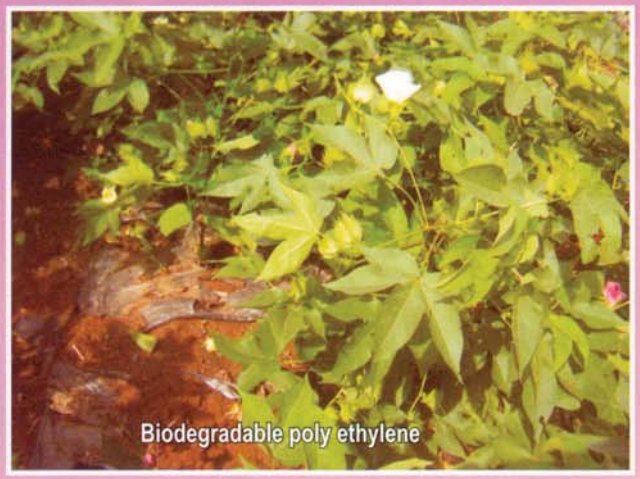
CICR

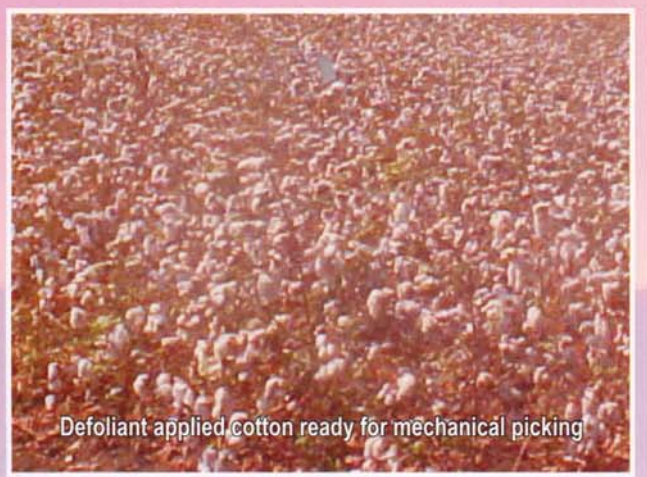
ANNUAL REPORT 2008-09

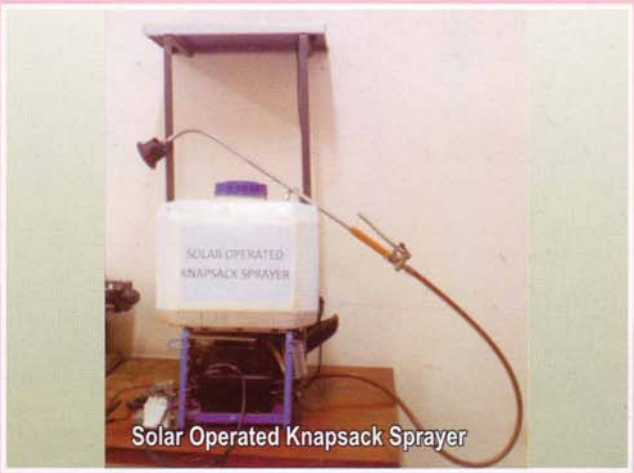

Multi-tier cropping system in cotton


Cotton + Maize intercropping


Biodegradable poly ethylene


Gunny mulch


Defoliant applied cotton ready for mechanical picking



Solar Operated Knapsack Sprayer

4.8: Nutrient Management

Nagpur

For Bunny Bt application of 100% RDF (120:60:60) and 125% RDF through drip were at par and superior to 75% of the fertilizer dose applied through drip.

Under rainfed conditions addition of limiting micronutrients through soil alongwith RDF on soil test basis increased seed cotton yield of Bunny-Bt over RDF alone by 12%.

Long term effect offertilizer and INM

Under long term trials higher yield of seed cotton (16.7 q/ha) was recorded under INM (N_{60} P_{13} K_{26} +Szo+Zn_{45} +PSB +FYM @5t/ha +DAP 2 % foliar) followed by N_{90} P_{20} K_{39} +5t FYM (16.1q/ha) as compared to fertilizer N_{90} P_{20} K_{39} without FYM (Fig. 4.14). Marginal improvement in staple length with the application of N_{90} P_{20} K_{39} + 5t FYM (applied in alternate years) was also observed. Higher yield of strip intercropped pigeon pea was recorded in FYM treated plots.

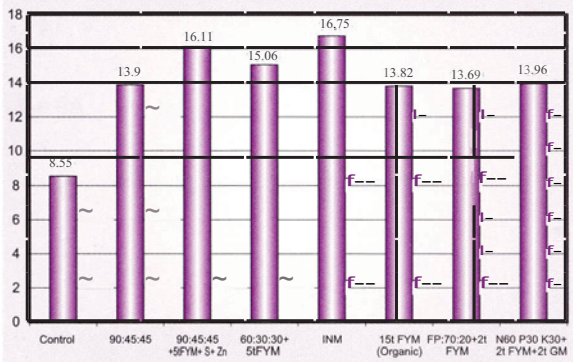


Fig. 4.14: Seed cotton yield(q/ha) as influenced by different fertilizers

Organic carbon build-up was noticed in organic manure plots. Fractionation of soil organic carbon pools under different nutrient management indicated that the mean active forms (very labile + labile forms) in the soil ranged from 47-55% in INM plots and organic plots as against 42% in recommended NPK (alone) plots and 42.5 % in absolute control. Physiologically important microflora viz., Azotobacter, PSM and Pseudomonads registered higher population in INM and organic plots compared to other treatments.

There was general decline in microbial population in 2009 as compared to 2008 in both rhizosphere and non-rhizosphere (Bulk) samples at 0-9" depth. The highest total microbial population was recorded in Treatment-5 (90: 45: 45: 20: 20: 0) followed by Treatment-7 (60: 30: 30: 0: 0: 5 tFYM in alternate year) (Fig. 4.15).

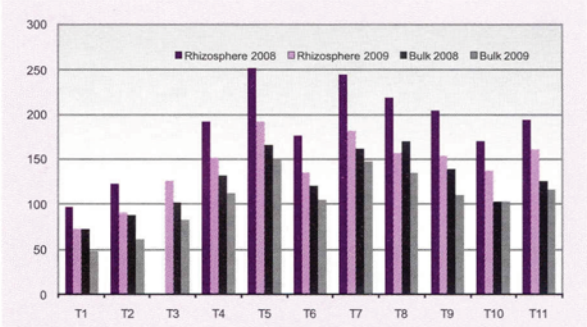


Fig. 4.15 : Impact of long term fertilization on total soil microbial population in cotton

Nutrient requirement of Soybean-Bt hybrid cotton rotation

The data from farmers participatory trials in three villages showed significant correlation between N fertilizer applied and seed cotton yields. The results also indicated that 1.5 times recommended dose of fertilizers improved the yields. With 1.5 times recommended dose of fertilizers in shallow soils without rain water conservation seed cotton yield was 15 q ha^{-1} and in medium deep and deep soils it was 20 q ha^{-1}. Shallow soils with imbalanced fertilization are more vulnerable to reddening of leaves with 30% red leaves which in turn reduced yields by 5 q ha^{-1}.

The red leaves were significantly reduced to 25% by soil application of $MgSO_4$ @ 20 kg ha^{-1}. Magnesium application and rain water conservation delayed the appearance of red leaves until late October/November. The plant analysis showed no deficiency of N, K or Mg whereas P was extremely low in red leaves.

Synchronizing Nand K supply with crop demand

For Bt hybrid (Bunny) grown under rainfed conditions on Vertisols of Agro-eco sub-region 10.2, split application of K along with N did not offer any yield advantage over splitting ofN alone and hence the entire recommended quantity of K

may be applied as basal dose. For high yield and high N utilization efficiency (27 kg seed cotton/kg N uptake), N may be applied in 3 equal splits at 10, 45 and 75 days after sowing in a year of normal rainfall and at 10,30 and 60 days after sowing in a drought year.

Effect of different nitrogen levels on oil and protein content in Bt cotton

Field experiment was laid out with 3 Bt hybrids (Bunny, NCEH 2R)) and their non- Bt counterparts in a split plot design with 3 levels of NPK (90:45:45,120:60:60 & 150:75:75). Crop growth was satisfactory except for NCEH 2R NBt.. No definite trend for total protein content at 110 DAS) was observed in the leaves with increase in nitrogen level beyond 120:60:60. There was difference in protein content between Bt and non-Bt hybrids. Seed oil content was in the range 15 - 25%. Bunny Bt and non-Bt hybrids were found to contain relatively higher oil content in the range 24-26%. There was no significant difference in seed cotton yield among the treatments. Among the cultivars, both Bunny Bt and non-Bt hybrids performed well..

Coimbatore

Long term sustain ability

In an upland cotton *(Gossypium hirsutum* L. cv. Surabhi) grown under irrigated condition on a medium fertile black clay loam soil the Sustainable Yield Index (SYI) (based on 5 years pooled yields) calculated on the basis of mean, highest and standard error in yield was maximum and relatively stable (0.42) under INM (NPK: 60:13:25 kg/ha + FYM@5t/ha)followedbyNPK + crop residue incorporation @ 2.5 t/ha (0.40) and organics (FYM @ 15 t/ha) only (0.39) (Table-4.16). Soil nutrient status after 5 years continuous cropping showed application of NPK or INM or organics slightly enhanced soil OC and decreased available K status in the root zone over the initial levels. Yet, significant enhancement in soil NaHCO) extractable P was observed under NPK, INM and FYM supplemented treatments over control (Table 4.16).

Table 4.16 : Sustainable Yield Index (SYI) and final soil nutrient status after 5 years of cropping

NPK (kg/ha)			FYM (t/ha)	SYI Cotton	OC (%)	P(ppm)	K(ppm)
0	0	0	0	0.37	0.61	8.4	352
60	13	25	0	0.38	0.65	12.8	384
90	0	0	0	0.36	0.61	9.0	366
90	19	0	0	0.37	0.63	10.6	374
90	19	37	0	0.37	0.65	11.6	396
0	0	0	15	0.39	0.66	13.6	403
60	13	25	5	0.42	0.68	14.4	408
60	13	25	2.5#	0.40	0.67	11.1	390
C.D.(0.05)				-	NS	3.9	NS
Initial status				-	0.60	7.7	410

<0.3 unstable, 0.3-0.7 relatively stable and >0.7 stable, #crop residues in t/ha)

Fertigation through drip

Trials for two consecutive years in large plots with RCHB 708 Bt indicated that fertigation @ 90:19:37 kg NPK/ha with 6 splits ofN andK (at 15 days intervals from 30 days after planting) through drip led to significantly higher seed cotton yield (3058 kg/ha) over that in both 75 % NPK applied in 6 splits (2842 kg/ha) and soil application through 3 splits (2784 kg/ha). Thus this dose and schedule was optimum resulting in a saving of

25% NPK by fertilizers, besides providing highest net return (Rs. 54,934/-) and B:C ratio (2.93).

Synchronization in Nand K supply with crop demand

Synchrony in N or N + K supply through multiple splits commensurating with crop growth stages was not apparent under irrigated conditions existing semiarid situation at Coimbatore especially for long duration cotton (RCH 708 Bt). Yet, averaged over 2 years, maximum seed cotton yield (3133 kg/ha), net return (Rs 68,195/- and B:C ratio (3.60) were obtained under 3 equal splits ofN only applied at 45,75 and 105 DAS (P & K as basal with NPK dose of 90: 19:37 kg/ha). It is concluded that under the existing condition, 3 splits of N only @ 30 kg/split at 45, 90 and 105 DAS is optimum.

Nutrient management to reduce the premature senescence (PS) in Bt cotton

Premature senescence in Bt cotton could be managed by balanced fertilization and split (4 times) Nand K application. RCH 20 Bt responded to split NK up to eight splits but the response was not significant beyond four splits. The balanced fertilization includes application of 120 : 60 : 60 kgs NPK in either 4 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. This combination recorded significantly higher yield and PS symptom was not observed.

Studies on mechanism of cuticular absorption of nutrients and hormones in Bt cotton

Foliar sprays of nutrients and hormones were tried on Bunny Bt cotton at 70th day after sowing followed by another two sprays at 10 days interval under both irrigated and moisture stress condition. Plants grown under irrigated condition gave significantly higher yield than plants grown under moisture stressed condition irrespective of the treatments with a mean increase of 25%. The effect of treatments was distinct only in plants grown under irrigated condition. Among the treatments, Hoagland 50%, Hoagland 100% and DAP 2% spray retained significantly more number of bolls at harvest.. Irrigation favoured a significant increase in boll weight by 9%, irrespective of the treatments effected. Under irrigated conditions, there was a significant increase in boll weight where 2% DAP and Hoagland solutions were sprayed.

Basic studies on nutrient uptake through foliar application indicated that the uptake of potassium in the leaf did not increase with increase in concentration of potassium applied. The amount of potassium absorbed by the foliage in 0.5 and 2% KCl spray was almost to the same level of 43 and 45 ppm respectively. Time of application was found to be an important factor in favoring the absorption of nutrients. Spraying during the early hours was not conducive for foliar uptake and sprays imposed during the evening hours helped in penetration of more nutrients. For instance, uptake of potassium was only 31ppm when sprayed at 8.00 am while spray at 4.00 pm gave a concentration of 49 ppm in the leaf.

4.9 : Irrigation Water Management

Nagpur

Development of production technology for Bt cotton and improvement of WUE and NUE with precision farming techniques

Results on different irrigation schedules and fertilizer levels in Bt cotton (Bunny) indicated that irrigation at 0.8 ETc was more economic in obtaining higher seed cotton yield, water use efficiency and fertilizer use efficiency in Bt cotton than irrigating at 1.0 ETc.

Coimbatore

Drip fertigation in cotton

Based on last 2 years trial, alternate day based irrigation at 0.8 ETc through drip was optimum for a long duration hybrid RCHB 708 Bt (Table 4.17). An average of 25.2 % lower water use and 31 % higher WUE was obtained with 0.8 ETc over surface irrigation at 0.6 IW/CPE.. Thus, an average 1564 litres of water were consumed per kg of seed cotton under 0.8 ETc drip (2057 litres/kg in IW/CPE of 0.6). In addition, drip fertigation with 90: 19:37 kg NPK/ha was optimum for realization of higher seed cotton yield and fertilizers beyond the above dose had little influence on the quantum of water use, WUE water productivity or yield. The results showed drip-fertigation at 0.8 ETc with 90:19:37 kg NPK/ha was optimum under the existing semi arid condition at Coimbatore where

the crop received a total rainfall of 57.3 cm out of which 17.4 cm (30.3%) was effective and the evaporation was 80 cm.

Irrigation scheduling under poly/biol biodegradable mulching for ELS Bt cotton

Field experiment was conducted to find out the performance of bio-mulching and biodegradable polyethylene mulching for moisture conservation, water saving, weed control and enhancing the productivity ofELS Bt cotton, (RCHB 708) under drip and conventional irrigation. The design used was split plot with eight mulch treatments in the main plot and three moisture regimes in the sub plot (Table 4.18). The results indicated that the total water requirement was 438,589 and 767 mm at O.4ETc (drip), 0.8 ETc (drip) and conventional irrigation. When no mulch was applied, the crop responded up to 0.8 ETc while with mulch combinations, the yield declined beyond 0.4 ETc. The highest water use efficiency of 126.2 kglha cm was recorded at poly mulch + drip at 0.4 ETc. Poly-mulching was on par with biodegradable mulching for seed cotton yield and closely followed by other mulches except surface coir and no mulch. The interaction between mulches and moisture regimes was significant. . Among the treatment combinations, poly mulching with drip at 0.4 Etc

Table 4.17: Mean effects of drip-fertigation on yield and water use parameters (pooled for 2 yrs)

Drip fertigation	Seed cotton yield (kg/ha)	Water use (em)	WUE (kg/ha-cm)	WP (Rs/M^3)
DripO.6ETc	2606	37.9	68.7	20.6
Drip 0.8 ETc	3017	47.2	63.7	19.1
Drip 1,0ETc	3008	56,4	53.3	16.0
Surface 0.6	3067	63.1	48.6	14.6
C,D.(0.05)	360	3.3	8.4	2.6

Table 4.18 : Seed cotton yield in extra long staple Bt cotton (cv. RCHB 708) as influenced by moisture regimes and mulches

Mulches	Drip (0,4 ETc)	Moisture regimes		
		Drip (0.8 ETc)	Conventional Irrigation	Mean
No mulch control	3046	3957	3262	3421
Sub soil coir pith (2kg/m^2)	4199	3957	4121	4092
Maize stover (5 kg / m^2)	4141	4086	3712	3979
S.Cane trash (5 kg / m^2)	4109	3967	3931	4002
Surface coir pith (5 kg 1m^2)	3798	3460	3069	3442
Gunny sheet	4255	4142	3585	3994
Biodegradable poly mulching	5105	4442	4489	4679
Poly mulching	5526	5310	5235	5357
Mean	4272	4165	3926	
CD (p=0.05) for mulches	683.7			
CD (p=0.05) for moisture regimes	296.2			
CD (p=0.05) for mulches x moisture regimes	1018			

recorded the highest seed cotton yield as against the lowest yield recorded under no mulch with drip at 0.4 Etc.

Optimization of irrigation and nitrogen requirement for Bt cotton

Field experiments were conducted in a split plot design during 2006-07 to 2008-09 to study the interaction effect of irrigation and N on yield, input use efficiency and water and nitrogen dynamics in Bt cotton (RCH2 Bt) on a mixed red and black calcareous sandy clay loam soil (Vertic Ustropept) of Periyanaickan Palayam series. Treatment details are presented in Table 4.19. Protective irrigation treatment refers to one irrigation at sowing, one life saving irrigation within one week after sowing and one irrigation after earthing up operation at 45-50 days after sowing in the absence of rainfall.. It was observed that all the irrigation treatments were statistically at par with respect to seed cotton and lint yield whereas N application up to 60 kg N/ha significantly improved the yield. There was no further significant difference in the seed cotton or lint yield at 90 and 120 kg N/ha. There was significant reduction in the earliness index at higher irrigation and nitrogen levels. There was significant reduction in water use efficiency and water productivity with the increase in the level of irrigation whereas there was increase in the water use efficiency and water productivity due to N application @ 60 kg N/ha over no nitrogen control. . The nitrogen utilization efficiency of cotton (i.e. kg seed cotton yield per kg of N uptake) decreased significantly with the increase in the level of irrigation whereas the N levels did not influence the nitrogen utilization efficiency significantly. However, partial factor productivity of nitrogen (PFPN) decreased significantly with the increase in irrigation and N levels. Thus, RCH2Bt cotton hybrid may be grown with protective irrigation and 60 kg N/ha to achieve higher water and nitrogen use efficiency without significant yield reduction in winter irrigated situation in the Southern zone of the country.

Table 4.19 : Water use efficiency/ Nitrogen use efficiency of RCH2 Bt cotton under varied irrigation and nitrogen levels (Pooled over 2006-07 and 2008-09)

Treatment	Water use efficiency (kg/ha-cm)	Water productivity (Rs/m^3)	N utilization efficiency (kg SCY /kg N uptake)	Partial factor productivity of N (kgSCY/kg N applied)
Irrigation				
Control (Protective irrigation)	48	10.96	32.7	24.7
0.6 IW/CPE	36	9.11	22.9	22.7
0.8 IW/CPE	30	7.45	22.1	22.6
1.0 IW/CPE	29	7.19	19.2	24.1
Nitrogen				
Control	31	7.84	24.1	
60 kgN/ha	36	8.85	24.2	32.1
90 kgN/ha	37	9.01	22.4	21.4
120 kg N/ha	38	9.02	26.2	17.1
LSD 0.05 (1)	2.5**	0.60**	2.61 **	1.39*
LSD 0.05 (N)	2.3**	0.55**	NS	1.21**

Water use efficiency on cotton based cropping systems

Higher water use in cotton genotype (Surabhi) to the extent of 8.2 % was recorded under cotton-

fallow over cotton-sorghum system. Similarly, significantly higher water productivity (by Rs.1.62/M^3) was recorded under INM (NPK @60: 13:25+FYM 5 t/ha) over control.. There was a significant increase in WUE and a decrease in water use to the tune of7.26 kg/ha-cm and 8.7 cm respectively under INM over control.. Thus, integrated nutrient management and efficient cropping system use less water for unit /crop productivity.

Comparative performance of Bt and non-Bt cotton under scanty rainfall situation

Bt cotton recorded the mean seed cotton yield of 1433 kg/ha as compared to 855/kg with non-Bt hybrids (rainfall 436.8 mm and effective rainfall 264.2 mm). Bt hybrid yielded 3.5 and 5.4 kg seed cotton/mm of total rainfall and effective rainfall use efficiency respectively as compared to non Bt hybrids which recorded respectively the least mean average of 2.0, and 3.2 kg/mm. Bartlett earliness index ofBt was 0.73 as compared to 0.62 with non Bt. Bt hybrids registered the mean gross return ofRs. 41,300/ha, net return ofRs. 24, 136/ha and benefit cost ratio of2.40. In non-Bt hybrids the average gross return was of Rs. 24,553/ha, net return was Rs. 10,180/ha and benefit cost ratio was 1.72. Bt hybrids registered the mean highest partial factor productivity of 11.94 kg of *kapas* /kg of added nutrients and economical nutrient use efficiency of 0.9 kg/rupee investment made on nutrients. The corresponding values for non-Bt hybrid were 7.1 kg/kg of nutrients and 0.55 kg/ rupee respectively.

4.10: Soil Moisture Conservation in BtCotton

Nagpur

Field experiment on different moisture conservation techniques on Bt cotton indicated significantly higher seed cotton yield and economic return with intercropping system *viz.,* cotton + green gram (1: 1) over the treatments of mulching with sunhemp or opening of alternate furrows.

Coimbatore

A field experiment was conducted in RBD with eight mulch treatments *viz.,* Sub soil coir pith, Maize Stover, Sugar cane trash, Surface coir pith, Gunny sheet, biodegradable polyethylene and polyethylene mulching were evaluated against no mulch control using RCH 20 Bt.. The results indicated that all the mulch treatments enhanced the seed cotton yield under rain fed condition. The yield increase ranged from 11.3 % to 83 %. Poly mulching recorded the highest (1646 kg/ha) seed cotton yield and was on par with all other mulch treatments except surface coir pith and no mulch control.. Surface application of coir pith recorded significant reduction in yield over other mulches.

4.11: Cropping Systems

Nagpur

Identification of innovative Bt cotton based cropping system for rainfed cotton

A large plot demonstration on Bt cotton hybrid indicated that intercropping with legumes like green gram and black gram, vegetable cluster bean and flowers like marigold was profitable. An innovative design for both bullock drawn and tractor drawn paired row planting system for Bt hybrid (67.5x45 cm) was developed and tested.

On shallow soils, the seed cotton yields were not significantly influenced by the different of cropping systems. However, cotton equivalent yields (4396 kg ha'i) and net returns (Rs. 98,425 ha'i) were highest in Bt hybrid cotton intercropped with maize + tomato followed by Bt hybrid cotton intercropped with Portuluca + Dolichus lab lab + fennel (3177 kg ha'l, Rs. 65, 117 ha'l) and Bt hybrid cotton intercropped with sweet com (baby com) +cowpea (2805 kg ha'l, Rs. 45, 412 ha'l). On the medium deep soils the highest cotton equivalent yields (CEE) 2933 kg ha'l, net returns Rs. 61, 870 ha'i was with cotton +maize (green cobs) intercropping followed by marigold intercropping (2850 kg ha'i Rs. 53, 223 ha'i) and spinach intercropping followed by relay cropping of green peas (2507 kg ha'i Rs. 52,675 ha'l). Soil moisture was a limitation for grain filling of majority of the relay crops such as safflower, gram and lentil..

Bt hybrid cotton was relay planted with green leafy vegetables, winter oil seeds, pulses and cereal grain crops. The most successful relay cropping system in a year with 50% less rainfall during crop growth period was Bt hybrid cotton paired row planted at 67.5 x 45 cm relay planted with castor at

the end of September. The relay crop harvested by January, produced 3 q ha^{-1} castor beans.

Coimbatore

Identification of Innovative Bt Cotton Based Cropping Systems for irrigated cotton

Short duration intercrops like clusterbean, coriander, radish, amaranthus, greengram and vegetable cowpea were evaluated against sale crop of Bt cotton. Normally, cotton crop is grown in one side of the ridge and the other side is kept vacant and in this novel experiment without altering the cotton crop geometry, short duration inter-crops were grown on the other side of ridge. The results indicated that all the intercrops evaluated were found suitable to grow with Bt cotton, RCH 20. The seed cotton equivalent yield from intercrops varied from 4.44 q to 10.12 q/ha and the cotton + coriander inter cropping recorded the highest seed cotton equivalent yield, gross return, net return and B/C ratio closely followed by cotton + radish system.

Incorporation (in situ) of cereals on productivity of succeeding cotton

The assumption is that sowing of cereals as bulk crop in the off-season by using available moisture and in-situ incorporation (45 days period) may provide similar cereal rotation effect to the succeeding cotton which help to break yield barrier and make the system sustainable was tested. The first years result revealed that significantly highest seed cotton yield (1598 kg/ha) was harvested with cotton, raised after *in situ* incorporation of ragi at 45 days after sowing (DAS) along with soil application of *Trichoderma viridi*. The results were on par with *in-situ* incorporation of sunnhemp + *Trichoderma viridi* (1449 kg/ha) and *in situ* incorporation ragi alone at 45 DAS (1402 kg/ha). The control (fallow-cotton) recorded seed cotton yield 1192 kg/ha. The highest gross return (Rs. 41,539/ha), net return (Rs. 21,551/ha), benefit cost ratio (2.08) were obtained with incorporation of ragi at 45 days after sowing with soil application of *Trichoderma viridi*.

Multi -tier cropping system

The highest net return (Rs. 1,16,81 O/ha), benefit cost ratio (3.51), per day profitability (Rs. 779) and relative economic efficiency (221 per cent higher than sale cotton) were obtained with multi tier system of cotton intercropped with radish, beetroot and coriander with application of 100 per cent recommended levels of fertilizer to intercrops. Sale cotton system had a with net return of Rs. 34,300/ha, benefit cost ratio of 2.20 and per day profitability ofRs. 243.

Sirsa

Intensification of cotton based cropping system for maximizing the use of natural resources under irrigated conditions

Three cropping sequences *viz* cotton-wheat, cotton-barley and cotton-mustard were evaluated (Table 4.20). Based on the system as a whole, the highest net income/ha of Rs 46935 and 51315 respectively was obtained in cotton followed by wheat with normal as well as transplanted cotton. The maximum (87.1 %) land use efficiency was recorded in normal sown cotton-wheat as well as normal sown cotton-barley cropping system. The production efficiency (kg/ha/day) was recorded higher in transplanted cotton-wheat (16.24) followed by nonnal sown cotton-wheat (14.69) cropping system.

Table 4.20 : Comparative evaluation of *rabi* crops after cotton

System	Cotton planting system	Performance of Rabi crops	
		Yield (q/ha)	Gross Income (Rs./ha)
Cotton-wheat	Nornlal	38.13	41943
	Transplanted	38.00	41800
Cotton-barely	Normal	38.63	25110
	Transplanted	39.41	25616
Cotton	Normal	13.50	24300
Mustard	Transplanted	12.90	23220

Soil plant narrations in intercropped *kharif* legumes with Bt cotton under irrigated condition

The performance ofBt. hybrid RCH 134 with and without intercrop combinations (Cotton + Mungbean, Cotton + Mothbean, Cotton + Cluster bean, Cotton + Groundnut) was evaluated. The yield (3301kg per ha) was significantly higher in sale cotton at spacing 67.5cm x 75 cmcompared to

paired row cotton (2771 kg per ha) with and without intercrops. The dry matter, N, P and K uptake (kg/ha), nutrient use efficiency, water use efficiency and water productivity was also higher in sole cotton (67.5 cm x 75 cm) than paired row cotton. The water use efficiency and water productivity was higher in sole and paired row cotton without intercrops than paired row cotton with inter crops.

4.12: Agronomic Evaluation of Cotton Genotypes

Nagpur

Effect of closer spacing on plant characters suitable for mechanical picking for Bt cotton

The effect of closer spacing on plant characters suitable for mechanical picking and was studied in replicated trials using Bunny Bt. Closer spacing of90 x 20 cm recorded highest yield (2286 kg ha!), followed by 90 x 30 cm (1942 kg ha!) whereas, wider spacing of 90 x 60 cm recorded less yield (1048 kg ha!). The closer spacing had an effect on compactness of the plants which is more desirable for mechanical picking.

Coimbatore

High density planting with genotypes

High density planting (HDP) of cotton varieties *viz.,* CCH 510-4 and CCH 724 at 90 x 10 cm resulted in realizing higher seed cotton yield, net return and B:C ratio at par with Bt hybrid (RCH-2 Bt) planted at recommended 90x60 cm. Thus, comparable yields and profits could be realized through agronomic manipulation of existing improved straight varieties . The additional benefits from HDP include early harvest in 2 pickings, escape from pests, weeds, and scope for rotational crops due to early pickings.

Productivity, profitability and water use efficiency of different genotypes of south zone

The trial was conducted to identify high potential and resource efficient genotypes to realize high productivity, profitability, and effective ~tilization of resources. The results (Table 4.21) indicated that significantly highest seed cotton yield (3975 kg/ha) was recorded with RCHB 708 Bt, which was followed by CCH 510-4 (3336 kg/ha), Narashima (3176 kg/ha) and Surabhi (3126 kg/ha). The Bartlett earliness index was high for Bunny Bt (0.81), MallikaBt (0.81) and Tulasi 9 Bt (0.76) higher value. The total quantity of water used was lower for Bunny Bt, Mallika Bt and Tulasi 9 Bt. The water use efficiency (kg/ha-mm) was observed higher with RCHB 708 Bt (6.5), Mallika (6.4), Tulasi (6.2) and CCH 510-4 (5.9). RCHB 708 Bt , Mallika Bt, and Tulasi Bt had higher water productivity of 22.0,18.0 and 17.5 rupees per cubic meter of water. Data on partial factor productivity for fertilizer and economic parameters are also presented in Table 4.21 .

4.13: Weed Management

Coimbatore

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

Field experiment was conducted during 2008-09 cropping season to find out efficient, economical and environmentally safe weed control method and to find out the efficacy of herbigation technique. The design used was split plot with two methods of application (Herbigation and conventional spraying) and six weed control treatments like (Flucholoralin 1.5 kg/ha (PRE)+HW (30 DAS), Pendimethalin 1.5 kg/ha (PRE) + HW (30 DAS), Pendimethalin + metalachlor 1.0 kg/ha (PRE) + HW (30 DAS), Pendimethalin 1.0 kg/ha fb 1 + HW + metalachor 1.0 kg/ha (30 DAS), hand weeding thrice (20,40,60 DAS), Un weeded check). Herbicide rotation of pendimethalin 1.0 kg/ha fb 1 HW + metalachlor 1.0 kg/ha on 30 DAS recorded lesser weedDMPofl2.4 . g/$m^2$to 16.4 g/m^2 and the WCE was up to 94.7 % on 60 DAS. The seed cotton yield was significantly enhanced under drip system with the yield level from 4015 to 5155 kg/ha as against 3569 to 4430 kg/ha under conventional method. Hand weeding thrice recorded the highest (4793 kg/ha) seed cotton yield and was on par with herbicide rotation + HW and herbicide mixture +HW.

4.14: Soil Microbiology

Nagpur

Impact of transgenic cotton on soil microbial population

Two field experiments one each in shallow and

Table 4.21: Productivity, water use efficiency and profitability of different genotypes of south zone

Genotypes	Seed cotton yield (kg/ha)	Bartlett index	Water productivity (Rs/m^3)	WUE (kg/ha-mm)	ENUE (kglRs)	PFp (kg / kg)	Gross Return (Rs/ha~	Net Return (Rs/ha)	B:C ratio
RCH2Bt	2884	0.71	14.6	5.6	1.2	16.0	74979	45213	2.52
RCH 2Bt11	2931	0.67	14.8	5.7	1.2	16.3	76211	46208	2.54
RCH 20Bt	3039	0.59	14.0	5.4	1.3	16.9	79004	48464	2.59
RCHB 708 Bt	3975	0.53	22.0	6.5	1.7	22.1	135163	99939	3.84
MRC 6918Bt	2670	0.75	16.1	4.7	1.1	14.8	90781	62084	3.16
BUNNYBT	1962	0.81	11.8	4.2	0.8	10.9	54925	29770	2.18
MALLIKABt	2982	0.81	18.0	6.4	1.3	16.6	83487	53231	2.76
THULASI 9 Bt	2895	0.76	17.5	6.2	1.2	16.1	81061	51239	2.72
DCH32	3039	0.53	16.8	4.9	1.3	16.9	103324	66433	2.80
SURABHI	3126	0.42	15.5	5.5	2.0	26.0	87516	50888	2.39
MCU5VT	2248	0.47	11.2	4.0	1.4	18.7	62957	31591	2.01
SVPR2	2271	0.43	9.7	4.0	1.5	18.9	54496	22997	1.73
NARASIMMA	3176	0.50	14.6	5.6	2.0	26.5	82585	45652	2.24
LRA 5166	3085	0.45	13.1	5.5	2.0	25.7	74043	37657	2.03
CCH 510-4	3336	0.49	15.4	5.9	2.1	27.8	86743	48851	2.29
CD 5%	443								

medium soil have were conducted to assess the impact ofBt cotton on soil microbial community at different stages (sowing, flowering, boll formation, harvest). It was observed that there are no much population changes in general (bacteria, fungi, actinomycetes and yeast) and physiological (azotobacter, PSM, fluoroscent pseudomonads and *Beijerinkia)* groups between Bt and Non-Bt cotton in all the stages (Fig. 4.16 & 4.17). The flowering stage recoded maximum population compared to other stages. Their population was found to increase with flowering with a decline towards harvest.. Medium deep soil recorded higher population count as

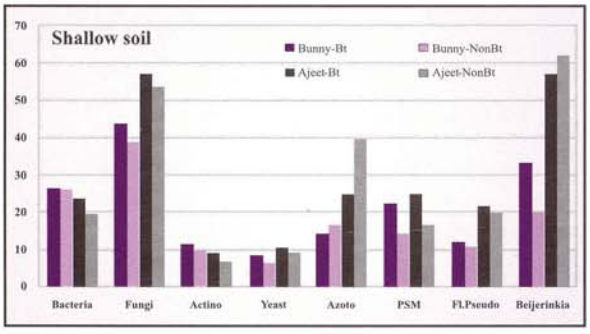


Fig. 4.16 : Per cent microbial changes in Bt and Non-Bt cotton - shallow soil (mean over stages)

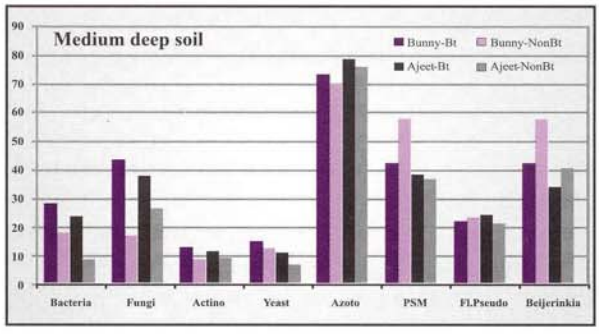


Fig. 4.17: Per cent microbial changes in Bt and Non-Bt cotton-Medium deep soil (mean over stages)

compared to shallow soil.. Among cotton hybrids, Bunny Bt recorded slightly higher microbial population as compared to BG-II cotton (Ajeet).

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

Three different methods of microbial delivery were taken up to study the survival and retention of applied bio-inoculants in cotton rhizosphere. Under the seed treatment, the bio-inoculants were applied as microbial suspension @ 10^8 cells/ml, while in the soil application method the treatment was simulated with FYM as carrier material with the cell load of 10^8 cells/g following standard procedure. The third treatment i.e. the newly identified solid carrier was impregnated with bio-inoculants *viz., Azospirillum* spp., *Bacillus polymyxa* and *Azotobacter* spp. and applied at the cotton rhizosphere. Results indicated that till 3 DAS, seed treatment retained maximum bio-inoculants population followed by soil application, but at later stage i.e. 60 DAS, the new identified solid carrier based delivery system recorded higher bio-inoculants count (Fig. 4.18).

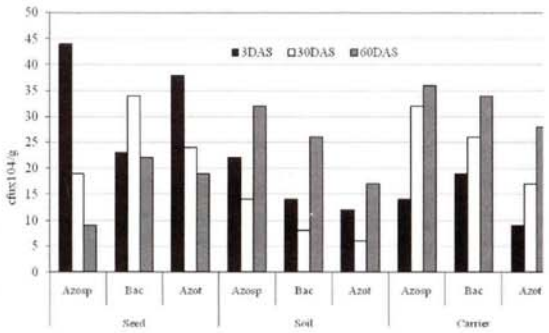


Fig. 4.18 : Effect of delivery system on survivability of bioinoculants in the cotton rhizosphere

4.15: Cotton Simulation Modelling

Coimbatore

The validation of the generic simulation model INFOCROP using the daily weather data and the data on biomass partitioning, leaf area index, incidence of insect pests, collected from field experiments conducted in a mixed red and black calcareous sandy clay loam soil (Vertic Ustropept) of Periyanaickan Palayam series at Coimbatore, for three cropping seasons 2006-07 to 2008-09, Results indicated that the root mean square error between the observed and simulated seed cotton yield was 333, which corresponds to 17.5% of the mean observed seed cotton yield. The index of agreement (D index) between the observed and simulated seed cotton yield was 0.52. The mean systematic error (MSEs) and the mean unsystematic error (MSEu) were 63720 and 111208, respectively.

INFOCROP can serve as a useful tool in taking critical decisions with respect to optimization of input use and assessing the global warming potential (emission of green house gases expressed as CO_2 equivalent = CO_2 + 21 x CH_4 + 310 x N_2O). It was observed that there was significant reduction in water use efficiency of cotton but significant increase in global warming potential and carbon efficiency (g CO_2 equivalent green house gas emission/ kg seed cotton yield) with the increase in the level of irrigation (Table 4.22). There was a trade-off between the cotton production and global warming potential estimated by the model.. This calls for efficient use of water to reduce the global warming potential..

4.16: Cotton Mechanization

Nagpur

Development of a novel sprayer: In order to overcome the disadvantages of a knapsack sprayer *viz.,* variations in pressure leading to non uniform generation of spray droplet sizes and hence ineffective sprayings and wastage of pesticide, and disadvantages of a battery operated sprayer due to long hours of load shedding in rural areas and inability of charging of battery, a novel Solar Operated Knapsack Sprayer was developed, tested and modified. It has a field capacity of 4 hrs/ha. The weight of the sprayer without pesticide is 9 kg, with a swath of 90 em giving 20 sprays with a single charge.

Defoliation of cotton plant for mechanical picking:

Nagpur

Since defoliation of cotton plant is a pre-requisite

Table 4.22 : Trade-off between cotton production and green house gas emissions (Pooled over 2006-07 to 2008-09).

Treatment	Seed cotton yield (kglha)	Water use efficiency (kglha-cm)	Global warming potential (kg CO/ha)	Carbon efficiency (g CO/kg SCY)
Irrigation				
Control (Protective irrigation)	1974	48	4572	2374
0.6 IW/CPE	1873	36	5862	3137
0.8 IW/CPE	1746	30	6210	3456
1.0IW/CPE	1947	29	6492	3521
Nitrogen				
Control	1662	31	5554	3406
60 kg N/ha	1926	36	5756	3040
90 kg N/ha	2005	37	5850	2980
120 kg N/ha	2046	38	5976	2963

for clean machine picking, defoliants Ethrel and Dropp alone and in combination with Roundup to suppress re-growth, at 3000,5000 and 7000 ppm concentrations were evaluated on Bunny Bt at three different spacings of 90x60, 90x30 and 90x20 em. Ethrel at 7000 ppm concentration gave the highest percentage of leaf shedding of 91% at the widest spacing of90x60 em.

Sirsa

The effect of foliar spray of 1500 ppm, 2000 ppm and 2500 ppm concentration of defoliant (ethrel) at 145 days after sowing and 160 DAS was evaluated. Compared to unsprayed crop, the crop sprayed with ethrel @ 1500 ppm at 145 DAS had a lower number of green leaves at harvest, a significantly higher boll number plant (42.1) and a significantly higher seed cotton yield (2855 kg/ha).

4.17: Morpho-frame/Boll Load Management

Nagpur

Bt morphoframe manipulation using action specific chemicals

Five Bt hybrids namely RCH 2 Bt, JKCH 99 Bt, NECH 2R Bt, NCS 138 Bt and NCS 145 Bt were tested. Chemical and mechanical treatments included (i) 5.7 millimolar ethrel foliar spray, (ii) 8.5 millimolar, (iii) mechanical removal of square (once) at 30-35 days days after sowing alongwith control.. Amongst hybrids, NCS 138 had given the highest yield of 1446 kg/ha which was significantly superior over RCH 2 Bt and JKCH 99 Bt. Foliar application of both doses as well as mechanical removal of square gave significantly higher seed cotton yield over control..

In another experiment, four Bt hybrids namely NCS 145 Bt, NCS 145 non-Bt, NCS 145 BG II and XL 708 Bt were tested under four morpho frame manipulating techniques *viz.*, detopping of main stem at different intervals and spray of foliar application of maleic hybdrazide @ 500 ppm at 95 DAS. The results indicated that de-topping treatments as well as maleic hydrazide application did not affect the yield.

Coimbatore

Manipulation of morpho-frame using action specific chemicals

Five entries viz Bunny Bt, RCH2 Bt, NECH 2R Bt, JK CH 99 Bt and NCS 138 Bt and four treatments (foliar application of ethrel @ 5.7 & 8.56 mM control and nipping of squares) was done at 35-40

DAS (square initiation). Sudden drop of all the young squares was noticed within 48 hours after foliar spray of ethylene.

There was a significant improvement in physiological parameters viz., plant height, leaf area and number of fruiting parts with foliar application of ethylene in the form of ethrel and square removal at 75 DAS. These effects synergistically worked and brought about changes in plant ideotype through out the crop growth. Higher plant height, square number, boll number and even the leaf area was maintained at 120 DAS. The effect offoliar application of ethylene @ 8.56 mM (T_3) yielded significantly higher seed cotton yield followed by T_2 (5.7 mM ethylene), T4 (mechanical removal of squares). All these treatments were significantly superior over the control (T J

Manipulation of morpho frame though nipping at grand growth stage and mimic the effect using using action specific chemicals- Maleic hydrazide in cotton.

The cotton genotypes - DCH 32 and RCH 708 XL (Bt) out yielded Suvin (Table 4.23). Application of Maleic hydrazide @ 500 ppm changed the plant morphology with reduced internodal elongation. Improved LAI with better LAD and there was a significant improvement in seed cotton yield (Table 4.23) De-topping (T2 & T3) and control (Tl) were on par with one another.

Table 4.23: Effect of morpho frame manipulation techniques on seed cotton yield in different cotton genotypes

Genotypes	Yield (kg/ha)
Vl:DCH32	2185
V2: RCH 708 XL	2055
V3: Suvin	935
CD5%	291
Morphoframe manipulating techniques	
Tl: Control	1691
T2: De-topping of main stem at 85 DAS followed by nipping of sympodia and monopodia at 95 DAS	1728
T3: De-topping of main stem at 95 DAS followed by nipping of monopodia and sympodia at 105 DAS	1420
T4:F oliar application of Maleic hydrazide @ 500 ppm at 85 DAS	2061
CD5%	404

4.18: Studies on Abiotic Stress

Coimbatore

Effect of water logging on morphological, biochemical and yield attributes:

Four Bt cotton hybrids namely Bunny, RCH 20, RCH 2 and Mallika were subjected to prolonged water logging for 20 days in 55 days old crop. Plant height was significantly retarded upto 70 days after sowing, irrespective of the Bt hybrids, recording 45 cm in water logged plants compared to 60 cm in control plants. Similarly, reduction of 31 % in leaf production was observed consequent to water logging as observed on 70th day. Water logged plants could produce only 10 squares compared to 17 in control plants regardless of the hybrids studied. At harvest, only 22 bolls were produced by plants subjected to water logging treatment compared to 25 in normal plants. Among the hybrids, Mallika cotton produced more number of bolls. Boll weight was not affected due to water logging. A reduction of 6-12 % in total yield was recorded in plants subjected to water logging. Among the hybrids, RCH 2 and Bunny Bt

were less affected than Malika and RCH 20 due to water logging in terms of total yield with a loss of 6-8 %. Total chlorophyll content started declining from 7 t4 day after logging and the increase was at a faster rate after 14th day of water logging (Table 4.24). Similar trend was observed for nitrate reductase activity.

When water logging was withdrawn, chlorophyll content recovered at a faster rate after 14 days. Interestingly, nitrate reductase activity appeared to be more in water logged plants to compared to control plants during recovery period after withdrawal of water logging treatment in Bunny cotton.

Table 4.24: Effect of water logging on Chlorophyll and NR activity

Bt cotton	Treatment	Days after water-logging			Days after recovery		
		7	14	21	7	14	21
		Chlorophyll content (mg/g)					
Bunny	control	3.32	3.30	3.28	3.32	3.37	3.40
	water log	3.00	3.15	2.53	2.75	3.18	3.28
RCH 20	control	3.42	3.46	3.41	4.34	3.34	3.36
	water log	3.40	2.96	2.81	2.76	3.02	3.30
CD 5%		0.08			0.15		
		Nitrate reductase activity (u mol NO_2 g fr wt)					
Bunny	control	4.99	5.04	4.98	4.48	4.44	4.45
	water log	5.34	4.03	2.75	4.80	4.81	4.77
RCH 20	control	4.51	3.81	2.36	4.34	4.37	4.37
	water log	4.46	3.79	2.29	4.74	4.84	4.68
CD 5%		0.22			0.14		

Alleviation of water logging stress by nutrient application:

Among other treatments, Hoagland solution of 50% strength as foliar application during water logging stress maintained better status of chlorophyll in the foliage. Similarly, during recovery stage after water logging, chlorophyll status was more under this treatment. Better activity of nitrate reductase activity could be maintained by spray of nutrient solution under water logging situation and among the treatments Hoagland 50 % appeared to be better. These favorable changes reflected on the productivity attributes at harvest with plants producing 24 bolls compared to 21 bolls per plant in control. Similarly, the yield per plant was significantly higher where Hoagland 50% nutrient solution was sprayed recording a yield of 147 g per plant compared to 127 g per plant in unsprayed.

Development of drought tolerant genotypes with good fibre quality

Fifty advanced culture lines of cotton *(G. hirsutum)* was raised in field and evaluated for drought tolerance during peak flowering stage. Biochemical parameters *viz.,* reducing sugars, amino acid, phenol and physiological parameters like chlorophyll content and membrane stability were analysed in both control and stress plants. The yield per plant and fibre quality was also quantified. Finally, the lines have been separated based on the differential expression of each biochemical factors in control and stress plants.

The difference is expressed as percent increase/ decrease over the control.. Based on these values 50 breeding lines have been rated for drought tolerance. The genotype was rated as tolerant if there was a positive cholorophyll value, negative membrane stability value, higher reducing sugars and amino acid content and less of phenols. These are rated with LRA 5166 which is known as moderately tolerant to moisture stress as a standard. Based on these values the lines DTS 39-08, DTS-44-08, DTS 62-08 and DTS -67-08 were found to be tolerant lines.

4.19: Fibre Development

Coimbatore

Physiological and molecular elucidation of fibre development process in cotton for enhancing fibre yield

Two lines of cotton *(Gossypium hirsutum* L.)- MCU 5 and its lint less mutant MCU 5 LL was grown under controlled conditions with optimum agronomical inputs. The flowers were tagged on the day of anthesis and samples were collected only from the tagged plants from anthesis till harvest at regular intervals. Biochemical constituent's *viz.,* reducing sugars, amino-acids, phenols and total soluble protein was estimated in developing ovules at 5 days interval from anthesis to boll bursting. The quantum of total soluble proteins is half of that of normal ovules.

RAPD PCR analysis among the MCU 5 and its mutant MCU 5LL was done with synthetic oligonucleotides of 20 base {5'- CAC AGA ATA TGA TCA CTC GC-3'}. Ovules at -2,0,2,4 and 6 DAA was utilized for the work.. The amiplfied product gave three extra bands of 700, 900 and 1000 kb in MCU 5 LL which was completely absent in lintless mutants. Similarly, there were two extra bands in MCU 5 at 300 and 250 kb.

For the first time isozye banding patterns for important rate limiting enzymes *viz.,* Peroxidases and SOD was attempted (Fig. 4.19).

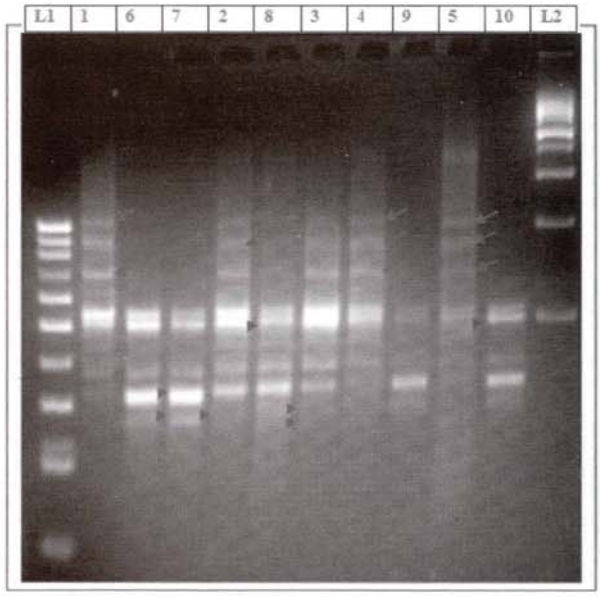


Fig. 4.19: Lane Description:
Ll: 100bp ladder (Chromous cat no. LAD 01)
L2: 500bp Ladder (Chromous Cat No. LAD 02)
1-5 no. is -2, 0, 2, 4 & 6 DAS MCV 5 ovules
6-10 no. is -2, 0, 2, 4 & 6 DAS MCV 5LL ovules

4.20: Socio Economic Dimensions of Cotton Farming

Nagpur

Economic Impact of Bt Cotton Cultivation

Analysis of data ofYavatmal and Wardha district of Maharashtra indicated that 100 per cent of cotton area of sample farms was under Bt cotton. The cost of cultivation of Bt cotton was Rs 13483/ha. The cost of human labour accounted for 38.75% of the total cost.. Cost of seed, bullock labour and fetilizers accounted for 19%, 18% and 11% of total cost respectively. Cost of plant protection chemicals accounted for only 3%. Total cost of production gross and net returns were higher in large and medium farms when compared with small and marginal farms. Human labour consumption was 23%more in Bt cotton when compared with non Bt cotton. Seed cost was 86% more and cost of fertilizers was 83% more in Bt cotton than in non Bt cotton production. Plant protection costs reduced by 81% after adoption of Bt cotton. Seed cotton yield ofBt cotton was 13.16 q/ha where as it was 9.69 q/ha in non Bt cotton. Net returns was 51% more in Bt cotton production when compared with non Bt cotton production.

Economic analysis of cotton based farming system in Vidarbha

The expenditure incurred on hired labour component contributed a major share, ranging from 18.9 to 21.6 per cent, in the total cost of cultivation of Bt cotton and pigeon pea system. This was the highest (Rs. 23164.80/ha) under

medium size group of farm. On an average, the total cost of Bt cotton and pigeon pea was Rs. 22727.55/ ha. The cotton equivalent yield ranged from 15.4 to 17.0 q/ha. This system recorded the highest net return ofRs. 12262/ ha and benefit cost ratio 1.57 in case of medium size group offarm.

Modernization of cotton production on marginal and small farmers in Vidarbha

The data ofNagpur district indicated that in case of marginal size group of farmer, the average land holding per household was 0.79/ha. The male and female family labour available per household was 1.06 and 1.0 respectively. Similarly, in case of small size group of farmers, the average land holding per household was 1.67 ha. The male and female family labour available per household was 1.36 each. Under existing practices the total cost of cultivation of cotton and pigeon pea/ha on marginal and small farm was Rs. 16344 and Rs. 17583 respectively. Whereas, under improved practices it increases to Rs. 20739/ ha. The surplus capital available for working expenses of cotton production was 9.2% higher with small farmers than marginal farmers.

Accessibility to mass media and information Technology

The data was collected from 100 extension workers and 300 farmers (100 each of progressive, less progressive and backward villages) from Wardha and Nagpur districts ofVidharbha region of Maharashtra state. The study indicated a very significant contributions of print as well as electronic media, since majority of extension workers and farmers realized better access to newspapers, farm magazines, radio, TV, Cable TV in cotton related information (Fig. 4.20) . Use of latest media/information technologies like Kisan call centre, mobile/cellular phones, web information/internet is increasing among extension workers as around 40% were occasionally utilizing these for updating their knowledge.

Overall, the utilization of mass media and information technology was medium to high levels by the farmers of progressive and less progressive villages whereas it was medium to low levels in case of backward villages (Fig. 4.21). The farmers were not very satisfied with the coverage, content and time as many times they observed that information not related to their situation, incomplete, complex, costly and not timely.

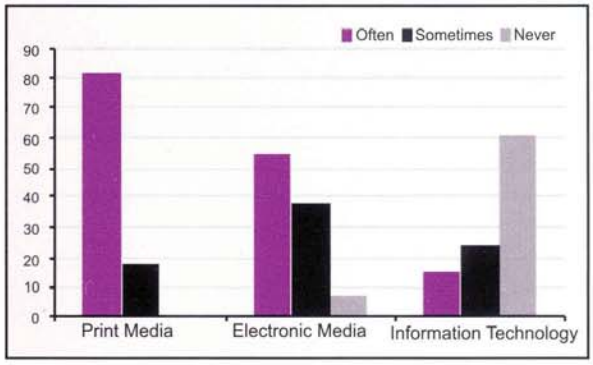


Fig.4.20: Utilization of mass media and information technology (Extension Workers)

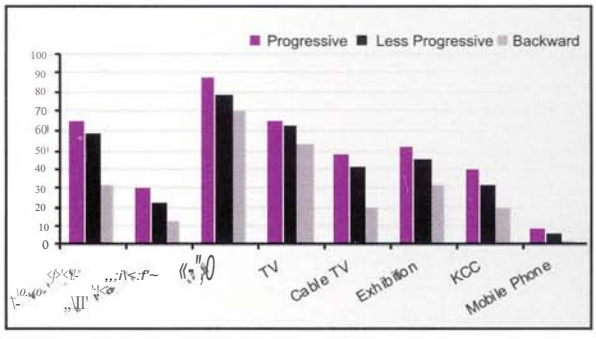


Fig.4.21: Utilization of mass media and information technology (Farmers)

The farmers as well as extension workers suggested that in newspaper, sufficient space may be devoted for cotton related information, the articles be simple, timely and should cover regular tips of cotton IPM. Similarly, the electronic media TV and radio programmes should be timely and attractive, duration of broadcast/telecast be enhanced with stress on success stories of farmers and coverage on market related information. There was a highly significant relationships of variables i.e., education, caste, socio-economic status, innovativeness and availability of mass media and mass media utilization.

Social dynamics of cotton production in distress areas

Analysis of the data collected from 200 sample farmers from 40 villages in distress district Wardha and Yavatmal in Vidarbha indicated that majority of cotton farmers from region had high

level of alienation (71.5 %). This alienation arises because of high degree of powerlessness, meaninglessness, isolations and self estrangement. They felt high powerlessness because of non-availability of capital/credit and lack of economic support from friends/relatives. Cotton farming becomes meaningless due to non availability of guaranteed remunerative price of the produce. They also feel that cotton farming is trapped in the vicious circle of uncertain rains and drought. The feeling of isolation is because majority of them lead a stressful life and they fail to obtain moral support during crises. The repeated cotton crop failures leading to poor financial condition and the cotton grower's feeling of high self estrangement that their work as a farmer is not rewarding compelled them to make serious reduction in the area under cotton farming and opt to some other crop which requires low input costs.

The social dynamics indicated that large proportion belongs to rainfed land holding (70.5%), around 40% percent were under low annual income category (Rs.25,000/- only). Expenditure on events per annum was observed to more by Rs.15274/- over net income and three-forth respondents (76.5%) have single cropping patterns. It was found that the income of the farmers is declining and falling short of expenditure to the tune of39%. The majority of the farmers (88%) in the study area were indebted and most of them had taken loan from various credit agencies for agriculture purpose and to meet family expenditure but could not repay the loan because they are incurring more on expenditure for household activities than income realized from agriculture.

Coimbatore

Documentation and validation of farmers' indigenous knowledge on farming system approaches in cotton

Eight types of integration with nine components were documented among 60 farms in western zone of Tamil Nadu (Salem, Erode and Coimbatore district). Traditionally majority of them. (43.33 per cent) had been adopting "cotton + other crops + Dairy" farming system approach. Due to the introduction of contract farming in poultry industries, 10 per cent of them were adopting cotton + Maize + poultry farming system. Due to the interventions by development departments, the components *viz.,* biogas, sericulture, vermiculture and farm machineries were introduced in some of the farms (46.67 per cent). 43.33 per cent of the respondents who adopt integration of cotton (1 acre) followed by sorghum with dairy (2 cows) had an average annual net return. of Rs.31562/- and employment generation of977 man days per year. Among the various integration types observed, integrating cotton (1.0 acre) with dairy (3 jersey cross bred), biogas (4m^3 capacity), vermicompost (800 square feet), sericulture (1000 square feet) and farm machinery (one tractor running for 150 days) resulted in the highest productivity of Rs. 2,05,500 (net return) and 1265 man days (employment generation). Comparative analysis between diversified cotton growers (60) and non-diversified cotton growers (60) indicated that the majority of the diversified farmers (66.67 per cent) had high level of economic efficiency than the non-diversified farmers (22.33 per cent). Similarly, the diversified farmers (70.00 per cent) had better ecological efficiency than the non diversified farmers (26.67 per cent). Experience in cotton farming for many years, big farm size, high annual income, high level of socio-economic status, good contact with extension agencies, 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.

Post evaluation of Farmers Field Schools (FFS) on cotton

During the year, using semi- structured interview schedules data on changes introduced by FFS on knowledge and decision making of cotton growers were collected from one hundred farmers from ten FFS (ten farmers in each FFS) in Coimbatore and Salem districts of Tamil Nadu and fifty farmers in five FFS of Dharwad district of Karnataka were collected. To find the changes in knowledge after attending FFS, teacher made knoweldge test was used. Three scores were derived from the farmers' ability to identify (identification score), define (functional score) and to describe (ecological score). Separate set of questions were asked to find out the changes in their decision making behaviour. To find out the changes in their adoption behavior, adoption quotient was used. The study indicated that after attending the FFS,

the beneficiaries had high identification knowledge score (5.5), functional knowledge score (5.4), ecological knowledge score (4.4) and decision making score (4.5). There were significant changes in their adoption behaviour *viz.,* adoption of more number (5.6) of new varieties and hybrids, reduction in number of irrigations (4.3), weeding operations (2.6) and pesticidal sprays (1.5). The strong correlation between knowledge level and adoption behaviour proved that a skill-oriented, knowledge intensive and hands-on education approach was adopted in FFS.

Comparative analysis of conventional, biotech and organic cotton production systems

Data collected from 120 Bt cotton fanners in Salem and Coimbatore districts of Tamil Nadu indicated that nearly half of the Bt cotton growers had high level of awareness about the cultivation aspects. More than one third of them (35.83 %) had known the how-to-do aspect of the various practices. 29.16 % of them had known the principle behind each practice recommended. Majority of them (52.50) fell under the category of low level with regard to extent of adoption of cultivation practices in Bt cotton. Majority (87.00 %) of them perceived that Bt cotton technology was efficient, economically feasible, physically compatible with other technologies existing in the farm, with visible results, with continuity and complexity. High cost of the seed, inadequate knowledge on Bt cotton's control over all pests, inadequate knowledge on ETL of different cotton pests, inadequate training in cultivation of Bt cotton, inadequate technical guidance from extension workers, no special price for kapas ofBt cotton, propaganda of NGO against Bt cotton varieties were the constraints expressed by the Bt cotton growers in Bt cotton cultivation.

An empirical analysis on cultivation ofbt cotton by growers with regard to insect resistance management (IRM) technologies

To find out the Bt cotton farmers' attitude towards IRM technologies in Bt cotton, a scale was constructed following the Equal Appearing Interval (EAI) method. Attitude was operationalised as the mental disposition of the respondents about IRM technologies in Bt cotton in varying degrees of favourableness and unfavourableness.

A total of 48 statements concerning the psychological o]jject were collected and edited. These were subjected to 30 judges and the scale and Q values were computed. Considering the time limitation from farmers' point of view, ten statements were finally selected based on scale and Q values. Along with the attitude scale based on the literature, other independent and dependent variables were operationalised. Using the scales and the variables the interview schedule was constructed. Pre-survey was conducted among 30 farmers and accordingly the schedule was modified.

Economic analysis of contract farming **in** cotton **in** Tamil Nadu

In Tamil Nadu, Super Spinning Mills is taking up contract farming of organic cotton in the form of centralized model at Vazhukkuparai of Madukkarai block in Coimbatore district.. This is the second year of the project on organic farming. Around 35 cotton farmers are part of this programme. The gross returns were Rs.22484/- per ha in organic cotton as against Rs.33359/- per ha in Bt cotton in the same area. With regard to cost of production, it was almost at par with each other to the tune of Rs.2450/- per quintal.. The organic cotton field is yet to reap its economies of scale.

Adoption, impact and returns to research investment on improved cotton cultivars **in** Tamil Nadu

Six districts *viz.,* Coimbatore, Dharmapuri, Salem, Madurai, Theni and Villupuram were taken up for the study. Average and percentage analysis, Disaggregate analysis, Cost and returns, Multiple regression analysis and Tobit analysis were the tools of study used to analyse the objectives. Education, non- farm income, farm size, irrigation, market distance, presence of private seed sector and district dummies were the independent variables considered for the study. The results indicated that adoption of hybrids from private sector was on an increase. 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. The results emphasize the need for strengthening rural education, extension service and provision of modem inputs and credit to the cotton farmers.

Impact of Bt cotton cultivation on farm economy in India

Two districts from Tamil Nadu *viz.,* Coimbatore and Salem were selected for the study. Sixty farmers from each district have been selected for the study. There is a skeweness towards Bt cotton over non-Bt cotton in regard to the number of sprays, thus escalating the cost of pesticide application in non-Bt cotton. This in turn results in a higher total cost of cultivation to the tune of Rs.4OOO/-per ha. in non-Bt cotton. Though there is just three per cent increase in yield, the gross returns is high in case of Bt cotton to the tune of 18.5 per cent.. The cost of production in case ofBt cotton is Rs.1324/q as against Rs. 1713/q in case of non Bt cotton.

4.21: Total factor productivity analysis

Nagpur

During the period of analysis (1980-2004) TFP index in Gujarat ranged from 43.59 in 1987-88 to 362.10 in 1997-98. TFP increased at the rate of 6.11 % per annum. In this state TII decreased at a rate of 1.13 %. Though input use showed a negative growth output increased at the rate of 4.6186 % per annum. This growth in output was mainly due to the growth of TFP. Contribution of TFP to output growth was worked out to be 110 %. TFP of cotton in Maharashtra and it increased at an annual rate of5.32 % during the period of analysis. T01 increase at the rate oD.49 % per annum where as TII increased by 0.52 % only, which is not significant.. The share of TFP in output growth is 86.63 %. In Madhya Pradesh all the three indices showed significant positive growth during the period of analysis. TII increased at the rate of 5.066 % per annum while the output index increased at the rate of 7.92 % per annum. TFP showed a compound growth rate of 5.177 % per annum. During this period TII increased at the rate of3.246 % per annum. Contribution of productivity increase in total output growth was 65.36 %.

Total input, output and productivity indices were worked out for five important cotton growing districts of Marathwada region ofMaharashtra for the period 1990-2008. During the overall period, input index as well as output index showed positive significant growth in almost all districts. Total factor productivity growth was also positiv~ and significant in all the districts except Beed. Contribution of productivity growth to total output growth ranged from 45.22 % to 76.35 %. It was highest (76.35 %) in Nanded followed by Jalna and Parbhani. After the introduction ofBt cotton i.e., after 2002-03 growth rates ofTFP were high when compared with previous period. Similarly total input, output and productivity indices were worked out for five important cotton growing districts ofVidarbha region of Maharashtra for the period 1990-2002. Of the five districts only two districts, Yavatmal and Buldhana registered positive growth in input use. Growth of output index was positive in Yavatmal, Wardha and Buldhana districts while it was negative in Akola and Amaravati districts. Growth of total factor productivity was positive in all the districts except Amaravati. Contribution of productivity growth to output growth ranged from 30.99 % to 121.08 % in this region.

Coimbatore

The growth rate of Total Factor Productivity indices was negative in case of Andhra Pradesh and Tamil Nadu over the years 1980-81 to 2003-04. The TFP Growth was negative and the Total Input Index and Total Output Index has shown positive trend in Andhra Pradesh. In case of Kamataka, the TFP Growth rate was positive whereas the Total Input Index and Total Output Index were negative. In case of Tamil Nadu, Total Input Index, Total Output Index and Total Factor Productivity Growth were negative. Data on household cost of cultivation for Tamil Nadu has been initiated by decoding the CCPC data obtained from TNAU, Coimbatore.

A Value chain for cotton fibre, seed and stalks: an innovation for higher economic returns to farmers and allied stakeholders

Nearly 600 quintal of ELS Bt hybrid (RCHB 708 Bt) *kapas* was produced with uniform quality for value addition research. Impact ofthe project (first year) was assessed and it was found that excess use of seed materials (0.8 kg/ acre) were found in base

line year was reduced to 0.5 kg / acre by following the optimum seed rate and spacing. Fertilizer application was followed as per the soil test; which in-turn. minimized the fertilizer quantity from 256 kg/acre to 216 kg/acre. Labour saving implements and machines were demonstrated which helped to reduce labour requirement. . Family labour utilized is reduced from 39.4 to 23.5, and hired labour is reduced from 50 to 36/ acre of cotton cultivation. The total cost of cultivation computed for base year is Rs. 10,903/acre as compared to first year of the project is Rs. 10,020/acre. Seed cotton yield (7.6 q/acre) is increased at the rate of25 per cent as compared to base value of 6.1 q/acre. The average gross return of Rs. 24,938 and net return of Rs. 14,918 were calculated per acre with benefit cost ratio of2.49. The base-line survey values for gross return is Rs. 18,220 and net return is Rs. 10,903 for acre ofland with benefit cost ratio of 1.67.

4.22: Cotton Information System

Coimbatore

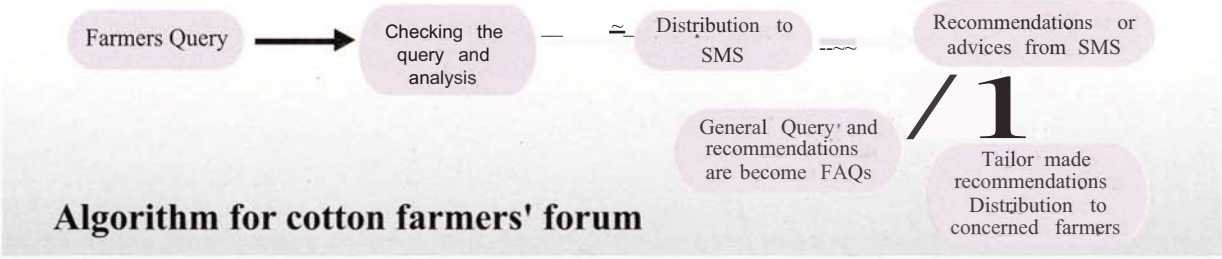
Indian Cotton Portal

Cotton portal (www.cicr.org.in) was periodically updated with latest information from different sources for different stakeholders. Integrated hit counter has been incorporated in our portal, an average of 100 users were visiting our cotton portal every day globally. Many cotton related queries were received from users after visiting our cotton portal.. Cotton portal was indexed in many of the leading search engines like google, yahoo, excite, lycos, dogpile, altavista, ask.com, mamma, webcrawler, etc. Keyword Search tool was integrated in our Cotton Portal to enable the user fetch the specified information from CICR website by invoking keyword search.

A module for Cotton Farmers' forum to be incorporated in our portal has been developed. The algorithm, for the farmers' forum was prepared (below diagram). The user/farmers can raise the cotton cultivation related queries in the forum and will be redistributed to the concerned subject matter specialist (SMS), after getting the recommendations or advices from the SMS the solution will be transmitted to the concerned farmer who raised the query. All the raised queries with appropriate recommendation would be placed under FAQs in the portal for the benefit of other farmers. The user/farmer can have the option to present their query along with any photograph of the symptom of the damage as an attachment so that SMS can have clear vision of the problem. There should be a check after farmers submitting the query and also should impose some condition attachment file to avoid vandalism to the portal..

Information Retrieval System

To strengthen the existing Cotton Information Repository, we have collated many new data sets from various sources which are secondary in nature. Around 25 datasets related to cotton identified for the information system and the Information Retrieval System software were developed with latest version of visual Basic. NET (2008) and for front end and Microsoft Access (2007) as backend. **In** the back end the data sets were stored in structured database. Visual basic. NET framework 3.5 have been used for forms deployment and ADO data connectivity have been deployed for data transfer from back end to front end and also Crystal Report tools were implemented to generate reports from the queried information. Interactive Cotton insect pest CD was developed. The CD was prepared in HTML codes with pictorial representation and information include life history, host plant, dynamics, symptom of damage, control measures, ETL levels etc, the same will be incorporated in cotton portal.. The CD for Package of Practice for cotton cultivation was also prepared for nine cotton growing states.



Algorithm for cotton farmers' forum