1-26-1-3-2

Sirsa

Breeding for high strength in *G. hirsutum*

Thirteen crosses were attempted between 5 long linted Coimbatore types with 3 high fibre strength Sirsa cultures. F₈ progenies of the two crosses viz; CSH-3119-10-30-60 (1842.6 kg/ha and MMO.3 (39-2-5)-3114-10-64 (1831.26kg/ha) were early in maturity and higher yielding than the Check H-1226 (1770.9 kg/ha). These progenies performed

better for yield and fibre quality for last three years.

Breeding for high GOT and seed cotton yield

Evaluation of 13 F₇ recombinant inbred progenies of the cross SA-977 (HG) x SA-112 (LG) in an un-replicated trial revealed that the progeny P-69 (2414 kg/ha) and P-164 (2220 kg/ha) had significantly higher seed cotton yield than Check H-1226 (1718 kg/ha). As many as seven recombinant inbred line progenies viz; P-68, P- 69,

P-70, P-84, P-139, P-164 and P-184 possessed GOT equal to or more than 40%.

F₅ individual plant progenies of three selected crosses were evaluated in a replicated trial. Progenies P-17 (2304 kg/ha), P-4 (2198 kg/ha) of the cross RS-875 x SA524 and F-1861 x SA668; P-15 (2202 kg/ha), P57 (1931 kg/ha) and P6 (1849 kg/ha) of the cross F-1861 x SA-668 recorded more than 40% GOT in comparison to check F-1861(1951 kg/ha) with GOT of 34%.

Breeding for CLCuV tolerance

Evaluation of *G. hirsutum* cultures : Twenty-three *G. hirsutum* cultures were evaluated against the check varieties RS 2013, LH 2076, F 1861 and susceptible check HS-6 in RBD with three replications. The highest seed cotton yield was recorded in the advance culture CSH 1602 (3111 kg/ha) followed by CSH 2916 (2675 kg/ha) as against the check variety LH 2076 (2505 kg/ha). Maximum ginning out turn of 40.3 per cent was recorded in the culture CSH 2931. The culture CSH 1602 also recorded the highest upper half mean length of 28.2 mm and CSH 2836 recorded the bundle strength of 26.1 g/tex.

Selection of single plants progenies : To develop the segregating populations of *G. hirsutum* cotton, 16 crosses were attempted among CLCuV tolerant germplasm lines in Line x Tester fashion. Out of 91 single plants progenies six progenies with high yield potential and tolerance to CLCuV were selected in F₅ generation. The culture CSH 1705 recorded the highest yield of 2140 kg/ha followed by CSH 1702 (1783 kg/ha) as compared to check variety LH 2076 (1708 kg/ha). The culture 1701 recorded the highest ginning out turn of 40.0 % followed by CSH 1707 (39.7%).

Screening of exotic germplasm against CLCuV: Two germplasm lines GVS 8 and GVS 9 were screened against CLCuV in poly house and screening nursery and were found to be free from cotton leaf curl virus disease.

G. barbadense

Coimbatore

Identification of extra long staple (ELS) genotypes

In all, 21 high yielding early maturing ELS

genotypes were identified. Among them, CCB-29 exhibited highest seed cotton yield of 16 q/ha with 38.4 mm staple length, 32 g/tex bundle strength and micronaire value of 3.4 μ /inch. The culture CCB-29 was sponsored in AICRP trial-2015-16 and subsequently promoted to zonal trial and ranked third in yield and second in fibre length and bundle strength. Six high yielding early maturing, ELS genotypes *viz.*, CCB-51, CCB-64, CCB-129, CCB-143, CCB-143B and CCB-93 were identified during 2016-17 crop season. The promising genotypes *viz.*, CCB-51 and CCB-11 were promoted from IET to PVT in 2017-18. Four promising advanced genotypes were entered in IET National Trial during 2017-18. Two promising ELS genotypes (CCB-143 and CCB-129) and one inter-specific hybrid CCHB-32 was entered in an initial evaluation trial during 2017-18. A stable complete cleistogamous plant progeny was identified in the segregating populations of *intra-barbadense* cross (Suvin x Giza-45).

G. herbaceum

Nagpur

Thirty one genotypes identified for early maturity in the last year and it was confirmed further during 2016-17 crop seasons in replicated trial. Early maturity traits *viz.*, days to germination, days to first squaring, days to first flowering, days to first boll opening, percentage of yield at first picking and days to harvest were recorded. Seasonal effects were highly significant with respect to seed cotton yield. IC - 371437 recorded highest seed cotton yield (3078 kg/ha) followed by G. Cot - 25 (3049 kg/ha). Out of 32 genotypes, 12 recorded seed cotton yield ranging from 20 to 30 q/ha. In the accessions Baluchistan-1, IC 371100, IC 371112, IC 371118, IC 371130, IC 371148, IC 371158, IC 371166, IC 371437, IC 371561, G. Cot - 25 and Jayadhar, 60 to 70% seed cotton was harvested in the first picking at 180 days. Significant negative association was found between percent first picking and days to germination (- 0.758), plant height (-0.579), days to first squaring (-0.472), days to first flowering (- 0.496) and days to first boll opening (-0.391).

Genetic enhancement

Nagpur

Eleven *G. hirsutum* cultures were evaluated with two checks *viz.*, Suraj and NH-615 in a multi-location trial at Sirsa, Nagpur and Coimbatore. It revealed superior performance of CNH-2046 with regard to seed cotton yield (3148 kg/ha), lint yield (1023 kg lint/ha) and GOT (39.3%) over check varieties Suraj (2963 kg/ha) and NH-615 (2861 kg/ha) at Nagpur Centre. CNH-2049 recorded better fibre quality (fibre length 30.3 mm, fibre strength of 23.3 g/tex) and CNH-2039 showed a synchronous flowering and high GOT (39.6%) at Coimbatore. CNH-2048 (lint yield 795 kg/ha) was superior to check Suraj (706 kg lint/ha) and NH-615 (477 kg lint/ha) at Sirsa. Nineteen jassid tolerant lines tested revealed superiority of CNH-2053 (3148 kg seed cotton /ha) and CNH-2067 (3056 kg/ha) over checks Suraj (2222 kg/ha), NH-615 (2222 kg/ha), and LRA-5166 (2500 kg/ha). CNH-2052 recorded fibre length 32.1 mm, fibre strength 25.4g/tex; CNH-2064 recorded fibre length 32.8 mm and fibre strength 24.6 g/tex. Of the 17 high fibre strength lines tested, CNH-2068 recorded fibre length (31.3 mm) and fibre strength of 33.5 g/tex (HVI mode). In two backcross populations *viz.*, LRK-516 x (LRK-516 x Deltapine-66) and PKV-081 x (PKV-081 x PIL-8), there was a visible genetic gain with GOT 40.0% and boll weight 5.3 g in the respective backcrosses from a base value of 36% in case of LRK-516 and 3.0 g in case of PKV-081. In the entire spectra of fibre quality, fibre length upto 33.5 mm and fibre strength of 33 g/tex were identified. CNH-2050 ranked fourth in Institute trial and was sponsored for IET AICRP trial for 2017-18.

Sirsa

GMS based random mating population

At flowering, the individual plant in the population was monitored for sterility/fertility at anthesis repeatedly at an interval of a week and tagged all the 440 sterile plants. All the out-crossed bolls from the sterile plants in the population were bulk harvested and ginned to constitute the next cycle of GMS based random mating population. After the fifth cycle of random mating 105 fertile plants having high yield potential and tolerance against CLCuV were selected for evaluation in progeny to row trial.

Interspecific hybridization

Nagpur

In order to develop synthetic polyploids which can help in introgression of genes from diploid *Gossypium* species for Upland cotton improvement with specific reference to CLCuV and whitefly resistance, pollen from *G. raimondii* ($D_5 D_5$ genome) plants were used for crossing with *G. herbaceum* ($A_2 A_2$ genome) cv. Jayadhar, G.cot. 25 and DDhC11 and F_1 seeds were harvested. *G. hirsutum* (AADD genome) cv. CNH 409-9, Arogya, CNH 1102, CCH 15-1, Ganganagar Ageti, Sahana and CCH 2623 were crossed with *G. arboreum* ($A_1 A_1$ genome) cv. Roja and PA 255. Very limited seeds were harvested. Colchiploidy was attempted on F_1 seeds of *G. arboreum* x *G. raimondii* developed in 2015-16 to obtain *G. arboreum* based synthetic polyploids. Plants treated with colchicine exhibited some strange phenotypes like Y forking of stem, smaller leaf size, thicker leaves, shorter internode, delayed growth and flowering (upto 1 month), etc. Very few bolls were set on the treated plants and very few seeds were harvested. Plants were pruned for regrowth and for confirmation of results including ploidy status through cytology.



Colchicine treatment of F_1 seeds of *G. arboreum* x *G. raimondii*

Breeding for earliness

Fifty-five F_1 s and 12 parents were evaluated in RBD for earliness and better fibre properties. Crosses IC 356847 × Suraj, Peedee-4548 A × IC 358438, Pee dee 4548 A × IC 358149, FTA 266 × IC 358438, Pee dee 875B × IC 358149, Sengul-2 × IC 358438, C1412 × IC 358438, C1412 × IC 358149, IC 358149 × Suraj and IC 358438 × Suraj were identified for better fibre properties and earliness. Cross Pee dee 4548 A × FTA 266 had recorded fibre strength of 32.6 g/tex, followed by IC 358149 × Suraj (32.1 g/tex) and FTA 266 × IC 358438 (31.5 g/tex). For earliness crosses Pee dee - 4548 A × IC 358438, FTA 266 × IC 358438 and FTA 266 × C 1412 recorded earliness index of 0.9 indicating early maturity. Parental lines *viz.* C 1412, PRS 72 and Pee dee 4548, Pee dee 875 B also recorded early maturity index of 0.9 and 0.8, respectively. Parents IC 358438 and C 1412 were good general combiners for earliness index.

Big boll character

Twenty-three advance progenies (F_8 generation) of a cross Ganganagar Ageti × Acala 44 B_2 which was reported to possess boll weight of 7.89g were evaluated for boll weight for the fourth consecutive year. The progenies are showing stability for boll weight (3.49 to 5.32 g). Some lines *viz.* 137/1, 137/2, 138/2, 140/1, 140/2, 148, 149 recorded high yield, boll weight upto 5 g and good fibre quality.

Drought tolerance

Nagpur

Three experiments were conducted under rainfed and irrigated condition to evaluate breeding materials for drought tolerance. During the crop season, intermittent to heavy rain was received until the month of October, hence, no moisture stress was observed obviating requirement of irrigation for the crop. Hence, all the experiments were treated as rainfed. Twelve crosses in F_4 generation were evaluated alongwith their parents and two checks *viz.* LRA 5166 and Rajat. Seed cotton yield (SCY) ranged from 1404 to 2877 kg/ha. Highly significant differences for SCY were observed. Six genotypes were at par to the check

LRA 5166 (2648 kg/ha SCY) and seven to Rajat (2386 kg/ha SCY). PKV 081 × CCH 510-4 recorded highest seed cotton yield of 2877 kg/ha with 7% increase over the check LRA 5166, boll weight of 4.1 g, GOT 35%, UHML 40 mm, fibre strength 29.9 g/tex, micronaire 3.9 ug/in, uniformity ratio of 83% and elongation 5.1%. This cross was followed by NH 615 × Rex, PKV 081 × P3 and PH 93 × Rajat.

Eight identified drought tolerant lines were evaluated alongwith five good performing genotypes and check LRA 5166. The treatments showed significant differences for seed cotton yield which ranged from 2378 to 3326 kg/ha. All the genotypes exhibited of 15% more SCY than the check LRA 5166 (2378 kg/ha). DTS 104 was the highest yielder recording 3326 kg/ha seed cotton yield, boll weight of 4.8 g, GOT 37.6%, fibre length 28.3 mm, fibre strength 25.6 g/tex and micronaire 3.5 ug/in.

Another experiment comprised of testing of 31 F_2 generation crosses of single, double, six, eight parental and three-way cross. The crosses showed significant differences for seed cotton yield and ranged from 1733 to 3395 kg/ha. Multi-parental crosses were attempted to obtain good combination of desirable characters which is otherwise very difficult to obtain in single cross. Boll weight in this material ranged from 3.1 to 5.2 g and GOT from 33 to 38%. Some of these crosses *viz.* PH 93 × Suraj, (CCH 510-4 × MOCO) × (NH 615 × Rex) × (PH 93 × Rajat), (28I × HSD) × (NH 615 × Rex) recorded very good fibre properties indicating scope to get good lines from these crosses.

Fifteen new crosses (single, eight and ten parental crosses) were evaluated alongwith parents. Single crosses involved parents with cluster boll bearing habit and good fibre quality to develop drought tolerant genotypes for high density planting system. All F_1 s showed cluster bearing indicating it to be a dominant trait. The seed cotton yield ranged from 1712 to 4373 kg/ha. Cross CB 228 × G 21-19-615 recorded boll weight of 6.76 g with GOT upto 37% and SCY of 3104 kg/ha.

To improve the fibre quality of identified drought tolerant culture, 28I, backcross progenies (5 nos.) were raised alongwith parents. Seed cotton yield

ranged from 1699 to 3191 kg/ha, lowest being for the cross where Suvin as donor parents was involved. The crosses showing good yield during this crop season had also recorded good yield in the previous year and recorded 50% increase in yield over the drought tolerant culture 28I (1981 kg/ha SCY).

Nineteen advance cultures were tested along with check at Regional Station, Coimbatore for the effect of stress on plant growth, changes in the biochemical and photosynthetic activities besides seed cotton yield. Based on the effect of stress on these parameters, DTS 402, DTS 404, DTS 406, DTS 407, DTS 408, DTS 419 and LRA 5166 were identified as drought tolerant and DTS 410 and DTS 413 as moderately tolerant genotypes.

Water logging tolerance

Ten tolerant (4314, 4409, 4393, 4458, 4460, 3694, 3844, 4282, 2283, 2289) and 4 susceptible lines (3742, 2085, 3207, 4231) were shortlisted for Marker Assisted Breeding (MAB).

Crosses between waterlogging tolerant and susceptible accessions were attempted. Based on information about submergence gene tolerance in rice, three primer sets were designed targeting submergence gene and ethylene - responsive element binding gene respectively to identify the submergence tolerance in cotton. Both tolerant and

susceptible genotypes under study showed amplification for the designed primers and no polymorphism was detected.

Two hundred and ten germplasm accessions were screened at Coimbatore based on morphological characters/reflecting growth, soil plant analysis device (SPAD) values, time of lenticels and adventitious roots formation, iron deficiency, nitrate reductase activity and yield and yield components to confirm the identified tolerant and susceptible accessions (Table 3.3.4).

Table 3.3.4 : Range of different parameters observed in 210 germplasm lines

S. No.	Parameter	Range
1	Plant height (cm)	25.0 to 72.7
2	Number of sympodia per plant	7.0 to 27.0
3	Height to node ratio	0.1 to 2.3
4	Number of leaves	14.0 to 115
5	SPAD value	3.3 to 22.7
6	% reduction of SPAD value over control	26.7 to 89.2
7	Nitrate reductase activity (NO ₂ g/h)	11-170 ug



Iron deficiency symptoms started at 5 days after initiation of waterlogging. However few lines did not show Fe deficiency symptoms upto 10 to 15 days after initiation of waterlogging.



Lenticels and Adventitious roots formation, Lenticels formed as early as 5 Days after initiation of waterlogging.

Submergence study in cotton based on information available in rice (Fukao et al. 2009 Annals of Botany 103: 143-150)

Primers	Sequence	Amplicons
Primer Sub1 F& R	Sub1-forward (5' <u>GAVGAMTGGGAGGCCGCTTCCRS</u> GAGTTC-3') Sub1-reverse (5'-GTCGWAGSCGGCGAGGAGGCT <u>GTCCATC</u> -3'), Where M=A or C, R=A or G, S= C or G, V=A or C or G, and W=A or t.	
Primer 3 & 4	Forward <u>AGCCCTGTT</u> CAGCCAAAT Reverse <u>TTGACCGATGGCTTCTCTTC</u> (<i>Gossypium hirsutum</i> ethylene-responsive element binding protein ERF2)	104
Primer 5 & 6	Forward <u>CAA</u> ACTTGAGCAGGGCTACTA Reverse <u>ATTCTCAGGGTCAGCAA</u> AAGG (<i>Gossypium hirsutum</i> putative ethylene responsive element binding protein mRNA, complete cds)	133



T-Tolerant S-Susceptible Accessions

Population Improvement

Nagpur

Conventional random mating population : The random mating population developed through conventional crossing was maintained by bulk harvesting one open boll from each plant in both *G. arboreum* and *G. hirsutum*.

GMS based simple recurrent selection: From among 296 single plant progenies of *G. arboreum* and 504 of *G. hirsutum* evaluated, about 5-7% superior plant progenies were identified separately for boll weight, seed cotton yield, GOT,

fibre strength and fibre length. The selected plant progenies seed from the previous year was bulked to form trait specific groups. Trait based bulk seeds of selected progenies were grown on large plots comprising population of about 1000 plants, and the populations were allowed open cross pollination. At flowering, all sterile and fertile plants were tagged. For enhanced out crossing, flowers from fertile plants were randomly collected and used for crossing flowers of sterile plants in the same trait specific population during the entire flowering period. All sterile plants from each group harvested separately for plant progeny

evaluation for second cycle of recurrent selection. About 50-60 single superior fertile plants from each group were selected for evaluations as plant to row progeny.

Evaluation of single plant selection : Large number of single plant selections from random mating population and reselected plants from the segregating progenies, about 2634, were evaluated in plant to row progeny plots. Based on the performance and uniformity of plant progenies about 40 progenies (16 of *G. hirsutum* and 24 of *G. arboreum*) were identified for evaluation in replicated trial. Based on manual evaluation for fibre quality traits, about 1650 superior single plants were reselected from the segregating plant progenies.

Evaluation of advance cultures : One hundred and

forty five *G. arboreum* cultures and 150 cultures of *G. hirsutum* were evaluated in 12 different trials (4 rows plots in 2 replications) during the crop season 2016-17. In all, 7 trials of *G. arboreum* and 5 of *G. hirsutum* were conducted following spacing of 60 x 45 cm and 60 x 60 cm, respectively. Seed cotton yield among the *G. arboreum* cultures ranged from 1277 to 4996 kg/ha while in *G. hirsutum* it ranged from 1488 to 3081 kg/ha. Based on the seed cotton yield performance about 60 cultures of *G. arboreum* and 55 of *G. hirsutum* were retained for second year replicated trial. From the evaluated selections, four *G. hirsutum* and six *G. arboreum* cultures entered in AICRP National trial. The cultures entered in AICRP trials were grown on large plots for seed multiplication which included CNA 1028 of *G. arboreum*, CNH 11-11, CNH 1123, CNH 1125, and CNH 1126 of *G. hirsutum*.

Plants with high boll number, big boll size and compact plant type selected from random mating population



G. hirsutum



G. arboreum

3.4: Genetic diversity through introgression

Twenty four (24) wild species, 15 races of cultivated species and more than 45 synthetic polyploids were conserved in the wild species garden and green house. During 2016-17, fresh crosses were attempted using wild species *G. capitata virides*, *G. anomalum*, *G. stocksii* and *G. longicalyx* for diversification of genetic base. Single plant selections were made from F₄ population of

crosses namely *G. herbaceum* x *G. longicalyx*, *G. arboreum* x *G. thurberi*, *G. arboreum* race indicum x *G. davidsonii* and *G. arboreum* (var. AK 8401) x *G. davidsonii*. Four hundred and sixty one (461) introgressed derivatives were evaluated for fibre and economic traits and three high fibre strength lines were identified (Table 3.4.1) which will be re-evaluated during the next cropping season. Among the introgressed derivatives, three light brown linted lines were also identified for registration as unique germplasm (Table 3.4.2).

Table 3.4.1: High fibre strength introgressed lines identified during 2016-17

S.No.	Genotype	Fibre length (mm)	Fibre strength (g/tex)	Micronaire
1	CICR-16004	29.6	36.2	4.14
2	CICR-16022	30.9	37.3	2.75
3	CICR-16280	30.5	34.5	3.04

Table 3.4.2: Light brown linted lines identified for registration as genetic stocks

S.No.	Genotype	Fibre length (mm)	Fibre strength (g/tex) HVI	Micronaire
1	CNH LB-1	26.7	28.7	3.42
2	CNH LB-2	26.2	28.2	3.17
3	CNA LB-3	21.2	19.4	3.45



CNH LB 16-1
 FL: 26.73 mm
 FS: 28.73 g/tex
 Mic: 3.42

CNH LB 16-2
 FL: 26.20 mm
 FS: 28.26 g/tex
 Mic: 3.17

CNA LB 16-3
 FL: 21.20 mm
 FS: 19.46 g/tex
 Mic: 3.45

Cloth from coloured lint : Dark brown lint of Vaidehi-95 (MSH-53) was spun in thread, woven into cloth in Handlooms and stitched into jackets in collaboration with Gram Seva Mandal, Gopuri, Wardha.

G. herbaceum

Introgression breeding was initiated to improve the fibre length of *G. herbaceum*. Three crosses namely GVHV - 655 x PA - 740, GVHV - 655 x PA - 785 and GVHV - 655 x PA - 812 and their reciprocals were attempted. A total of 960 F₁ seeds and 1145 selfed parental seeds were obtained during the crop season.

Inter specific hybridization between *G. herbaceum* and *G. arboreum*



Jacket stitched from Dark Brown lint at Gram Seva Mandal, Gopuri, Wardha

The plants in F₄ generation from *G. herbaceum* and *G. anomalum* cross were advanced to F₅.

Intra - specific hybridization in *G. herbaceum*

In order to improve early maturity and genetical traits of *G. herbaceum*, fourteen intra - specific crosses and their reciprocals were attempted. The crosses including Baluchistan - 1 x IC-371437, Jayadhar x IC - 371437, Jayadhar x IC - 371336, IC-371336 x IC-371366, IC-371177 x IC-371366, IC-371177 x IC-371437, Jayadhar x IC-371177,

Baluchistan - 1 x Jayadhar, G. Cot - 25 x Jayadhar, G. Cot - 25 x Baluchistan - 1, IC - 371527 x ayadhar, IC-371362 x Jayadhar, IC - 371527 x IC-371437 and IC-371362 x IC-371 437. A total of 2415 F1 seeds were collected. Among seven intra-*herbaceum* crosses; IC - 371437 x Baluchistan-1 and IC-371437 x Jayadhar showed better yield performance, boll numbers and boll size over the mid parent.

3.5 : Development of variety and Multi-location testing

Sirsa

Notification of *G. hirsutum* variety CSH-3075 : Variety CSH-3075 developed at CICR RS Sirsa was evaluated in closer spacing of 67.5 x 10 cm (HDPS) in the North Zone locations for three year during 2012 to 2014. It ranked 1st, 3rd and 1st during these years recording seed cotton yield 3050, 2061 and 2291 kg/ha respectively against 2036 and 2033 kg/ha of the local checks planted at 67.5 x 10 and 67.5 x 30cm spacing respectively. Zonal average lint yield recorded over three years for this culture was 873 kg/ha as against the local check 720 kg/ha.



Notification of *G. hirsutum* variety CSH-3129

G. hirsutum culture CSH-3129 developed at the CICR, Regional Station, Sirsa was identified for irrigated north zone. It recorded mean seed cotton yield of 2293 kg/ha as against 1935 kg/ha and 2068 kg/ha of zonal and local checks, respectively; The increase in SCY was 18.5 and 10.9 percent over the Zonal and local check, respectively.. The culture has 29.5 mm span fibre length and fibre strength of 23 g/tex. Full spinning fibre quality parameters

indicated that CSH-3129 was spinnable at 40's count.



Field view of CSH-3129 (Single Plant as well as Field)

Coimbatore

G. hirsutum variety CCH 4474

Long staple (30.6 mm) and high strength (24.0 g/tex) culture Central Cotton CCH 4474 (Subiksha) has been recommended by Central Variety Identification Committee for release in South Zone States under irrigated conditions. The variety is capable of spinning upto 60s count yarn. It combines high yield potential under closer spacing (as high as 3325 kg/ha in Coimbatore and 4201 kg/ha in Guntur), better ginning outturn and tolerance to pests and diseases.



Central Cotton CCH 4474 (Subiksha)

Proposals of three varieties viz., Central Cotton CCH 12-2 (Central Zone - irrigated conditions), Central Cotton CCH 12-3 (Central Zone - rainfed conditions) and Central Cotton CCH 13-2 (South Zone - irrigated conditions) were submitted for identification by Central Variety Identification Committee during AICRP Workshop 2017 at TNAU, Coimbatore.

G. hirsutum variety CCH 12-2

Central Cotton CCH 12-2 recorded mean seed cotton yield of 1767 kg/ha as against 1644 kg/ha of the Zonal check in Central Zone under irrigated conditions. The variety recorded an Upper Half Mean length (UHML) of 28.0 mm, micronaire of 4.2 and tenacity of 29.0 g/tex matching the CIRCOT norm for 40s count yarn.

G. hirsutum variety CCH 12-3

Central Cotton CCH 12-3 recorded mean seed cotton yield of 1060 kg/ha as against 1053 kg/ha of the Zonal check variety under rainfed condition in Central Zone States. The variety recorded an UHML of 27.0 mm, micronaire of 4.3 and tenacity of 28.7 g/tex matching the CIRCOT norm for 30s count yarn.

G. hirsutum variety CCH 13-2

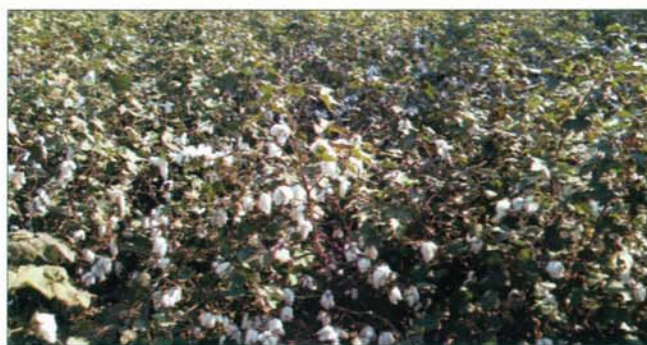
Central Cotton CCH 13-2 recorded mean seed cotton yield of 2178 kg/ha as against 2049 kg/ha of the Zonal check variety under irrigated condition in South Zone States. The variety recorded an UHML of 26.9 mm, micronaire of 4.2 and tenacity of 27.7 g/tex matching the CIRCOT norm for 30s count yarn.



Central Cotton CCH 12-2



Central Cotton CCH 12-3



Central Cotton CCH 13-2

Testing of cultures in AICRP on Cotton

In IET of *G. hirsutum*, entries CSH 3269, CCH 16-1, CCH 16-2, CNH 39 and CNH 108 were tested in Br 02 (a) trial. CNH 1125, CNH 09-77, CNH 7012, and CCH 16-3 were tested in Br 02 (b) trial. CSH 5640 and CSH 31292 tested in Br 06 (a) trial. In Br 06 (b) IET of compact genotypes, six entries CNH 15, CNH 75, CNH 09-4, CNH 09-62, CNH 1122, CNH 1123, CCH 16-7 and CCH 16-8 were tested. In IET of *G. arboreum*, four entries CNA 2030, CNA 1031, CNA 1032, CISA 333 and CISA 1793 were tested in Br 22 (a/b). *G. barbadense* genotypes CCB 51 and CCB 143 were tested IET Br 12a trial.

Besides, culture CSH 5640 promoted to HDPS Zonal trial and CSH 1613 sponsored in HDPS national trial of AICRP.

The culture Surabhi x M5Z2 18-5 (CCH 15-1) was tested in preliminary evaluation trial of *G. hirsutum* varieties under irrigated condition in both Central and South Zone locations. The culture recorded an upper half mean length of 31.6 mm in Central Zone and 32.7 mm in South Zone locations. Further, the culture also exhibited the highest bundle strength of 34.4 g/tex and 37.0 g/tex in HVI mode in Central and South Zone, respectively.

The long staple culture MM 03-39-4-2-3 (CCH 14-1) tested in coordinated varietal trial under irrigated conditions of both central and south zones also exhibited superior fibre quality combining good length and strength and has been recommended for Agronomic evaluation.

Entries promoted under AICRP trials:

G. arboreum entry, CSA 1028 promoted in Central Zone during 2016-17 that stood first in Br. 24b zonal trial in Central Zone and was retained for second

year trial. Two entries CNA 1031 promoted in central and south zone while CNA 1032 promoted for South Zone. *G. hirsutum* entry CNH 1123 ranked fourth in Br. 06(b) trial promoted in Central Zone.

3.6: State Multi-location Varietal Trial

Nagpur

A State Multi-location Varietal Trial (SMVT) of *G. arboreum* consisting of 20 + 3 (control varieties) genotypes and of *G. hirsutum* consisting of 13 + 4 (control varieties) genotypes with three replications following recommended package of practices was conducted at CICR, Nagpur.

In *G. arboreums*, the range for seed cotton yield was from 1183 to 2305 kg/ha. The maximum seed cotton yield of 2305 kg/ha was obtained with CNA 2016 followed by JLA-505 (2043 kg/ha) and CNA 1003 & CNA 1028 (2034 kg/ha). The control variety JLA 794 recorded highest seed cotton yield of 1995 kg/ha which was quite higher than other control varieties and genotypes under testing.

In *G. hirsutum*, seed cotton yield ranged from 1339 to 3428 kg/ha. CNH 09-5 recorded significantly high seed cotton yield of 3428 kg/ha followed by culture RCH 1217 (3078 kg/ha) and AKH-09-5 (3062 kg/ha). The seed cotton yield of control variety NH 545 was 2892 kg/ha.

3.7: Genetic diversity

Molecular characterization of the *desi* cotton (*G. arboreum*) from Arunachal Pradesh : Nineteen SSR polymorphic markers were used for diversity analysis of 14 *desi* cotton (*G. arboreum*) accessions collected from Arunachal Pradesh. Nineteen

primers produced 43 alleles across all the accessions. The number of alleles per locus ranged from 2 to 3 with a mean of 2.263. The polymorphism information content (PIC) values ranged from 0.071-0.529 with average value of 0.295. Neighbour joining tree showed three major clusters with the 14 accessions.



Perennial cotton *G. barbadense* of Phek, Nagaland



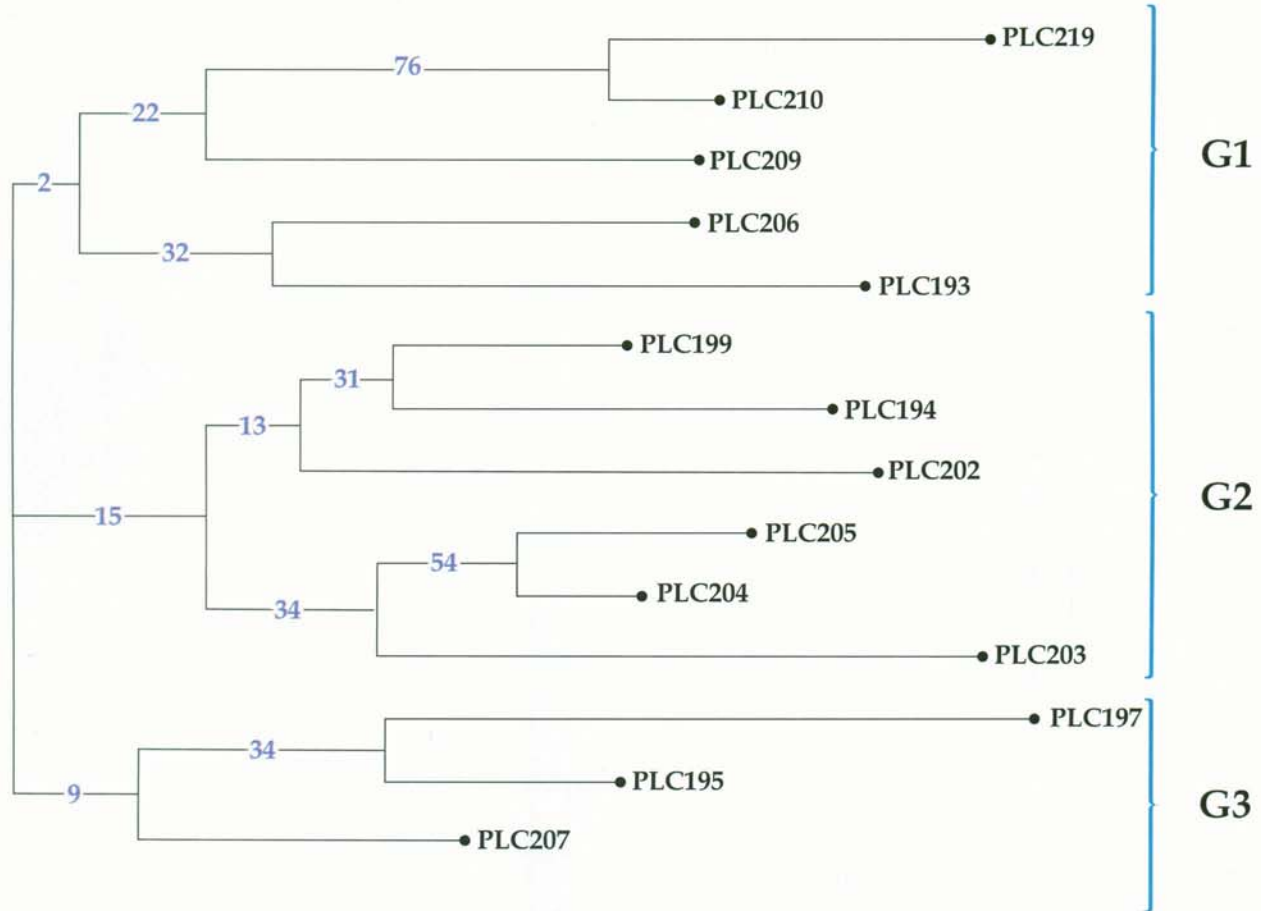
Landrace of *desi* cotton *G. arboreum* race *cernuum* of Karbi along, Assam



Perennial *G. barbadense* var. *brasiliense* of South 24-Parganas (Sundarbans of West Bengal)



Fig. 3.7.1: Banding pattern of 14 landraces of *G. arboreum* accessions generated using BNL 2965



Neighbour joining tree showing relationship of 14 landraces of *G. arboreum* collected from Arunachal Pradesh

Molecular Breeding

Maintenance of RILs in diploid cotton:

In *G. arboreum*, a set of 193 progenies were selfed and maintained by single seed decent method. The populations are intended to be used for genetic mapping.

Development of Bt cotton genotypes through backcross breeding

Sixty-one (61) genotypes from different cotton agro-ecological zones of the country are being converted into Bt background which are under various stages of backcross breeding. Fifteen of these converted lines were tested in replicated trial alongwith their non-Bt counterpart and two checks Ajeet 155 BG II and JKCH 8836. Though none of these Bt genotypes surpassed the check but they gave much higher yield than their non-Bt counterparts. Four of these genotypes were also sponsored for testing in AICRP multi-location trial

under HDPS. Sufficient quantity of seeds has been produced for other promising genotypes for evaluation in AICRP trial.

CLCuD: Twenty one F_1 crosses obtained by crossing resistant/tolerant parents were evaluated for CLCuD reaction. Most of the F_1 crosses were grouped in Grade 1. F_2 population from a cross MR 786 x HS-6 was screened for CLCuV.

BLB: Three BC_2 populations with Suraj as recurrent parent were grown at Nagpur. The BC_1 populations include-Suraj (Suraj x CSH 3047), Suraj (Suraj x GTHH 032) and Suraj (Suraj x CSH 3313). BC_2 plants (371) were screened with marker CIR 246 and phenotyped by artificial inoculation with BLB culture. Of the 371 BC_2 plants, 136 were phenotypically resistant and marker positive which were subsequently backcrossed with Suraj to obtain BC_3 seeds.

Nematode resistance: In previous years, nematode

resistant American Nectariless, G.cot 10 and Bikaneri Narma were crossed with elite parents Suraj, Surabhi and NH615. In 2016-17 BC2 populations were sown as boll to row. Sowing of F₃ seeds were also taken up for phenotyping with respect to reniform nematode resistance. For phenotyping F₃ (Suraj x G.cot10) were sown in pots and inoculated with reniform nematode *Rotylenchulus reniformis*. Observations on nematode reproduction were recorded 60 days after inoculation. Marker NAU 2152 located on chromosome 11 was validated for reniform nematode resistance. Nematode reproduction was taken as criterion to evaluate reaction of F₃ population to reniform nematode. Plants selected with NAU-2152 marker also showed reduction in nematode reproduction to the extent of 90-93%. F₃ marker positive 10 plants each were selfed to get F₄ seeds.

Introgression of genes for whitefly and CLCuD resistance in upland cotton

Pre-soaked seeds of identified *G. arboreum* varieties (i.e. CNA 1003, AKA 8401, AKA 5, AKA 7, AKA 8 PA 255, PA 402) were subjected to colchicine treatment of 0.1, 0.2, 0.5 and 1.0% for 18 hrs. Treated seeds were washed for two hrs. and then planted in pots. The growing axial buds were also subjected to colchicine treatment by applying colchicines to growing axial buds. Treatment of axial buds repeated 3-4 times on every alternate day. Plants showing some abnormality for leaf and boll characters were harvested separately for further advancement and cytological studies. Treatment of different concentrations of colchicine to seeds and growing axial buds for induction of autotetraploid in *G. arboreum* yielded positive results and putative plants were identified.



Bolls of untreated and treated plant



Established interspecific F₁ hybrid seedlings through embryo rescue technique

Interspecific crosses were attempted between the *G. arboreum* and *G. hirsutum* including reciprocals, modest number of crosses in *G. arboreum* (5862) and *G. hirsutum* (9507) background, a total of 15369, have been made and sizable amount of crossed seeds was obtained. A protocol for *in-vitro* culture of cotton ovules of interspecific wide crosses, embryo rescue technique, was standardized and more than 100 F₁ seedlings from a cross between *G. hirsutum* and *G. arboreum* and reciprocal crosses were established. The embryo rescue protocol would help introgression of desired traits/genes from other wild species of cotton into cultivated one. It would also help to advance the generations in short period.

Genetic diversity

Forty-eight released varieties (46 of *G. hirsutum* and 2 of *G. barbadense*) were characterized using 68 SSR markers. A dendrogram constructed using DARwin software grouped varieties from North zone into a separate cluster. A set of 14 SSR markers obtained, capable of distinguishing each variety which, could be complimented with DUS data. Twenty four released varieties of *G. arboreum* were



(a) Interspecific Crossed bolls between *G. hirsutum* and *G. arboreum*; (b) matured busted crossed boll

surveyed for polymorphism using 350 SSR markers having wide genome coverage. Among these, 32 markers were found to be polymorphic (Fig. 3.7.2). A set of 10 robust markers could distinguish each variety. A unique marker BNL

3971 could distinguish *G. barbadense* varieties specifically from *G. hirsutum* varieties (Fig. 3.7.3). This was repeatedly confirmed using 60 *G. barbadense* germplasm lines and 46 *G. hirsutum* varieties.

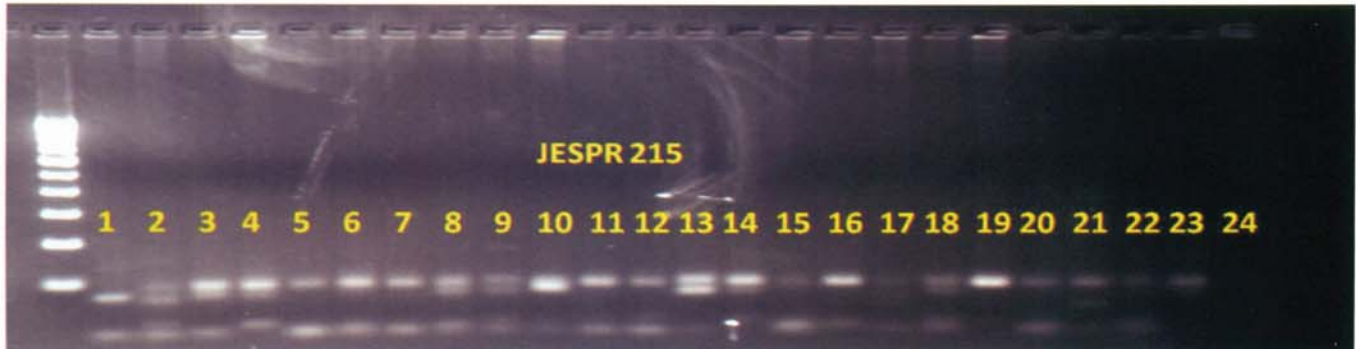


Fig. 3.7.2: SSR polymorphism in *G. arboreum* varieties M: 100bp Ladder; 1-24: Released varieties of *G. arboreum*



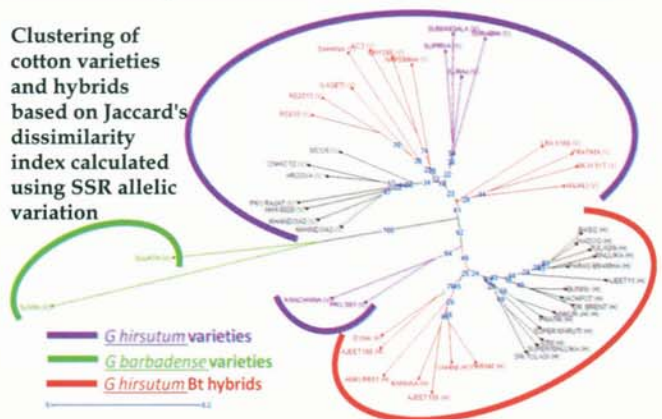
Fig. 3.7.3: Molecular differentiation of *G. hirsutum* from *G. barbadense* M-100bp ladder; 1-20: *G. hirsutum* varieties; 21-32: Germplasm lines of *G. barbadense*

Genetic diversity in Bt hybrids

Twenty-two most popular private sector Bt cotton (BGII) hybrids and 26 popular non-Bt cotton varieties released from different research institutes and SAU's were evaluated for 35 DUS characters under replicated RBD trial as per National DUS Testing Guidelines for tetraploid cotton. The genomic DNA of these cultivars was also profiled for 62 distinctly polymorphic SSR markers identified after extensive screening. Both morphological and molecular data was statistically analysed. Microsatellite markers in comparison to morphological characters clearly distinguished the *G. hirsutum* Bt cotton hybrids, *G. hirsutum* cotton varieties and *G. barbadense* cotton varieties. Significant variation for all most all the parameters of genetic diversity was observed between Bt cotton hybrids *vis-a-vis* cotton varieties (Table

3.7.1). Higher genetic similarity within narrow range was observed among the popular Bt cotton hybrids of India revealing their inherent genetic vulnerability to various biotic and abiotic stresses.

Clustering of cotton varieties and hybrids based on Jaccard's dissimilarity index calculated using SSR allelic variation



Molecular profiling of private sector Bt cotton hybrids *vis-a-vis* public sector cotton varieties

Table 3.7.1: Basic parameters of genetic diversity among cotton varieties vis-a-vis Bt cotton hybrids

Genetic Parameter	Cultivar	Mean ± SD	Minimum	Maximum
Genetic Similarity	Varieties	0.60±0.14	0.29	0.84
	Bt hybrids	0.75±0.07	0.54	0.93
Allele Number	Varieties	2.50±0.65	2	4
	Bt hybrids	1.97±0.75	1	4
Gene Diversity	Varieties	0.37±0.21	0.04	0.75
	Bt hybrids	0.29±0.23	0.00	0.71
Heterozygosity	Varieties	0.29±0.37	0.00	1.00
	Bt hybrids	0.35±0.41	0.00	1.00
PIC	Varieties	0.31±0.18	0.04	0.70
	Bt hybrids	0.23±0.19	0.00	0.66

A total of 74 varieties (Table 3.7.2) of *Gossypium spp.* (*G. hirsutum*-52, *G. barbadense*-2, *G. arboreum*-17 and

G. herbaceum-3) were established and conserved in perennial form as 'Cotton Varietal Garden' in the ICAR - CICR, Nagpur.



Cotton Varietal Garden established at ICAR - CICR, Nagpur

G hirsutum Varieties								G barbadense Varieties		G arboreum Varieties			
S. No.	Variety	S. No.	Variety	S. No.	Variety	S. No.	Variety	S. No.	Variety	S. No.	Variety		
1	Anjali	12	MCU5VT	23	F1054	34	JK4	45	NH615	1	Suvin		
2	Arogya	13	MCU5	24	DHY286	35	KC3	46	Phule688	2	Sujata		
3	CHNO12	14	GCot18	25	Deviraj	36	Khandwa2	47	PKV Rajat	TOTAL: 02	3	AKA8	
4	Khanchana	15	GCot16	26	Bikaneri Narma	37	Khandwa3	48	PKV081		4	AKA8401	
5	LRA5166	16	GCot12	27	AKH8828	38	LH900	49	RS2013	G herbaceum Varieties	5	GCOT15	
6	Pratima	17	GCot10	28	Abaditha	39	MCU10	50	RS875		S. No.	Variety	6
7	Sumangala	18	G Ageti	29	GCot20	40	MCU12	51	RST9	1	GCOT23	7	HD107
8	Supriya	19	F846	30	H1117	41	MCU8	52	Sahana	2	JAYADHAR	8	HD324
9	Surabhi	20	F1861	31	H1226	42	MCU9			3	RAGHAVENDRA	9	JAWAHAR TAPTI
10	Suraj	21	F1378	32	HS6	43	Narasimha			TOTAL : 03	10	LD694	
11	CISH3178	22	CCH2623	33	CCH4474	44	NH545				11	PA183	
TOTAL = 52											12	RG18	
Total cotton varieties conserved and maintained: 74											13	RG8	
											Varietal Garden, ICAR - CICR, Nagpur		
											15	Roja	
											16	PA255	
											17	Phule Dhanwantry	
											TOTAL: 14		

Table 3.7.2: Species-wise list of cotton varieties established in "Cotton Varietal Garden" at ICAR - CICR, Nagpur

3.8: Development of Transgenic Cotton

Screening of putative transgenic plants

Insect Resistance

Putative transgenic cotton varieties (T₃) LRK-516 (121 plants), LRA-5166 (310 plants) and Suraj (220 plants) were screened under contained facility after approval of CICR-IBSC. The plants were raised in green house condition and screened by PCR and Bt Quant ELISA test. PCR analysis showed positive amplification with 3 plants LRA 5166, one plant of LRK 516 and 4 plants of Suraj. However, ELISA results recorded very low *Cry* protein expression of transgene.

Around 1440 putative transformed seeds of *G. hirsutum* (var. Suraj) varieties were obtained by *in-planta* method using *Agrobacterium*. Younger leaves as well as seeds of these plants were tested for Bt gene expression by ELISA.

Among 1440 plants, 142 plants of *G. hirsutum* were tested positive for Bt gene using leaf, while 108 plants of *G. hirsutum* were tested positive using seeds. Plants no 982-14 and 982-20 were PCR positive.

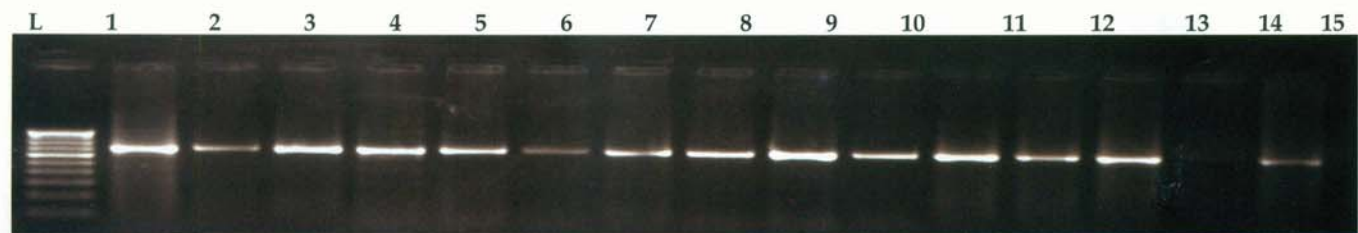
Plants with high OD 450 (app. >1 in both leaf and seeds) are shown in the Table 3.8.1.

Table 3.8.1: Plants with high OD 450

Sr. No.	Plant No.	leaf OD 450	Seeds OD 450
1	437	0.993	1.007
2	982	1.473	1.095
3	983	1.197	0.939
4	986	0.726	1.256
5	996	0.873	1.002

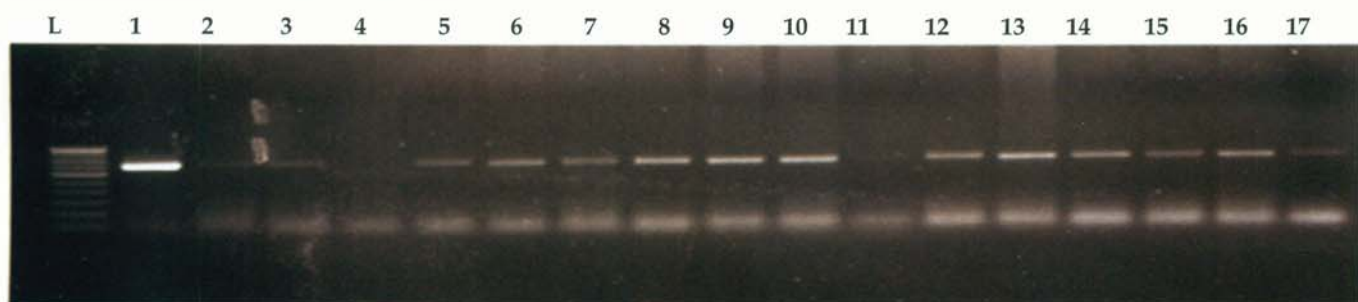
Leaf curl virus resistance

Cotton leaf curl virus resistance transgenics plants were developed using three genes, Sense coat protein (*SCP*), anti-sense coat (*ACP*) protein and antisense replicase protein (*AREP*) in three genotypes *viz.*, HS-6, H 777 and F 846. Transgenic seedlings of T₃ generation were raised in the polyhouse. Genomic DNA was isolated from the individual seedlings and screened for the presence of the specific gene. Fifteen plants showed amplification of *ACP* gene in H 777, 2 plants in HS6 and 3 plants in F 846 while 9 plants of F 846 showed amplification for *AREP* gene primer.



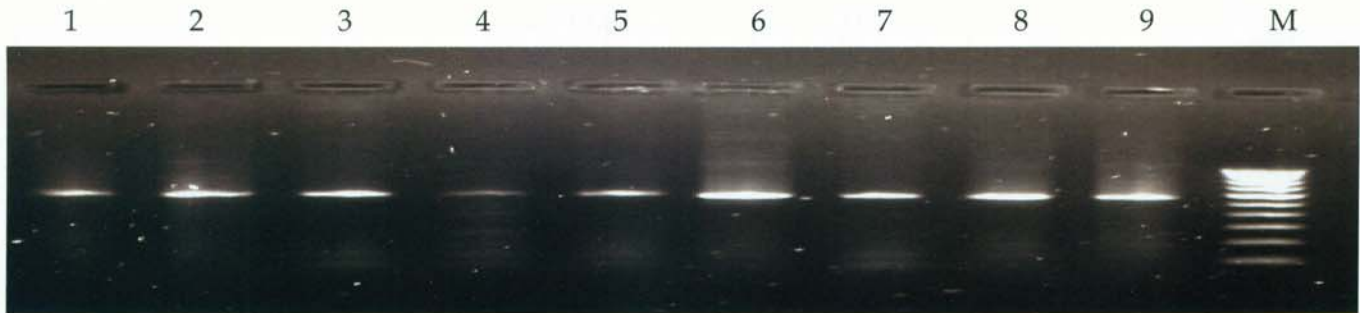
PCR analysis of the transgenic plants with Antisense Coat Protein (ACP) primer (5'-3') F-CATGAATTCATGTCGAAGCGAGC and R-TTAAAGCTTTAATCCAACAAA

Lane 1-15: H 777 positive plants (ACP)



Lane 1-9: HS6 positive plants (ACP); Lane 10-17: F 846 positive plants (ACP)

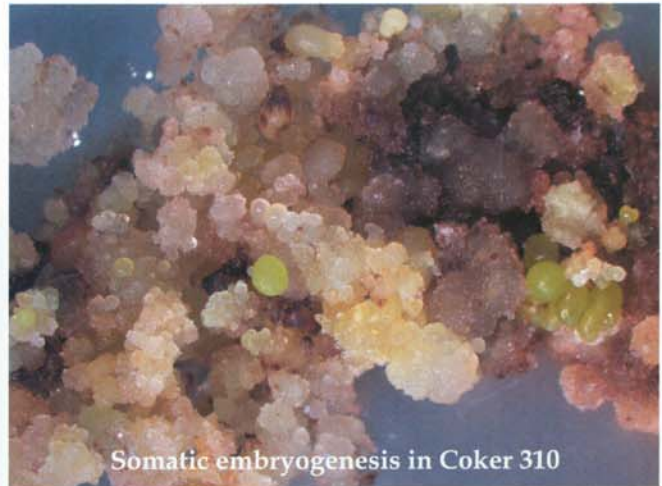
PCR analysis of the transgenic plants with *AREP* primer; F(5'-3') ATG CCA CGT GAT TTA AAA ACA and R- GTG GGG AGA GTT TCA GAT CG



Lane 1-9: F 846 positive plants (Arep)

Somatic embryogenesis of cotton

Cotton genotypes viz. AKA 07, PKV 081, Suraj and Coker 310 were screened for their response towards somatic embryogenesis under varied *in vitro* media regimes. Among the four genotypes, only Coker 310 showed positive response towards somatic embryogenesis. Tissue culture media was standardized for callus initiation and proliferation followed by somatic embryo initiation and maturation of Coker 310 under *in vitro* culture. High frequency somatic embryogenesis was achieved in Coker 310.

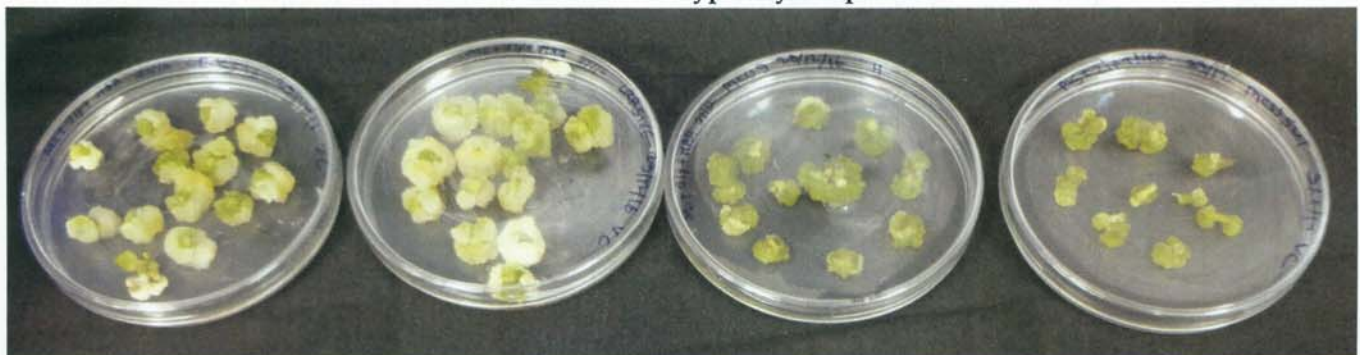


Somatic embryogenesis in Coker 310

Explants of hypocotyl and cotyledons of *Gossypium hirsutum* cvs LRA 5166, LRK 516, MCU 5VT and MCU9 were used to study their response to somatic embryogenesis. MS media was supplemented with 2iP 5 mg/L and NAA 0.1 mg/L for callus initiation and proliferation. Subsequent subculture was done on medium supplemented with the NAA 5 mg/L and 2iP 0.1 mg/L for embryogenic callus induction (Firoozabady and deBoer 1993). Hypocotyl

explants of LRK 516 and LRA 5166 produced creamy soft callus within 3 to 4 weeks of inoculation while MCU 5VT and MCU 9 produced green hard callus. But cotyledonary explants of all the genotypes produced only green callus. Subsequent subculture on embryogenic callus induction media produced responsive callus only in LRK 516.

Callus initiation on hypocotyls explants :



LRK 516

LRA 5166

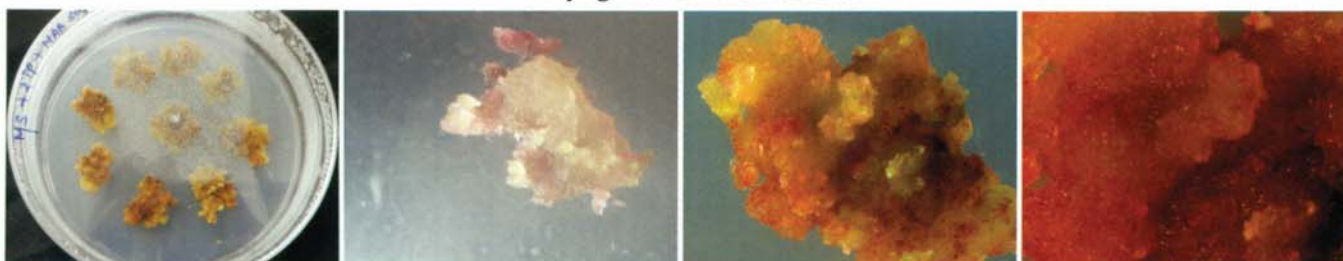
MCU 9

MCU 5VT

LRK 516 and LRA 5166 showed callus initiation in 3 to 4 weeks

Callus type : Creamy friable in LRK 516 and LRA 5166
Green hard callus in MCU 9 and MCU 5VT

Embryogenic Callus induction



LRK 516 showed good response on embryogenic callus induction medium

In planta transformation method

A novel *Agrobacterium tumefaciens* mediated *in planta* transformation protocol was standardized. In this system, sonication followed by vacuum pressure was applied to infiltrate *Agrobacterium*

strain harbouring the transgene deep into meristematic cell mass. Mature intact embryos with intact apex were used as explants and parameters for sonication and vacuum infiltration were optimized for higher transformation efficiency.



A- Explant-Excised embryo with apex; B-Transformed embryos showing *gus* gene expression; C-Expression of *gus* gene near target tissues (Apex and cotyledonary nodes)

3.9 Seed Production and Technology

Seed Quality Improvement

Nagpur

An experiment was conducted to assess the effect of exogenous application of plant growth hormones and other chemicals on seed yield and quality of *G. hirsutum* viz. Suraj. Based on positive response of hormone treatments in 2015-16, 14 treatments (putrescine (1.0 mM and 4.0 mM); spermidine (0.1 mM and 1.0 mM); spermine (0.1 mM, 0.5 mM and 1.0 mM); 5-sulphosalicylic Acid (0.5 mM and 1.0 mM); glycine betaine (4.0 mM); (KNO₃) (4.0 mM); NAA (0.5 mM); control water and absolute control) were used as foliar spray at 65 and 85 days after sowing.

The crop yield parameters were recorded during crop growth stages and post harvest data was statistically analysed. Results of the experiment indicated that the total number of bolls/plant

(25.5), boll weight (4.19 g), lint/plant (39.0 g), seed yield/plant (66.6 g), SCY/plant (105.6 g), GOT (36.98%), and SCY/ha (40.4 qt) were significantly higher with foliar application of glycine betaine (4 mM) followed by putrescine (4 mM) and KNO₃ (4 mM) as compared to the control and other treatments.

Post harvest seed quality studies indicated that the seedling vigor was significantly higher with glycine betaine (4 mM), and 5-sulphosalicylic acid (1.0 mM) treated seeds than control while the seed germination and 100 seed weight and other quality parameters were found to be non-significant.

Sirsa

The effect of growth hormones, pollinator attractant and pollinator population was estimated on boll setting and seed setting percentage. In nine (9) treatments, significantly higher boll setting (72%) was observed in hand pollination treatment

against control. In rest of growth hormone treatments, no significant enhancement for boll setting was observed over control (67.2%). Seed setting efficiency (83.8%) and yield (11.8 qtl. SCY/acre) in hand pollination treatment was significantly higher than in control (75.1% and 10.9 qtl. SCY/acre).

With augmented pollinators, the boll and seed setting in GMSDS 5 was not significant than without augmented pollinator.

Coimbatore

Enhancement of primed seeds quality through pulsed magnetic seed treatments

A laboratory experiment was conducted to enhance quality of primed seeds through pulsed magnetic seed treatments. Delinted seed of cotton cultivar Surabhi and Suraj were used with initial germination of 72% and 76% respectively. Seeds were primed with KH_2PO_4 priming (450 ppm), CaCl_2 hydration (2%), KCL priming (1.0%), MnSO_4 (seed soaking 0.1%), succinic acid priming (0.2%), prosopis leaf extract (seed soaking 1.5%), neem leaf extract (seed soaking 1%) and compared with untreated seeds. The primed seeds were subjected to pulsed magnetic field strength 750 nT (7.5 mA 10 Hz) for 15 days at the rate of 5 hours per day. The pulsed magnetic waves treated seeds were evaluated for seed germination, seedling vigour and biochemical parameters. The replicated mean data of treated seeds when compared with primed seeds and control seeds revealed that seed priming significantly enhanced seed germination in both the varieties. The enhancement was 12% due to KH_2PO_4 priming and MnSO_4 (0.1%) in Surabhi against the control. However, in Suraj, enhancement was 10% due to neem leaf extract (1%) and 8% due to KH_2PO_4 priming. Pulsed magnetic field treatment further enhanced the seed germination to the tune of 13% due to CaCl_2 hydration (2%) and 8% due to MnSO_4 in Surabhi and 7 and 5% respectively due to prosopis leaf extract and CaCl_2 hydration (2%) in Suraj.

Enhancement of coated seeds

In another laboratory experiment, delinted seeds of cotton cultivar Surabhi and Suraj were coated with Trichoderma (10 g/kg), Arappu leaf powder (@ 100 g/kg), turmeric rhizome powder (@ 20 g/kg),

polykote (@ 5 ml/kg), DAP (@ 20 g/kg), micro nutrient mixture (@ 10 g/kg), Pseudomonas (15 g/kg), phosphobacterium (50 g/kg), and compared with untreated seeds for germination and seedling vigour. The coated seeds were subjected to pulsed magnetic field strength 750 nT (7.5 mA 10 Hz) for 15 days at the rate of 5 hours per day. Seed coating significantly enhanced seed germination in both the varieties than the control seeds. The enhancement in seed germination was 13% due to Polykote (@ 5 ml/kg) and 12% due to Arappu leaf powder in Surabhi while in control it was 72%. In variety Suraj, enhancement in seed germination was 10% due to Polykote and 8% due to micronutrient mixture. Pulsed magnetic field treatment enhanced the seed germination to the tune of 10% due to micronutrient mixture and 9% due to Turmeric rhizome powder in Surabhi and 5 and 4% due to micronutrient mixture and Arappu leaf powder respectively in Suraj.

DUS testing

Nagpur

Seventy-three genotypes that includes (4 candidate varieties, 4 VCK varieties, 12 Essentially Derived Varieties and their initial variety and 30 reference varieties, were characterized for DUS traits under Protection of Plant Varieties and Farmers' Rights Act, 2001. Under varietal maintenance, 29 diploid lines were maintained and multiplied.

In trait behavior studies, varieties with diverse expressions for various traits were crossed and F_1 s were planted to study the phenotypic expression in a population of 50 plants/ trait.

Coimbatore

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

This programme is implemented with ICAR-CICR, Regional Station, Coimbatore as the nodal center and ICAR-CICR, Nagpur, National Seeds project Unit, UAS, Dharwad, Department of Cotton CCSHAU, Hisar; Regional Research Station Bhatinda, PAU; Department of Cotton, MPKV, Rahuri as participating centres.

Field trials for the establishment of Distinctiveness, Uniformity and Stability (DUS) of new cotton genotypes, varieties of common knowledge, and

essentially derived varieties was conducted in tetraploid and diploid cotton. A total of 49 new candidate varieties were tested in the second year trial, of which 48 were of *G. hirsutum* and one *G. arboreum*. For the first year trial, 5 new candidate varieties, 3 varieties of common knowledge, and 3 essentially derived varieties along with 3 initial varieties were taken up. In both trials, for comparison, 60 reference varieties were grown. The essentially derived varieties and their corresponding initial varieties were grown in unprotected and protected environment. The

characteristic measurement and visual assessment was done on randomly selected ten plants in each plot. The claimed characters of the applicant were compared with characters of reference varieties for establishment of DUS of candidate genotypes.

Seed Production

Nagpur

Seed production of cotton varieties, parents of hybrids and other crop varieties was taken up under ICAR-Mega Seed Project 'Seed Production in Agricultural Crops and Fisheries' (Table 3.9.1).

Table 3.9.1: Seed Production achieved during 2016-17 at ICAR- CICR, Nagpur, Coimbatore and Sirsa

Crop	Variety	Stage	Seed (quintal)
Cotton	Breeder Seed		
	CNA 1003 (Roja)	BS	0.5
	CICR-2 Female parent	BS	0.3
	CICR-2 Male parent	BS	0.2
	CISA 614	BS	3
	CISA-310	BS	1
		Total (BS)	5
	Stock Seed		
	48 varieties		2.2001
	CICR-2		2.805
	TFL (Institute)		
	9 varieties		3.146
	Suraj	TFL	2
		Total (TFL)	11.88
Phule Dhanvantari (under farmer's participatory mode)	Total (TFL)	8.63	
Wheat	HD 2967	CS	180
Red gram	BSMR-736	CS	14.5
Gram	Vijay	CS	25.2
		Total (CS)	219.7
		Grand Total	245.51

Besides cotton, certified seed of wheat cv. HD 2967, red gram cv. BSMR-736 and gram cv. Vijay were produced for State Seed Corporation at Haryana and Maharashtra. The total seed production was 245.51q of cotton, Red Gram, Wheat and Gram at 3 stations. Details are given in Table above. Resource of around Rs. 10.5 lakhs was generated through the

sale of these seeds or its by-products.

Coimbatore

Breeder Seed Production

Breeder Seed Production was undertaken in respect of Suvin, Suraj and Surabhi. During the year 2016-17, 126 kg of breeder seed was distributed to various seed producers.