

## 4.9: Nutrient Management

### Nagpur

#### Long term effect of fertilizer and INM on the productivity and soil fertility, under Bt cotton- soybean system

A field trial was continued for the sixth consecutive year on two cropping systems (cotton-cotton and soybean-cotton) with different fertilizer and INM treatments. Higher number of bolls, boll weight and seed cotton (NCS145 Bt) yield were recorded where cotton was grown after soybean. Highest number of bolls, biomass and seed cotton yield (15.96 q/ha) was observed in INM treatment and this was followed by addition of micronutrients with RDF treatment in soybean-cotton system. Higher nutrient apparent recovery was observed with INM treatment as compared to NPK alone (RDF) in both the cropping systems. There was no difference in yields of pigeon pea with the different fertilizer levels except control. There was a higher build up in organic carbon (OC) in INM treatment (0.61 %) and pure organic treatment (15 t FYM/ha) (0.62 %) in 2009-10 as compared to initial value of OC 0.30 % in 2004-05.

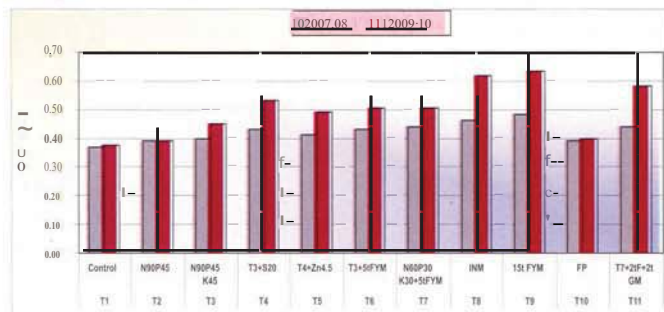


Fig.23: Cumulative effect of different fertilizers and manures alone and in combination on the soil organic carbon percentage

#### Nutrition requirement of Soybean-Bt-hybrid cotton in participatory mode

None of the variable doses of major nutrients tried improved the

seed cotton yields, red leaf numbers and per cent red leaf out of total leaves (from July to September months). About 70% leaves turned red due to sucking pests and 25-30% due to leaf spot diseases. The trials conducted in participatory mode in different villages confirmed that the major reason for leaf reddening was sucking pests as the lower leaves had distorted shapes. Controlling sucking pests early with effective insecticides reduced red leaves and increased yield. In station trials significant improvement in seed cotton yields (by 333 kg ha<sup>-1</sup> overcontrol or 31 %) was observed by the application of Zn, Mg, Band S @ 10, 10.3 and 6 kg ha<sup>-1</sup> y<sup>-1</sup>. In on farm trials in medium to deep soils of Antargaon and Vanoja villages and shallow to medium deep soils of Sukhli and Takli villages (all in Ralegaon Tehsil of Yavatmal district, Maharashtra) indicated that yields could be improved by the application of Zn and B to the extent of 200 kg/ha under rainfed conditions and 400-500 kg/ha with 2 supplemental irrigations.

#### Effect of different nitrogen application levels on Cry-protein in cotton seed oil and gossypol content

Field experiment was carried out with 3 Bt hybrids (Bunny, RCH-2 and NHH-44) and their non-Bt counterparts with 3 levels of NPK (90:45:45, 120:60:60 and 150:75:75). RCH-2 Bt and non Bt showed a stunted growth and the sucking pest incidence was severe. The oil content was in the range 22-24%. Leaf Cry protein estimated at 60, 86 and 110 DAS indicated that the Bt hybrids possessed a variable range of Cry toxin. But with respect to fertilizer treatment, no definite trend could be inferred. At 110 DAS old leaves contained more Cry protein. At 110 DAS total protein (measured by Lowry's method) was found to be more in case of Bt hybrids. Systematic effect of different fertilizer doses was not observed on oil and gossypol content. However, there was considerable variability in seed gossypol content among the Bt and non Bt hybrids.

### Coimbatore

#### Long term effect of continuous application of nutrients in fixed cotton based crop rotation on the productivity,

### nutrient balance and sustainability

Introduction of grain jowar as a sequential crop in cotton follows enhanced seed cotton yield by 21.6% (376 kg/ha) and total biomass yield by 32 % (1446 kg/ha) besides providing an additional yield of 63.4 q/ha of Jowar (5 yrs pooled data). Production Efficiency and Stability Index were higher under Cotton-Jowar system. Soil nutrient depletions were noticed recorded in control and nutrient deficit plots (N and NK) but not in balanced or integrated nutrient supply treatments (NP, NPK, NPK+FYM/CR). NPK levels viz., 60:13:25 kg/ha (RDF) significantly out yielded the control and crop residue treatment (due to partial nutrient immobilization). However, nutrients locked up in crop residues were made available subsequently, and thereby yielding on par with RDF as was evident from pooled data on yield (with similar biomass production, leaf chlorophyll content, microbial biomass and soil O.C.). Although petiole N was highest under 90 kg N/ha, the chlorophyll content was lowest. Application of N alone @ 90 kg prolonged vegetative growth and declined yield over balanced nutrition and INM. FYM alone though maintained soil O.C. at its highest level (0.65 %), could not supply nutrients commensurate with crop demand. Balanced fertilization (RDF) and more appropriately, INM (i.e., NPK+FYM) was optimum for cotton since they maintained a steady growth, development and yield. Highest Water Use Efficiency (WUE, 32.9 kg/ha-cm) along with lower water use (56.5 em) and highest total soil N were also observed with INM practice. Maximum water productivity (Rs.7.35/M<sup>3</sup>) was with the INM practice followed by RDF (Rs.6.98/M<sup>3</sup>). Application of 60:30:30 kg/ha as N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O (RDF) to *hirsutum* cotton (cv. Surabhi) and applying RD-N (90 kg/ha) to succeeding sorghum (Co 428) in rotation was ideal for higher and sustainable yields of both the crops. Based on consumptive use of water, around 4048 and 3257 litres of water were used per kg of seed cotton under cotton-fallow and Cotton-Sorghum, respectively. Highest water productivity (WP, Rs.6.86/M<sup>3</sup>) and highest nutrient use efficiency (NUE, 17.8 kg seed cotton/kg NPK uptake) were calculated under cotton-sorghum in comparison to cotton-fallow (with WP of Rs.5.52/M<sup>3</sup> and NUE of 13.6). Smothering effect of jowar on weed was evident as weed control efficiency increased over the years.

### Synchronizing Nand K supply with crop demand

Under the existing semi arid condition, in the winter irrigated tract of Tamil nadu, 3 splits of N only was optimum for desired efficiency and maximum yield. Weed control efficiency was increased drastically following 3 splits. The highest WUE was observed in 4 splits (55 kg/ha-cm), followed by 5 splits (54.3), 3 splits (52.7) and 2 splits (47.1).

### Studies on cuticular absorption of nutrients and surfactants in cotton

Surfactants- Propanol, Triton-X, Tween 20 and APSA (all purpose spray adjuvant) were found to be effective in facilitating stomatal opening in cotton and these chemicals were sprayed on the foliage at different concentrations (0.5, 1, and 2 mill). The study indicated that 1 ml per litre of water was optimum concentration to induce stomatal opening in all the chemicals tried. Irrespective of the chemical, 50 -60 % of the stomata opened within 30 minutes and extended up to 60 minutes and there after it started closing and by 120 minutes only 18 % if the stomata remained opened. APSA was found to be the best surfactant. When 1 % potassium was applied as foliar spray, maximum potassium absorption was seen in 4<sup>th</sup> to 8<sup>th</sup> leaf (34.5 to 36.6 ppm) compared to 25.3 to 33.8 ppm by other leaves in cotton within one hour of spray.

## 4.10: Irrigation Water Management

### Nagpur

#### Drip Irrigation and N-K fertigation

The seed cotton yield (NCS 145 Bt), water use and water use efficiency indicated that drip irrigation at 0.8 Etc produced optimum seed cotton yield (2164 kg/ha), highest WUE, net returns and B C ratio. The nutrient uptake was also the highest with 0.8 Etc.

Fertigation @ N 120, K 60 at 0.8 Etc led to higher yield, WUE water use and BCR. Fertilizer applied through fertigation in four splits resulted 25 % saving of Nand K.



Bt (NCS 145) cotton under drip irrigation

### Coimbatore

#### Drip Irrigation and Fertigation

Drip irrigation at 0.8 Etc registered the significantly highest seed cotton yield of 2021 kg/ha, which was on par with irrigation scheduling @ 1.0 Etc and 0.6 Etc through drip (Fig 24.). Different levels of fertilizers (75, 100 and 125 % RDF) applied as drip fertigation in six splits at 15, 30, 45, 60, 75, 90 DAS did not have significant influence over soil application of 100 % of RDF in three splits at 0.45 & 90 DAS. Drip irrigation scheduled at 0.6 Etc had the highest water expense efficiency (75.8 kg/ha-cm), water productivity (Rs. 35.2 1m<sup>3</sup>), and the least quantity of water (1325 litre / kg of seed cotton) used for production of unit quantity of seed cotton. Amongst the fertilizer levels, fertigation of 100% RDF (90:45:45 kg of N, P<sub>2</sub>O<sub>5</sub> & K<sub>2</sub>O/ha) in six splits registered the highest water expense efficiency (57.7 kg/ha-cm), water productivity (Rs. 26.81 m<sup>3</sup> of water) and the least quantity of water (1907 l) required to produce single kg of seed cotton.

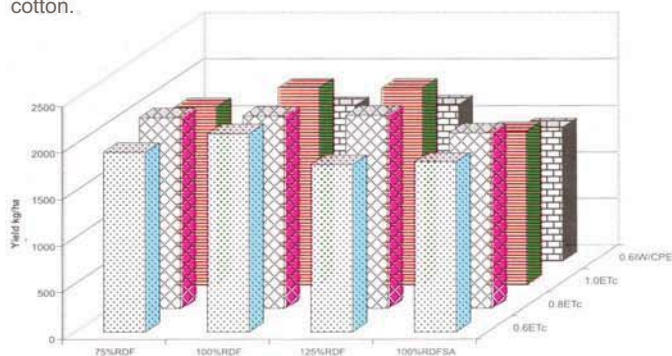


Fig.24: Seed cotton yield as influenced by irrigation schedule and fertilizer levels

### Drip Irrigation and mulching in 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 of ELS Bt cotton, RCHB 708 under drip and conventional irrigation. The total water requirement (including the effective rainfall of 26.8 ha em) at 0.4 Etc, 0.8 Etc and conventional irrigation was 48.9, 67.1 and 83.2 ha em respectively. When no mulch was applied, the crop responded up to 0.8 Etc, while with mulch combinations, the yield did not increase beyond 0.4 Etc. Among the treatment combinations, poly mulching with drip at 0.4 Etc recorded the highest seed cotton yield (5755 kg/ha) and was on par with biodegradable polyethylene mulching at 0.4 Etc (5362 kg/ha) and polyethylene mulching at 0.8 Etc (5526 kg/ha). The water use efficiency ranged from 41.6 kg/ha em under no mulching with conventional irrigation to 117.7 kg/ha em under polyethylene mulching at the lowest moisture regime of 0.4 Etc.



Biodegradable poly mulch

### Irrigation management for ELS Bt hybrid

Amongst surface irrigation methods, application of irrigation @ 0.4 and 0.6 IW / CPE ratio during vegetative and reproductive stage respectively recorded the significantly highest yield (3110 kg lha), which was on par with alternate furrow irrigation (3063 kg lha), protective irrigation (2744 kg lha), skip furrow irrigation (2594 kg lha) and paired row planting (2651 kg lha). The control that received only life irrigation registered the least seed cotton yield (2299 kg lha). The total quantity of water (517.7 mm) and irrigation water (25.6 em) used was maximum with irrigation @ 0.4 and 0.6 IW / CPE respectively for vegetative and reproductive stage and the lowest was recorded with control respectively of 340.5 and 90 mm. Amongst irrigation method, alternate furrow irrigation used the least quantity of irrigation water (18.4 em), recorded the highest water use efficiency of 69.2 kg / ha-cm, water productivity of Rs. 32.2 1m<sup>3</sup> of water and required less amount of water (1444 l / kg) to produce unit kilogram of seed cotton yield.

## 4.11: Soil Moisture Conservation in 8t Cotton

Nagpur

### Development of production technology for Bt cotton

Field experiment on the use of different moisture conservation techniques and nutrient management on Bt cotton was conducted during 2007-2008 to 2009-2010. Pooled data indicated that significantly higher cotton equivalent yield (1790

kg/ha) was obtained with green gram intercropped in Bt cotton (1:1) as compared to other moisture conservation treatments. Further, the yield and fertilizer use efficiency were the highest when 75% inorganic N was supplemented with 25% organic N.



Bt cotton (NCS 145) inter cropped with green gram

### Soil moisture Conservation and integrated nutrient management (INM)

Soil moisture conservation by opening of alternate furrow in cotton registered higher seed cotton yield (1691 kg/ha) and net return (Rs. 19,217/ha) than intercropping of cotton with soybean and *insitu* green manuring of sunhemp. Amongst INM practices, application of recommended dose of nutrients (112.5:45:33.75 kg of N, P<sub>2</sub>O<sub>5</sub> & Kp/ha) through inorganic fertilizer showed higher net return (Rs 22037/ha).

Coimbatore

### Evaluation of organic and inorganic mulches for rainfed Bt cotton

Field experiment was conducted to study the usefulness of various organic and inorganic mulches for efficient moisture conservation for growing Bt cotton under rain fed condition. 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 with RCH 20 B1. The results revealed that all the mulch treatments enhanced the seed cotton yield. Poly mulching recorded the highest (1985 kg/ha) seed cotton yield and was on par with biodegradable mulching, sub soil coir mulching and gunny sheet mulching. Surface coir pith application recorded significant reduction in yield over other mulches.

## 4.12: Cropping Systems

### Bt cotton based inter cropping systems

Nagpur

Pooled analysis of two years data on shallow and medium deep soils indicated that the reduction in seed cotton yields in both the soils by introducing intercrops in Bt hybrid cotton was not significant compared to respective paired row planted Bt hybrid cotton. Roselle (*Hibiscus sabdariffa*) was most drought resistant and the best leafy vegetable had a better shelf life (dried leaves for lean period). Its yield was 1.3 t ha<sup>-1</sup> on green leaves basis and 0.5 t ha<sup>-1</sup> dry bast fibre (4.6%) basis in very shallow soils. The cotton equivalent yields, cost of cultivation was also significantly increased in paired row planted Bt hybrid cotton intercropping.

On shallow soils, highest net profit was with paired row cotton intercropped with *Rumex* spp. + maize and tomatoes followed spinach + baby corn or *Portulaca oleracea* + field bean and fennel.

In medium to deep black soils, rain water was harvested by opening of furrow after 1<sup>st</sup> interculture within the paired row, but 264 mm post monsoon season rains (in October, 2009) created anaerobic conditions and reduced the seed cotton yields compared to 2008. The most profitable intercropping system with highest profitability was paired row planted Bt hybrid cotton intercropped with field bean and fennel or marigold.



Cotton + Portulaca+ Field bean



Cotton + Marigold

#### Coimbatore

Short duration intercrops viz. clusterbean, coriander, radish, amaranthus, green gram and vegetable cowpea were evaluated against sale crop of Bt cotton. In this novel experiment without altering the cotton crop geometry, short duration intercrops were grown on the other side of ridge. The results indicated that all the intercrops were compatible with Bt cotton, RCH 20. The seed cotton equivalent yield was highest with Bt cotton + coriander system (3795 kg/ha) closely followed by Bt cotton + radish system (3605 kg/ha) as against the lowest (3097 kg/ha) recorded with sale cotton. The economics of Bt cotton based inter cropping system also indicated that cotton + coriander resulted in highest gross return (Rs.121440), net

return (Rs.95215) and benefit cost ratio (3.63) closely followed by cotton + radish system. All the intercropping systems except vegetable cowpea recorded higher net return than sale cotton.

#### Bt cotton based double cropping systems for irrigated condition

Six Bt cotton based double cropping systems viz., two millets, two pulses and two oil seed crops were evaluated to identify the most profitable, productive and sustainable system. Amongst them Bt cotton-maize recorded the highest seed cotton equivalent yield (4168 kg/ha), gross return (Rs.1 0421 O/ha), net return (Rs. 69485/ha) and per day productivity (Rs.257.4/ha).

#### Multi-tier cropping system

Multi-tier systems are labour intensive with respect to weeding because of difficulties in using animal drawn implements. Integrated weed management did not influence seed cotton significantly as compared to hand weeding thrice at 15, 30 and 60 DAS. In multi-tier system of cotton + radish + beetroot + coriander, hand weeding thrice at 15, 30 and 60 DAS helped in realizing the highest net return (Rs.1,37,765), seed cotton equivalent yield (44.4 q /ha), relative production efficiency of 79.9 %, relative economic efficiency of 94.5 % and per day profitability of Rs. 623. Multi-tier system of cotton + radish + beetroot + coriander with pendimethalin @ 0.75 kg /ha + hand weeding at 30 DAS + targa super 50 g /ha gave a net return (Rs.87,269), seed cotton equivalent yield (41.4 q /ha), relative production efficiency of 67.7 %, relative economic efficiency of 81.7 % and per day profitability of Rs. 582. The sale cotton system with hand weeding thrice at 15, 30 and 60 DAS had produced the lowest seed cotton yield (25.6q/ha) , net return (Rs. 49,364 /ha) and per day profitability of Rs.329.



Multi tier cropping

#### Incorporation (*insitu*) of cereals on productivity of succeeding cotton

Sowing of cereals in off season as bulk crop and *in situ* incorporation (45 days period) may provide similar cereal rotation by breaking yield barrier in mono-cropping and makes system sustainable. The second year results indicated that incorporation of *in-situ* grown ragi at 45 DAS produced significantly highest seed cotton yield (2610 kg /ha), Bartlett index (0.89), total rainfall use efficiency of 5.94 kg /mm, effective rainfall use efficiency 10.24 kg /mm and partial factor productivity of 21.75 kg /kg of nutrients, gross return of Rs. 80,900 fha, net return of Rs. 53, 851 /ha and benefit cost ratio of 2.99. In comparison, the control (cotton-fallow system)

produced a seed cotton yield of 1847 kg/ha, Bartlett index of 0.83, total rainfall use efficiency of 4.20 kg/mm, effective rainfall use efficiency of 7.3 kg/mm, partial factor productivity of 15.4 kg/kg of nutrient, least gross return (Rs.57,248/ha) and net return (Rs.38,014/ha).

### Sirsa

#### Intercropping of kharif legumes with Bt cotton under irrigated condition

The performance of Bt hybrid RCH 134 with and without intercrop combinations was evaluated. The yield (3121 kg/ha) and number of bolls/plant (53.9) were significantly higher in sale cotton at spacing 67.5 cm X 75 cm as compared to paired row cotton with and without intercrops. The yield of cotton (2614 kg/ha) and number of bolls/plant (48.7) in sale paired row was statistically at par with paired row with intercrops. As inter crop with in paired row cotton, additional yield of mung bean (297 kg/ha), cluster bean (905 kg/ha) and groundnut (327 kg/ha), was harvested. The net income (Rs. 95197/ha), net return (Rs. 71622/ha) and B: C ratio (4.0) from sale cotton (67.5 cm x 75 cm) was higher than paired row cotton. Among paired row cotton with inter crops, net return (Rs 61604) was observed maximum in cotton + mung bean. The dry matter, N, P and K uptake (kg/ha), nutrient use efficiency (8.4), water use efficiency Rs/ha-cm (1133) and water productivity Rs/M<sup>3</sup> water (11.52) were observed to be higher in normal sale cotton (67.5 cm X 75 cm) than paired row cotton.

#### Evaluation of Bt cotton based double cropping system

The cotton-wheat (Rs.72769/ha) followed by cotton- mustered (Rs 61825/ha) system were observed superior to cotton-barley. Higher plant stand (97.5%) was noticed in transplanted cotton crop, with 21 days tray raised nursery in coco peat (50%) + FYM (35%) + soil (15%) against normal sown cotton 82.5%. Because of higher plant stand, the yield (2667.3 kg) in transplanted cotton was superior than normal sown cotton fields (2437 kg).

## 4.13: Agronomic Evaluation of cotton genotypes

### Nagpur

Separate field experiments were conducted in a Vertisol (> 100 cm depth) for NHH 44 Bt and an Inceptisol (< 50 cm depth) for BN Bt and both under rainfed conditions representing AESR 10.2, with 3 spacings and 4 N levels. In NHH 44 Bt, averaged across spacing, with an incremental increase in N by 30 kg/ha the seed cotton yield increased significantly up to 60 kg/ha and further increase to 90 kg/ha did not provide any additional benefit. However, N x Spacing interaction effect was significant and at reduced intra row spacing (90x20 cm), the response to N was significant up to 90 kg/ha. In BN Bt, averaged across spacing, the seed cotton yield increased significantly only with the first increment of 25 kg/ha. However, spacing x N effect was significant indicating that at a reduced intra-row spacing of 20 cm. (i.e. 60x20), a higher dose of 50 kg N/ha was optimum.

N uptake by BN Bt increased significantly with N application up to 50 kg N/ha, beyond which the increase was not significant. The mean apparent recovery (AR) of N decreased with increase in the rates of N application and increased with a decrease in intra-row spacing. Trend in N use efficiency and its components is presented in Fig. 25. N use efficiency declined with increase in N application but increased with a reduction in intra row spacing from 15.2 at 60 x 45 cm to 22.7 at 60 x 20 cm spacing. It is inferred that the increase in N use efficiency was primarily due to an increase in uptake efficiency at higher N levels, whereas the utilization remains more or less similar at all the spacings. N uptake efficiency declined with increase in N rates, but N

utilization efficiency remained unchanged. N utilization efficiency is a product of N biomass production efficiency (NBPE) and Harvest index (HI). NBPE remained largely unaffected by N rates or spacings but HI was the lowest at 60 x 20 cm spacing (highest population).

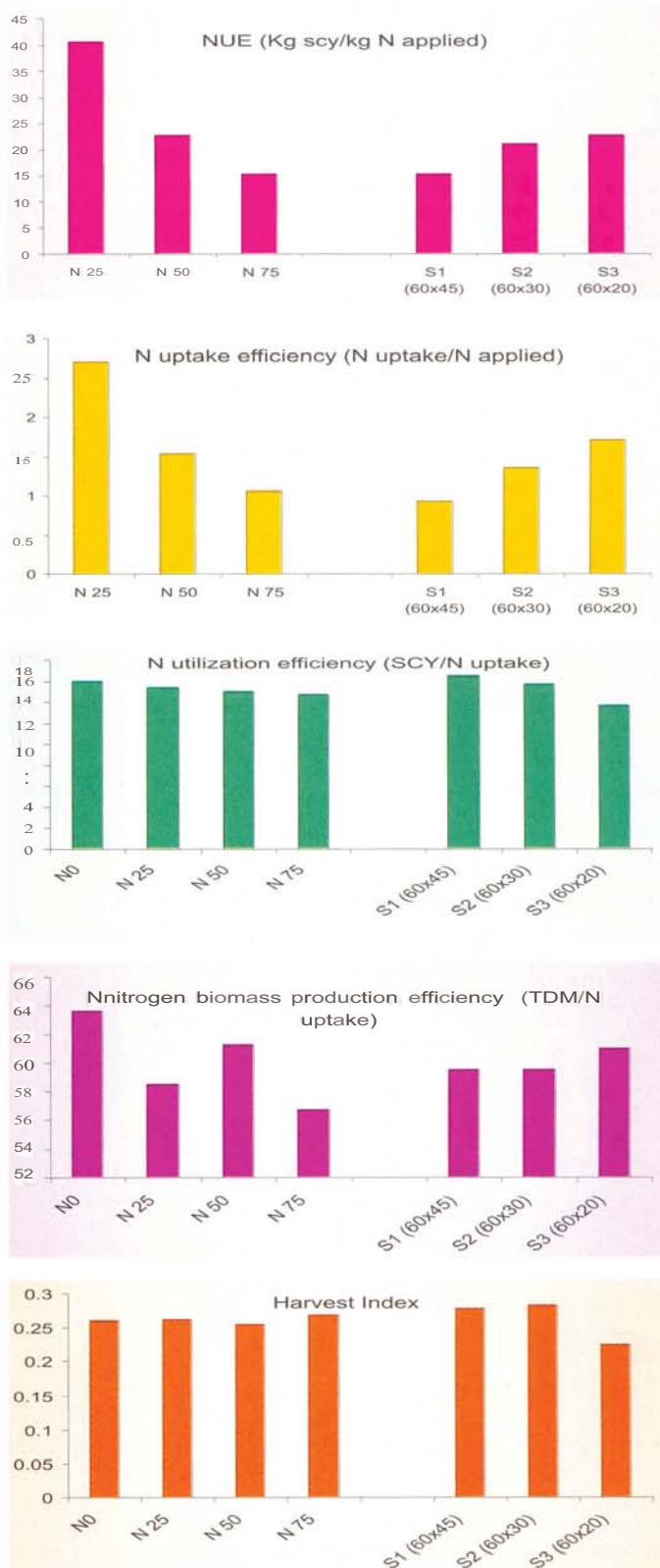


Fig. 25: Effect of N application and intra row spacing on N use efficiency and its components in BN Bt (SCY= Seed Cotton Yields, NUE= Nitrogen Use Efficiency, TDM= Total above ground Dry Matter)

## Coimbatore

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

Among the fifteen genotypes evaluated significantly highest seed cotton yield (2931 kg/ha) was harvested from RCHB 708 Bt and it was on par with MRC 6918 Bt (2903 kg/ha), Mallika Bt (2903 kg/ha), CCH510-4(2763 kg/ha) and RCH 2 Bt " (2738 kg/ha). The least quantity of water (440.2 mm) had been used by RCH2 Bt, RCH2 " Bt, Bunny Bt, Mallika Bt and Tulasi 9Bt. The highest water use efficiency of 62.6 kg/ha-cm was calculated with Mallika Bt, followed by RCH2Bt II (62.2 kg/ha-cm). In economic terms, RCHB 708Bt registered the highest gross return of Rs.1,36,291 /ha, net return of Rs.1,00,358 /ha and benefit cost ratio of 3.8. The highest partial factor productivity of 23.03 kg /kg of nutrient and economics of nutrient use efficiency of 1.77 kg /Rs invested was with CCH 510-4 whereas the highest water productivity of Rs. 27.55 1m<sup>3</sup> of water were with MCR 6918 Bt.

## 4.14: Weed Management

### Coimbatore

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

Field experiment was conducted to find out efficient, economical

Table 16. Weed control efficiency on 60 DAS and seed cotton yield of cotton (cv.RCHB 708 Bt) as influenced by weed control methods

Weed control treatments	Conventional			Herbigation		
	Weed DMP (g/m <sup>2</sup> )	WCE	SCY (kg/ha)	Weed DMP (g/m <sup>2</sup> )	WCE	SCY (kg/ha)
Pendimethalin 1.5 kg/ha (PRE) + HW (30 DAS, 60 DAS)	41.5	80.2	3502	30.7	83.4	4185
Pendimethalin 1.0 kg + metalachlor 1.0 kg/ha (PRE)+HW (30,60 DAS)	38.4	81.7	3915	24.5	86.8	4407
Pendimethalin 1.0 kg/ha followed by 1 HW + metalachlor 1.0 kg/ha (30 DAS) + HW 60 DAS	18.5	91.2	4460	8.5	95.4	4918
Hand weeding thrice (20,40 ,60 DAS)	36.5	82.6	4512	21.0	88.7	5187
Un weeded check	209.5	-	501	185.0	-	1100
Application method	4.25		417.4			
Weed control treatments	8.96		457.0			
Interaction	12.11		726.4			

\*DMP: Dry matter production, HW: Handweeding, DAS: days after sowing, PRE: Pre-emergence WCE: Weed control efficiency, SCY: Seed cotton yield

## 4.15: Soil Biology and Biochemistry

### Nagpur

Two field experiments were conducted to understand the impact of transgenic cotton on soil microbial population and related soil biological properties under rainfed condition on medium deep and shallow black soils. Soil samples from two Bt cotton genotypes (NHH 44 Bt and BN Bt) and their counterpart, the non-Bt cotton for NHH 44 and bulk soil for BN Bt have been used as test material. Rhizosphere and bulk soil samples were collected from 0-15 and 15-30 cm depth. Samples collected at periodical intervals viz., before sowing, flowering, boll formation and harvest were analyzed for biological properties viz. a) basal respiration, b) urease activity, c) dehydrogenase activity, d)



Evaluation of cotton genotypes

environmentally safe weed control method and to study the efficacy of herbigation technique for cotton crop. Herbicide rotation (pendimethalin followed by metalachlor) with hand weeding recorded significantly lesser dry matter of weeds irrespective of the application method (conventional or herbigation). However, significantly lesser weed dry matter (8.5 g/m<sup>2</sup>) recorded with herbigation technique which suggests that there is scope to use pre-emergence weedicide for post emergence application for killing late emerging weeds without damaging cotton crop (Table 16). Hand weeding thrice and herbicide rotation with hand weeding were on par for seed cotton yield and found superior to other methods. The bio assay crop of green gram grown after the harvest of Bt cotton was not affected due to any of the weed control methods.

Fluorescin diacetate hydrolysis and e) total microbial population (General and functional microflora). Result indicated that there is no adverse effect of Bt cotton on selected soil biological properties, rather higher biological properties were recorded in Bt cotton soil as compared to Non-Bt cotton. Among the soils, medium deep recorded higher biological values as compared to shallow black soil. Samples collected at flowering stage recorded higher values than later stages and values of all the biological properties decreased with increase in soil depth.

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

Three different methods of microbial delivery (seed treatment, soil application and newly identified carrier based delivery) were

taken up to study the survivability and retention of applied bio-inoculants in cotton rhizosphere. To increase the moisture availability for inoculated bio-inoculants, the newly identified carrier material was coated with different moisture retaining materials viz., cotton lint, cow dung, clay, talc and ash. The observation on moisture retention was assessed fortnightly interval. To inhibit the native microflora for better establishment

of inoculated bio-inoculants in cotton rhizosphere, turmeric powder, crude neem seed extract and crude eucalyptus leaf extract were studied. Results indicated that carrier coated with cotton lint retained higher moisture as compared to other materials (Table 17.). Crude neem seed extract gave a higher temporary inhibition of native soil microflora.

Table 17: Moisture retention percentage in carrier coated with different low cost materials

Days after soil inoculation (15 cm)	Cotton lint	Cow dung	Clay	Talc	Ash
15	40.5	32.0	30.0	28.5	19.0
30	32.0	19.0	22.5	19.6	13.0
45	19.5	14.8	16.0	13.5	8.50
60	14.0	8.35	9.65	8.10	5.00

#### Soil Biological properties of soils of Black soil region

The impact of management practices on soil biological properties of representative benchmark soils of Black Soil regions (BSR) of India was studied. Selected soil biological properties viz., soil urease activity, soil dehydrogenase activity and soil microbial population were analyzed in 195 (104- High management and 91- Low management) soil samples from 13 BSR Spots. In general it was found that high management (HM) recorded higher soil biological properties (soil enzyme activities and soil microbial population) as compared to low management/Farmers practice (FM). All the soil biological properties found to be higher at the surface layer and found to decline with depth. Considerable variation was observed with reference to bio-climatic regime and cropping system adopted.

#### Impact of long term fertilization in cotton on soil microbial population

A long term fertilizer experiment was conducted on a vertisol for 5 years (2005 to 2010) with 11 treatments. The microbiological properties of the experimental samples after five years of experimentation are presented in Table 18. The population of

general microflora (Bacteria, Fungi, Yeast and Actinomycetes) varied significantly between the treatments. The bacterial population was found to be more with the Treatment-7 (60:30:30+5tFYM) followed by Treatment-5, the same trend was observed with fungal population. Treatment-5 (90:45:45+S20+Zn20) recorded higher population of actinomycetes followed by treatment-7 and the lowest actinomycetes population recorded in treatment-1 (Control). Yeast population followed a similar trend as bacterial population.

Under physiological/functional groups of microbes, higher *Azotobacter* population ( $9-16 \text{ cfu} \times 10^4/\text{g}$ ) was recorded in treatment-5 (90:45:45+S20+Zn20) followed by treatment-8. Higher Phosphorus solubilising microorganisms (PSM) population ( $9-14 \text{ cfu} \times 10^4/\text{g}$ ) was observed in treatment-4 (90:45:45 + S20) followed by treatment-11. Higher *Beijerinckia* population was recorded in treatment-5 ( $12-18 \text{ cfu} \times 10^4/\text{g}$ ) followed by treatment-7. *Fluorescent pseudomonas* population found to be more in treatment-5 ( $24-36 \text{ cfu} \times 10^4/\text{g}$ ) followed by treatment-9. There are no significant differences in physiological groups of microbes between the treatments.

Table 18: Effect of long term fertilization on soil microbial population ( $\text{Cfu} \times 10^4/\text{g}$ )

Treatments		Bacteria	Fungi	Yeast	Actino
T1	Control	58.67	10.67	19.00	16.33
T2	90:45:0	59.00	8.00	19.67	30.67
T3	90:45:45	65.33	9.33	26.33	19.67
T4	T3+S20	94.33	11.67	31.67	28.00
T5	T4+Zn20	116.00	21.67	52.00	53.00
T6	T3+5t FYM	78.67	13.67	24.67	26.67
T7	60:30:30+5 tFYM	118.67	20.67	41.67	45.67
T8	60:30:30+S20+Zn4.5+5 tFYM+PSB+DAP	104.67	16.00	37.67	38.67
T9	15t FYM	103.33	15.67	33.33	34.33
T10	FP:70:20+2t FYM	85.67	12.33	27.00	27.67
T11	60:30:30+2t FYM+2tGM	90.33	14.67	29.67	28.00
CD @1%		17.71	4.22	8.93	9.17

FP= Farmers practice, GM= Goat manure

#### Long term effect of cotton-fallow and cotton-jowar cropping system on soil aggregation, aggregate associated carbon, soil enzyme activity and CO<sub>2</sub> evolution

Soil samples were analyzed after five years of imposition of integrated nutrient management treatments in a cotton

(*Gossypium hirsutum*)-fallow and cotton-sorghum (*Sorghum bicolor*) system to study the distribution of soil aggregates and aggregate associated carbon as influenced by cropping system and nutrient management in a mixed red and black calcareous clay loam soil (Vertic Ustropept) of Periyanaickanpalayam series at the Central Institute for Cotton Research, Regional

Station, Coimbatore.

Neither the cropping system nor the nutrient management significantly influenced the soil organic carbon (SOC) content. However, the SOC content decreased significantly with depth indicating stratification of SOC. Moreover, neither the cropping system nor the nutrient management significantly influenced the stratification ratio. There was no significant difference in the mean weight diameter (MWD) and percentage of water stable aggregates (WSA) among the nutrient management practices. However, both MWD and WSA in cotton-sorghum system were significantly higher than cotton-fallow system. In the 0-5 cm soil depth, cankers account for 50-59% soil mass. Irrespective of the nutrient management treatments, the maximum soil mass was observed in the micro-aggregate fraction (53-250  $\mu\text{m}$ ) followed by mineral associated fraction ( $<53 \mu\text{m}$ ) and macro-aggregate fraction (250-2000  $\mu\text{m}$ ) and negligible soil mass was observed in large macro-aggregate fraction ( $>2000 \mu\text{m}$ ). In the 0-5 cm soil depth, the maximum SOC concentration was recorded in the macro-aggregate fraction (250-2000  $\mu\text{m}$ ) and the minimum SOC concentration was recorded in the mineral associated fraction ( $<53 \mu\text{m}$ ), which was statistically at par with the micro-aggregate fraction (53-250  $\mu\text{m}$ ). Considering the soil mass as a whole, it was observed that around 54-60% of SOC

could not be accounted in the aggregates. The maximum SOC content was recorded in the micro-aggregate fraction (53-250  $\mu\text{m}$ ) and the minimum content of SOC was found in the mineral associated fraction ( $<53 \mu\text{m}$ ).

Soil dehydrogenase, urease and Fluorescein Diacetate Assay (FDA a measure of the total microbial activity in soil) were estimated in the surface (0-5 cm) soil. The mean soil dehydrogenase activity was maximum 1.69  $\mu\text{gTPF/g soil/24 h}$  with 15t FYM/ha. The dehydrogenase activity was not significantly influenced by the cropping systems. There was no significant difference among the cropping systems and nutrient management practices with respect to the soil urease activity and soil FDA.

Results of a laboratory incubation study revealed that the effect of cropping systems was not significant on cumulative  $\text{CO}_2$  evolution in a period of 30 days. However, nutrient management significantly influenced the cumulative  $\text{CO}_2$  evolution (Fig.26). Application of organic sources of nutrient resulted in significantly higher cumulative  $\text{CO}_2$  evolution over control, whereas the effect of the recommended dose of fertilizer NPK application and control showed a similar pattern of cumulative  $\text{CO}_2$  evolution.

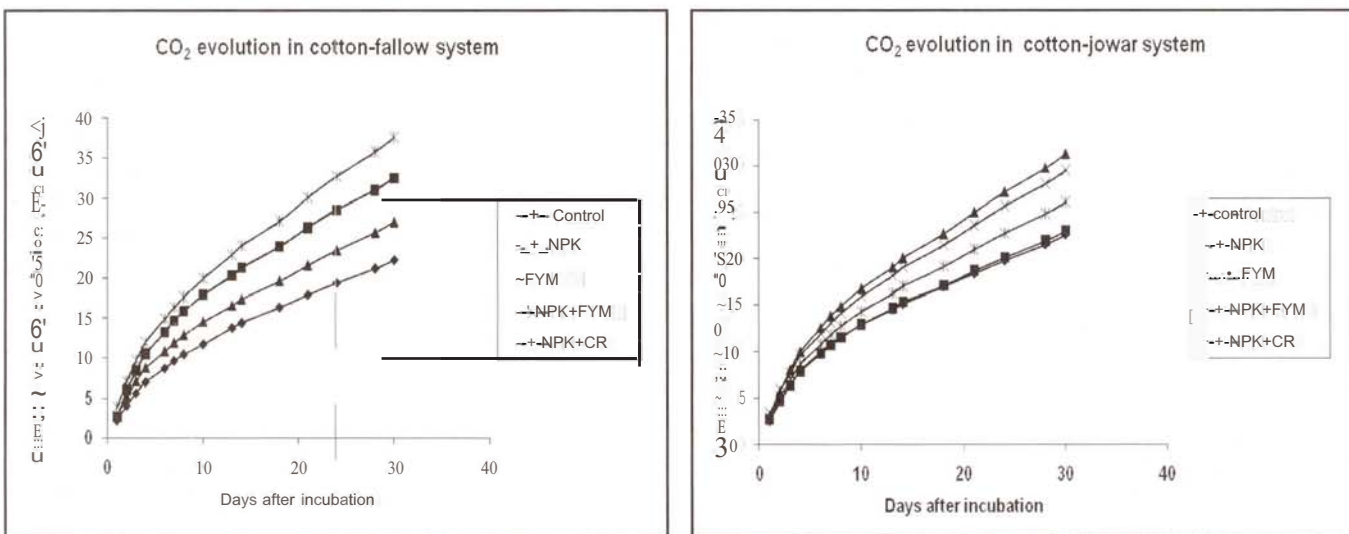


Fig. 26:  $\text{CO}_2$  evolution in cotton-fallow and cotton-sorghum system under different nutrient management practices

#### 4.16: Cotton Simulation Modelling

Simulation of the effect of irrigation and nitrogen on soil water and nitrogen dynamics and productivity and input use efficiency of Bt cotton in a Vertic Ustropept

A generic simulation model INFOCROP was validated using data a 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, to predict the seed cotton yield of RCH2 Bt vs Non Bt cotton. It was observed that the deviation between the observed and simulated seed cotton yield ranged from 6.0 to 34.2% (mean 20.1%) for RCH2 Bt cotton whereas the deviation was from -8.0 to 23.1% (mean 5.8%) for RCH2 Non Bt cotton (Table 19). The root mean square error between the observed and simulated yield for RCH2 Bt was 294.8 kg, which corresponds to 16.1% of the mean observed seed cotton yield. Whereas in case of RCH2 non Bt the root mean square error between the observed and simulated yield for RCH2 Bt was 309.6 kg, which corresponds to 15.3% of the mean observed seed cotton yield.

#### 4.17: Cotton Mechanization

Nagpur

Evaluation of Solar powered knapsack 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 has been 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 cm giving 10 sprays with a single charge. The sprayer was evaluated for the sustenance of pressure under solar spraying cum charging against the normal battery operated operation. The ANOVA results indicate that the solar operated sprayer sustain a pressure of  $20 \pm 1.0$  psi for a significantly longer time (44%) over the battery operated sprayer, thus generating uniform droplet size spectrum over a longer period of time.



Table 19: Observed and simulated seed cotton yield of RCH2 Bt vs non Bt cotton (pooled over 2006-07 to 2008-09)

Treatment	Observed seed cotton yield (kg/ha)	Simulated seed cotton yield (kg/ha)	Variation (%)
I,N3 Bt	1718	2024	+17.8
I,N3 Bt	1686	1788	+6.0
13N3Bt	1588	1935	+21.9
I,N3 Bt	1736	2330	+34.2
<b>Mean</b>	<b>1682</b>	<b>2019</b>	<b>+20.1</b>
# RMSE = 294.8 (16.1%); O = 0.43; MSEs = 65583; MSEu = 21307			
I,N3 NonBt	1923	1943	+1.0
I,N3 NonBt	1982	1823	-8.0I,N <sub>3</sub>
13NNonBt	1611	1983	+23.1
I,N3 NonBt	1806	2000	+10.7
<b>Mean</b>	<b>1831</b>	<b>1937</b>	<b>+5.8</b>
# RMSE = 309.6 (15.3%); D = 0.32; MSEs = 77773; MSEu = 15587			
# CRMSE = root mean square error; D = index of agreement; MSEs = Mean systematic error; MSEu = Mean unsystematic error			

**Design and Fabrication of prototype of fertilizer applicator as Blade Harrow (bakhar) attachment**

A prototype of fertilizer applicator for blade harrow as an attachment is being developed with a view to save time and labour by combining two operations in one pass especially for the rainfed cotton farmers using bullock power. Rate of application of the fertiliser was found to vary from 70 to 140 kg/ha. Data was collected under laboratory conditions to assess the rate of delivery of the fertiliser and the variation of delivery rates of both the tubes. The ANOVA results indicated that the distribution of fertilizer in the two tynes does not vary significantly when the distribution lever is in the maximum position, discharging an average of 140 kg/ha of fertilizer. However, the distribution is not uniform at minimum and central positions of the lever. Therefore, modification needs to be done in the distributor assembly so that distribution from two tubes is uniform over all the positions of the lever.



**4.18: Morpho-frame/Boll Load Management**

Nagpur

**Bt Morphoframe management using action specific chemicals**

Morphoframes of cotton hybrids viz Bunny Bt & NBt, Mallika Bt & NBt, RCH 2 Bt, MRCH2 Bt, NECH 2RBt, JK CH 99Bt and NCS138Bt were manipulated by spraying 5.7 mM ethylene or 8.56mM at 35-40 DAS(square initiation) or nipping of squares at 35-40 DAS(square initiation). Sudden drop of all the young squares was noticed within 48 hours after foliar spray of ethylene. At the time of spraying itself, all the early formed squares were removed.

Foliar application of ethrel brought about 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 135 DAS. These changes synergistically worked and brought about changes in plant ideotype. There was a positive change in the partitioning of photosynthates to the roots during initial stage and developing bolls in the later stages.

In Bunny Bt, there was a significantly higher seed cotton yield with foliar application of ethrel @ 5.7 mM (19.1 g/pl) followed by T4 (mechanical removal of squares (137.2 g/pl) and the least in control (115.1 g/pl) (Fig. 18). In Bunny NBt the treatment T3 (Ethrel @ 8.56 mM) yielded highest seed cotton yield (138.4 g/pl) followed by T4 (132.5g/pl) and least in T1 & T2 (124.8 g/pl) (Fig 27). Similar results were observed in mallika Bt, Mallika NBt and JKCH Bt.

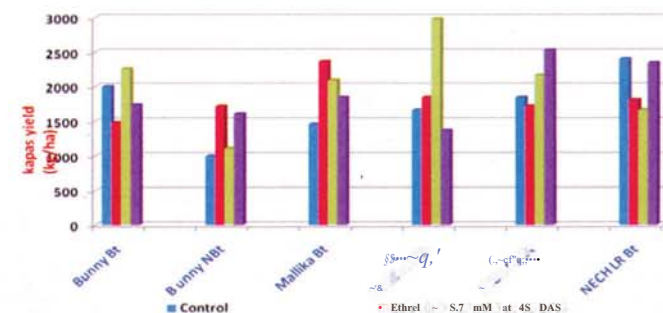


Fig. 27: Response of cotton hybrids to foliar application of ethrel on kapas yield

### Manipulation of morphoframe through nipping at Grand growth stage and mimic the effect using action specific chemicals- Maleic hydrazide

At Coimbatore four genotypes viz., RCH 708 Bt, DCH 32 and Suvin were studied for the effect of maleic hydrazide in comparison to nipping. Detopping at 95 DAS followed by nipping of monopodia and sympodia at 105 DAS yielded the highest seed cotton yield (1850 kg/ha) followed by foliar application of maleic hydrazide (1720 kg/ha). The lowest yield was in control (1253 kg/ha). Application of Maleic hydrazide @ 500 ppm changed the plant morphology with reduced internodal elongation. The LAI improved with better LAD.

At Nagpur averaged across genotypes, detopping at 95 DAS followed by nipping of monopodia sympodia at 105 DAS yielded the highest seed cotton yield (1050 kg/ha) and was on-par with foliar application of maleic hydrazide (1033 kg/ha) and control produced the least (933 kg/ha).

## 4.19: Studies on Abiotic Stress

### Coimbatore

#### Alleviation of water logging stress by foliar application of nutrients in Bunny Bt cotton

In pot culture, water logging was imposed in 30, 60 and 90 day old crop for a period of 5, 10 and 20 days. Modified Hoagland nutrient solution was sprayed during the water logging and recovery period. Water logging for 5 days did not affect the plant height, leaf number and boll weight significantly. However, further increase in water logging duration to 10 or 20 days adversely affected the morphological and yield parameters significantly. The yield was only 40.2 g in plants that suffered water logging continuously for 20 days compared to 60.6 g normal (control) plants which amounts to 34 % yield loss compared to 11 and 23 % in 5 and 10 days of water logging. Nutrient sprays during water logging and recovery period significantly alleviated the water logging stress. About 52.9 g per plant could be harvested in this treatment compared to 47 and 44 g per plant that received nutrient spray during water logging and during recovery period respectively. Water logging during the initial stage of 30 day old crop significantly retarded the morphophysiological characters of cotton. The adverse impact of water logging was reduced with advancement of the crop. For instance, the yield was 36, 48 and 56 and 61 g per plant that were water logged at 30, 60, 90 days after sowing and control respectively, irrespective of water logging duration and nutrient spray treatment.

## 4.20: Fibre Development

### Coimbatore

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

Four enzymes viz., Superoxide dismutase (SOD), Catalase (CAT), Peroxidase (POD) and Ascorbate peroxidase (AOD) were studied from the developing fibre and seeds. The ovules from MCU 5 and its mutant MCU 5 LL were harvested at regular interval (from -10 Days before anthesis to +1.0 DAS) and the assay was conducted.

The SOD activity was maintained around 0.286 units !J.min in both the genotypes from -10 days before anthesis to 6 DM, indicating that SOD activity may not be a rate limiting enzyme in fibre initiation process. The peroxidase enzyme was maintained at around 0.08 to 0.1 throughout the ovule development but the activity was maintained higher (0.004 to 0.01 units!J. min) in lintless mutant in comparison to MCU 5. Catalase activity was maintained relatively high in MCU 5 LL (0.04 to 0.1 units!J. min)

through out the period under study. MCU 5 maintained around (0.02-0.04) till anthesis and drastically reduced with the onset of fertilization. This enzyme might be one of the important enzymes associated with fibre development. Ascorbate peroxidase also maintained similar trend as that of Catalase, indicating a role for this enzyme also.

## 4.21: Socio Economic Dimensions of Cotton Farming

### Nagpur

#### Soil economic assessment of cotton based intercropping system

The data were collected from 150 farmers by proportionate random sampling method from eight villages namely Karanj, Madani, Sevagram and Paonar in Wardha tahsil and Girad, Dhondgaon, Huseinpur and Bhawanipur in Samudrapur tahsil of Wardha district, Maharashtra. The study pointed that there was medium level of awareness of intercropping practices by the farmers while knowledge and adoption of intercropping practices was low level (Fig. 28). Awareness of intercropping of soyabean, mung, urd, cowpea along with cotton among cotton growers was 43.33 %. The values of mean knowledge and adoption scores was 48.02 and 26.06, respectively, while the results of 'z' test indicated non-significant knowledge ( $z = 5.32$ ) and adoption ( $z = 4.37$ ) levels. The major constraints for adoption of cotton intercropping were lack of knowledge and proper understanding in intercropping system. The other bottlenecks were difficulty in intercultural operation, non-availability of seeds of appropriate crop/varieties, farmers mindset, lack of proper understanding on methods of sowing of main and intercrop, fear of more insect attack, labour problem, fear of low yields, stunted plant growth, lack of training and exposure.

The relationship between adoption of cotton intercropping practices and selected farmers socio economic and personal attributes such as education, occupation, land holding, social participation, annual income, awareness and knowledge was examined with Pearson's co-efficient of correlations. The values shows only land holding ( $r = 0.3991$ ) had significant relationship with adoption of intercropping at 1% level while other variables did not contribute towards adoption of intercropping system. Further, adoption of intercropping is more a function of extension and exposure rather than education and income. Multiple linear regression analysis regressing the level of adoption with independent variables indicated that all the selected variables taken together explained 38.4% variation in level of adoption of intercropping practices. It was therefore suggested for taking pro-active sustainable extension intervention by educational activity to train and motivate the growers to adopt cotton based intercropping system.

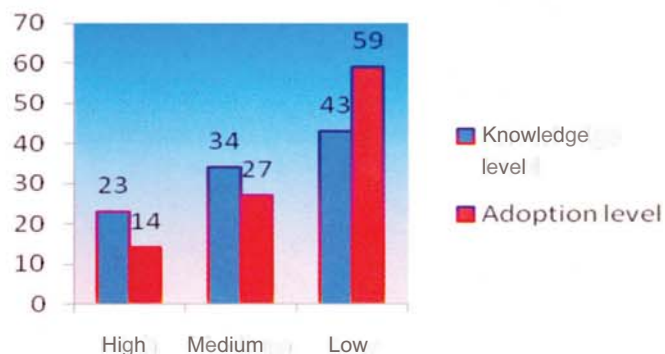


Fig. 28: Knowledge and adoption of inter-cropping practices

### Social dynamics of cotton production in distress areas

The data collected from 200 farmers from eight tahsils of 40 villages in distress district Wardha and non-distress Na-p-r, 20 villages from each district in Vidarbha revealed that m-Jorlt~ of cotton farmers from distress district had high level of alienation from land (73%) as compared to non-distress district (59%), (Fig. 29). The overall alienation was in medium level (Mean score = 59.37). The distress arises due to the feeling among the farmers that the cotton farming has trapped in vicious circle of uncertain rain and drought, repeated cotton crop failures leads to poor financial condition, their work as a farmer is not being rewarded, majority leads stressful life due to unworthy indebtedness and feeling of lost identity in society, no economic/financial support from friends/ relatives during crises and feeling of non involvement in decision making. The study further pointed out that total annual income of farmers is lower than expenditure irrespective of distress or non-distress situation. However, cotton farming is economically viable at growers level as expressed by B: C ratio in distress and non-distress situations, the net returns per hectare was RS.6733/- (B: C ratio 1:34) in non-distress district while Rs.5722/-(B: C ratio 1:1:31) in distress district.. Growing indebtedness (89 & 73% loan) and alcoholism (60 & 50%) among both distress a~d non-distress areas are also seriously increasing. The relationship among the independent variables- annual income, expenditure, income liability gap, family problems, alcoholism, social support with that of alienation found that expenditure (r= 0.3234) and income liability gap (r=0.2816) was positive and significantly correlated with alienation at 1% level in both distress and non-distress districts while alcoholism was significantly correlated at 5% level in distress district.. Annual income (r=-0.2456) and social support (r=-0.2216) was negatively significant at 1% level in distress district while in non-distress districts they were negatively significant at 5% level.. The multiple regression analysis indicated 35.29 and 39.24 per cent variations in the alienation of cotton growers in distress and non-distress district, respectively. Since income from farming was not sufficient to meet their day to day expenditure they expressed dissatisfaction of not being able to increase their income despite their best efforts. Moreover, due to lack of support from development agencies, relatives and friends during crises they are losing interest/enthusiasm in farming resulting in alienation. The study conducted on perception of farmers towards use of pesticide in distress and non-distress shows that farmers have very favorable perception to the positive statements like spraying of pesticide as need based, as per the ETL level and also avoiding frequent sprayings of insecticides. The perception mean index values were 56.64 for distress areas while 68.58 for non distress district

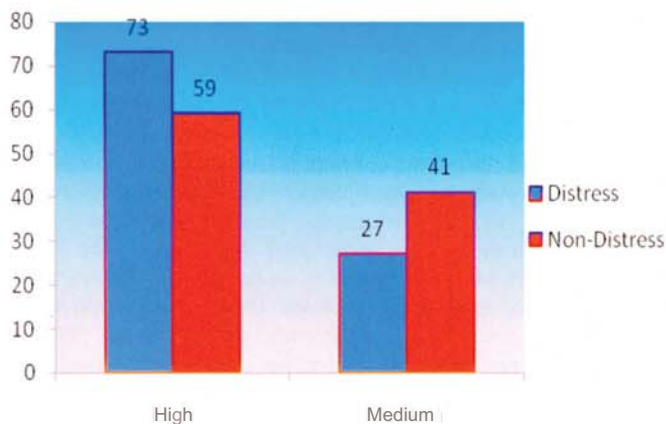


Fig. 29: Farmers alienation from land in distress and Non- distress areas

### Capital requirement for modernization of cotton production on marginal and small farms in Vidarbha

Analysis of the data from 120 small and marginal farmers of Wardha and Nagpur districts of Vidarbha region of Maharashtra indicated that small and marginal farmers of Wardha district are incurring a cost of Rs. 16955 and Rs. 17676/ ha for cultivation of cotton. If they cultivate cotton as per the modern technology they will incur an amount of Rs. 20739 / ha. Small and marginal farmers of Wardha district have only Rs. 5138 and Rs. 6082/ ha owned funds to grow cotton. Thus there is a gap of Rs. 15601 / ha in case of marginal farmers and Rs. 14657 in case of small farmers. In case of Nagpur district small and marginal farmers were using an amount of RS.16344 to Rs. 17583 / ha towards cotton cultivation. As per the survey cotton small and marginal farmers of this district have only Rs. 4599 and Rs 5138 respectively available for cotton cultivation. Thus there is a gap of Rs. 16140/ ha. in case of marginal and Rs. 15601 in case of small formers towards working expenses.

### Coimbatore

#### Documentation and validation of farmers' indigenous knowledge on farming system approach

To assess the sustainability level of cotton farms under diversified and non diversified conditions, data were collected from one hundred and twenty cotton growers. 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). Out of the nine economic indicators, the performance of seven indicators was significantly higher in this type of diversified cotton farms than in non-diversified cotton farms. They were production efficiency, employment generation capacity; farm family employment level, net return; technology use level, low cost technology use level and self sufficiency level.. The results showed that the economic efficiency of the system - 'Cotton + other crops + dairy' was the ~ighest.. T~e contribution of dairy activity to the high economic output in diversified farms was significant in terms of milk yielding potential, net return; generation of man days and self sufficiency level.. Similarly, the composite ecological efficiency index of the diversified farms was found to be significantly higher than non diversified cotton farms. The system which had highest ecological efficiency was 'Cotton + other crops + dairy' system. In this system, the dairy activity enabled use of more eco-friendly technologies by the farmers and increased the scope for better organic recycling in the farm.

#### Post evaluation of Farmers Field Schools (FFS) on cotton

Majority of the FFS beneficiaries were more than 45 years in age, middle school level educated, belong to backward class, lived in jointfamily, had 2.7 acres average farm holding, 19 years experience in cotton cultivation, an average annual income of 55,000 INR and highly innovative. The teacher made knowledge test used to compare the changes in knowledge of FFS and non FFS farmers revealed that the beneficiaries had significantly high identification knowledge score (6.97), functional knowledge score (7.11), ecological knowledge score (7.14) and decision making score (8.75) than t~eir counterpa~s.. There were significant changes in their adoption behavior viz., adoption of more number (5.325) of new varieties and hybrids, weed management (5.83), growth regulators (8.0), number of irrigations (5.9) and marketing behaviour (7.0).. 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. High cost, more time consumption, poor involvement of farmers, poor involvement of farm women, inability of the facilitators to provide advanced package of practices in Bt cotton and market intelligence and inconsistency of the farmers in adopting the learnt technologies through FFS are some of the major constraints expressed by the executing agencies.

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

To provide sound information on the environmental sustainability, soil fertility, and safety of organic cotton production system, economic viability, and production increase of biotech cotton production system and about the environmental pollution, high cost of production and low productivity of the conventional cotton production systems, data were collected from 120 Bt cotton growers, 32 conventional growers and 40 organic growers. Survey among the 120 Bt growers indicated that the prevailing major Bt cotton hybrids were RCH 20 Bt, RCH 2 Bt BG II, RCH 708 Bt and Bunny Bt. The average area under Bt cotton area was 1.79 acres and only 23 per cent of the respondents adhered to refuge practice. The attitude towards cultivating Bt cotton was highly favorable and they were willing to continue Bt cotton in next season too. The average cost of cultivation for one acre Bt cotton was Rs.16730/- and average yield was 9.30 q/acre. The major problems faced by them were high seed cost, spurious seeds, less knowledge on location suitability, of hybrids, susceptibility to sucking pests, lack of transgenic in popular varieties and practical difficulties in adopting refuge crop. Survey among the 32 conventional growers revealed that the major cotton varieties hybrids that prevailed in the fields were DCH 32 and Surabhi. The average area under conventional cotton area was 1.02 acres. The attitude towards continuing conventional cotton was highly unfavorable and they were willing to switch over to Bt cotton in next season. The average cost of cultivation for one acre conventional cotton was Rs.17404/- and average yield was 7.20 q/acre. The problems faced by the growers were non availability, and poor quality of seeds, high cost for plant protection, poor adoption of IPM and lack of tolerant varieties and hybrids in the market. Survey among the 40 organic cotton growers revealed that the major cotton varieties prevailed in the fields were MCU 5 and Surabhi. The average area under organic cotton area was 1.62 acres. The attitude towards continuing organic cotton was highly favorable and they were willing to continue organic cotton in next season too. The average cost of cultivation for one acre organic cotton was Rs.14338/- and average yield was 8.35q/acre. The problems faced by the growers were non availability and poor quality of seeds, non availability of organic materials, high cost of inputs, inadequate agencies to guide in getting organic certificates and poor market facilities.

#### An empirical analysis on cultivation of Bt cotton growers with regard to Insect Resistance Management technologies

To have a thorough study on the present status and concerns of end users with regard to Insect Resistance Management technology in Bt cotton, using the constructed attitude scale by Equal Appearing Method, fifty farmers were interviewed. 64.15 per cent of the respondents had highly unfavorable attitude towards cultivating non Bt cotton as refuge crop in Bt cotton fields. The fear of increase in production cost, yield loss, reduction in net gain and troublesome work of spraying separately for non-Bt cotton were the major concerns which compelled them to have unfavorable attitude towards this technology. Majority (68.33%) of the respondents had not adopted the technique as such, some (15.00%) mixed the

seeds and sown, some (8.33%) of them used it for gap filling, few (5.00%) of them cultivated in one or two rows and few (3.34%) persons collected all the non Bt seeds and sown in separate fields. The concerns expressed by them with regard to raising refuge crop were, need of educating all Bt cotton growers to be compliant with all guidelines of insect resistance management technologies through effective modes, justification of time and effort spent for planting the refuge crop in Bt cotton and recommending alternate strategies v;z., natural refuge crop, planting the refuge crop in adjacent fields separately, planting in strips ( in every row one refuge) and planting the Bt cotton without refuge crop.

#### Impact of Bt cotton cultivation on farm economy in India

Two districts namely Guntur and Warangal have been selected for the study pertaining to Andhra Pradesh under South Zone. Data were collected from 60 Bt farmers comprising of three villages v;z., Sakkamuru, Needumukulu and Thullur of Guntur district. 100 per cent of cotton area of sample farms was under Bt cotton. The details about non Bt cultivation was collected from the Bt farmers based on their earlier experience. The average number of sprays got reduced from 9 to 4 with reduction in cost by 48 per cent. The yields of Bt cotton were higher than non Bt cotton by 14 per cent. Human labour was the major input (35 to 40 %) in both the cases with higher share of fertilizers and pesticides in case of non Bt (14%, 36%) when compared with Bt cotton (15%, 24%). Seed cost was higher in Bt cotton (10%) than non Bt cotton (4%). Total cost of production, gross and net returns were higher in large and medium farms when compared with small and marginal farms. Since with the impact on yield, the value of output under Bt cotton is substantially higher, the profit as a per cent of the revenue is also substantially higher in Bt as compared to Non-Bt ( 20 % to 34%). Bt cotton farmers attributed for more profit (72.14 %), less pesticide (52.31 %) and comparatively more bolls (49.15 %) for the choice of Bt cotton.

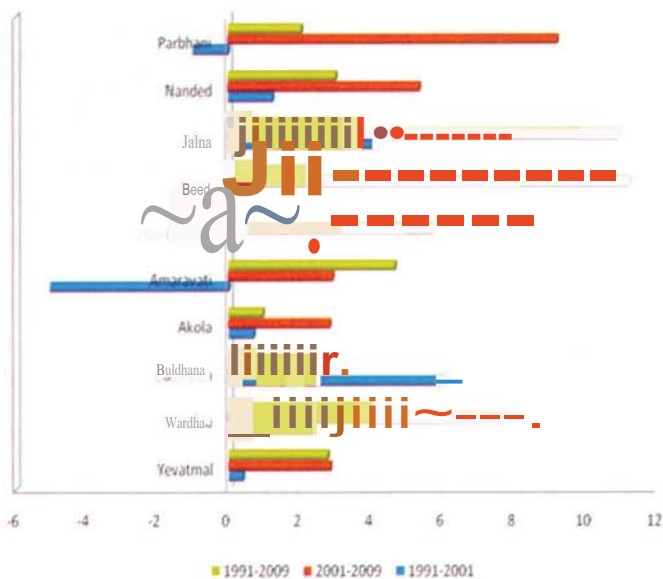
## 4.22: Total factor productivity analysis

### Central Zone:

Data on district level cost of production of cotton, quantities of inputs used in cotton and productivity of cotton were collected from Marathwada Agricultural University, Parbhani and Dr. Panjabrao Deshmukh Krishi Viswavidyalaya, Akola. Data were collected from ten major cotton growing districts belonging to two regions of Maharashtra. The districts for which data have been collected are Yavatmal, Wardha, Buldhana, Akola and Amravati of Vidarbha region and Aurangabad, Beed, Jalna, Nanded and Parbhani district of Marathwada region. Total input, output and productivity indices were worked out for each district using Torniquet-Tehil indexing procedure. Compound growth rates of these indices were worked out and their significance were tested. The analysis was carried out for the period 1991-2001, 2001-2009 and overall period 2001-2009 as per the availability of the data (Fig. 30).

During the first period six districts showed positive total factor productivity growth while four districts showed negative growth. Highest total factor productivity growth was observed in Buldhana followed by Jalna and Wardha. Total factor productivity growth was negative in Amravati, Aurangabad, Beed and Parbhani during this period. During the second period total factor productivity growth was positive in all the ten districts. During this period, total factor productivity growth was highest in Beed followed by Jalna and Parbhani. During the overall period no district registered negative growth of total factor productivity. Highest total factor productivity growth was observed in Amravati followed by Wardha and Jalna.

Fig. 30 :CGR of TFP of cotton in Maharashtra



#### South Zone:

In order to estimate district wise TFP, an attempt is made to collect time-series farm level data from the Government of India sponsored "Cost of Cultivation Scheme. Tamil Nadu is classified into seven agro-climatic zones: north-east, north-west, west, southern, Cauvery delta, high rainfall, high altitude and hilly Zones. Data pertains to the period 1995-96 to 2003-04. The results of TFP of Cauvery Delta zone (Trichy, Karur, Parambalur, Thanjavur, Thiruvarur, Nagapattinam) showed that there exist fluctuations in TII and TOI in most of the years. There exists an inverse relationship between the TII and TOI in the Cauvery Delta zone. Though the inter year fluctuations were seen, the TFP value has increased from 0.87 in 1995-96 to 1.28 in 2003-04. Thus over the years the returns to the cost of cultivation is greater for the cotton crop in the Cauvery Delta zone. Regarding Southern zone (Pudukkottai, Madurai, Theni, Dindigul, Ramanathapuram, Sivaganga, Tirunelveli, Thoothukudi, Virudhunagar), TFP shows a marginal increase from 0.48 in 1995 to 0.55 in 2003. In most of the years, the value of TFP is less than one indicates that the returns in the cotton cultivation is very meager in southern zone. In case of North Eastern Zone (Kancheepuram, Thiruvallur, Vellore, Thiruvannamalai, Villupuram, Cuddalore), TFP over ten years has increased from 1.55 in 1995 to 1.69 in 2003 which shows the better returns to scale for cotton cultivation in the north eastern zone for some of the years. While in the rest of the years TFP value is below one, which indicates that the value of inputs plays a greater role in deciding the output value besides the environment or technological factors. With some fluctuations, the value of output has decreased over the years in case of North Western Zone (Salem, Dharmapuri, Namakkal, Krishnagiri). Though the value of TOI has decreased, the TFP value is more than one in many years which shows higher returns through cotton cultivation. In western zone (Erode, Coimbatore), the value of TII has increased from 0.83 in 1995 to 0.96 in 2003, which explains the increase in the cost of all the inputs over the years. When the value of TOI is concerned it does not change much for 1995-2003. The TFP index has decreased slightly from 0.78 to 0.67 over the years.

#### North Zone:

In case of Bhatinda district, based on the input and output data related to cotton crop, the results indicated that growth rates of Total Input Index (TII) showed negative trend during the period 1990-91 to 2007-08. The Total Output Index (TOI) and Total Factor Productivity (TFP) during this period have been showing positive trends as it was indicated by the positive growth rate during this period. The growth rate of TFP during the period 2000-01 onwards increased at higher rate than the period from 1990-91 to 1999-00. In case of Mansa district, the compound growth rate of TII, TOI and TFP decreased during 1990s and increased during 2000s except TII which showed decreasing trend during this period.

## 4.23: Cotton Information System

#### Coimbatore

To strengthen the existing Cotton Information Repository, many new datasets were collected from various sources which are secondary in nature. Appropriate databases were created and also existing datasets were updated. Apart from this, time series data which are quantitative in nature, voluminous abstract datasets were also collected which are lacking in continuity. This abstract information includes both qualitative as well as quantitative information. Beside this, public domain and open access cotton related research as well as popular articles was also obtained. Already some of the articles downloaded from open access and donor articles were uploaded and some were linked to the original source in our portal. With the available datasets in the information repository, web enabled information system on cotton was developed with user friendly tools, which has its own advantage that user has the option to query the information in multi perspective. The software was developed with ASP.NET (2008) for front end and Microsoft Access (2007) as backend. In the back end, the data sets were stored in structured database. ASP.NET framework 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 also have the option to print the queried data. The software was validated and master copy of the CD version of the above Information retrieval system was developed and replication has to be done for release and distribution to the users.

Two separate sub-domains were created for All India Coordinated Cotton Improvement Project (AICCIP) and Technology Mission on Cotton Mini Mission-I (TMC). The URL for the above projects was [www.aiccip.cicr.org.in](http://www.aiccip.cicr.org.in) and [www.tmc.cicr.org.in](http://www.tmc.cicr.org.in) respectively. The two sub domains were created to have more access to the user and separate indexing were done that user query from the search engine directly fetches the pages of AICCIP and TMC without visiting CICR website. The newly revamped cotton portal developed under web 2.0 technologies and Search Engine Optimization (SEO) tools were introduced. Google Analytics tools in our portal helps in global users to access our site whenever they search any contents related to cotton and also our site will be well highlighted in any search engine. The latest web technologies like content stretch-shrink has been introduced which breaks the monotony of some of the sites. The Farmers' forum was developed and floated on trial basis at CICR portal. The forum was developed using the web tool hypertext preprocessor.