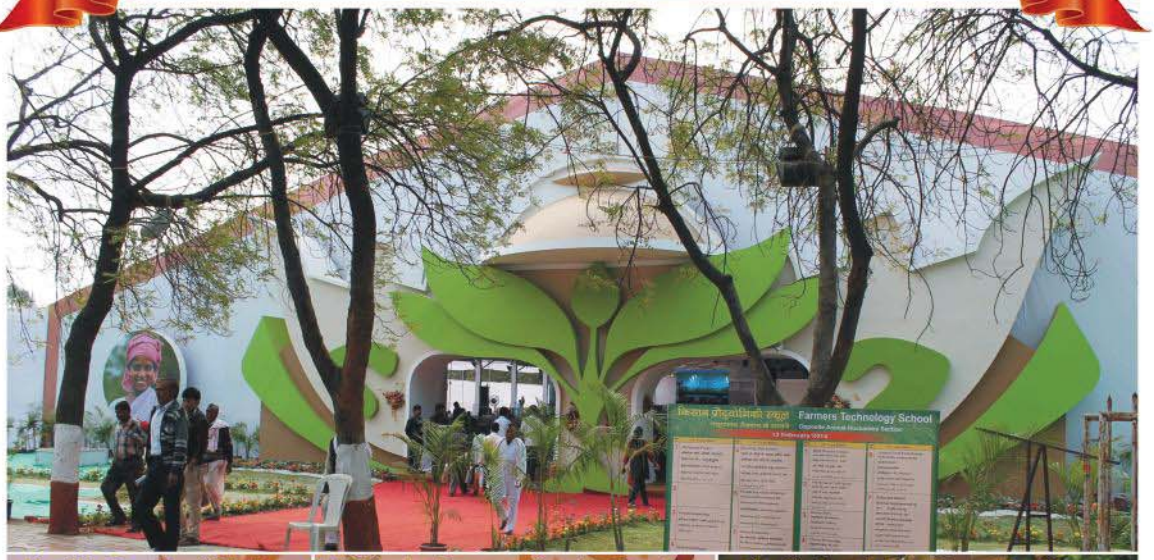
Annual Report 2013-14

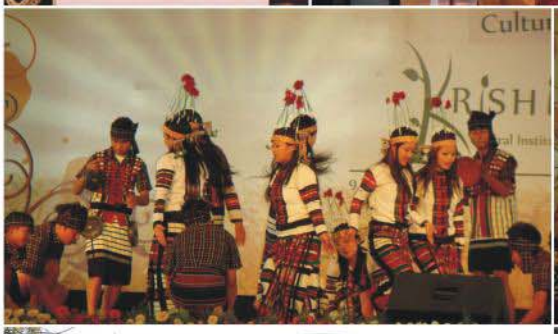
CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

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

Ariel View of the Mega Event

भाकृअनुप
ICAR

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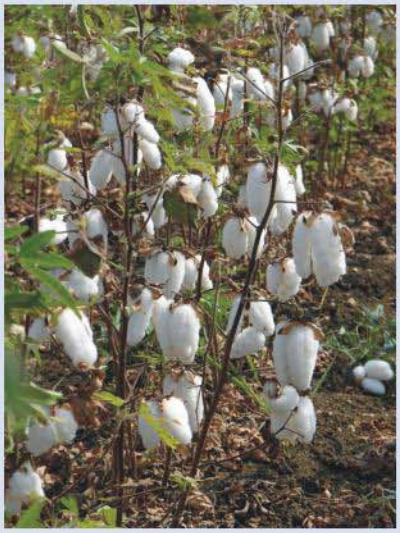
ANNUAL REPORT

2013-14



केन्द्रीय कपास अनुसंधान संस्थान, नागपुर

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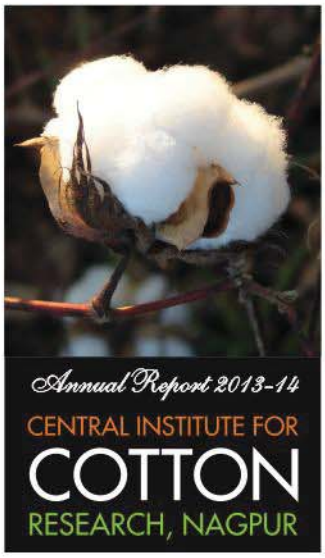

ANNUAL REPORT 2013-14
CENTRAL INSTITUTE FOR
COTTON
RESEARCH, NAGPUR
केन्द्रीय कपास अनुसंधान संस्थान, नागपुर

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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 33rd 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)

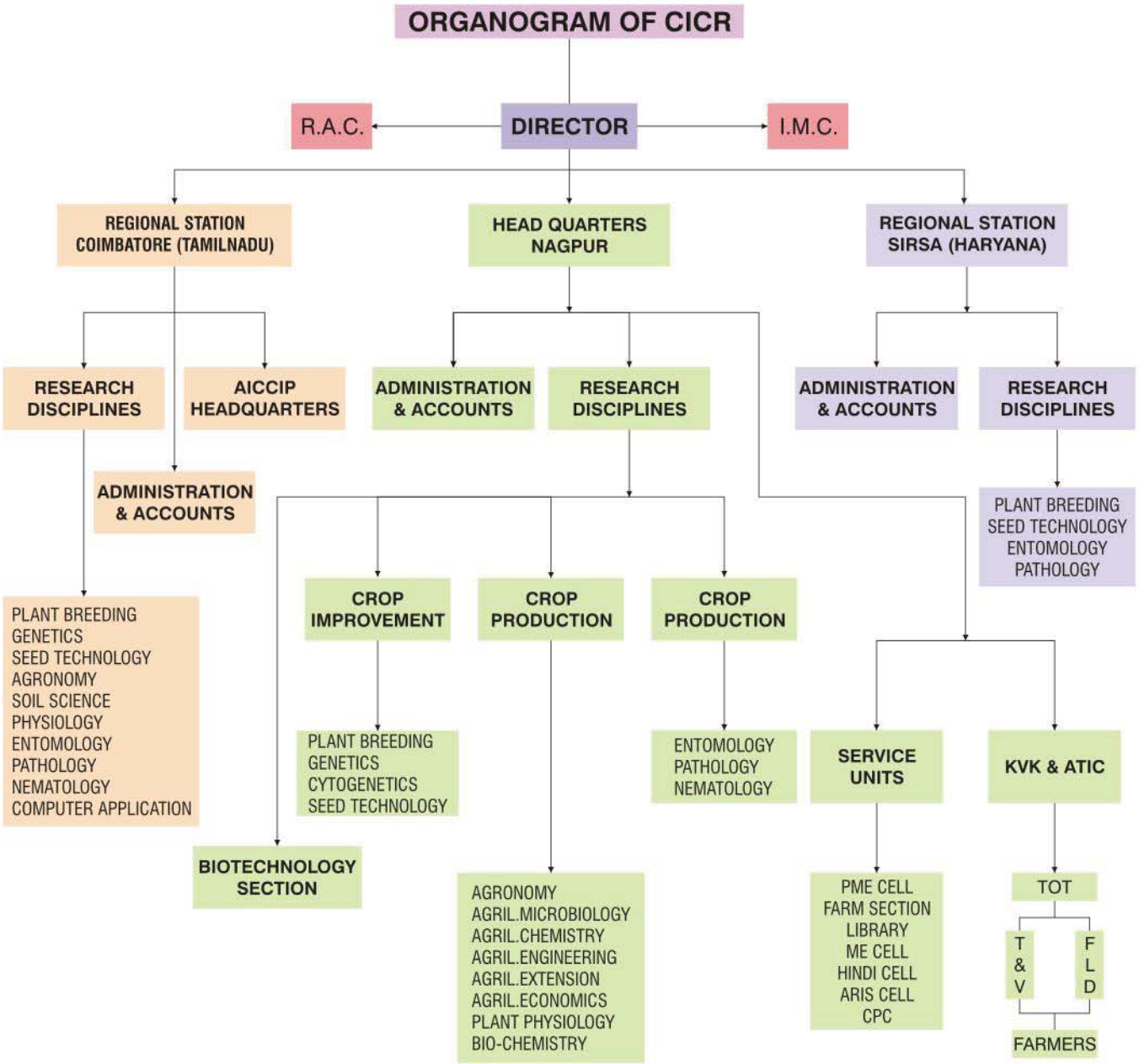
CONTENTS

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 31st 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**
Krishi Vigyan Kendra								
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
CICR			
1	Plan	200.00	198.23
2	Non- Plan	2741.52	2729.94
Plan Schemes		3593.08	1759.77
NAIP Plan Schemes		113.37	60.26
Deposit Schemes funded by outside agencies		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	*G. barbadense*	Perennial
Maharashtra	Wardha	2	*G. barbadense*	Perennial
Gujarat	Mehsana, Patan, Banaskantha & Kachchh	5	*G. herbaceum*	Annual
		4	*G. arboreum*	Annual
		1	*G. barbadense*	Perennial
Nagaland	Mon & Tuensang	3	*G. barbadense*	Perennial
Meghalaya	West Garo Hills	1	*G. arboreum*	Annual
Assam	Barpeta	3	*G. barbadense*	Perennial
	Total	**35**		

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_2 mapping population established

S.No	Derivative	Number of F_2 plants
a.	*G. herbaceum* x *G. longicalyx*	557
b.	*G. arboreum* race *indicum* x *G. davidsonii*	212
c.	*G. arboreum* x *G. thurberi*	53
d.	AK 8401 x *G. davidsonii*	34

Eleven fibre strength specific SSR primers were found to be polymorphic in the F_2 mapping population of *G. herbaceum* and *G. anomalum*. The F_1 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.

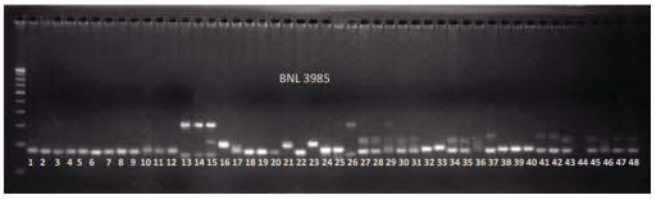


Fig. 3.1.1: Genetic diversity assessment in F_2 mapping population of wild species and races.

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 Kuhi 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)

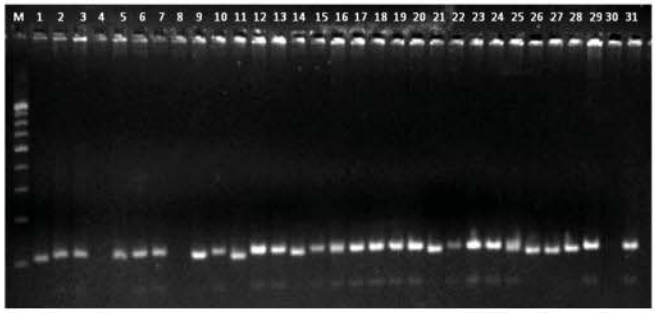


Fig. 3.1.2: SSR profile of 31 collected landraces of desi cotton and perennials from Tamil Nadu, Tripura and Gujarat with primer NAU 396

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	*Gossypium arboreum*	Narrow leaf lobe and brown linted
CNA-406	*Gossypium arboreum*	Broad leaf lobe and brown linted
CNA-407	*Gossypium arboreum*	Narrow leaf lobe, Pigmented plant body, brown linted
CNH -219	*Gossypium hirsutum*	Pigmented plant body, deeply palmate leaf lobe and brown linted
CNH CB-228	*Gossypium hirsutum*	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 CISAA 27 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 AICCIP trials.

G. hirsutum (Tetraploid cotton)

Breeding for compactness

Three F_1s *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_1s 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.

CNH-2015 , a medium duration, high yielding culture

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

S.No.	Name of theentry	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 LRA 5166.

The second set comprised of 12 genotypes in F_5 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_1s 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 LRA 5166. 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^2 values for early maturing accessions with normal leaf ranged from 46.4 to 132.9 µg/ cm^2.

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.

CCH 12-2: The high yielding *G. hirsutum* culture tested in south zone under irrigated condition

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 x15 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.

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

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 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 recored 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 4th 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_5 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_1 crosses attempted between agronomically superior varieties of north zone and high GOT germplasm lines (37 to 41%) were evaluated in unreplicated trial. Sixteen F_1's of these gave GOT% > 37% and 9 crosses among these had > 75 g seed cotton yield / plant. Three F_2 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_2 population of the above crosses. Thirteen F_6 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_2 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_5 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.


High boll number and 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_1s. 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_1s.

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.


CCH 2623 – High Yielding Medium Staple Culture

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
G. hirsutum		
Br 02 (a)	IET	CNH 1116, CNH 19
Br 02 (b)	IET	CNH 7008, C NH 2001, CSH 1115, CSH 95
G. arboreum		
Br 22 (a/b)	IET	CNA 375, CNA 1013, CCA 1021, CCA 3
HDPS Trial		
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 28I, 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_2 (EL 958 X UPA 57-17) population was grown. Few flowers of all the F_2 plants were selfed and carried forward to F_3 and subsequent generation following single seed decent method. At the end of F_8 273 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.

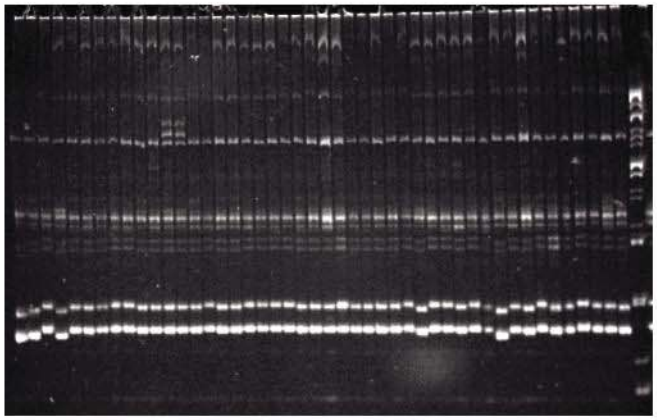


Fig 3.6.1: Genotyping of RILs with SSR marker CIR-203 in upland cotton

Maintenance of RILs in diploid and tetraploid cotton

In *G. hirsutum,* 273 F_9 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_2 seeds was obtained at Sirsa from a F_1 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_1 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_1s 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, 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.

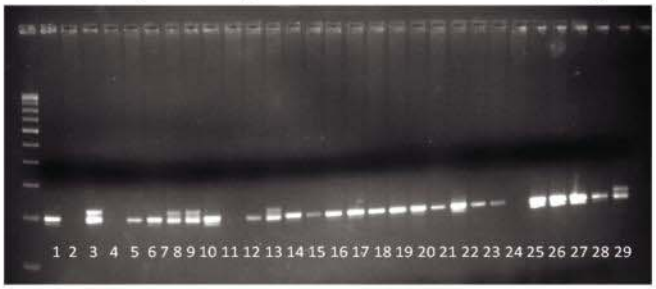


Fig. 3.6.2: Molecular profile of released *desi* varieties by SSR markers (DPL 209)

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

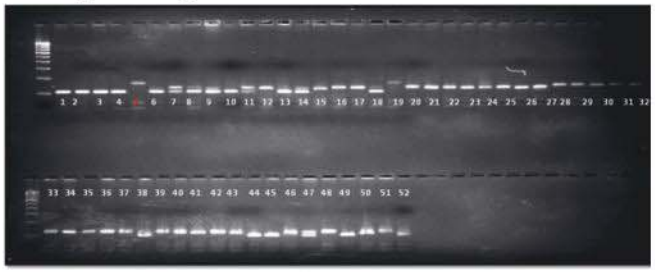


Fig. 3.6.3: Molecular profile of public sector released varieties (*G. hirsutum*) by SSR markers (BNL 2709)

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

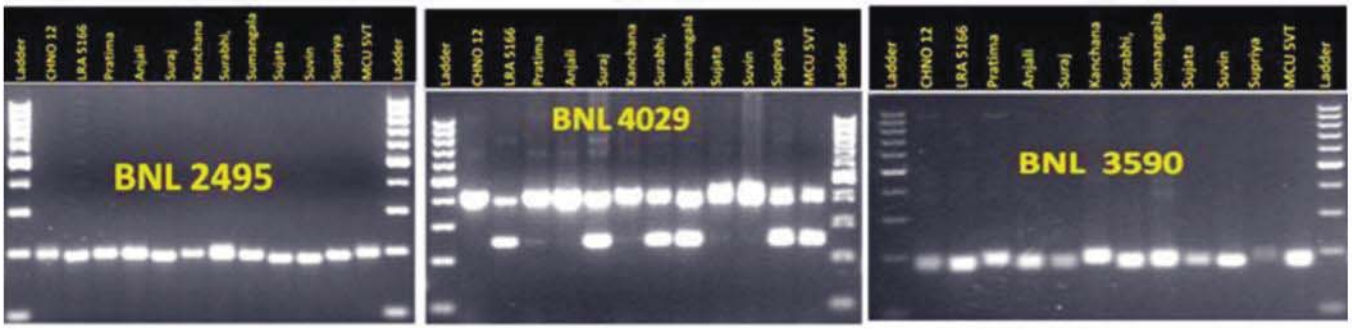


Fig. 3.6.4: Molecular profiles of CICR varieties as revealed by polymorphic SSR markers.

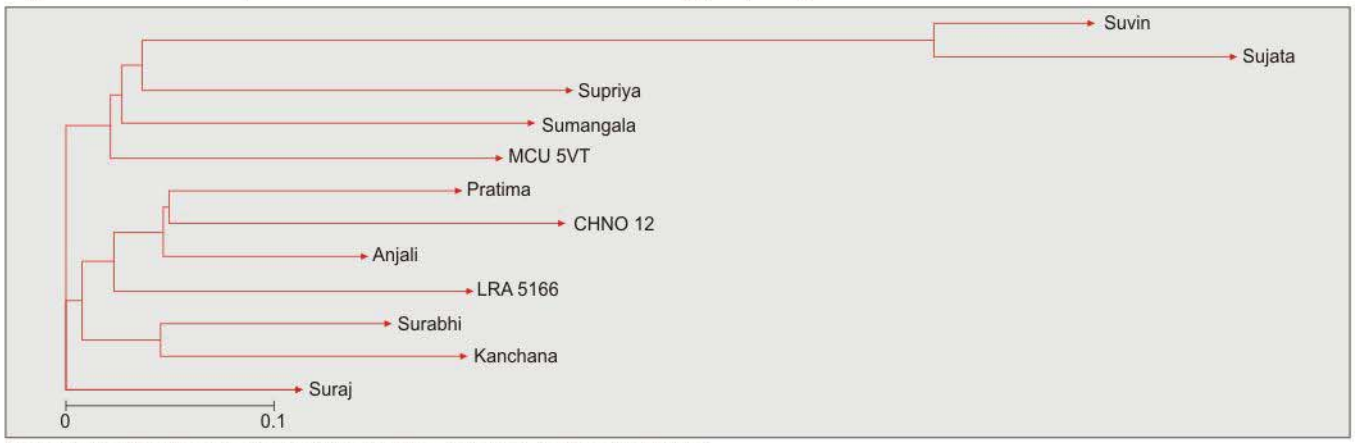


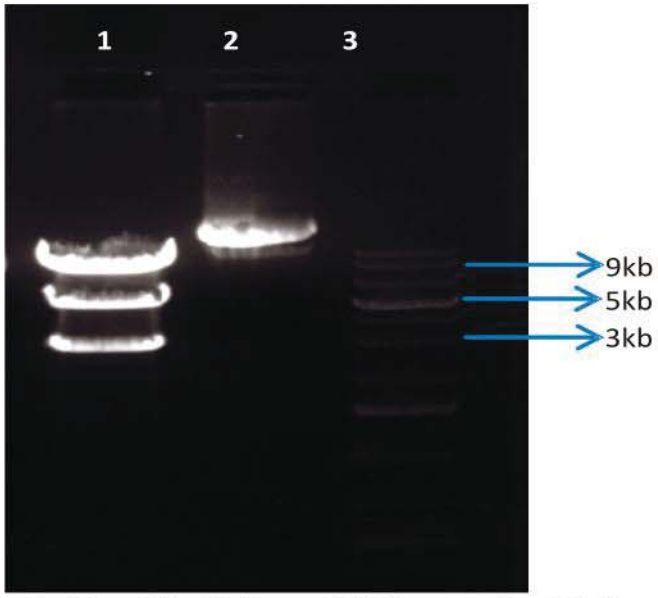
Fig. 3.6.5: Dendrogram constructed based on genetic similarity

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 *Cry*1Ac 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 *Cry*1F in Suraj variety was positive with gene specific primers were also selected for event selection trial. The new fusion genes of CICR-*Cry*2Ab1Ac 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 phytagel +30 g/l Maltose+ 0.1 g/l PVP. (Fig. 3.7.3).

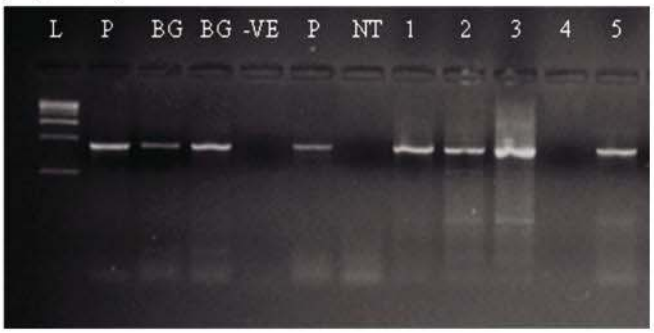


Fig. 3.7.2: L- 1kb ladder; P-Plasmid; BG-Bollguard; BGII-Bollguard-II; -VE- Negative Control; NT- No template; Sample – 1-6 Suraj-*Cry1Ac* samples.

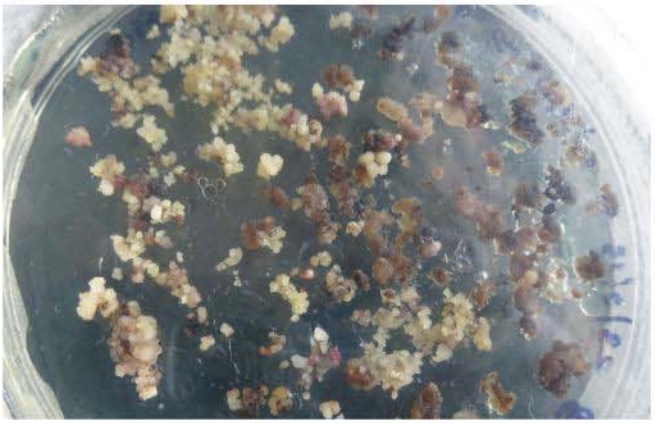


Fig. 3.7.3: Transformation of fusion gene *CICR-truncated Cry2Ab1Ac* with Coker 310/Suraj callus and regeneration through somatic embryogenesis.

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_0 plants were established. In another method of transformation, 328 seedling meristem were treated with *Agrobacterium* by removing one cotyledon and 105 T_0 plants were established. In AKA 7 however 20 plants were established from the treatment of 260 seedling meristem.

Removal of one cotyledon

T_0 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.

Boll set with transformed Pollen

Leaf curl virus resistance

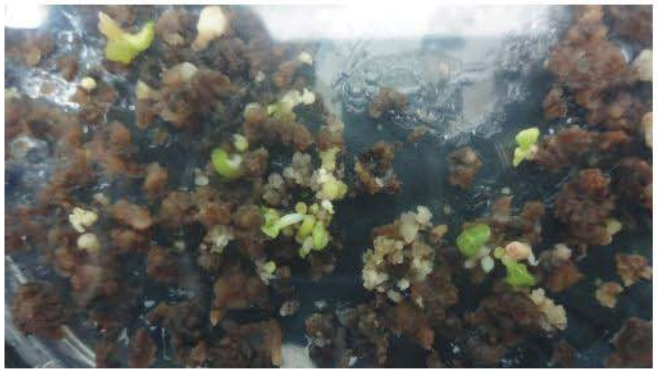
G. hirsutum varieties *viz.*, H 777, F 846 and HS 6 carrying ACP (Anti-sense coat protein) gene was confirmed by PCR with gene specific primers (700 bp) and were selected for event selection trial.

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 *Sus*A1, *GhcesA1 GhcesA2, GhcesA7*, *Ghcobl4, GhMT1* and GhFLA3 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 *Sus*A1, *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 *Sus*A1, *GhcesA1 GhcesA2,* and *GhcesA7 were* cloned and subjected to sequencing (Fig. 3.7.6 & Fig. 3.7.7).

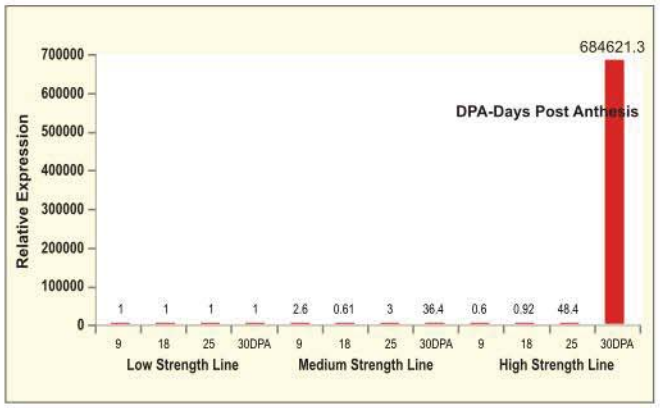


Fig. 3.7.4: Analysis of *GhCesA1* gene expression at different stages of fiber development in high, medium and low strength lines of RIL mapping population

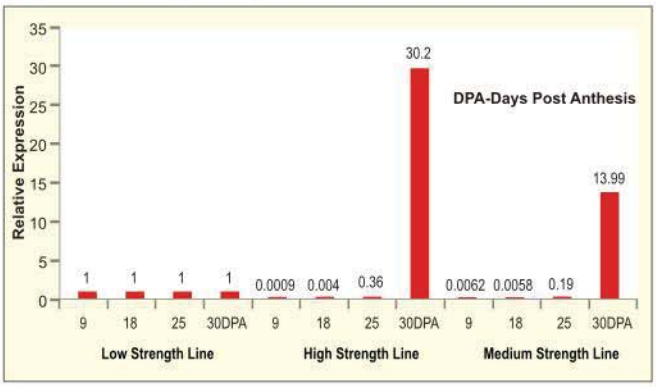


Fig. 3.7.5: Analysis of GhCesA2 gene expression at different stages of fiber development in high, medium and low strength lines of RIL mapping population

Cloning of SusA1 gene from *Gossypium hirsutum var Suraj*

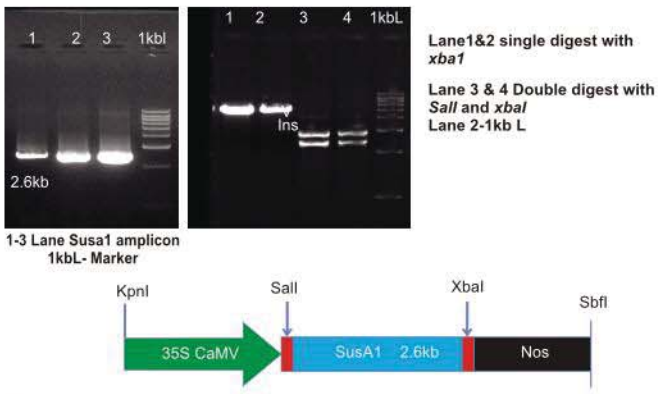


Fig. 3.7.6 : Cloning of SusA1 gene from *Gossypium hirsutum var Suraj*

Cloning of CesA1 and A2 gene from *Gossypium hirsutum*

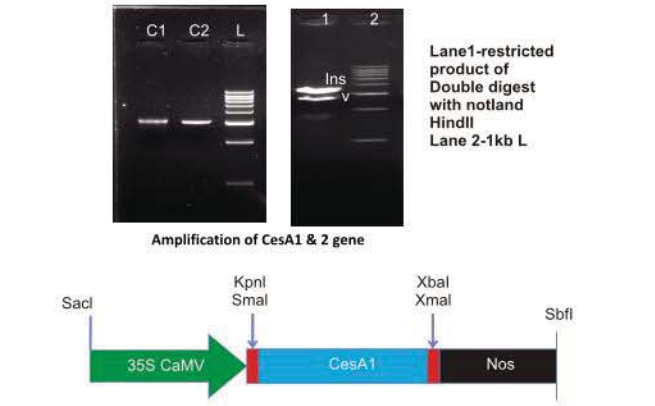
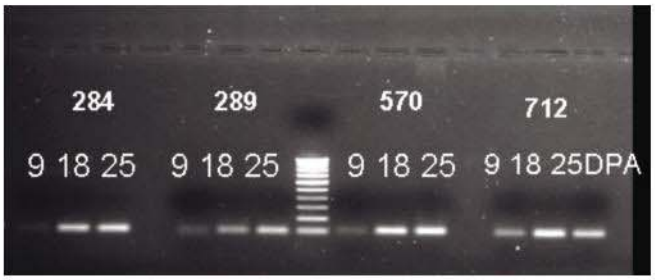


Fig. 3.7.7: Cloning of CesA1 and A2 gene from *Gossypium hirsutum*

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.

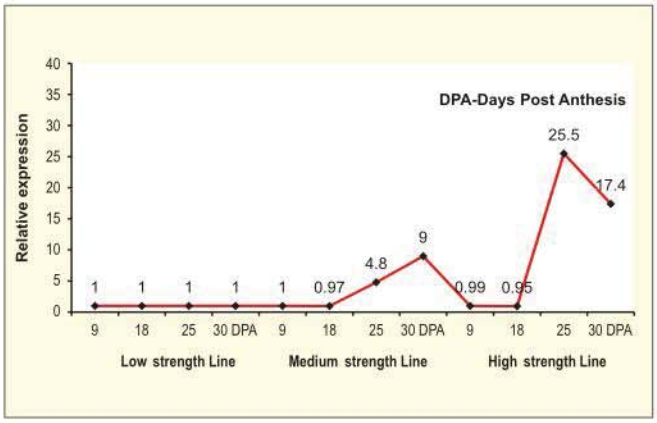


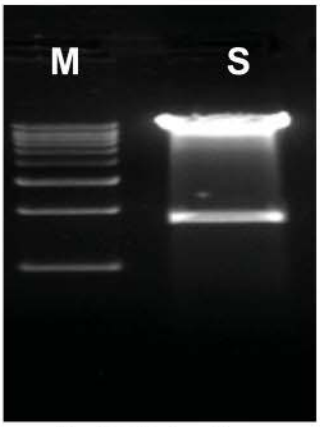
Fig. 3.7.8: Analysis of contig 570 expression at different stages of fiber development in high, medium and low strength lines of RIL mapping population

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 δ Cadinene synthase and δ 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. hirustum* elite genotypes with dsRNAi construct for gene coding δ Cadinene synthase driven by seed specific promoter is under progress.



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

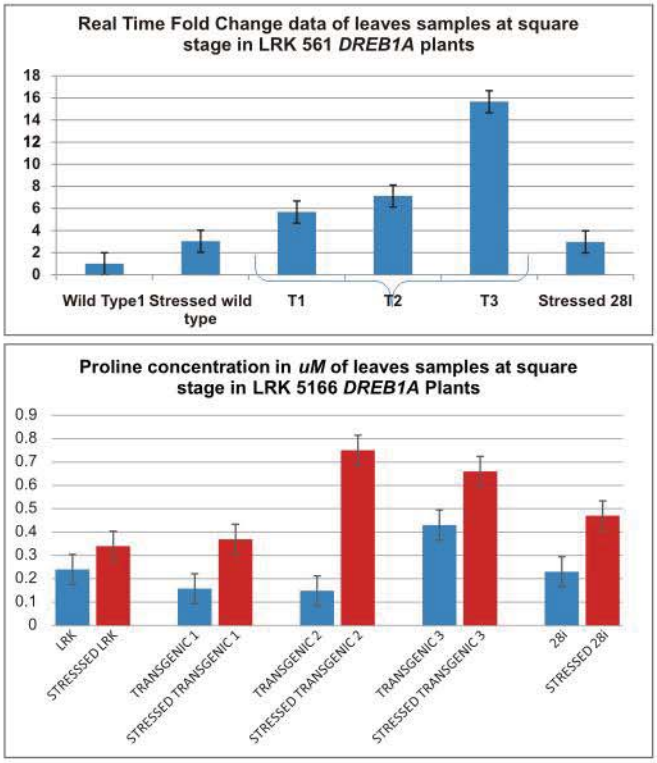
Restriction confirmation of Intron hairpinloop RNAi cassette for δ *Cadinene synthase* in plant expression vector

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 a internal control. Two transgenic 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 leaves samples at square stage in LRK 516 D*REB1A* Plants



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

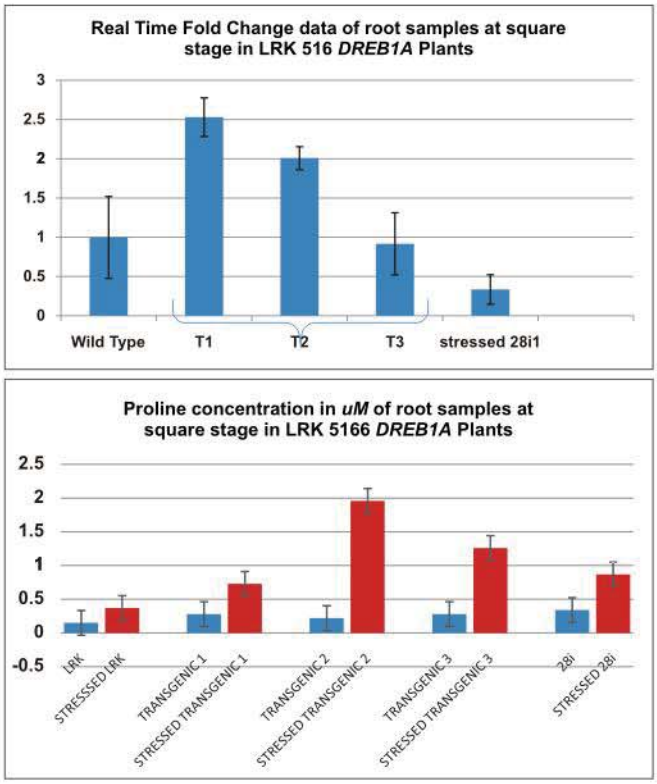


Fig. 3.7.9: Relative fold expression of *DREB1A* T_3 progeny and transgenic cotton plants at different growth stages. Expression of *DREB1A* in leaves at (a) squaring stage (left) and (b) roots (right). Plants were kept under water stress for 15 days at squaring stage.

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_2 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% 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_2O_2, 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_3 @ 0.5 %, Succinic acid @ 0.2 % and H_2O_2 @ 80 mM (95 % - 100 %). The final seed emergence was above 80 % for all the treatments.

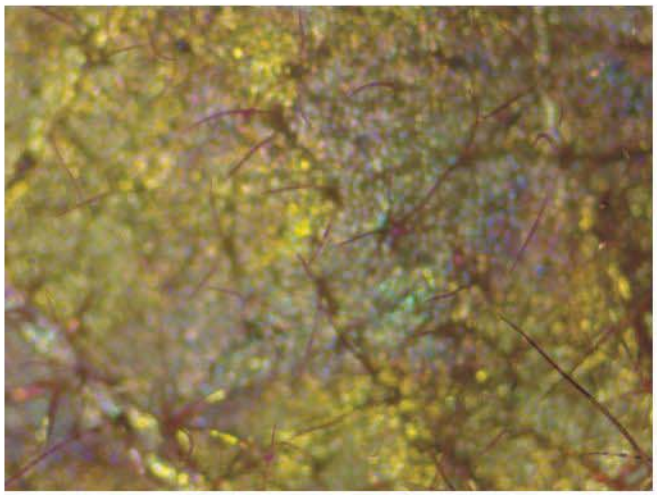
The treatment with plant protectants (thiram, thiomethoxam and imidacloprid) resulted in significantly higher seed cotton yield compared to all others. Among the microbials, seed treatment with *Pseudomonas putida* was found better. Among the other reported chemicals, succinic acid @ 0.2 % seed treatment 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 Main treatments	Seed cotton yield (kg/ha)	Boll wt. (g)
Without microbial seed treatment	2041	4.65
With microbial seed treatment	2291	4.77
CD (0.05)	**NS**	**NS**
Sub treatment s		
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
CD (0.05)	**362**	

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 X 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

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

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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 X 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

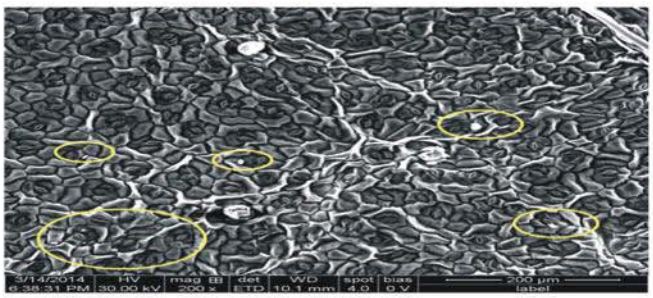
inoculation, seed treatment with Agrisil @ 500 ppm improved boll weight significantly. Seed treatment with potassium silicate powder (PSP) had no effect on seed cotton yield. BLB incidence under natural condition was significantly influenced by seed treatment with PSP, foliar spray of Agrisil and soil 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 ± 1000 nm. Surface charge, *ie*., 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 *ie*., + 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.

N-Chlorosis of the leaves, particularly the older leaves



Absorption of zinc loaded chitosan nanoparticles by cotton leaves

Sirsa

Bio enriched compost evaluation

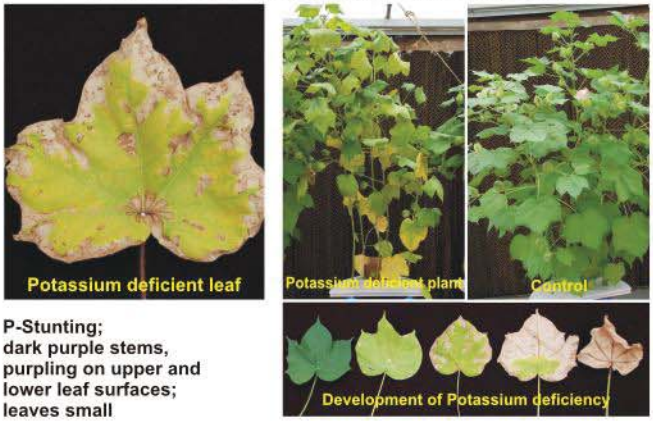
Bio-enriched cotton stalk compost prepared after chipping of cotton stalk was evaluated with JK1947 Bt hybrid *vis-a-vis* the control. Significantly higher seed cotton yield was noted in treatments with present INM practice treatment (12.5 q/ha) and enriched compost 12.7 q/ha as compared to the recommended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

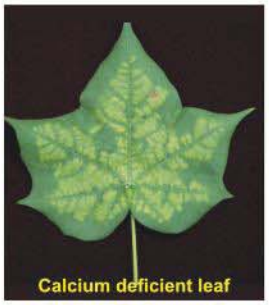
Coimbatore

Hydroponics is a subset of hydro-culture and is a method of growing plants using mineral nutrient solutions from water without soil. A hydrophonic 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



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

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, CINH Ti 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 Agrogya 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 + pyrithiobac sodium over the top application (each 0.035 kg a.i. ha^{-1}). A low cost alternative of directed spray of glyphosate (0.75 kg a.i.ha^{-1}) 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)

	Shallow soil			Medium soil		
Rank	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

Cloranitraniliprole 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)

	Shallow soil				Medium deep soil			
Rank	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-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.

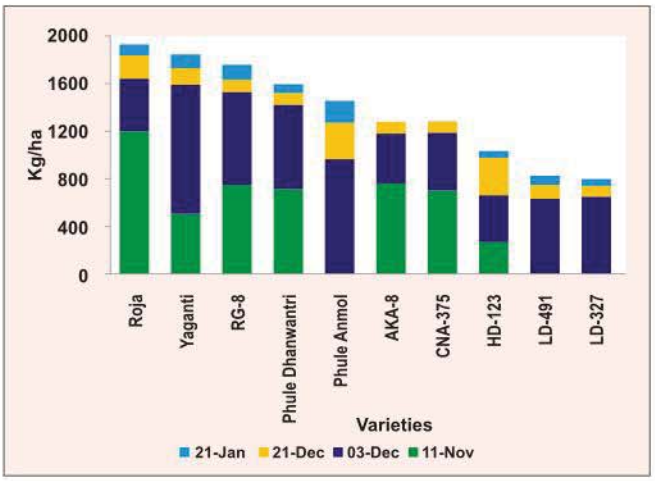


Fig. 3.10.1: Seed cotton yield (kg/ha) of *G. arboreum* genotypes planted at 60 x 10 cm spacing

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.

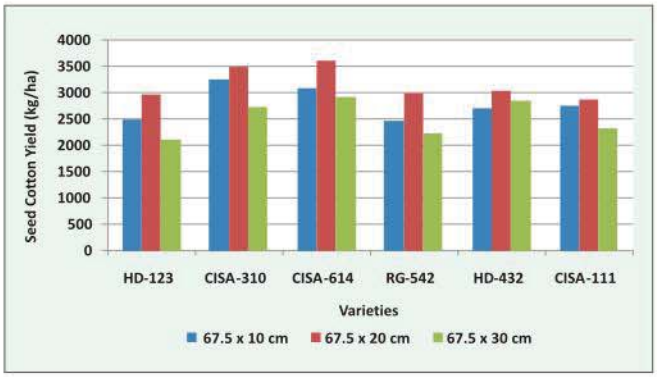


Fig. 3.10.2 : Seed cotton yield (kg/ha) of *G. hirsutum* varieties at different spacings (mean of 3 years – 2011 -12 to 2013 -14).

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 *Meremia imarginata* and *Cynotis auxillaris*, the resistance is due to waxy coating that prevents herbicide entry. *Echinocloa crussgalli* was found resistant to DNA herbicide Pendimethalin. Pyrithiobac 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	Pyrithiobac (Pyr)	Imzethapyr	Pyr+ Quizlofop	Pyr+ Fenoxoprop	Pyr+ Propquizafop
Merremia emarginata						
Acalypha indica						
Celocia argentia						
Digera arvensis						
Parthenium hysterophorous						
Euphorbea hirta/ microcephala						
Tridax procumbense						
Commelina benghalensis						
Cynotis auxillaris						
Phyllanthus niruri						
Sorghum halepense						
Echinocloa cerussgalli						
Cyperus rotundus						
Eriochloa Polystachia						

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 *(Echinocloa 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 %.

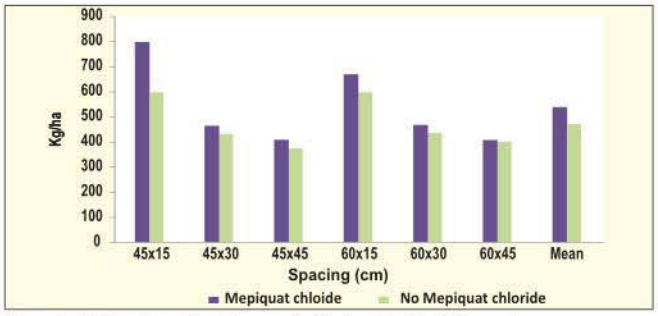


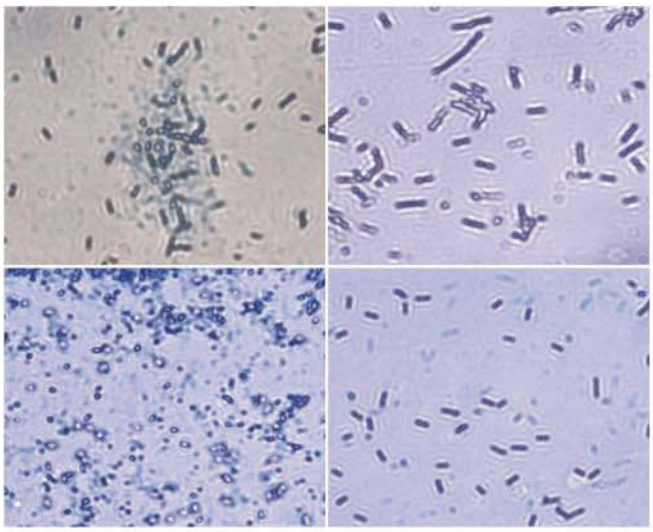
Fig. 3.12.1: Seed cotton yield (kg/ha) of *G. arboreum race cernuum* under different crop geometries and mepiquat chloride application

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.

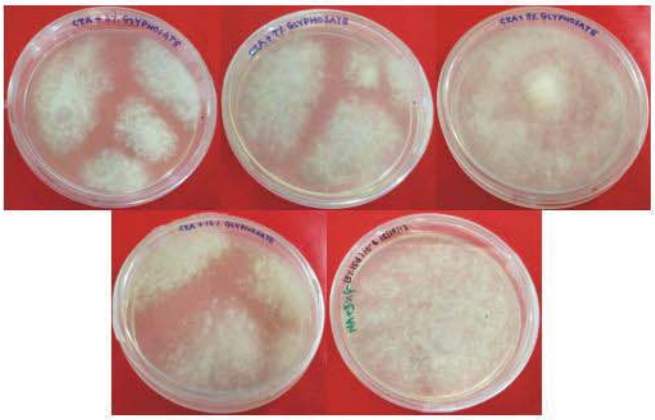


Spore staining of Bt isolates

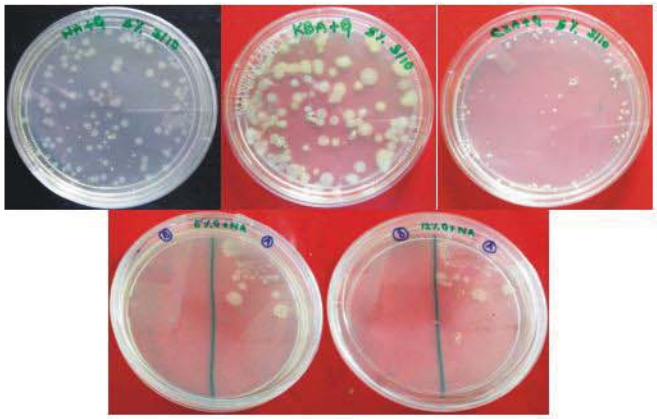
Isolation of glyphosate utilizing/degrading bacterial and fungal isolates

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 µg TPF g^{-1}) followed by semi-arid dry (SAd) (2.00 µg TPF g^{-1}) and the least DHA was recorded in arid bio-climate (1.62 µg TPF g^{-1}). Legume-based cropping system recorded significantly (p<0.01) higher DHA (2.32- 2.88 µg TPF g^{-1}) followed by cereal-based cropping system (1.29-2.82 µg TPF g^{-1}). The pooled comparisons of DHA from irrigated (1.98 µg TPF g^{-1}) and rainfed agro-system (1.97 µg TPF g^{-1}) did not show any significant differences. Intensive management practices increased soil DHA (2.15 µg TPF g^{-1}) than low management (1.78 µg TPF g^{-1}). Significantly higher microbial biomass carbon (MBC) was recorded in sub-humid dry (SHd) bio-climate (267 µg g^{-1}) followed by sub-humid moist and least in arid bio-climate (97.5 µg g^{-1}). Sugarcane-based cropping system had significantly higher MBC (246 µg g^{-1}) than the legume-based system (205 µg g^{-1}) and lowest in cotton-based system (128 µg g^{-1}). Significantly higher (175.7 µg g^{-1}) MBC was recorded in high management and irrigated agro-systems (173.9 µg g^{-1}) compared with low management (LM) (158 µg g^{-1}) and rainfed agro-systems (163 µg g^{-1}). Significantly higher microbial population was recorded in sub-humid moist bio-climate (6.26 $\log_{10}$ cfu g^{-1}) followed by sub-humid dry (6.21 $\log_{10}$ cfu g^{-1}) and the least microbial population was recorded in arid bio-climate (6.14 $\log_{10}$ cfu g^{-1}). Legume-based cropping system had significantly higher microbial population (6.23 $\log_{10}$ cfu g^{-1}) than the cereal-based cropping system (6.23 $\log_{10}$ 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%, KNO_3 3%, Monocrotophos 36% SL, Lime 0.5% Methomyl 40% SP, No Fertilizer, Normal Control (1% urea and 0.5% $MgSO_4$) 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

bolls 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_3 (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_3	24.4
Monocrotophos	17.3
Lime	15.5
Methomyl	44.4
No fertilizer	21.5
Urea + $MgSO_4$	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 3rd 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.

Pruned crop-Suraj | 40 days old crop | At harvest

Pruning technique for second fruiting cycle in cotton crop

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 ^{0}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.

3.18 : Seasonal Dynamics of Insect Pests and Diseases

Nagpur

Seasonal dynamics of cotton sucking pests and bollworms

Peak infestation of leafhoppers was recorded between 38th to 41st (SW) (Fig. 3.18.1). Similarly whitefly population was also at peak during this period (Fig. 3.18.2). Where as for aphids, two peaks were recorded at the beginning of the season (34 SW) and at harvesting stage of crop (2nd SW) (Fig. 3.18.3). The late infestation, severely affected the quality of seed cotton as sooty mold developed on leaves and lint. During initial phase of crop growth thrips population recorded was upto 5.03 thrips/ 3 leaves at 38 SW, however it declined subsequently and reappeared at the later part of season with peak at 3rd and 5th SW (Fig. 3.18.4). During the entire season, mirid *C. livida* population was low and negligible population of *H. armigera, E. vitella, P. gossypiella* and *S. litura* was recorded on Bt cotton during the season. Non Bt cotton recorded small population of the bollworms during 40 – 43 SW.

Fig. 3.18.1: Seasonal dynamics of leaf hopper

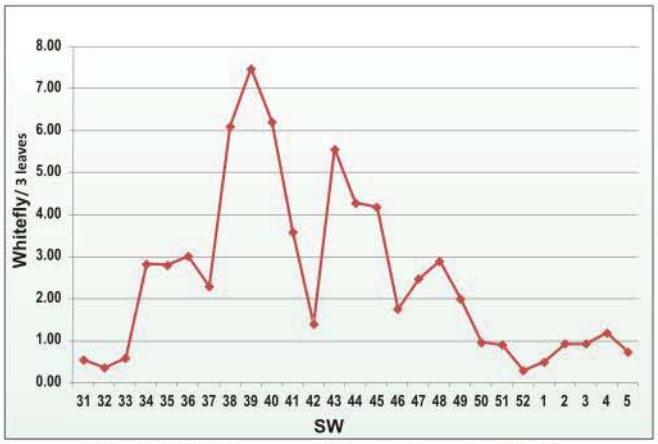


Fig. 3.18.2: Seasonal dynamics of whitefly

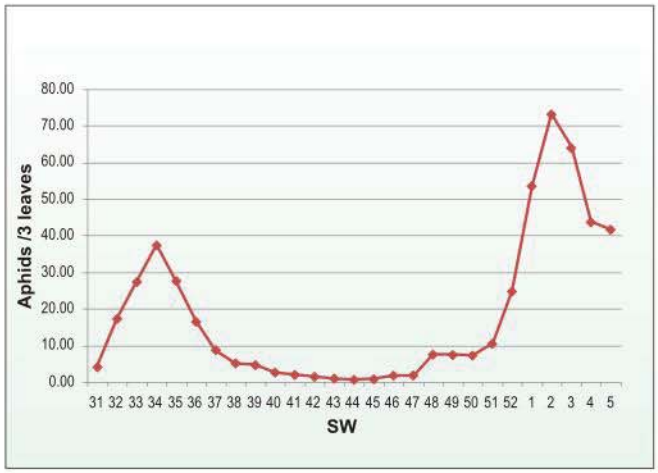


Fig. 3.18.3: Seasonal dynamics of aphid

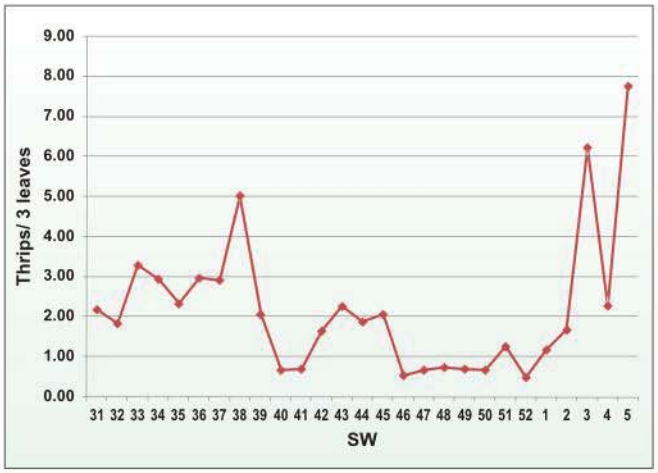


Fig. 3.18.4: Seasonal dynamics of thrips

The population dynamics of insect pests under high density planting system of cotton was recorded through out the season. The incidence of sucking pests was low at initial stage of crop at 33 DAS. In the entire cropping season leaf hopper was recorded below ETL except 70 DAS where it crossed ETL @ 7.43 Jassid nymphs /3 leaves /plant. The incidence of bollworm was low during the season with 3.5 – 8.7% square damage between 70 and 80 DAS. The per cent boll damage by bollworms was negligible throughout the season.

Correlation of insect pest with weather parameters

Leafhopper population was positively correlated with temperature and humidity while negatively correlated with rainfall and rainy days. Aphid population has positive correlation with T min, RH max & RH min and rainy days while negatively correlated with T max and rainfall. All the weather parameters were negatively correlated with mirid population.

Weather parameters	Leafhoppers /3 leaves	Aphids/3 leaves	Thrips/3 leaves	Whitefly/3 leaves	Mirid in top 1/3rd portion
T Max	0.556	-0.195	0.279	0.326	-0.030
T Min	0.459	0.2165	0.647	0.360	-0.634
RH Max	0.236	0.398	0.586	0.179	-0.610
RH Min	0.231	0.342	0.596	0.224	-0.654
Rainfall	-0.019	-0.422	-0.141	0.044	-0.095
Rainy days	-0.347	0.465	0.771	-0.18	-0.863

Pheromone trap catches of bollworms

Negligible pheromone trap catches as well as field damage of spotted bollworm was recorded during the season. American bollworm catches up to five moths/trap/week were recorded during 36-37th SW, subsequently decreased significantly, reappeared during the month of December at the boll opening stage with maximum catches during January (10 moths/trap/week). Population of pink bollworm never crossed ETL (8 moths/trap/night for three consecutive nights) during the normal season. Though large numbers of catches were recorded in case of *Spodoptera*, damage was not correlated with the pheromone trap catches.

Correlation between pink bollworm damage and pheromone trap catches

Pink bollworm damage on DCH32 and pheromone trap catches were positively correlated (r=0.41) during the crop season. The trapped moth catches and boll damage were initiated during second fortnight of October when T max and T min were 30°C and 21°C, respectively. Damage was seen to be increasing with decreased T max and T min subsequently. Highest moth catches and boll damage was recorded during last week of January (Fig. 3.18.5). Thus management of pink bollworm is crucial during second fortnight of October till the end of January. Bt cotton genotypes (BGII) were free from pink bollworm infestation.

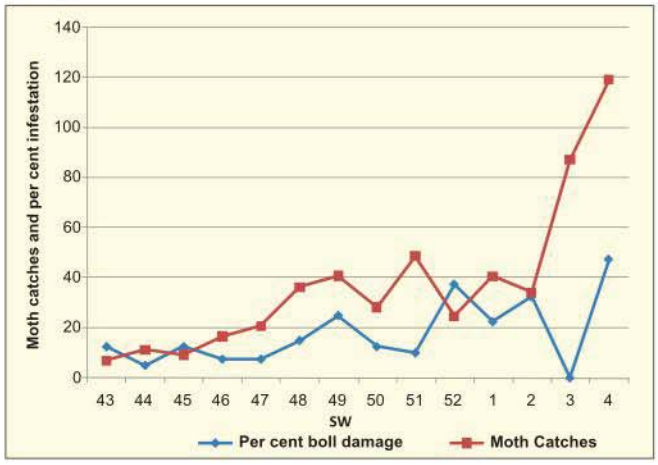


Fig. 3.18.5 : Pheromone trap catches vs percent boll damage

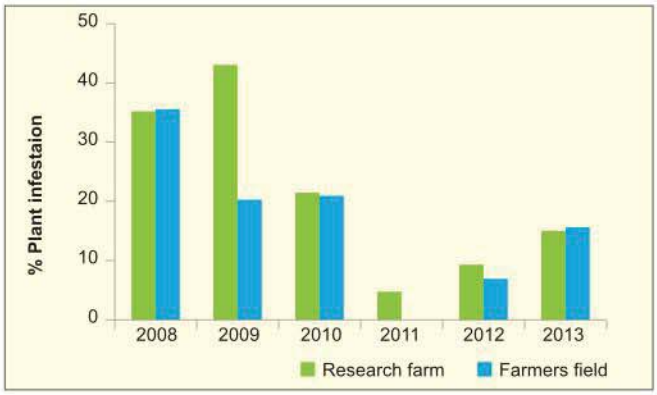
***Developmental studies* of mealybug *P. solenopsis* on 5 extreme constant temperatures**

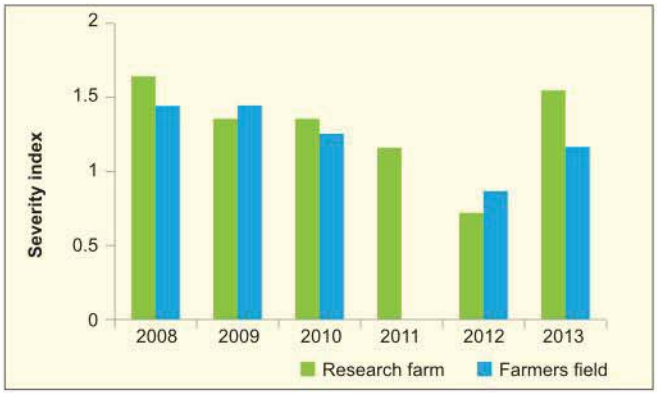
Life cycle of mealybug *P. solenopsis* at 5 constant temperatures (*i.e.* 12, 15, 18, 38, and 40 °C) with respect to fecundity, nymphal development, duration and average total life period, was studied. Maximum percent oviparity (97.7) was observed at 38 °C followed by18 °C (94.9). Adult longevity was maximum (28.6 days) at 18 °C followed by 12 °C, (27.1 days). The average total life cycle of female was longest at 18 °C of 82.8 days, followed by 12°C (54.1 days).

Sirsa

Population dynamics of cotton mealybug in north zone

Population dynamics of cotton mealybug in north zone indicated declining mealybug incidence from 2008-09 to 2011-12. However, the incidence and severity increased in the last two years (2012-13 and 2013-14).





Population dynamics to develop suitable forecasting model

Four varieties i.e. RCH-134 BG-II, RCH-134 Bt, HS-6 and Ganganagar Ageti (GA) were sown during 2013-14 to ascertain population dynamics of sucking pest (leafhopper, whitefly, thrips and mealybug), natural enemies (spider, chrysoperla and lady bird beetle) and bollworms. On the basis of 17 weekly observations, peak population of leafhopper, whitefly and thrips was recorded at 26, 30-31 and 30-32 SMW respectively in RCH-134 Bt, RCH-134 BGII, HS-6 and Ganganagar Ageti. No bollworm incidence was recorded in BG and its BG-II counterpart whereas in non Bt (HS-6: and Ganganagar Ageti) the bollworm incidence was recorded.

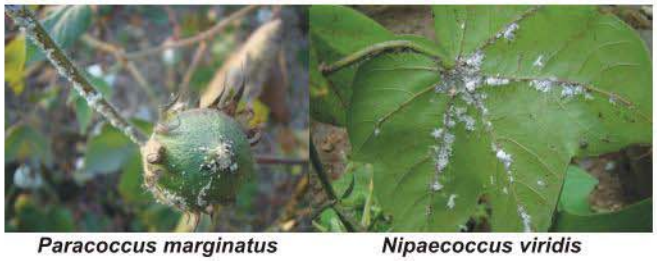
3.19 : Biological Diversity of Insect Pests and Pathogens

Nagpur

Biological diversity of insect pests of cotton in central zone

Mealybugs: During the crop season five mealybug species *viz*., cotton mealybug *Phenacoccus solenopsis* Tinsley, papaya mealybug *Paracoccus marginatus* Williams and Granara de Willink, pink hibiscus mealybug *Maconellicoccus hirsutus* (Green), spherical mealybug *Nipaecoccus viridis* (Newstead) and striped mealybug *Ferrisia virgata* Cockrell were recorded infesting cotton in sporadic manner. *P. solenopsis* was recorded from almost all the cotton growing districts of Vidarbha and Marathwada of central zone. *P. marginatus* which devastated cotton and other crops in South India is now being recorded on cotton in central zone. The mealybug was recorded from fields of Saoner of Nagpur district, Khairi–Taygaon village of Sausar Taluka of Chhindwada district (MP), and few locations of Aurangabad districts of

Phenacoccus solenopsis



Paracoccus marginatus *Nipaecoccus viridis*

Ferrisia virgta *Maconellicoccus hirsutus*

Marathwada region at the maturity stage of crop. *P. marginatus* infestation varied between 5-10% in the infested fields. *M. hirsutus* (Green), *N. viridis* (Newstead) and *Ferrisia virgata* Cockrell were recorded from Nagpur district. *Ferrisia virgata* was recorded on variety Suvin from experimental fields of CICR, RS, Coimbatore. Mango mealybug *Rastrococcus iceryoides* (Green) was not recorded in this season. Another mealybug species *Coccidohystrix insolita* Green has been recorded on pigeon pea which is the most preferred intercrop in central zone. *P. marginatus* was free of parasitoids in Nagpur.

Mirids : Three species of mirids *Campylomma livida* and *Hyalopeplus lineifer* Walker in central zone and *Creontiades biseratense* (Distant) in south zone were recorded infesting cotton. Nymphs and adults feed on squares and small developing bolls by piercing the plant tissues with their stylet. The affected area becomes dull in colour, then blackens and ultimately results in death of cells in the region. Feeding by these insects led to heavy shedding of medium sized squares and tiny bolls. Larger

Creontiades biseratense

Campylomma livida

Hyalopeplus lineifer

squares suffer damage that may cause development of deformed bolls which is often referred to as 'parrot beaking'. Diverse colour morphs (green, yellow and red) were noticed in *H. lineifer*.

Vertebrate pests : On as average, rodent pest caused 0.5 % loss by destroying whole cotton plants at maturity stage at CICR experimental fields during January 2014. Rodents made burrows in the cotton field and gnawed the tap root causing the separation of main stem from its tap root. Stored cotton were also damaged by rodents. Rat species *Bandicota bengalensis, Tatera indicia*, *Mus booduga* are known field rodents that cause damage in central India.

Monitoring of pink bollworm in India

The incidence of pink bollworm on BG, BG-II and non Bt cotton fields was monitored across India. The intensity of pink bollworm on non Bt was higher in Junagadh (78.68 %), Sirsa (61.21%) and Amreli (51.06 %) as compared to Surat, Bharuch, Anand, Rajkot, Surendranagar, Sriganaganagar, Hisar, Faridkot, Raichur, Rahuri, Dharwad and Khandwa. The lowest intensity of pink bollworm on Non Bt was recorded in Jalna and Nanded. The intensity of pink bollworm was more in Madhya Pradesh as compared to other cotton growing states in India.

Other minor pests : Green bug *Nazara virudula* at boll development stage was noticed. A large number of red cotton bug population was recorded at the boll opening

stage while dusky cotton bug was in lesser number.

Nematodes as pests of cotton

Characterization of plant parasitic nematodes associated with cotton in Vidarbha through pre-season and mid season surveys in Warud, Bhandara, Wardha, Katol, Kalmeshwar and Narkhed was initiated. Lesion nematode *Pratylenchus goodeyi* was found associated with cotton in samples from Warud and Bhandara districts. Populations in some samples ranged between 50-105 nematodes per 250 cc soil. Population of reniform nematodes crossed threshold (1 nematode /cc/soil) only in irrigated conditions. *P. goodeyi* characterized based on 18sRNA and populations were found to have significant variation in 18sRNA sequences. Molecular characterization of *Rotylenchulus reniformis* and *Hoplolaimus columbus* isolated from cotton fields at Buldhana heavily infested with reniform nematode was done. Sequences of 18sRNA genes KF275666 *(Hoplolaimus columbus)* and KF267455 *(Rotylenchulus reniformis)* deposited with NCBI.

All the common dicot weeds associated with cotton were found as good hosts of reniform nematode, *Rotylenchulus reniformis*

Sirsa

On the basis of three year data collected during 2010-2013, the average larval recovery at different locations in the north zone ranged from 0 to 15.54 % at different stages of crop. (Fig 3.19.1). No larvae were recovered from BG II cotton at any of the locations.

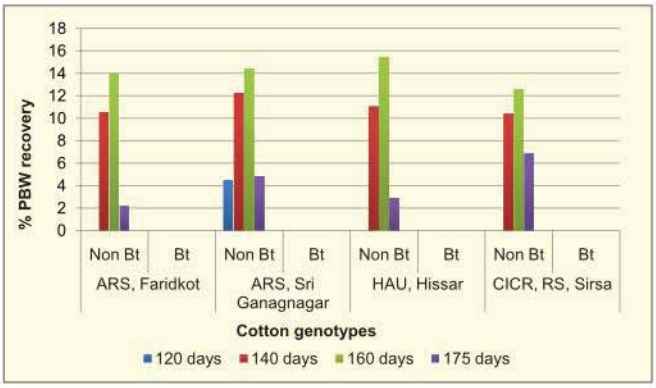


Fig. 3.19.1 : Pink bollworm (%) larval recovery from green bolls of Bt and Non Bt cotton collected at different stages of crop in north zone

Coimbatore

Occurrence of tailed mealy bug *Ferrisia virgata* (Cockerell) on cotton

Ferrisia virgata (Pseudococcidae: Hemiptera) was recorded on variety Suvin from experimental fields of CICR, Regional Station, Coimbatore. Percent infestation ranged from 16-83 during June – August 2013. The nymphs and adults were observed causing damage on the squares, leaves and bolls. Predator diversity was recorded on *F. virgata.* Grubs and adults of *Cryptolaemus* sp., *Scymnus* sp., and *Spalgis epius* fed on nymphs and adults of the mealy bug.

Tobacco Streak Virus (TSV) disease

Survey was carried out in two districts each in Andhra Pradesh (Guntur and Nandyal) and Tamil Nadu (Erode and Coimbatore). Of the 23 fields from ten mandals surveyed in Guntur district, TSV incidence was recorded in 20 fields; one field in Tuluru mandal and two fields in Pedanandipadu mandal were found free from the disease. One of the fields in Prattipadu mandal had the higher disease incidence of 27 %. Ten villages belonging to three mandals namely, Nandyal, Gospadu and Dornipadu of Karnal district were surveyed. No incidence of TSV was observed in one field in Bimavaram village (Nandyal mandal) and in two fields in Dornipadu village (Dornipadu mandal).

In Tamil Nadu, Coimbatore and Annur taluks in Coimbatore, and Anthiyur and Bhavani taluks in Erode districts were surveyed, where 1.5 % disease incidence was observed only in one field in Anthiyur block of Erode District. Others were completely free from TSV incidence.

At CICR Regional Station Coimbatore, 305 germplasm lines of *G. barbadense* L. were observed for natural incidence of TSV, as cotton with *G. barbadense* blood are considered to be more prone to TSV infection. Plants with typical TSV symptoms were observed in these germplasm lines and are documented.

TSV Symptoms on infected cotton plants

3.20 : New Genes and Gene Sources for Pest Management

Nagpur

Native lectin gene from *Trichoderma* cloned into expression vector and expression of lectin confirmed in the crude samples through ELISA. Also lectins produced from *Trichoderma* cross reacted with *Colocasia/ Amorphophallus* lectins.

Novel genes being deployed at CICR : CICR truncated toxin, Cry2Ab CICR, Fusion CICR were evaluated against *Spodoptera litura* F_1 neonates in a leaf dip assay. Also included in the bioassay were Cry2Ab corn leaf powder (96ug Cry2Ab/ml), MVPII 19.7ug Cry1Ac/ml and buffer control. Mortality was low varying from 6-13% with Cry2Ab CICR and Cry2Ab corn leaf powder. Cry2Ab CICR was on par to Cry2Ab corn leaf powder in terms of larval mortality but was superior to Cry2Ab from corn leaf powder in terms of growth regulation and percent larvae exhibiting growth regulation.

The crude toxin of CICR truncated Cry1Ac, Cry2Ab CICR, Fusion CICR were evaluated against *H. armigera* (F_1 one day old) in a diet incorporation bioassay. These were found inferior to the analogous toxins being produced in transgenic cotton in terms of larval mortality despite exhibiting excellent growth regulation. Further purification may help improve their toxicity in terms of larval mortality.

Isolated full length cDNA sequence of Chitin synthase A (4704 bp) of *Helicoverpa armigera,* and exons of alternative spliced variants (A1 and A2) 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 of chitin synthase A and B in whole insects of first and second instar, different stages and tissues (trachea, midgut and cuticle, of the 3rd, 4th and 5th instar larvae) of *Helicoverpa armigera* showed differential expression. The qPCR analysis using primers designed for conserved region of chitin synthase A and B remain highly expressed in the midgut tissue of all the tested larval stage.

RNAi mediated silencing of parasitism genes of *Meloidogyne incognita*

For molecular characterization rDNA sequences, the large subunit, small subunit and the internal transcribed spacer regions (ITS) were considered. The forward primer TW81 (GTTTCCGTAGGTGAACCTGC) and the reverse primer AB28 (ATATGCTTAAGTTCAGCGGGT) were used in the PCR reaction for amplification of the

complete ITS region. Amplicon was sequenced and blasted to confirm identity as cotton race of rootknot nematode.

RNA was extracted from Root-knot nematode females, males and juveniles. Quality of RNA was confirmed by running on Agarose gel and cDNA was synthesized. Based on sequences of oesophagial parasitism genes in data bases, primers were synthesized for twenty parasitism genes.

Egg masses of root knot nematode visible as brown specks

Reniform nematode infected field showing patchy growth

Screening for Lectins in cotton germplasm

Eight hundred and forty eight germplasm lines that were being evaluated for water logging and drought were also evaluated for the presence of lectins with cross reactivity to CEA/AMTL lectin in the seed and leaf using ELISA. None of the lines tested positive for the presence of the CEA/AMTL class of lectins.

3.21: Development of New Methods, Tools and Protocols

Nagpur

Evaluation of ethylene sensor

Digital hand held ethylene detection gadget (Portable ethylene gas detector 601 manufactured by Premier Controls, India) was evaluated for the first time for quantification of ethylene production under biotic stress. A leaf hopper stressed plant released upto 4 ppm ethylene at 60 DAS while ethylene levels were undetectable in control plants.

Three stress related genes (ERF 1,2,3) were studied for their expression in cotton leaves of leaf hopper infested and un-infested plants of *G. hirsutum* through RT PCR. 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 un-infested plants while ERF3 remained unaffected.

Diurnal variation in ethylene emitted from seventeen varieties was recorded using the hand held monitor. Ethylene emission was significantly higher in the morning as compared to the evening.

Ethylene sensor observations indicated insignificant difference between within infestation grades under protected and unprotected cotton plants while they were significantly different between different grades (Grade I and grade II to IV). Non infested plants emit least 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 and 1.65 ppm, respectively.

Sticky trap (28.5 cm x 22 cm) was used as a mobile trapping unit at 65 DAS. While it effectively trapped only leaf hopper and whitefly adults, nymphal population was

under estimated. If it is used early in the season it could help in mechanically controlling leaf hopper population build up in the field. The trapping of natural enemies was minimal when the sticky mobile trap was operated between 9.30 am to 12 noon.

Using this mobile sticky trap as a monitoring unit in 14 varieties manual counting was positively correlated (0.8) to the mobile sticky trap count with respect to leaf hopper adults.

Identification of suitable sensors for the development of electronic gadgets for the detection of pink bollworm

To detect the pink bollworm larva inside the bolls, techniques such as ultra sound and CT scan were applied. On using ultra sound, it was observed that the thick outer coat and cotton fibers inside the bolls prevented the penetration of the sound waves to get the clear picture of larva or boll content. However detection of pink boll worm using acoustic vibration sensors is found feasible in the development of the pest detection gadget.

1. Weather based population prediction model for sucking pests

***a. Campylomma livida* in rainfed cotton of central India**

Weather based population prediction model for Mirid *Campylomma livida* that was developed, revalidated and prediction accuracy was 92%. The criteria was satisfying ≥ 5, four and ≤ 3 of the six weather based parameters *viz*., temperature maximum > 31 ^{0}C and minimum 21-24 ^{0}C, relative humidity maximum > 85 % & minimum 30-70 %, rainfall < 25 mm and rainy days between 2 and 4 days on weekly basis predict the severity of *C. livida* on Bt cotton as to high (> 4 nos/plant), moderate (> 2-4 nos/plant) and low (0-2 nos/plant), respectively.

***b. Creontiades biseratense* in cotton with pulses as intercrop in south India**

Mirid bug *Creontiades biseratense* prediction modeling was developed in cotton with pulses as intercrop in south India. By using the mirid population data for (2008-09 to 2010-11) and weather parameters criteria taken for *C. livida,* a prediction model was developed. Prediction modeling developed for *C. biseratense* showed prediction accuracy of 80.00% during 2013-14.

2. Testing of weather based prediction for sucking pests

a. Jassids : Weather based heuristic rules for predicting jassids validated with data sets (2009 -2013) of Nagpur location indicated average 89 % accuracy. The prediction rules was developed by taking historical data sets (2001-2008). The criteria were mean temperature (25-28^{0}C), mean humidity (65-85 %), total rainfall (50-80 mm) and rainy days (2 to 4). Severity levels based on mean jassid population per three leaves were high (>8), moderate (> 4-8) and low (<4). All four, three and two or less of the formulated weather criteria being satisfied predicted high, moderate and low levels of jassid severity, respectively. Drawback of this rule was higher prediction accuracies at low levels of pest severity. The rules developed for Nagpur location tested across other locations of central zone indicated varying degree of accuracies and need fine tuning for individual locations.

b. Thrips : Weather based heuristic rules for predicting thrips were validated with independent testing data sets (2009-2013) of Nagpur location indicated average 97% accuracy. Weather based prediction rules was developed by taking historical data sets (2001-2008). Criteria were mean temperature (25-29 ^{0}C), mean humidity (67-86%), total rainfall (30-80 mm) and rainy days (3 to 6). Severity levels based on mean thrips population per three leaves were categorized as high (>10), moderate (>5-10) and low (<5). All four, three and two or less of the formulated four weather criteria being satisfied predicted high, moderate and low levels of thrips, respectively. This rule predicted well only at low levels of pest severity and therefore needs fine tuning.

3. Forecasting models for sucking pest

Forecasting models for sucking pest based on AICCIP historical data were worked out. Auto-Regressive Integrated Moving Average (ARIMA) model fitted. Goodness of fit statistics for the different pests for seven years (2005-11) average data for Junagarh and Akola indicated R^2 values for Junagadh 0.84, 0.93, 0.78, 0.86 and Akola 0.73,0.67, 0.63, 0.60 for aphids, jassids, thrips and whiteflies, respectively.

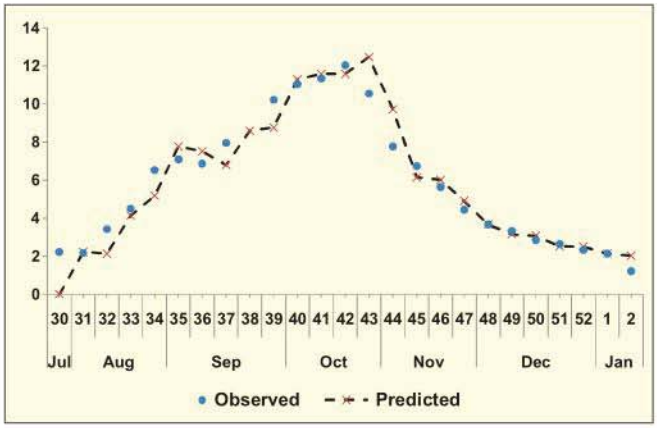


Fig. 3.21.1: Actual and predicted values of average Jassid incidence for seven years for the SMW 30-52 and 1 and 2 for Junagarh

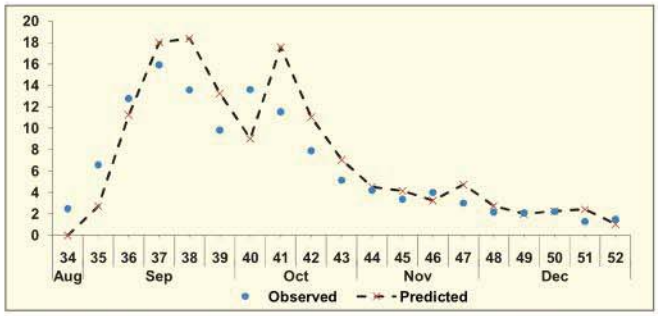


Fig. 3.21.2 : Actual and predicted values of average Jassid incidence for seven years for the SMW 34-52 for Akola

3.22: Host-Plant Resistance to Insect Pests and Diseases

Nagpur

Five cultures with elite fibre properties and comprehensive pest tolerance gave yields of 8 q/ha under unprotected conditions at normal varietal spacing. Of these 2 cultures ranked 3rd (14 q/ha) and 4th (13.9 q/ha) with respect to yields in station trial. One of these is compact with short sympodia, also making it suitable for HDPS.

CINHTi1 and CINHTi2 registered genetic stocks from the division were tested under HDPS. Minimal incidence and damage due to sucking pests were recorded on CINHTi2 while CINHTi1 recorded minimal pink bollworm infestation.

About 100 single plant selections for jassid resistance (ie those plants showing Grade 0) were made in Suraj plot at peak leaf hopper incidence.

Among the different cotton genotypes screened against reniform nematode, *Rotylenchulus reniformis*, G-Cot -10 was found to be moderately resistant and American Nectariless was found to be resistant. Based on biology and histopathological studies, all other genotypes were recorded with varying degrees of susceptibility to reniform nematode.

3.23: Biological Control

Nagpur

Three novel strains of *Trichoderma* (two *T. harzianum* and one *T. atroviride*) from wild mushroom and tree bark were isolated and evaluated for their biocontrol potential against *Sclerotium delphinii* infecting cultivated cotton seedlings. *T. harzianum* strain CICR-G, isolated as a natural mycoparasite on a tree-pathogenic *Ganoderma* sp. exhibited the highest disease suppression ability. This isolate was formulated into a talcum-based product and evaluated against the pathogen in non-sterile soil. This isolate conidiated profusely under conditions that are non-conducive for conidiation by three other *Trichoderma* species tested, thus having an added advantage from commercial perspective. Trichocash, a *Trichoderma harzianum* formulation developed at CICR, was submitted to AICCIP for multi-location testing.

A strain of *Trichoderma* that is sold widely in India as *T. viride* was analysed and a DNA-sequencing (tef1 gene) - based phylogeny revealed that this isolate is not *T. viride* (as claimed) but *T. asperelloides*. This analysis was also performed on a commercial formulation based on *T. viride* TNAU isolate (Phytoguard 1% WP, Central Biotech, Nagpur, India) and the sequence was identical with that of the original TNAU isolate, thus confirming the identification. The tef1 large (4th) intron sequence has been deposited with NCBI Gen Bank (accession no. KC679856). This finding necessitates the re-designation of more than 250 registered commercial formulations based on *T. viride* TNAU isolate as *T. asperelloides.*

Three native bio-control agents with demonstrated efficacy against cotton disease causing pathogens under *in-vitro* conditions registered with National Bureau of Agriculturally Important Microorganisms: *Trichoderma harzianum* CICR E: MTCC11500, *T. harzianum* CICR G: MTCC11511, *T. atroviride* CICR A: MTCC11512.

A native, rare, multiple Hymenopteran endo-parasitoid *Bracon lefroyi* (Dudgeon & Gough) caused large scale pink bollworm larval mortality in non Bt field populations of Nagpur for the first time. Dead pink bollworm larvae were placed individually in vials. Grubs of the parasitoid were seen in some vials along the body of pink boll worm. These grubs converted to pupae and adult emergence was noted. Emergence of the parasitoid was not recorded from all dead pink bollworm larvae indicating that parasitoid may have emerged prior to collection of pink bollworm larvae or that natural mortality of the pest may be due to more than one factor. This parasitoid was reported also from Iran on *Earias insulana* in 1976. Natural parasitisation of pink bollworm is being reported after a very long time in cotton. Avoidance of insecticide sprays from green boll - boll opening stage in this region would be necessary to conserve this endoparasitoid.

Sirsa

Seed treatment using IARI's biofilm technology was found effective in enhancing plant stand and seedling vigor of variety PKV 081 in Nagpur while it enhanced protection against *Rhizoctonia solani*.

Coimbatore

Isolation and charatersation of micro flora from the gut system of the insects

Three bacterial endosymbionts were isolated of which 2 endosymbionts were characterized from *H. armigera* larvae.

Bacterial endosymbionts isolated from *H. armigera* gut, submitted to NCBI Gene Bank

S.No	Organism	Gene accession Number
1.	*Asaia bogorensis* strain CICR8	KF747356
2.	*Klebsiella variicola* strain CICR14	KF747357

Nagpur

Evaluation of TrichoCASH (*Trichoderma harzianum* 1% WP) under field conditions

Seed treatment with TrichoCASH (*T. harzianum*) CICR-G 1% WP - (10 g/kg seed) recorded highest mean single boll weight (3.87 g), seed cotton yield (8.98 q/ha) and lowest myrothecium leaf spot (20.63 PDI) and grey mildew disease (15.33 PDI) incidence compared to control mean single boll weight (3.25 g), seed cotton yield (8.46 q/ha), myrothecium leaf spot (31.74) and grey mildew incidence (19.0) and statistically non significant.

Evaluation of microbial inoculants for seed treatment in cotton

Among microbial inoculums, *Bacillus* sp alone recorded highest root length (11.81 cm), shoot length (20.93 cm) and biomass (7.86 g) followed by Microbial consortia (MC)+TrichoCASH - root length (11.76 cm) and shoot length (20.90 cm) compared to control root length (10.41 cm), shoot length (19.76 cm) and biomass (6.05 g).

Bacillus sp. alone recorded highest seed cotton yield (12.58 q/ha) followed by TrichoCASH alone (12.55 q/ha) and *P. fluorescens* alone (12.08 q/ha) compared to control (10.35 q/ha).

TrichoCASH alone recorded significantly lowest PDI for Bacterial blight (11.38) followed by MC alone (15.51), Imidacloprid +Thiram (16.08), *Cedeceae davisae* alone (16.36) and *P. fluorescens* alone (18.32) compared to control (22.46).

Cedeceae davisae alone recorded lowest Grey mildew disease incidence (16.33) compared to control (17.33).

Evaluation of bio-inoculants for growth promotion and bio-control in *G. hirsutum* and *G. arboreum*

Anabaena laxa + *Providencia* based formulation recorded highest seed cotton yield (10.39 q/ha) and lowest *Myrothecium* leaf spot incidence (30.18 PDI) compared to control seed cotton yield (8.77 q/ha), *Myrothecium* leaf spot incidence (42.11 PDI) in genotype PKV 081.

Anabaena - *Azotobacter* biofilm based formulation recorded highest average single boll weight (2.17 g) compared to control (1.81 g) while *T. viride – B. subtilis* biofilm based formulation recorded highest seed cotton yield (5.03 q/ha) compared to control (3.62 q/ha) in genotype AKA 7.

Field evaluation of bio-inoculants against bacterial blight disease

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 with Cv. 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.

Field evaluation of potassium silicate formulations against bacterial blight disease

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) that were on par with each other and significant over control (47.60) under natural incidence 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 on par with each other and significant over control (52.38) under artificial inoculation conditions in Suraj under HDPS (Fig. 3.23.1).

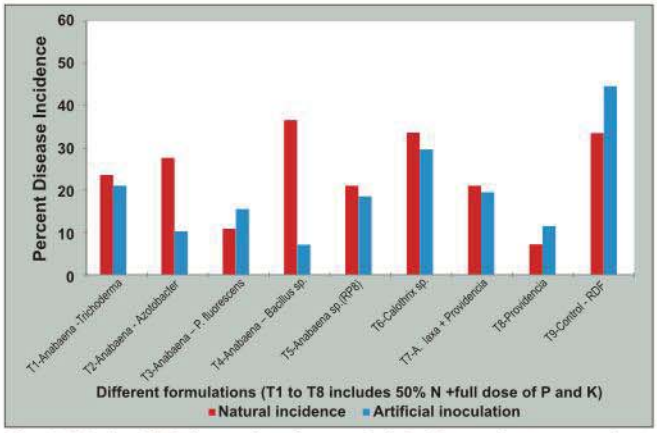


Fig.3.23.1: Field evaluation of bio-inoculants against bacterial blight disease in cotton using variety Suraj under HDPS

Taxonomic diversity of bioagents of cotton pests recorded in central zone

a. Parasitoids

Aenasius bambawalei Hayat (Hymenoptera: Encyrtidae) was seen to parasitize mealybug *P. solenopsis* on cotton in central zone. This species played a very significant role in keeping *P. solenopsis* population under check. During the season, parasitism ranged from 1 to 35 % with an average of 11.01 %. Highest parasitism was recorded during January from mealy bug colonies collected from Amravati.

Acerophagus papayae (Hymenoptera: Encyrtidae): Coincidental natural occurrence of a solitary endoparasitoid *Acerophagus papayae* Noyes & Schauff was recorded from colonies of *P. marginatus* collected from infested cotton fields from Nagpur, Aurangabad and Chhindwada. Up to 21 % parasitism of *P. marginatus* by *A. papayae* with an average of 8.1% was recorded from the collected mealybug colonies.

Anagyrus kamali Moursi (Hymenoptera: Encertidae) was found to parasitize mealybug *N. viridis* upto 14%. The species was recorded from mealybug colonies collected from Nagpur and Chhindwada districts.

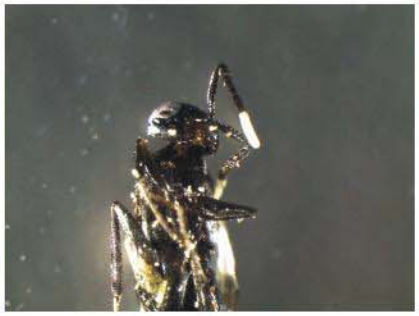
Aprostocetus sp. (Hymenoptera: Encertidae) was found to parasitize *N. viridis* about 7.5% from colonies collected from Aurangabad and Beed districts of Marathwada region.

Homalotylus sp. (Hymenoptera: Encertidae) was identified from the *P. solenopsis* colonies collected from Gujarat in the previous year. Insects from this genus hyper-parasitize ladybird beetles.

Aenasius bamabawalei

Acerophagus papaya

Anagyrus kamali



***Homalotylus* sp.**

b. Predators

Lady bird beetle, *Cheilomenes sexmaculata* (Fabricius) (Coleoptera: Coccinellidae) is a general predator of cotton whiteflies, mealybugs, leafhoppers, mites, and early instar lepidopteran larvae. Population started increasing during mid August, fluctuating during entire crop season with the highest population during 1st week of August to first fortnight of September.

Dipteran fly Cacoxenus perspicax (Knab) (Diptera: Drosophilidae) found to predate on *N. viridis* infesting cotton. The species predated 26.3% mealybug population at Amravati and Nagpur.

c. *Hyperparasitoids*

Promuscidea unifasciativentris was recorded from *N.viridis* colonies parasitized by *Anagyrus kamali* and *Aprostocetus* sp. Hyperparasitism was about 9.5%.

***Aprostocetus* sp.**

Cacoxenus perspicax

Promuscidea unifasciativentris

Lace wings, *Chrysoperla carnea* (Stephans) (Neuroptera:Crysopidae) feed on several species of small bodied insects especially aphids, mites, thrips, whiteflies, eggs of leafhoppers, etc. Negligible population was recorded during the current crop season.

Spiders (Arachnida) are the generalist predators, can kill a large number of insects per unit time and hence are of great importance in reducing and even in preventing outbreaks of insect pests in agriculture. Both nymphs and adult are predatory on host insect leafhoppers, aphids, mirids, whiteflies and all lepidopteran larvae feeding on cotton leaves, bolls and squares. In cotton agro ecosystem wide range of spiders are found which act as biological control agents of cotton insect pests. Nine species of spiders have been identified from cotton fields during crop season 2013-14. Spider population gradually increases with the increase in prey population with its first peak during 39th SW and another in 49th SW and thereafter declined.

Identified species of spiders

1. *Bianor sp.* (Peckham & Peckham, 1886) Family-Salticidae
2. *Leucauge decorata* (Blackwall,1864) Family-Tetragnathidae
3. *Lysiteles* (Simon, 1895)
4. *Neoscona theisi* (Walckenaer, 1841) Family-Araneidae

5. *Oxyopes pankaji* (Gajbe & Gajbe, 2000) Family-Oxyopidae
6. *Phintella vittata* (C. L. Koch, 1846) Family-Salticidae
7. *Thomisus spectabilis* (Doleschall, 1859) Family-Thomisidae
8. *Thomisus (*Walekenaer, 1805) Family-Thomisidae
9. *Thyene imperialis* (Rossi, 1846) Family-Salticidae

Neoscona theisi **(Walckenaer, 1841)**

Oxyopes pankaji **(Gajbe & Gajbe, 2000)**

Thomisus spectabilis **(Doleschall)**

Thyene imperialis **(Rossi)**

Coimbatore

Entomopathogenic-endophyte mediated plant defense as a novel approach for the management of boll worms

Twenty fungi and fourteen bacteria were isolated as endophytes from stem and leaf parts of cotton plant.

Bioassay was carried out with bacterial isolates, showed entomopathogenic activity (13.27% to 48.89%) against pink bollworm *P. gossypiella.*

Five endophytes were identified by morphological characterization. They were *Trichoderma pseudokoningi, Penicillium* sp, *Aspergillus flavus* and *Aspergillus terrus.*

Four bacterial and seven fungal endophytes were sequenced by 16S rRNA and 18S rRNA respectively. Two bacterial endosymbionts from *H. armigera* also sequenced by 16S rRNA.

Seven isolates of *Beauveria bassiana* were isolated from coffee berries. It has high virulence against aphids, spodoptera and pink bollworm. One *Beauveria bassiana* isolate was isolated from wild cotton plant.

Three virulent native nematode antogonists *viz.*, *Purpureocillium lilacinus, Bacillus* sp and *Pseudomonas flourescens* were isolated from nematode suppressive soils and proved to be effective against root-knot and reniform nematodes. Molecular characterization of three native entomopathogenic fungi have been carried out and submitted to Gene Bank.

Bacterial Endophytes

Totally fourteen bacteria were isolated as endophytes from stem and leaf parts of cotton plant. Among this nine belonged to *Bacillus* sp. Four bacterial endophytes were submitted to NCBI Gene Bank (Table 3.23.1).

Table 3.23.1 : Bacterial endophytes submitted to NCBI Gene Bank

S.No	Organism	Gene accession Number
	Bacteria (16s rRNA)	
1.	*Enterobacter cloacae* strain CICR11	KF747358
2.	*Bacillus safensis* strain CICR13	KF747359
3.	*Aeromonas hydrophila* strain CICR9	KF747360
4.	*Bacillus stratosphericus* strain CICR10	KF747367

Optimum temperature and pH for the mass multiplication of *Cladosporium cladosporioides* were 25-30°C and pH 5–6 respectively. Sorghum grains supported maximum multiplication and virulence of *C. cladosporioides*.

Potato Dextrose Agar supported maximum multiplication of *C. cladosporioides* whereas Sabaraud Dextrose Agar with Yeast Extract supported maximum multiplication of *Lecanicillium lecanii, Metarhizium anisopliae* and *Fusarium pallidoroseum.*

3.24 : Integrated Pest Management

Nagpur

Available new seed treatment methods for management of sucking pest population at 47 DAS were evaluated but the pests (jassid, whitefly and thrips) were below ETL. However, the treatment, *Pseudomonas fluorescens* alone @ 5 % (10^{10} Cfu/ml) (5.83 aphids/ 3 leaves / plant) and Imidacloprid + Thiram @ 7ml + 3.0 g/kg (6.11 aphids/ 3 leaves / plant) were numerically significantly superior over other treatments.

Evaluation of yellow sticky traps for monitoring IPM

Yellow sticky traps were employed to trap targeted pest whitefly and leafhoppers. Whiteflies were trapped in

large numbers during 38-43 SW that corresponds first week of September to last week of October (Fig 3.24.1). Leafhoppers were trapped in large numbers throughout the season (Fig 3.24.2). Aphids trapped were very small in numbers during the late season. Non targets insects trapped among them were Lady bird beetle, Dipteran flies and hymenopterans. Average per cent insect fauna trapped were whiteflies 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.

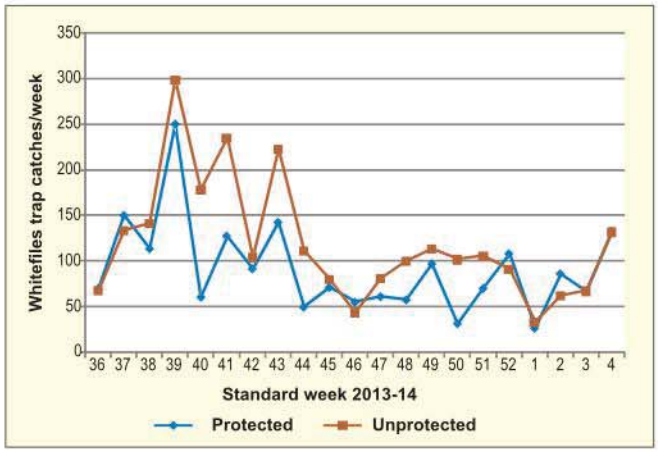


Fig 3.24.1: Yellow sticky trap catches of whitefly

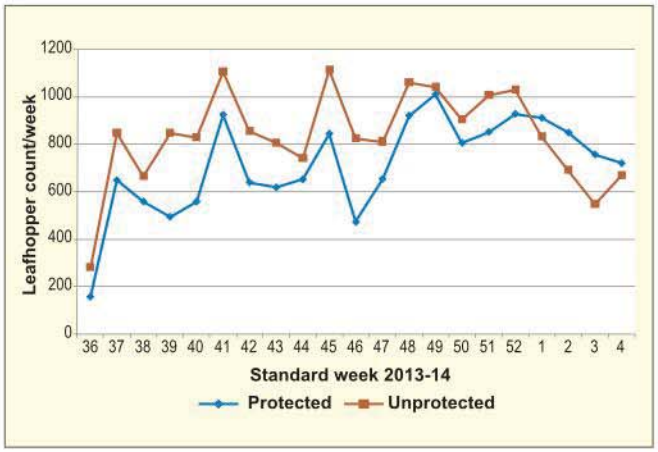


Fig 3.24.2: Yellow sticky trap catches of Leafhoppers

Protection technologies for management of bollworms under high density planting (HDPS) in different windows of 60,80,100 and 120 DAS with five insecticides namely Clorantraniliprole 18.5 SC, Flubendiamide 480 SC, Spinosad 45% SC, Indoxacarb 14.5 SC and Emamectin benzoate 5 % SG was attempted. Among all insecticides Clorantraniliprole 18.5 SC and Flubendiamide 480 SC were best for bollworm management recording lowest fruiting bodies damages at 60 DAS and 80 DAS as compared to other insecticides. During the season, the American bollworm however did not cross ETL. Insignificant differences among the treatments were recorded for natural enemies.

Insecticide and Bt resistance monitoring

Nagpur

Monitoring changes in baseline susceptibility to Cry toxins

Cotton semilooper *Anomis flava* is 1000 fold more tolerant to Cry2Ab (LC_{50}=0.212 µg/ml) as compared to Cry1Ac.

H. armigera from Sirsa were collected on BG I F_1's Demonstrated LC_{50} and EC_{50} value of 2.46 and 0.061 µg/ml of diet for Cry1Ac.

F_2 screen study of *H. armigera* was carried out using 256 iso-females for Gujarat 215 and iso-females for Maharashtra. Resistance to Cry1Ac was detected in the F_2 population of Surat A7, 2, 5 and F_1 population of Buldhana A10.

The resistant Surat *H. armigera* (Surat A7,2,5,1,5) line exhibited no mortality at the highest concentration of 1.97 µg/ml of diet of MVPII with an EC_{50} of 0.071 µg/ml for Cry1Ac while LC_{50} to Cry2Ab was 2.66 µg/ml of diet and EC_{50} was 0.712 µg/ml of diet.

Corn leaf powder was being used as a source of Cry2Ab protein for insect bioassays. Only Cry2Ab expressing cotton plants have been identified using ELISA in the segregating F_2 progeny of Mallika BGII whose seeds will serve as a source of Cry2Ab hence forth. We now have lines identified from the segregating F_2 population, expressing Cry1Ac alone, Cry2Ab alone, Cry1Ac and Cry2Ab together and lines without the Cry toxins.

Resistance to Cry1Ac and Cry2Ab in pink bollworm populations collected during 2013-2014 was monitored. Srivilliputtur, Sirsa, Junagadh and Khandwa recorded 2, 9, 4, and 20 fold resistance to Cry1Ac over susceptible check. Faridkot, Mansa, Sirsa, Rahuri, Akola, Junagadh and Khandwa populations of pink bollworm recorded 25, 35, 35, 30, 40, 45, 140 and 330 fold resistance over the susceptible check to Cry2Ab.

Ninety six iso-females were established using pink bollworms collected from non-Bt of Sirsa and Sriganganagar among which 11 iso-females yielded larvae for bioassays of which progeny of 4 iso-females were subjected to bioassays with 10 ppm and 1 ppm of Cry1Ac and Cry2Ab, each, and were found susceptible.

Coimbatore

To monitor the development of resistance in Pink bollworm neonates, II and III instars to Bt cotton bioassays were conducted with Cry1Ac.The LC_{50} in ppm

were recorded for Cry1Ac as 0.079 - (neonates),0.195 - (II instar) and 0.753 – (III instar) respectively. LC_{50} values against neonates with cry 2Ab was recorded as 0.040 ppm.

Insecticide resistance

Nagpur

Efficacy of a new insecticide Pyridalyl was compared to its nano formulation developed by IARI against one day old *H. armigera* in diet incorporation bioassays. Pyridalyl recorded an LC_{50} of 68.74 ppm while nano pyridalyl recorded an LC_{50} of 43.88 ppm. The EC_{50} of nanopyridalyl (16.74 ppm) was 3 fold higher than pyridalyl (51.26 ppm). Utility lies in the fact that less load of pyridalyl, if used as nano pyridalyl, would be delivered into the environment.

Against 3rd instar larvae of the pink bollworm, using diet incorporation bioassays, Pyridalyl recorded an LC_{50} of 13724 ppm while nano pyridalyl recorded an LC_{50} of 9166 ppm. The EC_{50} of nano pyridalyl was 11.8 fold higher (346 ppm) than Pyridalyl (4094 ppm). Pyridalyl (conventional and nano form) caused 100% mortality of neonate pink bollworm larvae in all the treatments except control and LC_{50} of Pyridalyl against neonate pink bollworm is less than 5 ppm.

Thiodicarb topically bioassayed against 2 strains of *H. armigera* (Coimbatore and Washim) at the 3rd instar recorded LC_{50} of 2.51 ppm and 1.91 ppm, respectively. Flubendiamide a new molecule topically bioassayed against 3rd instar larvae of 2 strains of *H. armigera* from Sirsa and Parbhani exhibited an LC_{50} of 0.297 ppm and 0.117 ppm respectively. The commercial formulation Fame, was used in diet bioassays against third instar larvae of 4 populations (Palem, Hingoli, Buldana and Nagpur) of *H. armigera* recording LC_{50}s of 0.0038 ppm, 0.009 ppm, 0.009 ppm and 0.0187 ppm respectively. Deltamethrin assayed topically against *H. armigera* from Sirsa demonstrated an LC_{50} of 22.39 ppm.

Sirsa

Lab and field monitoring of resistance in bollworms against Cry toxins

Eighty six isofemale lines from *Earias insulana* population of Sirsa have been screened for presence of rare resistance allele**.** Two isofemale lines and 5 individuals had survived up to 19th day on cry toxin incorporated diet without any moulting and gain in weight.

LC_{50} of Cry1Ac ranged from 0.14 to 0.70 µg/ml of diet for *H. armigera* population. LC_{50} of Cry1Ac for *H. armigera* population from Hanumangarh district found to be highest (0.70 µg/ml of diet). LC_{50} of Cry1C ranged from 1.59 to 4.05 ug/ml of diet for *H. armigera* population and highest being found for population from Bhiwani (4.05 µg/ml of diet). LC_{50} of Cry1C was found to be 0.91 and 0.72 µg /ml for population of *Spodoptera exigua* from Mansa and Hanumangarh respectively.

Dissemination of insecticide resistance management programme

Sirsa

A total of 757 acre area was covered for the implementation of IRM strategies in 7 villages of Sirsa. The weekly data on insects, diseases and beneficials was recorded in villages and used for decision making interventions. Major emphasis was given on the development of resistance in sucking pests against insecticides and bollworms against cry toxins. Farmers were encouraged to grow refugia around Bt cotton hybrids. This was followed by collecting information on insecticide consumption and number of sprays. Information on the seed cotton yield and cost of cultivation was also gathered to arrive at Cost Benefit ratios of IRM and non-IRM farmers. On the basis of 15 observations recorded under normal sown IRM field with Bt genotype, the population (per 3 leaves) of whitefly ranged between 9.91-38.51, thrips between 0.00-24.27 and leafhopper between 0.73-2.81/3 leaves where as in Non-IRM field the population of whitefly, thrips and leafhopper/3 leaves recorded was 8.95-46.65, 0.00-22.45 and 0.65-3.15.

Innovative interventions for leaf curl management

Based on two year pooled results the efficacy of best interventions (cow urine @ 6.6 %, kresoxim methyl @ 0.1 %, calcium nitrate @ 0.5 % , neem oil @ 1% and whey protein @ 5 %) were verified in larger plots with two CLCuD susceptible Bt hybrids (RCH 134 BG II and ABCH 157 Bt). The interventions were also validated under farmer field conditions at five locations with CLCuD susceptible Bt hybrids. 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 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.

Among various insecticides and biopesticides applied for CLCuD and its vector (whitefly) management in different modules, module- 3 (Nimbecidene at 30 DAS; Clothianidin at 45 DAS; Nimbecidene+YST at 60 DAS; *V. lecanii* at 75 DAS and Triazophos 40% EC at 90 DAS) resulted in maximum (63.03%) reduction of whitefly population after 7 days of spraying.

Nagpur

CICR demonstrates HDPS in cotton

The productivity of cotton in India is low, around 500 kg lint/ha and high density planting system (HDPS) with straight varieties appear to be a viable option to improve the productivity of cotton particularly under rainfed conditions at reduced production costs. Research efforts pioneered by the CICR, Nagpur culminated in a technology for high density planting system (HDPS). The peak water and nutrient demanding phase of long duration hybrids and varieties coincides with the post monsoon phase where the moisture release from marginal soils is low. Although no conscious efforts to breed dwarf, compact plant types have been made in the past. CICR tested several compact varieties and among them - AKH 081 (PKV 081), NH 615, Suraj, Anjali, F 2383, KC 3 (*G. hirsutum*) and AKA7, JK 5, HD123 (*G. arboreum*) could be planted at 60×10 cm, 45×15 cm or 45×10 cm under rainfed conditions depending upon the soil type. Thus by increasing the plant population from 50,000 plants/ha (for varieties) to 1.5 -2.0 lakh plants/ha, it is possible to realize 1800-2000 kg/ha seed cotton/ha with the above varieties on marginal soils under rainfed conditions with minimum inputs. The important components of the HDPS technology area s follows:

- Early dry sowing after the receipt of pre-monsoon showers
- Maintain a plant population: 1.2 -2.5 lakh plants/ha depending on the soil type, variety and growing conditions.
- Planting at spacing: 45-75 cm between rows and 10 cm between plants using a sarta, bullock or tractor drown seed drill @ 4-5 kg seeds/acre
- Planting semi - compact varieties:
  - SURAJ-best fibre quality with high adaptability
  - PKV 081-medium staple, early, tolerant to sucking pests
  - NH 615-medium staple, jassid resistant
- Sowing on ridges or ridges during inter-culture for moisture conservation
- Weed control : inter-culture and use of post-

emergence weedicides

- Low sucking pest incidence. Seed treatment and only 1-2 sprays depending upon the Economic Threshold Level to control bollworms

The production cost is low (Rs. 15000-20000/ha), high yield (20-25 q/ha) under shallow soils (rainfed) and moreover the seeds can be reused. Encouraged by the experimental results, CICR conducted 160 farmer participatory trials of HDPS of 1 acre each on shallow to medium soils under rainfed conditions in Vidarbha during 2012-13, which turned out to be a drought year, with a low cost input strategy. The varieties tested were Suraj, NH 615, AKH 081(PKV081), AKA 7 and HD 123. Across nine districts, the mean yields ranged from 15-18 q/ha which is more than twice the average yield of Vidarbha. Buoyed by the success and the enthusiasm among the farmers, CICR extended the on farm demonstrations to 2303 (of one acre each) in Maharashtra and other states Haryana, Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu and Odisha with the active involvement of the State Agricultural Department and SAUs with financial assistance from the Centre under TMC MM-II. The results are summarized in table below.

Yield (q/ha) in demonstration traials of HDPS in cotton (60 x 10 cm spacing) during 2013-14

State	Trials	Seed cotton yield in q/ha		
		Minimum	Maximum	Average
Haryana	12	22.5	40	30
Rajasthan	10	20	30	22
MP	50	15	30	24
Maharashtra	1740	10	37.5	18
AP	308	10	30	22
Odisha	52	27.5	37.5	32
Karnataka	51	10	32.5	20
Tamilnadu	80	10	25	18
Total	**2303**			

The HDPS system is proving to be a boon for cotton farmers across the country many of whom are cultivating cotton on marginal soils with low inputs.

Crop pest surveillance and advisory

Cotton pest management strategies through ICT tools (computer, internet and mobile) were disseminated as a part of Crop Pest Surveillance and Advisory Project (CROPSAP) in 28 districts of Maharashtra. Updated the pest management strategies for target pests, monitored online pests situation through information/data uploaded on website since August 2013 and 14 personal visits (in 11 districts of Vidarbha and Marathwada), analyzed pest situation weekly, alerted and issued advisories wherever required during the season.

IRM strategies for HDPS program

IRM strategies for the HDPS programme implemented in 2013–14 for Maharashtra, Madhya Pradesh, Andhra Pradesh, Odisha, Haryana, Karnataka and Tamil Nadu were extremely critical for non-Bt varieties that were being recommended under this programme. Pest management in Bt cotton was also disseminated through proactive strategies.

During 2013–14, IRM strategies were disseminated for 8982 farmers in 15,915 ha in a total of 371 villages of 35 districts from 10 different states across India.

A total of 918 field visits, 357 group meetings, 4 field days and 114 training programmes were organized for dissemination of the IRM strategies. Novel approaches such as 'Hello IRM' (live programme on radio), street plays, farmers' group meetings, field visits, training and demonstration etc. were also adopted as tools for dissemination of the IRM strategies to create awareness about the program among the farming community.

Coimbatore

Herbicide rotation technology

Application of pendimethalin 1.0 kg ai/ha on third day after sowing followed by one hand weeding and hoeing at 35–40 DAS and application of pyrithiobac sodium 50 g ai/ha + quizalofop ethyl 50 g ai/ha at 60–65 DAS was demonstrated in three farmers' field of Kanjapalli village of Coimbatore district.

On-Farm demonstration of CICR technologies

Six promising cotton technologies were assessed through on-farm demonstration. Improved cotton genotypes, enhancement of seed quality by sequential pelleting, Integrated Pest Management and Insecticide Resistance Management, CICR nutrient consortia for boosting yield, manipulation of morpho-frame through foliar application of ethrel and herbicide rotation were demonstrated on cotton variety Suraj. All the treatments showed a significant yield improvement over the control by 15–40 per cent.

Dissemination of IRM strategies under HDPS in Tamil Nadu

The IRM strategies under HDPS were successfully implemented in 4 districts of Tamil Nadu namely Coimbatore, Virudhunagar, Dharmapuri and Perambalur. The project was implemented in a total area of 79 acres involving 81 farmers and the high-density planting system was accepted by the farmers after realizing its advantages.

5.1 : Training Received

5.1.1 : International Training

Name of the Scientist	Name of the course/training	Place	Period
Mr. K. Velmourougane	International Training Programme on Carbon Trading/ Carbon Sequestration/Climate Change (Crop Science)	Centre for Environmental Risk Assessment and Remediation (CERAR), University of South Australia, Australia	08-01-2014 to 14-03-2014

5.1.2: National Training

Name of the Officials	Name of the course/training	Place	Period
Dr. H. B. Santosh	CAFT Training on Advances in Statistical Genetics	IASRI, New Delhi	02.07.2013 to 22.07.2013
Dr. M. Sarvanan	Short-Term Workshop on Molecular Phylogenetics	IISc, Bengaluru	01.08.2013 to 05.08.2013
Dr. Rishi Kumar	Detection and Measurement of Insecticide Resistance including Molecular Aspects of Insect Pests	NBAII, Bengaluru	02.09.2013 to 11.09.2013
Dr. K. Sankaranarayanan	Forecast Modeling in Crops	ICAR, New Delhi	03.09.2013 to 23.09.2013
Dr. Punit Mohan	Training Programme on Management of Plant Genetic Resources	NBPGR, New Delhi	16.09.2013 to 25.09.2013
Er. Gautam Majumdar Mr. Sanjay Kushwaha	Online Examination system for ARS/NET under NAIP Developing, commissioning, operating and managing an online system for NET/ARS Prelim Examination in ASRB ICAR.	ASRB, New Delhi	22-11-2013

5.2: Training Imparted

International training

Nagpur

Training programme on "Applied Cotton Biotechnology" under Cotton TAP for Africa

Technical Assistance Program for Africa (TAP) was launched by Hon'ble Ministry of Commerce, Industry and Textile, Government of India with IL&FS clusters, New Delhi as a project implementing agency. Ministry of Commerce identified CICR, Nagpur as implementing agency to undertake training on "Applied Cotton Biotechnology". Delegates from six African Countries viz., Malawi, Nigeria Uganda, Benin, Burkina Faso and Chad were participated. The training was conducted at Biotechnology section of Central Institute for Cotton Research, Nagpur from October 21st to December 20th 2013. Training programme was started with an orientation to the participants exposing them with the facilities available in biotech and other laboratories, field, polyhouses etc. Training was inaugurated by Dr. C. D. Mayee, Former Chairman, ASRB, Govt. of India and Dr. R.G. Dani, Vice Chancellor, Dr. PDKV, Akola. The training modules were prepared to cover all the basic and applied research of biotechnology and molecular breeding. The program included 5-modules on general techniques in biotechnology, techniques in isolation and cloning of genes, transgenic cotton development and their molecular characterization, molecular cotton breeding, biosafety issues and IPR. The training was planned with lectures and practical's to infuse basic and applied knowledge on cotton biotechnology to fulfil the needs in their respective countries. More "hands-on

training" was given to participants in all the modules with trained faculties in field and laboratory techniques. To impart training more uniform and for better understanding for the participants from C-4 countries like Burkinofaso, Benin and Chad, the lecture and practical notes were provided in advance to them in French as well as English language. Evaluation of the module using prescribed proforma in 1- 10 point scale containing lectures and speaker was obtained from the all the participants. The feedback was encouraging and shows their complete satisfaction about the training programme with an overall rating of 9.23. Field visit and Study tour were performed as per their program planned. They have visited GTC, CIRCOT, Nagpur, Breeding support centre, Ankur seeds Nagpur, Morarjee textile Mills, Nagpur, Dr. PDKV University, Akola, Mahyco Seeds, Jalna and historical places of Maharashtra. The training course was coordinated by Dr. G. Balasubramani and Dr. K.P. Raghavendra and the Nodal Coordinator was Dr. D. Blaise.

National Training

Nagpur

Training on Pest Assessment and Management

A one-day training on "Pest Assessment and Management" for agriculture officials, SRFs and pest scouts under HDPS was organized at CICR, Nagpur on 10.09.2013. About 106 trainees were trained during the programme.

Training on HDPS and INM

Four programmes were conducted for training farmers from Amravati on 10/5/2013, those from Wardha on 3/10/2013, Chandrapur on 18/11/2013 and Jalgaon on 11/12/2013 on production and protection technologies for HDPS in cotton. More than 1000 farmers benefitted from these training programmes. Besides these, two more training programmes were conducted for the benefit of the officials (agriculture) of Maharashtra State from Amravati and Nagpur divisions.

A one-day training for farmers on 'High Density Planting System' and 'Integrated Nutrient Management in Cotton' was conducted each at Kothadi village in Muktainagr tahsil and Rel Pardhi in Dharangaon tahsil of Jalgaon district of Maharashtra by Dr. S. M. Wasnik, Principal Scientist.

Field Experience Training for ARS probationers

Six ARS probationers from 99th FOCARS batch from NAARM, Hyderabad completed their Field Experience Training [FET] of 21 days duration w.e.f. 23.2.2014 to 15.3.2014 at CICR, Nagpur. Dr. Sunil Rokde, Principal Scientist, Livestock Management and Dr. V. Santhy, Senior Scientist, Seed Technology, co-ordinated the training programme.

Coimbatore

Training Programme on IRM/ HDPS - 2013

A one-day training programme on Insect Resistance Management/High Density Planting System (IRM/HDPS) was organized by CICR, RS, Coimbatore on 7 August 2013. The training programme was aimed to provide the technical details and guidelines on IRM/HDPS to the Agricultural Officers from the IRM/HDPS-implemented districts of Tamil Nadu. It was conducted under the leadership of the IRM State Coordinator (Tamil Nadu), Dr. (Mrs) B. Dharajothi, Principal Scientist. The trainees included State Agriculture Officers, Deputy Agriculture Officers and Agriculture Officers of Perambalur, Virudhunagar, Dharmapuri and Coimbatore districts of Tamil Nadu.

Training under TSP/AICCIP

Three on-campus training programmes were conducted under AICCIP-TSP for 50 tribal cotton growers from Vellore and Coimbatore districts during the months of February and March.

Sirsa

IRM training for HDPS

A one-day training was organized on Insecticide Resistance Management under High Density Planting System in cotton on 22 July 2014. Dr A.M. Narula, Project Director of KVKs of Zone-I was the Chief Guest.

Training on Cotton Production Technology

Training programme was organized for farmers on "Cotton Production Technology" in association with Agricultural Technology Management Agency (ATMA), Bhilwara at CICR, RS, Sirsa from 17 to 22 February 2014.

Awards

CICR wins Mahindra Samriddhi Krishi Sansthan Samman National Award 2014

The Central Institute for Cotton Research, Nagpur was conferred the 'National Award 2014-Best Research Institute-Krishi Sansthan Samman' by Mahindra Samriddhi India Agri Awards 2014. Dr. K.R. Kranthi, Director, CICR, received a cash prize of Rs. 2.11 lakh, a shield and citation from Shri. Tariq Anwar, Minister of State for Agriculture and Food Processing in a glittering ceremony held on 24 February at Hotel Ashok, New Delhi. Dr. Kranthi was accompanied by Dr. M.S. Yadav, Chief Technical Officer, CICR to receive the award. The institute was recognized for its innovative inventions patented as Bt detection kits which empowered farmers to identify good-quality Bt seeds from spurious seeds. The institute was also recognized for developing concepts of eco-friendly pest management and pioneering implementation of insect resistance management strategies which resulted in significant reduction in the usage of insecticides in India. The Mahindra Samriddhi awards in partnership with Zee News were given in seven categories to farmers and institutions from a total 40,000 applications. The Mahindra awards which are now recognized as one of the most prestigious in agriculture recognize purposeful contributions, made by individuals and institutions, in the field of agriculture. Mr. Anand Mahindra, Managing Director, Mahindra and Mahindra, Shri. Ashish Bahuguna, Secretary, Agriculture, Ministry of Agriculture and Dr. Pawan Kumar Goenka, President - Automotive and Farm Equipment were present during the awards function.

National Award for Technology Innovation

Dr. (Mrs.) P. Nalayini, Principal Scientist, Central Institute for Cotton Research, Regional Station, Coimbatore, was conferred a National Award for "Technology Innovation using Polymers in Agriculture and Water Conservation (2012-2013)" by the Department of Chemicals and Petrochemicals, Ministry of Chemicals and Fertilizers, Government of India. She received the award from the honourable Minister of State (Independent charge) for Chemicals and Fertilizers, Statistics and Programme Implementation, Shri. Srikant Kumar Jena, in the presence of the Secretary, Petrochemicals at New Delhi on 7 May 2013.

Dr. (Mrs.) Jagadiswari Rao Woman Scientist Award

Dr. (Mrs.) B. Dharajothi, Principal Scientist, Central Institute for Cotton Research, Regional Station, Coimbatore was conferred the Dr. (Mrs.) Jagadiswari Rao Woman Scientist Award-2012 by the Applied Zoologists Research Association (AZRA), Cuttack for her outstanding research contribution to the field of Plant Protection especially in Cotton Entomology at the AZRA Silver Jubilee International Conference on "Probing Biosciences for Food & Nutritional Security and Safer Environment" held from 16 to 18 February 2014 at the Central Rice Research Institute, Cuttack .

Dr. B. Vasantharaj David Award

Dr. (Mrs.) J. Gulsar Banu, Principal Scientist (Nematology) was conferred Dr. B. Vasantharaj David Award by Applied Zoologists' Association, Central Rice Research Institute, Cuttack, Odisha for her outstanding contribution to research in the field of Plant Protection especially Plant Nematology. She was conferred this award during the International Conference on "Probing Bioscience for Food Security and Environmental Safety" that was held at the Central Rice Research Institute, Cuttack, Odisha during 16-18 February 2014.

Best research article/paper presentation award

Dr. Blaise De Souza and Dr. M.V. Venugopalan received the Dhiru Morarji Memorial Award for Best Article in Agricultural Sciences by the Fertilizer Association of India, for their article entitled 'Soil Fertility Management Strategies for Maximizing Cotton Production in India', published in the Dec. 2012 issue of the Indian Journal of Fertilisers (Srinivas Rao C.H., D. Blaise, M.V. Venugopalan, K.P. Patel, D.P. Birader, Y.R. Aladakatti, S. Marimuthu, G.S. Buttar, M.S. Buttar, M.S. Brar, S. Ratnakumari and V.C Reddy).

Dastur Award

Dr S.E.S.A. Khader, Principal Scientist (Plant Physiology) was awarded the Dastur Award by ISCI, Mumbai on 26 March 2014 for lifetime achievement in Physiology of cotton.

Best Oral Presentation Award for the research article, "Refuge in Bag: A Concept in Resistance Management - An Experience" by S. Kranthi, Rishikumar, M. Bheemanna, H. Desai, G. M. V. Prasad Rao, B. Dharajothi and K.R. Kranthi presented at the National Seminar on Technology for Development and Production of Rainfed Cotton, held during 24-25 October 2013 at Navsari Agricultural University, Bharuch, Gujarat.

Dr. H. B. Santosh received the Best Oral Presentation Award for the research paper on "Wild Species and Introgression Breeding in Cotton" authored by Vinita Gotmare, Prachi Akhare, Kirti Kalmegh, M. Saravanan, H. B. Santosh & Punit Mohan in the National Seminar on "Technology for Development and Production of Rainfed Cotton" held during 24 & 25 October 2013 at Regional Cotton Research Station, NAU, Bharuch (Gujarat).

Best Oral Presentation Award for the research paper "HDPS - A Promising Option for Rainfed Cotton" by M. V. Venugopalan, D. Blaise, N.R. Tandulkar and Shubhangi Lakade during the National Seminar on "Technology for Development of Rainfed Cotton" at Navsari Agricutural University, Bharuch, Gujarat, 24 & 25 October 2013.

Recognitions

- Dr. Prasun Mukherjee, Principal Scientist, elected as NAAS Fellow 2013.
- Dr. J. Gulsar Banu, Principal Scientist (Nematology), has been elected as Fellow of Association for the Advancement of Biodiversity Science.

Areas of Linkages	Institution
NATIONAL	
Fibre testing, fibre quality evaluation and nanotechnology	CIRCOT, Mumbai
Multi-location testing of promising cultures, Bt cotton evaluation	AICCIP (21 centres)
Germplasm collection, maintenance and plant quarantine clearance	NBPGR, New Delhi
Seed technological research and breeder seed production	NSP, New Delhi
Development of *cry1A* (a) gene construct	NBRI, Lucknow
Supply of gene construct and molecular evaluation of transgenic plant.	NRC Plant Biotechnology, New Delhi
DNA fingerprinting of cotton	NRC DNA Fingerprinting, New Delhi
Technology for pink bollworm resistance monitoring and management	State Department of Agriculture, Haryana, KVKs, CCS, HAU, Hisar, NCIPM, etc
Crop pest surveillance and advisory for cotton pests in Maharashtra	Agriculture Department, Government of Maharashtra
Mechanization	CIAE, Bhopal, Precision tools, Nagpur
Decision support system for major insect pests of rice- and cotton-based cropping systems	CRIDA, Hyderabad
Testing of biofilm technology in cotton, *G. arboreum* and *G. hirsutum* and evaluation of nano pyridalyl against lepidopteran pests of cotton	Indian Agricultural Research Institute, New Delhi
Vision-based expert system for picking of cotton	IIIT&M, Gwalior; Jamia Milia Islamia University, Delhi; CMER‡CoEFM, Ludhiana

Hon'ble Chief Minister Shri Prithviraj Chavan and Shri Radhakrishna Vikhe Patil, Agricultural Minister, Government of Maharashtra visiting CICR to review the progress of organization of Krishi Vasant 2014

Shri Ajit Pawar, Deputy Chief Minister & Shri Anil Deshmukh, Minister of Food and Civil Supplies Works, Government of Maharashtra

Research Highlights

Crop Improvement

National Trials

- Eleven National Trials (conducted in all the three zones), six north zone trials, thirteen central zone trials and eleven south zone trials were conducted during the current year.
- In irrigated national trials, *G. hirsutum* cultures *viz*., SCS 1211 (2397 kg/ha), TCH 1777 (2150 kg/ha) and HS 292 (2596 kg/ha) were found to be the best in terms of seed cotton yield in north, central and south zones, respectively.
- In the initial evaluation trial under rainfed situations, IH 11 was found to be the best culture in both central (1525 kg/ha) and south zones (2489 kg/ha).
- In the preliminary intra *hirsutum* hybrids trial, the hybrid FHH 234 (2489 kg/ha) was found to be the best for seed cotton yield in the north zone, while RHH 1014 (2926 kg/ha) and SHH 818 (2842) were found to be the best in central and south zones, respectively.
- Thirteen intra *hirsutum* hybrids were evaluated in central zone and in south zone under rainfed conditions. In the central zone SHH 808 (2239 kg/ha) was found to be the best hybrid, while in the south zone, NHH 715 (1973 kg/ha) was the best.
- In the initial evaluation trial of compact genotypes in irrigated conditions with closer spacing, H 1465 was found to be the best in the north zone (2575 kg/ha), whereas in central zone and south zone, ARBC 3010 (3010 kg/ha) and F 2617 (4648 kg/ha) were the best, respectively.
- In initial evaluation trial of compact genotypes under closer spacing in rainfed situations, DSC 1352 was the best in central zone (1165 kg/ha), whereas, in south zone NH 635 (2274 kg/ha) was the best.
- Six *barbadense* cultures were evaluated in central and south zones. DB 1301 was the best genotype in central zone (1424 kg/ha), whereas, ARB 1302 was the best in south zone (1902 kg/ha). Quality-wise, Suvin was the best in both the zones.
- In the preliminary interspecific hybrids *(G. hirsutum x G. barbadense*) trial, DHB 1301 (2513 kg/ha) was the best hybrid in central zone and RHB-1014 (2645 kg/ha) was the best in south zone.
- Promising *G. arboreum* genotypes like LD 1026 (2601 kg/ha) in north zone and JLA 0603 (1730 kg/ha) in south zone have been identified for promotion which were found better than the check varieties in terms of seed cotton yield.
- Similarly *Desi* hybrid FMDH 36 (2897 kg/ha) was the best in north zone and NACH 433 (1808 kg/ha) was the top performer in central zone.

Zonal Trials – North zone

- In the *G. hirsutum* Preliminary Varietal Trial, LH 2306 (2123 kg/ha) recorded the highest yield.
- In the Coordinated Varietal Trial, LH 2256 was the best recording 1907 kg/ha of seed cotton yield.
- In the Coordinated Varietal Trial of compact genotypes, LH 2298 was found to be the best recording 2373 kg/ha of seed cotton yield.
- In the Coordinated Hybrids Trial, two hybrids performed better than both the check hybrids. FHH 209 (2362 kg/ha) was the best hybrid for seed cotton yield.
- *G. arboreum* genotype, LD 949 was found to be the best culture recording 2575 kg/ha.

Zonal Trials – Central zone

- Under irrigated situation, culture GISV-267 (2134 kg/ha) was the best in the Preliminary Varietal Trial and the genotype GISV 272 (2152 kg/ha) was superior in the Coordinated Varietal Trial. Similarly, in rainfed trials, GBHV 180 (1402 kg/ha) and GBHV 170 (1268 kg/ha) were promising in various trials.
- In the Coordinated Varietal Trial of compact genotypes, LH 2298 was found to be the best recording 2552 kg/ha of seed cotton yield.
- In the Coordinated Hybrid Trial, the hybrid GSHH 2646 (2422 kg/ha) was superior in intra-*hirsutum* category while DB 40 (1252 kg/ha) was the best in interspecific (*G. hirsutum X G. barbadense*) hybrid category under irrigated conditions.
- In the preliminary varietal trial of *G. barbadense* under irrigated condition, DB 40 recorded the highest seed cotton yield of 1252 kg/ha. In the Coordinated Varietal Trial, GSB 21 (1243 kg/ha) recorded the highest seed cotton yield.
- In the Coordinated Varietal Trial of *G. arboreum*, the highest seed cotton yield of 1400 kg/ha was recorded in JLA 0614.

- Under rainfed situations, the hybrid GSHH 2646 (1549 kg/ha) was the best in the intra-*hirsutum* hybrid category, and AKDH 96 (1455 kg/ha) was the best in *Desi* hybrid group.

Zonal Trials – South zone

- The *G. hirsutum* genotype, SCS 1062 (2673 kg/ha) was the best in Preliminary Varietal Trial and GSHV 159 (2393 kg/ha) was superior in Coordinated Varietal Trial under irrigated situations.
- In the Coordinated Varietal Trial of compact genotypes, LH 2298 was found to be the best recording 3763 kg/ha of seed cotton yield.
- Among the intra-*hirsutum* hybrids tested, the highest yield of 2377 kg/ha was recorded in TSHH 0629, while in interspecific hybrid category, the highest seed cotton yield was recorded in RHB-0812 (2996 kg/ha).
- In the preliminary varietal trial of *G. barbadense* under irrigated condition, DB 40 was the best recording 1833 kg/ha of seed cotton yield. In the Coordinated Varietal Trial, GSB 21 was the best entry with 1873 kg/ha of seed cotton yield.
- Under rainfed situation, SCS 1062 (2293 kg/ha) was the best in the Preliminary *G. hirsutum* varietal trial. In the Coordinated Varietal Trial of compact genotypes, ARBC 64 was found to be the best recording 1552 kg/ha of seed cotton yield.
- In the coordinated hybrid trial under rainfed situation, the highest seed cotton yield of 2350 kg/ha was recorded in RAHH 455.
- In *Desi* category, *G. arboreum* variety CNA 1016 (1434 kg/ha) was the best performing entry.

Crop Production

- Agronomic requirements of promising Pre release *hirsutum* / *arboreum* genotypes/ hybrids of cotton has been worked out in all the three zones under both irrigated and rainfed production system.
- Experiments for developing suitable Agronomy for ruling Bt hybrids of the region indicated that different spacing were at par at Sriganganagar, whereas, 67.5 x 75 cm at Faridkot and Bhatinda and 67.5 X 45 cm at Sirsa gave significantly higher seed cotton yield. 100 % RDF seems to be optimum at all the locations in north zone.
- In central zone, 90 x 45 cm (at Nanded, Akola and Banswara) 120 x 30 cm (Junagarh) and 60 X 60 cm (Indore) gave significantly higher seed cotton yield in Bt hybrids. Among the fertilizer levels, 75% RDF at Surat, 125% RDF at Banswara and Junagadh and 150 % RDF was optimum at Nanded, Akola and Indore.
- In south zone, 90 X 45 cm (at Lam and Nandyal) or 90 X 60 cm at (Raichur and Srivilliputtur) gave significantly higher seed cotton yield in Bt hybrids where as all the spacing had no impact on yield at Coimbatore and Dharwad. Among the fertilizer levels, 100% RDF (at Nandyal and Lam) or 125 % RDF (at Coimbatore, Raichur, Srivilliputtur and Dharwad) was optimum.
- Herbicides like Pendimethalin, Trifluralin, Quizalofop ethyl, Pyrithiobac Sodium, Glyphosate were evaluated in different combinations among themselves and with hoeing and the results are presented.
- Drip irrigation schedule at 0.6 ET gave significantly higher seed cotton yield at Lam and Banswara, whereas, all the irrigation schedules were at par at Rahuri, Dharwad and Indore. 100% RDN & K gave significantly higher seed cotton yield at Rahuri, Dharwad and Banswara, whereas, 75% and 50% RDN & K gave better yield at Lam and Indore respectively.
- Moisture conservation techniques of ET based Drip irrigation in Bt cotton showed that drip +poly mulch gave significantly higher seed cotton yield at all locations.
- Experiments for optimizing organic cotton (*G. arboreum* / *G. herbaceum* varieties) production was conducted in both central and south zone centres.
- Foliar spray of planofix at flowering and boll development stage significantly enhanced number of bolls and substantially improved boll weight and in turn the seed cotton yield.
- Nutrient consortia (CICR, Coimbatore) spray at 15 days interval from flowering gave significantly higher seed cotton yield.
- Field experiments were conducted with defoliants in different locations.

Crop Protection

Entomology

- Genotypes from zonal breeding trials were screened against insect pests and identified as resistant/ tolerant in all the three zones.
- In Faridkot, CSH 3129, FHH 200, Pusa 5760 and in Hisar CA 105, Pusa 5760, LH 2152, F 2276, LHH 1403, LH 1411 and FHH 200 were found to be tolerant to leaf hopper.
- In Surat, eight and seven entries were found to be promising against leafhopper population under field, field cage and morphological studies.

- In Akola, BS-30, BS-79 and P-1251 were found tolerant against spotted bollworm and BS-40 and P-2151 were found tolerant against pink bollworm with minimum open boll and loculi damage.
- In Khandwa, minimum numbers of leafhopper were found in genotypes GSHH-2729 and GSHV-162.
- In Rahuri, four genotypes GISH-272, TSHH-0629, RHH-707 and GJHV-445 were observed to be consistently resistance to leaf hopper.
- In Dharwad, Raichur and Srivilliputtur entry TSHH 0629 recorded consistently tolerant to leaf hopper and the entries GSHV 159 and TSH 0250 were also showed tolerance to leaf hopper in LAM Guntur and Srivilliputtur, respectively.
- Population dynamics of key pests of cotton in relation to climatic conditions were recorded at weekly intervals for both sucking pests and bollworms in various participating centers during 2013-14.
- Neem formulation namely Neemazal-T/S 1% EC and Neemazal 5% WSC were evaluated against sucking pests.
- For the revalidation of existing recommendation of insecticides, they were compared with label claim doses against sucking pests in cotton ecosystems.
- Integrated cotton crop management options with emphasis on biotic stress management were evaluated in all the participating centers of the three zones.

Plant Pathology

- Cotton leaf curl virus disease (CLCuD) appeared in 24-26 meteorogical week in North Zone and the incidence and severity of CLCuD and the whitefly was very high. The flare up of whitefly population in the entire north zone might be due to less rainfall received during June and July.
- *Alternaria*, Bacterial blight and Grey mildew were the major diseases in Central and South zone. In addition, Leaf rust in Karnataka and Andhra Pradesh and Tobacco Streak Virus in Andhra Pradesh and Tamil Nadu are gaining ground in South zone. The presence of TSV was confirmed through sequence analysis and Dot Blot Immuno Binding Assay and its local lesion hosts were identified.
- Based on two year field screening and one year artificial inoculation studies, lines *viz.*, MR 786 and Bihani 251 were found tolerant against CLCuD, whereas, lines like LH 2132, NDLH 1938, TCH 1707 were resistant against *Alternaria* blight and lines like BGDS 801, BGDS 802, BS 47 and GSHV 159 were resistant against bacterial blight. The entries *viz*., Digvijay, GBav-229, GBav-251, GBhv-253, GBhv-255, GBhv-270, GBhv -677, and GVhv-637 showed consistent resistance against *Fusarium* wilt for the last three years.
- Monitoring of breakdown of resistance against CLCuD in cotton revealed break down of resistance in earlier identified resistant / tolerant cultures.
- Seedling mortality was reduced significantly due to seed dressing with chemicals at all four test locations i.e., Junagarh, Dharwad, Guntur and Coimbatore at all tested concentrations except for Thiram and Carboxin @ 2 g at Junagarh and Carboxin @ 1 g at Dharwad.
- Significant reduction in mortality due to root rot pathogens (*Rhizoctonia spp)* was noted at Sirsa by seed treatment @ 10 & 5 g/kg seed with TrichoCASH either alone or in combination with Thiram. TrichoCASH @10 g/kg seed +Thiram @ 3 g/kg showed the maximum (18.67%) disease control due to *Fusarium* wilt at Pune.
- Seed treatment of bioagent (PF TNAU1 @ 10 g/kg of seed), soil application (*T. viride* @ 2.5 kg/ha) and chemical sprays (Ergon @ 1 ml/litre at 60 DAS and Taqat @ 1.5 g/Litre at 90 & 120 DAS) were found to be more effective in minimizing the *Alternaria* blight disease intensity by 66.40 in Bt hybrid-2 (module 3) and 63.28 per cent in Bt hybrid-1 (module 3) at Rahuri. Module 1 and 2 significantly reduced *Alternaria* leaf spot in Jadoo BG II while all three modules significantly reduced *Alternaria* leaf spot in RCH 2 BG II at Guntur. Seed treatment with *B. subtilis* (BSC5 – TNAU) @ 10 g/kg on either RCH 2 Bt or Bunny Bt along with soil application of *Bacillus subtilis* (BSC5-TNAU1) combined with foliar spray of *B. subtilis* @ 1 % on 60, 90 and 120 days after sowing was effective in controlling root rot, *Alternaria* leaf blight and TSV at Coimbatore.
- Reduction in boll number (ranging from 11.4 - 38.1%) and seed cotton yield (from 15.7- 46.3 %) was observed in different Bt cotton hybrids due to cotton leaf curl virus disease at Faridkot, Hisar and Sriganganagar.
- Pooled results (2010-12) of management of foliar diseases through application of Systemic Acquired Resistance (SAR) inducing chemicals at Dharwad, Guntur, Coimbatore suggest that SAR chemicals like Salicylic Acid (SA) and Iso Nicotinic Acid (INA) at 100 ppm protect cotton from fungal (*Alternaria* blight, grey mildew and rust) as well as bacterial (bacterial blight) diseases with good yields and cost benefit ratios.

Notification of Cotton Genotypes for Cultivation

During the year 2013-14, five cotton cultivars (five varieties and one hybrid) have been notified for commercial cultivation in the country for various agro-climatic zones.

Registration of Cotton varieties under PPV & FRA

List of registered cotton varieties during 2013-14 under PPV&FRA, 2001

Institute	Name of the Variety	Species	Variety/Hybrid	Remarks
CICR	CCH 510 -4	*G. hirsutum* L.	Variety	As New
CICR	CNHO 12	*G. hirsutum* L.	Variety	As extant
ANGRAU	NARASIMHA	*G. hirsutum* L.	Variety	As Extant
CICR	CSHH 243	*G. hirsutum* L.	Hybrid	As new

Tribal Sub-Plan A sum of Rs.15 lakhs was utilised to conduct exclusive training programme and dissemination of cotton production technologies to the tribal cotton farmers to improve their economic status

S.No	Centre Name	Amount earmarked (Rs.)
1	MAU, PARBHANI (Nanded Centre)	2,00,000/-
2	UAS, DHARWAR (Dharwar Centre)	2,00,000/-
3	TNAU, Coimbatore (Coimbatore Centre)	2,00,000/-
4	USA, Raichur (Raichur Centre)	2,00,000/-
5	MPUAT, UDAIPUR (Banswara Centre)	3,00,000/-
6	NAU, NAVSARI (Surat Centre)	1,00,000/-
7	CICR,RS, Coimbatore (PC Cell Unit)	3,00,000/-
	Total	**15,00,000/-**

Shri Ashish Bahuguna, Agriculture Secretary and Shri Sanjeev Gupta, Joint Secretary, Extension, DAC, MoA, GOI, New Delhi visited CICR, Nagpur

Sh. J. S. Saharia, Chief Secretary and Dr. Sudhir Kumar Goel, Additional Chief Secretary (Agriculture), Government of Maharashtra visited CICR, Nagpur

Training Achievements

Ninety eight short duration (1 to 3 days) on-campus and off-campus training courses were conducted in different disciplines (Crop Production, Horticulture, Plant Protection, Veterinary Science, Soil Science, Home Science and Extension) for training farmers, rural youth and extension functionaries. About 3331 participants including 924 SC/ST were benefited from the training programmes.

Fourteen sponsored training courses were organized in Crop Production, Horticulture, Plant Protection, Veterinary Science and Home Science for farmers and extension functionaries, deputed by State Agriculture Department of Maharashtra, ATMA, CIPMC, Nagpur, RCF, MAFSU, Nagpur, MCED & ICDS Nagpur, and NGO. Around 853 participants attended these courses.

Front Line Demonstrations

Eleven front line demonstrations on crops and seven FLDs on non- crops were demonstrated in the villages of Nagpur district *viz.,* Manori, Pipra, Thana, Navegaon (Sadhu), Ranmangli, Datala, Sukli, Boruzwada, Angewada, Patkakhedi, Tirkhura, Karhandla and Patansawangi. Several extension activities like field day, field visit of farmers to FLD, group discussions, and scientists-farmers meet etc. were conducted for effective implementation of FLDs.

Details of assessment of technologies under Front Line Demonstrations and On Farm Trials (2013-14)

S.No	Crop	Technology Demonstrated	No. of farmers	Area (ha)	Yield (q/ha)		Increase over FP (%)
					FLD	FP	
1	Cotton	HDPS	30	12.0	14.97	12.95	13.49
2	Pigeon pea	BSMR-736	30	6.0	14.87	10.50	29.38
3	Linseed	PKV NL- 260	12	2.4	8.25	6.25	24.24
4	Wheat	AKAW-4627	12	4.8	31.50	23.75	24.60
5	Nagpur Mandarin	Management of pre-harvest fruit drop	10	4.0	60.00	49.00	22.44
6	Nagpur Mandarin	Weeds Management	10	4.0	54.00	45.00	20.00
7	Okra	Variety Akola bahar	10	04	46.78	40.00	16.95
8	Bt-cotton (FLD)	Sucking pests management	25	10.0	23.60	19.40	17..80
9	Red gram (FLD)	Production technology	30	12.0	19.62	14.50	26.09
10	Chickpea (FLD)	Production technology	30	12.0	17.50	13.65	22.00
11	Nagpur Mandarin (OFT-Assessment)	Thrips & mites management	06	2.4	63.62	54.67	14.06

OFT on Cotton (High Density Planting System)

FLD of Wheat & Linseed at Adopted Villages

i) Dairy (Vitamin-mineral @ 30 g/day feed supplementation and De-worming repeated after 2 weeks) in Jersey Crossbred cows

ii) Dairy (Detection of mastitis) in Jersey cross bred cows

iii) Chelated mineral feeding for CB Jersey Cow

FLDs on Home Science

The FLDs on Maize Sheller, Improved cotton picking bag, Bhendi & Brinjal plucker and Gujarat sickle were demonstrated.

OFT

Under OFT on farmer's field, feeding bypass fat @ 200 g/day x 90 days for crossbred jersey cows, supplementary concentrate feeding @ 50 g/day for lactating dose (Goat) and breed assessment of Swarnadhara poultry were assessed.

Soy-laddu was assessed as a technology for reducing protein calorie malnutrition under OFT on farmer's field

Assessment of Bio-Briquettes - an alternative cooking fuel under OFT on farmers' field

Description(N=10)	Cooking with Bio-briquettes	% increase over farmers' practice
Rice & Dal (g)	250	
Quantity of coal required (g)	300	25
cost of coal (Rs)	07	31
Time required for cooking (minute)	34	18
Ash recovered (%)	04	39

Shetkari Melawa

Krishi Vigyan Kendra, CICR, Nagpur organized "Shetkari Melawa" on 13.12.2013 at Boruzwada, Taluka – Saoner, Dist, Nagpur. About 450 farmers from Ajni, Angewada, Bhivapur, Boruzwada, Kodegaon Malegaon, Manegaon, Patkakhedi, Patansawangi, Hingna, Kalmeshwar, Narkhed, Parseoni, Umred of Nagpur district participated in the event. Dr. A. R. Raju and Dr. Vishlesh Nagrare, Scientists from CICR, provided technical solutions to the problems faced by the cotton farmers. Dr. B.S. Chimurkar and Shri. G. C. Malwi, retired faculty members of Dr. P.D.K.V., Akola answered the queries of farmers on various crops. Dr. Raju discussed better cotton crop production practices and advocated cultivation of straight varieties of cotton like PKV-081, NH-615 and Suraj under High Density Planting System promoted by CICR. Dr. R. R. Gupta, SMS, KVK, convenor of Shetkari Melawa and demonstration trials on IRM technologies made introductory speech on the organizing of Shetakri melava at farmers' location. Progressive farmer Shri. Anandrao Raut, shared his experience on cultivation of cotton in new areas like Bhiwapur. Former ZP office bearer Shri. Ashok Dhote, Shri. Sonba Musale, Shri. Nanaji Raut attended the function. Programme was conducted by Shri. Roshan Dambare, Agriculture Asst., Saoner. Vote of thanks was proposed by Dr. U. V. Galkate, SMS, KVK, CICR, Nagpur.

Training Sponsored by ATMA, Nagpur

Three day training programme was organized by Krishi Vigyan Kendra for 36 members of Self Help Group of Hingna block on "Fruit and Vegetable Processing" at Community Food and Nutrition Extension Unit from 25th to 27th March, 2014. Smt. Sunita Chauhan, SMS, Home Science coordinated and trained the farmers.

Horticultural crops at KVK farm

Krishi Vigyan Kendra, CICR, Nagpur has established horticultural crops such as Guava (L-49), Pomegranate (Bhagva), Orange (Nagpur mandarin), Sweet Orange (Katol Gold), Mango and Sapota (Kali Patti) at its farm, for the benefit of farmers and other visitors.

Pomogranate (Bhagva)

Sapota (Kali Patti)

Ex-trainees Sammelan Organized

Ex-trainees Sammelan was organized at Wakeshwar village on 22.02.2014, with the objective to get the feedback information on the training programmes and field demonstrations conducted on horticulture crops. This village was adopted by KVK in 2002-2004 and several horticultural activities were undertaken. During the discussion, it was observed that the local ber plants which were budded by improved variety of "Umran" are yielding well. Three farmers are cultivating rose as commercial crop and some farmers are raising healthy seedlings of vegetables.

HDPS in Nagpur district

High Density Plating System (HDPS) in Cotton was implemented in 3 Talukas of Nagpur District *viz*., Hingna, Kameshwar and Saoner in collaboration with State Department of Agriculture and KVK. Cotton varieties such as Suraj, PKV 081, AKA 7, NH 615 were demonstrated in 169 farmers' fields. The farmers were guided on production and protection aspects. Dr. K. R. Kranthi, Director, CICR and Heads of various Divisions of CICR visited and guided the farmers for better utilization of medium to light soils, where Bt cotton crop does not sustain in later growth period once the monsoon is recedes.

A Scientist- farmers' group discussion on HDPS was conducted in Ramgiri village of Kalmeshwar Taluka on September 7, 2013. Dr. K. R. Kranthi, Director, CICR, Programme Coordinator, KVK, Head Crop protection and Dr. M.V. Venugopalan attended the programme and replied the queries raised by the farmers on HDPS. TAO, Kalmeshwar and other staff were also present. Shri. Harish Kumbhalkar and Sh. Gulbir Singh were the coordinators of the programme.

Soil Testing Activities

Four hundred and one soil samples were collected from Umrer, Bhivapur, Katol, Kalmeshwar, Saoner, Ramtek, Narkhed, Kuhi and Parshivani blocks of the Nagpur district through Mobile Soil Testing Van provided under Human Development Programme by Govt. of Maharashtra. These samples were analyzed for different soil testing parameters and 390 soil health cards depicting soil test based fertilizer recommendation for different crops were distributed to the beneficiaries.

Monitoring of Crop SAP programme of Nagpur district by KVK

Monitoring of Crop SAP programme in Nagpur district was done in twenty villages of 9 tahsils of Nagpur district on cotton, soybean and paddy. Incidence and damage of semiloopers, girdle beetle and stem borer was found under ETL in soybean crop due to heavy and continuous rains during the cropping period. The sucking pest in Bt cotton were observed in most of the cotton area. Cotton farmers sprayed the crop 2 to 4 times for sucking pest management. Low incidence of major insect pest and disease in paddy was also noticed.

Monitoring of Crop SAP in Paddy in Ramtek Taluka.

Participation in Exhibitions

i) Maharashtra Kapus Parishad cum Agriculture Exhibition at Jalgaon on 20.04.2013 and three days agricultural exhibition at Wardha during 31 May to 2 June 2013.

ii) "Dharmmachakra Pravartan Din" at Deekshabhoomi, Nagpur during 12-14 October 2013.

iii) MGNREGA WORKSHOP cum Agricultural Exhibition' organized by State Department of Agriculture on 14 December 2013.

iv) Agro-Vision Exhibition held at Reshimbagh, Nagpur from 26 to 29 December 2013.

Participation in MGNREGA WORKSHOP cum Agriculture exhibition at Krida Sankul, Nagpur

Participation in Kapus Parishad cum Exhibition at Jalgaon

List of publications

1. Behra, M.S., P.K. Mahapatra., Singandhupe R.B., Kundu D.K., Satpathy S. and Singh Amarpreet (2014). Drip fertigation effect on yield, quality, water use and economics of ashwagandha in rice based cropping system, in International Symposium on Integrated Water Resources Management (IWRM-2014) February 19-21, 2014 at CWRDM Kozhikode, Kerala, and Page. No. 1-11.
2. Sethi R.R., Kumar A., Sharma S.P., Singandhupe R.B., Das M., Jena S.K. (2012). Development and calibration of a soil water balance model for paddy field in humid climatic condition. Indian Journal of Coastal Agricultural Research, Vol. 30 (2): 55-59.
3. Chauhan, S. and Raju A.R. (2013). Innovative cotton harvesting bags. *International Journal of Agriculture Innovations and Research*, Vol.2 (1), ISSN (online) 2319-1473: 108-111.
4. Chauhan Sunita, Raju A.R. (2014). Participatory evaluation of ergonomically designed cotton picking bags. *Journal of Cotton Research Development*. 28(1) : 140-144.
5. Gulbir Singh (2013). Integrated pest management in vegetables, *Swet Swarnima* 2013,11.
6. Gulbir Singh (2013). Improved cultivation techniques from guava, *Swet Swarnima* 2013, 13.
7. M.V. Venugopalan, Keshav Raj Kranthi, Mahendra Singh Yadav and Vandana S (2014). *Saghan Ropan Padhhati se Kapas ki Bharpoor Pedavaar* (Bumper cotton yield through high density planting system). *Kheti Monthly Magazine (Spl. Issue Krishi Vasant)*, No. 11 (Feb. 2014), 12-15.
8. Mahendra Singh Yadav and Vandana S (2014). *Kapas uttpaadan mein aatm nirbharta* (Self sufficiency in cotton production). *Kheti Monthly Magazine (Spl. Issue Krishi Vasant)*, No. 11 (Feb. 2014), 5-10.
9. Vandana S (2013). *Soochna Sanchaar Prodyogiki-Kisaano ke liye vardaan. Shwet Swarnima* 2013, 20-21.

Leaflet Published

1. Fruit Processing – Preparation of Squash (2014) : Smt. Sunita Chauhan
2. Vegetable Processing – Cherry and Sauce preparation (2014) : Smt. Sunita Chauhan
3. Kapas Ke Nashikeeton Ka Prabhavi Prabandhan (2014) (in Hindi): Dr. Keshav Raj Kranthi, Dr. Chinnababu Naik, Dr. (Smt.) Sandhya Kranthi, Dr. Vishlesh Nagrare and Dr. RamRatan Gupta.

Radio Talks

Delivered a radio talk on "*Are Sansar-Sansar Nivad Udhyogachi*" (Selection of Enterprise for Supplementary Income) in Marathi programme in Otivar broadcasted by AIR, Nagpur on 18.06.2013 at 6.20 pm.

T.V. Talk

Delivered T.V. Talk on "Drudgery Reduction of Farm Women with Cotton Picking Bags" in Marathi programme in Sheti Darshan telecasted by Nagpur Doordashan on 20.01.2014 at 6.00 pm.

10.1 List of Publications

Research papers published in refereed Journals

1. Banu J.G. (2013). Effect of different storage conditions on spore viability of *Lecanicillium lecanii* formulations and infectivity to mealybug, *Paracoccus marginatus*. *International Journal of Plant Protection,* 6(2): 334-337. (NAAS Rating: 3.3)
2. Banu J.G. (2013). Effect of solid substrates on growth and sporulation of *Lecanicillium lecanii* and pathogenic activity to Mealy Bug. *Annals of Plant Protection Sciences,* 21(1): 208-209. (NAAS Rating: 3.7)
3. Bhattacharyya T., Pal D.K., Mandal C., Chandran P., S.K.Ray, Sarkar Dipak, Velmourougane K., A. Srivastava., Sidhu G.S., Singh R.S., Sahoo A.K., Dutta D., Nair K.M., R. Srivastava., Tiwary P., Nagar A.P. and Nimkhedkar S.S. (2013). Soils of India: Their historical perspective, classification and recent advances. (Review article) *Current Science, 104 (10), 1308-1323.* (NAAS Rating :7.4)
4. Blaise D., Venugopalan M.V., Singh J.V., Raju A.R. (2013). Fertilizer best management practices in cotton. *Indian Journal of Fertilisers,* 4 (2): 110-119. (NAAS Rating :3.8)
5. Dhamayanthi K.P.M., Rathinavel K. and Gotmare Vinita (2013). Induction of polyploidy in wild cotton species (*Gossypium armourianum* and *G. aridum*) by colchicine treatment. *Journal of Cotton Research* and *Development,* Vol 27 (2): 165-170. (NAAS Rating :4.3)
6. Dhamayanthi K.P.M. and Rathinavel K. (2013). Studies on flowering behavior and fruiting pattern of early maturing germplasm lines of Egyptian cotton (*G. barbadanse* L.). *Cotton Research Journal,* 5 (2):150-157. (NAAS Rating :2.6)
7. Gotmare V., Mohan P., Balasubramani G., Rodge C., Katre M., Tule B.N., Chakrabarty P.K. and Kranthi K. R. (2013). NISC 40(IC0584261; INGR13033), NISC 40(IC0584262; INGR13034), NISC 40(IC0584262; INGR13035) (2013) Jassid tolerant compact plant type introgressed derivatives of Cotton. *Indian Journal of Plant Genetic Resources,* Vol 26(3): 253 – 254. (NAAS Rating :3.0)
8. Gotmare V., Mohan P., Balasubramani G., Waghmare V.N., Rodge C., Katre M., Tule B.N., Chakrabarty P.K. and Kranthi K.R. (2013). Vaidehi 95 (MSH 53) (IC0584260; INGR13032) dark brown linted introgressed derivative of cotton. *Indian Journal of Plant Genetic Resources*, Vol 26(3): 252-253. (NAAS Rating :3.0)
9. Hebbar K.B., Venugopalan M.V., Prakash A.H. and Aggarwal P.K. (2013). Simulating the impacts of climate change on cotton production in India. *Climatic Change*, 118(3-4):701-713. (NAAS Rating :7.9)
10. Kranthi K.R., Venugopalan M.V. and Yadav M.S. (2012). Hybrid cotton revolution in India. *Seed Times,* Vol. 5(4): 29-38.
11. Kumar R., Nagrare V. S., Nitharwal Mukesh, Swami Dinesh and Prasad Y. G. (2013). Within-plant distribution of an invasive mealybug, *Phenacoccus solenopsis*, and associated losses in cotton. *Phytoparasitica*, DOI 10.1007/s12600-013-0361-6. (NAAS rating 7.3)
12. Meena, R.A., Monga D. and Ghanshyam (2013). Economics of GMS based *Desi* cotton (*gossypium arboreum*) hybrid seed production in north zone. *Journal of Cotton Research and Development,* 27(2): 175-178. (NAAS Rating :4.3)
13. Meena, R.A., Monga D. and Neha (2014). Studies to enhance cotton plant stand under north zone. *Journal of Cotton Research and Development,* 28(1): 12-17. (NAAS Rating :4.3)
14. Mukherjee, A.K., Kumar Sampath, Kranthi S. and Mukherjee P.K. (2013). Biocontrol potential of 3 novel *Trichoderma* strains: isolation, evaluation and formulation. 3 *Biotech* 10 1007/s 13205 013.
15. Mukherjee, P.K., Mukherjee A.K. and Kranthi S. (2013). Reclassification of *Trichoderma viridae* the most widely used commercial biofungicide in India, as *Trichoderma asperelloides*. *The open Biotechnology journal,* 7:7-9.
16. Nalayini P., Sankaranarayanan K. and Velmourougane K. (2013). Herbigation in cotton (*Gossypium spp*): Effects on weed control, soil microflora and succeeding greengram (*Vigna radiata*). *Indian Journal of Agricultural Sciences,* 83(11):1144-8. (NAAS Rating :6.6)

17. Raghavendra K.P., Sheeba, J.A. and Santosh H. B. (2013). Sucrose synthase, a major biomarker for sink strength in cotton. *Cotton Research Journal*, 5 (2):158-172. (NAAS Rating :2.6)

18. Raju A.R. (2013). Impact of insect resistant cotton. *IOSR Journal of Agriculture and Veterinary Science,* (IOSR-JAVS) 5 (2): 13-25.

19. Raju A.R. (2013). Seed bacterization with Azotobacter, PSB and foliar application of urea on drought affected cotton. *Int. J. Curr. Microbiol. App. Sci.*, 2 (10): 44-51.

20. Raju A.R. (2014). Improving hybrid cotton profitability and micronaire with stripcropping of soybean+pigeon pea with conservation furrows, Mn and B application. *African Journal of Agricultural Research*, 9 (2): 183-195. (NAAS Rating :6.0)

21. Raju A.R., Majumdar G. (2013). Evaluation of Portable Cotton Picker. *International J of Agricultural Innovations & Research*, 2 (1): 104-107.

22. Raju, A.R., Thakare S., Majumdar G., Bharambe P.R. (2013). Risk aversion in shallow soils with innovative intercropping systems. *Journal of Cotton Research and Development*, 27 (1): 37-44. (NAAS Rating :4.3)

23. Raju, A.R., Thakare S.K. (2013). Profitability and FUE of Bt cotton based intercropping systems under changing rainfall patterns in Vertisols of India. *African Journal of Agriculture Research*, 8 (24): 3177-3185. (NAAS Rating :6.0)

24. Rani, U. S., (2013). Participation, decision making and drudgeries faced by women in cotton cultivation. *Journal of Extension Education,* Vol.25 (3): 5078-5085. (NAAS Rating :2.7)

25. Rani, U.S. and Selvaraj G. (2013). Bt cotton in Tamil Nadu: An evaluation of farmers' experiences. *Indian Research Journal of Extension Education*,13 (3): 64-70. (NAAS Rating :3.5)

26. Rani, U S. and Nalayini P. (2013). Sustainability of diversified and non-diversified cotton farms in Tamil Nadu – An empirical analysis", *Cotton Research Journal,* 5 (2): 194-200. (NAAS Rating :2.6)

27. Santhy, V., Palve S.M., Virkhede Sonali, Mohan Pratibha, Khadi B.M. (2013). Characterization and genetic inheritance of temperature sensitive genetic male sterility in *Desi* cotton *(Gossypium arboreum). Indian Journal of Agricultural Sciences,* 83 (8): 809-14. (NAAS Rating: 6.6)

28. Singh J., Babar Shilpa and Venugopalan M.V. (2013). Interactive effect of moisture conservation and integrated nutrient management on yield and nutrient utilization efficiency of rainfed Bt cotton (*Gossypium hirsutum*). *Indian Journal of Agricultural Sciences,* 83 (10):1069-74. (NAAS Rating: 6.6)

29. Singh, J., Abraham Shalu and Sankaranarayanan, K. (2014). Impact analysis of Bt cotton production technologies on yield and profit of Vidharbha farmers. *Journal of Cotton Research and Development,* 28 (1): 62-65 (NAAS Rating: 4.3)

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31. Tiwary P., Venugopalan M.V., Blaise D., Chatterji S., Sen T.K. and Tandulkar N.R. (2013). Evaluation of sustainability of rainfed cotton yield under conventional and intergrated nutrient management practices. *Agropedology*, 23(1): 53-58. (NAAS Rating: 2.9)

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33. Tuteja O.P. and Agrawal Manish (2013). Heterosis for seed cotton yield and other traits in GMS based hybrids of American cotton (*Gossypium hirsutum*). *Journal of the Indian Society for Cotton Improvement,* 5 (2): 131-141. (NAAS Rating: 2.6)

34. Tuteja O.P. and Banga Manju (2013). Combining ability estimates for yield and quality characters of parents and crosses based on genetic male sterility in cotton (*Gossypium hirsutum). Indian Journal Agricultural Sciences*, 83 : 987-91. (NAAS Rating : 6.6)

35. Velmourougane K. and Sahu Apeksha (2013). Impact of transgenic cottons expressing c*ry1Ac* on soil biological attributes. *Plant, Soil and Environment*, 59 (3): 108-114. (NAAS Rating: 7.5)

36. Velmourougane K., Venugopalan M.V, Bhattacharyya T., Sarkar Dipak, Pal D.K., Sahu Apeksha, Chandran P, S.K. Ray, Mandal Champa, Nair K.M., Prasad Jagdish, Singh R.S., Tiwary Pramod (2013). Urease activity in various agro-ecological sub regions of black soil regions in India.

PNAS, India, Sec. B Biol. Sci., 83 (4): 513-524. (NAAS Rating: 6.1)

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10.2 List of On-going Projects

No.	Name of project
1.	Collection, conservation, evaluation, documentation and maintenance of germplasm of cultivated species of *Gossypium.* (Dr. Punit Mohan (PL), Dr. S.Manickam, Dr. R.A. Meena, Mrs. Chakrabarty, Dr. KPM. Damayanthi)
2.	Improvement of tetraploid and diploid cottons for fibre properties through population improvement approaches. (Dr. V.N. Waghmare (PL), Dr. Vinita Gotmare, Dr. O.P.Tuteja)
3.	Fine mapping of fiber quality and economic traits using RILs in diploid cotton. (DBT) (Dr. V.N. Waghmare (PL), Dr. T.R. Loknathan)
4.	Fine mapping and advance backcross QTL analysis of fiber quality and economic traits in diploid cotton. (Dr.V.N. Waghmare (PL))
5.	Development of saturated genetic linkage map for *Gossypium hirsutum* L. using SSR and SNP markers. (DBT) (Dr. V.N. Waghmare (PI) , Dr. Punit Mohan)
6.	Conservation, characterization and utilization of wild species, races of cultivated species and synthetic polyploids of *Gossypium.* (Dr.Vinita Gotmare (PL), Dr. Balasubramani)
7.	MAS/MAB for Water-logging in Cotton. (Dr.Vinita Gotmare (PL), Dr. SESA. Khade, Dr. M. Saravanan)
8.	Breeding of upland cotton for improved fibre quality and resistance to biotic stress (bollworms and jassid). (Dr. S.M. Palve (PL))
9.	Development of heterotic pool for superior medium staple in tetraploid cotton (*G. hirsutum*). (Dr.S.M. Palve (PL))

10.	Development of drought tolerant genotypes with good fibre quality in *G. hirsutum.* (Dr. Suman Bala Singh (PL), Dr. A.H. Prakash)
11.	Seed Production in Agricultural Crops and Fisheries. (MSP) (Dr.PR.Vijayakumari (Nodal Officer), Dr. V. Santhy, Dr. K. Rathinavel, Dr. R. A. Meena)
12.	Studies on Genetic Purity of Public released Cotton Hybrids and its Parents with the help of SDS-PAGE. (Dr. P.R. Vijayakumari (PL), Dr. K.R. Kranthi)
13.	Characterization of public sector released genotypes of cotton (*Gossypium* spp) based on molecular markers to serve as Special test for Varietal Protection. (Dr. V. Santhy (PL))
14.	Exploration, collection and conservation of perennials and land races of *Desi* cotton from different regions of India. (Dr. M. Saravanan (PL))
15.	Development of long staple *G. hirsutum* variety with improved fibre strength. (Dr. S. Manickam (PL), Dr. V.N. Waghmare, Dr. S.L. Ahuja)
16.	Development of extra-long staple high spinning hybrids with wider adaptability. (Dr.KPM. Dhamayanthi (PL))
17.	National Seed Project (Crops). (NSP) (Dr. K. Rathinavel (PI))
18.	Testing & Documentation of Extant Varieties, hybrids and their Parents for Distinctness, Uniformity & Stability (PVP & FR ACT, 2001). (DUS) (Dr.K. Rathinavel (Nodal Officer))
19.	Development of early maturing, medium staple varieties and hybrids Resistant to CLCuV. (Dr. O.P. Tuteja (PL), Dr. D. Monga, Dr. Rishi Kumar, Dr. S.M. Palve)
20.	Identification of male sterile plants in genetic male sterility (GMS) using molecular markers. (Dr. O.P. Tuteja (PL), Dr. S.B. Singh, Dr. M. Sarvanan)
21.	Development of *G. hirsutum* genotypes with high yield and high GOT. (Dr.S.L. Ahuja (PL), Dr. R. A. Meena, Dr. D. Monga, Dr. Rishi Kumar)
22.	Association mapping of fibre traits in *Gossypium arboreum* L. accessions using SSR, ISSR and AFLP markers (UGC) (Dr.S.K. Verma (PA))
23.	Studies to improve the seed setting efficiency in cotton. (Dr.RA Meena (PL), Dr. RishiKumar, Dr. K. Rathinavel)
24.	Allelopathy as an alternative weed management strategy in cotton. (Dr. Blaise Desouza (PI), Dr. P. Nalayini, Mrs. M. Chakrabarty)
25.	Georeferenced soil information system for land use planning and monitoring soil and land quality for agriculture. (NAIP) (Dr. M.V. Venugopalan (CCPI))
26.	Identification of 'crop-cycle' for Extra Long Staple (ELS) Cotton in non-conventional regions. (Dr. R.B. Singandhupe (PI), Dr. Blaise Desouza)
27.	Herbicide resistance weeds and their management strategies. (Dr.A. R. Raju (PI), Dr. K. Sankarnarayanan)
28.	A Value Chain for Cotton Fibre, Seed and Stalks: An innovation for higher economic returns to farmers and allied stakeholders. (NAIP) (Dr. K. Shankarnarayanan (Co-PI))
29.	Synthesis and characterisation of nano-formulated micronutrient foliar spray for yield maximisation in different cotton genotypes. (Dr.D.Kanjana (PL))
30.	An accelerated process for preparation of bioenriched compost from cotton plant residues. (IICP(CIRCOT)) (Mr. K. Velmourougane (PA))
31.	Physiological manipulation for extending cotton crop. (Dr.S.E.S.A Khader (PI), Dr. A.H Prakash)
32.	Phenotyping of cotton for drought tolerance traits. (Dr.J.H. Meshram (PI), Dr. R.B.Singandhupe, Mrs. M. Chakrabarty)
33.	Role of Leaf Phytochemicals in cotton leaf reddening and plant responses to management through growth chemicals, nutrients and insecticides. (Mrs. M.Chakrabarty (PI))

34.	Impact evaluation of Bt cotton in Maharashtra. (Dr. A. R. Reddy (PI), Dr. R. B. Singandhupe, Dr. S. N. Rokde)
35.	Design & Development of a cotton picking head. (DST) (Er. Gautam Majumdhar (PI))
36.	Identification of species specific dsRNA or siRNA or miRNA in cotton insect pest to explore their use in pest management through RNAi based technologies. (DBT) (Dr. K.R.Kranthi (PL), Dr. S. Kranthi, Dr. K.P. Raghavendra)
37.	Novel approaches for production of hybrid seeds with characteristics of improved insect res istance and higher yield. (CSIR-NIMITLI-Phase II) (Dr. K. R. Kranthi (CCPI), Dr. S. Kranthi)
38.	Evaluation of built in refuge for insect resistance management requirements for Bollgard II cotton. (Contract) (Dr. S. Kranthi, Dr. B. Dharajothi, Dr. Rishi Kumar)
39.	Research into development of decision support systems for management of insect pests of major rice and cotton based cropping systems. (NAIP) (Dr. VS Nagrare (CCPI), Er.G Majumdar, Dr. Rishi Kumar, Dr. B Dharajothi, Mr. M. Sabesh, Dr. M. Amutha)
40.	Crop pest surveillance and advisory project (CROPSAP)in Maharashtra. (Maha. Govt.) (Dr. V. S. Nagrare (PI))
41.	Isolation and characterisation of endophytes in cotton and endosymbionts in boll worms. (Dr. M. Amutha (PI))
42.	Use of innovative methods for management of cotton leaf curls virus disease. (Dr. D. Monga (PL), Dr. Rishi Kumar (PA))
43.	Development of nanoparticles based bio-control formulation for the management of major cotton pests and diseases. (Mr. A. Sampath Kumar (PL), Mr. K. Velmourougane)
44.	Disease monitoring of Tobacco Streak Virus (TSV) on cotton for South zone consisting of Andhra Pradesh, Karnataka and Tamil Nadu. (Dr. M. Gunasekaran (PI))
45.	Cloning and characterization of potent toxin gene from heat tolerant isolate of *Heterrorhabdus indica,* an Entomopathogenic nematode. (DBT) (Dr. N.G. Narkhedkar (PI) Dr. P.K. Charkrabarty)
46.	Production, stabilisation, formulation and validation of microbial agents and their natural products against insects and nematode pests of cotton. (Dr. Gulsar Banu (PL), Dr. M. Amutha)
47.	Molecular characterization and validation of fiber strength genes with fiber specific promoter for improvement in cotton. (NFBSFARA) (Dr. G. Balasubramani (PI), Dr. K. P. Raghvendra, Dr. J. Amudha, Dr. S.B. Nandeshwar)
48.	Genomics of cotton boll and fibre development. (NAIP) (Dr. G.Balasubramani (PI), Dr. K.P. Raghavendra, Dr. J. Amudha, Dr. S.B. Nandeshwar)
49.	Development of drought resistant transgenic cotton and identification of new genes for high water use efficiency. (Dr. J. Amudha (PI), Dr. AH.Prakash, Dr. G.Balasubramani, Dr. R.B. Singandhupe)
50.	Isolation and identification of seed specific promoter and gossypol synthesis genes for silencing through RNA interference. (DBT) (Dr. K.P. Raghavendra. KP (PI), Dr. J. Amudha)
51.	Development of multi-gene constructs and Bt cotton varieties for sustainable pest management. (TMC 1.1) (Dr. K.R.Kranthi (PI), Dr. P.K.Chakrabarty, Dr. K.P.Raghavendra, Dr. S.B.Nandeshwar, Dr. G.Balasubramani, Mr. K.Velmourougane, Dr. S.Kranthi, Dr. S.B.Singh, Mrs. M. Chakrabarty)
52.	Marker Assisted Breeding for Cotton Leaf Curl Disease (ClCuD), Bacterial Leaf Blight (BLB) and Nematodes Resistance in Cotton. (TMC 1.2). (Dr. V.N. Waghmare (PI) , Dr. P. K. Chakrabarty, Mr. Sampath Kumar, Dr. N. Narkhedkar , Dr. S. Manickam, Dr. Dilip Monga, Dr. S. K. Verma)
53.	Consolidation of repository of high strength cotton genotypes and evaluation for quality traits and yield in specific agro-eco zones". (TMC 1.3) (Dr. S. Manickam (PL), Dr. T.R. Loknathan, Dr. S.M. Palve, Dr. P. Nalayini)

54.	Agrotechniques for high density planting system and surgical cotton varieties. (TMC 1.4) (Dr. Venugopalan (PI), Dr. Blaise DeSouza, Dr. C B.Naik, Dr. A R.Reddy, Dr. Punit Mohan, Dr. T.R. Lokanathan, Dr. A.R. Raju, Mr. Sampathkumar, Dr. K. Sankarnarayanan, Dr. S. L. Ahuja, Dr. R.A. Meena)
55.	Simulation models/Sensor based gadgets for Cotton Protection and Production. (TMC 1.5) (Dr. Sandhya Kranthi (PI), Dr. V. S. Nagrare, Dr .K.R. Kranthi, Dr. C.B. Naik, Dr. A.R. Reddy, Dr. N. Anuradha, Mrs. M.Chakrabarty, Dr. A. H. Prakash, Dr. M. Amutha, Dr. K. Sankarnarayanan, Dr. Isabella Agarwal, Dr. B. Dharajothi, Dr. Rishi Kumar)
56.	E-Kapas Network and Technology Documentation. (TMC 1.6) (Dr.S.M. Wasnik (PI), Mrs. M. Chakrabarty, Dr. S. Usha Rani, Dr. O. P.Tuteja)
57.	Development of Cotton Picking Machinery for Small Scale Cotton Production Systems. (TMC 1.7) (Er. Gautam Majumdhar (PI))

10.3 : Consultancy, Patents, Commercialization of Technology

Revenue Generation

The Bt Referral lab generated a revenue of Rs.7, 00,260/- through sale of Bt express, Bt Quant, GUS detection kits in 2013-14.

Patented Technology Published in IPINDIA website

Three patents submitted by Dr. P. K. Chakrabarty, Er. G. Majumdar and Dr. Nandini Gokte Narkhedkar were published, anticipated for the first examination report from Patent office, Mumbai.

Two bio-pesticides to control Mealy bug called "Mealy Quit" and "Mealy Kill" are ready for commercialization.

MoU between CICR and M/s. Padgilwar, Nagpur

Memorandum of Understanding (MoU) was signed between CICR and M/s. Padgilwar, Nagpur for Solar Powered Knapsack Sprayer on 17th Dec 2013 in which the term and conditions including license fee and 5% royalty on each unit sold were fixed.

10.4 : Significant Decisions of RAC, IRC, IMC and Other Important Meetings

Research Advisory Committee Meeting

Research Advisory Committee (RAC) meeting was held at Central Institute for Cotton Research (CICR), Nagpur from 14th to 15th March 2014. The RAC meeting was chaired by Dr. B.V. Patil, Vice Chancellor, UAS, Raichur, Karnataka. The following RAC members attended the meeting.

- Dr. T. Pradeep, Principal Scientist (Breeding), Maize Research Centre, ARI, ANGRAU
- Dr. A. K. Dhawan, Ex. Prof. & Head, Entomology, PAU, Ludhiana
- Dr. A. J. Shaikh, Ex-Director, Central Institute for Research on Cotton Technology

Dr. K. R. Kranthi, Director, CICR welcomed the RAC Chairman and the members, Heads of the Divisions and Regional Stations, Coimbatore and Sirsa. The proceedings started with the opening remarks by the Chairman, RAC. In his opening remarks, the Chairman, RAC, welcomed the members of RAC for the meeting and appreciated the suggestions made in QRT report. He emphasized the problem of lower yield levels in India and suggested that all the scientific efforts should be consolidated to achieve higher cotton productivity. He also congratulated the institute for bagging Mahindra Samriddhi Krishi Sansthan Award for outstanding performance in cotton research. The action taken report for each of the institute, TMC and external funded projects was presented by Dr. M.V. Venugopalan, Member Secretary, RAC.

Recommendations of RAC

General recommendations (GR)

1. Identification of early maturing varieties for different situations under HDPS with incorporation of *Bt* gene, if possible and development of picker should be the overall objective

2. Plant type and mechanization of harvesting should be given priority
3. Time framing of the project objectives for effective monitoring and evaluation
4. Foreign training of young scientists should be arranged in the best laboratories especially in frontier areas of gene discovery aspects for crop protection

Crop Improvement Division:

1. DNA fingerprinting of all the public sector cotton varieties should be done on priority.
2. Reducing the number of projects to improve the focus of the research in crop improvement.
3. Strategies for improving seed vigour should be given emphasis. Changes in the biochemical profile within the seed during germination may be investigated.
4. Seed packaging material needs to be standardized for long term storage.
5. Breeding programme towards development of surgical cotton should be given impetus for meeting the future industrial requirement.
6. Registration of plant varieties should be taken up at the earliest.

Crop Production Division:

1. Trials to develop a comprehensive weed management strategy for HDPS are needed
2. Demonstration of one large scale precision cotton farming in all the zones with the latest HDPS concept
3. Variety 'F1054' along with other genotypes may be tested under HDPS in North India
4. Location specific agro-technology for HDPS in cotton to be worked out. The possibility of double cropping after HDPS cotton may be explored wherever earliness is obtained by this technology
5. Problems if any, pointed out by the farmers with HDPS system should be redressed. Seed production of varieties suitable for HDPS need to be given emphasis to enable wide spread adoption of technology by the farmers
6. Any herbicide (like paraquat) alone or in combination at low doses can be explored as an alternative to costly defoliants available in the market after ruling out its undesirable effects on fibre quality
7. Application of combination of herbicides should be done cautiously and checked for phyto-toxicity to popular cotton varieties
8. Bulletin on weed flora of cotton system may be published
9. Changes in soil health parameters should be monitored periodically from GPS fixed locations in CICR farm under continuous cultivation of Bt hybrids. Soil health card for these sites should be maintained.
10. Evolutionary significance of seed gossypol in relation to plant growth, stress abatement and crop development may be explored.
11. Cost benefit ratio of use of Pusa Hydrogel technology should be worked out for cotton
12. Ajwain as a cover crop may be explored.

Crop Protection Division:

1. Efforts can be taken to develop repository of the AICCIP entries known to be tolerant to different sucking pests and diseases at CICR
2. Collection and conservation of biodiversity of all the insect pests and natural enemies.
3. Management of jassids and whiteflies in cotton to be addressed on priority.
4. Role of pollinators in cotton ecosystem and the effect of different insecticides on pollinators needs to be studied.
5. Intensification of the work on gene silencing.
6. To investigate if north populations of pink bollworm undergo diapause when brought to central India and if so, the percentage of diapausing pupae.

Biotechnology Section:

1. Consolidate the efforts within a time frame towards development of Bt cotton varieties.

CICR, RS, Coimbatore:

1. Study of possible variation in Bt toxin levels in relation to elevated levels of CO_2, pruning and leaf reddening.

CICR, RS, Sirsa:

1. Studies on the whitefly populations carried over.
2. Reconfirm the efficacy of neem based insecticides on the management of whiteflies.

QRT meeting for finalization of recommendations

A wrap-up meeting of QRT for finalization of recommendations was held on 12.07.2013 at CICR, Nagpur under the chairmanship of Dr. C.D. Mayee. The following members attended the meeting:

Dr. D. P. Biradar, Member,QRT

Dr. (Mrs.) Usha Barwale, Member, QRT

Dr. K.R. Kranthi, Member, QRT

Dr. M.V. Venugopalan, Member Secretary, QRT

The recommendations prepared by the members were finalized during the meeting. The final report of QRT for CICR & AICCIP (2007-12) was prepared and submitted to the Council for further needful. Later, the Chairman, QRT presented the recommendations before the Director General, ICAR.

Institute Management Committee Meeting

The 51st Institute Management Committee (IMC) meeting was held on 21st August 2013 under the Chairmanship of Dr. K.R. Kranthi, Director, CICR, Nagpur. The meeting was attended by the following members.

1.	Dr. K. R. Kranthi , Director	CICR, Nagpur	**Chairman**
2.	Dr. R.G. Dani, Vice Chancellor	Dr. PDKV, Akola	Member
3.	Joint Director of Agriculture*	Govt. of Maharashtra, Nagpur	Member
4.	Shri. Sharad Tasare, Ex M.L.A.	Maharashtra Assembly, Amravati	Member
5.	Dr. Dilip Monga, Head	CICR Regional Station, Sirsa	Member
6.	Dr. P.K.Chakrabarty, Head	Division of Crop Improvement, CICR, Nagpur	Member
7.	Shri G. C. Prasad, Sr. F & AO	NBSS & LUP, Nagpur	Member
8.	Shri Sachin Agnihotri, Sr. Admn. Officer	CICR Nagpur	Member Secretary
9.	Dr. C.D. Mayee, Ex-Chairman ASRB, New Delhi	Chairman QRT for CICR & AICCIP	Spl. Invitee
10.	Dr. (Mrs.) Sandhya Kranthi, Head	Division of Crop Protection, CICR Nagpur	Spl. Invitee
11.	Dr. Blaise Desouza, Head	Division of Crop Production, CICR Nagpur	Spl. Invitee
12.	Dr. S.B. Nandeshwar, Pr. Scientist	Biotechnology Section, CICR Nagpur	Spl. Invitee
13.	Shri. Deepak Maheshwari, F. & A.O.	CICR Nagpur	Spl. Invitee
14.	Dr. M.V. Venugopalan, Pr. Scientist & Head	PME Cell, CICR Nagpur	Spl. Invitee

*Represented by Shri R. B. Chalwade, Superintendent Agriculture Officer, Nagpur Division

Dr. K.R. Kranthi, Director CICR & Chairman, IMC mentioned that this session of IMC was specially convened to facilitate an interactive meeting of the Chairman, QRT with the IMC for the presentation of the recommendations of QRT. The other major agenda was seeking approval of the committee for purchase of equipments, furniture & fixtures and execution of works proposed in XII Plan to be taken on priority as per ICAR guidelines and for proposing the same under R.E. of 2013-14. This is necessary as the XII Plan is yet to be approved by the Council. Elaborating on further, the Chairman informed that a recent accidental fire gutted the Bt. referral lab and the lab needs to be renovated. Losses caused due to the fire are being examined by the CPWD to write off the material damaged and the final report is awaited. Additionally, the training hall inaugurated on 12th Nov. 2012 needs to be furnished and fitted with audio-visual aids/fixtures to make it functional. Essential equipments are needed to carry forward the newly launched E-kapas programme (under TMC) which intends to connect farmers through voice mail.

The IMC unanimously recommended for approval from Council for purchase of proposed instruments, furniture/fixtures and also for renovation works.

Dr. R. G. Dani, Vice Chancellor, PDKV informed that with 93 % of the area under Bt hybrids, there are few takers for varieties like AKH 081 and AKA 7 even though these have a good potential under HDPS. Dr. Dani mentioned about the MoU signed with CICR and hoped that this would enhance the quality of PG research at Dr. PDKV and the collaborative programmes on biotechnology will be strengthened.

Shri. Sharad Tasare, Ex-MLA, Amravati appreciated the new initiatives in cotton by CICR but appealed the

research community to work hard to restore the confidence of farmers in the cotton production system so that they will get returns from the crop in commensuration with the investment made.

Shri. G.C. Prasad, SFAO, NBSS&LUP, Nagpur expressed satisfaction over the expenditure pattern and the resources generated of the institute. He added that the equipments / works / furniture / fixtures proposed are essential and need to be attended on priority.

Shri. R.B. Chalwade, Superintendent Agriculture Officer, Nagpur who represented the Joint Director of Agriculture, Nagpur endorsed that the farmers of the region are showing keen interest on two technologies - HDPS in cotton and broad bed- furrow system. He also informed that the cotton area in Nagpur division in 2013-14 was 419800 ha.

Institute Research Committee (IRC) meeting

The Annual Institute Research committee (IRC) meeting of CICR was conducted as a combined IRC for all the centres from 20-22nd March 2014 at CICR, Nagpur. Dr M.V. Venugopalan, Member secretary, RAC presented the specific recommendations of Research Advisory Committee meeting held on 14th March 2014.

Dr M.V. Venugopalan also presented the Quinquennial Review Team (QRT) recommendations. Mrs. Mukta Chakrabarty presented Research Framework Document (RFD) of the Institute. Mr. K. Velmourougane, Secretary IRC, presented the Action Taken Report of the previous IRC (2013). The IRC confirmed the minutes of the last IRC meeting.

The results of research projects at CICR, Nagpur, RS, Coimbatore and RS, Sirsa were presented by individual project leaders, discussed and critically reviewed as per the technical programme. The technical programmes for the year 2014-15 were also finalized for each project. The meeting was chaired by Dr. K. R. Kranthi, Director, CICR and scientists of Nagpur, Coimbatore and Sirsa participated in the deliberations.

The IRC recommended the closure of 5 projects, approved 8 new projects to be initiated during 2014-15.

Project Monitoring and Evaluation Committee (PMC)

The Project Monitoring and Evaluation Committee of the Central Institute for Cotton Research (CICR) was re-constituted as per the ICAR guidelines to review and evaluate the progress of ongoing research projects of the institute consisted of the following members from CICR, Nagpur.

1.	**Chairman**	Dr. K. R. Kranthi, Director
2.	**Member**	Dr. P.K. Chakrabarty, Head, Division of Crop Improvement
		Dr. Sandhya Kranthi, Head, Division of Crop Protection
		Dr. Blaise Desouza, Head, Division of Crop Production
3.	**Member Secretary**	Dr. M. V. Venugopalan, I/c, PME Cell

The committee evaluated the implementation of projects twice during the year (15-16 June, 2013 & 12-13 Nov., 2013) at Nagpur. At Coimbatore, the evaluation was done on 12-13 Dec., 2013

The Chairman and the members visited experimental fields and verified the implementation of the IRC approved technical programme. Modification of the approved technical program was suggested to derive additional information.

10.5 : Results – Framework Document (RFD) Committee

A RFD Committee was re-constituted as per the guidelines of the ICAR with the following officials of this institute.

Name	Designation
Dr. K.R. Kranthi	Director
Dr. M.V.Venugopalan	Nodal Officer (Principal Scientist and I/c, PME Cell)
Shri. Sachin Agnihotri	Sr. Administrative Officer
Shri. Deepak Maheshwari	Finance & Accounts Officer
Dr. (Mrs.) S.B. Singh	Co-opted Member
Dr. P.K. Mukherjee	Co-opted Member (Deputation completed & relieved on 01.05.2013)
Mr. A.Sampath Kumar	Co-opted Member
Dr. (Mrs.) Mukta Chakrabarty	Co-Nodal Officer & Co-opted Member

The committee meets periodically to discuss the success indicators of the monthly RFD report before sending to ICAR. This committee also finalizes the mid-term and annual RFD performance achievement reports.

RFD Cell has been constituted as per the guidelines of the ICAR with the following officials to manage the activities of the RFD.

S.No	Category	Name & Designation
1	RFD Nodal Officer	Dr. M. V. Venugopalan, Principal Scientist (Agronomy) and I/c, PME Cell
2	One Scientist	Dr. K. P. Raghavendra, Scientist (Biotechnology)
3	One Technical Officer	Dr. M. S. Yadav, Chief Technical Officer & Nodal Officer, PME Cell
4	One Administrative Staff	Mr. Ghanshyam D. Sakhare, Lower Division Clerk & Typist

The Institute set a high performance standard and achieved a total composite score of 91% (Ranked in Very Good category) in the Annual Performance Evaluation Report (April 1, 2012 to March 31, 2013). The details are given in **Annexure-I.**

10.6 : Participation of Scientists in Seminars/Symposia/Workshops /Meetings

Sr. No.	Seminars/Conferences/Symposia/ Workshops/ Meetings	Place and Date	Participants
Seminars			
1.	National Convention on Indian Cotton: Gearing up for Global leadership	MCRS, Surat 6-8 Jan., 2013	Dr. Suman Bala Singh, Dr. M. Saravanan, Dr. T. R. Loknathan, Dr. Punit Mohan
2.	AICCIP Workshop	MPUAT, Udaipur 8 - 10 April, 2013	Dr. A. H. Prakash, Dr. S. Manickam, Dr. K. Rathinavel, Dr. B. Dharajothi, Dr. K.P.M. Damayanthi, Dr. J. Gulsar Banu, Dr. S. Usha Rani, Dr. T. R. Loknathan, Dr. S. M. Palve, Dr. Punit Mohan, Dr. V. N. Waghmare, Dr. M.V. Venugopalan, Dr. D. Monga, Dr. S. L. Ahuja, Dr. O.P. Tuteja, Dr. R. A. Meena, Dr. Rishi Kumar
3.	Brain Storming Session on Research in Agrl. Extension	CIFE Mumbai 26 April, 2013	Dr. Blaise Desouza, Dr.M.V. Venugopalan, Dr. A.R. Raju, Dr. R.B. Singandhupe, Dr. S.M. Wasnik, Dr. S.N. Rokde, Mrs. Mukta Chakrabarty, Er. Gautam Majumdar, Dr. J.H. Meshram
4.	National Seminar on 'Soil Feasibility, Degradation and Contaminants'	BSKKV, Dapoli 8-9 May, 2013	Dr. Jagvir Singh, Dr. S.M. Wasnik
5.	41st Joint Agriculture Research and Development meeting (AGRESCO)	MAU Parbhani 30 May to 1 June 2013	Dr. S.M. Wasnik
6.	XIII National Seed Seminar	UAS, Bangalore 8-10, June, 2013	Dr. V. Santhy, Dr. P. R. Vijaya Kumari Dr. P.K. Chakrabarty

7.	Steering committee meetings for implementation of Technical Assistance Program (TAP) to seven African countries under Africa India Forum Sumit	New Delhi 3 July, 2013	Dr. D. Monga
8.	3rd International congress of Global warming on Biodiversity of Insects: Management and conservation	B U, Coimbatore 26-28 August, 2013	Dr. J. Gulsarbanu Dr. M. Amutha
9.	6th National Seed Congress organized by NSRTC Varanasi	Varanasi 12-14 Sept., 2013	Dr. K. Rathinavel
10.	Seminar on Possibilities of improving fibre quality through agronomic interventions	GTC, Nagpur 18 Sept., 2013	Dr. Blaise Desouza
12.	National Seminar on Technology for Development of Rainfed Cotton	Bharuch, 24 – 25 Oct., 2013	Dr. M. Saravanan, Dr. Vinita Gotmare, Dr. Punit Mohan, Dr. H.B. Santosh, Dr. M.V. Venugopalan, Dr. Sandhya Kranthi, Dr. A.H. Prakash, Dr. S. Manickam
13.	Zonal Extension and Research Advisory meeting (ZERAC) of Central Vidharbha Zone for *Rabi* 2013	Yeotmal, 28 Oct., 2013	Dr. S.M. Wasnik
14.	Seminar on 'Knowing the Biological Biodiversity Act'	TNAU, Coimbatore 26 Nov., 2013	Dr. K.P.M. Damayanthi
15.	Biopesticide International Conference	Palayamkottai 28-30 Nov., 2013	Dr. J. Gulsar Banu Dr. M. Amutha
16.	Water use and water use efficiency-Phenotyping and their relevance in improving adaptation of crops under water limited condition.	UAS, GKVK, Bengaluru 2-4 Dec., 2013	Dr. J.H. Meshram
17.	Third International Conference 'Extension Education Strategies for Sustainable Agriculture Development - A Global Perspective'	UAS, Bengaluru 5-8 Dec., 2013	Dr. S.M. Wasnik, Dr. S. Usha Rani
18.	Steering committee meeting of CROPSAP	Pune 6 Dec., 2013	Dr. V.S. Nagrare
19.	SIMA Farm to Finish Expo 2013 Workshop on Harnessing Cotton Cultivation Capabilities in India	Coimbatore, 13-15th December, 2013	Dr A. H. Prakash
20.	Steering committee meetings for implementation of Technical Assistance Program (TAP) to seven African countries under Africa India Forum Sumit	New Delhi 23 Dec., 2013	Dr. O. P. Tuteja
21.	National Seminar on "Corporate Social Responsibility in Community Development"	ADU, Coimbatore 22-23 Jan. 2014	Dr. S. Usha Rani
22.	International Conference on Biodiversity, Bioresources and Biotechnology	Mysore 30-31 Jan., 2014	Dr. J. Gulsarbanu
23.	Institute Management Committee meeting of NCIPM	New Delhi 7 Feb., 2014.	Dr. Sandhya Kranthi
24.	Institute Management Committee meeting of NRC Citrus	Nagpur	Dr. Sandhya Kranthi
25.	Institute Management Committee meeting of NBSSLUP	Nagpur 27 Nov., 2013	Dr. M.V. Venugopalan

26.	AZRA Silver Jubilee International Conference on Security and Environmental Safety	CRRI, Cuttack 16 - 18 Feb., 2014	Dr. B. Dharajothi, Dr. J. Gulsarbanu
27.	8th Review Meeting of DUS test centres	UAS, Bengaluru 28.Feb. to 01 Mar., 2014	Dr. K. Rathinavel
28.	Institute Technology Management Unit (ITMU) meeting	CICR, Nagpur 7 March,2014	Dr. Blaise Desouza, Dr. Sandhya Kranthi, Dr. M.V. Venugopalan, Dr. A.R. Raju, Dr. R.B. Singandhupe, Dr. J. Annie Sheeba, Dr. S.M. Wasnik, Dr. S.N. Rokde, Mrs. Mukta Chakrabarty, Mr. Gautam Majumdar, Dr. J.H. Meshram
29.	A brainstorming session on 'Where are the constraints for high cotton yields?' Organized by Indian Society for Cotton Improvement (ISCI).	CICR, Nagpur 15th March 2014	Director, HODs, all Scientists from HQ, Dr. D. Monga, Dr. A.H. Prakash,

10.7 : Distinguished Visitors

Name & Designation	Organisation	Date
Nagpur		
Dr. M.S. Swaminathan, Emeritus Chairman	MSSRF, Chennai	11.07.2013
Dr. T.P. Rajendran, OSD	NIBSM, Raipur	19.08.2013
Dr. Atanu Purkayastha, Joint Secretary (Seeds/TMOP/TMC)	DAC, MoA, GOI, New Delhi	06.09.2013
Dr. Anupam Barik, Additional Commissioner, Crop	DAC, MoA, GOI, New Delhi	06.09.2013
Shri Ashish Bahuguna, Agriculture Secretary	DAC, MoA, GOI, New Delhi	06.09.2013 29.01.2014
Dr. Sudhir Kumar Goel, Additional Chief Secretary, (Agriculture)	Agriculture Department, Govt. of Maharashtra, Mumbai	06.09.2013
Shri Sanjeev Gupta, Joint Secretary, Extension,	DAC, MoA, GOI, New Delhi	06.09.2013
Shri Umakant Dangat, Agriculture Commissioner,	Agriculture Department, Govt. of Maharashtra, Pune	06.09.2013
Shri B. Venugopal Reddy, District Collector	Nagpur, Maharashtra	07.09.2013
Dr. Dath K. Mita, Crop Analyst	International Production Assessment Division, Global Analysis USDA, USA	18.09.2013
Dr. Santosh Kumar Singh, Senior Agrl. Specialist	American Embassy New Delhi	18.09.2013
Dr. J. Sandhu, Agricultural Commissioner	DAC, MoA, GOI, New Delhi	26.09.2013
Dr. N. P. Singh, Director	ICAR, Research Complex, Goa	10.10.2013
Sh. B. K. Mishra, Chairman cum Managing Director,	Cotton Corporation of India (CCI), Mumbai	19.11.2013
Sh. M. M. Chockalingam, Director, Marketing	Cotton Corporation of India (CCI), Mumbai	19.11.2013
Sh. P. K. Agarwal, Director, Finance	Cotton Corporation of India (CCI), Mumbai	19.11.2013
Sh. Prithviraj Chavan, Hon'ble Chief Minister	Govt. of Maharashtra, Mumbai	16.01.2014
Shri RadhaKrishna Vikhe Patil, Agricultural Minister	Govt. of Maharashtra, Mumbai	16.01.2014
Sh. J. S. Saharia, Chief Secretary	Govt. of Maharashtra, Mumbai	22.01.2014
Dr. Sudhir Kumar Goel, Additional Chief Secretary, (Agriculture)	Agriculture Department, Govt. of Maharashtra, Mumbai	23.01.2014
Sh. B. Venugopal Reddy, Divisional Commissioner	Nagpur Division, Maharashtra	23.01.2014
Shri Ajit Powar, Deputy Chief Minister	Govt. of Maharashtra, Mumbai	25.01.2014
Sh. Shivajirao Moghe, Guardian Minister	Govt. of Maharashtra, Mumbai	02.02.2014
Coimbatore		
Dr. N. Gopalakrishnan, ADG (CC)	ICAR Head quarters, New Delhi	05.07.2013, 07.09.2013, 29.09.2013, 13.01.2014
Dr. S.K. Dutta, DDG (Crop Science)	ICAR Head quarters, New Delhi	30.07.2013
Dr. R. R. Hanchinal, Chairman,	Protection of Plant Varieties & Farmers Right Authority, New Delhi	28.11.2013

10.8 : Personnel

Director
K R Kranthi, Director, krkranthi@gmail.com

Project Coordinator (Cotton)
Coimbatore
A H Prakash, P.C. (Cotton) & Head, prakashcicr@gmail.com

Biotechnology

Nagpur
G Balasubramani, Principal Scientist, bala77bio@gmail.com
Smt. J Amudha, Senior Scientist, jamudhacicr@gmail.com
K P Raghavendra, Scientist, kpraghavendra@gmail.com

Plant Breeding

Nagpur
P K Chakrabarty, HOD, Crop Improvement
(Promoted as ADG (Plant Protection) relieved on 05.10.2013)
Smt. S. B. Singh, I/c Head & Principal Scientist,
sumanbalasingh2009 @gmail.com
T R Loknathan, Principal Scientist, loknathantr@sify.com
S M Palve, Principal Scientist, smpalve2kl@yahoo.com
V N Waghmare, Principal Scientist, vijayvnw@yahoo.com
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H B Santosh, Scientist, santoshgpb@gmail.com (Joined on 15.04.2013)

Coimbatore
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Sirsa
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O P Tuteja, Principal Scientist, optuteja2001@yahoo.co.in
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Genetics & Cytogenetics

Nagpur
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Coimbatore
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Seed Technology

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Coimbatore
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Sirsa
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Economic Botany

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Agronomy

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Coimbatore
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Smt. P Nalayani, Principal Scientist, nalayiniganesh@gmail.com

Soil Science

Nagpur
Jagvir Singh, Principal Scientist (retired on 31.12.2013)
A Manikandan, Scientist, poonamani223@gamil.com
(Joined on 10.04.2013)

Coimbatore
Smt. D Kanjana, Scientist, kanjana16@rediffmail.com

Agricultural Engineering

G Majumdar, Scientist, gama62@rediffmail.com

Plant Pathology

Nagpur
P K Mukherjee, Principal Scientist
(Deputation completed & relived on 01.05.2013)
A Sampath Kumar, Scientist, sampath_a@rediffmail.com

Coimbatore
M Gunasekharan, Senior Scientist, mgsekar@gmail.com

Sirsa
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Entomology

Nagpur
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Chinna Babu Naik V, Scientist, chinnaenton@gmail.com

Coimbatore
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Sirsa
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Nematology

Nagpur
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Coimbatore
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Plant Physiology

Nagpur
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Smt. Annie Sheeba, Scientist, anniephysiology@gmail.com

Coimbatore
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Nagpur
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Microbiology (PS)

Nagpur
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Live Stock Production and Management

S N Rokde, Principal Scientist, sunilrokde_2007@rediffmail.com (LMP)

Agriculture Extension

Nagpur
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Coimbatore
Usha Rani, Senior Scientist, ushajoshua@rediffmail.com

Agricultural Economics

Nagpur
A R Reddy Senior Scientist (Trf. To ZPD Hyderabad & relieved on
30.11.2013)
Smt. Anuradha Narala, Scientist, anuradhanarala@gmail.com

Coimbatore
Smt. Isabella Agarwal, Senior Scientist, is_agarwal@rediffmail.com

Computer Applications

Coimbatore
M Sabesh, Scientist, sabesh23@gmail.com (on study leave)

KVK

Nagpur
R B Singandhupe, Principal Scientist, rbsingandhupe@gmail.com

PME CELL

M S Yadav, Nodal Officer, cicrrcmunit@yahoo.co.in

Administration

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FINANCE & ACCOUNT OFFICER

Deepak Maheshwari, finance.cicr@rediffmail.com

10.9 : Other Information

Delegation visit to India

Visit of ITMF delegation

Members of the Spinners Committee of International Textile Manufacturers Federation (ITMF) visited CICR, Nagpur on November 16, 2013. The delegates had interactive session with Scientists of CICR, headed by Dr. C. D. Mayee, former Chairman, ASRB, Govt. of India and Dr. K.R. Kranthi, Director, CICR, regarding the various ongoing research activities at CICR. Dr. D. Blaise, Head, Crop Production Division, Dr. Sandhya Kranthi, Head, Crop Protection Division, Dr. Suman Bala Singh, Head I/c, Crop Improvement Division and Dr. S.B. Nandeshwar, Head I/c, Biotechnology Section coordinated the field and lab visits.

ITMF delegation members :

1) Mr. Andrew Macdonald, Chairman, Spinners Committee (Brazil)
2) Mr. Walter Simeoni, Member, Spinners Committee (South Africa)
3) Mr. Enrique Crouse , Member, Spinners Committee (South Africa)
4) Mr. M.N Vijayshankar, Spinners Committee (Malaysia)
5) Mr. M. B. Patodia, Member, Spinners Committee (India)
6) Mr. Bashir Ali Mohammad, Member, Member Spinners Committee (Pakistan) and Former President, ITMF
7) Dr. Christian Schindler, Director General, ITMF (Switzerland)
8) Mr. Jose Sette, Incoming Executive Director, ICAC (USA)
9) Mr. Mahesh C.Thakker, Special Invitee (India)

Visit of Delegates from African Countries

A team comprising of 30 international delegates from African Countries *viz.*, Kenya, Liberia and Malawi visited CICR Regional Station, Coimbatore on 16th November, 2013. They visited the station as a part of their exposure visit under 'US- India- Africa Triangular International Training Programme on new dimensions in Agricultural Extension Management' for Extension functionaries, organised by MANAGE. Dr. A.H. Prakash (Project Coordinator & Head), Dr S. Manickam and Dr K. Sankaranarayanan delivered talks about cotton status, breeding programmes and production aspects. Dr. Prakash, during his welcome address briefed the activities of the Regional Station, AICCIP and Cotton Scenario in India. Dr. S. Manickam, Principal Scientist (Plant Breeding) exposed the delegates about the varieties and hybrids released by CICR. Dr. K. Sankaranarayanan, Principal Scientist (Agronomy) made a presentation on Cotton Production Technologies (multi-tier cropping system, cotton-sorghum rotation, low cost drip system, *in-situ* grown ragi for monocropping of cotton, high density planting system and poly mulch). During the interactive session, the delegates discussed about its viability under African Condition.

National Agricultural Exposition- KRISHI VASANT 2014

Krishi Vasant -2014, the country's biggest ever Agricultural Exposition was organized at Central Institute for Cotton Research, Nagpur to celebrate farmers' great contribution to our economy from 9-13 February 2014 by the joint efforts of Govt. of India and Govt. of Maharashtra with Confederation of Indian Industry (CII) as the strategic partner. The event also marked the centenary celebrations of Late Shri. Vasant Rao Naik, Ex. Chief Minister of Maharashtra who played a major role in agricultural reforms in Maharashtra during the green revolution era. Honourable President of India, Shri. Pranab Mukherjee inaugurated the Krishi Vasant on 9th February, 2014. In his inaugural address, the President lauded the new dimension and new direction provided to Indian farming in the last ten years, which has seen the country achieving food security and becoming a top exporter of food grains. Mr. Sharad Pawar, Minister of Agriculture and Food Processing Industries, Government of India; Dr. S. Ayyappan, Secretary (DARE) & Director General (ICAR), Mr. K Sankaranarayanan, Governor, Maharashtra, Mr. Prithviraj Chavan, Chief Minister, Maharashtra; Mr. Ashish Bahuguna, Secretary, DAC; Mr. Anil Deshmukh, Minister of Food, Civil Supplies and Consumer Protection, Government of Maharashtra; Mr. Ajit Pawar,

Deputy Chief Minister, Maharashtra; Mr. Praful Patel, Minister of Heavy Industries & Public Enterprises, Government of India; Mr. Radhakrishna Vikhe Patil, Minister of Agriculture and Marketing, Government of Maharashtra; Mr. Shivajirao Moghe, Guardian Minister of Nagpur; Mr. S. Gopalakrishnan, President, CII were present at the inaugural function. Dr. S. Ayyapan, Secretary (DARE) and Director General (ICAR) proposed the vote of thanks.

Live crop demonstrations encompassing 321 varieties of 56 crops on 10 ha area were put up, an event of unprecedented proportions, at CICR, Nagpur. These included vegetable, fodder, fiber, oilseed, cereal as well as horticultural crops. Farmers were enthusiastic to visit these live crop demonstrations which were based on the novel way of cultivation used by progressive farmers. The theme pavilion was the biggest attraction of the exhibition in which the beautiful installations have been created representing the variety of farming in India. The exhibition not only gave the theoretical information about farming but also provided practical knowledge. Around 78 ICAR institutes/universities along with 8 zonal project directorates, state departments of various states and private companies from the country exhibited their innovative findings for the benefit of the farmers. The open areas dedicated to additional income sources like


CICR Stall

poultry and animal husbandry also evoked very enthusiastic response from farmers. The open display-cum-demonstration of high end machinery was the special attraction for farmers. Farmers' technology schools were organised by CICR under the guidance of Dr. K. R. Kranthi, Director, CICR, to educate and train the farmers in various aspects of farming and around 20,000 farmers had been trained during the event. CICR had put up 5 stalls (3 on behalf of the institute, 2 on behalf of the Ministry of Agriculture) for exhibiting the technologies of the institute. Theme specific conferences, cultural events, skit shows, quiz shows and kisan ghoshthies were part of the event. Farmer- scientist interactions on


Live cotton demonstration

various themes / subjects related to agriculture were also conducted during 5 days period by inviting specialists from ICAR institutes, SAU's and their doubts were cleared by the scientists. Farmers were given direct access to latest technologies. Success stories of farmers were highlighted during the Krishi Vasant to encourage the farmers to adopt the latest innovative technologies. More than eight lakh people visited the event from various parts of the country which included seven lakh and eighty four thousand registered farmers. An Award Ceremony was organised on the concluding day of the event.

The institute received an appreciation letter from Mr. Ashish Bahuguna, Secretary, DAC, Ministry of Agriculture, Government of India for successful organization of the event.

Kapus Melawa

'Kapus melawa' was organized by CICR on 11 December 2013 in which more than 700 cotton farmers from Jalgaon District, Maharashtra participated. The farmers' visit was coordinated by "Manish Dada Jain Foundation" Jalgaon District, Maharashtra. The scientists of CICR delivered lectures on various aspects of cotton cultivation. Dr. C. D. Mayee was the guest of honour and the event was coordinated by Dr. Sandhya Kranthi, Head, Crop protection & I/c Director.

Kshetriya Kisan Goshthi

Dr. A. R. Raju and Dr. V. S. Nagrare participated in '*Kshetriya Kisan Goshthi'* on September 27, 2013 at Jam, Samudrapur Taluk of Wardha District. *Kshetriya Kisan Goshthi* was organized under ATMA by Agriculture department, Government of Maharashtra. The CICR scientists interacted with the farmers and answered their queries on cotton production and protection aspects. Other invited experts discussed about cultivation of *Rabi* crops. About 100 farmers participated in the event.

Library

Additions

Forty two new books were purchased for the library during 2013-2014.

Documentation services

- Computerized bibliographic database on Cotton was developed in the library to provide comprehensive and updated information on cotton. About 4463 references along with abstracts have been stored in it. Based on this bibliographic database, the library publishes a current awareness bulletin namely "*COTTON RESEARCH ABSTRACTS*". The Bulletin is circulated to all the scientists of the Institute and to all AICCIP Centers in India. In the reported period, four issues of *COTTON RESEARCH ABSTRACTS (V27, (No. 1-4), January – December 2013)* were published and circulated.
- The Library is actively participating in the E-Journal Consortium by responding regularly through E-mails and thus also receiving updates. More than 2000 on-line journals on agriculture and crop sciences are made available over the network through this consortium.
- Four User Terminals installed in the Library have facilitated the library users to access the databases uploaded in the Library Server. Users can also access the Internet on these terminals. Similarly the entire catalog of the library has been downloaded on these terminals for ease of use.
- The Web OPAC version of the Library software SLIM21 was updated and by using this Library Application Software, the entire catalogue of holdings of the Library (books and bound volumes) is available on all terminals within the Institute. By its virtue, the entire holdings and the catalogue of the Library are visible on the LAN terminals within the Institute by clicking on the following link. Library Catalogue Web-OPAC Link http://dbserver/w27/

Progressive Use of Hindi

Nagpur

Hindi Week

Implementation of official language Hindi was taken on prime and priority basis. For this purpose, an Institute official language implementation committee was constituted and about four meetings of this committee have been organized this year for proper implementation.

Hindi awareness fortnight was celebrated at CICR Nagpur from 19.09.2013 to 11.10.2013 with enthusiasm and various competitions had been conducted to encou-

rage the staff to exhibit their proficiency in Hindi language.

The inaugural function held on 20.09.2013 was chaired by Dr. K R Kranthi, Director & Chairman, IOLIC, CICR, Nagpur. Dr. V. J. Shivankar, former Director, NRCC, Nagpur as the Chief Guest. Dr. Sandhya Kranthi, HOD, Crop Protection, DR. P. K. Chakrabarty, HOD, Crop Improvement, Dr. D. Blaise, Crop Production, Sh. Deepak Maheshwari, Finance and Accounts Officer and Sh. Rajnikant, Working Coordinator and Hindi Officer, addressed the audience on the occasion.

Dr. K.R. Kranthi, Director, CICR, Dr. Shivankar, Chief Guest, Dr. P.K. Chakrabarty, Dr. Sandhya Kranthi, Sh. Deepak and Sh. Rajnikant.

During the fortnight (20.Sept. to 11.Oct. 2013), various competitions like Hindi essay and poetry writing, general awareness quiz, dictation, slogan writing and other related competitions were organized. A total of 12 competitions were conducted, in which 90 staff members have participated.

Closing ceremony was held on 11.10 2013 under the chairmanship of Dr. K. R. Kranthi, Director and Chairman, IOLIC. Dr. M. S. Kairon, former Director, CICR, was the Chief Guest of the occasion. Heads of various divisions, Dr. Sandhya Kranthi, Crop Protection, Dr. Suman Bala Singh, Crop improvement, Dr. D. Blaise, Crop Production, and Coordinator Sh. Deepak Maheshwari, working coordinator Sh. Rajnikant and Senior AO Sh. Sachin Agnihotri were present. Children of Mundle Public School marvelously emphasized the importance of Hindi and seasons in Agriculture through songs and dance. Quiz competition (conducted by Mrs. Mukta Chakrabarty and Dr. M.V. Venugopalan) was held as a part of Hindi Day Celebration. Winning participants were awarded with first, second, third and consolation prizes and certificates. Cash encouragement prize was distributed for commendable work in Hindi to, scientific, technical and administrative staff members.

Entire function was organized under the able leadership of Dr. K.R. Kranthi, Director, & Chairman of Institute Official Language Committee, and ably coordinated by

Inauguration of Closing Ceremony by Chief Guest Dr. M. S Kairon, Former Director CICR and Dr. K.R. Kranthi, Director,CICR

the members of the Hindi function committee, Sh. Sachin Agnihotri, Sh. Deepak Maheshwari, Sh. Rajnikant Chaturvedi, Dr. M. V. Venugopalan, Dr,G Balasubramani, Dr. Mukta Chakrabarti, Dr. V. Santhy, Dr. Vinita Gotmare, Sh. Gokulpure, Smt. Vandana Satish, Smt. Sunita Chauhan, Dr. U.V. Galkate and Sh. Gulbir Singh and Sh. R.Lokhande.

One day Hindi Workshop

One day workshop on Hindi was organized by the Hindi cell of the institute by following the guidelines of Hindi Nideshalaya, ICAR on 29 March 2014. Dr. Sandhya Kranthi, Director I/c & Head, Crop Protection Division inaugurated the function. Dr. Nandini Bhattacharya Sahu, Archaeological Survey of India, delivered a lecture on "The discovery of Rock Paintings at Gavilgarh Hills". In her talk, Dr. Nandini explained about ancient paintings and carvings on rock shelters and caves found in Gavilgarh hills near Betul, Madhya Pradesh. According to her, the paintings were similar to the paintings of Gond tribes and the paintings in Gavilgarh might belong to ancestors of the tribe. Mr. Rajanikant Chaturvedi, Convenor, Hindi Cell, proposed the vote of thanks.

Dr. Nandini B. Sahu , delivering a talk during Hindi workshop

10.10: Weather

Nagpur

Month	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
June, 2013	34.13	25.03	75.23	57.4	426.00	12
July, 2013	30.24	24.24	93.1	78.8	513.00	16
August, 2013	29.42	23.60	91.8	96.0	261.50	15
September, 2013	33.48	23.28	87.5	59.4	93.00	5
October, 2013	31.31	22.13	91.6	72.5	99.00	5
November, 2013	30.56	15.83	64.4	40.1	0	0
December, 2012	29.01	11.86	75.0	63.83	0	0
January, 2014	28.58	14.77	81.3	62.0	4.0	1
February, 2014	30.85	15.10	81.1	70.3	26.2	5
Total					1422.7	

Coimbatore

Month	Temperature(^{0}C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
	Max.	Min.	Max RH	Min RH		
Aug.2013	31.3	22.6	86.1	55.2	27.3	5
Sept. 2013	31.2	22.6	85.1	57.8	46.5	4
Oct. 2013	31.5	21.7	88.3	55.9	141.2	9
Nov. 2013	29.8	22.3	88.7	60.3	57.9	5
Dec. 2013	29.2	19.8	88.0	52.0	24.8	3
Jan.2014	30.1	20.0	84.0	42.0	0.0	0
Total					297.7	26

Sirsa

Month	Temperature (^{0}C)		Rainfall (mm)	No. of rainy days
	Max.	Mini.		
April 2013	39.2	14.5	12.4	2
May 2013	46.6	18.9	0.0	0
June 2013	45.2	22.2	29.6	3
July 2013	40.2	25.0	70.8	8
August 2013	38.0	25.0	168.4	11
September 2013	37.6	22.0	0.0	0
October 2013	36.4	15.2	-	-
November 2013	30.4	18.6	4.0	1
Total			285.8	25

10.11 : Cotton Scenario

Details of state-wise cotton area, production and productivity are given below:-

State-Wise Cotton Area, Production and Productivity

Zone/State	2012-2013 *			2013-2014 *		
	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)
Punjab	4.80	21.00	744	5.05	21.00	707
Haryana	6.14	25.00	692	5.57	23.00	702
Rajasthan	4.50	17.00	642	3.03	14.00	785
North Zone	**15.44**	**63.00**	**694**	**13.65**	**58.00**	**722**
Gujarat	24.97	93.00	633	26.91	116.00	733
Maharashtra	41.46	79.00	324	38.72	81.00	356
Madhya Pradesh	6.08	19.00	531	6.21	19.00	520
Central Zone	**72.51**	**191.00**	**448**	**71.84**	**216.00**	**511**
Andhra Pradesh	24.00	84.00	595	21.42	72.00	571
Karnataka	4.85	15.00	526	5.78	18.00	529
Tamil Nadu	1.28	6.00	797	1.17	5.00	726
South Zone	**30.13**	**105.00**	**592**	**28.37**	**95.00**	**569**
Others	1.70	6.00	600	1.67	6.00	611
Grand Total	**119.78**	**365.00**	**518**	**115.53**	**375.00**	**552**

1 bale= 170 kg.

Source: Cotton Advisory Board, Ministry of Textile, Govt. of India. * - As estimated by CAB in its meeting held on 01.11.2013

Annual (April 1, 2012 to March 31, 2013) Performance Evaluation Report in respect of RFD 2012-2013 of RSCs i.e. Institutes **Annexure-I**

Name of the Division: Crop Science Division

Name of the Institution: Central Institute for Cotton Research, Nagpur

RFD Nodal Officer: Dr. M.V. Venugopalan

Objectives	Weight (%)	Actions	Success Indicators	Unit	Weight (%)	Target/ Criteria Value					Achievements	Performance		Reasons for shortfalls or excessive achievements, if applicable
						Excellent	Very Good	Good	Fair	Poor		Raw Score	Weighted Score	
						100%	90%	80%	70%	60%				
1. To conduct research for discovering and developing new genetic material for enhancing yield, stress tolerance, input use efficiency and fibre quality of cotton.	47	Augmentation, collection, characterization and utilization of cotton genetic resources	Germplasm accessions maintained	No.	4	1550	1500	1350	1150	1000	**1789**	**100**	**4**	-
			Germplasm accessions including perennials / land races added to cotton gene bank	No.	3	55	50	44	39	33	**50**	**90**	**2.7**	-
			Germplasm lines, varieties and parents of hybrids characterized through DUS	No.	2	111	100	89	77	66	**100**	**90**	**1.8**	-
			Genotypes characterized through DNA finger printing	No.	2	44	40	35	31	26	**44**	**100**	**2**	-
		Evaluation of cotton genetic resources/ improved varieties for suitable crop husbandry practices	Germplasm lines evaluated for adaptability and stress response	No.	5	620	600	590	570	550	**5020**	**100**	**5**	One time evaluation for water logging based on IRC Decisions
			Advance breeding material	No.	3	20	19	16	14	12	**25**	**100**	**3**	-

Objectives	Weight (%)	Actions	Success Indicators	Unit	Weight (%)	Target/ Criteria Value					Achievements	Performance		Reasons for shortfalls or excessive achievements, if applicable
						Excellent	Very Good	Good	Fair	Poor		Raw Score	Weighted Score	
						100%	90%	80%	70%	60%				
			evaluated for adaptability and stress response											
		Discovery of novel genes to combat stress and improve fibre quality / production	New genes discovered	No.	4	3	2	1	0	0	**3**	**100**	**4**	-
			New transgenic events developed and registered with RCGM	numbe	6	33	30	26	23	20	**33**	**100**	**6**	-
			Informative markers identified	No.	2	18	15	13	12	10	**15**	**90**	**1.8**	-
			Validation of association of markers available in public domain with desired traits	No.	2	3	2	1	0	0	**3**	**100**	**2**	-
		Discovery of novel genes to combat stress and improve fibre quality / production	New genes discovered	No.	4	3	2	1	0	0	**3**	**100**	**4**	-
			New transgenic events developed and registered with RCGM	No.	6	33	30	26	23	20	**33**	**100**	**6**	-
			Informative markers identified	No.	2	18	15	13	12	10	**15**	**90**	**1.8**	-
			Validation of association of markers available in public domain	No.	2	3	2	1	0	0	**3**	**100**	**2**	-

Objectives	Weight (%)	Actions	Success Indicators	Unit	Weight (%)	Target/ Criteria Value					Achievements	Performance		Reasons for shortfalls or excessive achievements, if applicable
						Excellent	Very Good	Good	Fair	Poor		Raw Score	Weighted Score	
						100%	90%	80%	70%	60%				
			with desired traits											
			Lines developed through marker assisted breeding	No.	1	2	1	0	0	0	**0**	**0**	**0**	-
		Development of improved varieties to suit diverse cotton production ecologies / situations	Advanced cultures developed	No.	2	65	60	55	50	45	**72**	**100**	**2**	-
			Promising cultures sponsored for AICCIP	No.	3	37	30	28	27	25	**37**	**100**	**3**	-
			Varieties released / proposals submitted	No.	2	2	1	0	0	0	**1**	**90**	**1.8**	-
		Development / identification of novel/promising germplasm / genetic stock / breeding lines	Germplasm / genetic stock / breeding lines registered with NBPGR	No.	2	3	2	1	0	0	**4**	**100**	**2**	-
		Production of nucleus / breeder 's seeds of cotton / formulations	Quantity of nucleus seed produced	kg	2	55	50	44	39	33	**85**	**100**	**2**	-
			Quantity of breeder seed produced	kg	2	550	525	515	505	500	**1610**	**100**	**2**	To revive the seed chain for HDPS trials
2. To develop efficient, eco-friendly crop husbandry tools for improved cotton genotypes for	41	Crop husbandry tools for improved cotton varieties / hybrids	Production technologies developed	No.	5	5	4	3	2	1	**4**	**90**	**4.5**	-
			Implements designed / fabricated/ tested and validated	No.	4	4	3	2	1	0	**3**	**90**	**3.6**	-

Objectives	Weight (%)	Actions	Success Indicators	Unit	Weight (%)	Target/ Criteria Value					Achievements	Performance		Reasons for shortfalls or excessive achievements, if applicable
						Excellent	Very Good	Good	Fair	Poor		Raw Score	Weighted Score	
						100%	90%	80%	70%	60%				
diverse agro-ecologies			Simulation/ stochastic / prediction / forecasting models	No.	3	3	2	1	0	0	**2**	**90**	**2.7**	-
		Tools of suppression of stresses due to biotic and abiotic factors	Districts monitored for insect pest / disease infestation	No.	5	43	41	39	37	35	**41**	**90**	**4.5**	-
			Populations monitored for insect resistance to insecticides and Bt toxins	No.	6	42	40	38	36	34	**42**	**100**	**6**	-
			New crop protection technologies developed	No.	6	6	5	4	3	2	**6**	**100**	**6**	-
			Techniques to combat abiotic stresses, drought,water logging, salinity/ alkalinity/leaf reddening / high temperature etc.	No.	4	9	8	7	5	4	**8**	**90**	**3.6**	-
		Products / processes disseminated, commercialized and patents filed	Technologies disseminated	No.	4	6	5	3	2	1	**5**	**90**	**3.6**	-
			Products / processes commercialized	No.	2	3	2	1	0	0	**2**	**90**	**1.8**	-
			Patents filed	No.	2	2	1	0	0	0	**1**	**90**	**1.8**	-

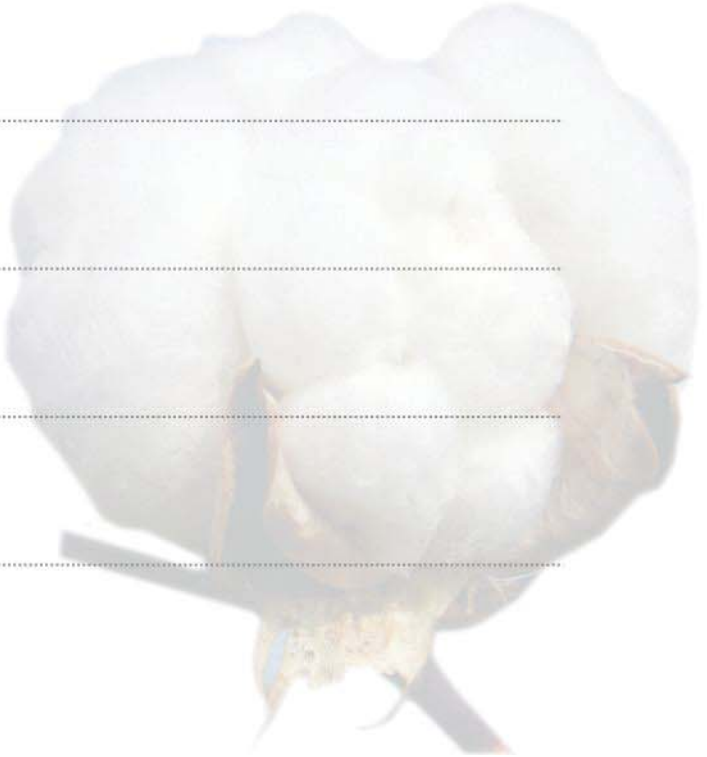
Objectives	Weight (%)	Actions	Success Indicators	Unit	Weight (%)	Target/ Criteria Value					Achievements	Performance		Reasons for shortfalls or excessive achievements, if applicable
						Excellent	Very Good	Good	Fair	Poor		Raw Score	Weighted Score	
						100%	90%	80%	70%	60%				
*Efficient functioning of the RFD System	3	Timely submission of RFD for 2012-13	On-time submission	date	2	Mar. 23 2012	Mar. 26 2012	Mar. 27 2012	Mar. 28 2012	Mar.29 2012	**May 23,2012**	**0**	**0**	-
		Timely submission of Results	On- time submission	date	1	May-01 2013	May-02 2013	May-03 2013	May-06 2013	May-07 2013	**May 01,2013**	**100**	**1**	-
Administrative Reforms	5	Implement ISO 9001	Prepare ISO 9001 action plan	date	1	June 4 2012	June 5 2012	June 6 2012	June 7 2012	June 8 2012	**June 1, 2012**	**100**	**1**	-
			Implementation of ISO 9001 action plan	date	2	Mar 25 2013	Mar 26 2013	Mar 27 2013	Mar 28 2013	Mar 29 2013	**Nil**	**0**	**0**	-
		Implement mitigating strategies for reducing potential risk of corruption	% of implementation	%	2	100	95	90	85	80	**95**	**90**	**1.8**	-
Improving Internal Efficiency /responsiveness service delivery of Ministry /Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80	**100**	**100**	**2**	-
			Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80	**100**	**100**	**2**	-
TOTAL WEIGHT=					**100%**									

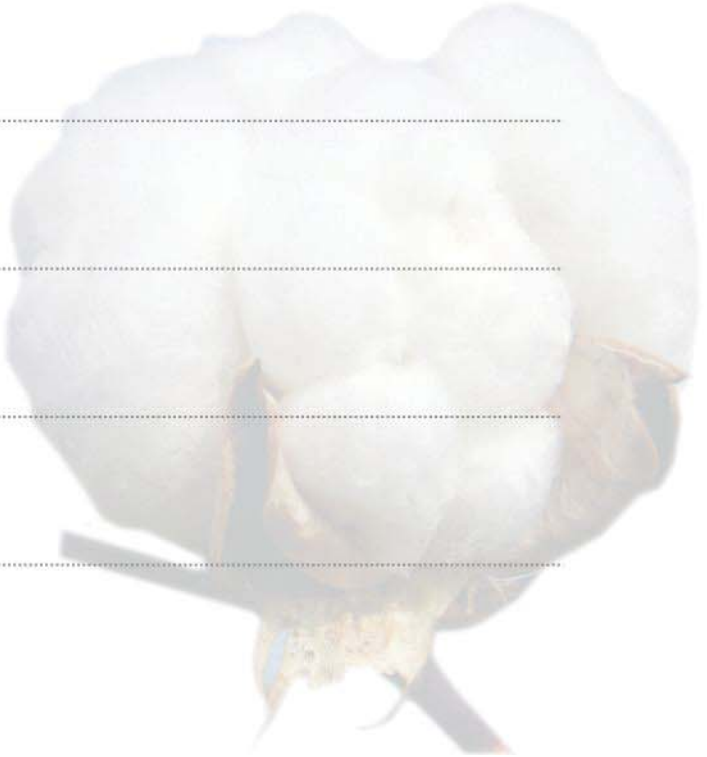
Total Composite Score: 91.0

Rating : Very Good

Procedure for computing the Weighted and Composite Score

1. **Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score / 100**
2. **Total Composite Score = Sum of Weighted Scores of all the Success Indicator**





GLIMPSES OF KRISHI VASANT 9-13 FEB. 2014

Fodder Demonstration Block

Oilseeds Demonstration Block

Vegetables Demonstration Block

Pulses Demonstration Block

Farmers from various states gaining knowledge from the high tech demonstrations & Exhibitions

भाकृअनुप
ICAR

केन्द्रीय कपास अनुसंधान संस्थान, नागपुर

CENTRAL INSTITUTE FOR COTTON RESEARCH

Post Bag No. 2, Shankar Nagar PO, Nagpur - 10 (MS)

- 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 28I 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 10th 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 CISAA 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_3 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^{-1})+ non residual pre plant foliage herbicide (Glyphosate 0.8 kg a.i. ha^{-1}) in 125 L water ha^{-1} 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 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 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 whereever glyphosate was applied continuously. The shift was in favour of broad leaved weeds (*Cynotis culculata* and sedges (*Cyprus rotundus*) from grasses (*Echinocloa 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 epiculticular 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_2 (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 LRA 5166.
- 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 Hydrophonic 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 AKA 7.
- *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 38th to 41stSW, whitefly population with its peak at 39thSW (7.47 whilteflies/ 3 leaves). Two peaks of aphid incidence, first at 34th SW and second at 2nd SW (harvesting stage) were recorded. Thrips incidence was high at 3rd SW (6.23 thrips/3 leaves) and 5th 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^{0}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 ^{0}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^2 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 parasioids *viz. Aenasius bambawalei, Acerophagus papayae, Anagyrus kamali*, *Aprostocetus* sp., *Homalotylus* sp. found parasitizing different species of mealybugs infesting cotton in central zone. Average parsitism 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 1st week of august to first fortnight of September. Dipteran fly *Cacoxenus perspicax* (Knab) was found to predate on *N. viridis (*26.3%). *Hyperprasitoids Promuscidea unifasciativentris* 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_{50} of 68.74 ppm while nano pyridalyl recorded an LC_{50} of 43.88 ppm against one day old *H. armigera* in diet incorporation bioassays. The EC_{50} of nanopyridalyl (16.74 ppm) was 3 fold higher than pyridalyl (51.26 ppm).
- Pyridalyl recorded an LC_{50} of 13724 ppm while nano pyridalyl recorded an LC_{50} of 9166 ppm against 3rd instar larvae of pink bollworm in diet incorporation bioassays. The EC_{50} 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 3rd instar larvae recorded LC_{50} of 2.51 and 1.91 ppm, respectively. Topical bioassay of Flubendiamide (new molecule) against 3rd instar larvae of 2 strains of *H. armigera* from Sirsa and Parbhani exhibited an LC_{50} of 0.297 and 0.117 ppm respectively.
- Cotton semilooper *Anomis flava* recorded 1000 fold more tolerant to Cry2Ab (LC_{50}=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_{50} of 0.469 µg/ml of diet in F_1 generation. Cry2Ab exhibited an EC_{50} of 27.26 µg/ml of diet on field resistant Sirsa population. Populations generated from BGII collections exhibited LC_{50} and EC50 values of 2.46 and 0.061 µg/ml of diet for Cry1Ac.
- F_2 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_2 population of Surat (A7, 2, 5) and F_1 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 MVPII with an EC_{50} of 0.071 µg/ml for Cry1Ac while LC_{50} to Cry2Ab was 2.66 µg/ml of diet and EC_{50} 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 42nd SMW (25.62/trap/week), American bollworm (ABW) during 12th SMW (48.1/trap/week), Spotted bollworm during 39th SMW (29.29/trap/week) and Tobacco caterpillar during 18th SMW (205.7/trap/week) was observed.
- The cotton leaf curl virus disease appeared in 24th meteorological week and reached 100% at 33rd 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 30th 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 ^{0}C and minimum temperature between 25.4-29.5 ^{0}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.