2. EXECUTIVE SUMMARY

2.1 Crop Improvement

Nagpur

- Sixty seven new germplasm lines of Asiatic cotton were collected from South India and added to germplasm repository ofCICR. .
- Gene Bank is enriched with 732 exotic cotton acceSSIOns.
- Six unique germplasm lines possessing novel traits were registered with NBPGR while 3 new germplasm with unique characters were identified.
- DNA fingerprinting of 100 germplasm of cotton was done.
- Three hundred forty one G. *hirsutum* germplasm including exotic accessions, 40 G. *barbadense,* 103 G. *arboreum* and 6 introgressed derivatives were distributed to breeders for cotton improvement. .
- GMS based hybrids NGMSH 5-09 and NGMSH 31-09 proved highly promising with superior yield and fibre quality characteristics.
- NHH 44 Bt was submitted for approval for commercial cultivation.
- New Bt hybrid CNH 415 was found highly promising in field trails.
- G. *arboreum* cultures CINA 369 proved highly promising in Nagpur while culture CAN103 excelled in South Zone.
- TGMS trait was found to be monogenic and recessive in nature.
- Culture CNHO 12 identified for high oil content was submitted for release under AICCIP..
- Three new inter-specific F, hybrids developed employing wild species were added to existing collection of hybrids. Besides 26 wild species, 13 races and 32 synthetic polyploid were maintained in the species garden.
- First public sector BN-Bt *G.hirsutum* variety released for commercial cultivation.
- Large number of transgenic events with *cry1Ac, cry1Aa3, cry1F* and *cryIIa5,* Chitinase genes were established in tetraploid and diploid cotton for bollworm tolerance and fungal resistance.
- Fifty two elite cultivars were under Bt-conversion at various stages of back crossing.
- Transgenic events were established with sense and anti-sense gene constructs in G. *hirsutum* cultivars H 777, F 846 and HS 6 for CLCu V resistance.
- For RN Ai mediated resistance against CLCu V were inverted repeat constructs pkSBGus-~C4-SA were cloned in binary plasmids pB inAR and pGreen developed for transformation of cotton.
- Ten new sense and anti-sense strands of CP, MP, AC2, ~C1, ~V4 sequences of CLCuV were created and cloned for generation of 5 inverted repeat constructs for transformation of cotton.
- Genes *AthA* and *RSW* associated with fiber development were cloned from *Arabidopsis* for cotton improvement. .
- 14 out of 40 RAPD and 30 SSR primers used for screening polymorphism among bacterial blight resistance and susceptible lines showed polymorphism among the contrasting parents.
- Out of 330 SSR and 60 RAPD markers screened for analysis polymorphism among diploid and tetraploid parental genotypes with contrasting fiber quality traits 12.72-33.3% showed polymorphism.

Coimbatore

- Culture CCH 510-4 was released and notified for commercial cultivation in South Zone comprising of the states of Tamil Nadu, Kamataka and Andhra Pradesh under the name Suraj. This variety was found tolerant to jassids under both South and Central Zone conditions.
- Culture CCH 801 recorded the highest yield of 2840 kg/ha with high ginning outturn of38 per cent, while CCH 812 recorded the highest

fibre strength of25.6 g/tex.

- In the National Trial under irrigated conditions, Culture CCH 2623 recorded the highest yield of 1995 kg/ha in the Central Zone and the second highest yield of 1911 kg/ha in the South Zone. CCH 4474 was found to possess a higher fibre length and strength.
- Fibre quality evaluation of lint samples of germplasm lines indicated wide variability with 2.5 % span length ranging from 26.4-37.9 mm, micronaire from 3.7-5.7 and bundle strength from 22.7 - 30.2 g/tex.
- The tetraploid interspecific hybrids CCHB-5339 (2662 kg/ha) and CCHB-51074 (2367 kg/ha) were found significantly superior in their yield performance than the best check hybridDCH 32 (1853 kg/ha).
- Seed viability can be retained at 76% by coating the cotton seeds with polykote @ 3ml/kg of seed diluted with 5 ml water combined with carbendazim @ 2 g /kg and imidacloprid @ 7g/kg and stored in polythene bags.

Sirsa

- The variety CISA 614 was tested in 32 locations in the North Zone (Punjab, Haryana and Rajasthan) during 2004-2007 and has recorded an overall mean seed cotton yield of 2204 kg/ha as against 1834 kg/ha ofHD 123 (zonal check) and 1990 kg/ha of local checks. It had a mean ginning outturn of36.6 per cent. In lint yield, the variety has recorded an increase of 25.15% over zonal check variety HD 123. It also possessed CISA 614 recorded slightly superior fibre technology characteristics in comparison to zonal, local check varieties and qualifying varieties. This variety, CISA 614, has been identified for commercial cultivation in North Zone.
- In the AICCIP North Zone trials, GMS based hybrid CSHG 1862 in 2nd year testing, recorded a mean seed cotton yield of 3389 kg/ha (3fd rank) with 27.4 mm 2.5% span length, 4.4 micronaire and bundle strength of 22.1 g/tex compared to zonal check CSHH 198 (2806 kg/ha) and was retained in the zonal trial for final testing.
- The GMS hybrid CISAA 14 recorded seed cotton yield of 2292 kg/ha (3'd rank) with 36.5% GOT, 2.5% span length and strength of 18.3 g/tex against zonal check CICR 2 (2100 kg/ha) and was promoted to Br 25a zonal trial for further testing.
- The hybrid CSHH 1907 recorded a mean seed cotton yield of2318 kg/ha (2nd rank) with 34.9 percent ginning outturn, 27.8 mm 2.5 % span length, 4.4 micronaire and bundle strength 21.5 g/tex compared to zonal check CSHH 198 (2062 kg/ha) and was promoted to Br05a1 CHT zonal trial for further testing.
- In the AICCIP National trial, G. *hirsutum* cultures CSH 3129 recorded a mean seed cotton yield of2285 kg/ha (4th rank) with 23.6 g/tex strength, micronaire 4.2 while CSH 612 recorded 2236 kg/ha (5th rank) with 26.5 mm 2.5% span length and bundle strength 20.4 g/tex compared to zonal check RS 2013 (1648 kg/ha) and both the varieties are promoted to Br 03 zonal trial for further testing.
- Mainly fertile plants were obtained while crossing CISA 2 (GMS), DS 5 (GMS) and GAK 413A in combinations indicating that the gene for sterility is different in all the three GMS lines.
- Fifty eight single plants were selected based on yield and fibre quality traits. These single plant selections had 2.5% span length (mm) in the range 21.8-27.8, fibre strength (g/tex) in the range 19.6-21.7 and their micronaire was <5.5.

2.2 Crop Production

Nagpur

- Studies on the long term effect of fertilizers indicated that INM (60: 13:26 kg NPK ha-1 + 20 kg S + Zn4.5 kg/ha + PSB + FYM@5t/ha+ DAP 2 % foliar application) recorded significantly higher seed cotton yield (16.7 q/ha). The mean active forms of organic carbon (very labile and labile forms) in soil ranged from 47-55 % in INM and organic plots as against 42 % under recommended dose of NPK alone. Physiologically important microflora viz. Azotobacter, PSM and

Pseudomonads registered higher population in INM and organic plots.

- Imbalanced nutrition resulted in 30% reddening ofleaves in cotton resulting in yield reduction to the extent of 500 kg ha-1. Magnesium application and rain water conservation techniques considerably checked the leaf reddening on farmers field.
- Microbial population was not significantly different in soils under Bt and non Bt cotton at all stages of crop growth. However at flowering stage it recorded maximum population. The new identified solid carrier based delivery system recorded higher bio inoculants count..
- Bt cotton intercropped with the green gram *1* soybean gave significantly higher yield of cotton and cotton equivalent yields over the opening of furrows in alternate rows. Addition of micronutrients with RDF on soil test basis recorded significantly highest seed cotton yield, nutrient use efficiency and water use efficiency followed by 75 % N through inorganic + 25 % N through organic.
- Irrigation through drip applied at 0.8 ETc followed by 1.00 ETc recorded significantly higher seed cotton yield than that at 0.6 ETc. However, highest water use efficiency was recorded at 0.6 ETc and it was lowest under furrow irrigation.
- For rainfed cotton grown on Vertisols of central zone, entire recommended quantity of K may be applied as basal dose instead of split applications. For higher seed cotton yield and high N utilization efficiency (27 kg seed cotton *1* kg N uptake), N may be applied in 3 equal splits at 10,45 and 75 days after sowing in a normal rainfall year and at 10,30 and 60 days after sowing in a drought year.
- Bt cotton + maize intercropping recorded highest cotton equivalent yield on shallow soil. Bt cotton + marigold was the best combination on medium deep soil under rainfed conditions in central zone.
- A novel solar operated knapsack sprayer has been developed tested and modified which has a field capacity of 4 hrs/ha. The weight of the sprayer without pesticide is 9 kg, with a swath of 90 cm giving 20 sprays with single charge.
- Closer spacing (90 x 20 cm) had an effect on compactness of the cotton plants which is more desirable for mechanical picking. Ethrel spray @ 7000 ppm concentration recorded highest percentage of leaf shedding of 91 % at the wider spacing of 90 x 60 cm, making plants amenable for mechanical picking.
- Ethrel sprayed@ 30 ppm (5.7 m molar SDM) at square initiation stage recorded significantly highest seed cotton yield in Bt cotton hybrid NCS 145.
- Total factor productivity of cotton (1980-2004) increased @ 6.111 per cent per annum in Gujarat, 5.321 per cent per annum in Maharashtra and 5.1776 per cent per annum in Madhya Pradesh.
- The cotton based cropping system cotton + arhar recorded cotton equivalent yield ranging from 15.35 to 17.0 q/ha. However, the system recorded the highest returns of Rs. *122621* ha with B : C ratio 1.57 in medium size group.
- Studies on social dynamics of cotton production in distress areas of Wardha and Yeotmal districts of Vidarbha revealed that majority of cotton farmers had high level of alienation (71.5 %) from land. This alienation arises because of high degree of powerlessness, meaninglessness, isolation and self estrangement. .
- The assessment of cotton based intercropping indicated that common practice of cotton + pigeon-pea strip intercropping is being practiced mostly by the farmers in cotton growing region ofMaharashtra. The adoption of other intercropping systems like cotton + soybean, cotton + mung *1* mid, cotton + cowpea, is negligible.

Coimbatore

- Highest net return (Rs. *1,16,810/ha),* benefit cost ratio (3.51), per day profitability (Rs. 779/day) and relative economic efficiency (221 per cent higher than sole cotton) were calculated with multitier system of cotton intercropped with radish, beet root and coriander with the application of 100 per cent

recommended levels of fertilizer to intercrops.

- Significantly highest seed cotton yield was harvested with cotton, raised after *in situ* incorporation of ragi at 45 days after sowing along with soil application of *Trichoderma viridi.*
- Cotton-sorghum system was superior to cotton-fallow system in this agro-climatic region with respect to improvement in soil health in terms of better aggregation, carbon sequestration besides additional crop yield and income generation.
- Herbicide rotation of pendimethalin 1.0 kg, 1 HW + metalachlor 1.0 kg/ha on 30 DAS recorded lesser weed DMP of12.4 g/m^2 to 16.4 g/m^2 and the WCE was up to 94.7 % on 60 DAS.
- Balanced fertilizer application of 120 : 60 : 60 kgs NPK in either 4,6 or 8 splits with entire P and 50 kg Mg S04+ Boron (as solubor 1 kg) as basal with two foliar spraying ofDAP 1.5 % + K 0.5 % + Mg S04 0.5 % + Boron as Solubor 0.15 % during flowering to boll development stages recorded significantly higher yield and prevented premature.
- Sustainable Yield Index (SYI) calculated on the basis of mean, highest and standard error in yield was maximum and relatively stable (0.42) under Integrated Nutrient Management (NPK: 60:13:25 kg/ha + FYM @ 5 t/ha), followed by NPK + crop residue incorporation @ 2.5 t/ha and organics (FYM @ 15 t/ha) only.
- Hoagland solution of 50% strength as foliar application during water logging stress and recovery period helped the plants maintain better status of chlorophyll, nitrate reductase activity, higher number of bolls all cumulatively resulting in better yield realization.
- Comparative analysis between diversified cotton growers and non-diversified cotton growers revealed that the majority of the diversified farmers had high level of economic efficiency than the non diversified farmers. Experience in cotton farming for many years, big farm size, high annual income, high level of socio-economic status, good contact with extension agency, high level of mass media exposure, high level of risk orientation and economic motivation were the factors that influenced the cotton growers for diversified farming.
- Econometric model suggested that education, irrigation, distance to market centre, distribution of seeds and regional characteristics have significantly determined the probability and degree of adoption. Frontier production function shows that none of the farms in the sample is fully efficient and that there is substantial scope for improving the technical efficiency of cotton production in Tamil Nadu.

Sirs a

- The seedling ofBt. hybrids RCH 134 raised in small, medium and large disposable containers containing mixture of coir pit + FYM + soil (50: 35: 15). The twenty days old seedlings raised in large containers gave significantly higher plant stand (98.6 %) and yield /ha (3035 kg/ha) than normal sown crop (2510 kg/ha).
- The performance of RCH 134 with (sole cotton, paired row sole cotton, groundnut, sesamum, mungbean, moth bean and cluster bean) and without intercrop combinations were evaluated and noticed that the yield (3301 kg/ha) was significantly higher in sole cotton compared to paired row cotton (2771 kg/ha) with and without intercrops.
- Among the cropping sequences (normal sown cotton-wheat, barley and mustard; transplanted cotton-wheat, barley and mustard) evaluated, the highest net income/ha Rs 46935 and 51315 was observed in cotton followed by wheat with normal and transplanted cotton sown, respectively.

2.3 Crop Protection

Nagpur

- Insect pest infestation during the season was minimum during 2008-09. Mealybugs were found to infest several weed plants, apart from cotton. Significant positive association of jassids and thrips; whiteflies and mirids; spiders with predatory mirids was observed

during their temporal occurrence.

- Forty different isolates of *Fusarium oxysporum* were categorized on the basis of virulence, speCIes specificity, growth, pigmentation etc. SSR primers were designed and synthesized from SSR motifs of nine different loci of *Fusarium* genome.
- The presence of Tobacco Streak Virus (TSV) was confirmed on six Bt hybrids (RCH 2 Bt, Bramha Bt, Nirja Bt, Dyana Bt, Sigma Bt, Mallika Bt) and two non-Bt pre-released hybrids (Warangal **HH** 2 and Warangal **HH** 3) samples collected from Andhra Pradesh.
- Eleven species of Hemipterans were recorded in the cotton ecosystem. Three species of Hymenopteran parasitoids and five species of Coccinellid predators were recorded on mealybugs. A new parasitoid, *Aenasius* sp. (Hymenoptera: Encyrtidae) was found to parasitize 57% of mealybug *(P solenopsis)* colonies infesting cotton. A predatory beetle, *Scymnus coccivora* was found to feed on the mealybug *(P solenopsis).* The beetle has been found to occur in the natural ecosystem of cotton in many parts of Central India.
- Amongst five new lectins tested for toxicity to aphids, soybean agglutinin was found to be the most effective with mortality levels exceeding >99% by the end of the 4th day. Banana lectin caused 100% mortality after 6 days. Artocarpin and jacalin were also found to be effective.
- A new diet recipe was developed and was found to sustain aphids for more than 20-30 days without any mortality. A novel bioassay was developed to evaluate the efficacy of lectins on cotton aphids *(Aphis gossypii).*
- Primary and secondary forms of bacterial symbiont of *Heterorhabditis indica* were isolated and protein profile of two phases of the bacterium was resolved on SDS PAGE. Protein fractions were tested against 3rd instar larva of *Helicoverpa armigera* for insecticidal activity. Observations on insect mortality after 24 hrs revealed that fraction >50 KDa recorded more than 98% mortality after 24 h while 10K fraction recorded 60% mortality.
- Low cost insect cages were designed and constructed with PVC pipe and muslin cloth. The cages can be used to conduct laboratory bioassay on insects, especially sucking pests on cotton plants.
- Mealybug reanng was standardized on sprouted potatoes. An initial inoculum of 5-10 gravid mealybug females was adequate. A temperature range of 20 _35^0 C was the most suitable for rapid proliferation.
- PCR amplified fragments of 28s rDNA and 18s rDNA from *Phenacoccus solenopsis* were sequenced and compared with the sequences of *Phenacoccus solani.* At least three unique restriction sites were identified for the two speCIes and used to develop molecular diagnostic tools to distinguish the two species.
- Locus specific tests have been designed for all the approved transgenic events of cotton based on sequences flanking trans gene inserts. The tests are being used under the Event Based Approval Mechanism through a Standing Committee of the GEAC.
- ELISA has been developed for NPT-**II,** VID-A, and *cry1F.* Antiserum has been raised against *cry1C, cry2Ab* and VIP-3A. Immunochromatographic 'dipstick' kits have been developed for crylF and NPT-II. Reaf-Time PCR was standardized for MoN-531 andMoN-15985.
- Thirty five Bt-cotton hybrids from four Bt events of Mon 531 *(cry1Ac),* Event 1 *(cry1Ac),* GFM *(cry1Ac+cry* lAb) and Mon *15985 (cry1Ac+cry* 2Ab) were evaluated in a replicated trial along with five non Bt cultivars to study the association of emerging and key sucking pests under completely unprotected conditions.
- 574 germplasm lines were evaluated for their reaction to sucking pests, effect on natural enemies and response to bollworm damage. Cultures CPT 1068 (B), CPT 1080, CPT 423 (A) and CPT 1094 had higher yield levels in addition to better quality parameters (> 25 mm staple length and >23 g/tex bundle strength) with tolerance to jassids and bollworms.
- Two bollworm tolerant genotypes 'CINHTi 3' and 'CINHTi 4' were developed by transferring a *trypsin inhibitor (Ii)* gene into

two elite genotypes BN and GCot 10, through back-cross breeding. These genotypes can also be used as donor parents for trypsin inhibitors to develop bollworm resistant cultivars.

- A synthetic analogue of jasmonic acid (Jasmine perfume) when sprayed on cotton crop, reduced jassid incidence, significantly increased the incidence of *Chrysopa* eggs while reducing the oviposition by *H. armigera*. Laboratory studies indicated that jasmine perfume has negligible insecticidal activity when applied topically. Spraying jasmine perfume enhanced the levels of LOX 1 (lipoxygenase 1) and LOX 2 (lipoxygenase 2).
- The germplasm line 116 TLYC Macha was found to be resistant to root-knot and reniform nematode. Bikaneri nerma, Sharda and Paymaster were found to be resistant to root knot nematode. Application of ascorbic acid at 0.1 % was found to induce resistance to root-knot nematode in susceptible host by reducing nematode penetration by as much as 48%. This correlates with the role of ascorbate oxidase and ascorbic acid imparting resistance to root-knot nematodes.
- Amongst the 32 genotypes evaluated for resistance to root rot, Bikaneri Nerma, NISC 19, Saubhagya, Abhadita and NISC 24 were found to be moderately resistant..
- From the population of various generations involving resistant lines as donor parents, 158 lines with bacterial blight resistance/grey mildew resistance and plant quality parameters were advanced for next generation. Six lines were identified as resistant to bacterial blight as well as grey mildew diseases. Eleven bacterial blight resistant selections were identified for better fibre quality parameters.
- Incidence of Alternaria leaf spot, Myrothecium leaf spot, bacterial blight and grey mildew was recorded on 43 Bt hybrid entries in three different trials along with NHH 44 as local check.. The incidence of Alternaria leaf spot varied from 8.02-29.4%, while incidence of Myrothecium leafspot was 8.30 29.91 %. The incidence of bacterial blight and grey mildew varied from 9.19-37.31% and 12.42-31.87%, respectively.
- The avoidable quantitative yield losses due to grey mildew disease were higher in susceptible Bt-hybrids as compared to non-Bt hybrid H 10. Early senescence and exposure to favourable weather during that particular stage could be one of the reasons for higher incidence of grey mildew on Bt-hybrids.
- *Bacillus thuringiensis* strains were isolated from soil samples collected from 57 locations of the country. One native Bt strain, from Ahmedabad produced toxin that caused high levels of larval mortality in *H. armigera* with LC_{50} of 0.077 !-lg/ml of diet against *crylAc* tolerant *H. armigera* field strain (Vadodara) and 0.004 !-lg/ml of diet against the field susceptible strain (Nagpur). The toxicity was equivalent to the standard BtK HD 1 and BTK HD73.
- Bioassays were carried out on mealybug *Phenococcus solenosis* (Tinsley) using 28 products comprising of 7 Bio-formulations. Maximum mortality was recorded in treatment Fish Oil Rosin Liquid+ Chlorpyriphos. A newly developed formulation 'Mealy-Quit' showed promising results in controlling mealybug populations and has been promoted for advanced stages oftesting.
- Two *Verticillium lecanii* isolates, VL 5, VL 7 were effective against mealy bug and prevented the development of adults in the treatments.
- Three hundred and twelve isolates of rhizobacteria were isolated from cotton rhizosphere from 47 locations and evaluated against *H. armigera* for efficacy. Out of these 67 isolates were found to have antagonistic properties against bollworm larvae. One *Bacillus cereus* isolate was found to be effective against Mealybug crawlers and can be further used for developing a formulation. A new fungal pathogen, *Fusarium sp.* was isolated from adults of Mealybugs in field epizootic incidence.
- Mortality of H. *armigera* due to *Heterorhabditis indica* was lower on larvae fed on okra as compared to chickpea, pigeon

pea and cotton. Nematode progeny production was highest from larvae fed on pigeon pea and lowest in larvae reared on cotton and weed plants.

- Crop rotation with sorghum and maIZe reduced the population of reniform nematode in cotton. Crop rotation of cotton with tomato drastically reduced root-knot nematode, *Meloidogyne incognita* population in Tomato under farmer's field condition
- Five microbial antagonists *(Streptomyces* spp., Pseudomonas, *Trichoderma* sp., *Penicillium* sp and *Aspergillus niger)* were identified against root rot causing pathogens *Rhizoctonia* and *Fusarium* sp.
- Out of the 100 isolates of rhizobacteria isolated from rhizosphere from different ecosystems, nine bacterial isolates were effective *in vitro* at 0.1 aD against juveniles of root knot and pre-adults of reniform nematodes. Two of the effective bacteria were tentatively identified as *B.subtilis.* and *Bpumilus.*
- *P solenopsis* was recorded on 91 plant species of24 families, whereas the pink mealybug *M hirsutus* was found to occur on 16 host plants spreading across 11 families. *Parthenium hysterophorus* and *Abutilon indicum* were the most common and favourable hosts.
- Foliar application of Acetamiprid, Thiomethoxam, Acephate at recommended doses and stem application ofThiomethoxam Chlorpyriphos and Imidacloprid were found effective in controlling sucking pests-aphid, jassids and thrips.
- The ETL (Economic Threshold Level) for S. *litura* was 2.0 ± 0.7 on non-Bt and 5.3 ± 0.9 larvae per plant on Bollgard-II.
- The enhanced yields from IPM with an increased returns ofRs. 1300 per hectare over RPP indicated the superiority of the symptom based insecticidal interyention in IPM and its feasibility for use in Bt cotton sucking pest management.
- Based on the specific cadherin insensitive resistance mechanism in *crylAc* resistant *Helicoverpa armigera,* primers were designed to amplify region between the exon eight and the retrotransposon in case of resistant insect and exon-eight and exon-nine of susceptible insect..
- Six *cytochrome p450* genes were tested on Real- Time PCR for their relative quantitative expression levels in pyrethroid resistant and susceptible *H armigera.* One of the genes *cyp6b* 7 was found to express selectively in higher quantities in pyrethroid resistant strains.
- Changes in the geographical variability in *H armigera* susceptibility levels to *cry* 1Ac and *cry2Ab* toxins from *Bacillus thuringiensis* were monitored. The LC_{so} values ranged from 0.040 to 3.12 g *cry* 1Ac/ml of diet across the North, Central and South India. LC_{so} values ranged from 2.46 to 34.26 flg *cry* 2Ab/ml of diet with 13.92-fold variability across the strains. The LC_{so} values for the *crylAc* of JK 'event-I', ranged from 0.192 g crylAc/ml of diet to 5.11 g *cry* 1Ac/ml of diet with 4.11- fold, 20.60-fold and 5.89 fold variability III susceptibility across the North, Central and South India.

Coimbatore

- The papaya mealy bug, *Paracoccus marginatus* Williams and Granara de Willink, was recorded in a severe form for the first time on cotton in Coimbatore. Infestation of *Pmarginatus* was observed on G. *arboreum* and G. *hirsutum* species and Bt cotton hybrids under field conditions.
- Hairy varieties were found to be highly susceptible to mealy bug infestation.
- Infestation of mealybug was 100% III unprotected Bunny Bt as compared to 50-60 % in RCH 2 Bt and non Bt. In general the infestation of papaya mealy bug, *Paracoccus marginatus* was high in the farm as well as in farmer's field. In addition to cotton, *P marginatus* infestation was observed on *Parthenium hysterophorum, Tridax procumbens, Acalypha indica, Euphorbia geniculata* and *Crotons sparsiflorus.*
- The observation on mealy bug infestation in 50 farmers' fields of five villages indicated that the mean intensity of damage ranged from

1.0 to 1.22 grade, and the per cent infested plants ranged from 55.0 to 83%. The mean infestation of mirid bugs ranged from 68 to 97% and the population ranged 16 to 85 nymphs per 100 squares.

- Population dynamics of mealybug species *viz., Paracoccus marginatus* and *Phenacoccus solenopsis* were observed under cotton+cowpea intercropping system. During initial period (October) of cropping season, *P solenopsis* incidence was high compared to *P marginatus.* From first fortnight of November onwards, *P. marginatus* populations increased.
- Nineteen weeds were recorded as alternate hosts for cotton mealybug. Initially *Paracoccus marginatus* recorded 100% incidence on *Parthenium hysterophorus* and continued throughout the cropping season and the incidence of *P solenopsis* was found to be 100% on alternate hosts such as *P hysterophorus, A. indicum, P neruri* and *T. procumbense,* at the end of the cropping season.
- Out of 78 Bt cotton hybrids (54 with *cry* 1Ac and 24 with cryIAc+cry2Ab) evaluated for their resistance against major sucking pests, four hybrids (PCH 2270 Bt, PCH 205 Bt, PCH 923 Bt, and ACH 33-1 Bt) recorded low intensity of mealy bug damage. Two Bt hybrids, Rudra Bt and JK Iswar Bt recorded low population of mirid bug (1.38 to 1.44/5 squares) while the check entry RCH 2 Bt had 6.77 mirid bugs per 5 squares.
- A Lycanid butterfly *Spalgis epius* (West wood) (Lepidoptera: Lycaenidae) was found to feed on the mealybug *P marginatus* on cotton, papaya, silk cotton, subabul, *Ixora* sp., *Crotons* sp., *Glyricedia* sp. and *Hibiscus* sp. etc. The larvae were observed as voracious feeders on the egg masses, nymphs, and adults of mealy bugs.
- Two parasitoids, *Torymus* sp. and *Prochiloneurus aegyptiacus* (Mercet) were recorded on the mealybug *P marginatus* with maximum per cent parasitisation of 21% and 7% respectively. The parasitoid, *Aenasius* sp. was found to parasitize *P solenopsis* up to a maximum of 45%.
- Histopathological studies of reniform nematode cotton was studied by inoculating 5000 adult females of *R.reniformis* under pot culture condition. The nematodes gain entry through epidermis and penetrate intercellularly as well as intracellularly through the cortex, endodermis and pericycle and reach the phloem where they feed. A passage slightly wider than the nematode body is formed by destruction of cortical cells.
- Twelve insecticides were evaluated with three entomopathogenic fungal pathogens for compatibility tests. For *B. bassiana,* only Chlorpyriphos was found to be compatible whereas, Spinosad, Econeem, Quinalphos, Acetamprid, Endosulfan and Thiodicarb were slightly toxic.
- Pathogenicity of Bacterial symbiont of EPN *viz., Photorhabdus lumunescens* and *Xenorhabdus* sp. was studied under laboratory condi tion against *Galleria mellonella, Heficoverpa armigera* and *Spodoptera fitura.* Both bacteria were able to cause mortality of test insects at varying levels.
- Antimicrobial property of bacterial symbiont ofEPN *(P lumunescens andXenorhabdus* sp.) was evaluated against plant pathogens *Fusarium* sp. and *Alternaria* sp. and entomopathogenic *(Metarhizium anisopfiae, Beuveria bessiana* and *Verticillium lecanii). P lumunescens* was found to significantly inhibit the growth of both plant pathogenic and entomopathogenic fungi.
- 25 entomogenous fungi associated with mealy bug were screened and *Lecanicillium lecanii* was found to be highly virulent against both *Phenacoccus solenopsis* and *Para coccus marginatus* under laboratory, green house and small scale field studies.
- Among seven isolates, three isolates namely VI 5, VI 9 and V12c were effective in causing mortality of both nymphs and adults of *Paracaccus marginatus,* whereas isolates VII and VI 5 alone were highly effective against *Phenacoccus solenopsis.*
- Acephate and Chlorpyriphos were more effective against the emerging pests (mealy bug and mirid bug) and recorded significantly

higher yield (58.4 % and 51.0 %) over other treatments and control.. Thiodicarb followed by flubendiamide+thiocloprid and thiocloprid treatments were effective against mirid bug and reduced the infestation significantly over other treatments and control..

- Pheromone trap catches of *P gossypiella* recorded throughout the cropping season was correlated with the level of infestation. Infestation was found to start in November with a peak adult moth catch during the month of February also correlated with the maximum larval infestation.
- Implementation of Insecticide Resistance Management (IRM) strategies in the project villages resulted in the reduction of number of sprays by 47% and the plant protection cost from Rs. 2,147 to Rs. 1,021, besides an increase in yield by 21 % over non IRM villages.

Sirsa

- Mealybug infestation in North India was low during 2008-09 and damage to cotton crop was negligible. The mealybug was found to infest at least 47 species of host plants belonging to 24 families. The parasitoids *Aenasius bambawalei* and *Paranathrix tachikawai* were also recorded. The parasitization efficiency of *A. bambawalei* from field collected mealy bugs was 57.0 per cent whereas under laboratory condition it was 60.6 per cent (45-74%).
- Whitefly population remained below ETL throughout the season. Among natural enemies, spiders were the most abundant as compared with natural enemies like Lace wing and Lady bird beetles. Maximum population of spider was recorded in first week of September.
- Anew fungal species *Fusarium pallidoroseum* was isolated from mealy bug cadavers from cotton stalks in Haryana and Punjab. Profenofos showed maximum inhibition of *Fusarium pallidoroseum* after one week of inoculation whereas minimum inhibition was observed in Confidor, Admire and Fipronil.. Fifteen days old crawlers showed lower mortality upto a maximum of 40% in case of *F pallidoroseum.* Formulations of *Verticillium lecanii* controlled 57.8 to 66.1 per cent mealybug after two sprays at weekly interval..
- White fly infestation and cotton leaf curl virus disease incidence was quite low in Haryana, Punjab and Rajasthan.
- DNA isolation from 124 weeds collected from during AprillMay 2008 followed by their amplification using Coat Protein (CP) primer did not show presence of virus in any of the weeds tested.
- A new sampling strategy was devised for mealybug field population assessment based on source of infestation. When sampled parallel to the source, infestation level was highest in fields along with water channel (4.6 to 15.4 %) followed by fields on roadside (5.2-9.8 %) and clean fields (2.07-12.0%). When sampled perpendicular to the source, infestation levels recorded were relatively lower.
- The mealybug *Phenacoccus solenopsis* was found to have 2-4 ovisacs. There are 2 nymphal instars in males and 2 instars in 3 instars in females. Each female produces about 300-500 crawlers. The total life duration extends from 36 to 45 days on cotton. There was a positive correlation between the population increase and temperature where as the relative humidity was negatively correlated.
- Insecticide Resistance Management (IRM) strategies were disseminated in 75 villages of three Districts of Haryana-Sirsa, Hisar and Fatehabad to cover a total of 11254 hectares area with 4511 farmers. There was 24.3% reduction in sprays and 31.2% reduction in consumption of insecticides in IRM over non IRM farmers. There was 10% increase in seed cotton yields and overall net profit of IRM farmers over non-IRM was 7140 per hectare.
- Maximum jassid resurgence was reported in treatment Cypermethrin+Monocrotophos (after the 7th spray). Cypermethrin caused 35.64 % resurgence of whitefly and spinosad alone exhibited moderate resurgence of Mealybugs. Maximum reduction in parasitization by *Aenasius bombawalei* as

compared to control was caused by Monocrotophos.

- Among various insecticides, Acephate and Chlorpyriphos reduced mealybug population by >70%. Among ecofriendly biopesticides, *Metarrhizium anisopliae* was the most effective.
- In a study conducted to integrate all eco-friendly strategies and validation of IPM packages, the average yield in IPM plots obtained was 12.80 q/acre as compared to 12.24 q/acre in RPP (recommended package of practices) plots.
- Foliar application was more effective than stem application. Stem application was found effective only in the initial phase of the cropping season. The predator and parasitoid populations were significantly more in case of stem application as compared to foliar application.
- Grade Percent Disease Index (5, 10,20,40 & 60%) of cotton leaf curl virus disease in Bt cotton hybrid 6488 Bt at village Khippanwali in Ferozepur district of Punjab revealed reduction in seed cotton yield to the extent of 0.08,0.29, 14.5, 17.2 and 40.0% respectively. Similarly 23.8 to 63.1 % seed cotton yield reduction was observed in case of one to four severity grades in case of Bt cotton hybrid Sigma at Chudiwalan village in Ferozepur district of Punjab.