Name of Variety/ hybrids		2005-06	
		Indent (q)	Production (q)
LRA 5166		3.81	4.80
LRK 516 (Anjali)		1.96	2.98
Surabhi		0.99	1.00
Supriya		0.80	1.00
Sumangala		0.15	0.50
CSHH 198			
	Female		0.50
	Male		0.20
CISAA2			
	Female		0.20
	Male		0.20

Integrated Water Management

Nagpur

Results showed that maximum (1904 kg ha^{-1}) seed cotton yield was recorded in the treatment where 50 % NPK (120 : 60 : 60 kg ha^{-1}) was applied as basal and rest 50 % through fertigation alongwith micronutrient (10 kg $ZnSO_4$ ha^{-1}) closely followed by 1773 kg ha^{-1} by the treatment with 50 % NPK as basal and 50 % through fertigation + micronutrient @ 10 kg $ZnSO_4$ ha^{-1}) and the mean minimum (1294 kg ha^{-1}) under control. Higher seed cotton yield in this treatment was supported significantly by yield contributing characters like number of bolls, boll weight (g) and yield per plant (g). Overall, the seed cotton yield improvement in all the treatments was > 372 kg ha^{-1}) over control.

However, split application of recommended dose of fertilizer (50 % NPK as basal and 50 % NPK through fertigation), with integration of $ZnSO_4$ + Biofertilizer + 1.5 t ha^{-1} FYM was found essential and economically suitable for cotton under drip in shallow soil.

In-situ moisture conservation

In-situ moisture conservation practice such as opening of alternate furrow was able to enhance seed cotton yield by about 220 kg ha^{-1}, while opening of furrow in each row after last interculture lead to enhancement by 55 kg ha^{-1} and almost similar increase in yield was recorded due to tied hoeing over control.

Water use efficiency

The impact of different moisture conservation practices on water use efficiency was evaluated. Maximum (1.91 kg ha^{-1} mm^{-1}) water use efficiency was recorded where greengram was intercropped with cotton followed by opening of alternate furrow after last interculture and the minimum (1.61 kg ha^{-1} mm^{-1}) under control.

Coimbatore

Poly mulching in cotton based cropping system

Irrespective of colour, all the poly films enhanced the growth and development of cotton significantly due to favourable microclimate like optimum soil moisture (nearer to field capacity) and higher temperature. The

Low cost drip system

Multi-tier inter cropping

Cotton crop under
drip + polymulching

PCR kit for
Xanthomonas detection

root CEC of poly mulched cotton ranged from 16.12 to 17.68 (m.eq/100 g) as against 13.0 m.eq in non mulching. Among the treatments, silver colour poly film accumulated the highest DMP of 215.1 g/plant at 90 DAS. The enhancement in seed cotton yield due to polymulching was to the tune of 2.10, 2.01, 1.98, 1.80 and 1.69 fold respectively in silver, red, blue, black and yellow colours than conventional method (Table 11).

Table 11: Root cation exchange capacity and growth attributes of cotton cv LRA 5166 as influenced by coloured poly mulching on 90 DAS

Treatments	Root CEC m.eq/100g	Plant Height (cm)	No. Leaves / Plant	Leaf Area (cm) / leaf	DMP g/plant
Control – T_1	13.00	96.3	114.0	96.4	96.8
Black – T_2	17.42	106.7	183.3	144.1	191.9
Red – T_3	16.90	107.3	163.0	155.5	179.1
Blue – T_4	16.12	104.3	162.7	157.4	205.8
Silver – T_5	17.68	114.0	173.7	162.0	215.6
Yellow – T_6	16.38	109.0	177.7	152.8	190.3
SEd	1.13	7.21	12.36	18.2	11.8
CD 5 %	2.51	16.07	27.53	40.6	25.2

Drip and polymulch in cotton maize cropping system

The growth of cotton cv. LRA 5166 was influenced favourably due to polymulching and drip + polymulching and found better than drip irrigated cotton. The polymulched cotton with drip irrigation scheduled at 0.4 ETC were taller by 27 cm than drip-irrigated cotton at 0.8 ETC. The growth attributes like number of leaves/plant, leaf area, node no. and dry matter accumulation were higher under polymulch + Drip at 0.4 ETC than Drip at 0.8 ETC. The polymulch + Drip at 0.4 ETC recorded the highest number of harvestable bolls/plant. The total water requirement for various treatments ranged from 57.3 to 92.7 ha cm and scheduling of irrigation at 0.4 ETC + polymulching recorded the highest (42.7 kg/ha cm) water use efficiency as against (16.10 kg/ha cm) recorded under conventional method.

Rain water management through agro techniques

Opening of furrow at each row at sowing registered the highest seed cotton yield (2690 kg/ha). The highest seed cotton equivalent yield (2800 kg/ha) and rainfall use efficiency (RUE - 7.0 kg/ha-mm) were calculated with cotton intercropped with black gram. Cotton +black gram system in addition to intercrop yield (203 kg/ha), produced moderately higher seed cotton yield (2480 kg/ha) which resulted in higher seed cotton equivalent yield and rainfall use efficiency.

Response of different growth stages of cotton to protective irrigation

The highest seed cotton yield of 2390 kg/ha was obtained with the application of irrigation water as per the climatic needs (0.8 = IW/CPE) of the crop (three irrigations were given). The least seed cotton yield (1970 kg/ha) was recorded in rainfed control. The results proved the necessity of supplemental irrigation in addition to rainfall

to realize higher growth and yield.

Water management in *G. hirsutum* cotton

Seed cotton yield was not influenced by different drip layouts. Polytube lateral drip system was found to be much cheaper than the LLDPE with dripper system. Higher irrigation use efficiency (85%) and water saving (51.5 %) were calculated with drip irrigation system treatments as compared to control (ridges and furrow method) (Table 12).

Table 12 : Seed cotton yield, water use efficiency (kg/ha-mm), irrigation use efficiency and economics of low cost drip irrigation system.

Particulars	LLDPE with		Polytube thickness			Control
	Dripper	Micro-tube	150 gauge	300 gauge	450 gauge	Ridges & Furrows
Seed cotton yield (kg/ha)	3020	2680	2650	2890	2870	3150
Irrigation use efficiency (kg/ha-mm)	41.5	36.9	36.5	39.8	39.5	21.0
Total cost of irrigation system (Rs/ha)	69025	35338	11990	12430	13310	-
Per annum cost of irrigation (Rs/ha)	13112	6710	3410	3905	4505	2200
Total cost of cultivation (Rs/ha)	41305	34903	31383	32098	32698	28193
Total gross returns (Rs/ha)	63420	56280	55650	60690	60270	66150
Total net return (Rs/ha)	22115	21377	24267	28592	27572	37957
Benefit cost ratio	1.5	1.6	1.8	1.9	1.8	2.3

Integrated Nutrient Management

Nagpur

Studies conducted on the effect of manurial treatments on yield of cotton and pigeonpea grown in strip cropping system indicate significantly higher seed cotton yield in the treatment N60 P30 K30 + 2t FYM + 2t goat manure (904 kg/ha) and N 90 P 45 K 45 + S 20 + Zn 20 (881 kg/ha) over farmers' practice (622 kg/ha) and FYM treated plots (736 kg/ha) applied in the same plots in the second successive year. Least seed cotton yield was recorded in control plot. Higher yield in pigeon pea was obtained in FYM applied plots. No significant difference in biological yields in the manurial treatments was observed although it was significantly higher over lower dose of NPK and control plots. An increase in staple length in NHH 44 hybrid (1.5 mm) in FYM plots over lower dose of NPK was observed.

Effect of nutrients on yield and fibre quality of rainfed Bt hybrids

Significantly higher seed cotton yield of Bt MECH 184 and non-Bt NHH 44 was recorded with foliar application of potassium nitrate alongwith Boron and Zinc (B @ 10 kg and Zn @ 2.25 kg /ha) over recommended dose of NPK. No significant difference in yield with Zn and B treatments was observed. MECH 184 Bt responded to foliar application of nutrients.

However, higher boll weight of MECH 184 Bt was recorded with Boron application. Combined foliar application of potassium nitrate with Zn and B increased bundle strength significantly over other fertilizer treatments. Among the hybrids, significant differences were observed.

Agronomical evaluation of Bt NCS 138 and NCS 913 (Bunny) under rainfed conditions

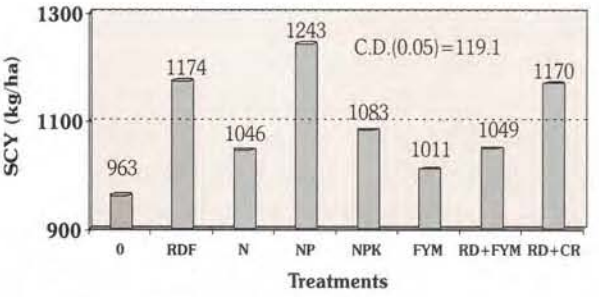
Data on Bt NCS 138, NCS 913, Bunny and NHH 44 (check) with different fertilizer and spacings indicate significantly higher seed cotton yield in Bt hybrids (ranging from 2080 to 2652 kg/ha) over non Bt hybrids Bunny (1000 kg/ha) and NHH 44 (1650 kg/ha). Among the spacings, all the hybrids (Bt and non-Bt) at 90 x 45 spacing gave an additional seed cotton yield of 250 kg/ha over 90 x 60 cm and 330 kg/ha over 90 x 30 cm. Boll weight in both the Bt hybrids was in the range of 4.2 4.8 gm where as in NHH44 it was 3-3.2 gm. Good fibre values viz. staple length and bundle strength in both the Bt hybrids were recorded. Significant varietal differences for fibre values were observed while fertilizer treatments (NPK 100:60:80 and 150:80:100) did not have any significant impact.

Coimbatore

Long term effect of nutrients in cotton based cropping system

Cotton-jowar out yielded (seed cotton yield of 1081 kg/ha) significantly cotton-fallow (834 kg/ha) with additional jowar grain and straw yield of 6480 and 1680 kg/ha respectively. Highest seed cotton yield (1243 kg/ha) was realized following application of N:P:K @ 90:19:0 kg/ha and was on par with RDF (60:13:25 kg/ha) and RD plus 2.5 t/ha of crop residues (RD+CR) at the end of 3 years of cropping (Fig. 8) in this K enriched mixed black calcareous clay loam soil PERIYANAICKAN-PALAYAM series-vertic ustropept) with medium fertility status.

Fig.8: Effect of long term nutrient supply on cotton



Conservation Tillage

Nagpur

Tillage and green manure effects on growth and yield of cotton and soil properties

Studies were conducted for the 10th consecutive year with a fixed layout for the tillage treatments. Bt (RCH-2) was the cultivar grown during the year. Among the tillage treatments, reduced tillage with two interculture operations (1874 kg seed cotton/ha) was at par with the reduced tillage without any interculture operations (2054 kg/ha). Both the reduced tillage treatments yielded significantly more than the conventional tillage treatment (1526 kg/ha). Improvements in the reduced tillage treatments were due to an effective weed control.

Green manure was grown *in situ* (in between crop rows) to evaluate the possibility of N saving. Yield with 80 kg N + GM (1864 kg/ha) was on par with 100 kg N plots (1791 kg/ha). A further reduction of fertilizer N to 60% of recommended N (1479 kg/ha) reduced seed cotton yield significantly. The results of this first year of study, indicate a potential saving of 20% N with an *in situ* green manure. Furthermore, *in situ* green manure plots had a lower weed

density and consequently lesser weed biomass (6.25 $\pm$ 1.5 g/m^2) as compared to the non-mulched plots (14.6 $\pm$ 4.2 g/m^2). The mulch also provides a better soil hydrothermal regime.

The results of the third year and pooled analysis indicate the benefits of rotation. Seed cotton yield in 2005-06 was significantly greater in the cotton-soybean rotation plots (1058 kg/ha) than the cotton-cotton monoculture treatment (750 kg/ha). Among the nutrient management practices, yield was the highest in the site-specific nutrient management treatment (1278 kg/ha) and was significantly greater than the application of recommended dose (90-19-37 kg NPK/ha) of fertilizers (886 kg/ha). Interestingly, no significant response was observed to application of Zinc or Boron, especially considering that the soils are low in Zinc (<0.6 ppm Zn). However, these results do not mean that Zinc or Boron is not needed. It is probable that the cultivar NHH-44 has a better capacity to grow under low Zn soils. A small addition of organic manure (25% of N) on a regular basis was found to improve yields (1074 kg/ha) as compared to application of mineral fertilizers alone (886 kg/ha).

In a second experiment, application of K to Bt transgenic hybrid resulted in a significantly greater seed cotton yield (1546 kg/ha) than the treatment NP (1301 kg/ha). However, there was no effect of foliar application over the soil application. Similar results were observed in on-farm trials conducted in Wardha district. Average of eight farms, yield in the farmers' practice, NP and NPK treatments was 710, 778 and 875 kg seed cotton/ha.

There was no significant difference among the various organic sources (crop residue compost, farmyard manure, vermicompost) in the first year of the study. Yield in the organic manure alone was the least and was at par with the control treatment.

Coimbatore

In situ green manuring

Application of FYM @ 5 t/ha along with RDF was found to be equally effective as that of RDF + dried grass @ 5 t/ha over only RDF, neem and cotton stalks applied on soil surface @ 5t/ha and control. Maximum yield was obtained with easily decomposable biowastes. Soft plant tissues such as dried leaves, Parthenium weeds and Trianthema were equally effective in realizing yield similar to that of FYM or RDF.

Cotton Based Cropping Systems

Nagpur

Cotton + soybean + pigeonpea and Soybean-wheat/sunflower were studied for additional micronutrient requirement, without changing randomization in order to improve profitability of cotton and cotton based cropping system. The excess rainfall and its distribution nullified the influence of soil depth from shallow to medium soils under similar nutrient supply. The foliar spray of micro nutrients brought about 8 % improvement in medium soil grain yield. Chelated and non chelated micronutrients foliar sprays brought about 35 and 30 % higher grain yield of pure soybean in shallow soils.

The intercrop biomass and yield of soybean with cotton were 50 % of pure crop yield i.e. proportion to its plant stand and was not significantly effected by soil depth, moisture management and micronutrient treatments. The biomass of cotton intercropped with soybean was significantly influenced by soil depth increasing from shallow to medium soils and also with soil and or foliar application of Zn, Mn and B together. The chelated micronutrients

found an edge over non chelated. The pure soybean biomass was significantly higher in medium deep soil but positively higher with soil and or foliar application of micronutrients. The intercropped pigeonpea responded well to micronutrients in medium soils (both chelated and non chelated micronutrient sprays).

The profitability of the system was analysed which was giving a minimum of 1.48, 1.59, 1.63, 1.85, 2.03, 1.91, 1.89, LER and BCR 4.65, 4.81, 4.62, 4.82, 4.84, 5.02, 5.44 in control, Zn 10, Mn 10, B3 kg ha^{-1} yr, Zn + Mn + Bo (75% soil + 2.5% foliar) chealated and non chelated foliar application of micronutrients. The best is soil and foliar application followed by chelated foliar sprays.

Cotton + pigeonpea 8: 2 seed treatment with bio-inoculants *Azotobacter, Azospirillum/ Rhizobium, Pseudomonas, Basillus subtilis* together at the time of sowing with soil moisture conservation through ridges and furrows and 2% urea alongwith micronutrients in chelated form two foliar sprays prior to flowering was found to be yield 32% over non chelated form, 39% over bio-inoculants and conservation measures and 49% over 50% RDF. Similar trend was also observed in *desi* cotton.

Impact of intercropping on seed cotton yield

The impact assessment of intercrops in cotton was conducted. It was found that maximum effect of intercrops on seed cotton yield was recorded in case of greengram (224 kg) followed by blackgram (75 kg) and least by soybean (15 kg). This showed that greengram being the short duration crop has no adverse effect on cotton crop performance over other crops. Not only this, greengram residue also improved organic matter content in the soil, alongwith soil moisture.

Gross yield and gross return (Rs ha^{-1})

Mean maximum (2466 kg ha^{-1}) gross yield was recorded in the treatment where soybean was intercropped with cotton followed by blackgram and greengram and the lowest (1278 kg ha^{-1}) under sole cotton. Similarly, the mean maximum (4811 kg ha^{-1}) gross return was recorded in the treatment where greengram was intercropped with cotton. Higher gross return in cotton with greengram as intercrop was mainly due to high produce value in the market, with the added advantage of higher water use efficiency also.

Significant mean maximum (1380 kg ha^{-1}) seed cotton yield was recorded with 3 irrigaitions; first at flowering, second at early boll and third at peak boll development stage, closely followed by (1257 kg ha^{-1}) two irrigations first at early boll and second at peak boll development stage.

Coimbatore

Cotton based multi-tier vegetables intercropping system for higher production and economic return

The highest seed cotton yield (2480 kg/ha) was obtained with the intercropping of radish + beetroot + coriander between the cotton rows. Periodical harvest of intercrops coriander (25 DAS), radish (45 DAS), and beetroot (75 DAS), lead to less competition within the component crops which ultimately resulted in significantly higher seed cotton yield with cotton + radish + beetroot + coriander system. The least seed cotton yield (2080 kg/ha) was harvested in control plot. The highest gross return of Rs. 167614/ha, net return of Rs. 118217/ha and benefit cost ratio 3.4 were realised with cotton intercropped with radish + cluster bean + beetroot system in Table 13.

Table 13: Seed cotton yield and economics of multitier cropping system

Treatments	Seed Cotton Yield (kg/ha)	Net profit (Rs/ha)	Benefit cost ratio	Seed cotton equivalent yield (kg/ha)
T1. Sole cotton	2080	15487	1.5	2080
T2. Cotton + radish + Veg.cowpea + beetroot	2430	90339	3.1	6300
T3. Cotton + radish + cluster bean + beetroot	2180	118217	3.4	7980
T4. Cotton + radish + dolichos + beet root	2310	90012	3.3	6190
T5. Cotton + Coriander + veg.cowpea + cluster bean	2340	98904	3.0	7080
T6. Cotton + coriander + dolichos + cluster bean	2110	75157	2.6	5880
T7. Cotton + beet root + veg.cowpea + cluster bean	2420	91430	2.8	6810
T8. Cotton + cluster bean + veg.cowpea + dolichos	2240	66212	2.3	5540
T9. Cotton + radish + beet root + coriander	2480	95025	3.4	6340
SED	110	-	-	-
CD (5%)	240	-	-	-

Organic Cotton Production

Nagpur

The field experiment was conducted in organic management with fermented cow dung + urine water four times and bioinoculants + Rockphosphate as RDF and inorganic as per recommended package. American hybrids, varieties and green gram (intercrop) were found significant with 50, 68 % and 37 % higher yield respectively under organic management (11th year). The superior hybrids were H 10 and PKV Hy2 confirming last year trial results. Among varieties Surabhi, Abadhita, Sahana, AKA 5 and 7 were statistically similar but superior over PKV Rajat, AKA 8 and CINA 316.

Ergonomically Efficient Implements for Cotton Production

Battery operated knapsack sprayer was evaluated in the laboratory, field condition as well as in the farmers' fields. It was found that it can spray maximum 22 spray tanks each having 16 litres spray liquid in single stroke of battery charge. The field capacity, comfort, convenience and other feed backs were analysed for fine tuning. Spray droplet analysis was done by using lever operated knapsack sprayer.

Multipurpose tool bar having an attachment for sowing of cotton with soybean and fertilizer placement was developed and is under field testing. Local and improved implements were studied. Wooden interculture hoes were designed for square planting, paired row planting and intercropping with adjustable spacing which can save man power with limited maintenance.

Production Physiology

Nagpur

Effect of plant growth regulators and nutrients on the growth and yield of cotton under rainfed condition

In a field experiment, MECH Bt 184, Bunny and NHH 44 were given foliar sprays of Naphthalene acetic acid 20 ppm, suphala 1% and, copper sulphate 0.3% during flowering. Detopping was included as one of the treatments. The results indicated that the treatment and interaction effects were non-significant, whereas significant genotype differences were noticed with regard to root length, leaf production and seed-cotton yield. Among the various treatments imposed during flowering, Suphala 1% foliar spray improved yield in all the cultivars.

Genotypes suitable for cultivation in shallow soil

Seven *G.arboreum* genotypes (AKA 7, AKA 8401, DLSA 17, G.Cot 19, PA 255, PA 402, Veena) and one *G.hirsutum* genotype (LRK 516) grown under deep and shallow soil conditions were sampled for growth in terms of root length, shoot length, production of nodes, leaves and squares, relative water content and biomass production of root, shoot, leaf and fruiting parts. Soil moisture status was recorded for both deep and shallow soils on two occasions.

The results point out that leaf production remained higher in G.Cot 19 followed by DLSA 17 under shallow soil. The genotypes DLSA 17 and AKA 7 had maintained higher square production. The performance of AKA 7 is also better under deep soil condition. The soil moisture content was found to be higher in deep soil as compared to shallow soil

Coimbatore

Physiological and molecular elucidation of fibre development process

Wide variability in amylase activity was seen during crop growth period in different cultivars. The biochemical changes from the date of anthesis to maturity has been analysed from seed and fibre of lint (MCU 5) and lintless mutant (MCU 5 LL) as well as in fuzz and fuzziless mutants (AKH 98-8-1). The biochemical constituents *viz.*, reducing sugars, proline, total soluble protein, total phenols, IAA oxidase and peroxidase were estimated. Significant polymorphism has been noticed between linted and lintless mutant for three primers studied. Ovule culture studies showed that the nutrient and hormonal changes brought about perceptible change in seed and fibre developmental pattern. With the application of GA @ 0.5 ppm, there was fibre initiation in fibre less mutants of MCU 5 LL.

Isolation and regeneration from cotton protoplasts

Effective digestion protocol for protoplast isolation from leaf tissues of cotton genotype Sumangala has been standardised. Cellulase (2.0%) + Macerozymes (0.5%) from Onozuka was found effective for digestion and release of healthy protoplast from leaves. The osmolarity was maintained by 9.0% mannitol. Cell wall formation and cell division was observed when protoplasts were cultured in liquid medium with 1 $mg.^{-1}$ L 2,4-D + 0.5 $mg.^{-1}$ L Kin.

Crop and yield modelling

Nagpur

Refinement of regional level prediction of cotton production

A field experiment was conducted involving Bt and non-Bt hybrids and varieties and date of sowing as treatments at CICR, Nagpur. The soil, crop and weather data of the experimental site

was calculated in Infocrop format for model calibration. The model, which was calibrated and validated earlier for the simulation of growth and yield of hybrids and varieties of cotton, was iterated to simulate the duration required for flowering and maturity. Adjusting the phenology related parameters in the model had correctly simulated the biomass and yield of MECH 184, RCH 2, Bunny and Suarbhi except in the case of late sown RCH2 hybrids. This requires further fine-tuning in the model.

At the macro level, the integrated approach for yield assessment at district level was undertaken in four cotton growing districts viz. Nagpur, Bharuch, Dharwad and Sirsa. The area, production and productivity estimates through integrated approach (remote sensed data, GIS and crop model) for the year 2005-06 were found to be quite satisfactory in respect of Sirsa, Bharuch and Dharwad districts with a variation ranging from 5-13 %. For Nagpur district, however, the figures derived from integrated approach in respect of production and productivity were found to be much higher than the observed values. Attempts are underway to refine the crop model as well as the approach and incorporate the pest factor in arriving at production and productivity estimates.

Coimbatore

Interaction effect of genotypes, nitrogen and date of sowing on cotton growth and development

Nitrogen had no significant influence on seedling emergence and germination. Delayed sowing showed greater root growth for the first 60-90 days. Plant height, root length, leaf area and other physiological parameters were significantly higher in delayed sowing (D2) compared to early sowing (D1) in cotton cv. Suvin, but was not partitioned to the kapas at harvest. The partitioning of photosyntahtes to boll development in cv. Surabhi was better in D1 than in D2.

Phenological variations between Bt and non-Bt versions of cotton

It was observed that the Bunny Bt showed a higher seedling vigor over non- Bt. The plant height, root length and leaf area was higher in Bt over its non- Bt counterpart, till 60-75 days, while the total fresh weight was higher till 135 days. The *kapas* yield was higher in Bt (115.1 g/plant) over the non Bt Bunny (55 g/plant). The plant growth characteristics like plant height, root length ceased to grow after 90 days, while the active growth of stem and root was observed till 120-135 days in non Bt variant. Hence, the partitioning to the economic part was not effective in non Bt Bunny. Similar trend was observed in Mallika Bt and non-Bt

Source-sink Relationship in Cotton

Nagpur

Plant mapping

Temporal and spatial distribution of fruiting forms, retention and their fate on the plant, shedding pattern and plants ability to compensate for the early loss of fruiting forms were recorded in 32 field grown plants. The above observations were recorded every alternate day both in Bt and non-Bt plants in order to analyze the genotypic and environmental interaction on fruiting forms. Genotypic as well as environmental influence was seen on the retention of fruiting forms at different positions on the canopy. Bt plants had lost fruiting forms more by physiological factors and less by entomological factors while it was vice versa in non-Bt plants.

Coimbatore

Foliar application of ethrel at 40 DAS brought about shedding of already produced squares and also delayed further square initiation by 15-20 days. Irrespective of the concentration, ethrel application brought about change in the plant biology leading to robust plant growth. There

was a significant change in the biochemical constituents with increase in NR activity, enhanced accumulation of reducing sugars, proline and protein.

The partitioning of the biomass was initially more to the vegetative part like stem and root. The stem girth doubled over the control plant. With the delayed initiation of reproductive growth, the shift in partitioning changed. There was total shift and more than 80% went to the fruiting part and very little to the stem and root. There was synchronous flowering and boll development with ethrel application leading to uniform boll bursting and picking was completed in 1-2 pickings. Application of ethrel @ 60 ppm brought about total shedding of squares transiting suppression of growth followed by total recovery alongwith higher seed cotton yield as compared to control (Table 14).

Table 14: Effect of ethrel on physiology and yield of cotton cultivars

Treatments	Plant height (cm)	Number of sympodia	Leaf area	Boll number	Boll weight (g)	Yield (kg/ha)
V1T1	79.4	21.0	943	26.6	3.00	1620
V1T2	136.2	27.0	6830	44.2	2.80	2490
V1T3	115.0	23.0	6831	36.6	2.80	2070
V2T1	107.0	20.4	1746	23.4	3.00	1418
V2T2	121.2	22.6	11524	50.0	2.80	2828
V2T3	131.2	25.8	10159	47.0	2.80	2658
CV (%)	17.1	13.8	33.8	34.4		
LSD -V	NS	NS	2194**	7.1*		
LSD-T	22.9**	3.8**	2687*	8.7**		
LSD- V X T	23.7*	3.9*	NS	12.2**		

V1 LRA 5166; V2 Sumangala; T1- Control; T2 - Ethrel @ 30 ppm; T3 ethrel @ 60 ppm

Response of elevated carbon dioxide on physiology and productivity of cotton

Suvin was raised under elevated CO_2 atmosphere of 650 ± 50 ppm throughout the cropping period under field conditions. At harvest, improvement in plant height, number of nodes, leaf area, boll number, boll weight, total dry matter production was noticed. Thus, the yielding ability of the plants under elevated CO_2 atmosphere was very apparent and significant. Plants grown under elevated CO_2 atmosphere always maintained a higher level of photosynthetic activity right from the initial stages until harvest. The lint index, seed index and seed oil content also showed an increase under elevated CO_2 atmosphere.

Physiological Disorders

Nagpur

Effect of 2,4-D on plant growth

2, 4-D spray (5 ppm) enhanced boll drying indicating involvement of hormonal action. The results reveal that pre-soaking of seeds with 2,4-D resulted with delay in germination, stunted growth and reduction in number of nodes and leaves. However, typical 2,4-D symptoms like leaf modification with prominent veins and tubular floral structures did not appear even after a prolonged period after sowing of the pre-soaked seeds. On the other hand, foliar application of 2,4-D (5 ppm) instantly brought out the typical 2,4-D symptoms within a week time. This indicates the differential mode of action of 2,4-D in the plant system. It is possible that in the pre-soaking treatment, seed constituents possibly reduced the deleterious effects of 2,4-D to a greater extent. The study needs further confirmation.

Stress Physiology

Nagpur

Screening cotton genotypes belonging to *G.hirsutum* and *G. aboreum* for drought tolerance

19 genotypes were screened for drought tolerance during flowering in a pot experiment. The genotypes are *G.hir* 4, CAT-385, 3556, 1058, 3815, 379, 1285, 3845, 848, 3796, MECH Bt 184, Bunny, LRA 5166, NHH 44 (*G.hirsutum*) CAT 7396, CAT 7861, AC 1, AC 3 (A), CAT 6962 (*G.arboreum*). Observations were recorded on leaf water potential, relative water content, solute concentration, stomatal resistance, transpiration rate, transpiration coefficient, biomass production, recovery of leaf relative water content, root-shoot ratio and yield. Nitrate reductase activity, anti-oxidant enzymes (Catalase and peroxidase) and protein profile were determined. The data were statistically analyzed. The treatment and genotype effects are mostly significant. The relatively tolerant lines identified ar -CAT 1058, CAT 848, CAT 385, CAT 3796, CAT 379, CAT 3596, CAT 7861, CAT 6962, AC 3 (A).

Drought stress imposed during flowering decreased leaf water status in all genotypes. Leaf solute concentration remained higher in *arboreum* genotypes indicating a trend towards higher osmotic adjustment. Stomatal resistance was found to be relatively higher in *hirsutum* genotypes due to the drought treatment. Transpiration rate and transpiration coefficient were found to be higher in *arboreum* lines indicating relatively higher leaf cooling tendencies in *arboreum*.

Root and shoot biomass production trends showed a tendency of increase under drought stress while the leaf and fruiting parts biomass

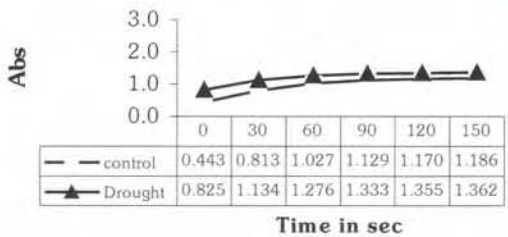
production tended to decrease under stress condition. The total biomass production decreased under drought environment and it remained higher in genotypes belonging to *G.hirsutum*. Root-shoot ratio increased under drought stress and remained higher in *arboreum* lines, on a comparative basis, root-shoot ratio both in micro-plots and pots remained mostly on par except differences in quantitative terms. The associative trends among important plant traits pertaining to stomatal and non-stomatal parameters remained higher under drought environment as compared to control. Seed-cotton yield remained higher in *G.hirsutum* genotypes and yield reduction occurred due to drought. However, yield stability was relatively higher in *arboreum* genotypes grown under stress condition.

Biochemical and molecular aspects

- Nitrate reductase activity (NRA) : The activity has been estimated in the leaves during 4th day of moisture stress. All the genotypes except 2 *hirsutum* lines showed more NR activity under stress as compared to control.

Anti-oxidant enzymes: Catalase activity measured during moisture stress did not show any definite trend in genotypes belonging to both the species. Peroxidase activity was mostly found to be more during stress in case of *hirsutum* (Figs 9 & 10) whereas no consistent trend was observed in *arboreum* genotypes.

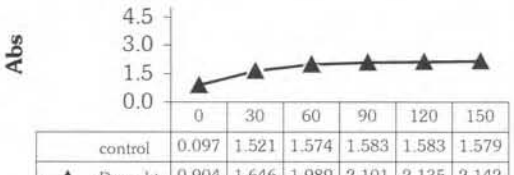
Fig 9 : Peroxidase enzyme G.hirsutum Leaf



	0	30	60	90	120	150
control	0.443	0.813	1.027	1.129	1.170	1.186
Drought	0.825	1.134	1.276	1.333	1.355	1.362

Time in sec

Fig 10 : Peroxidase enzyme G.hirsutum Leaf



	0	30	60	90	120	150
control	0.097	1.521	1.574	1.583	1.583	1.579
Drought	0.904	1.646	1.989	2.101	2.135	2.142

Time in sec

Protein profile: Protein profile determination through PAGE (polyacrylamide gel electrophoresis) banding pattern revealed accumulation of proteins during moisture stress in few genotypes (Fig. 11), which may correspond to heat shock proteins. In most of these cases, the strong protein band has been found to occur at 40 Kda and a number of bands have also been observed between 70 and 100 Kda (Figs 11& 12). Quantitative estimation of these leaf proteins by Lowry's method showed increase in leaf protein content during stress in those lines which also had protein accumulation in stress environment.

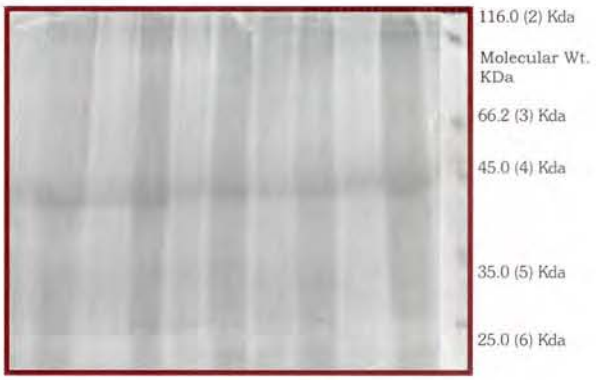
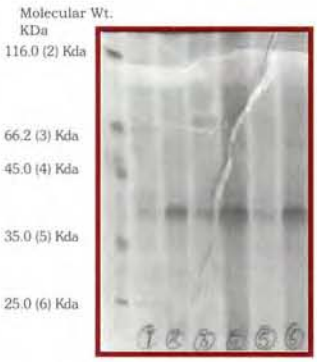


Fig. 11: PAGE showing response of cotton plants to moisture stress

C_{11}- C_{15} *G.hirsutum control*

D_{11}-D_{15} *G.hirsutum stress*



Sample No	Sample Name (genotypes of 2004-05 repeated)
1	*G. hirsutum* Leaf (Control)
2	*G. hirsutum* Leaf (Drought)
3	*G. arboreum* Leaf (Control)
4	*G. arboreum* Leaf (Drought)
5	*G. hirsutum* Leaf (Control
6	*G. arboreum* Leaf (Control)

Fig. 12: PAGE showing accumulation of more number of bands under stress conditions

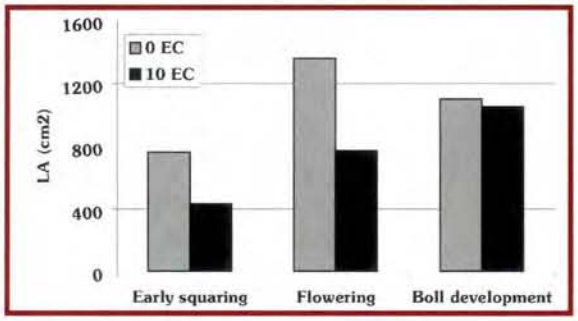
Salinity tolerance

The salinity tolerant genotypes selected from the previous experiments were grown in hydroponics (0, 5, and 10 d S m^{-1} NaCl), potculture (0, 5, 10, 15 and 20 d S m^{-1} NaCl) and in microplots (0 and 10 d S m^{-1} NaCl). The microplots had a dimension of 4m x 3m x 2m length x width x height respectively. At regular interval the salinity levels of pots and the microplots were monitored. The salinity levels of pots corresponded to 0.3, 3, 6.5, 8.5 and 12 corresponding to 0, 5, 10, 15 and 20 d S m^{-1} NaCl application respectively. Growth and yield of salinity treated plants was on par with the control plants up to 5 d S m^{-1} beyond that it started declining. Salinity levels corresponding to 8 and 12 d S m^{-1} NaCl showed a significant decline in yield. From the hydroponically grown plants it is clear that amongst the different plant parts roots are the most sensitive followed by leaves and the stem is the least sensitive. The salinity treated plants maintained higher relative water content and chlorophyll and thus the stomatal conductance and photosynthesis did not decrease significantly (Table 15). However, the decline in the leaf area (Fig.13) reduced the total biomass production and yield at higher salinity levels. Plants regulated their osmotic potential by the accumulation of proline. Proline accumulation was more in tolerant genotypes compared to susceptible genotypes.

Table 15: Photosynthesis (micro moles/m^2/s), transpiration (moles/m^2/s) and stomatal conductance (moles/m^2/s) of salinity treated plants

Genotype	Transpiration			Stomatal conductance			Photosynthesis		
	10 EC	0EC	Mean	10 EC	0EC	Mean	10 EC	0EC	Mean
G27	4.15	4.15	4.15	331.00	312.00	321.50	19.40	17.80	18.60
DHY 286	4.43	4.49	4.46	336.50	349.00	342.75	18.95	21.75	20.35
AK 32	4.84	5.09	4.96	394.00	471.00	432.50	19.85	22.55	21.20
320 F	5.24	4.56	4.90	485.00	369.00	427.00	23.25	20.10	21.68
PKV 081	5.11	4.81	4.96	433.00	410.00	421.50	22.45	20.55	21.50
BURI 0394	4.43	4.38	4.40	311.50	332.00	321.75	20.05	16.65	18.35
LRK 516	4.51	5.16	4.83	328.50	376.50	352.50	19.35	23.65	21.50
PKV HY 2	4.58	5.14	4.86	341.50	405.00	373.25	17.65	24.00	20.83
LRA 5166	4.41	5.37	4.89	317.50	495.50	406.50	17.15	22.45	19.80
Mean	4.63	4.79		364.28	391.11		19.79	21.06	
C.D at 5%	Gen 0.38	Salt NS	G x S NS	50	NS	NS	NS	NS	NS

Fig.13 Leaf area of control and 10 EC salinity treated plants at different growth stages



Water logging tolerance

The effect of waterlogging on growth, development and yield of cotton varieties and hybrids across the species was quantified in field experiments. Depending upon the stage and duration of waterlogging treatment, plants response to waterlogging varies. Waterlogging for a period of 16 days at 100 DAS reduced the growth and yield by more than 50 %. Similar decrease was seen in stomatal conductance and photosynthesis of waterlogged plants. The, prevailing weather conditions again found to influence the plants response to waterlogging. Unlike yellowing, senescence, shedding of leaves and fruiting parts observed with waterlogging under cloudy weather, under bright light and high temperature waterlogging elicited wilting in cotton known as parawilt. *Hirsutum* varieties and hybrids were more prone to wilting while it was not seen in Asiatic cotton. In a pot grown plants under bright sunlight and high temperature wilting could be observed within 2 hours of waterlogging treatment. Wilting was not elicited in pot grown shaded plants suggesting that high stomatal conductance of the plants under bright light in anaerobic condition elicited wilting. Chemicals, which inhibit the stomatal conductance, partially delayed the occurrence of wilting symptoms.

Effect of shade (left) and bright sunlight (right) on waterloggd plants grown in pots

Social Dynamics of Cotton Production

Nagpur

To characterize the diffusion rate of Bt cotton among the farmers in four selected villages in Hingna taluka of Nagpur district, a panel study was conducted involving 100 cotton growers and it was observed that 12 per cent cotton growers have gone for Bt cotton in very first year of introduction of this technology. During second year it was reduced to 11 per cent. During third year it was increased to 15 per cent and fourth year it was 20 per cent. Adoption behaviour was also affected by spatial distribution. Attempt was also made to explore the comparative adoption behaviour in relation to hybrid cotton, Integrated Pest Management (IPM) and Bt cotton, three most significant innovations in cotton crop to strengthen the prediction equation. It was observed that the adoption rate of hybrid cotton is much higher as compared to Bt cotton and IPM over the period of four years of their launching. However, during the first year of introduction of these technologies, Bt cotton had highest rate of adoption as compared to remaining two

technologies. From second year onwards the spread of hybrid cotton was much faster than Bt cotton.

Evaluation of technologies and economic viability

Nagpur

More than 100 farmers from three villages *viz.* Tishti, Dadhera, and Lohgadh in Kalmeshwar taluka of Nagpur district were involved in Lead Center of this project. Due to failure of the initial sowing of cotton, 30 client farmers could not continue the experiments. The technological interventions carried out on the fields of cotton growers reveal that dry sowing has increased the yield up to 3.2 per cent and large number of farmers are convinced that this simple technology can bring significant increase in yield. Soybean was found to be most profitable crop in intercropping system with cotton. Integrated Nutrient Management seems to make some difference in fiber quality also particularly in staple length. However, the difference is non-significant. On economic viability it was observed that BC ratio was higher for Bt cotton (2.15) as compared to farmers practice of growing another popular hybrid (1.60). Adoption of IPM technology leads to reduction in cost of production up to Rs.200/- per quintal of seed cotton.

Coimbatore

Seven technological interventions have been implemented in Keeranatham and Vellamadai villages of S. S. Kulam block of Coimbatore district *viz.*, Popularisation of Varieties (Surabhi and Sumangala), Introduction of Bt cotton, Date of sowing, Paired row technique in cotton, Fertilizer Application Based on Soil Test Plant response correlations (INM), Integrated Pest Management (IPM) and Integrated Disease Management (IDM). Intercropping with vegetables like radish, coriander, lablab and beetroot in cotton proved to be a successful technology with B:C ratio of 1:2.1 as against farmers' practice (1:1.42).

Nagpur

Accessibility to mass media and information technology

During the period the data were collected from randomly selected 55 extension functionaries from Nagpur and Wardha district through personal interview in a interview schedule proforma. Tabulated and analysed the data for the samples in respect of general profile of mass media/information technology, access to and use of modern mass medias (Electronic media-radio & television, Print media-newspaper/ magazines/printed literature and Information technologies- Internet, cellular/mobile phones). The perusal of data for general profile of extension workers including age, education, position/post held, experience, monthly income and training received in mass media/IT as well as possession of various mass media and It tools reveals that majority of the respondents i.e.60% belonged to middle age groups of 41-55 years, possessing diploma in agriculture and educated up to higher secondary, most of them (49%) holds posts of agril supervisors and had service experience more than 21 years, 36 % drawing monthly pay / income in the range of Rs.10,000 to 15000 and 29 % of them received training 'once' in IT sector. Further 89,87 and 62 percent extension workers possessed mass media and information technology sets like TV, radio, and fixed/mobile phone, respectively. 18% extension workers have possessed computers. In case of print media 75 % extension workers were subscriber of more than two news papers while 67 % of them were subscriber of farm magazines like Baliraja, shetkari, etc. It was also recorded that quite good numbers (63%) extension workers had cable TV connections.

Further, the data analyses for access and use of mass media revealed that 76 % extension

workers had access to and used newspapers viz Hitavada, Lokmat and Sakal for seeking cotton related information, 42 % of them have used 'often' the printed materials primarily Shetkari Masik and Baliraja and also other magazines/bn folders/leaflets and other extension bulletins produced by State Agril. Department/ICAR Institutes. Similarly, majority of 45% extension workers used to listen/hear cotton and other agril related programmes broadcasted in 'Mazhe Ghar Mazhe Wawar' by AIR and 45% watched 'occasionally' Doordarshan programme 'Amchi Mati Amchi Manse' and Cable TV 'Annadata' transmitted on use of Bio-pesticides in cotton, market information and price trend in various crops .The Kisan Call Center a toll free facilities established recently by Govt of India at ICAR Institutes and SAUs have been 'often' used by 15 percent extension functionaries for getting scientific information from scientists or experts on Bt cotton and organic cotton production. Mobile/Cellular Phones though quite expensive but are being used in a communication nowadays and it was observed that 15 % highly educated and younger officials have 'often' used it for seeking solutions from the scientists during drought situation and outburst of pests and diseases on cotton crop. Internet/Web a vast global information resource or library, which has been emerged recently as a powerful communication technology, have 'often' been used by 5 % extension workers from the private Internet services of cyber café and availed latest information in cotton production technologies.

Coimbatore

FLD on cotton

Front line.demonstration (20) on Introduction of Bt cotton, Intercropping with vegetables, Application of neem cake, foliar application of DAP & Potash and seed, soil and foliar application of bio inoculants have been conducted at S.S.Kulam and Thondamuthur blocks. IPM was demonstrated in an area covering 48 ha in the same village. In general, heavy rains have drastically reduced the yield and quality of cotton in most of the project farmers' fields.

Cotton Economics and Marketing

Coimbatore

Cottonseed production in Tamil Nadu

The contract seed growers were selected from Erode (55) and Salem (20) districts. Cost of cultivation was more in Salem than in Erode but the cost of production was very less because of higher average yield in Salem (1312 kg/ha) as compared to Erode (1142 kg/ha). Marketing channel in Salem was of three types. Seed growers-Seed organizers-Seed firms-Distributors-Dealers -Consumers; Seed growers -Seed firms-Dealers-Consumers; Seed growers -Seed firms -Consumers.

Economic analysis of contract farming in Tamil Nadu

Majority of non contract farmers felt lack of knowledge about improved technologies of cotton production. Few contract farmers faced rejection of their produce due to poor quality. Few contract farmers, in spite of enjoying higher price, were not satisfied with the stipulated contract price by the sponsor. It could be seen that the contract farmers were more benefited than the non contract farmers. To make this venture a success, contract farmers and sponsoring firms should strictly adhere to the contract procedures.

Information system on cotton

Nagpur

The website is given new look with more linkages and new data sets. Interactive website

is being made. Appropriate data bases were collected for the information system on cotton.

Coimbatore

Information on cotton was collected from different government as well as authentic private sources. The information includes primary data from area production productivity to tertiary data like cloth/yarn production/export/import. The collected data were checked for consistency and the transformation of scale of the data was done, wherever necessary. Appropriate databases were created with the provision to update the database, with new datasets and corrected datasets, in the future. So far around 30 datasets were collected on different aspect on cotton production and post-production components. The collected datasets were categorized as districtwise as well as statewise domain time series data.

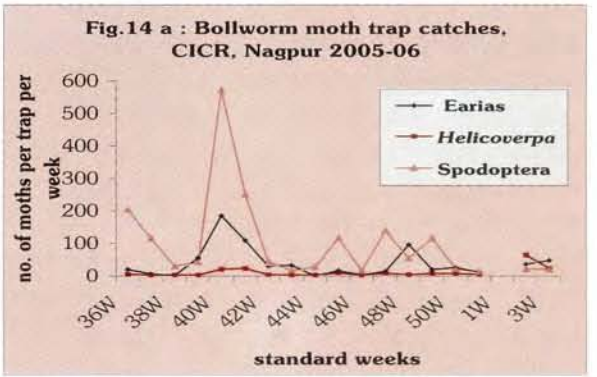
Beta version of the Information retrieval system was developed with advanced tool using Visual Basic.NET. The developed system is menu driven with embedded user friendly tools like drop down menus, list boxes, combo box, and radio buttons. The system also has the facility to report and take print out the queried results using Crystal Reports.

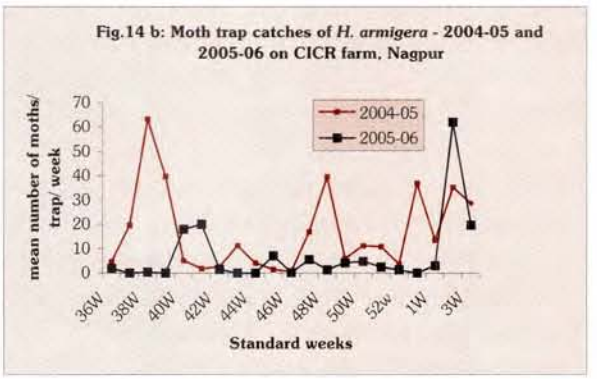
Pest Scenario

Nagpur

Temporal variation of cotton bollworms

Helicoverpa armigera moth activity was significantly lower in the year 2005-06 as compared to 2004-05. Of the four bollworms *Spodoptera litura* moth activity was the highest although there was no significant damage due to *Spodoptera* on CICR, Nagpur farm (Fig.14 a & b). *Earias vittella* was the major bollworm that caused significant damage in mid reproductive stage of the crop this season. Incidence of *Earias insulana* in moth trap catches of Central India was also seen. Off-season pheromone trap catches of *P. gossypiella* indicated contribution from the diapausing population into the ensuing crop season.





Increasing population of jassids in three successive generations during the vegetative crop growth phase that continued development till the crop harvest was observed. The season had damaging population of jassids during 3rd week of August and 2nd week of September. Peak population of thrips was seen during mid-September. Build-up of mirids commenced with the squaring of the crop and peaked during the last week of September. Aphid infestation occurred at low levels during August and September months with peak infestation during first week of September, but with no visible