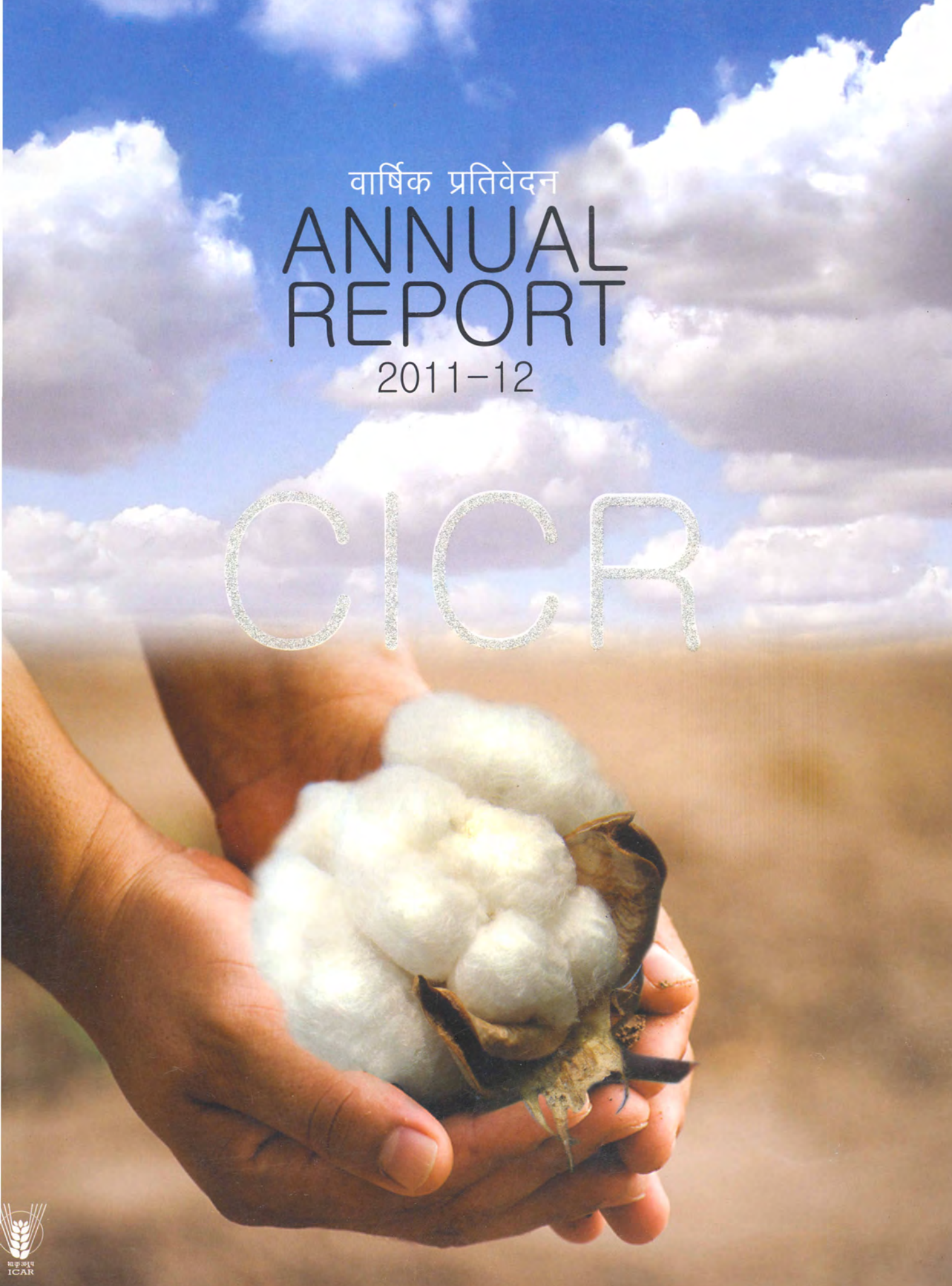
वार्षिक प्रतिवेदन

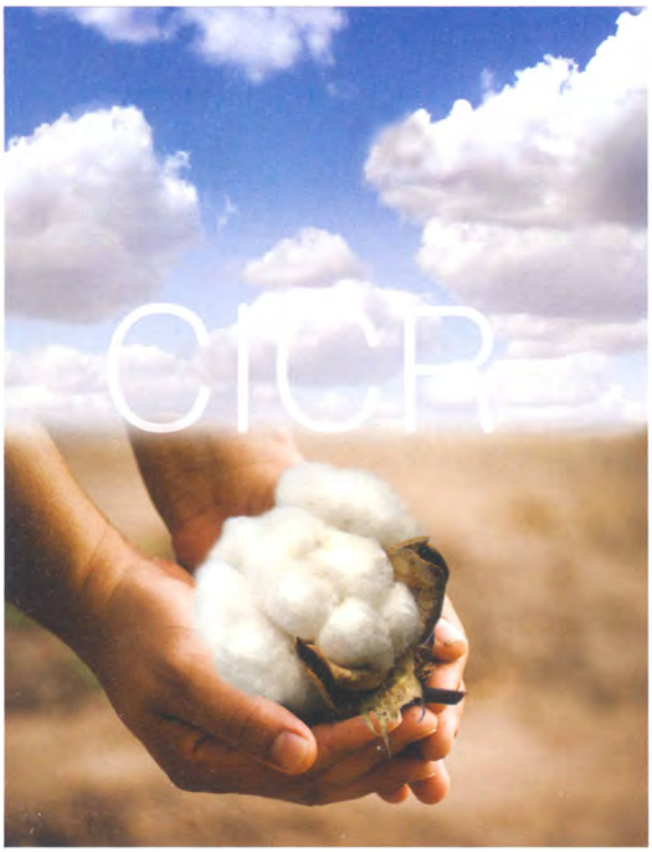
ANNUAL REPORT

2011-12

CICR



भाकृअनुप
ICAR



वार्षिक प्रतिवेदन

ANNUAL REPORT

2011-12

Published by
Dr. K. R. Kranthi
Director, CICR, Nagpur

Editorial Committee
Dr. K. R. Kranthi
Dr. M. V. Venugopalan
Dr. D. Blaise
Dr. Sandhya Kranthi
Dr. P. K. Chakrabarty
Dr. A. H. Prakash

Compilation, Collation and Production
Dr. Mahendra Singh Yadav
Mrs. Vandana Satish

Hindi Version: Dr. Ram Ratan Gupta

Correct Citation
CICR, Annual Report 2011-2012
Central Institute for Cotton Research, Nagpur, India
PP 79

Printed At : Surya Offset, Ramdaspeth, Nagpur

भाकृअनुप
ICAR

वार्षिक प्रतिवेदन

ANNUAL REPORT

2011-12

केन्द्रीय कपास अनुसंधान संस्थान, नागपुर

CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

CICR, Nagpur

CICR, Regional Station, Coimbatore

CICR, Regional Station, Sirsa

PREFACE

Bt cotton completed 10 years in India. Cotton area increased to an all time high of 121.91 lakh hectares with 91.2% under Bt-cotton. With all the best of technologies available for cotton cultivation, the production was highest ever at 345 lakh bales. It is clear that Bt-cotton as a technology has played a significant role in bollworm management. The impact of the Bt cotton technology has been perceptible on at least three main aspects. 1. Effective control of bollworms, 2. Significant reduction of insecticides for bollworm control from 70% in 2001 (before Bt cotton) to 10% in 2011 and 3. decline of 'bollworm-fear'. Yields increased because of Bt and a few other efficient technologies such as micro-irrigation, high yielding hybrids, seed treatment and effective pesticides for sucking pest control.

The cost of inputs for cotton cultivation increased recently. Bt-cotton seed cost increased from Rs 750 to Rs 930 per packet of 450 gms. Fertilizer costs, labour costs and pesticide costs increased as well. Taking all these factors into consideration, the minimum support price was increased to Rs 3300 per quintal for medium staple and Rs 3900 for long staple cotton. The impact of this increase remains to be seen once the harvested produce reaches markets. However, there is an imminent need to develop low cost technologies to sustain higher yields, to make cotton cultivation more profitable.

Some of the recent results from the institute showed that drought resistance, disease resistance and insect resistance could be possible through conventional breeding as well through genetic modification. While the science appears promising, it is important to convert the useful findings into tangible technologies. Specifically, efforts need to be intensified to develop technologies for rainfed tracts. And, the institute is gearing up for the same.

Cotton in rainfed regions, especially in Vidarbha has always been a challenge. We need short-duration early maturing varieties for the region, that are resistant to sucking pests. The institute's variety 'Suraj' gives us plenty of hope for the future. With the best-ever quality fiber attributes at 30 mm and 25 g/tex, Suraj has been found to be amenable for high density planting. We have plans to demonstrate cultivation of 'Suraj' and a few Desi varieties with CICR technologies in about 240 acre demonstration plots of high density planting systems (HDPS) in 8 districts of Vidarbha, in shallow soils under rainfed conditions. The density at 100,000 plants per acre in the HDPS would be at least

16 to 20 times more than the density of Bt-hybrids. Thus 5 bolls per plant in HDPS would be equivalent to 100 bolls per plant in Bt-hybrids. If the trials succeed, the institute would have paved the way for a new low-cost alternative approach of sustainable cotton cultivation in rainfed regions and more specifically in Vidarbha. We earnestly hope to succeed.

I would like to personally acknowledge the guidance and encouragement we always receive from Dr S. Ayyappan, DG, ICAR., Prof S. K. Datta, DDG (CS), Dr C. D. Mayee, Chairman, QRT, CICR, Dr S.A. Patil, Chairman RAC and Dr N. Gopalakrishnan, ADG (CC). The heads of divisions CICR, Nagpur Dr P. K. Chakrabarty, Dr Sandhya Kranthi and Dr Blaise Desouza, and Dr D. Monga, Head of regional station, Sirsa, and Dr A. H. Prakash, Head and PC, Coimbatore deserve appreciation for the timely inputs and editorial assistance. I would like to personally thank Dr M. V. Venugopalan, and Dr M. S. Yadav for the tremendous amount of energy, effort and dedication.

K. R. Kranthi
Director

CONTENTS

CONTENTS

2. Executive Summary

2.1 Crop Improvement

Nagpur

- One hundred and nineteen cotton germplasm, including 82 perennials, 14 land races and 23 traditional cotton belonging to G. *arboreum* and G. *barbadense* species were collected from states of Maharashtra, Madhya Pradesh, West Bengal, Andhra Pradesh, Tamil Nadu, Punjab, Meghalaya, Assam and Mizoram.
- Twenty three varieties of cotton, including 17 G. *hirsutum* and six G. *arboreum,* were procured from Pakistan under Reciprocal Germplasm Exchange Agreement and evaluated.
- Species garden with 26 wild species, 15 races and more than 40 synthetic polyploids of *Gossypium* and related species were maintained and used in introgression breeding.
- Drought tolerant culture of G. *hirsutum* CNH 301 was registered with Plant Germplasm Registration Committee (Regd NO.INGR 11061 and IC No. 0587405).
- Four genetic stocks of G. *hirsutum* with unique morphology *viz.* CNH-CB 215, CNH-CB 211, CNH-CB 212 and CNH-CB 205 and one inter-racial pigmented G. *arboreum* line CAN 5, identified for registration.
- 137 G. *harknessii* based CMS, 15 G. *aridum* based CMS, 57 restorers and 20 GMS lines were maintained. GMS lines ofPKV 081 ,AK 32, L 147, Suman and Sharda developed.
- Promising G. *arboreum* cultures CNA 389 and CNA 390 and G. *hirsutum* culture CNH-315 identified / developed in the Institute was sponsored in National trial of AICCIP based on their performance in Institute trial..
- CNA 398 that ranked first among the G. *arboreum* cultures and CNH 14 ranking fourth among G. *hirsutum* cultures in the central zone were promoted for further evaluation in the zone.
- Sixty one genotypes under conversion to Bt background were advanced to subsequent generations of back-crossing with populations existing in various generations from BC_2 to $BC.F_3$.
- Fifty single plant progenies were selected based on tolerance to jassid, earliness and yield potential and advanced to F_6 generation.
- Two hundred thirty five working germ plasm accessions of G. *hirsutum* were characterized using 44 SSR markers.
- Out of 335 SSR primers surveyed to screen polymorphism between bacterial blight susceptible and resistant parents, 30 SSR markers were found polymorphic between the parental genotypes, Ganganagar Ageti and S 295.
- Confined field trial was conducted with seven transformation events of *Bt-cry1Ac* gene to characterize and select effective events. Three new events of *cry1Ac* and two events of *cry1* F were generated in G. *hirsutum* variety Anjali.
- Confined field trial was conducted to select and characterize effective events of *cry1Ac* gene in G. *arboreum.* Besides, 22 new events of *cry1Ac* and *cry1F* genes were generated in cvs RG 8 and PA402 by *in planta* transformation.
- Five out of eight events generated using dsRNA interference construct of CP gene in G. *hirsutum* cvs F 846, LH 2076 and HS 6, were found PCR positive for the transgene.
- Putative transformants of G. *hirsutum* cvs LRA 5166 and LRK 516 generated with *DREB 1A* and *ZF1A* genes were characterized and evaluated for drought tolerance in confined field trials.
- Seed-specific legumin (beta globulin) promoter sequence from cotton (G. *hirsutum)* was identified; PCR amplified and sequenced.
- Potassium Chloride @ 2% and Hydrogen peroxide @ 40mM promoted superior seedling growth under soil moisture stress conditions.
- About 4.37 quintal TFL seeds of G. *hirsutum* and G. *arboreum* cultures/cultivars of cotton besides, 1.78 quintals of certified seeds of Gram and Kabuli Chana were produced under Mega Seed Project.. Revenue of 13.0 lakhs was generated through sale of these seeds.

Coimbatore

- Cernuum race of G. *arboreum* was characterized for stem, leaf, flower and boll characters as per germ plasm index card.
- Three exotic lines of G. *barbadense viz.,* EC-617836, EC-617837 and EC-617840 recorded significantly higher yield than the check Suvin. Three exotic genotypes EC-617836, EC-617840 and EC-617844 had better GOT compared to Suvin (27%).
- Medium staple culture CCH 2623 based on its superior performance in central zone and south zone locations has been recommended for testing the agronomic requirements in both the zones.
- Nine G. *hirsutum* x G. *barbadense* hybrids were identified with superior seed cotton yield over the check hybrid RCHB-708 Bt. CCHB 12 documented the highest seed cotton yield (24.75 q/ha) and bundle strength (33.5 g/tex), while CCHB 11 had the highest staple length (38 mm). Hybrid CCHB-6 recorded highest GOT (35%) with suitable micronaire value (4.21J/inch).
- A promising G. *hirsutum* x G. *barbadense* hybrid CCHB-4 was sponsored in multi-location yield evaluation trial under AICCIP.
- Breeder seeds (336 kg) for cultivars Suraj, LRK 516 and LRA 5166, well beyond the target to meet the requirement ofDAC indenters, were produced.

- Plant variety registration certificate for 21 extant cotton varieties have been obtained from PPV&FRA.
- Working group of 333 cotton germplasm was characterized for distinctiveness, uniformity and stability as per the National test guidelines for tetraploid cotton.
- Polymer coating of seeds with Polykote (3 ml/kg) diluted in 5 ml of water containing Imidacloprid (6 ml/kg) or Royal flow 40 SC (2.4 ml/kg) + Imidacloprid (6 ml/kg), supported improved seed viability under ambient storage conditions.

Sirsa

- 3954 accessions of cotton were evaluated in north zone and ten superior genotypes each with superior yield, boll weight, number of bolls / plant were identified.
- Cytoplasmic male sterile local adapted cultivars and parents of promising hybrids of cotton having cytoplasm of G. *harknessii* and new restorer lines identified were maintained through sibmating.
- Studies on development of heterotic pools showed that in G. *arboreum* male parents CISA-6-187, CISA 9, CISA 8 and female parents OS 5 were good general combiners for seed cotton yield while in G. *hirsutum* the male parents OK 2885, CSH 2912, CSH 3129, CSH 2907 and female parents GMS 26, GMS 17, GMS 27 were good general combiners for seed cotton yield and GMS 17 for ginning percentage.
- *Intra-hirsutum* GMS hybrid CSHG 1862 with 11.68% increase in yield over the zonal check was identified for release in irrigated tracts of north zone.
- In the first year trial, 20 G. *hirsutum* cultures were evaluated against CLCuV alongwith check. Cotton leaf curl virus resistant advanced cultures viz. CSH 2833, CSH 2811 and CSH 2844 showed 9.28 and 6.66 per cent yield superiority overthe local check variety RS 2013 (1652 kg/halo
- One hundred kilogram breeder seeds of male and female parents of four released hybrids and 82 kg breeder seeds of two *desi* cotton varieties were produced during 2011-2012.
- The seed cotton yields of Bt cotton sown as sole crop was significantly higher than the paired row sole cotton with intercropped *khariflegumes* under irrigated condition.
- In general, 3-5 q/ha higher seed cotton yield was realized in *desi* cotton at a spacing of 67.5 x 20 em as compared to 67.5 x 10 and 67.5 x 30 em spacing.

2.2 Crop Production

Nagpur

- Out of 13 American cotton varieties evaluated under organic conditions, NH 615, Suraj, PKV 081, LRK 516 and AKH 8828 performed better and had acceptable fibre properties. Among the *desi* varieties, JLA 794, CNA 347 and AKA 7 were the high yielders. These varieties also possessed good staple length of26.2 to 27.9 mm.
- G. *hirsutum* varieties namely Suraj,, ADB 39, PKV 081 and 28 I were found promising in terms of yield, morphology, earliness and nutrient use efficiency under high density planting system (HOPS) on rainfed Vertic Inceptisols of Nagpur. Averaged over ten genotypes, mean yield in HOPS with 125% RDF was 1409 kg/ha as against 1088 kg/ha under normal planting with normal RDF indicating a 29% advantage with HOPS.
- Among 8 genotypes of G. *arboreum* evaluated, on the basis of yield, plant type and growth characteristics CINA 404, HD123 and JLA 505 performed well under high density planting (2,22,000 plants/ha).
- Bt hybrid cotton intercropped with either roselle, soybean and marigold produced similar cotton equivalent yields and was significantly greater than sole cotton.
- On bench mark locations of black soil regions, soil microbial diversity i.e. Shannon diversity index (H') was similar in both legume-based and cereal-based cropping system. All other diversity indices (Simpsons index (D), Simpsons reciprocal index (1/0), and Simpson evenness (E)) were found to be significantly ($p < 0.05$) higher in cereal-based cropping system over legume-based system.
- Foliar applications of maleic hydrazide (500 ppm) at 85 days after sowing (DAS) recorded highest plant height, leaf area and Leaf Area Index (LAI) of 82.3,6964.0 cm^2 and 1.3 respectively and produced significantly higher yield than detopping main stem at 95 DAS and sympodial meristem at 105DAS.
- Foliar application of ethrel at 39 DAS increased the photosynthetic leaf area, leaf area index and produced more bolls on the cotton plants than control..
- Foliar application of potassium silicate (40, 60, 80 IJI/l)done at 30 and 60 DAS positively influenced the leaf water relations in terms of relative water content (RWC) and leaf water potential.
- A wick applicator was developed to smear the weeds with herbicide solution in between the rows of cotton plants for HOPS system since spraying chemicals has the risk of killing nearby cotton plants by drift of the weedicides.
- Conceptual design of a cotton picking machine to be operated by a pair of bullocks or a person behind the machine was prepared in CAD. Machine, plant and soil parameters were analysed to design the cotton picking machine. CAD drawing and 3D solid model of the picker were made. Fabrication of all the components was completed after testing the assembly for its strength and stability in the standing crop of cotton at each stage of fabrication, and suitable modifications thereof.

Coimbatore

- Application of arbuscular mycorrhizae and phosphorus solubilising bacteria along with recommended dose of fertilizers improved germination percentage and plant growth compared to application of 50% dose of fertilizers along with bioinoculants.
- New plant geometry (120 x 45 em) for the Bt cotton + coriander, Bt cotton + radish and sole cropping system had greater seed cotton equivalent yield, net return and benefit cost ratio than the normal spacing of 90 x 60 em.
- Among genotypes, under high density planting system, KC-3 recorded higher seed cotton yield (2655 kg/ha) followed by PKV 081 (2253 kg/hal, Anjali (2215 kg/ha) and NH 615 (2121 kg/ha) than the control RCH 2 Bt (1596 kg/halo The highest gross return (Rs. 79,650/ha) was obtained with KC-3, and Anjali registered the highest net

return (Rs. 39,805/ha) and benefit cost ratio (2.1) because of higher market price.

- Genotypes x nutrient interaction results revealed that Anjali planted at 45 x 15 cm and applied with 150 per cent of RDF registered significantly highest seed cotton yield (24.91 q/ha), gross return (Rs. 94,658/ha), net return (Rs. 54,730/ha) and benefit cost ratio (2.37).
- Sowing under high density planting system is labour intensive. An alternate strategy of sowing using tractor drawn inclined plant planter (1918 kg/ha) was similar to manual method of sowing (2003 kg/halo
- Stale Seed Bed Technique (application of pendimethalin 1.0 kg + glyphosate 1.0 kg with one hand weeding at 35-40 DAS) produced maximum seed cotton yield and net return.
- Weed control by application of residual chemical, pendimethalin @ 1.25 kg a.i./ha as pre emergence followed by post emergence application of quizalofop ethyl @50ga.i./haand pyrithiobac sodium @ 75 g a.i./ha at 30 and 35 DAS respectively registered significantly highest yield (2116 kg/ha), gross return (Rs. 74,043/ha) and net return (Rs. 37,506/ha), which was on par with pendi methalin @1.25 kg a.i./ha followed by post emergence application of tank mixing of quizalofop-ethyl @ 50 g a.i./ha + pyrithiobac sodium @ 75 g a.i./ha at 30 DAS and pre emergence application of pendimethalin @1.25 kg a.i./ha + HW at 30 DAS.
- Pendimethalin 1.0 kg as pre emergence herbicide on third day followed by HW 35 - 40 DAS and pyrithiobac sodium 50 g + quizalofop-P- ethyl 50 g on 60 DAS recorded the highest seed cotton yield, net return and B:C ratio. It was on par with pendimethalin followed by HW and pyrithiobac sodium 50 g + fenoxoprop-P-ethyl 50 g on 60 DAS and Hand weeding thrice (20, 40 and 60 DAS).
- Percentage increase in yield due to foliar application of nutrient consortia was about 12-13% in non- Bt genotypes while Bt recorded an increase of 15 to 19%. Irrespective of non- Bt genotypes and Bt cotton, Nitrate reductase activity was significantly more in nutrient sprayed plants. Photosynthetic activity was significantly higher in Bt cotton than conventional genotypes.
- Nutrient consortia spray revealed that Bt cotton was more affected by water logging and responded more favourably to nutrient consortia spray than conventional genotypes. Yield was significantly more in Bt cotton (86 to 109 g/plant) than conventional genotypes (62 to 70 g/plant). This reduction in yield per plant due to water logging could be improved by 5-9% in conventional genotypes while the improvement in yield was 29 to 46% in Bt cotton through nutrient consortia spray.

2.3 Crop Protection

Nagpur

- Highest population of sucking pests was recorded during 2'd to 3"' week of September. Mealybugs *Phenacoccus so/enopsis* and *Nipaecoccus viridis* were recorded in some fields with negligible population during late season of crop. Negligible population of all the three bollworms and *Spodoptera /itura* was recorded during the year.
- Diversity of four mealybug species *viz, P so/enopsis, N. viridis, Ferrisia virgata* and one unidentified mealybug species (Homoptera: Pseudococcidae) was recorded. They were found infesting cotton with Grade- IV infestation in cotton+ pigeon pea-fallow cropping system of central India.
- With six new parasitoids recorded during the year, a cumulative of 16 parasitoids and 9 predators have been recorded on mealybugs in India.
- Weevil *Tanymecus pronceps* (Faust) (Coleoptera: Curculionidae) was recorded infesting non-Bt cotton during off-season. Mirid bug *Creontiades biseratense* which is predominant in southern cotton growing states especially Tamil Nadu and Karnataka is now observed in central India although in lesser number.
- Comparatively higher sucking pest population was recorded in cotton field adjacent to soybean and in unprotected fields.
- Out of twelve under-release Bt hybrids, GK-228 BGII and PCH-66 were tolerant to aphids; PCH-44 and KDCHH-553 BGII to leafhoppers and PCH-55 and PCH-22 to whiteflies. No significant difference was observed with respect to thrips, mirid and spider population on Bt hybrids.
- Sampling from top 1/3"' plant canopy with 15 plants/acre was found to be optimum for assessing field population of *C./ivida.*
- At constant temperature of 27°C and RH 60%, highest fecundity of *P so/enopsis* was observed on congress grass (268 eggs) followed by hibiscus (239 eggs), okra (200 eggs) and tomato (186 eggs).
- Aphid, whitefly and mirid populations were significantly higher in IPM as compared to RPP over the season, whereas no significant difference in population of leafhoppers and thrips was observed. Spider population was significantly higher in IPM while coccinelids were at par. Statistically there was no difference in yield.
- Cotton pest management strategies were disseminated through ICT tools (computer, internet and mobile) as CICR was one of the stakeholders in Crop Pest Surveillance and Advisory Project (CROPSAP) 2011-12 in Maharashtra.
- Insecticidal toxin genes - tcaA (4.5 kb), tcaC (2.5 kb), tccA (3 kb), tccC (around 3 kb) and W14tccC (around 3 kb) could be amplified with long range Taq (Promega). tcaA, tcaC, tccA were amplified from *Xenorhabdus indica* and X. *poinarii* isolates, while WI4tccC was amplified from *Photorhabdus.*
- Molecular characterization of 16sRNA and 18sRNA of bacterial and fungal antagonists for DNA fingerprinting of potential fungal *(Fusarium pallidoroseum, Metarhizium anisopliae, Lecanicillium /ecanii* Coimbatore and NBAII isolates) and bacterial bioagents *(Xenorhabdus* and *Bacillus spp.)* was carried out and the sequences were deposited in the gene bank.
- Biochemical and molecular characterization was carried out for six isolates of bacteria *Xenorhabdus* and *Photorhabdus* symbiotically associated with entomo-pathogenic nematodes which were effective against sucking pests and mealy bug.

- Multiplex PCR protocol was standardized for detection of all cotton pathogens in one PCR reaction. This technique can be used for quick detection and identification of cotton pathogens in soil as well as plant sample.
- *Thrips palmi* is predominant on cotton in north India, especially Haryana, during the early vegetative stage while *Scirlothrips dorsalis* is dominant on cotton in Maharashtra during early reproductive stage.
- Acephate and Imidacloprid at the recommended doses were compatible with microbial consortia and *T viride* for use as seed treatment.
- The incidence of pink bollworm moths was moderate in the third week of January in Nagpur with 15.53 moths/trap/week.
- BG, BGII were free of pink bollworm incidence and damage as compared to the non Bts in India.
- Survival of pink bollworm on extended BG crop was observed in pockets of Nandurbar, Dhule and Jalgaon.
- Trait purity with reference to *cry2Ab* was an issue in fields recording pink bollworm incidence on BGII of this region.
- Translation of COI sequences of leaf hopper populations from different regions of India showed little variation.
- Transmission of CLRDV (Cotton Leaf Roll Dwarf Virus) from cotton to chickpea was successful but transmission from chickpea to cotton was not established.
- Five collateral hosts of *Myrothecium rorridum* have been identified.
- Three genes encoding man nose-specific lectins have been identified in the *Trichoderma virens* genome.
- No genetic differences were found between CLCuV infected plant samples showing upward and downward curling.
- Silencing chitin synthase A and trehalose phosphate synthase was found to be promising in terms of their mortality and growth regulating effects on *H. armigera.*
- A robust replicable bioassay protocol for evaluating the direct and indirect toxicity of lectins to *Chrysoper/a* sps and *Mallada boniensiswas* standardized.
- Leaf hopper samples from 10 locations were subjected to resistance monitoring studies. $LC_{SO}$to imidacloprid ranged from 0.00012 mg/L (Bhatinda) to 0.128 mg/L (Buldana). LC_{SO}s of thiamethoxam ranged from 0.00013 mg/L (Bhatinda) to 0.145 mg/L (Buldana). Seven populations of leaf hoppers were subjected to bioassays with acephate and monocrotophos and its LC_{50}sranged from 0.0008 mg/L to (Bhatinda) 0.1622 mg/L (Nagpur) and 0.008 (Bhatinda) to 0.0779 mg/L (Jalna) respectively.

Coimbatore

- Nymph and adult population of mirid bug *Creontiades biseratense* (Distant) build up was observed from the second week of December, lowest and highest nymphal population was recorded during 50th std week (0.36 nymphs/plant) and 1st std week (4.17 nymphs/plant) respectively. Lowest and highest adult population was recorded during 50th standard week (0.14 adults/plant) and 2nd std week (1.39 adults/plant) respectively. The percentage of green boll damage and square damage varied from 1.85 to 17.14 % and 2.37 to 18.55 %, respectively.
- No mealybug infestation *(Paracoccus marginatus* and *Phenacoccus so/enopsis)* was observed throughout the observation period (September - February) on cotton or other alternate hosts in experimental and farmers fields.
- Under IRM farmers fields at Tirupur district of Tamil Nadu sucking pests *viz.,* aphids, leafhoppers, thrips and whiteflies population were below threshold level.. Mirid and mealybug population were negligible. Incidence of bollworms was nil.
- Cotton seed based artificial diet has been standardized for continuous rearing of pink bollworm *Pectinophora gossypiella* and the ingredients of the diet are easily available and cost effective. The per cent recovery, egg hatchability, adult emergence were superior than the other available diets.
- Monitoring for development of resistance against Bt hybrids in *Pectinophora gossypiella* revealed that among RCH 2 Bt, RCH 20 Bt and RCH 2 NBt, number of exit holes and damaged locules were maximum in NBt than Bt. Mines on the epicarp were minimum in Bt as compared to NBt.. No significant difference was recorded in the number of warts observed in the epicarp of the bolls in Bt and NBt hybrids. Maximum number of surviving and dead larvae were recorded in NBt hybrid and Bt hybrids respectively.
- Recovery of *P gossypiella* larvae was significantly higher in NBt hybrids than Bt hybrids collected from different centres of south zone from Tamil Nadu (Srivilliputhur), Karnataka (Dharwad, Haveri) andAndhra Pradesh (Nandyal).
- Among the insecticides tested (Imidacloprid, Confidor and Victor), Thiamethoxam (Actara), Acephate (Asataf) and Monocrotophos) for resistance against leaf hopper *Amrasca devastans* Dist., Victor registered the minimum LD_{SO} value (0.0035 milL) followed by Confidor (0.0050 ml/L), Monocrotophos (0.0054 ml/L), Thiomethoxam (0.0130 milL) and Acephate (0.0184 ml/L).
- Bioassays with *cry2Ab* against *P gossypiella* from Dharwad recorded LD_{50} and LD_{gO}values as 0.002 ppm and 0.087 ppm respectively and Coimbatore population recorded LD_{SO} and LD_{gp}values of 0.0623 ppm and 0.095 ppm, respectively.
- Twenty four isolates of bacteria and five isolates of fungi were collected from soil samples. Dual culturing of bioagents, revealed that there was no mutual antagonism between the two bioagents *viz.,* isolates of *Trichoderma* spp. and *Pseudomonas.*
- Two isolates of *Trichoderma* spp. and an isolate of *Pseudomonas* (from soil samples) were found effective against *A/ternaria* spp.
- Molecular characterization of five native Entomo-pathogenic fungi *(L. attenuatum* (Gene Bank Accession No. JQ327150), M. *anisop/iae-ARSEF-9613* (Gene Bank Accession No. JQ062986), M. *anisop/iae-ARSEF-9612* (Gene Bank Accession No. JN712743), *L. araneico/a* (Gene Bank Accession No. JN255572) and *L. fusisporum* (Gene Bank Accession No. JF 427909) isolated from mealybug were submitted to Gene Bank.

- Mass multiplication of a native entomopathogeic fungus, *L. /ecanii* using six nitrogen sources (Peptone, Ammonium Nitrate, Sodium Nitrate, Beef extract, Urea and Thio Urea) revealed that Ammonium Nitrate and Thio Urea supported maximum growth and sporulation of *L./ecanii.*
- Effective temperature for the growth of two isolates of M. *anisop/iae* (ARSEF 9612 and 9613) was recorded as 35 °C.
- *L. /ecanii* multiplied in SDAY Broth and formulated in talc supported maximum spore viability of 70 per cent at the end of six months storage under refrigeration.

Sirsa

- 'Seasonal dynamics' of insect pests and diseases was studied where the infestation of mealybug was observed in the month of October onwards indicating late initiation of infestation. In north, during 2011 crop season on cotton, presence of a single species *i.e, Phenacoccus so/enopsis* Tinsley was observed. But at four locations the *Drosichiella* spp. of mealybug was also recorded with minimal economic damage. One predator was recovered from the mealybug *i.e Droschia* spp. and was identified at Entomology Division, IARI, New Delhi as *Rodo/ia fumida* (Mulsant) (Coleoptera:Coccinellidae). Till date 71 alternate hosts of mealybug have been recorded. Parasitisation of cotton mealybug due to A. *bambawa/eiwas* also reported.
- A total of 31 Bt cotton cultivars (newly released) and popular were sown at CICR, RS, Sirsa to study their association with emerging and key pests. No mealybug incidence was observed in any of 31 Bt cotton hybrids. The hybrids did not differ significantly for leafhopper incidence but the difference for whitefly incidence was statistically significant. CLCuV incidence (0.84-10.53%) and root rot (0.00-29.50%) was recorded from 31 Bt cotton cultivars.
- Out of 3954 germplasm accessions evaluated under north zone, 2159 lines free from CLCuD were recorded at experimental area of CICR, RS, Sirsa.
- Among various insecticides and biopesticides, maximum thrips population was reduced by biopesticide, Pest guard LS_0EC(56.97%). The biopesticides and entomopathogens were found safer to generalist predators. Entomopathogen, *Fusarium pallidoroseum* for mealybug management was identified. The efficacy of the entomopathogen was also tested at various AICCIP centres.
- In development and validation of IPM/IRM strategies for Bt cotton hybrids carrying different events against sucking pest complex, observations on the population of leafhoppers ranged between 2.78 to 3.18, average whitefly ranged between 4.64 to 6.36 and average thrips population recorded in different hybrids was 4.09 to 5.84 per 3 leaves under IPM practices where eco friendly strategies like spray of *neem* oil, V */ecanii* were practiced which were less than RPP (Recommended package of practices), where only insecticides were used forthe management of insects.
- Among different treatments whey protein @ 5% found most effective in managing disease (9.8 % incidence, PDI-3.8) followed by calcium nitrate @ 0.5% (10.1 %,5.4), *neem* oil @ 1% (12.5 %, 5.5) and strobilurin @ 0.1 % (13.5 %, 6.4) as compared to control (31.5 %, 14.3) in innovative interventions applied for leaf curl management. . White fly reduction was observed only in case of *neem* oil and Acephate.
- Insecticide Resistance Management strategies were demonstrated in the districts of Sirsa (2540 ha) and Hisar (5215 ha) of Haryana, fifteen villages were selected for this purpose in each district. IRM farmers sprayed 3.59 and 2.38 as compared to 4.22 and 3.82 sprays in non IRM farmers' fields. Insecticide consumption was reduced upto 27.1 and 31.4% respectively in IRM farmers of Sirsa and Hisar. A saving from insecticides by around Rs. *11001-* per ha and an improvement in yield by around 4 q/ha of IRM farmers showed an overall C: B ratio of 1:3.72 and 1:3.65 over 1:3.00 and 1:2.93 at Sirsa and Hisar respectively.
- To monitor the resistance in bollworms to Cry toxins, during 2011 total 42 bioassays were conducted from Haryana, Punjab and Rajasthan where for *cry1Ac* the LD_{SO}ranged between 0.125 IJg/ml to 2.026 IJg/ml and for *cry2Ab* LD_{SO} value of 0.36 IJg/ml to 712.596 1J9/miwas recorded. Pink bollworm larval recovery from north zone was 4.17 - 20.37 % from non Bt cotton. In Bt cotton bolls, no larval recovery was observed at any stage of crop growth. Pheromone trap catches reveal mean male moth catch per trap per week during the 2011 were 3.58 for pink bollworm, 2.43 for American bollworm, 3.79 for spotted bollworm and 14.22 for tobacco caterpillar on CICR farm.
- Technology assessed and transferred through front line demonstration during 2011-12 on hybrid seed production and production technology. In 20 FLD for hybrid seed production of hybrid CICR 2, around 30 q seed of CICR- 2 *(desi* cotton hybrid) was produced by the farmers trained at this centre in hybrid seed production technology. Fifty five FLDs on production technology were conducted.
- Evaluation of entries for insect pests and diseases was done under various trials in AICCIP. In station trials of 7 G. *hirsutum* entries, promising G. *hirsutum* cultures CSH 2932 and CSH 3114 out yielded the check H 1226 with 10-20% higher yield. These entries were sponsored in Br.02a AICCIP trial. In station trial of 6 G. *arboreum* entries promising cultures CISA 111 and CISA 8 out yielded the check and were sponsored in Br.22a/b AICCIP trial. CSH 3088 was promoted to Br.03a trials of north and south zone. CSH 3129 has been recommended for Agronomy after its performance over 4 years in AICCIP trials. The GMS based hybrid CSHG 4207 was sponsored in AICCIP trial Br.05 PHT.
- Effect of defoliant on physiological parameters and seed cotton yield, the experiment on effect of defoliant Thiadiuron 36% SC + Diuron 18% SC on cotton showed that the yield/ha was significantly higher in MRC 7017 (31.2 q/ha) and MRC 7361 (31.0 q/ha) than F 1861 (28.1 q/ha). The uniformity in opening of bolls with both the concentration of Thiadiuron 36% SC + Diuron 18 % SC at both the intervals was observed but the difference for number of unopened green bolls was non-significant as compared to unsprayed control.

3. Introduction

3.1 : Brief History

Nagpur

Indian Central Cotton Committee used to sponsor cotton research schemes on an adhoc basis till the work of the committee was taken over by the ICAR in 1966. All India Coordinated Cotton Improvement Project (AICCIP) initiated by the Council in the year 1967 with headquarters at Coimbatore gave new fillip and direction in terms of multidisciplinary and multi-centre approaches with the active involvement of State Agricultural Universities. The project has contributed significantly in tackling location-specific problems in terms of varietal improvement and development of appropriate production and protection technologies. However, looking to the low level of productivity since major cotton growing area is under rainfed conditions, a need for expanding the research efforts in the spheres of basic and strategic research was felt, 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.

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

3.2 : 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.**

3.3 : Salient Achievements During XI Plan (2007-12)

- One thousand eight hundred and fifty four (1854) accessions of germplasm were procured and two wild species were added to enrich the gene bank. 505 accessions were evaluated for economic characters.
- Twenty-seven (27) genetic stocks (G. *hirsutum*- 21 and G. *arboreum* - 6) have been registered for their unique, novel and distinct characteristics.
- Two high yielding G. *hirsutum* varieties *viz.* CCH 510-4 (Suraj) and CNHO 12 were released for Irrigated: south and central zone and central zone, respectively. Two high yielding G. *arboreumvarieties* *viz.* CISA614and CNA 1003 (Roja) were released for irrigated: north zone and rainfed: south zone, respectively. Two high yielding Intra-specific hybrid (Intra *hirsutum)* *viz.* CSHH 243 with CLCuV resistance and CSHG 1862 (GMS based) were released for irrigated: north zone.
- Population of public sector varieties containing Bt gene *viz.* Anjali Bt (G. *hirsutum),* PA 255 and RG 8 Bt (G. *arboreum)* was advanced for commercialization following partial characterization of the events.
- The inverted repeat constructs developed in the Institute *viz.* plasmids pBin-CP-S-int-A and pBin-~C4-S-int-A were transformed in G. *hirsutum* cultivar HS6 by agro inoculation. Putative transformants were characterized for integration of the transgenes.
- New transgenic events for *cry1Ac, cry1F* and Chitinase gene have been developed by *in-planta* transformation technique.
- A high-tech ELS cotton production technology combining the use of poly-mulch and drip irrigation was standardized. This technology can help in realizing 5 tonnes/ha of ELS cotton. Irrigation through drip at 0.4 Etc under this system could maximize WUE to 118 kg/ha em water.
- **Refinement of production technologies for Bt cotton**
  - Optimum planting geometry for RCH 2 Bt at Coimbatore was 90 x 45 em and 125% of RDF (90:45:45) was optimum fertilizer dose. In north zone, optimum spacing identified was 67.5 em x 75 em.
  - In central zone, for shallow soils (vertic Haplustepts) Bt cotton + maize was the best, whereas for medium - deep black soils marigold, green gram and black gram were found promising. Coriander and radish were promising intercrops for Bt cotton in peri-urban situations of Coimbatore.
  - Irrigation through drip system @ 0.80 ETc produced the highest seed cotton yield in Bunny-Bt on Vertisols of Nagpur whereas the highest water use efficiency and water productivity was at 0.6 ETc.
  - Transplanting Bt cotton using seedlings raised in plastic containers with sand + saw dust mixture and transplanted at 25 DAS was identified as a viable option for gap filling.
- **Mechanization of cotton production**
  - A novel solar operated knapsack sprayer which has a field capacity of 4 hrs/ha, a swath of 90 em giving 20 sprays with single charge was developed.
  - For small and marginal farmers, ergonomically efficient bullock drawn implements *viz.* cotton planter, iron

plough with sowing attachment, ridger, adjustable hoe and bund former were designed, fabricated and evaluated under rainfed cotton based cropping systems.

- A small sized manually operated cotton planter was developed for planting cotton seed and an adjustable cultivator was designed and developed for intercultural operation for narrow spaced cotton crop and a fertilizer aplicator has been modified for equal distribution of fertilizer from both tubes. Field efficiency of manually operated small hand picker varied from 56% to 100% of the manual picking.

- **High density planting system (HOPS)**
  - On rainfed Vertisols (Nagpur), G. *hirsutum* genotypes PKV 081, Suraj and ADB 39 were most suitable for HOPS (150000 plants/ha). A spacing of 45 x 15 em was optimum for short compact types.

- **Biological control to strengthen IPM**
  - Three parasitoid species *viz.,* A. *bambawalei, Metaphycus* sp. and *Promoscidia unifaciventris* have been observed to parasitize mealybug P. *solenopsis.* A new entomopathogen identified as *Fusarium pa/lidoroseum* was observed from mealybug cadavers. Application of 5% w/w formulation resulted in effective control of mealybug.

- **Ecological studies to strengthen IPM**
  - Coccinellids - *Brumoides suturalais* (F.), *Cheilomenes sexmaculata* (F.) *Scymnus coccivora* and *Crypto-laemus montrouzieri* on P. *solenopsis* were documented as predators while *Gitonides perspicax* Knab (Droso-philidae: Diptera) was recorded as predator on *N. viridis/M. . hirsutus.*
  - Lab multiplication protocol was standardized *for* C. *montrouzieri, Aenasius bambawalei* and *Scymnus coccivora.*
  - Bio formulations Mealy Quit and Mealy Kill were developed forthe mealybug management. .
  - Novel non- phytotoxic, botanical bio- emulsifier (soap nut) in combination with limonene, ocimene and jasmine perfume was identified and evaluated as 5% spray and found effective against sucking pests in multi-location trials.
  - Pest Guard L, Pest Guard 0, Pest Guard J, Acephate and Chlorpyriphos were most effective for management of mealybug.

- **Studies on Bollworm resistance to Bt and Bollworm and sucking pest resistance to conventional insecticides**
  - Jassids demonstrated resistance of 110 fold, 57 fold, 2500 fold and 5450 fold, to Acephate, Monocrotophos, Thiomethoxam and Imidacloprid, respectively.
  - The variability in susceptibility in *H. armigera* field strains to *cry1Ac* was 2.2 fold with respect to LC_{50} and 10 fold with respect to IC_{50}.
  - IRM strategies have reached out 1,63,895 farmers across 3, 18,719 ha in the country between 2007-11.

- **Novel genes**
  - The most effective native Bt strain from Ahmedabad was 14 fold toxic as B. *thuringiensis var kurstaki HD73.*
  - Primer sets were designed to identify, Cry toxins that are specific to Lepidopteran pest..
  - Cotton leaf roll dwarf virus (CLRDV) and Tobacco leaf streak virus were documented on Cotton.

Genetic diversity in cotton leafhopper was documented. There were distinct differences in insecticide resistance patterns with leafhopper populations from Central and South India being atleast 5000 fold more tolerant to chlornicotinyls compared to leafhopper populations from Gujarat and north India.

3.4 : Staff Position (as on 31st March, 2012)

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	-	1	-	1	-	1	-	1
Scientific	50	22	7	79	34	14	6	54
Technical	50	20	7	77	45	13	7	65
Administrative	34	9	5	48	26	7	4	37
Supporting	56	30	10	96	39	16	11	66
Krishi Vigyan Kendra								
Training Organizer	1	-	-	1	1	-	-	1
Technical	11	-	-	11	11	-	-	11
Administrative	2	-	-	2	2	-	-	2
Supporting	2	-	-	2	2	-	-	2

NGP - Nagpur; CBE - Coimbatore

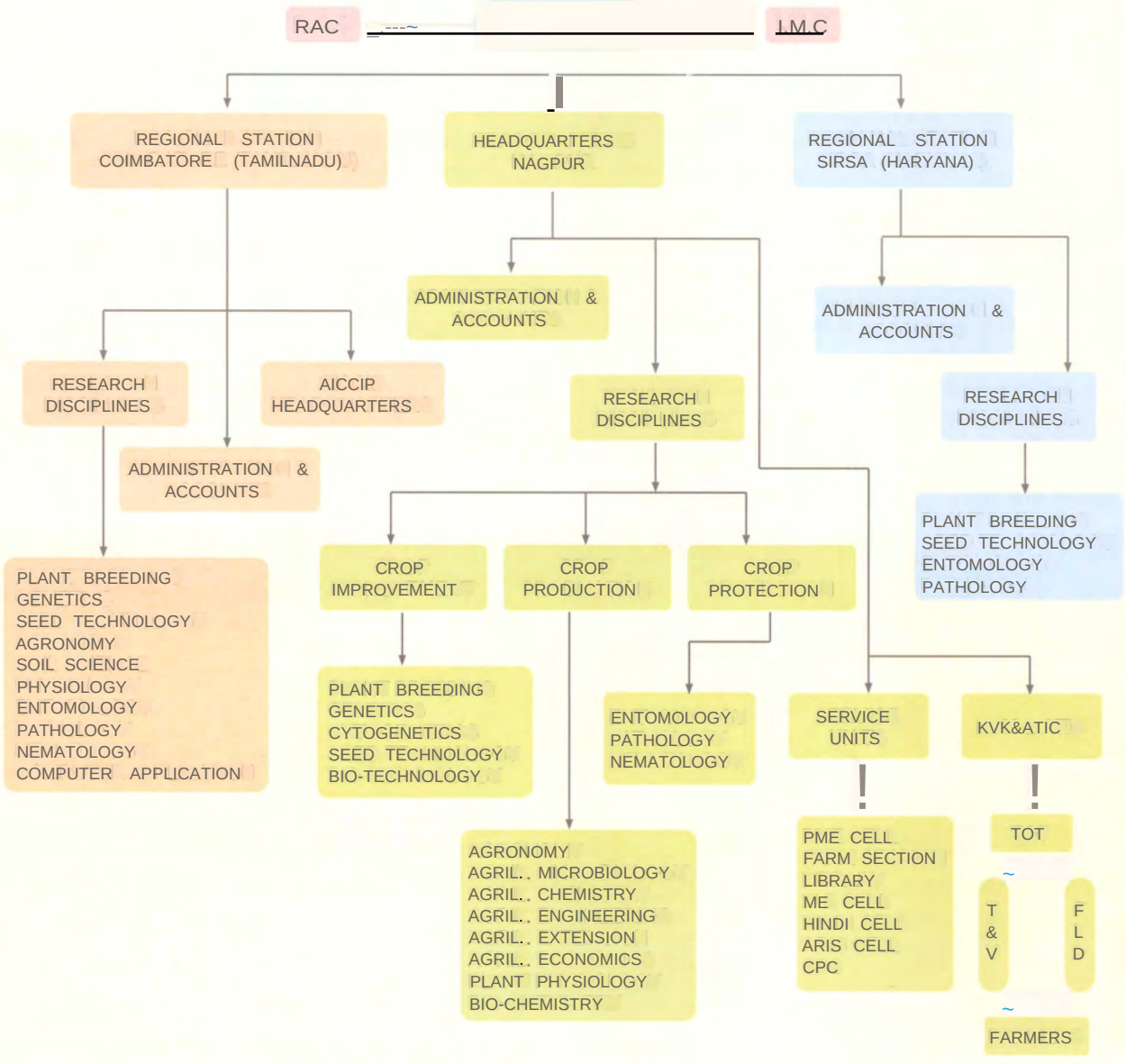
3.5 : Financial Statement

The budget grant and actual expenditure for the year 2011-12 are furnished below:

Rs. in Lakhs

S. No.	Scheme	Sanctioned	Expenditure
1.	CICR		
	Plan	82.00	80.93
	Non-Plan	2385.92	2385.20
2.	Plan Scheme	1650.64	1627.88
3.	NAIP	47.70	40.78
4.	Deposit Schemes	532.22	247.62

Organogram of CICR



4. Research Achievements

4.1: Cotton Genetic Resources

Nagpur

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

Exploration of land races of *des;* and perennial cotton

To preserve rich traditional diversity of Indian cotton and enrich cotton genetic resources, exploratory surveys were conducted in different regions of the country in the International year of biodiversity.

One hundred and nineteen germ plasm (Table 1) including 82 perennials, 141and races and 23 traditional cultures belonging to G. *arboreum* and G. *barbadense* were collected from states of Maharashtra, Madhya Pradesh, West Bengal, Andhra Pradesh, Tamil Nadu, Punjab, Meghalaya, Assam and Mizoram. Further characterization and establishment of these cotton land races / perennials in species garden is underway.

Table 1: Perennials and landraces of cotton collected from different regions of India

S.No	Districts	State	No. of Accessions	Species	Annual/Perennial/ Landrace
1.	Bhandara	Maharashtra	11	G. *arboreum*	Perennials
2.	Wardha	Maharashtra	1	G. *arboreum*	Perennial
3.	Nagpur	Maharashtra	2 1	G. *barbadense* G. *arboreum*	Perennials Perennial
4.	Washim and Parbhani	Maharashtra	9 1	G. *arboreum* G. *barbadense*	Perennials Perennial
5.	Sehore	Madhya Pradesh	8	G. *arboreum*	Perennials
6.	Jalpaiguri	West Bengal	5	G. *barbadense*	Perennials
7.	East Godavari, West Godavari, Jammikunta & Srikakulam	Andhra Pradesh	20	G. *arboreum*	Perennials
8.	Srikakulam (Ponduru Cotton)	Andhra Pradesh	1	G. *arboreum* race 'indicum'	Landrace/Perennial
9.	Theni	Tamil Nadu	1	G. *arboreum*	Perennial
10.	Pondichery	Pondichery	1	G. *arboreum*	Perennial
11.	Talwadi	Punjab	1	G. *arboreum*	Perennial
12.	Faridkot	Punjab	1	G. *barbadense*	Perennial
13.	West Garo hills	Meghalaya	3	G. *arboreum*	Perennial
14.	Kaziranga National Park	Assam	1	G. *arboreum*	Perennial
15.	West Garo hills	Meghalaya	23	G. *arboreum* race 'cernuum'	Traditional cultivars/ Annual
16.	Mizoram	Mizoram	16	G. *barbadense*	Perennials
17.	Mizoram	Mizoram	13	G. *arboreum* race 'cernuum'	Landraces/Annual
Total			119		

Perennial cotton in the backyard of Farmer's house in Bhandara district of Maharashtra

G. *arboreum* race cernuum collected from Meghalaya in bloom with typically elliptic bolls

Enrichment of germplasm

Twenty morphologically distinct variants of G. *arboreum* race cernuum were added to the germ plasm repository of the Institute and characterized for fiber quality traits. Highest boll weight was recorded in Comilla-22 (6.4 g), Comilla PR-2 (6.3 g) and Comilla 14 (6.3 g). The ginning outturn was higher in Comilla 1 (44.4%), , Comilla 9 (44.2%) and Comilla 14 (43.5%), while a narrow range of variability was observed in fibre quality traits like staple length (17.7-19.5 mm), micronaire value (5.2 - above scale) and fibre strength (15.3 -16.9 *g/tex).*

Twenty three exotic genotypes including 17 varieties of G. *hirsutum* and 6 varieties of G. *arboreum* were procured from Pakistan under Reciprocal Germplasm Exchange Agreement. . These were evaluated at CICR Nagpur and in Regional Station Sirsa. Range of variability was recorded for seed cotton yield (22.4-83.5 g/plant), boll weight (2.8-3.1 g), ginning outturn (32.0-37.1%), staple length (23.2 - 28.2 mm), micro-naire (2.2-5.7) and fibre strength (16.5-22.1 *g/tex)* in G. *hirsutum* cultures.

Registration of promising cultures and germplasms of cotton

CNH - CB 205: cluster boll bearing

One drought tolerant culture CNH 301 developed through pedigree breeding was registered by Plant Germplasm Registration Committee of Indian Council of Agricultural Research (INGR 11061; IC 0587405. The culture recorded 15 q/ha seed cotton yield in All India Coordinated Cotton Improvement programme (AICCIP) and was promoted and tested in pre-release trial (Agronomy Trial).

Four genetic stocks of G. *hirsutum viz;* CNH-CB 215 (Dark Brown linted, pigmented & Cluster bearing habit), CNH-CB 211 (Okra leaf lobe and cluster bearing habit), CNH-CB 212 (Zero monopodia, Compact and cluster boll bearing habit) and CNH-CB 205 (Cluster boll bearing habit) and one promising inter-racial pigmented G. *arboreum* line (CNA 5) were identified for registration as unique genetic stocks.

CNA-5: one G. *arboreum* inter-racial pigmented square and flower

Evaluation of germ plasm for drought tolerance under rainfed conditions

Based on performance of seven thousand one hundred and eighty five (7185) G. *hirsutum* germplasm lines under rainfed conditions, 400 promising lines were identified. Further observation of 400 lines showed higher single plant yield (ranging from 40.0 to 67.3 g/plant) in atleast 21 germplasm lines and higher epicuticular wax (ranging from 93 to 283 *lJg/cm*^{2}) in atleast 67 lines. Germplasm lines with high epicuticular wax are expected to possess high WUE, less transpiration rate, better tolerance to sucking pests and greater drought tolerance.

Assessment of gossypol content in germ plasm

To explore the possibility of using leaf gossypol content as a special test for varietal identification, gossypol content in cotyledonary leaves of 11 G. *hirsutum* germ plasm lines were estimated. Estimated gossypol content showed positive correlation with gossypol gland density which needs further confirmation. Assessment of seed gossypol content in 43 G. *arboreum* working collection of high yield group showed wide variability with gossypol content ranging between 0.44 - 0.99%.

Conservation of germ plasm and use in breeding programme

Seeds of 3000 accessions (G. *hirsutum-2200* and G. *arboreum* - 800) were conserved in Medium Term Cold Storage Module at CICR, Nagpur. Passport data for 3145 germ plasm lines were prepared, compiled and sent to NBPGR, New Delhi for allotment of IC/EC Numbers.

Molecular characterization of cotton germplasm

Characterization of 235 working germ plasm accessions of G. *hirsutum* was carried out at CICR, Nagpur and NBPGR, New Delhi. A total of 44 SSR markers were employed to characterize 235 entries in the working collection.

Core collection of 94 accessions was characterized using 58 SSRs markers of which 54 were polymorphic. So far, 89 polymorphic SSRs, 5 TRAP, 13 SRAP and 10 RAPD (total 117 markers) were used for genotyping 94 core accessions.

Distribution and use of germplasm in breeding programme

One hundred and thirty one elite germ plasm lines of G. *hirsutum* were selected in field condition by scientists for utilization in various research programmes.

Maintenance and evaluation of wild **species**

Twenty-six wild species, 15 races and > 40 synthetic polyploids of *Gossypium* and related species was maintained in the Institute. The wild species were employed in introgression breeding for improvement of fibre quality traits and biotic stress tolerance. Twenty germplasm lines from Israel were grown in the pots and field all of which were found to be male sterile. These lines were received without the restorer lines.

Seeds of five wild species of *Gossypium viz; Gossypium africanuum-A, Gossypium anoma/um-B1, Gossypium thurberi-D1, Gossypium soma/anse-E2* and *Gossypium bickii*-G1 were supplied to Principal, Matreyi College, University of Delhi for research purpose under Material Transfer Agreement. .

Coimbatore

Maintenance and evaluation of germ plasm

Two hundred and thirty five G. *hirsutum* germ plasm lines were grown in field besides cernuum race of G. *arboreum* that was characterized morphologically as per germ plasm index card.

One hundred and fifty five G. *barbadense* germ plasm lines including exotic accessions were grown in field for evaluation. Twenty-six exotic lines were evaluated in replicated yield trial with Suvin as check. Three lines *viz.,* EC-617836 (1024 kg/hal, EC-617837 (988 kg/ha) and EC-617840 (714 kg) recorded significantly higher yield than the check Suvin (371 kg/halo Three exotic genotypes EC-617836 (33%), EC-617840 (34.3%) and EC-617844 (31%) showed better GOT compared to Suvin (27%).

Sirsa

Collection, conservation and maintenance of genetic resources

Three thousand nine hundred and fifty four accessions were evaluated for their field performance in North zone. The yield / plant ranged from 16-209.3 g, boll weight from 2-4 g, boll number 5-64, plant height 35-182 cm with monopodia and sympodia ranging from 0-13 and 0-21, respectively.

Several compact genotypes amenable to High Density Planting System (HDPS) were identified with marker characters. Further, 2159 accessions were found free from CLCuD.

4.2 : Hybrid Cotton

Nagpur

Maintenance of parental lines (male steriles and restorers)

One hundred and thirty seven G. *harknessii* based CMS, 15 G. *aridum* based CMS, 57 restorers and 20 GMS lines were maintained by crossing with their counterpart B lines, selfing and sibmating. Single plant to progeny rows of M_3 generation were raised with 96, 48 and 212 plants for Rajat CMS G. *harknessii,* AK 32 CMS G. *aridum* and GMS line G 67. Fertile plants in case of GMS with comparatively bigger bolls were harvested for further studies. No distortion in fertility to sterility ratio in case of GMS line was observed.

Under GMS line development programme, four single plant to progenies were raised for PKV 081, AK 32 and L 147. They were tested for second year for confirmation of 1:1 segregation for male sterility and fertility. Forty-eight and twelve single plant progenies were raised for Suman and Sharda respectively, to identify, progenies with 1:1 segregation and were maintained through sibmating for use in hybrid development programme.

TGMSsystem

The flowers of individual plants in TGMS line 1-1 sown during February (summer flowering) were observed for their fertility/sterility behavior. Complete male sterility was documented in line 1-1 during the month of May with no self boll-setting. Restoration of low levels of fertility (10-30%) was observed during the months of July, August and September while complete fertility was restored when minimum temperature was between 16-18 °c during November to January. Hence, exploitation of TGMS phenomenon during normal *kharif* season for hybrid seed production is not advisable.

Exploitation of male sterility in TGMS line during normal *kharif* season was attempted with application of chemicals known to induce sterility. Among the five sterilants studied at different concentrations, application of Maleic hydrazide @ 200 ppm resulted in flowers with maximum male sterility. Out of total of 110 flower buds treated with Maleic hydrazide, 60 produced male sterile flowers and 29 partially fertile flowers during the period when lines showed completely fertile flowers. Potential of chemical sterilants to induce male sterility need further standardization and validation.

EGMSsystem

Observations involving 8 EGMS lines showed that the phenomenon could not be fixed for exploitation for hybrid development even though complete sterility was observed in two EGMS lines 35 and 08093-1 OR in the month of May 2011 when temperature was above 40°C.

Coimbatore

Interspecific hybrids

Nine G. *hirsutum* x G. *barbadense* interspecific hybrids were found to be superior in yield over the check hybrid RCHB-708 Bt with highest seed cotton yield of 24.75 q/ha in CCHB 12. This hybrid also possessed highest bundle strength of 33.5 g/tex followed by CCHB-8 (33.4 g/tex) while the check RCHB-708Bt had 31.0 g/tex. Hybrid CCHB-11 had the highest span length of38 mm followed by CCHB-6 (37.3 mm) and CCHB-13 (37.2 mm). CCHB-6 was found superior in yield as well as the fibre qualities. This hybrid had the highest ginning outturn of 35 per cent and highest micronaire value of 4.21J/inch.

Another set of 30 cross combinations were evaluated in a separate trial with check hybrid RCHB-708 Bt. Four hybrids showed yield superiority over the check hybrid RCHB-708 Bt. The hybrid CCHB-4 recorded highest yield of 27.50 q/ha with superior fibre quality traits.

Based upon superior performance over last five years, CCHB-4 was sponsored in multi location yield evaluation trial under AICCIP.

Sirsa

Tetraploid Cotton

Maintenance of male sterile lines

The local adapted cultivars and parents of promising hybrids *viz.* CMS LRA5166, CMSJhorar, CMS RB281, CMS LH 1134, CMS Pusa 31, CMS HS 6, CMS K 34007, CMS F 505, CMS F 1183, CMS CSH 25 M and CMS SH 2379 having cytoplasm of G. *harkensiiwere* maintained through sibmating. Ten restorer lines were also maintained through selfing. Number of GMS lines *viz.,* K 34, J 34, MCU 5 and GMS 13 were maintained through selfing. Crosses were affected between GMS lines and good combiner lines.

Identification and maintenance of restorer lines: Fertility restorer lines *viz.* CIR 8, CIR 12, CIR 15, CIR 23, CIR 26, CIR 32, CIR 38, CIR 47, CIR 70, CIR 72 were mantained through selfing. The new restorer lines CIR97P1, CIR97P3, CIR119P1, CIR119P3, CIR126P1, CIR526P1, CIR526P3, CIR 920 P1, CIR 926 P2, CIR 926 P3, CIR 1169 P1 and CIR 1169 P2 were developed through pedigree method of breeding.

Heterotic pools in G. *arboreum* and G. *hirsutum*

Evaluation ofGMS hybrids

G.arboreum

To develop heterotic pools of G. *arboreum,* 40 GMS hybrids along with parents were tested in randomized block design with three replications. The highest seed cotton yield was recorded in RED x CISA6- 295 (1511 kg/ha) followed by CISA-2 x CISA 6- 209 (1503 kg/ha) as against 1375 kg/ha of check hybrid CICR-2. Highest GOT of 39.4% was recorded in the hybrid DS 5 x CISA 6-165 while the highest 2.5% span length (25.3 mm) and tenacity (19.3 g/tex) was documented in hybrids CISA 2 x CISA 9 and GAK 413 A x CISA 6-123, respectively.

CISA-6-187, CISA 9 and CISA8 as male and DS 5 as female parents were found to be good general combiners for seed cotton yield. The cross combinations RED X CISA6-123, CISA 2 x CISA 6-209 were the high yielding hybrids which possessed significant specific combing ability effect..

G.hirsutum

To develop heterotic pools of G. *hirsutum* cotton, 50 GMS hybrids along with their parents were tested in Randomized block design with three replications. The highest seed cotton yield was recorded in GMS-17 x CSH 3129 (1821 kg/ha) followed by GMS-27 x CSH 2907 and

GMS-26 x CSH 2912 (1728 kg/ha) as against 1688 kg/ha of conventional check hybrid CSHH 198. Maximum ginning outturn of 37.1 % was recorded in hybrid GMS-27 x CSH 2907 DA. The highest 2.5% span length (29.6 mm) and tenacity (23.5 g/tex) was recorded in hybrids GMS-27 x 004 NAH and GMS-27 x 004 NAH, respectively.

In general of G. *hirsutum* cotton OK 2885, CSH 2912, CSH 3129, CSH 2907 as male parents and GMS-26, GMS-17, GMS-27 as female parents were found to be good general combiners for seed cotton yield and GMS-17 for ginning percentage. The cross combinations GMS 20 x CNH 91 and GMS 17 x 004 NAH were high yielding hybrids possessing significant SCAeffect. .

Intra-hirsutum GMS based hybrid CSHG 1862 identified

An *intra-hirsutum* GMS based hybrid CSHG 1862 recorded an average seed cotton yield of 21.02 q/ha over 21 locations as against 18.82 q/ha yield of CSHH 198 (zonal check) and 19.87 q/ha of local checks, registering an overall increase of 11.7 and 5.8 per cent over the two checks, respectively. This hybrid performed best in 23 out of 27 trials as against 15 out of 27 in case of common check CSHH 198. The hybrid documented GOT of 34.5% which was superior to that of zonal check CSHH 198 with 33.7% and local check with GOT of 34.1%. Hybrid CSHG 1862 recorded 2.5% span length of 27.8 mm, micronaire value of 4.2, uniformity ratio of 50% and fibre strength of 22.0 g/tex at par with common check CSHH 198 and superior than other check hybrids. Hybrid CSHG 1862 is a superior medium staple hybrid and possessed high fibre strength, capable of spinning at 40s counts. The hybrid was identified for release in irrigated tracts of north zone by the Central Varietal Identification Committee (AICCIP) during its Annual Group meeting held at Hisar.

4.3: Genetic Improvement

Nagpur

A. G. *arboreum* (Diploid cotton)

Identification of promising cultures

Two promising cultures *viz.,* CNA 389 and CNA 390 were identified for further evaluation and seed multiplication during the season.

Development of medium and long linted diploid cottons (G. *arboreum)*

Three cultures *viz.,* PAIG-62 (22.4 g/tex), Dia-08-25 (22.1 g/tex) and Dia-08-26 (22.3 g/tex) recorded fibre strength above 22 g/tex in all the three trials. PAIG-358 recorded highest 2.5% span length of 29.4 mm. Most of the cultures tested were found to be superior in staple length with desirable micronaire value.

Thirty four high yielding long staple G. *arboreum* cultures with moderately high strength upto 21 g/tex were developed, that hold promise for fibre quality improvement in G. *arboreum.*.

Promotion of G. *arboreum* and G. *hirsutum* cotton in Melghat region

Promotional activity to popularize public bred varieties in marginal soils of Melghat regions of Amravati districts in Vidarbha was undertaken. Seeds of *Desi* cotton (including CNA 1003, CAN 348, CAN 385, JA 505, JLA 794, AKA 5 and PA 255) and G. *hirsutum* (CNHO 12, Suraj, AC 738 and CIHS-18) were distributed among the farmers. Encouraged with the benefits and additional income generated from their marginal lands number of farmers participating in this promotional activity swelled from 46 in the previous year to 100 during the current year, with 70 being tribal farmers.

A promising culture CNA 398 (G. *arboreum)* was identified based on highest seed cotton yield in National Varietal Evaluation trial of AICCIP 2011-12. It ranked first in central

zone and was promoted in the zone for further evaluation. G. *arboreum* culture CNA 1007 was retained in the zonal trial Br. 24(b) trial in south zone.

G. *hirsutum* (Tetraploid cotton)

Nagpur

Drought tolerance

Twelve F, crosses showed significant differences for seed cotton yield. Pusa 56-6 x 281 recorded highest seed cotton yield of 511.10 kg/ha with 69 per cent increase over the check. It was followed by 281x Pusa 56-4, 281x Pusa 56-6 with 62 and 54 per cent increase overthe check Rajat.. The parents 301, 281 and 291 recorded upto 15 per cent increase which indicated that they were superior to the check for seed cotton yield. The crosses showed three fold increase in yield over their parents.

Advance generation for 64 single plant selections were tested in replicated trial with check LRA 5166 and Rajat.. DTS 120 recorded highest seed cotton yield of 953.20 kg/ha with 68 and 39 per cent increase over the check LRA 5166 and Rajat respectively. It recorded fibre length of 27.6 mm, fibre strength of 18.1 *g/tex,* uniformity ratio of 50 per cent and micronaire value of 4.7 IJ/inch. DTS 114, DTS 102, DTS 126, DTS 131, DTS 134 were some of the other superior selections. DTS 111 recorded fibre length of 30.2 mm with fibre strength of 20.4 *g/tex.*

Out of seventeen single plant selections tested, the seed cotton yield ranged from 260-452 kg/ha. DTS 46-04 recorded highest yield of 452 kg/ha followed by DTS 31-14, DTS 31-12, DTS 31-13, DTS 41-02. Selection DTS 41-02 recorded fibre length of 27.6 and fibre strength of 22.2 *g/tex* while DTS 31-14 recorded fibre length of 31.0 mm, fibre strength of 23.8 *g/tex,* micronaire of 3.31J/inch and uniformity ratio of 48 per cent..

Two cultures *viz.* DTS 123 and DTS 110 were tested in institute common trial and DTS 123 ranked fourth recording 473 kg/ha seed cotton yield, fibre length 28.1 mm, uniformity ratio 53 per cent, micronaire 3.8 IJ/inch. DTS 95 was tested under State Multilocation Varietal Trial and recorded 1013 kg/ha seed cotton yield with boll weight of 3.25 g and GOT of 38.89 per cent..

Jassid tolerance

Fifty single plant progenies were selected based on tolerance to jassid (Grade I and II), earliness (130-140 days) and for yield potential in F_5 generation. These single plant selections were derived from 12 individual crosses involving promising lines with tolerance to drought, sucking pests and were inter-specific derivatives.

Genetic enhancement

Under the programme on enhancement of genetic potential of cotton for yield and yield contributing traits, advanced 13 row bulk populations were evaluated in an unreplicated trial.. CNH *2011 viz.* (Pedigree - LRA-5166 x CIHS97 -9) was found free from sucking pests. In the 16 advanced backcross populations in BC,F. generation, the backcross *viz.,* LRK-516 x (LRK-516 x Deltapine-66) gave high yields with high boll number. There was an increase in boll weight upto 3.8 g in case of PKV-081 x (PKV -081 x PIL-8) and H-777 x (H-777 x Rex) over PKV 081 with 2.9 g boll weight..

In the advanced *intra-hirsutum* populations (F7-FB)' CNH 2056 *viz.,* (Pedigree- LH-1134 x Reba- Pvt-9) was found to be high yielding and early with an average 18 bolls per plant compared to 15 bolls per plant in check variety NH 615. Also CNH 2013 in pedigree- Gcot-1 0 x Reba- Pvt 9) was observed uniform in maturity with 32 bolls per plant with boll weight of 3.2 g. These populations were grown under 60 x 30 cm spacing. A new culture CNH 2013, early maturing, with synchronized boll bursting has been identified as a promising entry.

CNH 2013, early maturing with synchronized boll bursting

In advanced cultures developed by crossing G. *hirsutum* x G. *barbadense* cotton, all five entries which involved Suvin as male parent were observed as high yielding with lustrous white cotton. The cultures on an average supported 15-18 bolls per plant with good sympodial plant types. Development of value added advanced populations, new cultures and elite trait specific gene pools for further improvement of cotton is available.

Breeding short duration cotton suitable for **HOPS**

In *Kharif201* 0-11, 550 selective G. *hirsutum* germplasm lines with zero monopodia were evaluated at 30 x 20 cm spacing. Based on their performance 86 lines with one or more traits like short sympodia, high strength, bacterial blight resistance, leaf hopper resistance, high boll weight, early maturity and compactness, the traits critical for development of cotton amenable to high density planting system (HDPS) were selected. Out of 86 lines 34 accessions were evaluated in replicated trial at 45 x 15 cm spacing during the crop season. The selected plants showed dwarf habit and possessed short

sympodia and resistance against bacterial blight and leaf hopper. The below mentioned lines including one highly compact early maturing G. *hirsutum* germ plasm N-170, were selected for breeding cotton suitable for HDPS.

Short duration, compact *Gossypium hirsutum* cultures selected for developing cotton suitable for HOPS

S.No.	Name of germ plasm	Traits
1	IC-358080	Bacterial blight resistance
2	IC-358358	High strength and long staple
3	IC-358221	High strength
4	IC-358207	Dwarf type
5	IC-358771	High bolls per square metre area
6	IC-357126	High boll no. per square metre
7	N-170	Early maturing compact short sympodia as base female parent
8	Gcot-100	Semi-compact type as check

Population improvement

Random mating population in G. *arboreum* and G. *hirsutum*

The random mating population through conventional crossing was constituted and maintained by bulk harvesting one burst boll from each plant.. The economic yield of the conventional G. *hirsutum* randomly mated (RM) population was compared with the base population and it was observed that population yield declined to the extent of 27.54% than that of base population. This may be due to fixation of the *segregants*/ heterozygotes in successive generations. The performance of diploids was very poor during the season, hence performance of the RM population could not be compared.

Use of GMS for developing random mating population

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

Similarly, sixth cycle of GMS based random mating was completed in G. *arboreum* during 2011-12 and the composite population shall be taken to the next cycle.

Single plant selection

During 2011-12, 458 single plant selections from random mating population have been evaluated in plant to row progeny plots. From the composite random mating population 492 plants were selected based on manual testing for fibre quality traits. About 506 superior single plants were reselected from the segregating single plant progenies. Several single plant selections were identified for big boll size, better fibre quality and compact plant type for further evaluation.

Entries sponsored under AICCIP

CCH 1111 G. *hirsutum* culture ranked second in the central zone has been promoted to zonal trial Br. 03(b) trial in central zone. Two G. *arboreum* cultures, CNA 1016 and CNA 1020 were sponsored to Br. *22(a/b)* National trial of the AICCIP for the crop season 2012-13.

G. *hirsutum* culture CNH 14 registered promising higher yield in National Varietal Evaluation trial of AICCIP 2011-12 and ranked fourth in central zone. The culture has been promoted in the central zone for further evaluation.

Culture CNH 315 found promising in Institute trial was sponsored in Br02 (b) trial of AICCIP during 2011-12.

Similarly, CNH 1110 G. *hirsutum* culture was sponsored for Br. 02(b) National trial.. Two more G. *hirsutum* cultures namely CNH 1105 and CNH 1109 were sponsored for compact plant type trial Br. 06 (b).

Development of heterotic pool for superior medium staple

From 140 single plant progeny rows, 30 most productive progeny rows were bulked at F_6 The selections were made on the basis of earliness (120-140 days) and for superior medium staple (25.5 mm -27.0 mm) cotton coupled with yield potential.. Crosses involved LRK 516 x Acala 1517, PKV Rajat x Acala 1517, LRK 516 x DHY 286 and PKV Rajat x DHY 286 in one group and LH 1948 x MCU 9, ACCLD 163 x H 1252, H 1252 x LH 1948, H 1252 x MCU 9 in other group. Thus, 30 breeding lines derived from these two heterotic groups will be evaluated for initial yield trials.

Coimbatore

Genetic improvement

The medium staple culture CCH 2623 was tested in various centres of All India Coordinated Cotton Improvement Project during the past four years in both central and south zones. It showed yield superiority in both the zones and recorded a mean seed cotton yield of 1739 kg/ha in central zone and 1798 kg/ha in south zone locations with 34 and 13 per cent increase over the zonal checks LRA 5166 and Surabhi respectively. The culture has been recommended for testing the agronomic requirements in both the zones.

From segregating generation (F_6)' 125 superior single plants were selected based on morphological characters. Some plant progenies combined both yield and quality. Progeny PI-32-1-2 recorded a seed cotton yield of 105 g/plant and also had a very good bundle strength of 24.6 *g/tex* with 29.5 mm 2.5% span length.

Sirsa

Genetic improvement for high productivity and superior quality

In G. *hirsutum,* two crosses *viz.* CSH-3119 x MM03-27-5-1-8 and MM22-1-2 x CSH-3047 out of 13 affected between long linted cultures from Coimbatore and high fibre strength cultures from Sirsa were early in maturity and high yielding.

CISA 6-165 yielded seed cotton yield of 1934.2 kg/ha with 40.30% increase over the local check HD-123. CISA 6-165 had fibre length of 22.3 mm and value less than 6.0. In the station trial ofTMC genotypes CISA-8 significantly out yielded all the three local checks. As many as 17 out of 22 single plant progenies out yielded the checks CISA-31 0 (86.7 g/plant) and CISA-614 (83.0 g/plant).

Evaluation of CLCuV resistant cultures

Out of 20 cultures tested against CLCuV at Sirsa, 6 cultures *viz.*, CSH 2808, 2810, 2811, 2813, 2836, and 2916) were found to be resistant to the virus, whereas in the hot spot area at Sriganganagar, only three cultures *viz* CSH 2907, 2908 and 2916 showed resistance. Highest seed cotton yield was recorded in the advance culture CSH 2833 (1821 kg/ha) followed by that in CSH 2811 and CSH 2844 with 1770 kg/ha compared to check variety RS 2013 recording only 1652 kg/ha seed cotton. Highest GOTof35.7 per cent was recorded in the variety CSH 2916 while CSH 2907 recorded the highest 2.5% span length of 29.1 mm and bundle strength of 22.4 *g/tex.* In another trial with 16 cultures of G. *hirutum* highest seed cotton yield was recorded in the culture CSH 2931 (2016 kg/ha) followed by CSH 2941 (1584 kg/ha). Maximum ginning out turn of 37.3% was recorded by CSH 2941 as compared to local check varieties 34.8% in RS 2013 and 34.7% in LH 2076. The culture CSH 2944 recorded the highest 2.5% span length (28.6 mm), whereas the highest bundle strength of 22.9 *g/tex* was observed in CSH 294 .

4.4: Genetic Diversity through Introgression

Nagpur

A new cross between G. *arboreum* and an African species G. *somalense* (E_2 - genome; known for drought tolerance) and its reciprocal cross was harvested which will be advanced to next generation for drought tolerance studies.

G. *arboreum* x G. *somalense* G. *somalense* x G. *arboreum*

Reciprocal crosses between G. *arboreum* and G. *somalense*

Thespesia lampas - a related species of *Gossypium* known for possessing thick boll rind thereby conferring resistance to bollworm was established and crossed with all the six races of G. *arboreum.* A single F_1 boll was set and harvested only from the cross between G. *arboreum* race indicum and *Thespesia lampas* to transfer this trait of thick boll rind for further inheritance study.

G. *arboreum* Race indicum

F_1 boll harvested

***Thespesia lampas*, flower (Inset)**

Cross ball (F_1) of G. *arboreum* race indicum and *Thespesia lampas*

Introgression Breeding

Four hundred and twelve introgressed lines of cotton were evaluated for fiber quality traits based on which 29 lines with diverse fibre properties were selected. Lines CICR 1-29 showed diverse fiber traits with 2.5% SL ranging between 19.3 - 31.7 mm, strength ranging between 16.9 - 26.4 *g/tex,* micronaire ranging between 2.8 - 6.2 and uniformity ratio ranging between 40 - 56%.

4.5: State Multi-Varietal Trial (SMVT)

Nagpur

A State Multi-location Varietal Trial (SMVT) consisting 20 genotypes of G. *arboreum* and 16 G. *hirsutum* were conducted at CICR, Nagpur, which stood vitiated due to continuous rains.

4.6: Molecular Breeding

Nagpur

Mapping QTLs for fibre quality traits

In an effort to develop linkage map of diploid A genome in cotton, an interspecific F_2 mapping population (G. *arboreum* cv. KWAN-3 x G. *herbacum* cv. Jaydhar) was developed. During 2011-12, parental polymorphism studies were carried out using 625 SSR markers based on which 38 SSR polymorphic markers were identified (Fig. 1). Genotyping of mapping population with 76 informative markers (66 SSR, 9 SRAP and 1 RAPD) has been completed.

Fig. 1 : Survey for parental polymorphism using SSR markers in tetraploid and diploid cotton, 1-EL-958 (G. *hirsutum),* 2-UPA-5717 (G. *hirsutum),* 3- Jaydhar (G. *herbaceum),* 4- KWAN-3 (G. *arboreum)*

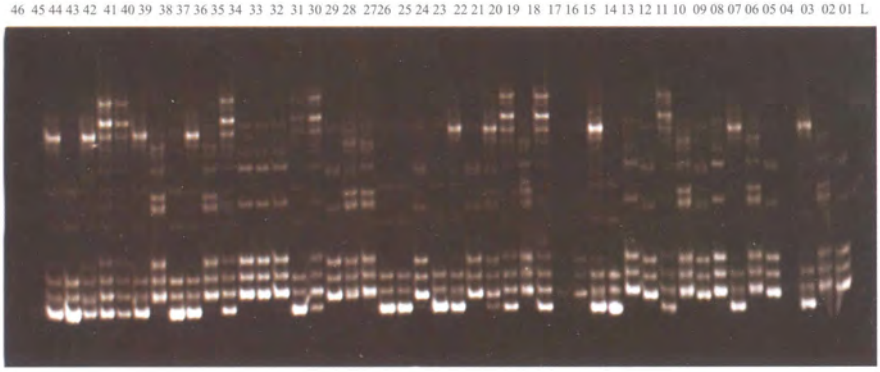


Fig. 2: Genotyping of F, mapping population with SSR marker BNL 3261 in tetraploid cotton

Development of mapping populations (RIL's) for fibre quality traits in diploid and tetraploid cotton

In diploids, 193 F_7 plant progenies were raised. One random plant from each progeny was selfed for further advancement to next generation. In few of the progenies, segregation for morphological characters was observed; hence, the progenies need to be further advanced for two more generations to attain uniformity. In G. *hirsutum* 273 F_7 boll to row progenies were grown, selfed bolls were obtained. The lint samples of each progeny are being evaluated for fibre quality traits using HVI. A set of 273 progenies of RILs are ready for mapping fibre quality traits.

Mapping bacterial blight resistance gene(s)

During 2011-12, a set of 335 SSR primers were surveyed to screen polymorphism between bacterial blight susceptible and resistant parents out of which 30 SSR markers were found to be polymorphic with the parental genotypes, Ganganagar Ageti and S295. A total of 73 informative markers were identified with the above parental genotypes. Fifty five informative markers were identified with Acala-44 and IM216. The extent of polymorphism ranged from 6.04 to 9.1 per cent among the contrasting parents, Acala 44 and 1M216, GA and 1M216, GAand S295, GAand 101-102B.

Inheritance of *Rhizoctonia* root rot in upland cotton

Five F_2 populations developed using root rot tolerant (Saubhagya, B.N., NISC-19, NISC-14 and Abhadita) and susceptible (LRA 5166) genotypes were screened against the disease in *Rhizoctonia* root rot sick plots. The segregation in all five F_2 populations revealed that inheritance of *Rhizoctonia* root rot is digenic (two genes) with a ratio of 15 resistant: 1 susceptible and duplicate gene interaction. The susceptible variety LRA 5166 showed 100% susceptibility in the sick plot. The results obtained will facilitate development of resistant varieties in upland cotton.

Development of mapping population for drought tolerance

F_2 generation of three crosses Pusa 45-4 x 301, 281 x Pusa 56-4 and Pusa 56-4 x 291 were raised for advancing the generation. These crosses recorded high drought tolerant efficiency for two consecutive years.

4.7: Development of Transgenic Cotton

Nagpur

Bollworm resistant transgenic cotton in tetraploid and diploid cotton

Confined field trial was conducted with 7 transformation events of Bt-cry1Ac gene (ILK Bt-77-1 to ILK Bt-77-7) to characterize and select effective events. Cry toxin expression was evaluated in all 7 events from early bloom phase (50-55 DAS) to late maturity phase (155 DAS). Average concen-tration of Cry protein in leaves, squares and *lor* bolls in transgenic plants across the events was 0.52, 0.28 and 0.23 *~g/gm* respectively, in 55 days old plants. After 155 days, concentration of Cry protein was 0.61 and 0.30 *~g/gm* in leaves and bolls respectively. Three new events of *cry1Ac* in G. *hirsutum* variety Anjali (Anjali FBt-1 and 2) were also evaluated for Cry protein expression. Plants were raised in boll to row progenies and presence of transgenes was confirmed by PCR (Fig. 3). New transformation events were also generated using *cry1Ac* and *cry1F* genes in LRA 5166 and Suraj. Plant growth, seed oil content, seed cotton yield, besides fibre quality traits were recorded as per the RCGM recommendations. The original characteristics of the recipient host plants were not altered as a result of transformation with Bt genes.

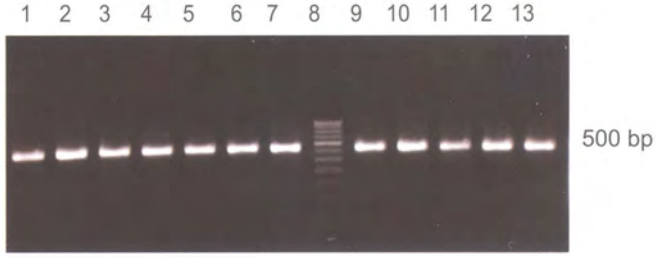


Fig. 3: PCR amplification of *Bt cry1F* gene in putative transformants of G. *hirsutum* cv. LRK 516. Lanes 1-7 and 9-13, PCR positive plants; Lane 8,100 bp ladder

Putative transformants of G. *hirsutum* cv. Suraj carrying Bt *cry1Ac* gene

Bollworm resistant transgenic diploid cotton

Event selection trial

Confined field trial for event selection of PA 255 and RG 8 transgenic G. *arboreum* cotton containing *crylAc* gene was conducted at CICR, Nagpur. In all ten events including 4 events of Bt RG 8 *(Des;* Bt G-822-1 to *Des;* Bt G822-4) and six events of Bt PA 255 (CICR Bt *Des;* 1 to CICR Bt *Des;* 6) were characterized. Expression of Cry protein was estimated in leaves of 1350 transgenic plants of two varieties. Cry protein expression was upto 3.0 IJg/gm. PCR analysis of Bt-RG 8 events showed amplification of *cry* 1*Ac* gene in 108 out of 180 plants tested for four events. Individual bolls from the Bt positive plants were harvested for further characterization.

Molecular characterization of new Bt·events

Twenty two new events of G. *arboreum* cvs. RG 8 and PA402 containing *cry1Ac* and *cry1F* genes were developed by *;n planta* transformation. PCR carried out with 340 putatively transformed plants of new events of cv. RG 8 showed 166 PCR positive plants. While of 35 cv. PA 402 *cry1 F* agro-inoculated plants five plants were PCR positive. These plants were also ELISA positive. The selfed bolls from PCR positive plants were harvested separately.

Molecular characterization of CICR transgenic events

Junction-specific primers used to amplify and sequence flanking regions in transgenic events generated previously, resulted in non-specific amplification. Therefore, genespecific primers based on the sequences of *nptll* marker and *cry1Ac* transgene present in the binary plasmid pBinAR, were designed and synthesised to characterize the transgenic events.

Contained green house trial

Contained green house trials on Chitinase transgenic diploid cotton (3 events), RNAi mediated transgenic events (5 events with virus coat protein andAC2 genes), *cry1Ac* (4 events) and *cry1F(3* events) were approved by IBSC (Fig. 4).

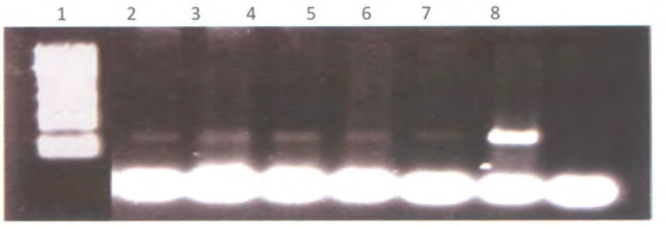


Fig. 4: PCR amplification of *cry1F* gene in putative cotton transformants of G. *arboreum* cv PA 402. Lanes:1, 1 kb ladder; Lane-2-7, PCR positive plants.

Transgenic cotton for leaf curl virus resistance

RNA interference approach

New transformants of G. *h;rsutum* cv HS 6, F 846 and LH 2076 were generated with dsRNAi constructs *v;z.,* pBinAR-int-CP-SA (12.19 kb), pBin AR-int-BC4-SA (12.24 kb) and pBin AR-int-BV4-SA (12.17 kb). By shoot-tip and *;n planta* transformation methods 8 events involving dsRNA of CP gene including two events in cv F 846, 3 in LH 2076 and three events in cv HS 6 were established. Out of 8 new events, five events were found to be PCR positive for the transgene. Seeds of individual bolls of PCR positive plants were harvested for evaluation against virus and screening of homozygous transgenic plants under contained green house trial at CICR RS, Sirsa (Fig. 5).

Fig. 5: PCR amplification of CP gene fragment used for creating dsRNAi construct in transgenic HS 6-CP plants. Amplification was done using two sets of primers P1 (F1 + R1) and P2 (F1 + R1) amplifying sense and antisense strands ofthe construct. . M-100 bp: Lanes: 1-3, PCR amplification using primer set P1; 4, pBSK-CP-SA (plasmid); 5, cotton (wild type) HS 6; 6, PCR -ve sample; 7-9,Amplification using primer set 2; 10, pBSK-CP-SA plasmid; 11, HS6 cotton HS 6 (wild type) ; 12, PCR -ve sample.

Antisense approach

The T_3 generations of F 846 and H 777 transgenic cotton with one event each with *ARep, ACP* and *SCP* genes were grown for multiplication of the seeds in the confined field trials. New events were also generated and the T, generation of RS 875 was screened against CLCuV in green house at Sirsa. The resistant plants were selfed and seeds were harvested.

Genetic engineering for abiotic stress tolerance

Putative transformants of G. *h;rsutum* cvs. LRA5166 (2 events each with *DREB 1A* and *ZF 1A)* and LRK 516 (one event each with *DREB 1A* and *ZF 1A)* were grown for multiplication in the confined field trials with the approval of RCGM.

Eighty T, plants of each of the six transgenic events alongwith 20 control plants were screened for presence of transgene as well as the marker gene *nptll.* Out of 160 T, plants of two events of OREB 1Agene in LRA5166, 46 plants were positive for the marker as well as transgene while 55 out of 160 T, plants of two events of OREB 1Ain LRK 516 were positive for both the genes. In one event each of BcZF1 in LRA 5166 and LRK 516, 30 and 28 plants respectively, were found positive for the marker as well as transgene. New events were

developed with *DREB1A* and *ZF1* in LRA 5166 and LRK 516 with transformation frequency of 4.2 to 4.8%, respectively.

Physiological and biochemical characterization showed that the transgenic plants exhibited higher relative water content, leafwater potential and proline content compared to wild type cotton.

Development of inverted repeat construct of ~ *cadinene synthase* gene

The 0 *cadinene synthase* gene was PCR amplified in sense and antisense orientations (Fig. 6 & 7) with suitable restriction sites and cloned in inverted repeat generating plasmid pBSK-int (HQ 343203). The cloned product was further confirmed by PCR and Restriction enzyme analysis.

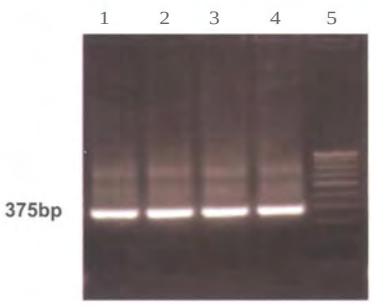


Fig. 6: PCR amplification of 15 *cadinene synthase gene* for cloning in sense and antisense orientations. Lanes 1-2, sense strand; lanes 3-4, antisense strand; 5, 100 bp ladder.

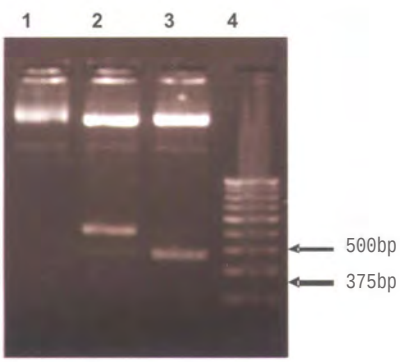


Fig. 7: RNAi construct of 15 *cadinene synthase* gene in plasmid pBSK-int. . anes 1, pBSK-int (undigested); 2, *BamHI* and *KpnI* digestion resulted in release of 500bp product containing *Cadinene synthase* gene (375 bp) and Chitinase intron (125 bp); *3. KpnI* and *EcoRI* digestion resulted in release of *Cadinene synthase* (375bp) gene

Isolation of ~ *Cadinene hydroxylase*

Another candidate gene for RNAi, 0 *Cadinene hydroxylase* was PCR amplified using cDNA synthesised from mature embryo as template and sequenced.

4.8: Seed Production and Seed Quality Improvement

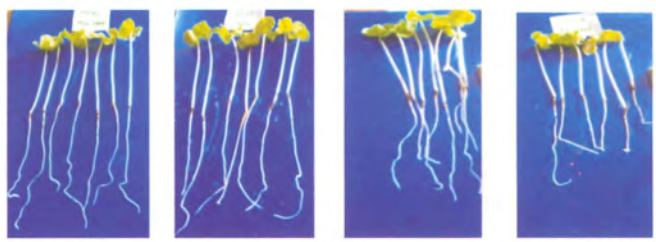
Nagpur

Screening for moisture stress tolerance and determination of effective seed treatments

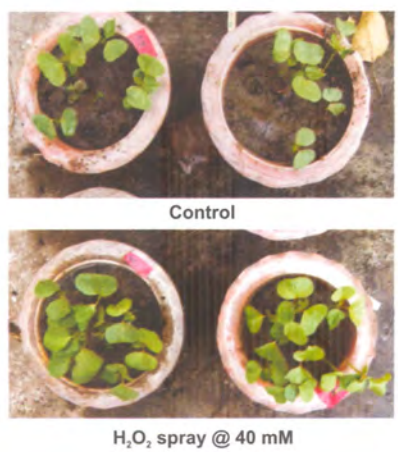
Tolerance of 25 working collections each of G. *arboreum* and G. *hirsutum* to seed germination in PEG osmotic medium constituted to exert variable osmotic pressures revealed one G. *arboreum* line (6565-M11-AC-65) to be highly tolerant (more than 70% germination) to high osmotic pressure of -1.5 mPa. In general, G. *arboreum* cotton were more tolerant to PEG stress with superior seed germination than G. *hirsutum.*

Seed treatments with 2% Potassium Chloride and 40 mM Hydrogen peroxide showed superior seedling growth compared to untreated and water treated controls. Furthermore, spray application of chemicals compared to seed soaking was more effective in promoting higher seedling growth. Seedlings raised from H_2O_2 sprayed seeds demonstrated better stand and better growth under moisture stress compared to untreated controls.

Enhanced growth of cotton seedlings as a result of seed treatment with KCl and H_2O_2



Seedling stand of G. *hirsutum* cv NH 615 (pots) at soil moisture level of 60% field capacity



DUS characterization

Ten candidate varieties/hybrids from private sector were DUS characterised with the help of four reference varieties of G. *hirsutum* and one reference variety of G. *barbadense.*

In addition to the characters observed as per the National Test Guidelines, variation for gossypol gland density was also studied. Unit sections (0.2 mm^2) from seed cotyledons and 7 days old cotyledonary leaves of the same variety under Light-Stereo microscope revealed variation in gossypol gland density. In general, gossypol gland density per unit area was higher in seed cotyledonary sections compared to that in the cotyledonary leaf sections. Genotypes differ in frequency of their gland density in cotyledonary leaf section. While density of gossypol gland was high in Surabhi and Khandwa 2, Vikas, MCU 5 and MCU 10 showed less density with scattered glands. However, feasibility of using gossypol gland density as

a special DUS test in varietal identification would depend upon its reproducibility.

Surabhi MCU 5

Variation for gossypol gland density in cotyledonary section

Sample size for assessment of Bt seed purity

In an experiment with simulated seed lots having different percentage of Bt cotton seeds, sample sizes of more than 60 seeds drawn from a seed pack of 450 g could provide a near accurate measure of Bt seed purity. Per cent Bt seeds in seed lots was tested based on estimation of *cry1Ac* protein. It was concluded that, the existing norm of assessing Bt seed purity on the basis of 10 seeds will not hold good to assess purity of the entire seed lot.

Coimbatore

Implementation ofPVP legislation, 2001

During 2011-12, Plant Variety registration certificate for 21 extant cotton varieties have been obtained from PPV&FRA. Fifteen G. *hirsutum* genotypes were sown for maintenance and seed multiplication. A total of 28 G. *arboreum* and 10 G. *herbaceum* varieties were seed multiplied, purified and being maintained at CICR, Nagpur for reference seed supply.

Characterization of germ plasm lines for DUS

Working germplasm lines (333) received from CICR, Nagpur were characterized for DUS (distinctiveness, uniformity and stability) adopting test procedures of national test guidelines for tetraploid cotton. Wide variability was observed in growth habit and reproductive traits (Table 2). Germplasm lines such as XAB 5 X TANGUIS -126 -DH ,LYY, 21-1-1-4-5, 62 -2- (S) 2-3, BMCOT 95 BLL, B 4 EMPIRE, SAJAR 314, SOBHAGYA, TEXAS- 1050, CSH - 911, Arizona super okra leaf (green), MDH 89, MDH 90, B 56-181, KEKCHI(RED), 101-102 Bwere identified for early, compact, dwarf types with high yielding ability and good fiber traits.

Establishment of genetic purity of hybrid seeds through bio molecular profile

Table 2 : Variability observed in working germplasm

Characters	Min.	Max.
Plant:. Growth habit (cm)	8.0	46.0
Plant:. Height (cm)	37.0	107.0
Days to 50% flowering	49.0	71.0
Boll Weight (g)	1.86	5.49
Number of sympodia	7.0	27.3
Number of bolls	2.7	23.0
Seed cotton yield (g/plant)	20.3	133.85
Seed Index (g)	6.63	14.9
Ginning %	14.06	42.96
Fibre: Length 2.5% Span (mm)	22.1	34.9
Fibre: Strength *(g/tex)*	16.6	26.0
Fibre: Fineness (~glinch)	2.1	6.5
Fibre: Uniformity	42.0	51.0
Elongation Percentage	3.8	7.1

Seed proteins were estimated using Tris Soluble Proteins, Salt Soluble Globulins and Methanol precipitated fraction and separated by SDS-PAGE electrophoresis in CSHH-243 and its parents CSH 2013 and CSH 43. Presence of specific protein bands of defined mobility and intensity were observed in all the samples which will be useful for identification of hybrids and parental seeds after characterisation and assessment of reproducibility.

Standardization of seed coating with synthetic polymers and additives

The results on seed coating treatments revealed that Polymer coating (Polykote @ 3 ml/kg of seed), diluted with 5 ml of water with insecticide (Imidacloprid @ 6 ml/kg of seed) or Polymer + Royal flow 40 SC @ 2.4 ml/kg seed + insecticide (Imidacloprid @ 6 ml/kg of seed) was found better in retaining the seed viability under ambient storage condition.

Seed Production

Nagpur

In Nagpur, 4.37 quintal TFL fuzzy seeds of 40 G. *hirsutum* and G. *arboreum* cultures were produced under Mega Seed Project.. In addition, 1.78 quintals of certified seeds of Gram (Vijay) and Kabuli Chana was also produced under the programme. A revenue of 13.0 lakhs has been generated through sale of these seeds and their byproducts. Protective irrigation was provided to the seed production plots from the farm pond.

Farm ponds with conserved rainwater for protective irrigation of cotton

Seed production of G. *arboreum* race *cernuum* collected from Meghalaya was taken up in the Institute. Plants with upto 14 bolls of7 -8 gms were recorded.

Coimbatore

Breeder seed production of cotton was undertaken at CICR Coimbatore under National Seed Project.. In all, 336 kg of breeder seed of cultivars Suraj, LRK 516 and LRA 5166 was produced during the season. Under Mega Seed Project, 39.5 quintals of TFL seeds including Sorghum (C01), hybrid Maize (C06) and its male parent ofC06 were produced.

Sirsa

Ninety kg seeds of male and female parents of four popular cotton hybrids and 82 kg seeds of two *Desi* cotton varieties were produced during the season under Mega Seed Project.. In addition, 320 quintals seeds of wheat variety PBW 550 was also produced.

4.9: Nutrient Management

Nagpur

Performance of American (G. *hirsutum)* and *Desi* (G. *arboreum)* cotton varieties was evaluated under rainfed organic conditions. Among the species, *Desi* cottons yielded less than the *hirsutum* varieties due to greater shedding of fruiting parts. Out of the 13 *hirsutum* varieties evaluated, seed cotton yield in the range of 11.0 to 14.9 qlha was recorded in NH 615, Suraj, PKV 081, LRK 516 and AKH 8828. High value of bundle strength and staple length was observed in the variety of Suraj (24.1 *gltex,* 30.7 mm), followed by LRK 516 *(22.6 gltex,* 28.1 mm) and PKV 081 (18.9 *gltex,* 28.1 mm). Among the *Desi* varieties, JLA 794, CNA 347 and AKA. 7 recorded higher seed cotton yield ranging from 8.0 to 9.7 q/ha. These varieties also possessed good staple length of 26.2 to 27.9mm.

Total microbial population, total microbial biomass, nitrogen and carbon were found to be higher in the surface soil as compared to sub surface soil..

On farm trials were conducted at Nandura and Loni villages in Yeotmal district on different nutrient management production technologies in Bt cotton. Results indicate that highest seed cotton yield was obtained under recommended package of practices with INM technology (NPK: 80:40:40 +Zn 10+1t1ha FYM+PSB +2%DAP foliar spray) + along with a protective irrigation (26.25 q/ha). This was 147% higher over the Farmer's practice

Potassium silicate and Calcium peroxide - as growth enhancer of cotton plants

Potassium silicate is known to alleviate nutrient imbalance, impart resistance to abiotic stress, sucking pests and improve crop vigour and quality. Calcium peroxide is an oxygen releasing compound which supplies O_2 to the roots constantly and continuously and adjusts rhizosphere pH making nutrients available to the plants. A field experiment was conducted during 2010 to evaluate the growth promoting effect of potassium silicate and calcium peroxide (60%) in cotton (Bunny Bt) plants. Potassium silicate is a liquid fertilizer containing 8-1 0% K_20 and 20-24 % $Si0_2$.

Seeds of Bunny Bt cotton were soaked overnight in 2% or 4% calcium peroxide slurry and 1001-11or 5001-11potassium silicate solutions and sown. Seeds soaked overnight in water were sown as control.. The results indicated that among the potassium silicate seed treatments, 500 ppm was found to be effective in increasing the number of leaves (75.3) , bolls (16) and single plant yield (43 g/plant) over control with 66 leaves, 12 bolls and 30.16 g of seed cotton yield per plant.. Seed treatment with 2% calcium peroxide slurry showed better seedling vigour, plant height and shiny green leaves compared to control..

Alleviation of moisture stress

Foliar application of potassium silicate (40, 60, 80 1-11/) was done at 30 and 60 DAS to evaluate its effect on leaf water relations and lipid peroxidation under irrigated and water stress conditions in cotton var. Bunny Bt 2. Potassium silicate treatments positively influenced the leaf water relations in terms of relative water content (RWC) and leaf water potential.. Under stressed conditions, plants sprayed with 40 1-11of potassium silicate were found to exhibit higher RWC compared to control.. Cell membrane integrity was also higher in potassium silicate treatments than control and hence the membrane injury was lower in plants treated with potassium silicate both under irrigated and stressed conditions. Under stressed conditions, potassium silicate treatments recorded higher proline content and lower levels of lipid peroxidation than control..

Hydroponic studies

Hydroponic studies was conducted to understand the effect of potassium silicate as growth supplement in varying concentrations *viz.,* 20, 40, 60, 80,100 and 1201-111The supplement of 60 1-1101 potassium silicate was found to be optimum induced better root growth and also vigour in seedlings. There was no negative effect at higher doses of even 120 1-1101 potassium silicate.

4.10: Cropping Bystems

Nagpur

Innovative Bt cotton based cropping systems

Averaged over three seasons (2008-11) on medium deep soils, Bt hybrid cotton intercropping with roselle, soybean and marigold produced similar cotton equivalent yields and net returns and significantly greater than sole cotton. Recommended dose of fertilizer along with soil application of $MgS0_4$ (25 kg ha^{-1}) and Borax (10 kg ha^{-1}) produced significantly lower seed cotton and cotton equivalent yields, net returns and B: C ratio than higher dose of fertilizer or foliar application of N treatments in a deficit rainfall year..

Coimbatore

Strategies for maximizing productivity of Bt cotton based intercropping systems

New plant geometry was studied (120 x 45 em) in comparison with the normal recommended geometry of 90 x 60 em for the Bt cotton + coriander, Bt cotton + radish and sole cropping system.. Modified geometry of 120 x45 em was better than the normal spacing of 90 x 60 em.

Sirsa

Studies on soil plant narrations in intercropped *kharif* legumes with Bt cotton under irrigated condition

Feasibility and profitability of mung bean as an intercrop between the paired row lines with Bt hybrid MRC 7017 and Bioseed 6488 was evaluated. The check included sole cotton and paired row sole cotton. The seed cotton yield of sole cotton (28.0 to 31.6 q/ha) was significantly higher than the paired row sole cotton (26.3 to 30.2 q/ha) and intercropping systems. Inclusion of mungbean in Bt cotton hybrid was not a profitable option in the irrigated north zone conditions at Sirsa.

4.11: High Density Planting Systems (HDPS) for Maximizing Productivity

Nagpur

Identification of compact and zero monopodia genotypes for HDPS for maximizing productivity of rainfed cotton

Thirty four germ plasm lines were identified on the basis of

- Compact plant body and short sympodia
- Shorter internode
- Development offruiting units closer to main axis
- Perfect locule opening pattern

for their likely superiority under HDPS. All these germplasm lines showed determinate growth of lateral branches, reduction in boll numbers (6-8 bolls/plant), boll weight (2.5 g-3.1 g) and perfect locule opening. Among them higher retention of mature and open bolls (6-11) was observed in IC 358660, IC 358655, and IC 359710. Higher seed cotton yield was recorded in IC 357444 (28.3 g/plant), IC 357126 (30.0 g/plant), IC 358434 (30.8 g/plant), IC 356774 (31.8 g/plant) and IC 132026 (34.3 g/plant). The fibre quality range was recorded for staple length (22.2-29.1 mm), uniformity (45-52), micronaire (2.6-5.2) and fibre strength (14.6-20.7). The promising lines with better fibre quality namely G.cot 100, IC 358205, IC 359649 and IC 3571 06 were identified.

Eight genotypes were evaluated under two spacing (60 x 15 cm and 45 x 15 cm) and among them RS 875 was found to be most suitable for high density planting.

High Density Planting Systems (HDPS) for maximizing productivity

Ten genotypes of G. *hirsutum* (LH 900, SURAJ, PKV 081, NH 630, CNH 2, CNH 1109, CNH28 I, CNH 1108, ADB 39 and DSC 115) were evaluated at 60 x 30 cm (normal density) with RDF (M 1), 45 x 15 cm (high density) with RDF (M2) and 45 x 15 cm with 125% RDF (M3) on rainfed Vertic Inceptisols of Nagpur representing sub-humid dry agro-eco-sub-region. Averaged over genotypes, the mean yield in HDPS (M2) was 1409 kg/ha as against 1088 kg/ha under normal planting (M 1) indicating a 29% advantage with HDPS. Under HDPS (45 x 15 cm, 148000 plants/ha), genotypes Suraj,, ADB 39, PKV 081 and 281 were found promising in terms of yield (Fig.8), morphology, earliness and nutrient use efficiency. The N response ratio or partial factor productivity of N ranged from 11.7 in DSC 115 to 30.8 in Suraj. The N utilization efficiency was higher in ADB 39 (18.6), PKV 081 (15.8) and Suraj (14.5) compared to the other genotypes.

Genotypes - PKV-081, Suraj and LH -900 under HDPS

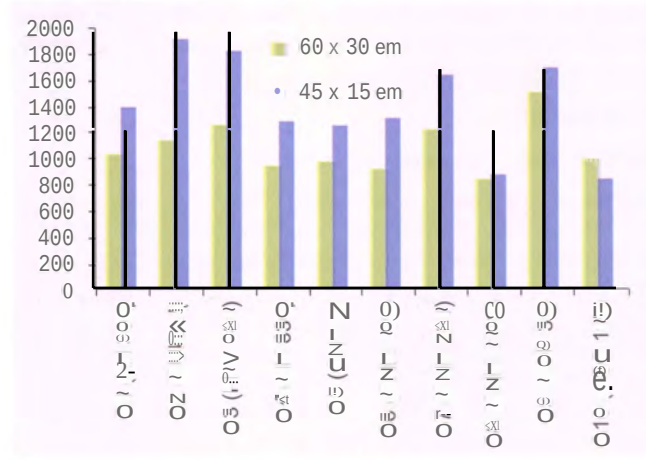


Fig. 8: Seed cotton yield (kg/ha) in G. *hirsutum* genotypes at normal (60 x 30 em, 55000 plants/ha) and high density planting (45 x 15 em, 148000 plants/ha)

Similarly, among the 8 genotypes of G. *arboreum* (AKA 07, CINA 404, JK 5, HD 123, PA 183, JLA 794, JLA 802 and JLA 505) evaluated, on the basis of yield, plant type and growth characteristics CINA404, HD123, and JLA505 performed well under high density planting (222000 plants/ha). The N response ratio or partial factor productivity of N ranged from 13.3 in PA 183 to 35.4 in CINA404. The N utilization efficiency was higher in JLA 794 (14.2) and JLA 505 (13.6) compared to the other genotypes.

Pest and disease incidence under HDPS

The mean incidence of leaf hopper population (number of nymphs/3 leaves/plant) on the 10 hirsutum genotypes were similar under normal and HDPS. The mean population was well below the economic threshold level (6 nymphs/3 leaves/plant). Among the 10 genotypes of G. *hirsutum,* the least leaf hopper population was observed on LH-900 and CNH-1108.

On the basis of the incidence of bacterial blight disease, *Myrothecium* leaf spot and *A/ternaria* leaf spot disease, Suraj showed the highest susceptibility followed by PKV 081 and NH 630. Continuous dry spell from September to harvesting, resulted in negligible incidence of grey mildew in G. *hirsutum* varieties. CNH 1108 and LH 900 showing resistance to most of the diseases under field conditions. The early incidence of grey mildew was observed in all the G. *arboreum* varieties

except HO-123 but due to longer dry spell during September till the harvesting of cotton further spread of the disease was not observed. The incidence of bacterial blight and other fungal leaf spot diseases were more with a spacing of 45 x 15 in comparison to 60 x 30 spacing in G. *hirsutum* varieties.

Compatibility studies of various plant protection inputs for HOPS cotton

Compatibility between seed treatment chemicals (pesticides and fungicides) and bio-control agents (microbial consortia consisting of ten bacterial isolates and *T. viride)* was evaluated *in-vitro.* Acephate and Imidacloprid were compatible with microbial consortia and *T. viride.* Carbendazim and Thiram were compatible with microbial consortia but not with *T. viride.* Imidacloprid was compatible with individual isolates of microbial consortia and Acephate was incompatible with isolate no. 4, 7 and 10. Based on these observations a seed treatment schedule for protection against pests and diseases under HOPS was worked out.

Coimbatore

Identification of genotypes for HOPS

Ten genotypes (Anjali, C 1412, CCH 724-5, TCH 1608, KC-3, F-2383, NH 615, MCU 7, SVPR-3, PKV 081) were screened for suitability under HOPS under irrigated condition under high density planting system at spacing of 45 x 15 cm and compared with RCH 2 Bt planted at 90 x 60 cm. Results indicated that KC-3 recorded higher seed cotton yield (2655 kg/ha) followed by PKV 081 (2253 kg/hal, Anjali (2215 kg/ha) and NH 615 (2121 kg/halo RCH 2 Bt planted at 90 x 60 cm registered seed cotton yield 1596 kg/ha.

The highest gross return (Rs. 79,650/ha) was observed with KC-3. However, Anjali registered the highest net return (Rs. 39,805/ha) and benefit cost ratio (2.1) because of higher market price (Table 3)

Anjali under HDPS

Sowing by inclined plate planter

Sowing under high density planting system is labour intensive. An alternate strategy of sowing using tractor drawn inclined plate planter was attempted. Tractor drawn inclined plate planter could not maintain plant to plant spacing (15 cm). However, yields (1918 kg/ha) were similar to manual method of sowing (2003 kg/halo While, gross return were maximum with manual method of sowing (Rs. 70,1 05/ha) the increased cost associated with manual method lowered the net profit (Rs. 32,992/ha) as compared to tractor drawn inclined plate planter (Rs. 34,883/ha).

Table 3: Seed cotton yield and economics as influenced by genotypes planted under high density planting system

Genotypes	Seed cotton (kg/ha)	Cost of cultivation (Rs/ha)	Gross Return (Rs/ha)	Net Return Rs/ha)
T1. Anjali	2215	37720	77525	39805
T2. C1412	1645	33160	49350	16190
T3. CCH7245	2079	36632	72765	36133
T4. TCH1608	1823	34580	63788	29208
T5. KC-3	2655	41240	79650	38410
T6. TCH 1705	1904	35230	66631	31401
T7. NH615	2121	36970	70001	33031
T8. MCU7	1293	30340	38775	8435
T9. SVPR-3	1385	31080	41550	10470
T10. PKV081	2253	38020	67575	29555
T11. LH 900	1711	33690	51338	17648
T12. RCH2 Bt*	1596	32768	60648	27880
SED	107			
CD	221			
CV(%)	14			

* Planted at recommended spacing of 90 x 30 cm.

Genotypes x nutrient interaction under HOPS

Genotypes (Anjali, C1412 & CCH 7245) and their interaction with nutrient levels (75, 100, 125 & 150% ROF) under high density planting system (planted at 45 x 15 cm) were compared with RCH 2 Bt. RCH 2 Bt was planted at 90 x 60 cm 18,519 plantlha with 100 per cent ROF recorded the lowest seed cotton yield of 14.7 q/ha. High density planting system (45 x 15 cm) recorded additional yield of 2.2 to 8.7 q/ha over that of RCH 2 Bt. Seed cotton yield was not affected by levels of nutrient application. However, genotypes by nutrient level interaction was significant. . Anjali planted at 45 x 15 cm and applied with 150% ROF registered significantly highest seed cotton yield (24.91 q/ha), gross return (Rs. 94,658/ha), net return (Rs. 54,730/ha) and benefit cost ratio (2.37), which were 69.5, 60.9, 102 and 28 per cent respectively higher than RCH 2 Btapplied with 100 percentofROF (Fig. 9).

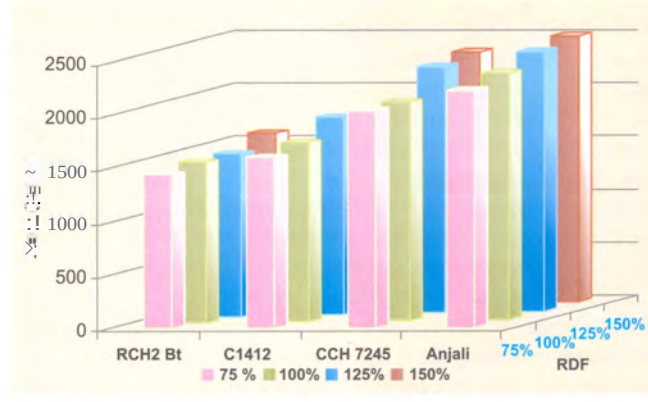


Fig. 9: Yield (kg/ha) under HOPS (Anjali, CCH 7245 & C 1412) and conventional (RCH 2 Bt) one with nutrient levels

Sirsa

Identification of genotypes for HOPS

G. *arboreum* genotypes i.e. HD-123, RG-542, HD-432, CISA-310, CISA-111 were evaluated under three spacing (67.5 x 10, 67.5 x 20 and 67.5 x 30 cm). Higher yield in general was recorded for 67.5 x 20 cm spacing followed by 67.5 x 30 cm. Only CISA-31 0 performed well under 67.5 x 10 cm spacing. In 67.5 x 20 cm spacing an increase of 3-5 q/ha in yield was obtained over67.5 x 30 cm.

4.12: Weed Management

Nagpur

Herbicide weed management strategy of pendimethalin (1 kg a.i./ha) as pre emergence) and pyrithiobac Na (70 g a.i./ha) as early post emergence) provided timely and effective weed control..

Herbicides were evaluated 0.5 to 2.5 times the recommended dose and allowing sufficient time for toxicity expression. Resistant weeds were noted. *Cynodon dactylon* and *Digera arvensis* with reported tolerant *to Glyphosate* while *Merremia emarginata* and *Acalypha indica* were susceptible. *Tridax procumbense* and *Cyperus rotendus* weeds were susceptible to Pyrithiobac:/ Imzethapyr herbicides were noted. No tolerant weeds were observed for Quizalofop ethyl..

Coimbatore

Stale seed bed technique of weed control

Stale seed bed weed control (pendimethalin 1.0 kg and glyphosate 1.0 kg per ha applied one week before sowing) resulted in the highest weed control efficiency (83.7%) due to broad spectrum weed control.. The germinated weeds were killed by glyphosate and the germinating weeds by the residual herbicide, pendimethalin. This technique also resulted in maximizing seed cotton yields.

Weeding by post emergence

Weed control by application of residual chemical, pendimethalin (1.25 kg a.i./ha as pre emergence) followed by post emergence application of quizalofop-ethyl (50 g a.i./ha) and pyrithiobac sodium (75 g a.i./ha at 30 & 35 DAS) respectively was similar to pendimethalin (1.25 kg a.i./ha) followed by post emergence application of tank mix of quizalofop-ethyl (50 g a.i./ha) and pyrithiobac sodium (75 g a.i./ha at 30 DAS) and pre emergence application of pendi-methalin (1.25 kg a.i./ha) + with one hand weeding 30 DAS.

Herbigation with herbicide/mixture/herbicide rotation for efficient weed control in cotton and its effects on succeeding pulse crop

Among the combinations of rotation herbicides pendimethalin (1.0 kg a.i./ha) as pre emergence herbicide on third day followed by hand weeding 35 - 40 DAS and pyrithiobac sodium 50 g + quizalofop-P- ethyl 50 g on 60 DAS recorded the highest seed cotton yield, net return and B:C ratio. It was on par with Pendimethalin followed by hand weeding and pyrithiobac sodium 50 g + fenoxoprop-P-ethyl 50 g on 60 DAS and hand weeding thrice (20, 40 and 60 DAS).

4.13: Soil Biology and Biochemistry

Nagpur

Developing efficient carrier based microbial delivery system for cotton nutrition and soil health

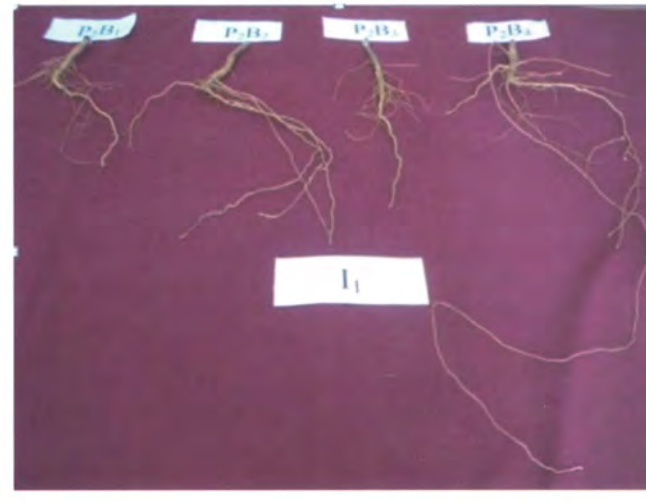
Two field experiments were taken up during the 2011-12 season. In the first experiment, microbial delivery methods were compared with different levels of nutrient on cotton growth and productivity, while in the second experiment, microbial delivery methods were tested on one G. *hirsutum* variety **NH** 615, one conventional hybrid **NHH** 44 and 2 Bt hybrids *viz.* Bunny and Rasi 138.

Microbial consortia as carrier based delivery system recorded significantly higher (27%) seed cotton yield compared to absolute control (no nutrient and no microbial cons), followed by microbial consortia delivered through seed treatment (13%) and soil treatment (11%). The interaction between variety/hybrid and delivery system was not significant. .

Among microbial delivery methods, significantly higher mean seed cotton yield was obtained with seed treatment (511 kg/ha) followed by 100% RDF (483 kg/ha) and carried based microbial delivery (454 kg/halo

Coimbatore

Evaluation of arbuscular mycorrhizae and phosphorus



solubilising bacteria for enhancing phosphours acquisition and mitigation of water stress in Bt cotton

Combined application of arbuscular mycorrhizae (AM) and phosphorus solubilising bacteria (PSB) followed by sole application of AM and PSB enhanced the germination percentage and plant growth. Under irrigated conditions, all the above parameters were improved by sole inoculation of AM compared to sole application of PSB. Recommended dose of phosphorus, nitrogen and potassium with combined bioinoculants *viz*., AM and PSB enhanced the agronomical, physiological and biochemical characteristics in Bt cotton as compared to 50 per cent recommended dose of P and bioinoculants.

Geo-referenced Soil Information System for Land Use Planning and Monitoring Soil and Land Quality for Agriculture

A survey on established benchmark (BM) soil series in different agro-ecological sub regions (AESR) of Black Soil Regions (BSR) of India was done to investigate the impacts of bio-climates, cropping systems, soil sub groups, land use, and management practices on the soil biological attributes such urease, dehydrogenase (DHA), microbial biomass carbon (MBC), culturable microbial population, and microbial diversity indices in BSR.. All the soil biological attributes declined with soil depth and the maximum activity was observed in top 30 cm soil. Cropping systems and bio-climates significantly ($p<0.01$) influenced urease activity. The average urease activity in different bio-climates were in decreasing order of arid> sub humid (moist) > sub humid (dry) > semi-arid (dry). Among cropping systems, cotton based systems had lesser activity than the legume or sugarcane or cereals based cropping systems. Urease activity was higher in irrigated compared to the rainfed systems. Cropping systems and bio-climates significantly ($p<0.01$) influence the DHA in soil. Significantly higher *($p<0.01$)* DHA was recorded in sub humid moist bio-climate (2.45 IJg TPF g^{-1}) followed by sub arid dry (2.00 IJg TPF g^{-1}) and the least DHA was recorded in arid bio-climate (1.62 IJg TPF g^{-1}). Legume-based cropping system recorded significantly *($p<0.01$)* higher DHA (2.32- 2.881Jg TPF g^{-1}) among the cropping systems. Significantly higher *($p<0.001$)* MBC was recorded in Sub humid dry bio-climate (267 IJg g^{-1}) followed by sub humid moist (179 IJg g^{-1}) and the least MBC was recorded in arid bio-climate (97.5 IJg g^{-1}). Significantly higher ($p<0.01$) 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 recorded significantly *($p<0.01$)* higher microbial population (6.23 $\log_{10}$ cfu g^{-1}) followed by cereal based cropping system (6.23 $\log_{10}$ cfu g^{-1}). Significantly ($p<0.01$) higher microbial diversity indices was recorded in sub humid moist and sub humid dry compared to semi arid dry and arid bio climates. Among the cropping systems, except Shannon diversity index (H') which was similar in both legume-based and cereal-based cropping system, all other diversity indices (Simpsons index (D), Simpsons reciprocal index (1/D), and Simpson evenness (E)) were found to be significantly ($p<0.05$) higher in cereal-based cropping system followed by legume-based system. The pooled analysis of diversity indices indicated a significant difference *($p<0.01$)* between the land use types (irrigated and rainfed agro ecosystems). In management, BM spots which adopted high management practices recorded significantly *($p<0.05$)* higher Shannon diversity index (H') (H' = 2.48) compared to low management (H'=2.45). The microbial diversity indices found to significantly *($p<0.01$)* decline in all the BM spots with increase in soil depth. The maximum diversity indices were recorded in the surface soil (0-15 cm) and nearly 50% of diversity was found to be restricted within 0-30 cm soil depth.

4.14: Cotton Mechanization

Nagpur

Development of Wick Applicator

A Wick Applicator was developed to smear the weeds with herbicide solution in between the rows of cotton plants.

This was developed especially for HDPS system since spraying such chemicals has the risk of killing nearby cotton plants by drift of the weedicides. The wick applicator has a cylindrical tank of 10 lit. capacity, one conveying pipe from tank to wicks at the end of a long handle. It is shoulder mounted, the fluid is injected by gravity from the small openings of the wicks. The brush width is 24 cm, below the tank one cock is provided which regulates the flow.

The wick applicator was tested in the laboratory and calibrated in field. The field capacity of wick applicator was found to be 100 lit./ha to 550 lit./ha which could be changed depending upon the density and age of weeds.

Herbicide Wick Applicator

Development oftrolley mounted chain type cotton picker

Conceptual design of a cotton picking machine to be operated by a pair of bullocks or a person behind the machine was prepared in CAD. Various parameters like machine

parameters, plant parameters and soil parameters were analysed to design the cotton picking machine. The list of parameters considered for the design of cotton picking machine were plant parameters: crop height, lateral spread, lowermost boll height, percent compression of crop; Machine parameters: forward speed of machine, weight (approx.), height, width of machine, power required to operate picking mechanism, power required for forward travel of the machine. The machine is divided into mainly three components i.e. 1. picker trolley 2. crop guider and compressing mechanism and 3. picking mechanism. GAD drawing and 3D solid model of the picker was made. Fabrication of all the components was completed after testing the assembly for its strength and stability in the standing crop of cotton at each stage of fabrication, and suitable modifications thereof.

Chain type cotton picker

4.15: Morphoframe / Boll Load Management

Nagpur

Physiological manipulation of Bt plant morphoframe

Effect of manipulation of Bt plant morphoframe (NGS-145 Bt and Mallika Bt vs NGS-14 nBt) using plant growth regulators and mechanical methods on crop productivity was evaluated. Among the treatments, foliar application of maleic hydrazide (500 ppm) at 85 DAS recorded highest plant height, leaf area and Leaf Area Index (LAI) of 82.3, 6964.0 em' and 1.3 respectively and produced significantly higher yield than detopping main stem at 95 DAS and sympodial meristem at 105 DAS.

Physiological manipulation of cotton morphofame by spraying Ethrel

Foliar application of ethrel (5.7mM ==0.75 ml/litre) at 39 DAS in cotton hybrid Jai Bt increased the photo-synthetic leaf area and leaf area index of the cotton plants than control. Ethrel treated plants recorded more bolls and resulted in greater seed cotton yield than control (Table 4).

Table 4: Effect of Ethrel and growth and yield of cotton hybrid Jai Bt

Treatments	Plant height (em)	Height to node ratio	No. of Sympodia	No. of bolls	No.of leaves (em')	Leaf area	LAI	Yield (kg/ha)
Control	72.0	1.3	15.8	13.4	66.2	3298.4	0.92	890
Ethrel (0.75 mill)	87.7	1.4	18.0	24.7	125.0	8003.2	2.22	1116

M H Treated cotton plants

4.16: Studies on Abiotic Stress

Nagpur

Leaf reddening

Different combinations of nutrients, growth retardants, reflectants and insecticides were tried to ameliorate leaf reddening in the hybrid RGH2Bt. Only a low degree of reddening was observed and these symptoms appeared towards the end of the crop growth period. During that period, plants treated with 3% KNO_3, 2% DAP, Lime 0.5% at 60 DAS and 1% at 80 DAS, Lihocin *(GGG)* 50 ppm, 1% potash, Acephate (1g/litre), Monocrotophos (3 ml/litre) appeared healthy and green except for lihocin treated plants which appeared greenish but the plants were extremely stunted. Higher N content was observed in plants treated with 60 ppm potassium silicate, Kaolin and 50 ppm Lihocin *(GGG)* - than control. P content was higher in plants treated with 50 ppm Lihocin (GGG) - (0.388%), 1% KOH (0.360%) and Kaolin (2 and3%) (0.304%) overcontrol (0.181 %).1%KOH(3.71%), and insecticides such as acephate (3.71 %), confider (3.66%) and monocrotophos (3.39%) recorded higher K content over control (2.33%). Yield was significantly higher in the potash, DAP and lime, potassium silicate and KNO_3 (924 to 1046 kg/ha) treated plants overcontrol.

Leaf total chlorophyll content varied from 0.54 to 0.82 mg/g fresh weight of leaf at 76 DAS and 0.65 to 0.9 mg/g at 97 DAS. Higher values were observed in *GGG* (chloromepiquat chloride) 50 ppm and 2,4 dinitrophenol treatments at both the stages. Leaf chlorophyll content was high as plants did not experience any severe leaf reddening stress. The same is also true for leaf anthocyanin content which was in the range 0.0055 to 0.0033 mole/em'. Since leaf reddening incidence was low, anthocyanin concentration was also low. The role of anthocyanin for its protective role during plant stress could not be ascertained. Further, leaf peroxidase activity was not affected during the season as the enzyme activity was not triggered to combat the oxidative stress.

Physiology of drought resistant transgenic cotton

Thirty transformed plants for *DREB* and *ZAT* 12 genes were subjected to different soil moisture levels under pot culture. Five transgenic plants along with one non transgenic plant were subjected to different moisture levels (100, 75, 60, 45, and 30%). Few transgenic plants performed better than the control by exhibiting high leaf water potential, relative water content, cell membrane stability and proline content. Transgenic plants that performed well under 30 and 45%

moisture levels can be considered as highly drought tolerant when compared to non transgenic plants.

Coimbatore

Nutrient foliar spray, under moisture stress condition increased boll number in Bt cotton. Significant increase in boll weight was also recorded irrespective of genotypes resulting in a significant increase in yield compared to the control (Fig. 10). Irrespective of genotypes and Bt cotton, Nitrate reductase activity was significantly more in nutrient sprayed plants. The photosynthetic activity was higher in Bt cotton (24.7 to 27.2 µ mol CO_2 $m^{-2}s^{-1}$) than the genotypes (22.8 to 25.8 µ mol CO_2 $m^{-2}s^{-1}$).

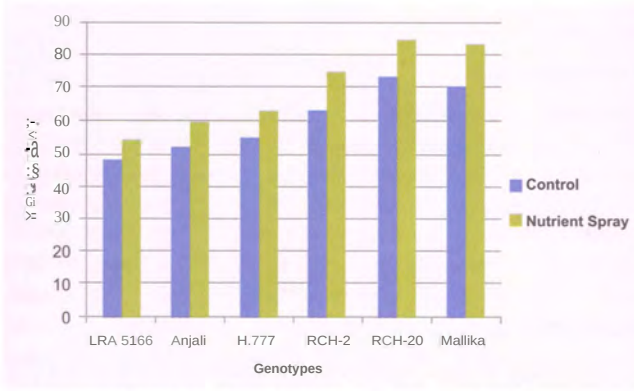


Fig. 10 : Effect of Nutrient spray on yield

Alleviation otwater logging by nutrient consortia spray

Waterlogging reduced the boll number from 18 - 23 to 12 - 15 per plant. In general, boll weight was not significantly affected due to water logging and only a marginal improvement was discernible in plants that received nutrient spray. A drastic reduction in yield was observed due to water logging irrespective of genotypes and Bt cotton. The reduction in yield was significant in Bt cotton (30 - 37 %) than genotypes (15 - 24 %) (Table 5). This reduction in yield per plant could be improved by 5-9% in genotypes while the improvement in yield was 29 to 46% in Bt cotton through nutrient consortia spray. Nutrient foliar sprays was effective in alleviate waterlogging stress to a greater extent in the Bt cotton than the genotypes.

Table 5: Seed cotton yield (g/plant) under normal (control) and waterlogged conditions with and without nutrient spray.

Genotypes Bt hybrids yield / plant (g)	Control	Water Logged (No spray)	Water Logged (Nutrient spray)
LRA 5166	62.0	47.0	51.4
Anjali	64.8	51.5	54.3
H 777	70.1	60.7	60.9
RCH 2	86.7	61.2	79.1
RCH 20	109.7	69.0	100.8
Mallika	90.4	58.7	77.0
CD at 5% (VXT) =8.8			

4.17: Socio Economic Dimensions of Cotton Farming

Analysis otyield gap and constraints in cotton production

Central zone (Gujarat and Madhya Pradesh)

Meeting with farmers to prioritize constraints in cotton production

Identification and prioritization of constraints and yield gap in cotton production was done in Gujarat and Madhya Pradesh. This study was conducted in Bharuch, Vadodara, Surendranagar, Ahmadabad and Surat districts of Gujarat and Khandwa, Khargone and Barwani distrists of Madhya Pradesh. Yield gap in Gujarat ranged between 8 to 25 q/ha while it ranged from 1.2 to 20 q/ha in Madhya Pradesh. It was found that in Gujarat incidence of sucking pests was the major constraint in cotton production followed by non availability of labour, weed infestation and high cost and shortage of genuine seeds. In Madhya Pradesh incidence of sucking pests, weed infestation, leaf reddening and shortage of fertilizer were identified as major constraints affecting cotton production.

Besides, excess rains during initial crop growth period, late sowing, shortage of capital for purchasing inputs, mealy bug infestation, price fluctuations, drought during later crop growth period, pink bollworm, labour shortage/high wage, shortage of irrigation/electricity, cloudy weather/rains during flowering and non availability of seeds are causing considerable yield loss. These constraints need to be addressed on priority basis to bridge the yield gap and to improve average productivity in all three districts.

North zone (Haryana and Rajasthan)

In Haryana, Sirsa and Hisar districts selected for the study had a yield gap of8.15 q/ha and 7.07 q/ha, respectively. In Haryana state, damage caused due to sucking pests, dry spell during flowering stage and lack of knowledge about recommended practices were major constraints affecting cotton production. Beside these, lack of availability of genuine plant protection chemicals, incidence of cotton leaf curl viral disease, lack of credit, deficiency of micro nutrients were other constraints affecting productivity in this state. Delayed sowing due to non-availability of canal water in Haryana, that caused considerable yield loss was the added constraint. In Rajasthan, Sri Ganganagar and Hanumangarh districts, incidence and damage caused due to sucking pests, and delayed sowing

due to non-availability of canal water were the major constraints. Besides these, higher degree of use of non-certified seed, dry spell during flowering stage and incidence of cotton leaf curl viral disease caused considerable cotton loss.

South zone (A.P. and Karnataka)

In A.P., Guntur district has a yield gap of 11.0 q/ha. Weed infestation, low price offarm produce at the time of harvesting, non availability of canal water, delayed payment by the marketing agencies, lack of storage facilities, reduced use of organic manures, leaf reddening were major constraints faced by the cotton farmers with an average yield loss of 4 to 6 quintals per ha. In Karnataka, Dharwad and Haveri districts had yield gap ranging from 9.2 to 10.2 q/ha. Non availability of labour, weed infestation, unable to take proper care due to non availability as well as high cost of human labour, incidence of sucking pests and sub optimal use of inputs were important constraints in this zone.

Assessment of cotton based intercropping system

Adoption behaviour and perception of cotton intercropping by farmers of Gujarat and Tamil Nadu was studied with focus on Surendranagar district in Gujarat and Coimbatore and Vellore districts in Tamil Nadu.

Majority of the respondents (72%) were aware about cotton intercropping techniques and more than half of the respondents were aware about the varieties suitable for intercropping, and about the benefits of intercropping such as economic gains, minimizing the soil erosion and increasing soil fertility. However, adoption levels was medium to low (52.5%). The major problems experienced by farmers in adoption of intercropping were labour scarcity followed by difficulty in intercultural operations, fear of more insect pest attack, fear of low yield and the complex nature of technology.

Farmer-to-farmer technology dissemination model was assessed and studied in Wardha, Maharashtra for popularisation of intercropping technology. Results indicated adoption of intercropping specially cotton + soyabean increased among young and educated farmers. Further, farmer to farmer approach also improved adoption of intercropping packages. Mean score of adoption prior to launch of programme was 28.6 which increased to 66.4 during implementation of the farmer to farmer dissemination. These farmer innovators are likely to represent important sources of information amongst other local farmers and for technology dissemination.

Agrarian distress among cotton farmers

The study was conducted in Gujarat and Madhya Pradesh cotton belt to investigate socio- psychological and economic factors and distress like situations if any faced by the cotton growers. In the irrigated areas, there was no distress like situation among cotton growers. However, several social, psychological, economical, situational, technical and marketing problems played an indispensable role in cotton production in progressive and backward regions. The major socio- psychological factors perceived by farmers in non-progressive and progressive areas of selected districts were low income from agriculture as compared to high expenditure for livelihood. Other problems perceived were high cost of fertilizers, insecticides and implements, non-availability of labour, absence of quality based price policy and insufficient income from farming. Heavy incidence of sucking pests, electricity and water shortage, climatic conditions, non-availability of good seed at proper time, lack of awareness about improved technology were prominent situational and technical factors perceived by the farmers engaged in cotton farming.

Interaction with farmer on agrarian distress among cotton farmers

Coimbatore

Implications oftrade openness on Indian cotton economy

Secondary data on world cotton production, consumption, exports - quantity and value, percentage of exports by the trading partners - share of world cotton fibre imports were collected. Nominal Protection Co-efficient (NPC) and Effective Protection Co-efficient (EFC) were estimated to be 0.83 and 0.67. Domestic Resource Cost (DRC) and Social Cost Benefit (SCB) estimated around 0.78 and 0.62, respectively, indicating comparative advantage of domestic versus the international prices. It is observed that the domestic markets of cotton were strongly integrated with central market in the post-WTO compared to pre - WTO period. Among different cotton markets, Tiruppur, Mumbai and Ahmedabad markets were highly integrated with international markets. Residual trend linear regressions estimated for international prices revealed a positive and significant trend for cotton in the post-liberalisation period. It was observed that the international price variability was almost equal or less than the domestic price variability during the reform period. Moreover, variability in both international and domestic price declined during the post-liberalisation period. The co-efficient of cross product trend for cotton was significant at 10 per cent level of probability indicating that movements in international prices affect the domestic prices.

Identification and prioritization of constraints in the Bt cotton scenario

In the north zone, Total Factor Productivity (TFP) growth rate showed a positive trend in all the three States *viz.,* Punjab, Haryana and Rajasthan indicating the better perspectives of adoption of Bt cotton (Table 6). In the central zone, the trend was similar in Gujarat and Maharashtra but in case of Madhya Pradesh, it showed a negative trend due to the non significant growth in output index and positive growth in input index.

Table 6: State wise Total Factor Productivity of Cotton in India (1981-2009)

States	Total input index (TII)				Total output index (TOI)				Total Factor Productivity Index (TFPI)			
	1981-90	1990-00	2000-09	1981-2009	1981-90	1990-00	2000-09	1981-2009	1981-90	1990-00	2000-09	1981-2009
North Zone												
Punjab	1-02	0.99	-4.65	0-71	10.58	-10.91	11.75	0.81	9,45	-11.79	17.20	0.10
Haryana	-0.24	-0.11	1.85	0.54	1.67	-6.25	12,49	0,42	1.91	-6.14	10,45	-0.12
Rajasthan*	-	1.67	1.97	0.97	-	-2.18	4.11	1.65	-	-3.78	2.10	0.68
Central Zone												
Maharashtra	4.56	-4.66	0.63	0.25	4,41	6,49	13.37	5.00	-0.14	11.69	12.65	4.74
Gujarat	-1.81	-1.71	1,41	-0.27	-0.76	6,43	12,20	5,44	1.05	8.14	10.79	5.71
M.P.	9.30	1,43	7.27	4.39	15,47	8.20	0.89	8.20	5.64	6.68	-5.95	3.65
South Zone												
A.P.	-2.97	-0.17	-0.74	-0.17	-4.90	3.07	6.67	4.10	-1.99	3.25	7,46	4.28
Karnataka	-3.64	-1.53	-1.81	-1.53	5.22	0.95	7.28	4.24	9.19	2.51	9.25	5.86
Tamil Nadu	0.60	-2.25	-2,44	-1.07	5.07	2.13	6.63	4.29	4,45	4,48	9.29	5,41

In the south zone too, the TFP growth rate showed a positive trend in A.P., Karnataka and Tamil Nadu.

Comparative analysis of conventional, biotech and organic cotton production systems in India

The study revealed that more than 80 per cent of the 8t cotton growers had positive attitude towards 8t cotton cultivation, more than half of the organic cotton growers had positive attitude towards organic cotton cultivation and less than one third of the conventional cotton growers had favorable attitude towards their practices. The major factors *motivated* 8t cotton growers to adopt the technology were financial motives and quality of output related motives. The factors *viz.,* soil health oriented and environmental motives prompted the organic cotton growers. The analysis on knowledge profile of the growers in three different production systems revealed that the organic cotton growers had high level of knowledge profile than the growers in other two systems. The analysis on adoption profile of the growers in different production system revealed that the organic cotton growers had the high level of adoption followed by the 8t cotton growers and the conventional cotton growers. Poor adoption rate of refugia, unavailability of organic cotton seeds and high production cost were top most threats observed respectively in biotech, organic and conventional production systems.

Gender and labour issues in hybrid cotton seed production sector in India

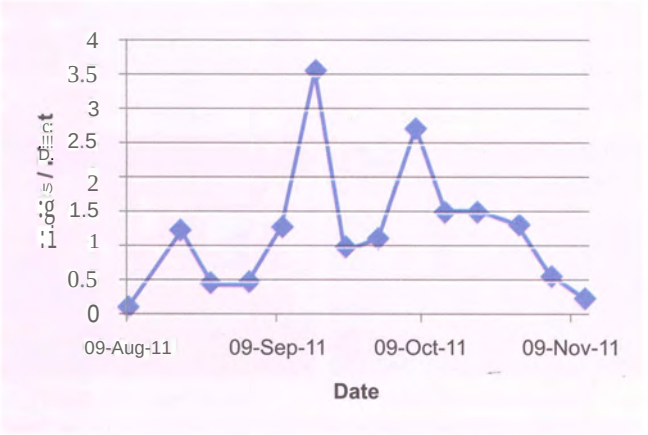
The survey among the labourers working in hybrid seed cotton farms revealed that more than 82% of the labour was spent for crossing works and majority of them were female workers belonging to middle age group and had 25 per capita man days per hectare per season. On an *average,* they earned Rs. 3000-4000 per season through wages. Inward migration behavior for other works within the village was observed among majority of the female workers due to *Government* schemes. Less wages, lack of organizations for collective bargaining, drudgeries and health hazards faced in the agricultural works, lack of specific development schemes for agricultural labourers, lack of supportive farm machineries, lack of training programs especially for agricultural labourers and lack of subsidies were the major problems expressed by the agricultural labourers. Focus groups discussions among cotton seed producers indicated that limited availability of labour, their cost, their less technical know- how and work efficiency were major threats faced by the cotton seed producing industries.

4.18: Seasonal Dynamics of Insect Pests and Diseases

Nagpur

Seasonal dynamics of cotton sucking pests and bollworms

Two major peaks were recorded for mirid *(Campylomma livida)* population, first on 17th Sept.. 2011 (3.56 miridsl plant) and another on 8th October 2011 (2.72 mirids /plant). During the season leafhopper *(Empoasca devastans)* population was above 3.28 leafhopper/ 3 leaves while highest leafhopper population was noticed on 10th September (Fig.11) Thrips *(Thrips* sp.) population was highest in the initial phase of crop growth and thereafter gradually decreased and was negligible after 17 Sept.. 2011. Mealybugs *Phenacoccus solenopsis* and *Nipaecoccus viridis* were recorded in some fields with negligible population during late season of crop. Negligible population of all the three bollworms and *Spodoptera litura* was recorded.



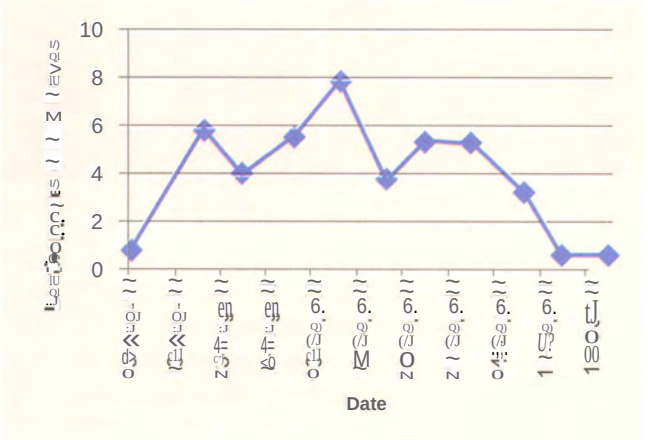


Fig.11 : Mirid and leafhopper population on cotton in Nagpur

MRC-6301 Bt (Mon 531), Fusion Bt (Nath event), Dr Brent BG-II (Mon 15985) and Ajeet-155BG-11 (Mon 15985) hybrids exhibited zero pink bollworm larval population, nil exit holes and zero per cent locule damage throughout the crop growth period as compared to JK Bt (Event I) and the corresponding non Bt hybrids in central India. Larval population was highest

on AKH - 8828 and PA-255 which are non Bt hybrids.

Moth caches of pink bollworm were recorded from 14/07/2011 to 09/02/2012 and the lowest moth catches was on 20/10/2011 with 1.53 moths/trap/week. The incidence of pink bollworm moths was high in the third week of January with 15.53/trap/week.

Incidence of pink bollworm was absent on all the Bt hybrids evaluated at 100 DAS, 115 DAS, 130 DAS, 145 DAS and 160 DAS.

Coimbatore

Population dynamics of mirid bug *(Creontiades biseratense)*

Nymph and adult population of mirid bug *Crenotiades biseratense* (Distant) build up was observed from the second week of December, lowest and highest nymphal population was recorded during 50th std week (0.36 nymphs / plant) and 1st std week (4.17 nymphs/ plant) respectively. Significantly lowest and highest adult population was recorded during 50th standard week (0.14 adults /plant) and 2nd std week (1.39 adults / plant) respectively. The percentage of green boll and square damage were increasing from 1st standard week to the 5th standard week and the percentage of green boll damage and square damage varied from 1.85 to 17.14 % and 2.37 to 18.55 %, respectively. Buildup of coccinellids and spiders were recorded corresponding with the increase in mirid nymph an adult population. Negligible population of spider was recorded.

Population dynamics of mealybugs

No mealybug infestation *(Paracoccus marginatus* and *Phenacoccus solenopsis)* was observed throughout September - February. Population of mealybug was recorded as nil on the weed hosts identified earlier - *Trianthema portulacastrum, Achyranthus aspera, Celosia argentea, Parthenium hysterophorus, Tridax procumbense, Cleome viscose, Euphorbia hirta, Phyllanthus niruri* and *Leucas aspera.*

Occurrence and seasonal dynamics of emerging pests and their predators in Tiruppur district

Mealybug infestation was not observed in any of the villages throughout the season. The mean infestation of mirid bug ranged from 0 to 1.6 per cent and the nymphal population

ranged from 1.3 to 4.5 per 50 squares. The predominant predators were coccinellids and spiders. The former ranged from 7.17 to 25.17 and the latter from 0.33 to 2.83 per 50 plants.

Pest scenario in IRM and non IRM fields at project village

a) Sucking pests *viz.,* aphids, leafhoppers, thrips and whiteflies population were below threshold level and averaged 7.64,2.86,2.24 and 0.31 and 11.20,4.10,3.37 and 0.53/3 leaves in IRM and non IRM fields, respectively. The mirid and mealybug populations were recorded in all the project villages as 1.62 and 2.03 and grade 0 and grade I in IRM and non IRM fields, respectively. IRM fields showed reduction in population of aphids (31.00 %), leafhopper (46.00 %), thrips (43.00%), whiteflies (50.00%) and miridbug (25.00%) when compared to non IRM fields.

b) Bollworms

Incidence of bollworms was nil.

c) Natural enemies

Natural enemies *viz.,* coccinellids, spiders and *Chrysopa* averaged at 0.89,0.84 and 0.17 per plant, respectively in IRM fields, whereas it was 0.61, 0.60 and 0.12 in non participatory fields.

Sirsa

Field dynamics of mealybug revealed that late initiation (October) of infestation of mealybug was observed at 3 locations and severity grade did not reach 4 at any locations. A total of 71 alternate hosts of mealybug have been recorded till date.

Parasitisation of cotton mealybug

Maximum parasitization (%) due to the dominant parasitoid, *A. bambawa/ei* was 83% per cent in 2011, whereas mean parasitization (%) recorded was 14.26 and 5.25 at farmers fields. Data were also recorded from ten new locations at the end of season where mealybug incidence was available. The average incidence (%), severity index and per cent parasitization due to *A. bambawa/ei* reported were 27.53, 1.58 and 24.92, respectively.

Cotton leaf curl disease

Survey on the incidence of CLCuD was carried out in major cotton growing districts of North India (Haryana, Punjab and Rajasthan) in August, 2011 and the incidence was recorded as lowto moderate PDI (5.0-25.0%) in few places likeAbohar and Fazilka regions of Punjab and Hisar of Haryana in an isolated manner, while it was absent in most parts of north zone.

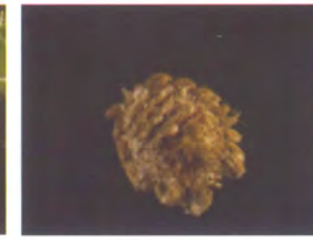
4.19: Biological Diversity of Insect Pests and Pathogens

Nagpur

Biological diversity of mealybug in central India

Diversity of four mealybug species *viz, Phenacoccus so/enopsis, Nipaecoccus viridis, Ferrisia virgata* and one unidentified mealybug species (from Saoner, Nagpur) (Homoptera: Pseudococcidae) was recorded. They were found infesting cotton with Grade- IV infestation in cotton+ pigeonpea-fallow cropping system of central India. However all the mealybug populations were under control..

Ferrisia virgata

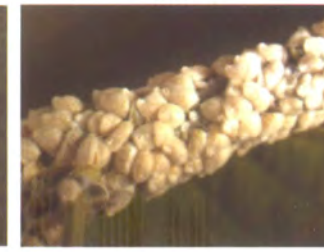


Unidentified mealybug

Other insect biodiversity

Weevil *Tanymecus pronceps* (Faust) (Coleoptera: Curculionidae) was recorded infesting non-Bt cotton during off-season. Mirid bug *Creontiades biseratense* which was mostly predominant in southern cotton growing states was observed in Central India in very small number. Mirid bug *Campy/omma lívida* which is mostly prevalent in central India also showed its presence as usual.. One mealybug species *Coccidohystrix in so/ita* Green and scale insect *Orepanococcus cajani* (Homoptera: Pseudococcidae) have been recorded on pigeonpea, a preferred intercrop crop in cotton.

Tanymecus pronceps



Drepanococcus cajani

Creontiades biseratense

Coccidohystrix insolita

Cropping system based population dynamics for mirid *(C./ivida),* leafhopper *(E. devastans) and* spider in cotton + pigeon pea - fallow cropping system

Highest population of mirid *(C. lívida)* was recorded in unprotected condition followed by cotton field adjacent to soybean. Cropping systems *viz.,* cotton field along roadside, cotton field adjacent to water canal, cotton field adjacent to cotton, cotton field adjacent to fallow land indicated no distinct trend with reference to mirid infestation. Leafhopper nymphs were highest in unprotected conditions followed by cotton field adjacent to soybean. Comparatively higher sucking pest population was recorded in cotton field adjacent to soybean. Identical numbers of nymphs were recorded in cotton field adjacent to water canal, cotton field adjacent to cotton and cotton field adjacent to fallow land. Least spider population

was recorded in cotton field adjacent to fallow land followed by cotton field adjacent to soybean and were statistically different from each other.. Spider populations were same in three cropping systems *viz.,* cotton field along roadside, cotton field adjacent to water canal, cotton field adjacent to cotton. It has been seen from the data that overall pest and spider population was higher in unprotected condition than protected.

Genetic diversity ofthrips

Thrips were collected from north India (Sriganganagar of Rajasthan, Bhatinda, Faridkot and Mansa of Punjab and Hisar, Fatehabad and Sirsa of Haryana), central India (Nagpur, Akola, and Buldhana of Maharashtra) and south India (Adilabad of Andhra Pradesh) from cotton. DNA was isolated from individual insect using a refined protocol for extraction of DNA from museum specimens.

***Thrips* species**

The sequence analysis of cytochrome oxidase I (CO *I)* of *Thrips sp.* from different locations revealed that a mixed population of thrips occurs on cotton across India comprising mainly of three different species *viz. Thrips palmi, Scirtothrips dorsalis* and *Scirtothrips oligocheatus.* The tree derived from the bootstrap analysis produced two main clusters. Clade A was represented by genus *Thrips* and clade B was represented by genera *Scirtothrips* and Thrips. Cluster A was strictly represented by *Thrips palmi* species. Some of the samples that showed identities with *Thrips palmi* were also included in Cluster B. Cluster B was divided into two main sub-clusters C and D, where sub-cluster D was represented by only *Thrips palmi* and cluster C was represented by the genus *Scirtothrips.* Again sub-cluster C was divided into two sub-clusters C1 and C2 representing *Scirtothrips dorsalis* and Scirtothrips oligocheatus respectively. *Thrips palmi* is predominant in north India especially Haryana during the early vegetative stage while *Scirtothrips dorsalis* is dominant in Maharashtra during early reproductive stage.

Genetic diversity of leafhoppers

Effect of nucleotide changes on the COI amino acid sequence of leafhopper was examined. Translation of COI sequences of leafhopper from different regions of India showed little variation. The changes that occurred in the protein sequence were not significant and did not result in changes in protein structure. Graphical analysis of the representative protein sequence showed that the changed amino acids were mainly located in the a-helix region of the protein. a-helix region of the protein is membrane integrated and is not involved in the reaction of the electron transport chain. Sequence analysis revealed one conserved domain of 28 amino acids from amino acid numbers 70 to 97 that were located mainly outside the a-helix region.

Identification and characterization of viral diseases of cotton in India

Very low incidence of cotton leaf roll dwarf virus, CLRDV was observed in Nagpur, Akola and Warangal.. Artificial methods of transmission of CLRDV from cotton to chickpea was successful but transmission from chickpea to cotton could not be established. Sequences of the PCR amplicon (Fig. 12) for CLRDV and Chickpea stunt disease associated virus, ChPSDaV showed more than 95% similarity indicating the possibility of their same origin.

No genetic differences were found between upward and downward curling of cotton leaf curl virus, CLCuV.. Primers designed on the basis of consensus sequences for amplifications of DNA-A, B and coat protein gene could be used for molecular diagnostics of CLCuV. Late incidence of tobacco streak virus, TSV was observed in cotton growing districts of Andhra Pradesh except Adilabad. The incidence was highest in Guntur district (3-25%) followed by Warangal (0.1 to 7%) and Karimnagar (up to 5%).

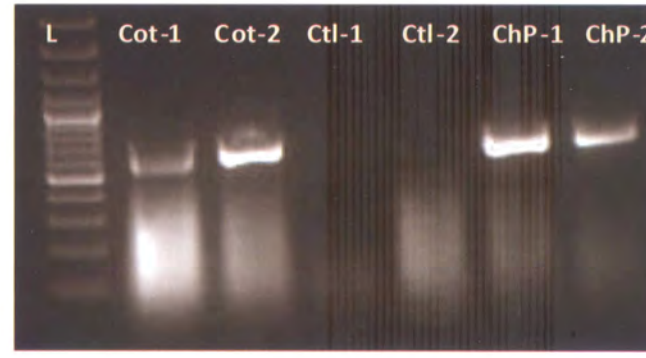
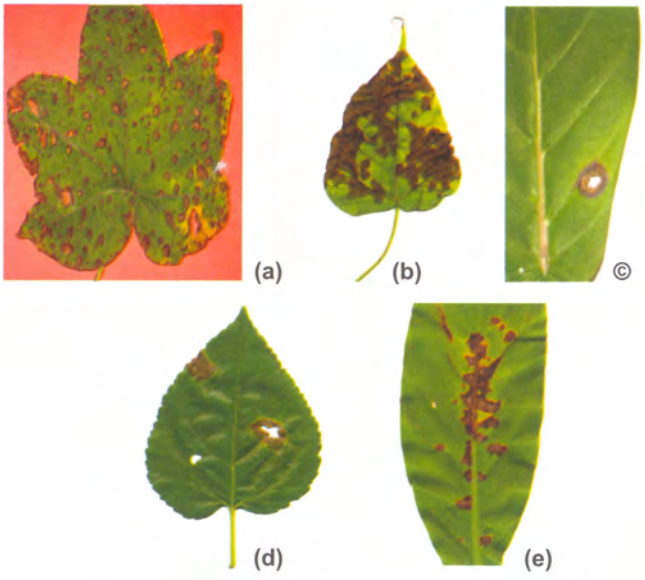


Fig. 12: Detection of CLRDV and and ChPSDaV from infected cotton (Cot-1& Cot-2) and infected chickpea (ChP-1 & ChP-2) respectively. Ctl-1 is uninfected cotton and Ctl-2 is uninfected chickpea.

Genetic diversity of *Alternaria*

Differences among three species of *Alternaria* infecting cotton were recorded using spore morphology and molecular markers. *Myrothecium* leaf spot is emerging as one of the major emerging diseases alone or in combination with *Alternaria* leaf spot.. The incidence of grey mildew was observed in the AICCIP trial of Bhawanipatna of Odisha. Higher incidence of *Alternaria* leaf spot in combination with *Myrothecium* leaf spot in Bt cotton was observed in the farmers' field of Guntur district of Andhra Pradesh. Five collateral hosts of *Myrothecium rorridum* have been identified. Bacterial boll rot is also one of the emerging diseases in the farmers' field.



Myrothecium leaf spot on (a) Cotton, (b) Peepal, *(c)* Calitropis, (d) Mulberry and (e) Cana leaf.

Determination of emerging pests and natural enemies associated with Bt hybrids

Twelve under-release Bt hybrids belonging to 5 seed companies with 4 events were evaluated. Out of these, GK-228 BGII and PCH-66 were tolerant to aphids; PCH-44 and KDCHH-553 BGII to leafhoppers and PCH-55 & PCH-22 to whiteflies. No significant difference was observed with respect to thrips, mirid and spider population on Bt-hybrids. Highest seed cotton yield (917 kg ha^{-1}) was observed in PCH-44Bt under rainfed conditions.

Developmental studies of *P. so/enopsis* on alternate hosts

Developmental studies of *P so/enopsis* was carried out at constant temperature of 27°C and RH 60% under laboratory conditions on four different alternate hosts *viz.* okra *(Abelmoschus esculentus),* congress grass *(Parthenium hysterophorus),* hibiscus *(Hibiscus rosasinensis),* tomato(*Lycopersicon esculentum).* Highest fecundity was observed on congress grass (268 eggs) followed by hibiscus (239 eggs), okra (200 eggs) and tomato (186 eggs).

Intensity of pink bollworm infestation in India

Incidence of pink bollworm on BG, BG-II and non Bt cotton fields was monitored across India. In North India, 9 districts from three states (Hisar, Fatehabad and Sirsa of Haryana, Mansa, Abohar, Bathinda and Faridkot of Punjab, Sriganganagar and Hanumangarh of Rajasthan), 23 districts of Central India namely Wardha, Yavatmal, Washim, Hingoli, Nanded, Parbhani, Aurangabad, Buldana, Akola, Amravati, Nandurbar, Dhule and Jalgaon districts of Maharashtra; Surat, Bharuch, Vadaodara, Anand, Ahmedabad, Bhavnagar, Amrelli, Junagadh, Rajkot and Surendranagar districts of Gujarat and 7 districts of Andhra Pradesh namely Guntur, Nandyal Krishna, Khammam, Warangal, Karimnagar and Adilabad were monitored.

The intensity of pink bollworm infestation on non Bt cotton (Table 7) was maximum in Karnataka (83.64%, Dharwad), Rahuri, Nanded and Akola in Maharashtra recorded pink bollworm incidence on non Bt cotton while there was no incidence of pink bollworm on Bt cotton in these district.. Non Bt cotton was not found in Hingoli at the time of collection. Larval intensity on extended crop of BG from Hingoli (4.70%), Nandurbar (26.14%), Dhule (19.80%) and Jalgaon (18.18%) was recorded. The corresponding larval intensity on non Bt was 0.45% *(Desi* cotton) 6.92% *(Hirsutum)* and 25.89% *(Desi* cotton) from Nandurbar, Dhule and Jalgaon, respectively. Gujarat (3.97% specifically in Surat, Bharuch, Vadodara and Bhavnagar) recorded minimal incidence of peak bollworm. In BG-II the per cent larval recovery was nil from all the districts monitored both at 140 and 160 DAS.

Table 7 : Intensity of Pink bollworm infestation in different state of India

Sr. No	State	Larval incidence % in green bolls		
		NBt	BGI	BG II
1	Gujarat	23.22	3.97	0.00
2	Maharashtra	17.30	20.58	0.00
3	Andhra Pradesh	10.96	0.00	0.00
4	Tamil Nadu	13.66	0.00	0.00
5	Karnataka	83.64	0.00	0.00
6	Punjab	13.70	0.00	0.00
7	Rajasthan	16.73	0.00	0.00
8	Haryana	10.71	0.00	0.00

Coimbatore

Infestation of *P. gossypiella* recorded from different centres of south zone

Recovery of *P gossypiella* larvae was significantly higher in NBt hybrids than Bt hybrids collected from different centres from Tamil nadu, Karnataka and Andhra Pradesh. Significantly, higher number of exit holes were recorded from Dharwad and Coimbatore followed by Haveri and Srivilliputhur. Mean recovery of *P gossypiella* on NBt hybrids was maximum from Dharwad (77.21 %) followed by Coimbatore (25.26%), Srivilliputhur (18.00%) and Nandyal (12.33%).

Isolation of cotton foliar pathogens

Isolations from Bunny Bt - BG yielded cotton leaf spot pathogen, *Alternaria* sp., whereas isolations from LRA 5166 yielded *Alternaria* spp., *Drechslera* spp., *Fusarium* sp., *Colletotrichum* sp. and *Curvularia* sp. At present there are 10 isolates of *Alternaria* spp., four isolates of *Drechslera* spp., three isolates of *Fusarium* sp., two isolates of *Colletotrichum* sp., five isolates of *Curvularia* sp., and one isolate of *Rhizoctonia* in our culture collection.

Sirsa

A single species *i.e, Phenacoccus solenopsis* Tinsley was observed on cotton in north India. At four locations *Drosichiella* spp. of mealybug was recorded, that did not cause significant economic damage.

Male and Female of *Drosichiella* sp.

Cotton plant infested with *Drosichiella* sp.

Ber tree infested with *Drosichiella* sp.

Rodolia fumida (Mulsant) (Coleoptera: Coccinellidae) was a predator observed on *Drosichiella* spp.

4.20 : Isolation and Identification of New Genes and Gene Sources for Pest Management

Nagpur

Lectins from novel sources

Using bioinformatics three full length genes encoding man nose-specific lectins have been identified in the *Trichoderma virensgenome.*

RNAi for *Helicoverpa* management

For generating ds RNA, using gene sequences of same and related species, primers were designed and amplified to obtain fragments of the desired gene of interest in *Helicoverpa armigera.* Amplicons of expected sizes were obtained for Juvenile Hormone Esterase, Trehalose Phosphate Synthase and Helicostatin using cDNAand genomic DNAof *Helicoverpa* as template. *In vitro* transcription for generating dsRNA of Chitin synthase A, Juvenile Hormone Esterase, Trehalose Phosphate Synthase, and Helicostatin was found effective in terms of desired yield. The sequences showed homology to the target sequences of the organism from which primers were designed. Surface coating bioassay method was standardized with dsRNA that demonstrated an effect on two day old larvae. Chitin synthase A and Trehalose Phosphate Synthase were found to be promising in terms of their mortality, and growth regulating effects on *Helicoverpa.*

Cloning and characterisation of potent toxin gene from heat tolerant isolate developed of *Heterorhabditis indica,* an entomopathogenic nematode

Bacterial symbionts associated with heat tolerant entomopathogenic nematodes (EPN) were isolated and characterized. Apart from entomopathogenic nematodes a number of bacterial flora were found associated with EPN. For molecular characterization, 16sRNA was amplified and sequenced and bacterial flora belonged to *Photorhabdus, Paenibacillus* and species of *Xenorhabdus* as *Xpoinarii, Xindica* and species of *Bacillus* as *B.cereus,* B. *subtilis, B.nealsonii* etc.

Primers were designed for toxin genes *viz.* tcaA, tcaB, tcaC, tcaZ, tccA, tccB, tccC, tccZ, tcdA, tcdA2, tcdB, tcdAB, txp40, W14tccA, , W14tccB, W14tccC, W14tccZ, W14tcbA, Pae tca, Pae TcaB2, Pae tcaC, Pae tccC and Pae cry. Genomic DNA of all the bacteria were extracted and used for amplification reactions with these primer sets.

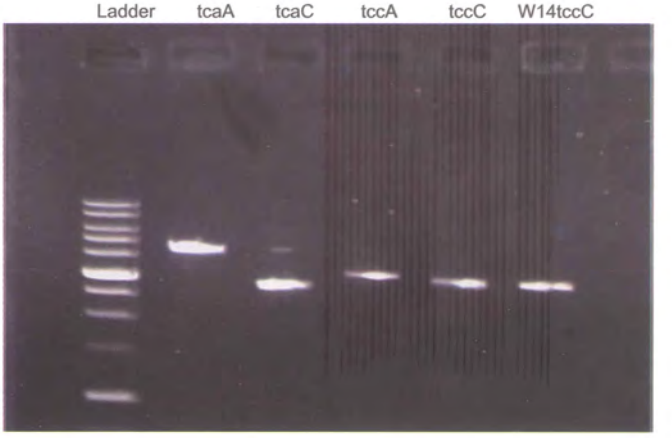


Fig. 13 : Amplification of toxin genes from bacterial symbionts of EPN

From *Photorhabdus* tcaA (4.5kb), tcaC (2.5kb), tccA (3kb), tccC (around 3kb) and W14tccC (around 3kb) could be amplified using long range Taq from Promega (Fig. 13). tcaA, tcaC, tccA were amplified from *Xenorhabdus indica* and X *poinarii* isolates. These were cloned in pGEM- T vector and sequenced. Sequencing oftccA, tccC and W14tccC has been carried out and shows 95-97% similarity to *Photorhabdus* genes. Tcc Genes from *Paenibacillus sp.* is significant as this appears to be first report of a *Paenibacillus* species, strain, or protein having toxicity to lepidopterans.

4.21: Development of New Methods, Tools and Protocols

Nagpur

Validation of sampling method and sample size for field population of mirid *Campylomma livida*

Validation of sampling methodology with respect to visual sampling method and sample size for mirid bug *Campylomma livida* was done on Jai Bt BG II. The results showed variation in nymph and adult counts in different plant portions; however for ease in observation, top 1/3,dportion was found to be ideal.. A sample size of 15 plants/ acre was optimum. Sampling from top 1/3,d plant canopy with 15 plants *lacre* was found to be optimum for assessing field population of C. *livida.*

Standardisation of a robust replicable bioassay protocol for evaluating the direct and indirect toxicity of lectins to *Chrysoperla sps* and *Mallada boniensis*

Direct toxicity was measured by providing LC_{10}, LC_{50}, LC_{75} and LC_{90} doses of each of the three lectins (CEA, AMTL and Banana lectin) that were most effective against sucking pests. Lectin concentration (100 lll) was dispensed in PCR tubes with a cotton wick passing through its lid and placed in separate containers into which neonate or 4 day *Chrysoperla* grubs were released. Fresh lectins were provided each day. The bioassays were continued up to pupation. Aslight modification in the feeding device was made with the adults.

Bioassays were standardized to quantify the indirect toxicity of lectins by exposing aphids across different time periods and concentrations to lectin laced diet and subsequently feeding *Chrysoperla* grubs with both live and dead aphids, separately. Protocols to identify and quantify the lectin in the prey as well as predator through lectin ELISA were standardized.

Coimbatore

Cotton seed based cost effective artificial diet was standardized for continuous rearing of pink bollworm *Pectinophora gossypiella.* The basic ingredients are cotton seed flour (processed) and chick pea flour with carbohydrate, protein, fat sources, multi vitamin, antimicrobial agents and agar as thickening agent are used as other ingredients. Micro centrifuge tubes were used as rearing containers. Individual neonate larvae were released on each piece of the diet inside the micro centrifuge tube and the lids were closed tightly. This prevented larval escape thus retaining them inside the tubes and also prevented diet dehydration. The per cent recovery of the insect reared on diet was recorded as 95.56 per cent.. Egg hatchability, adult emergence are 100 per cent and pupal malformation was nil. Eggs, larval and pupal periods were recorded as 4.8 ± 0.632, 25.10 ± 0.994 and 7.9 ± 0.88 days, respectively. Larval and pupal weight were recorded as 21.40 mg ± 3.63, 18.00 mg ± 2.73, respectively.

4.22: Host-Plant Resistance to Insect Pests and Diseases

Nagpur

RNAi mediated crop protection against root-knot nematode

Root-knot nematode genes especially genes that encode esophageal gland proteins were taken up for their amenability to RNAi.. Based on sequences of esophageal parasitism genes in data bases, primers were synthesized for ten more parasitism genes. Evaluation of dsRNA for parasitism genes against root-knot juveniles and reniform preadults was carried out *in-vitro.*

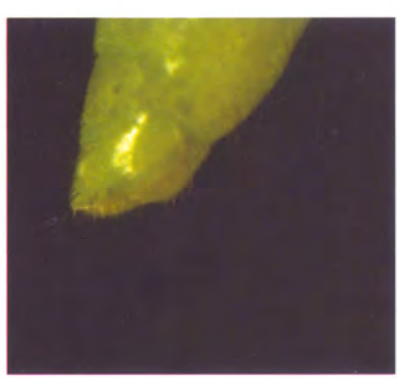
dsRNA for parasitism genes was synthesized using Ambion megascript kit. dsRNA for genes including MjTis11, ADF 1-4 were evaluated for penetration and reproduction of root-knot and reniform nematode. Out of these MjTis11 reduced penetration of rootknot nematode by 58% while the effect on reniform nematode penetration was significantly less at 28%. However, cessation of nematode reproduction was not recorded with these genes, indicating the need for screening of other parasitism genes for use in RNAi for nematode management. .

Coimbatore

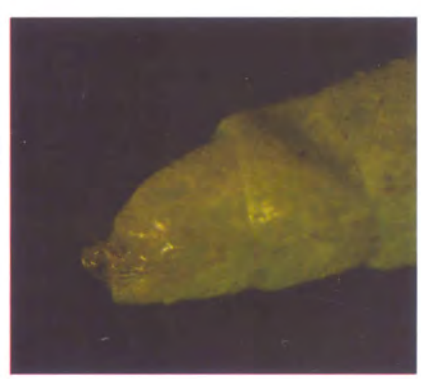
Monitoring for development of resistance against Bt hybrids in *Pecfinophora gossypiella* during different growth period ofthe crop

Bt hybrids namely, RCH 2 Bt, RCH 20 Bt and RCH 2 NBt were monitored under field conditions for the development resistance if any against *P gossypiella.* Number of exit holes was maximum in RCH 2 NBt followed by RCH 20 Bt. Damaged locules/5bolls were significantly maximum in RCH 2 NBt hybrid (0.63/5 bolls). The overall seasonal mean of percentage of locules damage was higher in RCH 2 NBt

Rearing of sucking pests on artificial diet



Female *Chrysoperla*



Male *Chrysoperla*

Stages of Pink bollworm

(73.12%), minimum in RCH 2 Bt (1.12%) and RCH 20 Bt (12.58%). Mines on the epicarp were minimum in Bt as compared to NBt. No significant difference was recorded in the number of warts observed in the epicarp of the bolls of different Bt and NBt hybrids. Number of surviving larvae recorded on NBt hybrid (RCH 2) was maximum as compared to the larvae present in the RCH 2 and RCH 20 Bt hybrids. Mean number of dead larvae of 0.07, 0.025 and 0.04 were recorded in RCH 2, RCH 20 and RCH 2 NBt hybrids, respectively.

Insecticide resistance monitoring against sucking **pests**

Leafhoppers *(Amrasca devastans* Oist.) were assessed for their resistance levels to insecticides such as Imidacloprid (Confidor & Victor),Thiamethoxam (Actara), Acephate (Asataf) and Monocrotophos through leaf dip bioassay. Among the insecticides tested Victor registered the minimum LD_{50}value (0.0035 milL) followed by Confidor (0.0050 milL), Monocrotophos (0.0054 milL), Thiomethoxam (0.0130 milL) andAcephate (0.0184 milL).

Monitoring for resistance against Cry toxins

Bioassay with *cry2Ab* against *P gossypiella* from Oharwad recorded $LO_{50}$and LO_{90}values as 0.002 ppm and 0.087 ppm respectively and Coimbatore population recorded LO_{50} and LO_{90} values of 0.0623 ppm and 0.095 ppm, respectively. Bioassay with *cry1C* indicated that the population collected from Oharwad recorded $LO_{50}$and LO_{90}values of 0.0312 ppm and 0.507 ppm respectively and Coimbatore population recorded $LO_{50}$and LO_{90}values of 0.0001 ppm and 0.630 ppm, respectively.

Sirsa

Determining cultivar association with emerging pests

A total of 31 Bt cotton cultivars were grown to study their association with emerging and key pests. No mealybug incidence was observed in any of the hybrids. The mean incidence of leafhopper *13* leaves on the basis of 7 fortnightly observations varied between 2.79 (MRC-6025 Bt) to 5.26 (SWCH-4713 BG-II). The maximum population of leafhopper *(12.60/3* leaves) was recorded in hybrid NCS-905 Btduring 32 SW of the season and minimum population (0.00) was recorded in MRC-6025 Bt during 36 standard week of the season. The mean incidence of whitefly *I* 3 leaves on the basis of 7 fortnightly observations varied between 4.26 whiteflyl 3 leaves to 6.39 whiteflyl 3 leaves. The maximum population on the basis of 7 fortnightly observation was recorded on RCH-569 BG-II (6.39 whiteflyl 3 leaves), Bioseed 6488 BG-II (6.13 whiteflyl 3 leaves) and VICH-309 BG-II (6.11 whiteflyl 3 leaves) where as the lowest population was recorded in case of SWCH-4713 BG-II (4.26 whiteflyl 3 leaves) followed by SP-7007 Bt (4.73 whiteflyl 3 leaves). The peak whitefly population was recorded during the 42 Sw.. The mean thrips population *I* 3 leaves based on 7 observations recorded ranged between 7.39 (MRC-6304 Bt) to 15.01 (Shakti 9 Bt).

Minimum CLCuO incidence (0.84%) was recorded in VICH309BG-11 and maximum (10.53%)was in RCH134 BG-II.. In case of root rot the minimum (0.00%) and maximum (29.50%) disease incidence was recorded in RCH134 BG-II and RCH605 BG-II, respectively.

Resistance monitoring in sucking pests to commonly used insecticides

In case of the leafhopper population collected from Kot Samir (Bathinda) under sprayed condition, the lowest LO_{50} value (0.000003 ppm) was recorded for BYI 02960 and highest LO_{50} value (0.0058 ppm) was obtained in dimethoate. RR ranged from 1933.33 (dimethoate) to 33.00 (victor) fold when compared with the highly susceptible population.

4.23: Identification of Germplasm Sources of Resistance to Insect Pests and Diseases

Sirsa

Out of 3954 germplasm accessions evaluated under north zone, 21591ines were found free from CLCuO.

4.24: Biological Control

Nagpur

Parasitoid diversity

Six new parasitoids of *P solenopsis* were recorded out of which two parasitoids *viz., Prochiloncurus albifiniculus* and *Prochiloncurus pulchellus* showed parasitisation up to 4 and 2 % respectively. One parasitoid *Aprostocetus* sp having distinct red eye have been recorded from Vidarbha and Marathwada region while *Promuscidea unifasciativentris* recorded 1-35% parasitization. Two parasitoids have been recorded from mealybug population collected from Gujarat.. Cumulative 16 parasitoids and 9 predators have been recorded on mealybugs infesting cotton in three cotton growing zones of India.

A new *Trichoderma* strain naturally parasitizing a pathogenic *Ganoderma basidiocarp* has been isolated and purified.

Development, validation, utilization and/or commercialization of biopesticides and bioinoculants

DNA finger printing of bio-pesticides

DNA finger printing of native bio-pesticides shortlisted as effective against cotton insect pests was done for registration with Central Insecticidal Board (CIB). Molecular characterization of bacterial and fungal antagonists was done by amplification of 16sRNA and 18sRNA region respectively. Amplicon size for 16sRNA amplification of bacterial antagonists identified as belonging to *Bacillus cereus,* B. *nea/sonii,* B. *subti/is, B.nea/sonii, Xenorhabdus indica,* X. *poinarii, Brevibacterium* and *Photorhabdus spp.* was about 1.5Kb (Fig. 14). Theamplicons were cloned in pGEMTvector and sequenced. The sequences have been submitted to NCBI.

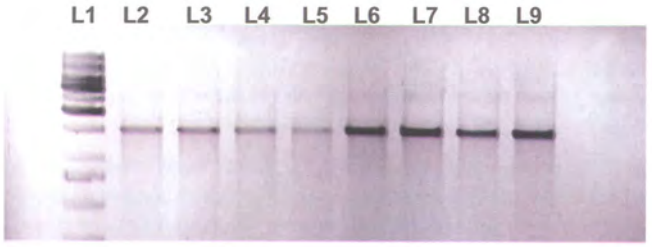


Fig. 14: Amplification of 16sRNA gene of bacterial antagonists. Lane 1, DNA ladder, Lane 2-9- *Bacillus cereus* CICR X1, *B. cereus* CICR X2, *B. nealsoni* CICR PKV, *Xenorhabdus poinarii* CICR WR, *X.indica* CICR WG, *Brevibacterium epidermidis* CICR G1, *X.indica* CICR WGR1

Amplicon size for fungal antagonists as *Fusarium incarnatum (Fusarium pallidoroseum), Metarrhizium anisopliae* (Ma4), *Lecanicillium lecanii* (VL-5 & Coimbatore) isolates ranged between 552-569 bp. The sequences *(F incarnatum* Ace. No. JN206645, M. *anisopliae* Ma4 Ace. No. JN206646, *L. lecanii* VL-5 Ace. No. JN206647 & *L. lecanii* Coimbatore Ace. No. JN982329) have been deposited in NCBI gene bank.

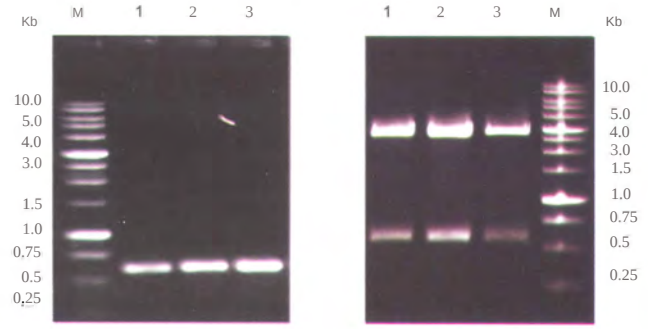


Fig. 15: Cloning and sequencing of rRNA genes. Lane 1, *Lecanicillium lecanii,* 2, *Metarrhizium anisopliae; Fusarium pallidoroseum*

Biochemical and molecular characterization of bacterial isolates

Biochemical and molecular characterization was carried out for six isolates (GV1 , GV2, GV4, GV5, BB and BW of bacteria *Xenorhabdus* and *Photorhabdus* symbiotically associated with Entomopathogenic nematodes and which had been found effective against sucking pests as mealy bug. The biochemical parameters taken up were Colony Morphology on Nutrient Agar, Gram Stain, Pigmentation, Levan production, Methyl Red, Voges-Proskauer Test, starch hydrolysis, oxygen requirement, H2S production, indole production, nitrate reduction, Urease test, ADH test, citrate, catalase, gelatinase, motility, tyrosinase, Galactosidase. Carbohydrate fermentation studies were carried out for 21 carbohydrates.

Molecular characterization of these bacterial isolates was done by amplification of 16sRNA.. Amplicon of 1.5 kb was cloned in pGE~T vector and sequenced. Using OPA primers delineation of similarity and dissimilarity of bacterial was carried out and dendrogram made. Further analysis is underway. Restriction enzyme profiling of 16sRNA amplicon of bacterial isolates was done with five restriction enzymes MSP1 ,Alu1, Dde1, Haelll and Hinf1.

peR Multiplex for detection of cotton pathogens

Multiplex PCR protocol was standardized for detection of cotton pathogens. PCR conditions and primers were standardized to achieve amplification of all cotton pathogens in one PCR reaction. This technique can be used for quick detection and identification of cotton pathogens in soil as well as plantsample (Fig.16).

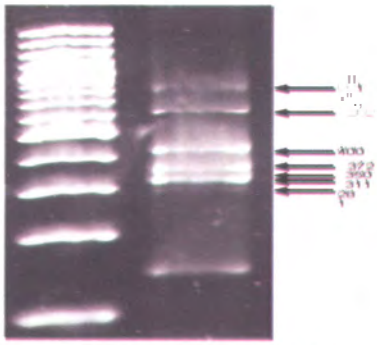


Fig. 16 : Multiplex PCR for detection of cotton pathogens

Development of nanoparticles based biocontrol formulation for the management of major cotton pests and diseases

Silver nanoparticles have been synthesized through 0.01 and 0.001 M silver nitrate solution using boiled fresh cotton leaf extract as reducing agent in green method.

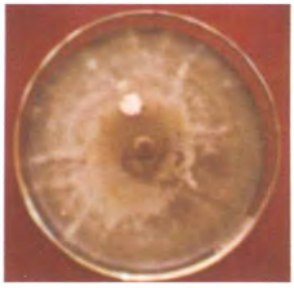
Coimbatore

Testing the compatibility of efficient bioagents for mutual antagonism

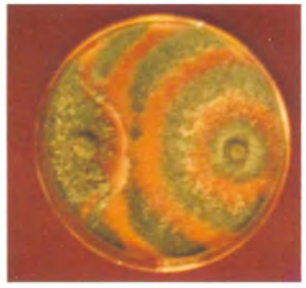
On dual culturing of bioagents isolated from soils of experimental field, it was observed that there was no mutual antagonism between the two bioagents *viz.*, isolates of *Trichoderma* spp. and *Pseudomonas.*

Assessing the antagonistic property of bioagents against leaf spot pathogen, *Alternaria* sp.

Dual culture testing of bioagents, for their antagonistic activity, against cotton foliar pathogen, *Alternaria* spp. was done with all available bioagents. Two isolates of *Trichoderma* spp. and an isolate of *Pseudomonas* (from soil samples) were found effective against *Alternaria* spp.



Alternaria sp.



Alternaria sp. X *Trichoderma* Sp.

Evaluation of solid substrates for mass multiplication of bioagents

Grains of sorghum and finger millet were used as solid substrates for growing isolates of *Trichoderma, Drechs/era* and *Alternaria;* finger millet supported more spore growth in all the isolates.

Molecular characterization of native entomopathogenic fungi from mealybug

Molecular characterization of five native entomopathogenic fungi isolated from mealybug from 2009 to 2011 were carried out and submitted to Gene Bank. The fungi identified were *L. attenuatum* (Gene Bank Accession No.JQ327150), M. *anisop/iae-ARSEF-9613* (Gene Bank Accession No. JQ062986), *M.anisop/iae-ARSEF-9612(Gene* Bank Accession No. JN712743), *L. araneico/a* (Gene Bank Accession No. JN255572) and *L. fusisporum* (Gene Bank Accession No. JF 427909).

Mass multiplication of a native entomopathogeic fungus, *L./ecanii*

A total of six nitrogen sources (Peptone, Ammonium Nitrate, Sodium Nitrate, Beef extract, Urea and Thio Urea) were tested for the mass multiplication of *L. /ecanii.* Among them Ammonium Nitrate and Thio Urea supported maximum growth and sporulation.

Standardization of temperature optima for multiplication of native entomopathogenic fungi

Effect of temperature on growth of six native entomopathogenic fungi *(L. /ecanii, L. aphanoc/adii,* M. *anisop/iae* ARSEF - 9612, M. *anisop/iae* ARSEF-9613 and V */ecanii* , were studied at wide range of temperature from 10 to 40°C. Though all fungi were able to grow at a wide range of temperature from 15-30^{0}C 20-30^{0}C was found to be optimum for growth and sporulation. Two isolates M. *anisopliae* (ARSEF 9612 and 9613) were able to grow well at 35°C.

Standardisation of methods to increase the virulence of *L. /ecanii*

Media supplemented with insect extract was found to increase the growth, sporulation and virulence of *L. /ecanii.* High activity of pathogenesis related enzymes was also observed.

Development of formulation of promising entomopathogenic fungi and testing

Talc and oil based formulations of *L. /ecanii* and M. *anisopliae* (ARSEF-9612) were developed and tested for the efficacy under pot culture condition. Among two formulations tested, oil based formulation of *L. /ecanii* recorded significantly higher mortality of aphids under pot culture condition.

Development of talc based formulation of a native entomopathogenic fungus, *L./ecanii*

Three talc based formulations of *L./ecaniwere* developed and stored at room temperature and refrigerator. Spore viability and virulence were tested for six months. *L. /ecanii* multiplied in SDAY Broth and formulated in talc supported maximum spore viability of 70 per cent at the end of six months storage under refrigerated condition. The same result was recorded for two years.

Production of insecticidal toxin by *Xenorhabdus stockiae,* a bacterial symbiont of a native entomopathogenic nematode, *Steinernema siamkayai* was proved. Mortality of *H. armigera* due to different aliquots ranged from 66 to 100 per cent 24 h after inoculation.

Pathogenicity of bacterial symbiont of native entomopathogenic nematode

Pathogenicity of X. *stockiae* to *Aphis gossypii* Grover was studied under lab condition. The bacterial cells and their cell free supernatant of both primary and secondary phase of X. *stockiae* were tested against *A. gossypii.* Cell suspension and cell free supernatant of X. *stockiae* were found to be highly pathogenic to *A. gossypii* when compared to control.. The results revealed primary phase of X. *stockiae* was found to be more toxic than secondary phase and cell free supernatant of both phases were more virulent than bacterial cells alone. Spraying of primary and secondary phases of bacteria alone recorded a maximum of 87 and 82% mortality whereas cell free supernatant of both primary and secondary phase recorded 100 and 99% mortality at 48 hours after treatment..

Sirsa

Among various insecticides and biopesticides, imidacloprid (57.17 %) resulted in maximum reduction of leafhopper population and VL-5 resulted in maximum (51.06%) reduction of whitefly population. Thrips population was effectively reduced by biopesticide, Pest guard L 50EC (56.97%). The biopesticides and entomopathogens were found safer to generalist predators.

Entomopathogens for mealybug management

Based on a three year study of off-season survey (2007-08 to 2009-10) of mealy bug cadaver collection in hot spots of north zone followed by isolation of fungi, their identification and proving of Koch's postulates, *Fusarium pal/idoroseum* was identified as an entomopathogen of mealybug *(Phenococus so/enopsis).* The efficacy of this entomopathogen was then established against mealybug under *in-vitro* and field conditions (Talc based preparation@ 1-2%) at Sirsa and other AICCIP centres i.e. Faridkot, Coimbatore and Rahuri. During 2011-12, there was increased mortality of mealybug *P so/enopsis* with increased concentration of *F pallidoroseum* in first spray whereas it remained at par in case of second spray. Maximum mortality of 88.1 % was recorded after two sprays of entomopathogen @ 2% talc based preparation.

The effect of *F pal/idoroseum* was also studied on other sucking pests and beneficial insects and it was effective against jassids (59.3% mortality) and white fly (34.6% mortality). It did not cause any harmful effect on beneficial insects. Colony forming units (CFUs) of *Fusarium pallidoro-*

seum were observed above required threshold after 9th month of storage under room temperature.

4.25: Integrated Pest Management

Nagpur

Evaluation and validation of IPM/IRM strategies for Bt-cotton against sucking pest complex

An experiment was carried out on development and validation of IPM/IRM strategies against sucking pests. Results indicated that significant higher population of aphid, whiteflies and mirid was recorded in IPM as compared to RPP over the season. Whereas, no significant difference in population of leafhoppers and thrips was observed. Spider population was significantly higher in IPM while coccinelids were at par. Statistically there was no difference in yield.

Evaluation ofecofriendly biopesticides

Evaluation of Pest Guard L, Pest Guard J and Pest Guard M in multi location trials

(carried out in network mode with CICR as Lead centre)

North India: Sirsa, Faridkot, Sriganganagar, Hisar

Pest guard J 50 EC, Pest guard L 50 EC, *Fusarium pallidoroseum,* VL-5, MA-4, *neem* oil + Nirma powder, Buprofezin, *Beauveria bassiana,* Imidacloprid, Cactus extract and control with water. The latter two were at Sirsa alone while the rest were evaluated at 4 centres of north India on RCH 134 BGII/Mist.. The total number of sprays ranged from 1-4 and the trial was replicated thrice. As the incidence of sucking pests was noticed, 4 applications of treatments were repeated at an interval of fifteen days at Sirsa. Among various treatments for leafhopper, the differences in the reduction of leafhopper populations between treatments were non-significant. . Maximum reduction in whitefly population was due to VL-5 (51.06%) followed by Pest Guard L and the reduction was statistically superior over other treatments.

Maximum reduction (%) in thrips population was reported in biopesticides Pest Guard L 50 EC and Pest Guard J 50 EC with 56.97 and 56.36 respectively and was statistically superior over other treatments. The lowest per cent population reduction was observed in MA-4 (31.32%).

The population of natural enemies was also numerically affected by different insecticides, bio-pesticide and entomo-pathogens. However treatment differences were non-significant.. Highest yield was obtained in Imidacloprid treatment (32.25 q/ha). Yields between treatments when compared were statistically insignificant. .

At Sriganganagar, maximum reduction of leafhoppers was brought about by Imidacloprid and Pest Guard series. Maximum reduction in whitefly population was observed with Pest Guard series and *F pallidoroseum.* Pest Guard series and Buprofezin were most effective against thrips. Yields were highest with Pest Guard Land *neem* oil.

At Hisar leafhoppers were reduced effectively by Pest Guard O that was on par with Buprofezin followed by *Fusarium pallidoroseum.* Buprofezin was on par with Pest Guard O against whiteflies and thrips.

At Faridkot, based on the pre and post-count data it was concluded that Pest guard O 50 EC, Pest guard L 50 EC and *neem* oil + Nirma powder proved statistically superior against whitefly and jassid as compared to the control however, their efficacy was significantly low as compared to the standard control Buprofezin and Imidacloprid. The biopesticides *Fusarium pallidoroseum, Verticillium /ecani,* and *Beauveria bassiana* proved to be ineffective and were at par with control.. The predator population was at par among all the treatments, however slightly low population was recorded in the Imidacloprid and Buprofezin after the 1st spray. In terms of the yield on whole plot basis the maximum yield was recorded in imidacloprid (7.2 kg/plot (44.44 q/ha)) and this was statistically at par with all the other biopesticides except *Verticillium /ecani,* and *Beauveria bassiana.*

South India: Guntur

Bio-agents like *Verticillium lecani@* 2500 g/ha and 5000 g/ha, *Metarrhizium anisopliae* @ 2500 g/ha and 5000 g/ha not effective against leafhoppers, which is evident from the data on per cent reduction of leafhopper population over control at three, seven and ten days after spray. On the other hand, compounds like NSKE @ 5% and Surf powder were comparatively better over bio-agents. In these treatments, per cent reduction over control ranged from 33.30 to 43.3% at three days after spray. Highest reduction was recorded in surf powder @ 5000 g/ha. Non-significant differences were recorded among treatments at seven and ten days after spray. Seed cotton yield ranged from 967.2 to 642.2 kg/ha with non-significant differences among the treatments. Pest Guard, L, M and O were not tested at this centre.

Central India: Khandwa

After 1st, 2'd and 3,d spray, aphids and leafhopper were minimum in Pest Guard J 50 EC 600 g/ha. Minimum open boll damage was observed in Pest Guard J 50 EC and it was at par with Pest Guard L 50 EC and Fish oil rosin soap. The next better treatments were *Verticillium lecani,* Pest Guard O 50 EC, NBAII *Lecanicillium lecanii-5,* L1,*Fusarium pallidoroseum,* Ma4 *(NBA II), neem* oil 1% and Mealy Quit.. Minimum locule damage was observed in Pest guard J 50 EC and it was at par with Pest Guard L 50 EC Fish Oil Rosin Soap, *Fusarium pallidoroseum,* LI and Ma 4 (NBAII). Maximum seed cotton yield was recorded in Pest Guard J 50 EC which was at par with seven other treatments while rest of the treatments was found superior to control..

Coimbatore

The effectiveness of bio-pesticides on the mirid bug was low and there were no significant differences among the treatments. *Verticillium lecanii* (NBAII, Bangalore) followed by *Metarhizium anisopliae* (CICR, Coimbatore Strain) and neem oil brought about minor reduction of 29.96,27.4. and 23.12% respectively as against 18.08 and 0 % in unsprayed and water sprayed controls respectively. When coccinellid predators were affected by the pesticide treatments, spiders survived.

Sirsa

Innovative interventions for leaf curl management

The following treatments ie T1- Whey protein @ 5%, T2- Cow urine @6.6%, T3- Neem oil @1%, T4- Mustard oil @3%, T5- Kaolin @ 2%, T6- Calcium nitrate @ 0.5%, 17- Potassium

nitrate @ 0.5% T8- Paraffin liquid @ 2% T9- Strobilurin @ 0.1 %, T10- Acephate @ 0.4% and T11- Control were sown with three replications under RBD to study their effect on the cotton leaf curl virus disease control.. Six sprays starting from appearance of disease were given at fortnightly interval.. Pre and post spray data (weekly) on CLCuD incidence were recorded. Data on whitefly incidence was recorded at weekly interval..

Among different treatments whey protein @ 5% found most effective in managing disease (9.8% incidence,PDI-3.8) followed by Calcium nitrate @ 0.5% (10.1 %,5.4) neem oil @ 1% (12.5%,5.5) and strobilurin @ 0.1 % (13.5%,6.4) as compared to control (31.5%, 14.3). White fly reduction was observed only in case of *neem* oil and Acephate.

Pink bollworm larval recovery from north zone

Monitoring for PBW incidence in Bt cotton was conducted in North Zone (Faridkot, Sriganganagr, Sirsa and Hirsar) through examinations of 150 green bolls, thrice at 140,160 and 175 DAS.

Recovery of pink bollworm larvae from the non Bt cotton bolls received from north zone ranged from 4.17% in Faridkot 124 to 7.44 % in H-1098 Hisar at 160 DAS. But no larval recovery was observed from these locations from the bolls received of Bt cotton at 160 DAS.

Recovery of pink bollworm larvae from the non Bt cotton bolls received from north zone ranged from 6.67% in Faridkot 124 to 20.37% in non Bt *Des;* at Sirsa at 175 DAS. But no larval recovery was observed from these locations from the bolls received of Bt cotton at 160 DAS.

Adult moth catch of cotton bollworms in pheromone traps

Pheromone traps were installed in the experimental area. The lures were changed after each 15 days. Pheromone trap catches reveal mean male moth catch per trap per week during the 2011 were 3.58 for pink bollworm (PBW), 2.43 for American boll worm (ABW), 3.79 for spotted boll worm (SPW) and 14.22 for tobacco caterpillar (TC). The peak catch for pink bollworm was during 43th SMW (21.67/trap/week), for American boll worm 14th SMW (19.10/trap/week), for spotted boll worm was during 45 SMW (19.29/trap/week) and for tobacco caterpillar was during 39 SMW (51.43/trap/week) (Fig. 17 and 18).

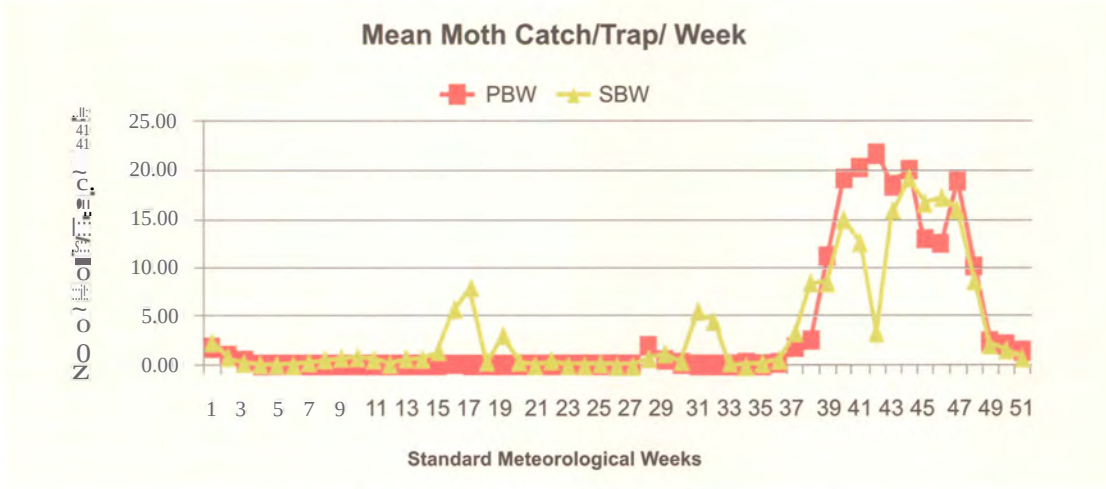


Fig. 17: Pheromone monitoring data at Sirsa (2011-12)

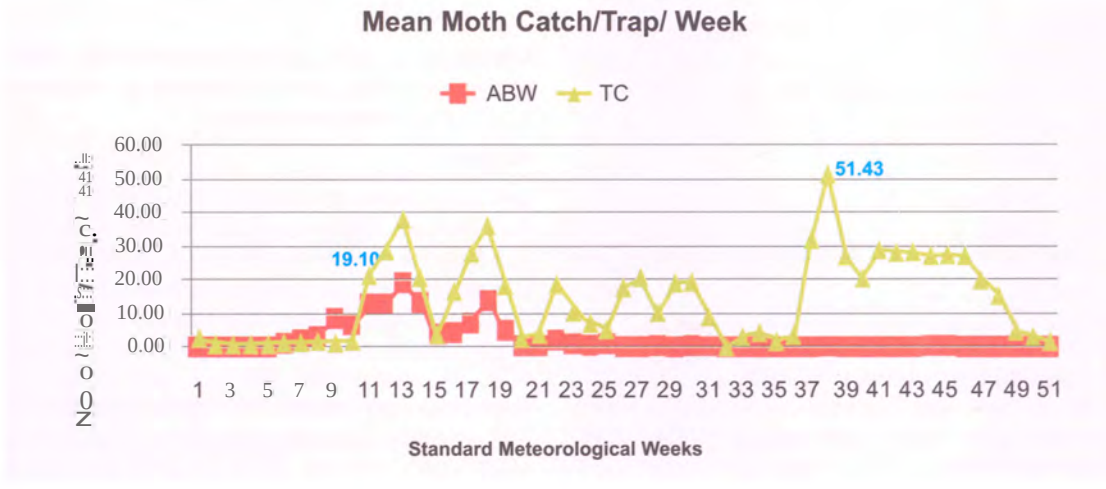


Fig. 18 : Pheromone monitoring data at Sirsa (2011-12)

Insecticide Resistance Management

Nagpur

Insecticide resistance monitoring of 5 insecticides against leaf hoppers (carried out in network mode)

Leaf hopper samples from 10 locations were subjected to resistance monitoring studies. LC_{50} to Imidaclorprid ranged from 0.00012 mg/L (Bhatinda) to 0.128 mg/L (Buldana). LC_{50}sof thiamethoxam ranged from 0.00013 mg/L (Bhatinda) to 0.145 mg/L (Buldana). Seven populations of leaf hoppers were subjected to bioassays with acephate and monocrotophos and its LC_{50}s ranged from 0.0008 mg/L to (Bhatinda) 0.1622 mg/L (Nagpur) and 0.008 (Bhatinda) to 0.0779 mg/L (Jalna) respectively. Bhatinda populations were at least 100 fold more susceptible than the populations that showed the highest LC_{50}. Bioassays with population from 8 locations were carried out at CICR, Nagpur while the rest were carried out at NAU Navsari (populations from Gujarat) and CICR RS Sirsa (populations from Bhatinda).

Monitoring of changes in baseline susceptibility of Cry toxins in 4 bollworms (carried out in network mode)

Bioassays with *H. armigera* collected from 16 districts from crops other than cotton and reared to F, were carried out with *cry1Ac*. LC_{50}values were derived from 11,200 larvae tested, from 16 districts, ranged from 0.245J-lg *cry1Ac/ml* in Dhule strain to 5.10 J-lg *cry1* Ac/ml in Bharuch strain with a low value of 0.026 J-lgcry1Ac/ml of diet in the reference susceptible strain. The variability in the field strains was about 22-fold. The IC_{50}values ranged from 0.003 in the reference susceptible strain and 0.036 ~g/ml in Akola and Mansa populations and 0.363 ~g cry1Ac/ml of diet in Surat population with 10 fold variability between the field strains. *Cry2Ab* bioassays were carried out on F, *H. armigera* obtained from populations collected across 14 districts and the EC_{50} ranged from 1.33 J..'.!!ml(Guntur) to 8.58 J-lg/ml of diet (Amrelli). Bioassays on F, from 10 populations were carried out with *cry1Ac* + *cry2Ab* in wherein the ratio of *cry1 Ac* to *cry2Ab* was maintained at 1:4. S. *litura* populations were collected from 8 locations and bioassays with *cry1Ac*, *cry2Ab* revealed the LC_{50} values to range from 5.0 (Bhatinda) -18.9 (Sriganganagar) ug/ml of diet, 2.41 (Abohar) -6.03 (Sirsa) J-lg/ml of diet. EC $_{50}$values ranged from 1.19 (Bhatinda) - 26.4 J-lg/ml (Baruch) of diet for *cry1Ac*. Log dose probit assays with *cry1Ac* indicated that LC_{50} against pink bollworms ranged from 0.02 J-lg/ml (Jalgaon) to 0.2 J-lg/ml (Dhule).

Diagnostic dose bioassays with *cry1Ac* were conducted for populations of pink bollworm collected from different locations of India on Bt and non Bt cotton fields using diagnostic doses viz. 10 ppm, 1 ppm and 0.1 ppm. Cent per cent mortality was recorded over the control except for population from Jalgaon. Jalgaon non-Bt population at 10 ppm and more than 50 per cent mortality at 1 ppm in non Bt population but PBW populations collected from Dhule, Nandurbar and Jalgaon on extended BG less than 100.00 per cent mortality over control was recorded at the diagnostic dose of 10 ppm (Table 8).

Table 8: *Cry1Ac* diagnostic dose bioassays with F, generation collected on Non Bt

States	% Corrected mortality		
	10 ppm	1 ppm	0.1 ppm
Punjab	100.00	78.65	45.32
Haryana	100.00	78.57	7.14
Rajasthan	100.00	100.00	83.97
Gujarat	100.00	100.00	15.38
Maharashtra	90.00	61.86	16.71

Sirsa

Dissemination of insecticide resistance management programme

The program of dissemination of insecticide resistance management was taken up in Haryana in the districts of Sirsa and Hisar. Fifteen villages were selected in each district. A total of 2540 ha and 5215 ha area was covered. This was followed by engagement and training of field workers about insecticide resistance management strategies. The weekly data on insects, diseases and beneficials was recorded in villages and used for decision making interventions. Major emphasis was given on the management of resistance in sucking pests against insecticides and bollworms against cry toxins and farmers were encouraged to grow refugia around Bt cotton hybrids. This was followed by collecting information on insecticide consumption and number of spays. Information on the seed cotton yield and cost of cultivation was also gathered to arrive at Cost Benefit ratios of IRM and non-I RM farmers.

There were 3.59 and 2.38 sprays by IRM farmers as compared to 4.22 & 3.82 sprays in non IRM farmers fields. Insecticide consumption was reduced upto 27.1 and 31.4% respectively in IRM farmers of Sirsa and Hisar. There was saving from insecticides by around Rs. 1100/- per ha and an improvement in yield by around four q/ha of IRM farmers showing an overall C:B ratio of 1:3.72 and 1:3.65 over 1:3.00 and 1:2.93 at Sirsa and Hisar respectively. Net profit in IRM was Rs 84087 per ha and in non IRM is Rs. 64038 per ha in Sirsa. The net profit per ha of IRM farmers over non IRM was Rs. 20049. Whereas net profit in IRM was Rs. 84747 /ha and in non IRM is Rs. 64294 /ha in Hisar .The net profit per ha of IRM farmers over non IRM was Rs. 20453.

Validation of efficacy of neonicotinoid seed treatment against sucking pests of cotton in multilocation trials (carried out in network mode)

Nagpur

Jassid incidence did not cross ETL upto 50 DAS. There were no significant differences between the treatments at 15 DAS. Although the pest did not cross ETL at 25 DAS, Gaucho and Cruiser untreated plots harbored statistically significant higher leafhopper nymphs than the treated plots especially in the susceptible Bt genotype RCH 2. This was not true of RCH 20 BGII (a moderately tolerant genotypes) wherein the treatments were on par. The treated plots 40 DAS in RCH 2 BGII and RCH 2 non Bt continued to be statistically superior. Leafhoppers crossed ETLs 50 DAS and the treated and untreated plots were on par with each other, genotype wise.

The genotypes tested would have done well in the absence of seed treatment this year as the pest did not cross ETL till 50 DAS. Neonicotinoids as seed treatment was effective upto 50 DAS in central India as far as leafhopper nymph numbers were concerned.

Gujarat

Cotton leaf hoppers did not cross ETLs upto 56 DAS in any of the treatments. Neonicotinoid (both Imidacloprid and Thiamethoxam) treatment conferred protection to RCH 2 BGII and RCH 20 BGII upto 56 DAS as can be observed from the data. There were no statistically significant differences 63DAS between the treatments despite the leafhopper population having crossed ETLs. There were statistically no significant differences between the incidence of aphids and whiteflies between the treatments and their numbers were low numerically.

When yields were compared across genotypes Bts clearly out yielded their counterparts by about 300 kg/ha and seed treatment gave an advantage of approximately of 307 kg/ha and 222 kg/ha with Imidacloprid and Thiamethoxam respectively. In Gujarat seed treatment still is advantageous to Bt cotton for protection against sucking pests.

Guntur

Leafhopper nymphs did not cross ETLs till 45 DAS. Observations on leaf hopper incidence were recorded up to 80 DAS. The incidence of ieafhopper nymphs on treated genotypes was significantly lower than on the untreated in the susceptible genotype RCH 2BGII.. The treated and untreated genotypes were on par with each other just 10 DAS. Treated plots harbored statistically significant lower numbers of nymphs although they did not cross ETL upto 37 DAS as compared to untreated plots. However at 45 DAS treated and untreated plots were statistically on par with each other with the pest having crossed ETL.. The pest crossed ETL at 45 DAS at Guntur and neonicotinoids were ineffective in checking the outbreak. The jassid injury grade ranged between 1-2 in the treated and untreated plots of susceptible, moderately susceptible and highly susceptible genotypes upto 45 DAS. Only seed treatment did not contribute to yield increase in any genotype as the crop succumbed to leaf hopper damage in treated and untreated plots 45 DAS.

Sirsa

Development and validation of IPMIIRM strategies for Bt cotton hybrids carrying different events against sucking pest complex, observations the population of leafhoppers ranged between 2.78 to 3.18 average whitefly ranged between 4.64 to 6.36 and average thrips population recorded in different hybrids was 4.09 to 5.84 per 3 leaves under IPM practices. Under RPP (Recommended package of practices) the leafhopper population recorded between 2.84 to 4.11, whitefly between 5.11 to 5.89 and thrips between 4.58 to 7.73 per 3 leaves in various hybrids sown .The net profit gained was Rs. 26865 in IPM where as it was Rs. 21656 in RPP with a cost:. benefit. ratio of 1: 2.00 and 1:1.56 respectively in IPM and RPP plots, respectively. Increase in net profit in IPM over RPP was 19.39%.

Bioassay with *cry1Ac, cry2Ab* and *cry1* C to *Earias vitella*

During 2011 a total of 42 bioassays were conducted. Bioassay conducted with *cry1Ac* indicated that larval population of spotted bollworm collected from Sirsa on 13/07/11 was recorded with highest LC_{50} value of 2.026 IJg/ml and larval population collected from Sriganganagar on 17/08/11 was with lowest LC_{50} value of 0.125 IJg/ml. Bioassay with *cry2Ab* recorded that larval population of spotted bollworm collected on 13/11/11 from Sriganganagar demonstrated highest LC_{50} value of 712.596 IJg/ml and larval population collected from Sirsa on 13/07/11was with lowest LC_{50} value of 0.36 IJg/ml. Bioassays with *cry1Ac, cry2Ab* and *cry1C* on *HelicDverpa* collected from Sirsa on 24/4/11 showed a LC_{50} value of 1.001 IJg/ml, 168.223IJg/ml and 3.729IJg/ml respectively.

Insecticide induced resurgence

The experiment conducted for insecticides induced resurgence for commonly used insecticides against sucking pests revealed that in cumulative of 10 sprays no resurgence in population leaf hopper, whitefly and thrips was recorded, but in some of the treatments like Fipronil (at recommended dose) resurgence of whitefly was recorded after individual spray applications.

5. Technology Assessed and Transferred

Nagpur

Assessment of production technologies in Bt cotton

In station trials, site specific nutrient management (SSNM) and intercropping with cotton were compared with conventional practices. The SSNM with closer spacing (60 x 60 cm) recorded higher seed cotton yield (1178 kg/ha) than the conventional practice of (90:45:45 at 90 x 60 cm spacing) (636 kg/ha). Among intercropping systems the seed cotton yield was higher in cotton + cowpea and cotton + soybean.

Front Line Demonstrations in cotton

Sixty five FLDs on cotton production technologies and one on IPM were conducted in villages Rasa-Mohagao, Kesalapar, Girad, Shivanphad, Jogigumpha, Khursapar, Arvi, Mirzapur in Samudrapur Tahsil and Jangona in Hinganghat Tahsil of Wardha district.. The technologies demonstrated were integrated nutrient management (INM), cotton based intercropping (cotton + soybean), performance of newly released varieties (CHNO 12 and Suraj), control of reddening by foliar application of DAP & MgSO., weed management- through post emergence spray of Quizalofop-ethyl (Targa super) and IPM. The demonstrations resulted in an average yield of 1149 kg seed cotton /hectare as compared to farmers local practice 998 kg/ha. On an average benefit of additional monetary returns of Rs.13, 174/- (25.52 % profitability) was observed by adopting intercropping of cotton+ soybean over sole cotton. The newly released CICR varieties CHNO 12 and Suraj introduced and tested for performance in rainfed areas were appreciated by farmers in Girad areas mainly due to less attack of insect pests, tolerance to leaf reddening and abiotic stresses. Farmers showed keen interest in these varieties despite spread of 8t cotton. IPM technology was demonstrated in 25 hectares using IPM module and need based sprays helped the farmers to minimize expenditure on management of insect pest and diseases.

CROPSAP

Cotton pest management strategies were disseminated through ICT tools in Crop Pest Surveillance and Advisory Project (CROPSAP) in Maharashtra.

- Pest and disease situation were regularly monitored through personal visits and information was uploaded online on website.
- Advisory reports of jassids injury, whitefly, red leaves or leaf reddening, thrips and spodoptera trap catch which crossed ETL on cotton from 22"d August 2011 to 13th November 2011 was circulated among all stakeholders.
- Analysis of pest situation in different districts of Maharashtra and accordingly their management advisories were issued on 8th September, 16'h September, 17th September, 27'h September, 04th October, 15th October, 16'h October, 22"d October, 05'h November, 08'h November, 16th November and 30th November 2011.

Coimbatore

On farm Trial: Stale Seed Bed Technique of weed control

The Stale seed bed technique of weed control was demonstrated in two farmers' fields in Coimbatore district.. The seed bed was prepared and irrigation was given two weeks in advance of sowing and spraying of glyphosate 1.0 kg + pendimethalin 1.0 kg/ha one week after irrigation (one week before sowing) resulted in efficient control of weeds. The germinated weeds were killed by glyphosate and the germinating weeds were killed by the residual action of pendimethalin. Due to efficient weed control, the seed cotton yield was 37.5 q/ha. The farmers' were very much convinced about this technique for managing weeds.

Cotton value chain

Adoption of integrated cotton production technologies enhanced seed cotton yield, gross return and net return, 50.1, 50.0 and 76.1 per cent respectively as compared to non project farmers. Demonstration of interventions include alternate furrow opening recorded 23.4 per cent higher yield in comparison to non adopters. Off season *in situ* grown ragi helped to increase 22 per cent of seed cotton yield. Pendimethalin (Stomp) @ 700 ml per acre under lay - by method controlled late emerging weeds successfully. Combination of quizalofop-ethyl@ 50 g a.i. /ha + pyrithiobac sodium @ 75 g a.i. /ha was followed for controlling emerged weeds. Application of maize straw @ 5 t/ha as mulch was adopted by selected farmers as moisture conservation technique. Vermicomposting was demonstrated to project farmers. Tricho compost was prepared. Adoptability of low cost drip systems helped to increase 22.3 per cent higher yield with water saving of 32.9 per cent.. Effective utilization of natural resources by multi tier cropping system enhanced the profitability@ Rs. 28, 118/ha higher than sole cotton.

Demonstration of low cost drip irrigation system in cotton

In low cost poly-tubes drip system, instead of LLDPE lateral, poly tubes 150 micron was used. Poly tubes were punctured at single side at regular intervals (60 cm) and placed within the pair (60 cm) of paired rows planted cotton. Poly tubes were positioned in such a way that perforated holes face towards bottom side for water delivery and were stretched and fixed. Poly tube drip system (150 micron) was cheaper by 57.8 % in comparison to existing drip system. Poly tube drip systems was demonstrated at NAIP village found that water saving to the tune of 32.49 per cent and yield increase of 22.3 per cent.. The economics of adoption of low cost system found that higher gross return (Rs. 1,67,540/ha) and net return (Rs. 1,02,446/ha) realized as compared to conventional method of irrigation, which calculated gross return of Rs. 1,29,527/ha and net return of Rs. 65,835/ha.

Demonstration of production technologies

Multi-tier cropping system

At main farm, CICR, Coimbatore, RCHB 708 Bt Hybrid cotton was planted at 120 x 45 cm. Two ridges at 60 cm apart were formed making 120 cm. Cotton, radish, beet root and coriander were planted on 4 sides of the 2 ridges in sequence. Harvested 23.89 q/ha of seed cotton, 6387 kg of radish, 1127 kg of coriander leaf and 2220 kg of beet root from per hectare of land. The control recorded only seed cotton yield of 22.8 q/ha.

Split application of nutrients to EIS cotton

At main farm, CICR, Coimbatore in RCHB 708 Bt, nitrogen (90 kg N/ha) was applied in three splits (45, 90 & 105 DAS) as compared to control plot (two split of nitrogen dose of 90 kg N/ha - 50% N as basal and top dressing remaining at 45 DAS). Split application enhanced seed cotton yield (16.71 q/ha) by 27.3 percent. .

***In situ* incorporation of off season ragi**

Demonstration conducted at NAIP village found that *in situ* incorporation of off season ragi registered 22 per cent higher seed cotton yield (29.2 q/ha) of ELS cotton and higher net return of Rs. 1,23,065/ha realized overthat control (SCY 22.7 q/ha and net return Rs. 97,871/ha).

Foliar nutrition

Foliar application of Mg SO. @ 1 per cent produced mean of 25.2 q/ha of seed cotton with advantage of 11.2 per cent as compared to control plots arrived with 22.5 q/ha. Foliar application of DAP @ 1.5% increased seed cotton yield by 15%. Foliar application of 600 g/ha of solubor increased seed cotton yield by 11%. Increased seed cotton yield @ 13.2 per cent was observed with foliar application of multi K @ 1 per cent.. Yield harvested from control and Planofix @4.5 ml per 10 liter foliar application recorded mean seed cotton yield of 25.2 and 23.24 q/acre, respectively.

Success story in EIS cotton cultivation

Rangaraj M., a farmer of Thoppampalayam village, Arasipalayam (post) Kinathukadav (block), Pollachi (TK) Coimbatore has 4.25 acres of rainfed land. The soil is sandy clay loam in texture, low in available N (138.3 kg/hal, medium in available P (13.6 kg /ha) and high in available K (358.2 kg /ha) with neutral pH (6.3) and EC (0.14 dsm⁻¹). He cultivates tomato, chillies, cotton and fodder sorghum.

The Extra Long Staple (ELS) RCHB 708 Bt Hybrid was planted at 150 x 60 cm in July, 2011 under rainfed condition under NAIP-cotton value chain. He adopted moisture conservation practice of all furrow opening after last inter-culture. Integrated

nutrient management of 3 tons of poultry manure, 7 tons of farm yard, bio fertilizer and 81.5:89.0: 174.0 kg of N, P_2O_5 and K_2O fertilizer nutrient applied for 1.6 acre of land. Three split of nutrients had been adopted followed by basal at 45, 75 and 105 DAS. Clean cotton picking were followed as per the advice of project personnel's that resulted in less quantity (7.75 kg) of bad *kapas*. Sucking pest was effectively suppressed by five sprays.

He had harvested 26.5 q of seed cotton yield from 1.6 acre of land (equal to 40.9 q/ha) along with 70 kg of cowpea and one quintal of maize from border crop. The cost of cultivation was Rs. 40000 (equal to Rs. 61,750/ha), gross return was Rs. 1,19,250 (equal to Rs. 1,84,092/ha) , net return of Rs. 79,250 (equal to Rs. 1,22,342/ha) giving a benefit cost ratio of 2.98. He is happy with the high yield and profit realized in ELS cotton cultivation by adopting integrated cotton management practices prescribed by CICR.. He narrated his experience to other project and non project farmers during farmer's interactive meeting and field day function.

Assessment and on farm demonstration of CICR technologies

Eleven promising cotton technologies including four cotton varieties were assessed through on farm demonstration in the CICR, Regional Station, Coimbatore. The improved cotton varieties *viz.,* Suraj, Surabhi, MCU 5 VT and LRA 5166 were demonstrated in large plots with the spacing of 90 x 45 em that yielded 23.67 q/ha, 19.86 q/ha, 17.32 q/ha and 14.99 q/ha, respectively. Demonstration of Polyethylene Mulch technology resulted in 27.21 q/ha seed cotton yield as against 20.41 q/ha without mulch. IPM module of the institute demonstrated with Bunny Bt yielded 18.04 q/ha as against 12.17 q/ha in control.. Manipulation of morphoframe through foliar application of ethrel was demonstrated on Suraj with 90 em x 45 em spacing. The technology resulted in 15.33 q/ha as against the 9.8 q/ha in control.. Demonstration of CICR nutrient consortia for boosting yield in cotton Anjali with 90 em x 45 em spacing resulted in 16.22 q/ha as against (12.41 q/ha) in control..

Front line demonstrations in cotton

CICR, Coimbatore centre conducted fifty demonstrations on cotton production technology and one unit demonstration on cotton IPM in Ezhoor village of Coimbatore district and Thamelaeri Muthur, Vangayapalli and Kodiyannur villages of Vellore District.. The technologies *viz.,* integrated crop management practices for Suraj and ELS cotton hybrid DCH 32, intercropping with pulses, pre-emergence application of weedicides, application of growth regulators and soil test based fertilizer recommendation were demonstrated under cotton production technology. The demonstrations on production technology in total resulted in an average seed cotton yield of 2020 kg/ha. One unit demonstration (50 ha) on cotton IPM using the IPM module developed by the institute resulted in an average seed cotton yield of 1576 kg/ha as compared tothe non -IPM fields (1449 kg/halo

Insecticide Resistance Monitoring (IRM)

Through the implementation of the project IRM in 15 villages of the Tirupur district of Tamil Nadu, the strategies were successfully adopted by the farmers. Fourteen extension programmes - weekly field visits, training programmes and farmers' group meetings enhanced the farmer's knowledge about the cotton pests, symptoms, natural enemies and the IRM strategies of pest management in cotton.

Economics of IRM and non-IRM farmers

S.No	Particulars	IRM	Non IRM
1.	Area in acres	85	90
2.	Number of sprays	3	6
3.	Quantity of insecticide used 9 a.i.lha	1144.5	1934.0
4.	Yield q/ha	31.25	29.0
5.	Gross returns (Rs. / ha)	2,03,125	1,88,500
6.	Plant protection cost (Rs. / ha)	4,440	7,040
7.	Other cultivation cost (Rs. / ha)	91,310	94,685
8.	Total cultivation cost (Rs. / ha)	95,750	1,01,725
9.	Net profit. (Rs. / ha)	1,11,815	86,775
10.	Cost benefit. ratio	1:1.15	1:1.08

Sirsa

Front line demonstration

Ten FLD programmes for hybrid seed production of hybrid CICR 2 in the farmers field were conducted. Around 30 quintals seed of CICR- 2 *(Desi* cotton hybrid) was produced by the farmers trained at this centre in hybrid seed production technology.

6. Education and Training

6.1: Training Received

6.1.1: **International Training**

Name of the scientist	Topic of training	Place	Period
Dr. Vinita Gotmare	Genome Resource Conservation	Mississippi State University, USA	04-04-2011 to 04-07-2011
Dr. V.S. Nagrare	Sensor based Technologies and Application for Natural Resource Management in Precision Farming	Colorado State University, Colorado, USA	15-08-2011 to 15-11-2011
Dr. S. Manickam	Marker Assisted Selection in Crops	North Carolina State University, Raleigh, USA	15-09-2011 to 15-12-2011

6.1.2: National Training

Name of the Scientist	Name of the courseltrainnig	Place	Period
Dr. V.N. Waghmare	Bioinformatics in Agriculture	IASRI, New Delhi	29-08-2011 to 07-09-2011
Dr. T.R. Loknathan	Pre-breeding in Crop Improvement	PAU, Ludhiana	07-09-2011 to 27-09-2011
Dr. K.P.M. Dhamayanthi	Allele Mining: Basic, Principles, Methods and Applications	TNAU, Coimbatore	10-10-2011 to 21-10-2011
Dr. K. Velmourougane	Synthesis and characterization of nanomaterials and their application in agriculture	CIRCOT, Mumbai	16-11-2011 to 29-11-2011
Dr. V. Santhy & Mrs. Mukta Chakrabarty	Sampling and Detection Methods Applied to Transgenic Crops	NIN, Hyderabad	17-11-2011 to 19-11-2011
Dr. D. Kanjana	Nanoparticle production, characterization and utilization in Agriculture	CAZRI, Jodhpur	23-02-2012 to 03-03-2012
Dr. S.M. Palve	SAS: Genetics and Genomics Data Analysis	CIFE, Mumbai	27-02-2012 to 03-03-2012
Dr. K. Sankaranarayanan	Application of Geo-informatics and crop simulation models for Agricultural Management	NAARM, Hyderabad	13-03-2012 to 26-03-2012

6.2: Training Imparted

Multi skilled training programme for casual labours conferred with temporary status

A fourteen days training program was conducted for Casual labours conferred with temporary status at CICR, Nagpur and Coimbatore. The main objective of the training programme was to upscale their knowledge about scientific, technical and administrative works.

At Coimbatore, 44 Casual labours attended this training from 05.03.2012 to 09.03.12 and 20.03.12 to 29.03.2012. Dr (Mrs) S. Usha Rani, Scientist (SS) (Extension) coordinated the programme.

At Nagpur, 117 Casual labours attended this training from 07.03.2012 to 21.03.2012. Dr. S.M. Wasnik, Principal Scientist (Extension) coordinated the programme.

Trianing programmes for the Tribal farmers under Tribal Sub Plan (TSP)

At Nagpur, two trianing programmes on "Recent Advances in Cotton Production Technologies" were conducted for tribal farmers. One hundred tribal farmers of Hingna Taluka and 343 tribal farmers of Gadchandur, Dist Chandrapur participated in the training programmes organized by CICR, Nagpur on 10.2.2012 and 27.03.2012 respectively.

At Coimbatore, fourtrianing programmes on Integrated Cotton Management techniques were conducted for 75 tribal cotton growers from Vellore and Salem Districts of Tamil Nadu under TSP. The programs were convened by the Project Coordinator and Head and co-convened by Dr. (Mrs) S. Usha Rani, Scientist (SS) (Agrl. Extension).

Training-cum-awareness programme for farmers on PVP &FR

CICR conducted one day training-cum-awareness programme for updating the knowledge of cotton farmers on Plant Variety Protection and Farmers' Rights as well as DUS testing. At Nagpur, this training programme was conducted on 28.3.2012 and 30.3.2012 and was attended by 120 farmers from Bhiwapur, Umred and Khapa blocks of Nagpur District.. Dr. V. Santhy, Scientist (SS) conducted the programme.

At Coimbatore, this training programme was conducted on 26.3.2012 and 27.3.2012 and was attended by 118 and 131 farmers respectively from cotton growing villages- Vadapudur, Kinathukadavu, Annur, Kanjapalli, Kallapuram, Meenakshipuram, Veerappagoundanor in and around Coimbatore District.

Nagpur

National training on varietal purity-testing of specified traits

A National Training on "Varietal Purity-Testing of Specified Traits" was organized during 31st Jan.- 4th Feb. 2012 (5 days) at CICR, Nagpur, wherein 30 candidates participated from Seed Testing, Seed Certification, Seed Production departments and research institutionslAgril.. Universities. Dr. P.R.Vijayakumari, Principal Scientist conducted the programme.

Training on cotton production technology to FLD beneficiary farmers

One day training programme on 'cotton based intercropping system' and 'integrated nutrient management-leaf reddening in cotton' was organized for FLD beneficiary farmers at villages Girad in Samudrapur and Jangona in Hinganghat tahsils of Wardha district in Vidharbha region of Maharashtra. 96 farmers attended these training programmes. The programme was conducted by Dr. S. M. Wasnik, Principal Scientist (Extension).

Coimbatore

Field experience training of 94th FOCARS

A field experience training program for eight ARS Scientist Probationers of 94th FOCARS from NAARM, Hyderabad was conducted in CICR, Regional Station, Coimbatore from 08.11.2011 t028.11.201 for21 days. Asa part of the program, the scientist trainees applied Participatory Rural Appraisal (PRA) technique in Vadapudur village, Kinathukadavu blaock, Pollachi Taluk, Coimbatore District.. They also conducted a seminar in the village and Institute to explain their findings of PRA exercises, to share the researchable and non-researchable problems and to finalize the action plan with the villagers, line department officials and the scientists. Their studies revealed that water scarcity was the major impediment for agricultural productivity in Coimbatore district and proposed research proposals to tackle the problem. As a part of their training, they had industrial orientation with MIs SIMA CORA, Coimbatore. The program was coordinated by Dr. (Mrs) B. Dharajothi and Dr. (Mrs.) S. Usha Rani, Scientists of CICR, Coimbatore.

7. Awards and Recognitions

1. Dr. A.B. Joshi Young Scientist Award

Dr. (Mrs.) Suman Bala Singh, Principal Scientist (Plant Breeding) received the prestigious Dr. A.B. Joshi Young Scientist Award for her pioneering work and valuable contribution in the field of cotton breeding. Since her joining as a Scientist, she has worked in many projects involving thrust areas related to drought tolerance, male sterility and bollworm resistance under National Agricultural Technology Project and Technology Mission on Cotton. She has also developed many lines for further exploitation in biotic and abiotic stress management, productivity and fibre quality improvement. . The A.B. Joshi Award is being given for the first time and it is a matter of pride that Dr. Suman Bala Singh is its first recipient. .

2. Rao Bahadur Ramnatha Iyer Award

Dr. K.N. Gururajan, Retd. Principal Scientist (Plant Breeding), CICR Regional Station, Coimbatore has been awarded Rao Bahadur Ramnatha Iyer Award for his outstanding research in the field of Cotton Improvement. . He was associated with the release of varieties *viz.* Supriya, Kanchana, Anjali, Surabhi, Sumangala and Suraj and hybrids *viz.* Savitha, HB 224, TM 1312andSruthi.

3. Bhumi NirmanAward 2011

Dr. K.R. Kranthi, Director CICR, was awarded Bhumi Nirman Award 2011 from Bhumi Nirman Group for his leadership and contribution to Indian agriculture particularly cotton.

4. Fellow of the Indian Society of Genetics & Plant Breeding

Dr. V.N. Waghmare, Senior Scientist, CICR, Nagpur has been Elected Fellow of the Indian Society of Genetics & Plant Breeding based on his outstanding scientific contribution and achievements. The certificate was presented by Dr. S. Ayyappan, Secretary, DARE & DG, ICAR on April 22, 2011 in the National Seminar on 'Contemporary Approaches to Crop Improvement' organized by ISGPB & ICAR at UAS, GKVK Campus, Bangalore.

5. Other awards

i. Central Institute for Cotton Research, Regional Station, Coimbatore received the award for outstanding performance - DUS test Center under ICAR category during 201 0-11

ii. The CICR technologies were exhibited in the State level Farmers Day at TNAU, Coimbatore for three days from 22.07.2011 to 24.07.2011 and the stall of CICR, Coimbatore bagged the "Best Stall Award among the Central Government Institutions"

8. Linkages and Collaborations

Areas of Linkages	Institution
NATIONAL	
Fibre testing, fiber quality evaluation and nanotechnology	CIRCOT, Mumbai
Multi-location testing of promising cultures, Bt cotton evaluation	AICCIP (21 centers)
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 finger printing of cotton	NRC DNA Finger Printing, New Delhi
Efficacy of lectins on sucking pests- New Millineum Initiatives of Technologies Leading India (NMITLI)	NBRI, Lucknow, Bose Institute, Kolkata, Nil, New Delhi, Delhi University, New Delhi, UAS, Dharwad, JK seeds.
Technology for pink bollworm resistance monitoring and management	State department of Agriculture, Haryana, KVKs, CCS HAU, Hisar, NCIPM etc
Mechanization	CIAE, Bhopal
INTERNATIONAL	
Insect transgene detection kits	Indo- Australian Project with TERI, CEASAR

9. All India Coordinated Cotton Improvement Project

Crop Improvement

The salient achievements under AICCIP during the year is presented below.

Breeding trails - National trials

- G. *hirsutum-CA* 105, GISV 272 and GJHV 398 were found to be the best in terms of seed cotton yield in north, central and south zones, respectively under irrigated condition.
- All the ten *barbadense* cultures were superior in terms of yield over the common check variety Suvin in both central and south zones. DB 16 was the best genotype in central zone, whereas, GSB 40 was the best in south zone. However, quality wise, Suvin was the best in both the zones.
- The interspecific hybrid ARBHB1 047 was found to be the best in both the central and south zones.
- Among the G. *arboreum* varieties tested under irrigated condition in north zone and under rainfed condition in central zone and south zones, FDK 230 was the top yielder in north zone, while in central zone and south zones, the cultures CNA 39 and Das 385 recorded the highest yield, respectively. Several entries were found to have superior fibre quality attributes.
- Among the *desi* hybrids tested under irrigated condition in north zone and under rainfed situation in central zone, the hybrid MH 33 was the best in north zone and CISM 20 was the top performer in central zone.

Zonal trials - north zone

- In the G. *hirsutum* preliminary varietal trial, the highest seed cotton yield was recorded in LH 2152 (2293 kg/halo
- Ten cultures were tested in the Coordinated Varietal trial, wherein, F 2228 was the best recording 2454 kg/ha of seed cotton yield.
- In the Coordinated Hybrids trial, three hybrids performed better than the check hybrids. LHH 1350 (2274 kg/ha) was the best hybrid.
- In the Coordinated G. *arboreum* varietal trial, LD 949 was found to be the best culture recording 2248 kg/ha of seed cotton yield.
- In the Coordinated *desi* hybrid trial, FMDH 23 (2406 kg/ha) out performed the checks and other test entries.

Central Zone

Irrigated Trial

- In the Coordinated intra *hirsutum* hybrid trial, the test hybrid GSHH 2729 ranked 1st with 2005 kg/ha followed by RHH 0622 with 1960 kg/ha.
- Eleven compact genotypes were tested under close spacing along with a local check variety under recommended spacing. Three genotypes recorded higher yield as compared to local check. The highest yield was recorded in RHC 2022 with 2331 kg/ha.
- In the preliminary varietal trial of G. *barbadense* under irrigated condition, GSB 41 recorded the highest seed cotton yield of738 kg/ha.
- In the Coordinated interspecific (G. *hirsutum* x G. *barbadense)* hybrid trial, ARBHB 1011 recorded the highest yield of 1812 kg/ha.

Rainfed Trials

- When 13 compact genotypes were tested under close spacing, three genotypes recorded higher yield as compared to local check variety. The highest yield was recorded in NH 615 with 1029 kg/ha.
- In the Coordinated varietal trial of G. *arboreum,* the highest seed cotton yield of 1790 kg/ha was recorded in GAM 162.
- In the Coordinated Desi hybrid trial, two test hybrids were superior to both the checks and the highest yield of 1442 kg/ha were recorded inAKDH 91.

South Zone

Irrigated Trials

- Eleven compact genotypes were tested under close spacing along with a local check variety under recommended spacing. All the test genotypes recorded higher yield as compared to local check variety. The highest yield was recorded in ADB 39 with 2331 kg/ha.
- In the preliminary varietal trial of G. *barbadense* under irrigated condition, all the test entries showed yield superiority over the check variety Suvin.
- In the inter specific hybrids trial, five test hybrids were superior to the check hybrid and the highest seed cotton yield of 1867 kg/ha was recorded in the test hybrid ARBHB 1011.

Rainfed trials

- In the coordinated hybrid trial, ten test hybrids showed yield superiority over the check hybrid Bunny. The highest seed cotton yield of 2223 kg/ha was recorded in the hybrid MRC7385.
- In the initial evaluation of compact genotypes under rainfed condition, fourteen genotypes were tested under close spacing along with a local check variety under recommended spacing. The highest yield was recorded in NH 545 with 1889 kg/ha.
- In the Coordinated G. *arboreum* varietal trial, two cultures performed better over the check varieties and the highest seed cotton yield of 1652 kg/ha were recorded in GAM 162 followed by 1554 kg/ha in AKA2005-3.
- In the Coordinated *desi* hybrid trial, six hybrids were better than both the check hybrids and the highest mean seed cotton yield of2293 kg/ha was recorded inMH 32.

Crop Production

- The promising G. *hirsutum* genotypes *viz.,* LH2207, LH 2018 and F 2164 as well as promising G. *hirsutum* hybrid FHH 141 were evaluated for agronomic requirement in north zone. Similarly, promising G. *arboreum* variety RG 542 and two *desi* hybrids *viz.,* FMDH -9 and FMDH -10 were also evaluated.
- In central zone, promising pre-release cultures *viz.,* GISV 218, AKH 9916, BS 279 and H 1316; H x H hybrid RAHH 259 and ARCHH 3028; H x B hybrid RAHB 189 were evaluated.
- Agronomic requirements of pre-release cultures like BS 279 and BS 277; H x B hybrids RAHB 301 and DHB *871; desi* hybrids *viz.,* FMDH -8 and RAJDH 279 were worked out in South zone centres.
- Foliar feeding of micronutrients with FeSO. @ 0.5% at Bhatinda and MgSO.@ 1.0% + ZnSO.@ 0.5% at Faridkot, Ludhiana, Sriganganagar, Nanded and Srivilliputur gave significantly higher seed cotton yield.
- Three sprays of 3% $KN0_3$ at Nanded and four sprays of 3% $KN0_3$ at Rahuri gave significantly higher seed cotton yield.
- Management of leaf reddening in Bt cotton has been worked out in different centres.
- Stress tolerant genotypes have been identified with drought susceptibility index in Surat.. Different C:N ratios did not affect plant height, number of sympodial and monopodial branches, biomass and seed cotton yield.
- Drought resistant genotypes have been identified in Khandwa. The defoliation treatment of Ethrel @ 3000 ppm at 130 DAS had significant and beneficial effect on defoliation.

Entomology

- Breeding trial entries were screened and tolerant / resistant genotypes to sucking pests have been identified in north, central and south zone trials.
- In the advance screening of promising entries to key pests, the genotypes identified in preliminary screening were test verified for reaction to pests and tolerant / resistant ones were confirmed.
- Population dynamics of key pests in relation to climatic conditions were worked out in all the cotton growing zones. Raichur, Coimbatore and Dharwad recorded very high population of pink bollworm in sampled green bolls.
- Various standard insecticides used in cotton ecosystem effective against sucking pests were identified in different Bt cotton hybrids.
- Buprofezin, Acephate and Spinetoram at different concentrations in various locations were found to be effective against sucking pests and boll worms.

Plant Pathology

- Alternaria, bacterial blight and grey mildew were the major diseases in central zone and in addition to that Leaf rust in Karnataka and Andhra Pardesh and Tobacco streak virus in Andhra Pardesh and Tamil Nadu are gaining ground in south zone.
- Studies on the variability of cotton pathogens revealed that *Alternaria alternata* was responsible for this disease in north zone where as A.. *macrospora* was predominant in central zone. However, both these species were reported from south zone in disease samples causing Alternaria blight..
- Based on pooled data of seven locations minimum PDI of Fungal foliar spots was observed in Kresoxim methyl (Ergon 44.3 %) @ 500 ml/ha followed by Propiconazole (0.1 %) and Kresoxim methyl (Ergon 44.3 %)@400 ml/ha.
- In another experiment, fungal foliar spots, grey mildew and bacterial blight showed minimum PDI with Kresoxym methyl 15% WG treatment followed by Acephate 60%WP + Kresoxym methyl 15% WG when tested at seven locations.
- Pooled data over three years (2010-12) indicated that five sprays of copper oxychloride and streptocyclin at 35, 50, 65, 80 and 95 days after sowing showed reduction of bacterial blight PDI from 28.8 to 12.0 and reduction of yield loss upto 22.0%.
- Out of 244 diploid cotton genotypes tested against *Fusarium* wilt for seedling resistance, 10 cotton genotypes exhibited 1-5 per cent ® and 17 cotton genotypes exhibited 6-15 % (MR) incidence in Seedling Resistant Test.. Out of above twenty seven genotypes, twenty five genotypes (R) showed> 50% hyaline reaction (vascular discoloration) and remaining two entries (S) showed <50% hyaline reaction in Adult Plant Resistance Test..

Notification of Cotton Genotypes for Cultivation in 201112

During the year 2011-12, four cotton cultivars have been identified for commercial cultivation in the country for various agro-climatic zones. Out of the four, three cultivars are straight varieties and one is hybrid.

Name of the variety / hybrid	Species	Year of identification	Developed by	Area released for
H-1300	G. hirsutum	2011	CCSHAU, Hisar	North Zone
ARBH-813	G. hirsutum	2011	UAS, Dharwad	South Zone
CNA-1003	G. arboreum	2011	CICR, Nagpur	South Zone
CSHG 1862	G. hir x G. hir	2011	CICR, RS, Sirsa	North Zone

Breeder Seed Production:

An effective maintenance of Nucleus and Breeder seed programme was undertaken by the concerned participating centres of AICCIP. The Breeder seed production in respect of National indent 2011-12 was taken up at seven AICCIP centres and at CICR, Nagpur. The production of LRA 5166 was only 0.06 q as against 0.15 q during the year.

Tribal Sub plan

A new programme on "Tribal Sub plan" with a budget of Rs 30.00 lakhs was taken up. The programme was implemented in 12 centres.

Front Line Demonstrations in Cotton

During the year 2011-12, three types of FLDs were conducted all over the country. They were FLDs on cotton production technology (950), FLDs on farm implements (12 units) and FLDs on cotton IPM (7 units) through 15AICCIP centres.

10. Krishi Vigyan Kendra

Training

Seventy nine short duration (1 to 3 days) on-campus and off-campus training courses were conducted in different disciplines for practicing farmers, rural youths and extension functionaries. In all 1482 participants including 401 SC/ST participants benefited from the training programmes conducted by SMS and Programme Assistants of KVK, as details below:

S. No.	Discipline	No. of courses	No. of participants	*SC/ST* participants
1	Crop Production	15	265	30
2	Horticulture	14	231	35
3	Plant Protection	12	354	66
4	Veterinary Sci.	15	376	124
5	Soil Science	10	130	53
6	Home Science	13	256	93
	Total	79	1482	401

Front Line Demonstrations (FID)

Crops:

Fourteen technologies in agriculture, plant protection, horticulture, livestock production and home science were demonstrated under Front Line Demonstrations on farmer's field of villages - Manori, Pipra, Saisar, Ranmangli and Dongargaon. Extension activities like field days, field visits of farmers to FLD demonstrations, group discussions, scientists-farmers meet, etc. conducted for effective implementation of FLDs. The data on production parameters as well as feedback from farmers and visitors was recorded.

Details of Assessment of technologies under FLDs on Farmers Practice (FP) (2011-12)

Sr.No	Crop	Technology demonstrated	No. of farmers	Area (Ha)	Yield (q/ha)		Increase over FP
					FID	FP	(%)
1	Cotton	Drip irrigation	5	2.5	41.00	27.50	49.09
		INM	10	4.0	17.50	14.00	25.00
2	Wheat	Raj 4037	07	3.0	33.75	26.00	29.80
3	Linseed	NL 260	06	2.4	9.75	7.5	26.66
4	Pigeonpea	PKV Tara	04	1.6	15.30	12.00	27.50
5	Tomato	PKM -1	10	4.0	85.50	74.00	15.84
6	Chilies (Dry)	Tejas	15	6.0	15.00	12.70	18.11
7	8t Cotton	IPM	25	10.0	19.37	17.75	09.13
8	Nagpur Mandarin	Gummosis Management	10	4.0	53.4	39.1	36.57
9	Pigeonpea	Production Technology	30	12.0	17.20	13.44	27.98
10	Chickpea	Production Technology	30	12.0	15.85	11.88	33.42
11	Rice	Drudgery Reduction	18	1.0	138	128	10.4
12	Soybean	Drudgery Reduction	18	1.0	47	35	37

Livestock:

Two FLDs on 20 cows and 40 local goats were conducted on the farm of 20 farms families in villages - Dongargoan and Navegaon-sadhu of Nagpur district.. The details of FLDs are as follows:

Enterprise	Breed	No. of farmers	No. of animals	Performance parameters / indicators	Average yield		% change in the parameter	Cost benefit ratio of demo
					FLD	Local check		
Dairy farming (Urea treatment of wheat straw)	CB Jersey Cows	10	20	a) Av. Milk yield (l/cow/day) b) Milk fat	8.7 3.9	7.8 3.8	12% -	1:2.65
Use of Chelated mineral in cows diet	CB Jersey Cows	10	20	a) Av. Milk yield liUcow/day) b) Milk fat	12.7 4	11 3.85	15.5% -	1:2.80

On Farm Trail (Refinement)

KVK, CICR designed cotton pickingl harvesting aid

To overcome the problem of manual picking of cotton pickers, improved cotton picking bags were recommended by MAU, Parbhani and HAU, Hissar was initiated in 2008 consequently for three years. For assessing the benefit of the bag it was modified and tested during the year 2010-11 and 2011-12. Results of 2011 season indicated that the farm women endured back pain and shoulder pain while using conventional, MAU and HAU bags respectively. Therefore, KVK, CICR, Nagpur has designed a manual cotton picking aid suitable for central zone especially for Vidarbha farm women.This designed aid holds more cotton seed. The bag load is evenly distributed to the body which facilitates ease and comfort in loading and unloading of cotton which improves the working efficiency of cotton pickers.

Details of assessment of livestock production technologies under OFT on farmer's field

S. No	Animal	Technology Demonstrated	No. of farmers	No. of animals	Yield		% Increase over Farmers Practice
					Demonstration	Farmers Practice	
1	First calf heifer	Supplementation of Vitamin-mineral + Deworming	10	20	10.5 lit/cow/day	9.0 lit/cow/day	16.67
2	Lactating does	Supplementary concentrate feeding @ 50 *g/day*	10	20	0.947 lit/goat/day	0.800 lit/goat/day	18.33

Technology Park at KVK : Technology Park has been established in KVK's instructional farm for depicting cropping pattern of Nagpur district.. The area of technology park is protected by erecting chain linked fencing around it to safeguard the crops from predators.

Cotton Technology Week : Cotton Technology Week was organized during 21-26 Nov, 2011 and information on improved cotton production and protection technologies was provided to the cotton farmers. More than 250 numbers of farmers have participated in this week from Chandrapur, Akola, Wardha, Yeotmal and Nagpur districts of Vidarbha region. Demonstrations on cotton implements, Bt kits, Solar sprayers, identification of harmful and beneficial insects, field visits of the farmers were organized during the week. Created awareness among farmers about the importance of soil testing and methods of soil sampling and importance of INM in cotton crop etc.

Other extension activities

On Campus Crop Demonstrations: Twenty crop demonstrations on cotton, pigeonpea, soybean, sunflower, linseed, fodder jawar, fodder maize, berseem, vegetables *viz.* onion, brinjal, radish etc., fruits and flowers were undertaken during *kharif* and *rabi* season in its instructional farm and technology park. The production and protection technologies of these crops were demonstrated on area ranging from 0.2 ha to 0.4 ha for each crop. Several farmers, farmwomen and extension functionaries from Nagpur district and other states visited these demonstrations.

Kisan Mobile Advisory Services (KMAS) : KVK, Nagpur has launched Kisan Mobile Advisory Services (KMAS) for the benefit of the farmers of Nagpur district.. Advisory messages on agriculture and allied technologies on the mobiles of the farmers who are registered with KVK, are regularly being sent.. Thirty five advisory messages have been sent to 200

registered farmers during 2011-12.

Re-designing of KVK's website : Website with domain name: www.kvknagpur.org.in has been re-designed after incorporating web pages of weather forecasting, location map, soil map of Nagpur district, downloads, achievements of KVK Nagpur etc. Linking the website with ICAR institutes, CICR, AGMARK, IMD and agricultural universities.

Technology Park at KVK : Technology Park has been established in KVK's instructional farm for depicting cropping pattern of Nagpur district.. The area of technology park is protected by erecting chain linked fencing around it to safeguard the crops from predators.

Cotton Technology Week : Cotton Technology Week was organized during 21-26 Nov, 2011 and information on improved cotton production and protection technologies was provided to the cotton farmers. More than 250 numbers of farmers have participated in this week from Chandrapur, Akola, Wardha, Yeotmal and Nagpur districts of Vidarbha region. Demonstrations on cotton implements, Bt kits, Solar sprayers, identification of harmful and beneficial insects, field visits of the farmers were organized during the week. Created awareness among farmers about the importance of soil testing and methods of soil sampling and importance of INM in cotton crop etc.

Kisan Mela : Organized a Kisan Mela at village Manori Tq. Umred, Dist. Nagpur on February 21 ,January 2012. Dr. G. Malvi, Retd. Professor (Agronomy), Dr. Singandhupe and Dr.R.R.Gupta SMS, (Plant Protection) and Sh. Harish Kumbhalkar (Program Assistant) addressed the farmers and advised for the pest problems and their management.. More than 150 farmers who have grown cotton and pulses participated and benefited through information provided by the experts.

Kirtankar Mela : Kirtankar Mela was organized at village Thana, Tq. Umred, Dist. Nagpur on 21.09.2011. Dr. Peshkar Retd. Professor (Entomology) convinced the farmers on cotton cultivation through his innovative style of kirtan. More than 350 farmers were present..

Exhibitions : KVK participated in the following State and National level Agricultural Exhibitions "Dhammachakra pravartan Din" from 5th to 7th October 2011 at Dikshabhoomi, Nagpur, organized by Joint Director of Agriculture, Nagpur Division Nagpur. More than 1800 farmers visited to exhibition stall of KVK during exhibition.

State level Agricultural Exhibition at Gadchiroli on the occasion of "Dr. Panjabrao Deshmukh birth anniversary" from 27/12/2011 to 29/12/2011 organized was by Dr. PDKV, Akola . More than 2500 farmers visited to stall during exhibition.

Agro vision - 2012 : A State level exhibition organized at Reshimbagh Ground, Nagpur from 27th to 30th January 2012 . In this connection cotton workshop for the benefit of cotton growers was also organized in which DrAR.Raju, DrVishlesh Nagrare and DrAS.Tayade advised the cotton farmers.

Cotton Advisory services to Maharashtra Cotton Growers: As per guidelines of Director CICR and Scientific Advisory Committee (SAC) directive, cotton advisory services was started with active involvement of Head Division of Crop Protection and Production and others scientists. In all 13 advisories covering management of Para wilt in Bt cotton, leaf reddening, boll rot, white fly, sucking pest management, mealy bug management disease management, nutrient management, soil sampling techniques etc. were given through daily news such as Agro-won, Loksahi Warta, Deshonnati and Krishokannati. Overwhelming response to cotton advisory services from the cotton growers of Maharashtra was received and nearly 366 farmers have interacted through the mobile phones and their queries were solved.

Diagnostic surveys conducted: Thirty five diagnostic surveys were undertaken in adopted villages and other non adopted villages of Nagpur district and suggested the remedies to overcome specific problems in crops, citrus orchard and animals. Around 103 ha cropped area and 82 animals in six villages of Nagpur district were covered.

Group discussion on horticultural crops: Three group discussions on cultivation of pomegranate in village Makardhokda tahsil Umred, pre-harvest fruit drop in Nagpur mandarin in village Ubali and storage of onion bulbs in village Manori were organized on 21.12.2011, 02.03.2012 and 14.02.2012, respectively. In all 51 farmers, rural youth and extension personnel participated in the programmes.

Soil Testing Activities: One hundred fifty seven soil samples were collected from adopted villages of Umrer, Bhivapur and Saoner tahsils of the Nagpur district.. These samples were analyzed for different soil testing parameters and 149 soil health cards recommending soil test based fertilizer application for different crops were distributed to the farmers.

Oral Paper Presentation Award : Smt.. Sunita Chauhan presented paper on "Drudgery reduction of farm women through cotton picking bags" in 6th National Extension Education Congress -2011 conducted by Society of Extension Education from 17-19 Dec 2011 at ICAR Research Complex for Goa, Goa and received Best Oral Paper Presentation Award.

Scientific Advisory Committee Meeting : The 16th SAC

meeting was conducted on 12 July, 2011 under the chairmanship of Director, CICR, Nagpur. More than 18 members of agriculture and allied departments participated in the SAC meeting.

Visitors: More than 1100 visitors including practicing farmers, farm women, rural youths and extension functionaries and school children visited the instructional farm, technology park, goat unit, NADEP compost and vermi compost unit of KVK, CICR, Nagpur

Foundation stone of Farmer's Hostel: Dr. S. Ayyappan, Director General, ICAR laid the foundation stone of Farmer's Hostel of Krishi Vigyan Kendra (KVK), CICR, Nagpur on 11.12.2011 in the presence of Dr. C. D. Mayee former Chairman, ASRB and Dr. M. M. Pandey, DOG (Engineering). The hostel will facilitate the stay for the farmers who come to KVK for trainings.

Success Stories

1. Farmer's endeavor in Dairy farming

Shri. Rajendra Gulabrao Mahant, age 41 years is a resident of village Gondi digras, Post- Yenwa, Tah - Katol, Dist- Nagpur, having 3 acres of land and the income generated from land was insufficient to meet expenses of his family. Hence, he decided to start dairy entrepreneurship. He purchased one crossbred Jersey cow in 2007. During next year, he received one crossbred Jersey cow under Vidarbha Development Package.

Innovative approach ofthe farmer

Under the guidance of Krishi Vigyan Kendra, CICR, Nagpur, he started maintaining his dairy farm adopting scientific practices :-

- Strict vaccination schedule
- Regular deworming and dipping
- Scientific feeding and watering
- Storing medicines for emergency use
- Artificial Insemination technique
- Producing clean milk by using milking machine
- Cultivation of fodder crops - Hybrid fodder jowar (SSG) + fodder maize (African tall) + Perennial grass Napier (Jaywant phule) during *kharifand* Berseem / lucerne during *rabi*

He is maintaining continuous contact with KVK, Dept. of Animal Husbandry, NABARD officials & Bank Officials, for seeking advisory services and benefit of schemes.

Fruits of his efforts

He purchased two more cows out of resources generated by selling milk. In addition, he purchased 3 high yielding cows out of loan received Rs. 3.751akh under NABARD scheme.

Income generated from dairy farm

Addition of new high yielding cows increased his milk production from 50-55 lit/day to 90-95 lit /day. He is currently supplying milk to Nagpur based Oinshaw Company @ Rs. 20.25/ lit (for 5% fat containing milk) and @ Rs. 17.00 /lit (for 4% fat containing milk). His monthly gross income is Rs. 54,000/-.

Interest in extension activities

A week long training programme was organized for 45 intensive milk producing farmers of Katol tahsil on his farm in collaboration with KVK and LOa (Extn.), Panchayat Samiti, Katol.. A live demonstration of urea treatment of wheat straw was conducted on his farm.

Initiative to motivate other farmers of adjoining area

Three rural youth of his village established dairy farming due to his motivation and 18 milk producing farmers from surrounding villages joined him to supply milk to Oinshaw Company.

His expectations

Now he is extending his efforts to register this group as a co-operative society. KVK is providing its all possible support to make this endeavour successful.. To fetch remunerative prices for their produce, this group is looking forward to open their own outlet in Katol..

Benefit of consistent income from dairy farming

Unfortunately, his house caught fire on 19th March, 2012. But he didn't loose his courage and repaired his house by spending Rs. 1.00 lakh.

He is very proud to say, 'I don't find any need to borrow money to overcome such calamity as I am getting consistent income from my dairy farming'.

2. Establishment of Horticulture Nursery

Sh. Mahender Vasudeoji Karbhari, age 31 years is a resident of village Post- Ubali, Tah- Kalmeshwar, Oist- Nagpur, is a middle class farmer.. He has 21 acre of land out of which 7.5 acre land is irrigated. Earlier he was doing traditional farming with less irrigation facilities. His agriculture annual net income was about Rs. 22-25 thousand and he was taking loans from Banks and other Societies for agriculture needs and other social welfare. Often, he was unable to repay the installments of loans and was again taking loan from his relatives for paying the bank loans.

He started horticulture nursery in 2005 with a small rose nursery and some ornamental plants. Then, he came in contact with Krishi Vigyan Kendra, CICR, Nagpur.. KVK provided him all the technical guidance and arranged training programmes and exposure visits.

Present status of nursery

After adopting the scientific methodologies, he has developed horticulture nursery on about 5 acre of land including lawns of grasses, medicinal and ornamental plants, rose nursery and fruit plants. He has developed sprinklers, drip and micro-irrigation system and about 1000 sq. mts area under covered shed net.

Present social status

- Net profit about Rs. 1,00,000 /year by selling the nursery produce
- He has purchased one motor cycle, several agricultural implements, bullock pairs and other animals
- He has installed sprinklers, drip and micro irrigation system
- He has covered an area of about 1000 sq. mts with shed net
- He is repaying the loan installments with the income generated from nursery
- He is sending his nursery produces to Nagpur city for sale
- He has mobile and telephone connection

Self Help Group Installed Soy-Cow Plant

Self help group of backward class named as TULSI MAHILA BACHAT GAT was established in 2010. All the members of this group were previously doing labour work and were in search of some income generative activity.

Home Science SMS motivated them to learn the skill of preparing soymilk, tofu, soyflour, soynuts and okara based soygulab jamun and soysev in Feb, 2011.

They had applied for loan in Nagar Parishad, Kamtee. They had received loan of Rs. Seven lakh from "Swarna Jayanti Shahari Swa-RojgarYojna". They started this unit in Jan, 2012 and are preparing 5000 to 7000 bottles (200 ml capacity each) per month and gaining profit of Rs. 18000 to 22000 per month.

11. General

11.1 List of Publications

Papers Published in Research Journals

Acharya L., Mukherjee A K. and Panda P.C. (2011). Separation of the genera in the subtribe cassiinae (Leguminosae: Caesalpinioidae) using molecular markers. Acta Botanica Brasilica, 25(1):223-233. (NAAS Rating 6.8)

Amudha J., Balasubramani G., and Mohan Punit., (2012). Identification of DNA markers for resistance to grey mildew disease in cotton. Journal of Cotton Research and Development, 26 (1): 8-13. (NAAS Rating 4.3)

Amudha J., Balasubramani G., Malathi *VG.,* Monga D. and Kranthi K. R. (2011). Cotton leaf curl virus resistance transgenics with antisense coat protein gene *(AV1).* Current Science, 101 (4): 1-8. (NAAS Rating 7.3)

Blaise D. (2011). Tillage and green manure effects on Bt transgenic cotton *(Gossypium hirsutum* L.) hybrid grown on rainfed Vertisols of central India. Soil and Tillage Research, 114: 86-96. (NAAS Rating: 7.7)

Blaise D.and Kranthi K.R. (2011). *cry1Ac* expression in transgenic Bt cotton hybrids is influenced by soil moisture and depth. Current Science, 101: 783-786. (NAAS rating 7.3)

Dhamayanthi K. P. M. and Manickam S. (2011). Genetic variability studies in *Gossypium barbadense* L. genotypes for seed cotton yield and its yield components. Indian Journal of Agricultural Sciences, 81: 560-562. (NAAS rating 6.6)

Ohara Jothi B., SuruliveluT., Sonai Rajan T. and Valarmathi R. (2011). First Record on theEstablishment of the Parasitoid *Acerophagus papayae* Noyes & Schauff on *Para coccus marginatus* Williams and Granara de Willink in cotton. *Karnataka Journal of Agricultural Sciences,* 24(4): 536-537. (NAAS rating 3.3)

Ohara Jothi, B., Nagarajan, T. and Karthikeyan, A (2011). Cotton stem weevil and its management. . Madras Agricultural Journal, 98: 10-11. (NAAS rating 4.0)

Druzhinina I., Seidl-Seiboth V., Herrera-Estrella A., Horwitz BA., Kenerley, C.M., Monte E., Mukherjee P.K., Zeilinger S., Grigoriev IV, and Kubicek CPo (2011). Trichoderma: The genomics of opportunistic success. Nature Reviews Microbiology, 9: 749-759. (NAAS rating 10.0)

Kumar Rishi, Monga D., Nitharwal M., Jat S. L. and Kishor Chand. (2011). Validation of eco-friendly IPM packages in Bt-cotton at farmer's participatory field. Journal of Cotton Research and Development, 25 (2): 243-247. (NAAS Rating 4.3)

Kumar Rishi, Swami Dinesh, Kumhar Kishor Chand and Bhawaria R.S. (2011). New formulation of acephate and other insecticides against sucking pests in cotton Indian. Journal of Plant Protection, 39(3): 236-238. (NAAS Rating 4.3)

Kurian Raphael and Velmourougane K. (2011). Chemical and microbiological changes during vermicomposting of coffee pulp using exotic *(Eudrilus eugeniae)* and native earthworm (Perionyx ceylanesis) species. Biodegradation, 22:497-507. (NAAS Rating 7.7)

Meena N.K., Nagrare VS. and Medhi R.P. (2011). Thrips, *Dichromothrips nakahari* Mound (Thysanoptera: Thripidae) infesting the Orchids in India-A new report. Indian Journal of Horticulture, 68(4):587-588. (NAAS rating 6.7)

Mukherjee P.K. (2011). Genomics of biological control- whole genome sequencing of two mycoparasitic *Trichoderma* spp. Current Science, 101 :268. (NAAS rating 7.3)

Mukherjee P.K., Buensanteai N., Moran-Diez M., Druzhinina I.S. and Kenerley C.M. (2012). Functional analysis of NRPSs in *Trichoderma virens* reveals a PKS/NRPS hybrid enzyme involved in induced systemic resistance response in maize. Microbiology, UK 158: 155-165. (NAAS rating 7.8)

Mukherjee P.K., Horwitz BA and Kenerley C.M. (2012). Secondary metabolism in *Trichoderma-* a genomic perspective. Microbiology, UK 158: 35-45. (NAAS rating 7.8)

Nalayini P., Paul raj S. and Sankaranarayanan K. (2011). Growth and yield performance of cotton *(Gossypium hirsutum)* expressinJ the *Bacillus thuringiencis* var.Kurstaki as influenced by polyethylene mulching and planting techniques. The Indian Journal of Agricultural Sciences, 81 (1) : 55-59. (NAAS rating 6.6)

Nalayini P., Paul raj S. and Sankaranarayanan K. (2011). Evaluation of drip and polymulching for improving water use efficiency and productivity of cotton maize cropping system. Cotton Research Journal, 2(1): 39-44. (NAAS rating 2.6)

Palve S.M., Venilla S. and Kate N. (2011). Genetic analysis of agronomic traits and bollworm resistance in upland cotton. Cotton Research Journal, 2: 15-20. (NAAS rating 2.6)

Prabhakar M., Prasad YG., Thirupathi M., Sreedevi G., Dharajothi B., Venkateswarlu B. (2011). Use of ground based hyperspectral remote sensing for detection of stressin cotton caused by leafhopper (Hemiptera: Cicadellidae). Computers and Electronics inAgriculture, 79:189-198. (NAAS rating 7.5)

Praharaj C.S., Sankaranarayanan K., Kumar Narendra, Singh K.K. and Tripathi AK. (2011). Low input technologies for increasing crop productivity and sustainability: A review. Current Advances in Agricultural Sciences, 3 (1): 1-12. (NAAS rating 3.9)

Raghavendra K.P., Phanindra M. LV, Kumar Kiran B, Dhandapani G. and P Ananda Kumar. (2011). Identification of differentially expressed genes during bud stage of cotton boll development using suppression subtractive hybridization and cDNA macroarray. Journal of Plant Biochemistry and Biotechnology, 20(1): 12-19. (NAAS Rating 6.9)

Rajendran K., Palchamy A., Sankaranarayanan K., Prabakaran K. and Bharathi K. (2011). Enhancing the productivity of summer irrigated cotton through plant growth regulator and foliar nutrition. The Madras Agricultural Journal, 98(7 -8):248-250. (NAAS rating 4.0)

Raju A. R., Majumdar G., Thakre Soniya K., Reddy A. R., TaydeA S., Vijaya Kumari P. R., Chauhan S. N., Mahalle P. S. and Katore J. R. (2011). Rain water harvesting as strategic tool for drought mitigation in cotton. Journal of Cotton Research and Development, 25 (2),186-196. (NAAS Rating 4.3)

Raju AR., Majumdar G. and Reddy A. R. (2011). Validation of farm pond size for irrigation during drought. Indian Journal of Agronomy, 56(4): 356-364. (NAAS Rating 5.0)

Reddy A R., Yelekar Sachita M. and Agarwal Isabella. (2011). Total Factor Productivity and input utilization in cotton production in Maharashtra. Journal of Cotton Research and Development, 25 (2), 291-295 (NAAS Rating 4.3)

Reddy A R., Yelekar Sachita M., Petkar Rajendra B. and Anuradha N. (2011). Analysis of Human Labour Utilization in Cotton Production in Gujarat. Agricultural Economics Research Review, Vol. 24: 551. (NAAS Rating 4.7)

Sankaranarayanan K., Praharaj C.S., Nalayini P. and Gopalakrishnan N. (2011).Grain legume as a doable remunerative intercrop In rainfed cotton. Journal of food legumes, 24(1):18-22. (NAAS Rating 4.3)

Sankaranarayanan K., Praharaj C.S., Nalayini P. and Gopalakrishnan N. (2011). Growth, yield and quality of Bt cotton hybrid under varied planting patterns, NPK levels and season variations. Indian journal of Agricultural Sciences, 81(9):871-874. (NAAS Rating 7.3)

Sankaranarayanan K., Praharaj C. S., Nalayini P. and Gopalakrishnan N. (2012). Performance of intercrops in Bt cotton hybrid and assessment of its refugia system. Journal of Cotton Research and Development, 26:52-57. (NAAS Rating 4.3)

Sankaranarayanan K., Praharaj C.S., Nalayini P. and Gopalakrishnan N. (2011). Evaluation of Bt and non-Bt cotton hybrids under varied planting time. Indian Journal of Agronomy, 56 (1):68-73. (NAAS Rating 5.0)

Singh Jagvir, Bhaskar K.S. and Bharambe P.R. (2011). Available soil moisture and yield of rainfed hybrid cotton *(G.hirsutum)* as influenced by rainwater conservation practices. Indian Journal of Agronomy, 56(2): 154-158 (NAAS Rating 5.0)

Singh Jagvir, Babar Shilpa and Venugopalan MV (2012). Multi-location trial on high density planting in *desi* cotton (G. *arboreum)* with fertilizer management for improvement of cotton productivity of rainfed regions. Green Farming, Vol.3(2): 137-141. (NAAS Rating 2.9)

TayadeA S., Raju A. R. and Meshram M. K. (2011). Farmers participatory evaluation of transgenic Bt cotton in Nagpur district of Maharashtra through institute village linkage programme. Journal of Soils and Crops, 21(1): 60-64. (NAAS Rating 3.1)

Tayade AS., Raju A R. and Dhoble MV (2011) Studies on correlation and path coefficient analysis in Bt and Non Bt cotton hybrids *(Gossypium hirsutum* L.). Journal of Cotton Research and Development, 25(2): 147-151. (NAAS Rating 4.3)

Tayade A.S., Raju A R. and Dhoble M. V (2011). Effects of nutrient and pest management modules on fibre qualities of Bt and non Bt cotton *(Gossypium hirsutum I)* hybrids. Journal of Soils and Crops, 21(1):60-64 (NAAS Rating 3.1)

Tuteja O. P., and Verma S. K. (2011). Effect of alien cytoplasmic and nuclear genes on seed cotton yield and fibre quality traits in cotton *(Gossypium hirsutum).* Indian Journal of Agricultural Sciences, 81(4):296-304. (NAAS Rating 6.6)

Tuteja O. P., Banga Manju (2011). Effect of cytoplasm on heterosis for agronomic traits in upland cotton *(Gossypium hirsutum).* Indian Journal of Agricultural Sciences, 81 (11): 1001-1007. (NAAS Rating 6.6)

Tuteja O. P., Verma S. K. and Banga Manju. (2011). Heterosis for seed cotton yield and other traits in GMS based hybrids. Journal Cotton Research and Development, 25:14-18. (NAAS Rating 4.3)

Tuteja O.P, Banga Manju and Nirania K.S. (2011). Heterosis studies on GMS based hybrids in *Gossypium hirsutum* cotton. Journal of Cotton Research and Development, 25 (2): 162-164. (NAAS Rating 4.3)

Uma B., Raju A. R., Majumdar G., Meshram M.K., Mahalle P. S., Laxman S. and T. Pradeep. (2011). Integrated nutrient management for desi cotton (G. *arboreum)* in Gaurani cotton tract. Journal of Cotton research and Development, 25(2):202-206. (NAAS Rating 4.3)

Usha Rani, Sand Sankaranarayanan K. (2011). Post Evaluation of Farmers Field Schools on Cotton in Tamil Nadu. Journal of Extension Education, 23(1): 4592-4596. (NAAS Rating 2.7)

Velmourougane K., Bhat Rajeev, Gopinandhan T. N., Panneerselvam P. (2011). Management of *Aspergillus ochraceus* and Ochratoxin-A contamination in coffee during on-farm processing. Biological Control, 57: 215-221. (NAAS Rating 7.7)

Velmourougane K., Bhat Rajeev, Gopinandhan T. N., Panneerselvam P. (2011). Impact of delay in processing on mold development, Ochratoxin-A and cup quality in arabica and robusta coffee. World Journal of Microbiology and Biotechnology, 27: 1809-1816. (NAAS Rating 7.5)

Velmourougane K. and Bhat Rajeev. (2012).Changes in the physico-chemical and biological quality attributes of soil following amendment with untreated coffee processing wastewater. European Journal of Soil Biology, 50: 39-43. (NAAS Rating 7.6)

Venugopalan MV, Blaise D., Yadav M.S. and Deshmukh Rachna. (2011). Fertiliser Response and Nutrient Management Strategies for Cotton. Indian Journal of Fertilizers, 7(4): 82-94. (NAAS Rating 3.8)

Waghmare VN., Sutar *SR.,* Thakre PB., Deshmukh P.K., Badole AM. and Salame RV (2011). Diversity analysis in core accessions of upland cotton *(Gossypium hirsutum* L.). Cotton Research Journal, Vol. 2(2):37-46. (NAAS Rating 2.6)

Waghmare VN., Sutar *SR.,* Thakre P.B., Salame RV, Badole AM., Sapkal D.R. and Patil B.R. (2011). Comparative assessment of microsatellite and RAPD markers and their efficiency in DNA fingerprinting of upland cotton (G. *hirsutum* L.). Indian Journal of Agricultural Sciences, 82(12): 1116-11123. (NAAS Rating 6.6)

Yeotkar, S., Malode S.N., Waghmare VN. and Thakre P. (2011). Genetic relationship and diversity analysis of Clitoria ternatea variants and Clitoria biflora using random amplified polymorphic DNA (RAPD) markers. African Journal of Biotechnology, 10(79): 18065-18070. (NAAS Rating 7.0)

Zhang Z., Rang J., Waghmare V.N., Chee P.w., May O.L., Wright R. J., Gannaway *JR.* and Paterson AH. (2011). QTL alleles for improved fibre quality and yield from a wild Hawaiian cotton *(Gossypium tomentosum* L.). Theoretical and Applied Genetic, 123: 1075-1088. (NAAS Rating 7.9)

11.2 List of On-going Projects

Sl. No	Name of Project	Principal investigator (PI)/ Project Leader (PL)/ Project Associate (PA)/ CCPII Dr	Duration
	INSTITUTE		
	Crop Improvement		
1.	Collection, conservation, evaluation, documentation and maintenance of germ plasm of cultivated species of *Gossypium.*	Punit Mohan (PL) S Manickam (PA) VS Nagrare (PA) RA Meena (PA) V Santhy (PA) PR Vijayakumari (PA) Vinita Gotmare (PA) M Chakrabarti (PA) KPM Damayanthi (PA) K Rathinavel (PA) KP Raghvendra (PA)	2006-2013
2.	Improvement of tetraploid and diploid cottons for fibre properties through population improvement approaches.	VN Waghmare (PL) Vinita Gotmare (PA)	2000-2015
3.	OTL mapping for fibre quality traits in diplod cotton.	VN Waghmare (PL)	2011-2014
4.	Conservation, characterization and utilization of wild species, races of cultivated species and synthetic polyploids of *Gossypium.*	Vinita Gotmare (PL) G Balasubramani (PA)	2008-2013
5.	Breeding of upland cotton for improved fibre quality and resistance to biotic stress (bollworms and jassid).	SM Palve (PL) Vinita Gotmare (PA)	2005-2012
6.	Development of heterotic pool for superior medium staple in tetraploid cotton (G. *hirsutum).*	SM Palve (PL)	2006-2013
7.	Development of drought tolerant genotype with good fibre quality.	SB Singh (PL) AH Prakash (PA)	2008-2017
8.	Development of improved male sterile lines through induced mutation.	SB Singh (PL) OP Tuteja (PA)	2008-2012
9.	Development of mapping population for different economically important traits.	PK Chakrabarti (PL) VN Waghmare (PA) SM Palve (PA) SB Singh (PA) Vinita Gotmare (PA) TR Loknathan (PA) PR Vijayakumari (PA) Punit Mohan (PA) S Manickam (PA)	2008-2012
10.	Development of drought resistant transgenic cotton and identification of new genes for high water use efficiency.	J Amudha (PI) AH Prakash (PA) G Balasubramani (PA)	2008-2013
11.	Development of transgenic cotton resistant against major diseases of cotton.	PK Chakrabarty (PL) SB Nandeshwar (PA)	2009-2012
12.	Studies on genetic enhancement of *hirsutum* cotton.	TR Loknathan (PL)	2002-2012
13.	Identification of compact type and leaf hopper resistant genotype for HOPS.	TR Loknathan (PL)	2011-2014
14.	Development of transgenic diploid cotton for insect resistance.	SB Nandeshwar (PI) SB Singh (PA) PK Chakrabarty (PA) VS Nagrare (PA)	2008-2012

15.	Exploration, collection and conservation of perennials and land races of desi cotton from different regions of India.	M Saravanan (PL)	2011-2014
16.	Screening and Evaluation of PEG stress tolerance during seed germination in cotton (G. *hirsutum* and G. *arboreum)*	V Santhy (PL)	2011-2012
17.	Development of long staple G. *hirsutum* with improved fibre strength.	S. Manickam (PL) V. N. Waghmare (PA) S. L. Ahuja (PA)	2008-2014
18.	Development of extra-long staple high spinning hybrids with wider adaptability.	K.P.M.Damayanti (PL) S. Manickam (PA)	2006-2012
19.	Development of heterotic pools in G. *arboreum* and G. *hirsutum.*	S. K. Verma (PL) a. P. Tuteja (PA) S.L. Ahuja (PA)	2008-2012
20.	Development of markers for breeding programme.	S. K. Verma (PL) S. L. Ahuja (PA)	2008-2012
21.	Development of varieties and hybrids resistant to CLCuV.	a.p. Tuteja (PL) D. Monga (PA) Rishi Kumar (PA)	2008-2013
22.	Technology to enhance the better crop establishment and yield in cotton.	R. A. Meena (PL) D. Monga (PA)	2007-2012
	Crop Protection		
23.	Development of farmer friendly diagnostic kits for transgenic event purity	K R Kranthi (PI)	2007-2012
24.	Molecular characterization of transgene integration events, new gene constructs and discovery of new genes	P K Mukherjee (PL)	2011 - 12
25.	Identification and characterization of viral diseases of cotton in India.	AK Mukherjee (PL) A Sampathkumar (PA)	2010-2012
26.	Development of nanoparticles based biocontrol formulation for the management of major cotton pests and diseases.	A Sampathkumar (PL) V Chinna babu Naik (PA) K Velmourougane (PA)	2011-2014
27.	Bt resistance in pink bollworm *Pectinophora gossypiella* (Saunders) - monitoring mechanism and management. .	V. Chinna Babu Naik (PI) S Kranthi (Co-PI)	2010-2012
28.	Identification of sources of resistance and phylloplane microflora against *Rhizoctonia* root rot in tetraploid and *Fusarium* wilt in diploid cotton and their utilization for management. .	R C Ukey (PL) V N Waghmare (PA)	2006-2012
29.	Standardization of bioassays techniques for resistance monitoring in *Pectinophora gossypiella* Saunders to transgenic cotton and development of management strategies.	B Dhara Jothi (PI)	2007-2012
30.	Establishment of *Beauveria bassiana* as an symbiotic insecticide against major insect pests and diseases of cotton.	M Amutha (PI) M Gunasekaran (PA)	2010-2012
31.	Isolation of novel insecticidal proteins from bacterial symbionts of native entomopathogenic nematodes.	J Gulsar Banu (PI) B. Dharajothi (PA) Nandhini G. Narkhedkar (PA)	2009-2012
32.	Management of foliar diseases of through SAR including chemicals and *Pseudomonas fluorescens.*	M Gunasekaran (PI)	2010-2012
33.	Use of innovative methods for management of cotton leaf curls virus disease.	D. Monga (PL) Rishi Kumar (PA)	2011-2013
	Crop production		
34.	Development of high density planting systems (HDPS) for maximizing productivity of rainfed cotton.	MV Venugopalan (PL) Jagvir Singh (PA) Punit Mohan (PA)	2010-2014

		Vinita Gotmare (PA) SM Palve (PA) AH Prakash (PA) S Kranthi (PA) V Chinna Babu Naik (PA) AK Mukherjee (PA) G Majumdar (PA) AR Reddy (PA) SL Ahuja (PA) D Monga (PA) Rishi Kumar (PA) RB Singandhupe (PA)	
35.	Herbicide resistance weeds and their management strategies.	AR Raju (PL) Sankarnarayanan (PA)	2011-2014
36.	Management of waterlogged soils through cotton based cropping system.	RB Singandhupe (PL)	2011-2012
37.	Screening of cotton varieties with production technologies for organic cultivation under rainfed conditions.	Jagvir Singh (PL), K Velmourougane (PL) VS Nagrare (PA)	2011-2012
38.	Developing efficient carrier based microbial delivery system for cotton nutrition and soil health.	K Velmourougane (PL) Jagvir Singh (PA) AR Raju (PA)	2008-2012
39.	Amelioration of leaf reddening and parawilt in cotton.	AH Prakash (PI) Jagvir Singh (PA) VS Nagrare(PA) M Chakrabarty (PA)	2010-2014
40.	Screening of water logging tolerance of *Gossypium hirsutum* Germplasm lines.	J Annie Sheeba (PL), RB Singandhupe (PA)	2011-2014
41.	Effect of strigolactones on morphology and physiology of cotton (Ad hoc).	J Annie Sheeba (PL)	2011-2012
42.	Analysing and forecasting of cotton prices.	Anuradha Narala (PL)	2011-2013
43.	Assessment of cotton based intercropping system and its popularization through farmer to farmer participatory learning approach.	SM Wasnik (PL) S Usha Rani (PA) AR Raju (PA)	2008-2012
44.	Technological need assessment for sustainability and stability of cotton production.	SM Wasnik (PL) Anuradha Narala (PA)	2011-13
45.	Performance of white leghorn layers under feeding of Bt and Non-Bt cotton seed.	SN Rokde (PL)	2010-2012
46.	Herbigation with herbicide/ herbicide mixture/ herbicide rotation for efficient and environmentally safe weed control and its effects on succeeding pulses.	P.Nalayini (PL) K.Sankaranarayanan (PA) K,velmourougane (PA)	2008-2012
47.	Studies on the mechanism of cuticular absorption of nutrients and hormones in Bt cotton	S.E.SAKhader (PL)	2008-2012
48.	Economic impact of trade liberalization in cotton economy of India	Isabella Agarwal (PL)	2010-2012
49.	Gender and labour issues in cotton sectors of India	S. Usha Rani (PL), M. Sabesh (PA) S.M. Wasnik (PA)	2010-2012
50.	Evaluation of VAM and P solubilising bacteria and for enhancing P acquisition and mitigating water stress in Bt cotton cultivation.	D. Kanjana	2011-2012
	NAIP		
51.	Research into development of decision support systems for	VS Nagrare (CCPI)	2008-2012

	management of insect pests of major rice and cotton based cropping systems.	G Majumdar (CoPI) Rishi Kumar (CoPI) B Dharajothi (CoPI) M Sabesh (CoPI) M Amutha (CoPI)	
52.	A Value Chain for Cotton Fibre, Seed and Stalks: an innovation for higher economic return to farmers allied stakeholders.	Sankaranarayanan (CCPI) Jagvir Singh (CoPI) D Monga (CoPI) Rishi Kumar (CoCCPI)	2009-2012
53.	Georeferenced soil information system (Geosis) for land use planning and monitoring soil and land quality for agriculture.	MV Venugopalan (CCPI) K Velmourougane (CoCCPI)	2009-2013
	DBTIDST		
54.	Enhancing sustainability of transgenic crops through gene stacking Funded by the DBT under 'Indo-Australian -International Science Linkages' programme.	KR Kranthi (CCPI)	2008-2012
55.	Cloning and characterization of potent toxin gene from heat toleran isolate of *Heterrorhabdus indica,* an Entomopathogenic nematode. (DBT)	NG Narkhedkar (PI)t PK Charkrabarty (PA)	2009-2012
56.	Identification of Molecular markers and tagging genes for Bacterial blight resistance. (DBT)	PK Chakrabarty (PI) Punit Mohan (PA) VN Waghmare (PA) BM Khadi (PA)	2008-2012
57.	"Gene stacking in Bt Cotton". (DBT)	G Balasubramani (PI) SB Nandeshwar (PA) SB Singh (PA)	2008-2012
58.	Isolation and identification of seed specific promoter and gossypol synthesis genes for silencing through RNA interference. (DBT)	KP Raghavendra (PI) J Amudha (PA)	2010-2013
59.	Design and development of cotton picking head. (DST)	G Majumdar (PI) AR Raju (PA)	2010-2013
60.	DBT; Fine mapping of fibre quality and economic traits using RILS in diploid cotton.	VN Waghmare (PI) TR Loknathan	2010-2012
	GEAC		
61.	Event based approval mechanism (GEAC)	S Kranthi (PI)	2009-Continuous
	CSIR : NMITLI		
62.	Novel approaches for production of hybrid seeds with characteristics of improved insect resistance and higher yield.	KR Kranthi (CCPI)	2008-2012
	ICAR Network Project		
63.	Impact, adaptation and vulnerability of Indian agriculture to climate change. Sub project- changes in soil carbon reserves as influenced by different ecosystems and land uses in India.	MV Venugopalan (CCPI)	2009-2012
64.	Transgenics in Crops (NPTC): Development of bollworm resistance transgenic cotton.	G Balasubramani (PI) SB Singh (CoPI) J Amudha (CoPI) SB Nandeshwar (CoPI) KR Kranthi (CoPI) PK Chakrabarty (CoPI)	2006-2012
65.	Mega Seed Project - Seed production in Agriculture crops.	PK Chakrabarty (Nodal Officer)	2007-2012

		PR Vijayakumari (PI) V Santhy (PA) K Rathinavel (CCPI) RA Meena (CCPI)	
66.	National Seed Project (crops).	K.Rathinavel (PI) P.RVijayakumari (PA) R. A. Meena (PA)	1999-2012
	PRIVATE SEED COMPANIES		
67.	Monitoring changes in baseline susceptibility to Cry toxins in the cotton bollworm, *H. armigera*	S Kranthi (PI) KR Kranthi (CoPI) CB Naik (CoPI)	2002- 2012
	DUS		
68.	Testing & Documentation of Extant Varieties, hybrids and their Parents for Distinctness, Uniformity & Stability (PVP & FR ACT, 2001).	K Rathinavel (PI) V Santhy (CCPI) PR Vijayakumari (CCPI) RK Deshmukh (CCPI)	2003-2012
	Govt . of Maharashtra		
69.	Crop pest surveillance and advisory project (CROPSAP) 2011-12 in Maharashtra.	VS Nagrare (PI)	2010-2012

Technology Mission on Cotton (TMC): Mini Mission-I : 2007-2012

Project code	Project Title	Name of PI/CCPI Dr.
MM 1.1	Development and promotion of medium and long linted diploid cottons (G.arboreum and G.herbaceum)	S. K. Verma (on leave) - PI 1, R. Loknathan - CCPI Punit Mohan - CCPI S. L. Ahuja - CCPI
MM 1.2	Development of extra long staple G.barbadense cotton with improved fibre qualities to meet the requirements of textile industry	K. P. M. Dhamayanti - CCPI
MM 1.3	Identification of G. hirsutum genotypes suitable for machine picking and development of agronomic package	V. Gotmare - CCPI
MM 1.4	Development and promotion of Bt transgenic cotton for bollworm resistance	S. Manickam - CCPI Suman Bala Singh - CCPI S. B. Nandeshwar - CCPI S. M. Palve - CCPI O. P. Tuteja - CCPI
MM 1.5	Molecular characterization of cotton germplasm using DNA markers	V. N. Waghmare - PI P. R. Vijaya Kumari - CCPI V. Santhy - CCPI K. Rathinavel - CCPI R. A. Meena - CCPI
MM 1.6	Exploitation of apomixis and TGMS system in hybrid cotton seed production	S. M. Palve - PI V. Gotmare - CCPI V. Santhy - CCPI
MM 2.1	Development of production technologies for Bt cotton and improvement of water and nutrient use efficiency with precision farming techniques	J. V. Singh - PI M. V. Venugoplan CCPI K. Sankaranarayanan - CCPI
MM 2.2	Identification of innovative Bt cotton based cropping systems.	P. Nalayini - PI K. K. Bandopadhyay - CCPI A. R. Raju - CCPI R. A. Meena - CCPI
MM 2.3	Mechanization of cotton production	G. Majumdar - PI A. R. Raju - CCPI
MM 2.4	Physiological manipUlation of Bt plant morphoframe for enhanced productivity under varied agro-climatic conditions	A. H. Prakash - PI Annie Sheeba - CCPI

Project code	Project Title	Name of PIICCPI Dr.
MM 3.1	Emerging and key pests: - their characterization, taxonomy, genetic diversity and control	Sandhya Kranthi - PI K. R .Kranthi - CCPI V. S. Nagrare - CCPI A. K. Mukherjee - CCPI V. Chinna Babu Naik - CCPI T. Surulivelu - CCPI (Mrs) B. Dharajyoti - CCPI Dilip Monga - CCPI Rishi Kumar - CCPI
MM 3.2	Development and validation of IPM fiRM strategies for Bt Cotton under different ecosystems.	(Mrs) J. Gulsar Banu- CCPI Sandhya Kranthi - CCPI V. S. Nagrare - CCPI V. Chinna Babu Naik - CCPI Rishi Kumar - CCPI
MM 3.3	Development, validation, utilization and f or commercialization of bio-pesticides and bio inoculants	T. Surulivelu - CCPI J. Gulsar Banu - CCPI N. Narkhedkar - PI Dilip Monga - CCPI
MM 3.4	Development of farmer friendly diagnostic kits for transgenic event seed.	K. R. Kranthi - PI
MM 4.1	Quality evaluation of cotton fibres	M . Chakrabarty - CCPI
MM 5.1	Total factor productivity of cotton in India	Isabella Agarwal - PI A. R. Reddy - CCPI S. M. Wasnik - CCPI
MM 5.3	Indian cotton portal	M. Sabesh - PI G. Majumdar - CCPI
MM 5.4	TMC MMI Co-ordination and Monitoring Cell	A. R. Reddy - PI M. V. Venugopalan - CCPI V. Santhy - CCPI

Technology Mission on Cotton: Mini Mission II 2007-2012

Project Title	Name of PI/CCPI Dr.
Dissemination of IRM strategies in India.	K. R. Kranthi (PI) B. Dharajyoti - CCPI D. Monga - CCPI Rishi Kumar - CCPI

11.3:Consultancy, Patents, Commercialization of Technology

Patent published in Patent office

S. No.	Title	Provisional Application No. alotted by Patent Office	Date of Publication	Name of Inventor
1	Enhancing *cry1Ac* expression in Bt cotton using jasmine perfume	*111/MUM/2009* Dt. *19/01/2009*	*04111/2012*	Dr. Sandhya Kranthi
2	Propagation of diploid cotton *Gossypium arboreum* by multiple shoot induction	*1557/MUM/2009* Dt. *2/07/2009*	*19/12/2012*	Dr. S.B. Nandeshwar
3	PCR detection Kit for *Xanthomonas oxonopodis* pv. *Malvecearum*	*1558fMUM/2009* Dt. *2107/2009*	*14/01/2012*	Dr. P.K. Charabarty
4	Solar Powered Knapsack Sprayer with tilting arrangement	*1559/MUM/2009* Dt. *2/07/2009*	*20101/2012*	Er. Gautam Majumdar
5	Bullock drawn vertical rotor cotton planter for vertisols	*1560/MUM/2009* Dt. *2/07/2009*	*20101/2012*	Er. Gautam Majumdar
6	Cotton Seed Blower	*1561/MUM/2009* Dt. *2/07/2009*	*20101/2012*	Er. Gautam Majumdar

Revenue Generation

The Bt Referral lab sold Bt Quant, Bt Express, Gus Detect kits and tested judicial samples earning a revenue of Rs. 2,65,796 in 2011-2012.

Technology Commercialized

CICR, Nagpur in collaboration with MIs. Precision Tooling Engineers, Nagpur has developed Cotton Seed Blower(Patent No. 1561/MUM/2009) to clean healthy seeds from impurities, broken and unviable seeds which will translate into better crop stand and population. The machine could be used by the farmer individually or on a custom hire basis. The machine was commercially launched on 12th Nov. 2011.

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

Research Advisory Committee Meeting

The Research advisory Committee (RAC) Meeting for the year 2011 was held under the Chairmanship of Dr. S.K. Patil, Ex. Director IARI & Ex-VC, UAS Dharwad on 10th May, 2011. The RAC members who participated in the meeting included Shri Suresh Warpudkar, Ex-Minister Agriculture, Maharashtra, Shri Sharad Tasare, Ex-MLA,, Dr. V. Kumar, Head, Cotton Research Station, Surat, Dr. Jadhav, Ex-Director Extension, MAU Parbhani and Dr. MV Venugopalan, Principal Scientist, Agronomy, CICR as Member Secretary.

Dr. P.R. Bharambe, Head, Division of Crop Production, Dr. R.K. Deshmukh, I/C Head, Crop Improvement Division, CICR, Nagpur, Shri M.K. Meshram, I/C, Head, Crop Protection Division, Dr. D. Monga, Head, CICR Regional Station, Sirsa, and Dr. Surulivelu, Head I/C, CICR Regional Station, Coimbatore were special invitees. Dr. Nandini Gokte Narkhedkar, Principal Scientist, Crop Protection Division and Dr. VN. Waghmare, Senior Scientist, Crop Improvement were the rapporteurs.

In his opening remarks Dr. SA Patil appreciated pivotal role played by NAS system in development of farmer oriented technologies. He further mentioned significant role played by cotton in country's economy. He suggested that adaptive research trials are must for determining suitability of Bt hybrids and agronomists of SAU may be involved in these trials. Introduction of new genes in breeding is important and needs to be strengthened. Cotton pickers for small farmers also need to be developed. Dr. K.R. Kranthi, Director, presented the action taken report, which was discussed and approved by the chairman and members of the RAC. Dr. K.R. Kranthi presented an overview of cotton in the country and world alongwith problems that plague Indian cotton. He advocated growing cotton in high density planting system (HOPS) to achieve breakthrough in productivity. He mentioned that straight growing dwarf plants with a single stalk would meet the criterion of HOPS. He added that new gene discovery, construct making, transgenic development, implements for mechanization in cotton have been taken up as flagship programmes by CICR, Nagpur. Shri Suresh Warpudkar stressed need for research on validating quality of hybrids developed by private companies. Shri Sharad Tasare suggested that attention be given to management of weeds in cotton system. Shri Jadhav desired that research on reducing cost of cultivation be taken up and system productivity needs to be enhanced.

In his concluding remarks Chairman emphasized on interaction with International organizations for fibre quality improvement and suggested that research on seed technology be taken up in depth. The meeting concluded with vote of thanks presented by Dr. Venugopalan, Member Secretary, RAC.

The Research Advisory Committee (RAC) Meeting for the year 2012 was held on 23,d Feb. 2012 under the Chairmanship of Dr. S.K. Patil, Ex. Director IARI & Ex-VC, UAS Dharwad. The RAC members who participated in the meeting included Dr. V Kumar, Head, Cotton Research Station, Surat, Dr S. Srinivasan, Ex-Director, CIRCOT, Mumbai, Dr N. Gopalakrishnan, ADG (CC), ICAR New Delhi and Dr. MV Venugopalan, Principal Scientist, Agronomy, CICR as Member Secretary.

At the outset, Dr. K.R. Kranthi, Director, CICR welcomed the Chairman and members of the RAC. In his opening remarks Dr. S. A. Patil appreciated the contribution of CICR, Nagpurfor development of Bt Diagnostic kits and its commercialization. He expressed his concern about the slow progress of cotton improvement work. He desired that field breeding should be strengthened. To renew the importance of public sector research, he insisted for public-private partnership in strategic areas with more visibility and transparency. International collaborations are required especially in biotechnology.

Dr. Patil felt that with the enormous number of private Bt cotton hybrids available in the market, it has become a challenging task to assess their suitability and yield benefits at different locations. Proper research methodology should be evolved to identify appropriate hybrids suitable for specific regions. He suggested simplicity in breeding, for instance selection of traits by 4-5 rounds at each intermated cycle of selection, for which comprehensive field work is required in compartmental and convergent mode to compete with the private sector.

Dr M. V. Venugopalan, Member Secretary, presented the action taken report, which was discussed and approved by the Chairman and members of the RAC.

Institute Research Council (IRC) Meeting

Annual Institute Research Council meetings were held at CICR, RS Sirsa on AprilS, 2011 and CICR, Nagpur on May 21 and June 6-8, 2011 under the Chairmanship of Dr. K.R. Kranthi, Director, CICR, Nagpur.. The results of research projects at CICR, Nagpur and CICR RS Sirsa were presented by individual Project leaders and discussed in IRC. Technical programme for 2011-12 was also finalized for each project.. IRC Meeting for CICR RS Coimbatore was organized on August 29, 2011 and October 18, 2011 through video conferencing in two sessions. The meeting was chaired by the Director Dr. K.R. Kranthi, Dr. A.H. Prakash, PC and scientists at Nagpur and Coimbatore participated in the deliberations. The first session was conducted at Sugarcane Breeding Institute, Coimbatore and NBSS&LUP, Nagpur and the second session was organized at CICR, Nagpur and CICR, RS, Coimbatore without any interruption. Scientists of CICR, RS Coimbatore presented their research findings for the year 201 0-11.

Under the aegis of IRC scientific talks were delivered by Dr. P.K. Mukerjee, Principal Scientist, Plant Pathology, on 'Fungal Genetics to Cotton Improvement Novel Strategies For Management of Cotton Pests and Diseases' on July 23, 2011 and Dr. Vinita Gotmare, Senior Scientist on 'Genome Resource Conservation' on Sept.. 17,2011.

Institute Management Committee (IMC) Meeting

The 49th Meeting of Institute Management Committee of CICR, Nagpur was held on 10 May 2011 at CICR, Nagpur under the Chairmanship of Dr. K. R. Kranthi, Director, CICR, Nagpur..

The following Committee Members were present during the meeting:

Dr. V.M. Mayande, Vice Chancellor Dr. PDKV, Akola,

Shri Sharad Tasare, Ex. Deputy Maharashtra Assembly, Amravati - Non-Official member

Sh. SA Warpudkar, Ex-Minister Parbhani- Non-Official member

Dr. D. Monga, Head, CICR-RS, Sirsa - Member

Dr. G. Balasubramani, Senior Scientist, CICR, Nagpur - Member

Shri. O.P. Nagar, Senior F&AO, NBSS&LUP, Nagpur - Member

Shri. NVR.N. Murty, F&AO, CICR, Nagpur - Spl.. Invitee

Shri. Sachin Agnihotri, I/c Sr. Administrative Officer, CICR, Nagpur - Member Secretary

The Committee members noted the progress on Financial Management / Progress of works/ Farm Development / KVK activities and Research Achievements of the Institute and expressed their Satisfaction.

The meeting ended with thanks to Chair and the Members by the Member Secretary.

Results -Framework Document (RFD) Committee

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

S.No	Category	Name & Designation
1	RFD Nodal Officer	Dr. M. V. Venugopalan, Principal Scientist (Agronomy)
2	One Scientist	Dr. K. P. Raghavendra, Scientist (Biotechnology)
3	One Technical Officer	Dr. M. S. Yadav, Technical Officer (7-8)
4	One Administrative Staff	Mr. Ghanshyam D. Sakhare Lower Division Clerk & Typist

Stakeholder meeting on Surgical and Absorbent cotton

The Central Institute for Cotton Research (CICR), Nagpur is working its way towards partnering with surgical cotton manufacturers and farmers and absorbent cotton manufacturers by promoting organic *Des;* cotton as the raw material..

A stakeholder meeting on Surgical and Absorbent cotton was held under the Chairmanship of Director CICR, at CICR, Nagpur on 29-11-2012 in which around 12 manufacturers of medical/surgical/absorbent cotton participated. Chairman in his opening remarks expressed concern about the gradual decline in the area of *des;* cotton and the erosion of biological diversity. Dr. Punit Mohan, PS made brief presentation on the genetic resources of *des;* cotton with special reference to their use of surgical purpose. The stakeholders expressed the difficulties faced in procuring coarse quality *Des;* cotton needed for manufacturing surgical grade cotton. The current

annual national and international demand for surgical and absorbent cotton as well as projections for future was discussed. It was agreed that demand surgical and absorbent cotton is growing at the rate of 10 per cent per annum across the world. In India itself, the demand is of up to 20 lakh bales per year. Besides Indian market it has export potential too. Japan, USA and EU countries import absorbent cotton from India with specific standards.

The absorbent cotton of pharmaceutical grade, which is used for surgical purposes, has to satisfy certain specifications with respect to micronaire, absorbency, water-soluble matter, pH, staple length, ash content etc. These fibre qualities were enumerated. Technical feasibility and cost effectiveness of making surgical cotton in a more eco-friendly way was also explored. The potential of G. *arboreum* race *cemuum* (comilla) cotton for surgical cotton manufacture was explained. The idea of adopting a 'cluster of villages' approach to cultivate *desi* cotton of fibre quality suited for surgical and absorbent use in Vidarbha and Madhya Pradesh, the heart land of G. *arboreum* cotton under a buy back agreement was worked out..

11.5:Participation of Scientists in Seminars/ Symposia/ Workshops

Sr. No.	Seminars/Conferences /Symposia/ WorkshopslTraining	Place and Date	Participants
1.	State Level Seminar on Women in Agricultural Development: ChallenQes and Opportunities	TNAU, Coimbatore 19-04-2011	Dr. S. Usha Rani
2.	Contemporary Approaches to Crop Improvement	GKVK Campus, Bangalore 22-04-2011 to 23-04-2011	Dr. S. M. Palve
3.	Farmers Workshop on Agriculture	Nagpur 14-05-2011 to 15-05-2011	Dr. S.M. Wasnik
4.	National Workshop on Strengthening NBPGR-NAGS Partnership for Efficient Management and use of Plant Genetic Resources	NBPGR, New Delhi 29-07 -2011 to 30-07-2011	Dr. Vinita Gotmare
5.	APS International Plant Protection Congress, Joint Meeting, Root - Knot resistance in cotton by RNAi mediated silencing of parasitism genes of Meloidgyne incognita	Honolulu, Hawaii, USA 6.8.2011 to 10.8.2011	Dr. (Mrs) Nandini Gokte-Narkhedkar
6.	National Consultation on Gender Perspective in Agriculture	NASC, New Delhi 08-08-2011 to 09-08-2011	Dr. Mukta Chakrabarty
7.	National Workshop on Information and Communication Technology in Agriculture (ICT-A)	TNAU, Coimbatore 9-08-2011 to 10-08-2011	Dr. B. Dharajothi Dr. S. Usha Rani
8.	Workshop on Understanding Biosafety Clearing House (BCH) - as an *effective* tool for global information on LMOs/GMOs	NASC, New Delhi 12-09-2011	Dr. Mukta Chakrabarty
9.	International conference on microbial biotechnology for sustainable development,	Punjab University, Chandigarh 03-11-2011 to 06-11-2011	Dr. P.K. Mukherjee
10.	World Cotton Research Conference - 5	Mumbai 7-11-2011 to 11-11-2011	Dr. K.R. Kranthi and other scientists *
11.	Innovations in Farming System Research and Extension for Inclusive Development	Madras Veterinary College, Chennai 24-11-2011 to 25-11-2011	Dr. S. Usha Rani
12.	International Conference of Biopesticides (ICOB-6)	Maejo University, Ching Mai,Thailand 11-12-2011 to 16-12-2011	Dr. J. Gulsar Banu
13.	National Extension Education Congress on Emerging Models of Technology Application for Agri-Rural Development	ICAR Research Complex for Goa, Goa, 17-12-2011 to 19-12-2011	Dr. S. Usha Rani
14.	State level Seminar-"Breaking yield barriers in major field crops".	Dr. PDKV,Akola 06-01-2012 to 07-01-2012	Dr M.V. Venugopalan
15.	Microbes in health and agriculture	JNU, New Delhi 12-03-2012 to 13-03-2012	Dr. P.K. Mukherjee

* Dr. S. Kranthi, Dr. A.H. Prakash, Dr. B. Ohara jothi, Dr.K.P.M. Dhamayanthi, Dr. P. Nalayini, Dr. K. Sankaranarayanan, Dr. J. Gulsar Banu, Mr. M. Sabesh, Dr. S. Usha Rani, Dr. Blaise Desouza, Dr. M. V. Venugopalan, Dr. Jagvir Singh, Dr. Mukta Chakrabarty, Dr. A. R. Reddy, Dr. S. M. Wasnik, Dr. A.R., Raju, Er. G. Majumdar, Dr. Punit Mohan, Dr. G. Balasubramani, Dr. V.N. Waghmare, Dr. S.B. Nandeshwar, Dr. S.M. Palve, Dr. T.R. Loknathan, Dr. Vinita Gotmare, Dr. J.Amudha, Dr. P.R. Vijayakumari, Dr. V. Santhy, Dr. V. Chinna Babu Naik

11.6: Distinguished Visitors

Name & Designation	Organisation	Date
Nagpur		
Dr. SA Patil, Ex- Director, IARI & Chairman, RAC	Chairman, Farmers Commission of Karnataka, Bengaluru	11.05.2011 & 23.02.2012
Dr. Norberto Mahalambe, Director	Institute of Cotton, Mozambique	06 ..07.2011
Mrs. Olga Mulima, Cabinet Member	Ministr Agricultue, Govt.. of Mozambique	06 ..07.2011
Shri Atanu Purkayastha, Joint Secretary (TMC)	Department of Agriculture & Cooperation, New Delhi	21.09.2011
Dr. S. Ayyappan, Secretary, DARE and Director General,	Indian Council of Agricultural Research, New Delhi	11.12.2011
Dr. M. M. Pandey, DOG (Engineering)	Indian Council of Agricultural Research, New Delhi	11.12.2011
Dr. C. S. Prasad, Vice-Chancellor	MAFSU, Nagpur	11.12.2011
Mr. Kirk Benton, Global Director	Fertilizer and Agro-chemicals, Archer Daniels Midland, USA	15.12.2011
Coimbatore		
Dr. N. Gopalakrishnan, ADG (CC)	Indian Council of Agricultural Research, New Delhi	19.07.2011
Dr. S. Ayyappan, Secretary, DARE and Director General,	Indian Council of Agricultural Research, New Delhi	31.07.2011
Dr. P.L. Gautam, Chairman	PPV&FRA, New Delhi	20.09.2011
Sirsa		
Dr. S. R. Singh, Ex Vice Chancellor	RAU, Bikaner	11.08.2011
Dr. H. S .Lohan, Ex Additional Director Agriculture	Govt.. of Haryana, Haryana	11.08.2011

11.7: Personnel

Name of the Scientists/Officers, Designation & E-mail

Director

K R Kranthi, Director, krkranthi@gmail.com

Project Coordinator (Cotton)

Coimbatore

A.H. Prakash, P.c. (Cotton) & Head, prak_ah@rediffmail.com

Biotechnology

Nagpur

G Balasubramani, Senior Scientist, bala77bio@gmail.com
Smt. J Amudha, Senior Scientist, jamudhacicr@gmail.com
K P Raghavendra, Scientist, kpraghavendra@gmail.com
Smt. Pratiksha Mayee, Scientist, ever_pratiksha@yahoo.com

Plant Breeding

Nagpur

P. K. Chakrabarty, HOD, Crop Improvement, pranjibc@hotmail.com
Smt. S. B. Singh, Principal Scientist,sumanbalasingh2005@yahoo.com
T R Loknathan, Principal Scientist, loknathantr@sify.com
S M Palve, Principal Scientist, smpalve2kl@yahoo.com
V N Waghmare, Senior Scientist, vijayvnw@yahoo.com
M Saravanan, Scientist, msaranjari@gmail.com

Coimbatore

S Manickam, Principal Scientist, manickam.cicr@gmail.com

Sirsa

S L Ahuja, Principal Scientist, slahuja2002@yahoo.com
O P Tuteja, Principal Scientist, optuteja2001@yahoo.co.in
S K Verma, Senior Scientist, surenderkumar64@yahoo.co.in

Genetics & Cytogenetics

Nagpur

S B Nandeshwar, Principal Scientist, sbn3@rediffmail.com
Smt. Vinita Gotmare, Senior Scientist, vinitag22@gmail.com

Coimbatore

Smt. K P M Damayanthi, Senior Scientist, kpmdham@yahoo.com

Seed Technology

Nagpur

R K Deshmukh, Principal Scientist
Smt. P R Vijayakumari, Principal Scientist, rachelvk123@gmail.com
Smt. V Santhy, Scientist (SS), santhylOO@gmail.com

Coimbatore

K Rathnivel, Principal Scientist, krathinavelus@gmail.com

Sirsa

R A Meena, Principal Scientist, rameenacotton@rediffmail.com

Economic Botany

Nagpur

Punit Mohan, Principal Scientist, punitmohan@gmail.com

Agronomy

Nagpur

P R Bharambe, HOD, Crop Production, (Retd. 30.06.2011)
D. Blaise, HOD, Crop Production, blaise_123@rediffmail.com (2.9.2011)
M V Venugopalan, Principal Scientist, myvenugopalan@gmail.com
R B Singandhupe, Principal Scientist, rbsingandhupe@gmail.com
A R Raju, Senior Scientist, bumaraju@gmail.com

Coimbatore

K Shankaranarayanan, Senior Scientist, sankaragro@gmail.com
Smt. P Nalayani, Senior Scientist, nalayiniganesh@gmail.com

Soil Science

Nagpur

Jagvir Singh, Principal Scientist, mr.rawatjsS6@rediffmail.com

Coimbatore

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

Agricultural Engineering

G Majumdar, Scientist (SG), gama62@rediffmail.com

Plant Pathology

Nagpur

M K Meshram (Retd. 31.05.2011)
P K Mukherjee, Principal Scientist, prasunmala@gmail.com
R C Ukey, Principal Scientist
A K Mukherjee, Senior Scientist, titirtua@gmail.com
A Sampath Kumar, Scientist, sampath_a@rediffmail.com

Coimbatore

M Gunasekharan, Senior Scientist, mgsekar@gmail.com

Sirsa

Dilip Monga, Head of Station, dmonga2009@gmail.com

Entomology

Nagpur

Smt. Sandhya Kranthi, HOD, Crop Protection, sandhya.kranthi@gmail.com
V S Nagrare, Scientist (SS), vs.nagrare@gmail.com
Chinna Babu Naik V, Scientist, chinnaenton@gmail.com

Coimbatore

T Surulivelu, Principal Scientist, surulivelu@gmail.com (Retd. 31.08.2011)
Smt. B Dhara Jothi, Senior Scientist, bdhara.jothi@gmail.com
Smt. M Amutha, Scientist, amu_ento@rediffmail.com

Sirsa

Rishi Kumar, Senior Scientist, rishipareek70@yahoo.co.in

Nematology

Nagpur

Smt. Nandini Narkhedkar, Prin. Scientist, nnarkhedkar@rediffmail.com

Coimbatore

Smt. J Gulsar Banu, Senior Scientist, gulsarsci@gmail.com

Plant Physiology

Nagpur

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

Coimbatore

S E S A Khader, Principal Scientist, sesakhader@yahoo.co.in

Biochemistry (PS)

Nagpur

A B Dongre, Principal Scientist (Retd. 30.06.2011)
Smt. M. Chakrabarty, Scientist (SG), budiya12@yahoo.com

Microbiology (PS)

Nagpur

K Velmourougane, Scientist, velicar@gmail.com

Agriculture Extension

Nagpur

S M Wasnik, Principal Scientist, wasniksm2007@yahoo.co.in

Coimbatore

Usha Rani, Scientist (SS), ushajoshua@rediffmail.com

Agricultural Economics

Nagpur

A R Reddy, Senior Scientist, ar.reddy@gmail.com
Smt. Anuradha Narala, Scientist, anuradhanarala@gmail.com

Coimbatore

Smt. Isabella Agarwal, Senior, Scientistis_agarwal@rediffmail.com

Computer Application

Coimbatore

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

Livestock Production and Management

Nagpur

S N Rokde, Principal Scientist, sunilrokde_2007@rediffmail.com

PME CELL

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

Administration

Sachin Agnihotri, Administrative Officer, sach_agni123@rediffmail.com
N V R N Murty, Finance & Accounts Officer, finance.cicr@rediffmail.com

11.8: Other Information

Visits Abroad

Dr. P.K. Chakrabarty, Head, Crop Improvement Division, CICR, Nagpur was on Sabbatical Leave under the programme on Plant Molecular and Cellular Biology Programme at University of Florida from 15.03.2011 to 14.03.2012.

Dr. O.P. Tuteja, Pr. Scientist, CICR, Regional Station, Sirsa visited C-4 Countries (Burkina, Faso, Benin, Chad & Mali) to study the viability of "Creating Sustainable Textile & Apparel Value Chain in Cotton-4 Countries" from 1 - 19 May, 2011.

Foreign delegation visits to CICR

Dr. Norberto Mahalambe, Director of Institute of Cotton and Mrs. Olga Mulima, Cabinet Member, Ministry of Agriculture, Government of Mozambique visited CICR Nagpur on July 6, 2011 as members of a high level delegation. The delegation visited CICR, Nagpur to get acquainted with strides made by India in Cotton particularly transgenic cotton and to discuss ways to access transgenic varieties/ germ plasm for improvement of cotton in Mozambique. Dr. Mahalambe during his interaction with CICR scientists discussed prospect of long term partnership as desired by Mozambique with India. During this visit, Dr. Mahalambe and Mrs. Olga Mulima visited experimental fields and laboratories.

Visit ofWCRC-5 delegates to Nagpur

A post conference tour was arranged during Nov 12-13, 2011 for 38 foreign delegates who participated in WCRC5, Mumbai. The tour was aimed at showcasing to the delegates the cotton cultivation practices as well as post harvest scenario (ginning, pressing, spinning and weaving to finished goods). The programme was oriented in the way that the delegates could experience the all round advancement of cotton industry, cotton cultivation and seed production in Nagpur through visit to Morarjee Textiles Ltd., Butibori, Nagpur, Bhagirath Ginning and Pressing Mills, Kalmeshwar, Nagpur, CIRCOT Ginning Training Centre, Amravati Road, Nagpur, Bajaj Steel Double Roller Gin Manufacturing, HingnaUnit, Precision Tooling Engineers, Hingna Road andAnkur Seed Production Farm.

Visit to CICR was a prominent part of the tour on 12th Nov, 2012. Dr. K.R. Kranthi, Director, CICR welcomed the delegates and explained briefly the activities of the Institute. The delegates were taken around the experimental fields, demonstration plots and wild species garden. Discussions were held with the concerned scientists relating to their experiments. Farmers of local adopted villages and involved in Front Line Demonstrations were called for an interactive meeting with the delegates. CICR KVK Programme coordinator and other officers helped the farmers during the interaction. The visit was coordinated by Dr. G. Balasubramani and Mrs. Mukta Chakrabarty.

Biotechnology Laboratory

Ultra modern facilities was created to carry out biotechnological research in the CICR and it was inaugurated at the hands of Dr. S. Ayyappan, Director General, ICAR & Secretary, DARE on 11.12.2011.

Library

Additions

In the period from 2011-12, the Library purchased 2 new books and subscribed to 3 foreign journals and 191ndian journals.

Documentation Services

- Library has developed computerized bibliographic database on Cotton to provide comprehensive and updated information on cotton. About 4182 bibliographic 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 (V26, (No. 1-4), January - December 2011) 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 science are made available overthe 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 WebOPAC 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.

Institute Sio Safety Committee Activities

The Institute Bio Safety Committee (IBSC) conducted 3 meetings (02-04-11,11-04-11 and 27-02-12) during the year under the Chairmanship of Director with Dr. Ashok P.Giri, Senior Scientist from NCL, Pune as DBT Nominee. Dr. Giri along with the Committee members, visited the Molecular Biology and Tissue Culture Laboratories, the Poly House and Green House facilities and also checked the related bio safety measures and observed that all facilities are as per the norms of DBT guidelines.

The first two meetings were convened mainly to finalise the trials (Contained and Confined Field) on transgenic cotton development (for bollworm resistance with *cry1Ac* and *cry1F* genes, leaf curl virus resistance with acp x scp gene and drought resistance with DREB gene) to be conducted during 2011-12 season and to apply for permission to RCGM and the third meeting was held for evaluation of the results of the trials of 2011-12 and to recommend trials for 2012-13 for applying to RCGM. Proposed trials for 2012-13 also include transgenic development containing chitinase gene for disease resistance, *CP* and *AC2* genes for leaf curl virus resistance, *cry1Aa3, cry1Ac* and *cry1F* genes for bollworm resistance and *acp, scp* and *arep* genes for leaf curl virus resistance. IBSC has also communicated to State Govt.. of Maharashtra and Haryana for obtaining NOC for conducting the Confined Field Trials. The No Objection certificate from Govt of Haryana has already been received to conduct trials at CICR Regional Station, Sirsa.

CICR Foundation Day

CICR celebrated its Foundation Day on 1st April, 2011. Dr. C.D. Mayee, Ex- Chairman, ASRB, New Delhi delivered a talk on "Potential benefits of agriculture biotechnology". Students from biotechnology department of different colleges of Nagpur and retired scientists of CICR participated along with the CICR staff.

Progressive Use of Hindi

Nagpur

Hindi Week

Hindi awareness week was celebrated at CICR Nagpur from 08.9.2011 to 14.9.2011 with great enthusiasm. Various competitions were conducted to encourage the staff members to showcase their potential in the Hindi language. On the spot poem composing on a given subject, namely "Corruption" was one of such events apart from translation of English words to Hindi and a Quiz in Hindi.. The events were well represented by the staff belonging to different categories. Dr. v.J. Shivankar, Director, NRCC, Nagpur graced the occasion as the Chief Guest commended the level and spirit of participation in various events. Apart from the winners of various competitions, prizes were given away to staff who had made use of Hindi language as a medium of official work as well as to those who had a maximum number of scientific and technical articles in Hindi. The entire programme was organized under the leadership of Dr. K.R.. Kranthi, Director CICR and was ably coordinated by Mrs. Mukta Chakrabarty, Dr. G. Balasubramani, Mr. S. Agnihotri, Dr. R.R.. Gupta and Shri.. P.P Gokulpure.

Coimbatore

Official Language Implementation Activities

The Official Language Implementation is being effectively carried out at CICR, Regional Station, Coimbatore The station received First Prize in Hindi Implementation Activities for the year 2010-11 instituted by the Town Official Language Implementation Committee, (TOll C) Coimbatore.

11.9: Weather

Nagpur

Month	Temperature (DC)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
June, 2011	30.1	24.5	84.5	69.2	148.0	13
July, 2011	32.4	25.0	89.2	68.7	120.0	13
August, 2011	30.2	24.2	92.4	78.0	322.0	18
September, 2011	31.8	23.8	88.9	66.2	149.0	12
October, 2011	33.0	18.9	74.2	33.6	-	-
November, 2011	31.7	15.8	70.9	28.6	-	-
December, 2011	29.3	12.9	66.2	29.4	-	-
January, 2012	27.5	14.3	80.0	48.1	-	-
February, 2012	32.8	15.6	58.2	24.3	9.0	1
Total					**748**	**57**

Coimbatore

Month	Temperature (DC)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days (>2.5 mm)
	Max.	Min.	Max.	Min.		
April, 2011	33.4	22.9	89	49	168.8	7
May, 2011	34.2	23.0	92	52	24.8	3
June, 2011	30.7	23.0	84	57	93.0	7
July, 2011	30.7	23.2	83	57	32.3	4
August, 2011	31.3	22.9	87	57	7.1	1
September, 2011	31.9	22.2	88	59	67.9	4
October, 2011	31.6	22.6	91	59	305.3	14
November, 2011	28.7	20.8	90	61	243.1	10
December, 2011	29.3	19.1	89	52	11.6	1
January, 2012	29.7	18.4	89	46	1.0	-
February, 2012	32.3	19.2	83	35	0.0	-
March, 2012	34.9	22.5	84	36	1.2	-
Total					**956.1**	**51**

Sirsa

Month	Temperature (DC)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days (>2.5 mm)
	Max.	Min.	Max.	Min.		
April, 2011	35.5	18.9	58.0	22.9	7.3	5
May, 2011	41.9	26.5	47.7	22.8	27.3	5
June, 2011	40.7	28.2	63.2	37.4	32.8	5
July, 2011	36.9	28.0	75.6	51.9	14.8	7
August, 2011	33.7	26.5	86.9	70.7	289.8	17
September, 2011	33.0	24.9	86.8	65.2	122.2	8
October, 2011	33.1	17.9	75.5	35.3	0.0	-
November, 2011	29.0	12.9	78.2	35.6	0.0	-
December, 2011	23.4	5.8	80.1	37.4	0.0	-
Total					**494.2**	**47**

11.10: Cotton Scenario

Cotton provides natures best fibre in the form of lint for an array of textile products. It also yields oil for human consumption, feed for livestock, biomass for particle board, corrugated box, paper etc. and base chemicals for a plethora of industrial products. Currently, 51 per cent of the domestic fibre consumption of our country for textile production is constituted by cotton whereas 41 per cent is constituted by man-made fibre. The global scenario is, however, slightly different.. At the global level, the proportion of synthetic fibre consumption to cotton consumption is 60:40.

For *five* consecutive years after 2005, India has harvested a record average of 300 lakh bales, leaving behind the best *ever* historical record of 1651akh bales before the introduction of Bt cotton. A 35% increase in area under cotton (from 78 lakh hectares in 2002 to 121.91 lakh ha in 2011), increase in hybrid cotton area from 40% in 2001 to 92% in 2011, favourable weather conditions and extremely low bollworm infestation, good market price for the cotton *have* contributed to the rise in production. During the 11'h Plan period the area under Bt cotton increased from 63.31akh ha in 2007-08 to *over* 100 lakh ha during 2011-12. Long staple cotton which constituted 20% in 2000, increased to 74% of the total cotton produced in 2010 because of the Bt cotton hybrids, most of which are of the long staple category

Details of state-wise cotton area, production and productivity are given in Table 2.

Table 2: State-Wise Cotton Area, Production and Productivity

Zone/State	2010-2011 *			2011-2012 *		
	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)	Area (Lakh ha)	Production (Lakh bales)	Productivity (kg/ha)
Punjab	5.30	18.50	593	5.60	19.50	592
Haryana	4.92	17.00	587	6.05	20.00	562
Rajasthan	3.35	10.10	513	5.30	17.10	548
North Zone	13.57	45.60	571	16.95	56.60	568
Gujarat	26.33	106.20	686	30.23	120.00	675
Maharashtra	39.32	87.75	379	40.95	73.75	306
Madhya Pradesh	6.50	17.70	463	7.06	17.70	426
Central Zone	72.15	211.65	499	78.24	211.45	459
Andhra Pradesh	17.84	59.50	567	18.54	54.50	500
Karnataka	5.45	11.10	346	5.49	13.25	410
Tamil Nadu	1.22	7.20	1003	1.21	7.20	1012
South Zone	24.51	77.80	540	25.24	74.95	505
Orissa	0.74	2.05	471	1.02	2.05	342
Others	0.45	2.00	756	0.46	2.00	739
Grand Total	111.42	339.10	517	121.91	347.05	484

1 bale= 170 kg.
Source: Office of the Textile Commissioner, Mumbai. * - As estimated by CAB in its meeting held on 18.04.2012

Impressions of Visitors

It is a pleasant experience visiting CICR.. Congratulations and best wishes in all endevours

Dr. S. Ayyappan
Secretary, DARE & DG
ICAR, New Delhi

Very impressed with the work of Research Centre. Please carry on as activities here will decide the fate offarmers engaged with cotton cultivation in the country. My Best Wishes toAl1.

Shri .Atanu Purkayastha
Joint Secretary, DAC
GOI, Krishi Bhawan, New Delhi

The work underway is really forward looking and very important.. It is our feeling and believe that the technology for the future will flower from Nagpur, from CICR.. Congratulations and hoping on fruitful cooperation.

Dr. Norberto Mahalambe
Director, Institute of Cotton
Mozambique

Wonderful facilities, dedicated staff, the institute is really doing very well.. Compliments to Director and his team. The addition of KVK will provide a platform to reach the unreachable, the farmers in remote areas. Keep it up.

Dr. C. S. Prasad
Vice-Chancellor, MAFSU
Nagpur

Excellent facilities,labs and research. Compliments to the Director, Scientists & Staff.

Dr. M. M. Pandey
DDG (Engg.)
ICAR, New Delhi

भा कृ अनु प
ICAR

केन्द्रीय कपास अनुसंधान संस्थान, नागपुर
CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR
(Indian Council of Agricultural Research)
Post Bag No.2, Shankar Nagar Post Office, Nagpur - 440010
(Maharashtra), India