REPORT
ON
IMPACT EVALUATION
OF
MINI MISSION I AND MINI MISSION II
OF
TECHNOLOGY MISSION ON COTTON

Submitted to :

Department of Agriculture and Cooperation
Ministry of Agriculture
Government of India

By :

Agricultural Finance Corporation Ltd.
Head Office, Mumbai

October 2010

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A CONCISE REPORT ON THE EVALUATION OF MINI MISSION I AND MINI MISSION II OF TECHNOLOGY MISSION ON COTTON

SECTION A – GENERAL

Introduction

The Technology Mission on Cotton introduced during 2000-01 by the Government of India is a major intervention to bring forth new vitality in cotton production, in order to garner all the advantages and opportunities opening up due to globalization and liberalization in the international economic scenario.

A number of factors could be relevant for consideration of any critical study of the impact of Technology Mission on Cotton. While the generation of awareness of the program, the subsidy assistance provided to farmers on various components and adoption of technology spread through FLDs and trainings under FFS are certainly vital, consideration of abiotic factors like weather condition, price support, marketing and relevant profitability of cotton vis-à-vis other crops are also important as these act as strong motivating factors in farmers' decision on area expansion and yield maximizing efforts.

The impact study has, therefore, necessarily confined to the relevant usefulness of and priority of different programme components which had an impact on farmers' attempt to yield maximization. Performance of various programme components, both qualitative and quantitative, along with discernible impact of the various components has been discussed at length in relevant chapters. The findings and conclusions are based on an objective assessment of the achievements of the programme interventions in terms of project targets & goals. In view of the substantial investments made by the Government of India for promotion and development of cotton in the country, an attempt has also been made in this study to analyse the actual benefits derived in terms of increase in yield as well as increase in income from the perspective of sampled beneficiary farmers to assess the component-wise impact at the ground level as well as the overall impact of all components cumulatively. The aim has been to analyse how far the investments have resulted in creating the desired impact and to see the extent to which the objectives of Mini Mission I and Mini Mission II have been fulfilled in its nine years of operation under mission mode.

Technology Mission on Cotton

1. The Technology Mission on Cotton (TMC) was launched by Government of India during 2000-01 with special consideration to improve cotton production and productivity along with adequate care to bring in internationally competitive fibre quality, which could be utilized in export-oriented commerce of this commodity in our country. TMC comprises of four Mini Missions. While Mini Mission-I takes care of cotton research and technology generation including development of transgenics, improved crop production and protection technologies, development of suitable farm machinery for cotton cultivation and fiber quality improvement; Mini Mission-II undertakes transfer of new technologies and development. MM-III is concerned with modernization of marketing system and infrastructure development while MM-IV is responsible for modernization and upgradation of ginning and processing establishments.

2. The synergy to increase productivity with lowered farm-level cost of production is the major aim of the Mini Mission I (MM I) with emphasis on quality and global competitiveness. Technologies generated out of judicious and logical integration of various location-specific farm-resources are the primary target of this Mini Mission. Mini Mission II (MM-II), on the other hand, aims at increasing production and productivity of cotton, making available the quality seeds of improved varieties / hybrids to the farmers, transferring production technology to farmers through front line demonstrations and training of farmers/extension workers, bringing more area under irrigation & promoting efficient use of water by popularizing drip and sprinkler irrigation, minimizing losses to cotton crop by pests through popularizing IPM module & IRM strategies, pest surveillance etc. and last but not the least, promoting the use of bio-agent, bio-pesticides and quality inputs in cotton through standard package of practices.

3. MM-II is being implemented in the cotton growing areas of 9 major States like Haryana, Punjab, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamilnadu, two non-traditional States of Orissa and Uttar Pradesh and two minor cotton growing States of Tripura and West Bengal.

Monitoring & Evaluation

4. An effective monitoring and evaluation mechanism is an essential component for the success of any project, particularly, where multiple agencies are involved in implementation with a very diverse target group. The Government of India has devised an in-built mechanism for monitoring and evaluation of TMC on a periodic basis through state and National level review committees and regular departmental monitoring. As a sequel to this, the Ministry of Agriculture has commissioned an independent third party impact evaluation of MM-I and MM-II to make an objective assessment of the achievements of the programme interventions in terms of project targets & goals, the task of which has been entrusted to Agricultural Finance Corporation Ltd. (AFC), the premier consultancy organization in the country.

Terms & Reference of the Study

5. The terms of reference (TOR) of the study in respect of Mini Mission I includes, inter alia, evaluating the development of long linted and fine quality diploid and tetraploid cotton genotype; demand and production of nucleus & breeder seed; development of integrated nutrient and water management practices for better resources utilization; refinement of location specific IPM modules and mass production protocols for various bio-agents; performance of newly developed implements for planting, inter culture and spraying operations; development of new technologies in improving cotton productivity; technological interventions in various cropping systems to increase cotton production and lastly the development of commercially viable processes for value addition of cotton bi-produce.

6. Under Mini Mission II, the TOR entailed studying the growth rate in area, production & yield during the TMC period since its launch in 2000-01, finding out reasons for fluctuations in yield and quality of cotton in the country, studying the seed multiplication chain and seed replacement rate, assessing the effectiveness of the training programs organized under FFS, evaluating the benefits of IPM/IRM technology and its adoption by farmers. It also envisages assessing the additional area brought under irrigated cotton through the use of water saving devices, varieties/hybrids popular amongst cotton growers,

extent of Bt cotton cultivation, impact of FLDs besides suggesting suitable remedial measures to overcome constraints identified.

Approach & Methodology

7. The study has been conducted on the set parameters applied for conducting socio-economic impact evaluation process through a sample survey of 3760 cotton growing framers covered under the program benefits and 920 non-beneficiary cotton farmers from the sampled districts spread over 13 cotton growing States, the reference period for the study being 2000-2001 to 2008-09. A multi-stage, systematic and purposive sampling method has been adopted for the study. The sample is a representative group comprising of cotton growing beneficiary farmers and non-beneficiary farmers drawn from various socio-economic categories [SC/ST/OBC/Women/General, Small/Marginal/Large Farmer, etc.].

8. The tools for the study included specially designed primary survey schedules for eliciting authentic and unbiased information from various sources on different aspects of the program implementation. Separate survey schedules were designed for obtaining necessary and relevant information from both beneficiary & non-beneficiary farmers and other stake holders namely, State Governments, District Agriculture Department, CICR, SAUs, KVKs, CCI besides all the Principal Investigators and their Associates for each programme / target set under MM-I.

9. The data collected from the primary and secondary sources was coded, tabulated, collated and analyzed using appropriate statistical tools like frequency, percentage and simple correlation to draw inferences thereon. The sample design of the impact evaluation study exercise, howsoever broad based, the data collected from the sample districts, cannot be made the basis for projecting trends for the State as a whole. This is so, particularly, because cotton has the distinct characteristics and is grown under varying agro-climatic conditions. The feedback from the sample farmers may, therefore, be regarded as indicative in character. However, the completeness of the impact study is ensured with the support of data from secondary sources enlisted above and interactions with several stake holders.

Structure of Report

10. The report has been structured and organized into twelve chapters divided into three Sections. Section A contains chapters giving brief introduction on the cotton scenario in India and the World as well as different approaches and methodologies adopted in conducting the study. Section B contains three chapters exclusively devoted to evaluation of Mini Mission I. Section C of the report comprehensively deals with Mini Mission II. Under this Section, there are seven exclusive chapters which make a critical evaluation of the program implementation in the cotton growing States during the entire TMC period and deduces specific impact of the program from the primary survey in respect of each of the component namely, certified seed, bio-agents/bio-pesticides, pheromone/light traps, sprayers, water saving devices viz. drip & sprinkler irrigation systems, farmers' field school, training of facilitators, coverage and impact of IRM, impact of FLDs on production technology, IPM and farm implements. The report makes an earnest attempt to suggest an approach plan / road map for future policy direction and gives suitable recommendations both in respect of MMI-I and MM-II based on the overall findings and conclusions of the study.

SECTION B - MINI MISSION I

Fund Allocation and Utilisation under Mini Mission-I

The Ministry of Agriculture, Government of India has provided fund support to the tune of Rs. 4618.12 lakh under Mini Mission I during the nine year period from 2000-01 to 2008-09 against a program outlay of Rs. 4668.18 lakh. The cumulative fund utilization at 99.5% is remarkable.

Evaluation of Programmes under MM-I

Based on the research findings and achievements under various programmes and targets under Mini Mission-I during X and XI Plan periods, the following are the key findings & conclusions:

X PLAN PROGRAMMES

(I) Genetic improvement with inbuilt resistance to biotic and abiotic stresses for the quality cotton production

A) Identification of long fibre length and high fibre strength of *G. arboreum* types from germplasm and breeding materials coupled with high yield suitable for high speed spinning

i) Before the launch of TMC, the desi varieties were found to be low yielding, poor in fibre quality and not suitable for high speed ginning and spinning in textile sectors. Therefore, major emphasis was laid on fibre quality improvement with desired level of seed cotton yield. Developing *desi* genotypes with high fibre length (27-30 mm), strength (24 g/tex and above) with low micronaire (<4.5) suitable for high speed spinning and high lint percentage is imminent to compete in global market by way of meeting international quality parameters.

ii) During the TMC period till date, Thirteen high yielding (12-18 q/ha) varieties with desired fibre quality coupled with resistance / tolerance to pests and diseases were released during the project period. Further, more than 130 superior genotypes (yield and fibre quality) of G. arboreum and 123 genotypes of G. herbaceum have been identified for future use by the breeder. The details of *G. arboretum* varieties released so far during the period of TMC alongwith their fibre quality and strength are listed in Annexure 3.1.

iii) After the scheme of Germplasm Registration was launched, almost all the cotton breeding centres in the country have registered their unique material and obtained the Registration Number.

iv) A total of 115 FLDs were conducted to make the visibility of released / pre-released varieties for higher economic returns as well as to popularize them among the farmers. In all such demonstrations, the new varieties had recorded higher yields than the local checks.

Conclusions

- The improvement made in the development of diploid cotton genotypes through the project is appreciable. However, while yield improvement in all the released varieties

is clearly visible, fibre quality is still not up to the desired level in many of the varieties. Therefore, more efforts are required for fibre quality improvement.

- The *desi* cotton produced earlier in India was fit for spinning 10s to 30s only. The improved quality genotypes developed through the project indicated the spinnability upto 20s to 50s counts. However, to see the impact of these genotypes, there is need to adopt Bt technology either by the public institutes or parting the genotypes to the private sector so that the improved genotypes with quality can see the light of the day and benefit the farming community.

B) Development and identification of tetraploid cotton materials with high fibre quality and resistance to drought and biotic stresses

i) *G. hirsutum* cottons are capable of yielding upto 35 q/ha with a spinning potential upto 60s count. After the introduction of hybrids, the area coverage under *G. hirsutum* varieties started declining and today stands at 19 per cent of the total cotton area in the country. The *hirsutum* cottons are grown in all the three zones, both under irrigated and rainfed situations.

ii) Four *G.hirsutum* varieties i.e. MCU13, Aurobindo, Suraj & Anusaya were released for commercial cotton cultivation for different agro-climatic conditions of the country. These varieties out yielded the checks in respect of seed cotton yield by 16-27 per cent and also possessed desired fibre quality and medium to high degree of resistance / tolerance to diseases and pests.

iii) Three Genotypes viz. TCH 1705, TCH 1710 and CSH 3129 are in pipe line for release by virtue of their high yield and superior fibre quality.

iv) Based on the trials conducted by their respective centres and TMC multi-location testing, fifty seven high yielding genotypes combined with superior fibre quality were identified for further testing in AICCIP trials.

v) Large number of donors for various economic traits have been identified for using in breeding programme i.e. boll worm tolerant (2), resistant to Jassid (more than 150), leaf curl virus disease (more than 600), Alternaria leaf spot (1), multiple disease resistance (2) and drought tolerant (17).

vi) Eight genetic stocks namely, Pusa 95-33-4-22 (high fibre strength), Pusa 17-52-10 (tolerant to high diurnal temperature variation), CPF1 x CSP4 (Pink flower and pink filament mutant), CSH14 (Alternaria disease resistant), BTS 5, BCS 7 and BTS 23 (tolerant to bollworms) with unique genetic traits have been registered with NBPGR as donor for future use by breeders.

vii) FLDs of varieties released under TMC programme i.e. Suraj, MCU 13 and NH615 have been conducted at 120 locations on farmers' fields. Two field days to popularize the variety NH615 have also been organized.

Conclusions

- Due to very little or no demands of non-Bt versions and preference for Bt cotton genotypes by the farmers, vigorous efforts should be made to incorporate Bt genes in the newly released varieties as being done in the case of Suraj variety.

C) Diversification of genetic materials through introgressive breeding of identified sources using useful genes for better fibre properties, resistance to drought, bollworms and key diseases

i) 26 wild species (out of 50 identified in the world), 15 races of cultivated species and inter-specific derivatives are very well maintained and being utilized in breeding programmes to diversify the genetic material.

ii) Wild species are good source for resistance to insect pests, diseases and fibre quality attributes especially fibre length and strength.

iii) Sources for superior fibre properties, biotic and abiotic stresses (combination) also identified such as jassid and bollworm resistance, Fibre strength and Bacterial blight and fibre length and strength.

iv) Hybridization between wild species and cultivated species (cultivars) resulted in identification of genotypes with high yield and superior quality traits. The range for various economic characters in advance generation material was – 10-14 q/ha for seed cotton yield, 30-42 % for ginning outturn 20-31 mm in 2.5 % span length and 16-22 g/tex for fibre strength.

v) Resistant genotypes identified includes –

GISV 206, GISC 248, GISC 253 (Drought)

GYMH 8, AKH 8828, TCH 1653 & many more (Bollworm)

DWR1R2, TCH 1648 (Jassids)

DWRM1R, IH35, GISV 206, Rai7B2….many (whitefly)

I4MH8, GISV-33, GISV-6, TCH 1693…..many (CLCuV)

GISC – 17, GISC – 185, GISC – 218, GISC – 246……many (Root rot)

vi) For fibre quality attributes also, superior genotypes have been identified. The range for 2.5 % SL was 27.5 to 32.5 mm, for fibre strength it was 20.5 to 24.6 g/tex and for fibre fineness (micronaire) it was between 3.2 to 4.0.

vii) Two introgressed interspecific derivatives viz. CCH5-1 and CCH5-2 have been sponsored into AICCIP field trials.

viii) Introgressed culture RAC 024 had been evaluated in multi-location field trials in Central Zone.

Conclusions

- The superior introgressed materials identified are good sources for various desired characters though they may not possess very high yield potential.

II. Assessment of nucleus and breeder seed production

A) To make available genetically pure seed of popular varieties and parents of hybrids through large scale multiplication

i) Availability of pure seeds of varieties to the farmers is very important for realizing the full potential of a technology (variety) and simultaneously increasing the production and productivity of the crop.

Nucleus Seed

ii) Nucleus Seed production consists of selection of single plants, its evaluation and constitution of progeny bulks of true to type progenies. The nucleus seed production depends upon the breeder seed requirement. Hence, the quantity of nucleus seed produced for each variety varies according to the number of progenies grown and the quantum of breeder seeds required, as shown in the table below.

Year	Variety/Parent of Hybrid	Area sown (acres)	No. of progenies maintained	Nucleus Seed Qty produced (kg)
2000-01	NA	NA	NA	NA
2001-02	NA	NA	NA	NA
2002-03	101	-	950	1001
2003-04	86	6.0	1420	465
2004-05	81	2.5	3120	369
2006-07	NA	NA	NA	NA
2007-08	72	1.27	2670	141
2008-09	104	4.15	4728	507

iii) As can be seen, on an average, about 1.5 to 1.7 quintals of nucleus seeds are being produced depending upon the requirement. The number of varieties and parental lines of hybrids taken up for maintenance varied from 72 to 101. The land allotted for nucleus seed production varied from 1.27 to 6.0 acres.

Breeder Seed

iv) Breeder seed production of National varieties is the mandate of the Indian Council of Agricultural Research (ICAR) and is being implemented through 14 AICCIP centres situated in various State Agricultural Universities (SAUs) and the ICAR Research Institutions.

v) In the initial years of the TMC program, there was lot of demand from the farming community for the seeds of released varieties and parental lines of the hybrids which were duly met through proper seed chain.

vi) Under this programme, every year as per demand, 200-300 quintals of breeder seeds of different released varieties and parental lines of hybrids are produced and supplied to seed producing agencies across the country.

vii) With the advent of “Bt cotton” and its wide spread adoption by farmers across the country, the production and demand of breeder seed of public sector varieties/parental lines of hybrids has come down drastically and at present it is hardly between 60-80 qtl. Year-wise cotton Breeder Seed production and the demand are presented in the table below:

Year	Indent	Production
2000-01	113.82	307.03
2001-02	153.34	185.36
2002-03	97.47	190.41
2003-04	74.63	263.1
2004-05	112.12	195.94
2005-06	170.05	258.17
2006-07	62.21	217.29
2007-08	153.62	176.53
2008-09	86.21	80.48
TOTAL	**1023.47**	**1874.31**

viii) Breeder seed produced at various centres against the indents during the period under study is presented Zone-wise and variety-wise in Annexure 8.1. It can be seen that the total breeder seed production over the years has been far more than the indented quantity in the production centers of Northern Zone except in 2004-05 & 2007-08; while the number of cultivars were high (26) in 2004-05, it was 19 in 2007-08. Production of breeder seed at individual centers have been generally good but was less than indented quantity of 16 cultivars in 2004-05 & 8 cultivars each in 2007-08, 2005-06 and 2002-03; parental lines of RAJ DH 9 & H 974 in 2007-08 and H 1226 in 2005-06 were not produced at all.

ix) Total breeder seed production over the years, except in 2004-05 & 2007-08, has been far more than the indented quantity in the production centers of Central Zone; while the number of cultivars were high (21) in 2004-05, it was 14 in 2007-08. Production of breeder seed in individual centers has been generally good

Conclusions

- It is noteworthy that the number of progenies selected was sufficient to constitute required quantity of Nucleus seeds
- Evidently, there has been a steady increase in the production of breeder seed over the years and the production has been much higher than the actual indent.
- 'Produce seed at your Farm's concept is appreciable but it should be enlarged so as to cover all the cotton growing states.
- The demand for breeder seeds would increase once the Bt technology is incorporated into the public sector varieties and hybrids to meet the requirement of the cotton growers in the country.

III. To evaluate the development of integrated nutrient and water management practices for better resource utilization to improve productivity and quality of cotton

A) Integrated Nutrient Management (INM) for high quality fibre and yield

i) Application of 75 to 100 per cent RDF + organic manures (local specific) every year produce higher and stable yields over RDF. It improves soil fertility, soil health and productivity as well as it takes care of deficit nutrients. This practice certainly reduces the cost of cultivation and dependency on FYM over a period of time making cotton cultivation sustainable.

ii) Application of RDF + micronutrients (based on soil test values) has got beneficial effect on yield wherever soils are deficit in micronutrients. This system improves productivity at lower cost on sustainable basis.

iii) Instead of soil application of K, potassium can be supplied through foliage. Thus, cost on fertilizer K can be reduced to greater extent.

iv) An integrated nutrient supply system with partial substitution of N through organic sources was found to improve the productivity and fertility of the soil over RDF. Thus, cost on fertilizer N can be reduced to the extent of 25 to 50 per cent.

Conclusions

- Promising INM interventions were tested in the farmers' fields across the country and results indicated significant yield improvements over the farmer practice. Increase in yield was 11 to 23, 8 to 43 and 28 to 113 per cent in North, Central and South zones, respectively as compared to farmer practice.
- Location specific INM modules developed under the programme have reduced the dependence on FYM and have potential to save on fertilizer P and K to large extent and N to limited extent over a period of time. Thus, cost of cultivation can be lowered. As an alternative to present INM practice (RDF + 5 to 10 t/ha FYM), these INM practices can be used.
- A positive externality is improvement in soil health (higher fertility and productivity).

B) Integrated Water Management System in Cotton for Quality Fibre Production

i. Opening of furrows in every/alternate row or tied ridges in rainfed cotton were found effective in enhancing the cotton yield to the extent of 12.5 per cent as compared to rainfed control. B:C ratio was also improved from 2.22 to 2.44.

ii. Intercropping of greengram/blackgram/soybean as effective cover crops in rainfed cotton produced 25.2 per cent more cotton equivalent yield and prevented the runoff, conserved the soil moisture by reducing evaporation during cropping period (intercrop acted as cover crop and its residues acted as mulch).

iii. The most critical stage was boll development in cotton and supplementing one irrigation at early boll development stage (1603 kg/ha) improved the yield by 241 kg per ha (17.70%) as compared to rainfed control (1362 kg/ha). B:C ratio also improved from 2.02 to 2.15 due to one irrigation at boll development stage.

iv. Giving one irrigation at boll development stage improved the yield from 1278 to 1670 kg per ha (31%), whereas irrigations at two stages (square and boll development) gave 59 per cent more yield (2036 kg) over rainfed control (1278 kg). B:C ratio was also enhanced from 1.9 to 2.4.

v. Drip irrigation and fertigation saved 25 per cent of fertilizers when applied in six splits and it saved 38 per cent irrigation water as compared to surface irrigation. Drip irrigation at 0.8 ETC was found to be optimum to get potential yield with better WUE.

vi. Improvement in yield over rainfed control (1720 kg) was 19 and 57 per cent due to supplementation of one irrigation at boll development and two irrigations at flowering + boll development stages, respectively under paired row planting.

vii. IMC practices, intercropping with pulses, protective irrigation at critical stages did not improve the fibre quality significantly.

Conclusions

- As the soil moisture is main constraint for high yields in rainfed cotton cultivation, the techniques developed in this programme have greater impact on improving the productivity of rainfed cotton as well as cotton production in India. IMC practices, intercropping and irrigation at critical stages are simple technologies to adopt easily and quickly. However, popularization is required.
- Wherever irrigation water is scarce or limited, integration of IMC practices and irrigation at most critical stages also helps in expansion of irrigated area.
- Saving of irrigation water (30 - 40%), fertilizers (25%), electricity, manpower *etc.* are the advantages and impacts of drip irrigation. But, initial cost of installation of the system and availability of the durable materials limiting its use and adoption by the Indian farmers.
- It is interesting to note that on an all India basis, rainfed cotton productivity was 76 to 85 per cent of irrigated cotton and irrigating rainfed cotton at only one critical stage of boll development has produced 84 to 95 per cent of irrigated cotton yield. Thus, giving one irrigation at boll development stage has got tremendous effect on yield improvement of rainfed cotton and Indian cotton production.

IV. To evaluate the refinement of location specific IPM modules and mass production of protocols for various bioagents

A) To develop location specific, holistic, eco-friendly and cost effective pest suppression strategies

i. A basic framework of IPM approach was synthesized by NCIPM for 5 villages selected in each of the three cotton zones in the country. Overall reduction of pesticide use by 59.7 in IPM over 261 ha was evident to testify the IPM in conventional cotton. Increase in seed cotton yield was 24% to enhance net return by 35% over farmers practice.

Location specific IPM modules validated across three zones

Zone	Area Under IPM (ha)	Quantity of Pesticide used (kg/ha)		% Reduction in pesticide use	Seed Cotton Yield (kg/ha)		Net returns(Rs.)	
		IPM	FP		IPM	FP	IPM	FP
North	145	4.37	10.55	58.58	1678	1319	24135	15004
Central	315	3.02	9.77	69.09	1423	1192	19828	1527
South	192	4.89	10.07	51.44	1314	1051	18351	12557
Total:	**652**	**4.09**	**10.13**	**59.7**	**1472**	**1187**	**20771**	**14396**

ii. Educational tools such as Pest Management Information System and films on IPM covering different aspects have also been developed.

iii. Online pest monitoring and reporting system has been initiated.

iv. With the introduction of modern cultivars including Bt cotton, the IPM modules had been re-oriented to provide strength to technology for adoption on these cultivars. The activities included i) development of model IPM form in nucleus IPM village and promotion of IPM in the cluster villages ii)validation of Bt cotton as a component of IPM and iii) development & utilization of pheromone technology and IPM films in vernacular language.

v. Incidence of sucking pests (thrips, aphids & whiteflies) has been reduced by 26-40% in non-Bt and 22 to 67% in Bt cotton. IPM practices were found to be more effective with 40% reduction in Central Zone followed by South & North Zones. Similarly, bollworm reduction over non-IPM was from 15 to 25% in non-Bt and upto only 9% in Bt. Central & North Zones exhibited highest & lowest reduction of bollworms.

vi. Pest suppression effect was reflected in yield enhancement from 13-21% in non-Bt and 1-16% in Bt cotton. Impact of IPM strategy, measured in terms of yield revealed increase in yield from 13 to 21% in non Bt as against 1 to 16% in Bt cotton Farmers who practiced IPM on Bt were enriched with net gain from Rs 0.2 to 2.45 for every rupee investment and benefit cost ratio was maximum (Rs 2.45) in Central Zone.

vii. The larger quantum of pesticides usage is against bollworms which is well taken care by transgenic event. Converse effect of IPM on natural biocontrol agents was most visible with greater conservation of predators on non-Bt than Bt and it is most pronounced in Central Zone followed by North Zone.

Conclusions

- The validation effort lead to horizontal spread of technology in the 4 year operational period, besides fine tuning of IPM module to suit locations.
- The results of pest suppression reveal that IPM practices against sucking pests are more rewarding in Bt cotton as it is prone to be more susceptible to these pests. In contrast, IPM effect was not visible on Bt cotton as the transgenic was developed exclusively to resist bollworms damage.
- IPM is found to be most effective in North Zone to realize maximum production potential that endowed in the Zone in non –Bt, while Central Zone gained maximum from IPM on Bt cotton. Differential zonal response to Bt & non-Bt convey differential biotic and biotic pressures across zones.
- The technology was disseminated to around 5-6 cluster villages around nucleus IPM village constituting a total of 48-60 villages. This programme has created greater impact for acceptance & adoption by the nucleus farmers and to the extent 5 to 10 times more by others.
- Most of the components have been included in the package of practices for adoption. Future strategy to promote this technology should focus on supply of quality inputs in time & space at reasonably acceptable price.

B) Assessment of pheromone blend profiles for *Helicoverpa Armigera* in cotton based cropping system and evaluation of indigenous pheromones

i. A total of 14 combinations with variable proportion of Z-11 Hexadecenal and ZM-9 Hexadecenal have been evaluated for their efficiency of attraction in various geographical regions in association with two important host of *Helicoverpa armigera*

(cotton & chickpea) Ratios of Z-9 in Z-11 Hexadecenal ranged from 0 to 10, 15, 30, 50, 75 and 100. Blends with 4 and 10% of latter component elicited highest and significantly more attraction of male moths over others.

ii. In North India, in cotton – chickpea cropping system, 3 and 10% blends in cotton, 3,4,5,10 and 15% in chickpea blends attracted maximum number of moths. Thus, it can be concluded that multiple blends will serve as better indicators for decision making. Variable options are available to use 2 (10 & 3%), 3 (10, 3 & 5%) and 4 (10, 3, 5 & 15%) blends for inclusion in IPM.

iii. The evaluation trials at Nagpur, Coimbatore, Delhi and Dharwar indicate the superiority of multiple blends with 2 and 15% was best with about 500 moths/trap.

iv. Pheromone components synthesized indigenously at Lac Research Institute, Ranchi and evaluated at Delhi, Coimbatore and Sirsa revealed existence of pheromone polymorphism. If only one ratio is used, trap catch will reflect 1/3 rd of actual field population and therefore it is crucial that bouquet of blends be used for effective monitoring.

Conclusions

- Multiple blend is superior and a better indicator tool for intervention with IPM strategies.
- At present only single blend with 97:3 (z-11 & z-9 Hexadecenal) is commercially available. Use of multiple blend is a new concept to enhance dependability on pheromone traps for cost effective and environmentally safe IPM. However, cost effectiveness of multiple blend concept is yet to be established.
- Technology needs to be perfected to level off the cost with increased efficiency in pest control management technology. Alternatively, commercial viability of technology can be made possible through rotational selection of few of them.

C) Development of commercially viable protocols for factory sale, production of promising parasitoids/predators & subsequent extension to pilot scale

i. As many as 10 micro and macro-organic have been identified as potential bioagents for suppression and control of insect pests and diseases in cotton. Under the programme, pilot scale system for *Trichoderma horianum* has been developed to mass produce the antagonistic fungi in 3 days. The formulation retained 67% progules even up to 180 days at room temperature from 18-35^{o}C. This achievement is not a break through instead it appears like reinvention of wheel. This technology is already in vogue with entrepreneurs.

ii. Solid state mass production protocols for entomopathogenic fungi. *Metarhizium anisopliae, Beauveria bassiana* have been standardised using cereal grains and yeast. There is little or no improvement over practices in vogue.

iii. A formulation standardized of bacterial biocide developed against sucking pests is under process of patenting. Protocols for its mass production have been standardized.

iv. New strain (PDBCTH-10) of *T. harzianum* is nearly twice effective over strain in use. This invention certainly sharpens biocontrol weapon to reduce cost and quantum of microbial pesticide.

Conclusions

- Greater scope exists for exploitation of these agents. However, their availability at cost effective price has been the principal set back for adoption at field level by farmers.
- The superiority of protocol claims seem to have come from laboratory/greenhouse investigations. Their strength in open field conditions need to be verified to create demand to replace existing ones by commercial multipliers.
- Development of pilot scale system for *Trichoderma horianum cannot be considered* a break through since the technology is already in vogue with entrepreneurs.
- Mass production of entomopathogenic nematodes on cottage scale industry on lepidopteran larvae is already a known technique. However, rearing of nematodes on artificial diet to dispense natural insect host sums to be a progressive achievement.
- Protocol development for commercial scale production of bioagents is not greatly visible. Interest shown by a lone entrepreneur is a testimony to this statement.
- It was aimed that output from this programme will energise or stimulate existing producers to expand installed capacity or attract new agencies to adopt this technology. New or more effective strain of microbial pesticide is the only consoling outcome. Thus, impact of this programme on pest management to either increase production & productivity or lower cost protection to make cotton production more profitable is not visible or measurable.
- Greater impetus has to be given to produce bioagents and make them as accessible as pesticides in sale points to farmers.

V. To evaluate the Performance of newly developed implements for planting, inter-culture and spraying operations

A) Evaluation of existing designs of sprayers/nozzles techniques of spraying for their efficacy and ergonomics.

i. Knapsack sprayers and tractor operated sprayers are used most commonly for spraying cotton crop of variable biomass, but the use of power operated sprayers is limited. Dispersal through knapsack sprayer is not uniform, depends on operators and pressure developed. Lack of selection of desirable nozzle and lack of calibration techniques lead the spray ineffective. Traditional equipment is also hazardous, time consuming and tedious. Motorized back pack sprayers cause drudgery and effective coverage is low.

ii. Under the programme, three power operated and one battery operated manual sprayer has been developed to overcome the shortfalls and to enhance cost effectiveness in the existing appliances, as detailed hereunder:

- **Tractor Mounted Sprayer** – Suitable for spraying cotton crop of any height or any other wider row crops.
- **Aeroblast Sprayer** - The machine is mounted on and operated by tractor. It is repoertedly ready for commercialization and 2 entrepreneurs are commercially manufacturing the sprayer.
- **Air Assisted Sprayer** – Uses high velocity airflow to improve automization, transportation, penetration and deposition of spray materials. The sprayers ensures coverage to the underside of leaves, promote deeper penetration into the crop canopy and makes it easier for small droplets to deposit on the target surface, cover more area per load and reduce drift. Labour saving is upto 30% and operational cost saving is upto 20%.
- **Battery Operated Sprayer** - Carries out maximum work without drudgery, coverage 1.5 ha/ 8 hr. Performs noiseless operation.

Conclusions

- Field trials have been carried out in farmers' field to create conviction. The equipments help reduce cost of cultivation to enhance profitability to growers.
- Though the cost of newly developed sprayers is higher than conventional knapsack sprayers, they eliminate occupational and environmental hazards substantially.
- Capital cost if discounted over continued use due to larger & effective coverage, the sprayers do increase impact in pesticidal use efficiency, input cost and health hazards. They need to be popularized. The only limitation that is foreseen is that these equipments are accessible to medium or large farmers except manually operated battery sprayer.

B) Mass production of prototypes and commercial production of proven designs and equipments

i. At present bullock/tractor drawn implements are being used by the farmers to carry out field operations and human power is used exclusively for cotton picking. Tractor drawn equipments are used by few farmers for planting, spraying and inter-culturing under irrigated conditions whereas mechanized seed bed preparation is the common practice under irrigated/rainfed conditions. Shortage of labour, animal power as well as non-availability of proper equipments are the constraints to carry out the field operations timely and properly.

ii. Under the programme, tractor drawn rotavator has been tested for seed bed preparation in single operation and found most suitable for seed bed preparation and incorporation of crop residues and green manures. Saving of labour was 50 to 70 per cent and savings in cost is found to be around 30 to 40 per cent.

iii. Cotton stalk puller has been developed and evaluated. Its coverage area is 1 to 1.5 ha per hr and resulted in 31 and 97 per cent saving of cost and time, respectively as compared to manual pulling. Operational efficiency was found to be 61 per cent.

iv. Cotton stalk shredder cum *in situ* applicator has been developed and evaluated. Its coverage area was 0.24 ha per hr and operational efficiency was found to be 81 per cent.

v. One row sub-soil coir pith applicator for cotton has been developed and evaluated for increasing the soil moisture content.

vi. Multicrop planter (inclined plate/spoon feed) and pneumatic planters have been tested for cotton planting. The seed distribution and plant density per unit area is satisfactory (only 6% missing) with multicrop planters, but it is not so satisfactory with pneumatic planter (23% missing). Thus, further improvement in pneumatic planter is required and its field capacity is 0.25 to 0.30 ha per hr and operation speed is 1.5 to 2.0 km per hr.

vii. Bullock drawn automatic planter has been developed and found satisfactory under field testing. Its coverage area was 0.17 ha per hr with 75 per cent operational efficiency. Seed distribution is uniform with 15 per cent missing.

viii. Tractor operated belt type and metering planter for cotton has been developed and field tested. In this equipment, seed singulation produced more consistent row to row distribution of seeds with a numerical reduction in plant stand variability.

ix. The belt type planter designed to plant four rows at spacing of 75 cm covering 2.25 m width is suitable for sowing all varieties of cotton. It has resulted in 68 and 98 per cent saving of cost and time, respectively when compared with manual planting.

x. Self propelled rotary weeder has been developed and tested for inter row weeding and inter-culturing in cotton. Saving of labour and cost was 67 and 50 per cent, respectively. Injury to plant was found to be less than one per cent.

xi. Tractor operated rotary and sweep weeders have been developed and evaluated. Besides, weeding cum earthing up equipment has also been developed. Saving of labour and cost was 65 and 60 per cent, respectively. Operational efficiency is 80 to 85 per cent. Injury to plant was found to be in the range of 1 to 4 per cent.

xii. Saving in cost of weeding with bullock drawn hoes, self propelled power weeder, tractor drawn weeding cum earthing up unit was 79, 80 and 89 per cent respectively and saving in time of weeding was 97, 97 and 99 per cent, respectively.

xiii. Tractor drawn Rotary spading machine for rice fallow cotton was also developed and tested. It resulted in 26 to 30 and 77 to 98 per cent saving in cost and time, respectively as compared to manual spading. It covered one ha per day.

Conclusions

- Field trials have been carried out in farmers' field to create conviction. All these equipments help in reducing labour, time and reduce cost of cultivation besides improvement of productivity and soil fertility by incorporating the weed/crop residues in the soil.
- Rotovator, inclined plate planter, pneumatic planter, self propelled power weeder, tractor drawn rotary weeder, tractor drawn sweep weeder developed for seed bed preparation, planting, weeding and inter-culturing in cotton are under commercial production by local manufacturers.
- Design protocol of tractor operated rotary spading machine for rice fallow, single row stalk puller, stalk shredder and incorporator, sub-soil coir pith applicator are ready for commercialization.

- All these equipments help in reducing labour units, time and cost to carry out field operations. They also help in carrying out the field operations timely, improvement of productivity and soil fertility by incorporating the weed/crop residues in the soil.
- These equipments reduce the dependency on labour which is most important under the present situation. Planters have got more advantages since they are very effective in proper seed distribution and plant stand, which is very important for getting potential yields. Thus, they have greater impact on cotton production.
- Rotavators, inclined plate planter, tractor operated tine type sweep weeder are quite popular with farmers in Northern Zone. These equipments are included in the package of practices of cotton.

VI. To evaluate the development of new technologies in improving cotton productivity through –

(A) Molecular characterization of released varieties, parents and hybrids

1) Cataloging and characterization of a) morphological, b) molecular markers c) cotton germplasm in the currently cultivated varieties and hybrids using DNA markers / molecular techniques available

i. Under the WTO Regime, there is a need to protect the genotypes and germplasm in the public institutes. Thus, several molecular based DNA marker techniques for rapid estimation of genetic purity of parental lines, hybrids have been developed. Three marker systems viz., RAPD, ISSR and SSR have been recommended for testing genetic purity of hybrids.

ii. Fifteen hybrids and eight varieties were characterized using RAPD, ISSR and SSR marker systems. The RAPD polymorphic primer OPA 13 and OPA 14 and ISSR polymorphic primer 152 led to the conformation of Shruthi as hybrid and, hence, can be used as a discriminating marker for testing of genetic purity of hybrid.

iii. Ninety four G. Hirsutum lines and 103 accessions of G. arboreum have been used for characterization.

iv. A total of thirty seven primer pairs giving sharp and scorable amplifications have been identified in the ninety *G. hirsutum* germplasm lines.

Conclusions

- Among the three markers developed, RAPD looked rapid, easy and cheap. However, combination of all these three markers can be used for testing genetic purity of Cotton seeds which will be highly reliable and may be a substitute for GOT (Grow Out Test).
- Molecular characterization of germplasm and varieties/parents of hybrids is continuing. Molecular characterization of all the released varieties and parental lines of hybrids will ensure their purity and protection from unauthorized use.

(B) Development of diagnostic kits for rapid detection of important insects and pathogens

1) Differentiation of races and biotypes of xanthomas

i. Bacterial blight is known to affect cotton health since many years. The disease is managed through cultural manipulations, adoption of resistant varieties and use of chemical bactericides. Occurrence of more than one race / biotype is evident in cotton growing zones. Distinction or differentiation of these races is time consuming and not possible through morphological description. Existing technology in vogue to detect and distinguish new ones is through host plant interaction, a laborious and unreliable method if a resistant cultivar is not developed.

ii. Using molecular techniques, PCR protocol has been developed for diagnosis of strains of *Xanthomonas* irrespective of the races and not for differentiation of races & biotypes. However, RFLP markers can reliably distinguish the virulent race No.18 from lesser virulent ones. This technology enabled to detect existence of atleast 3 biotypes (new ones) among 18 isolates sampled. It takes 90 minutes to detect a strain. PCR kit for detection of strains has been tested and an application has been submitted to patent the process.

Conclusions

- The technique is useful & reliable to detect presence of organism in seeds/source for extension workers & seed testing/certification laboratory. It will help in reducing or avoiding the source of infection, a most desirable approach in disease management. It will not only increase production but also reduce cost of input on recommendation of suitable strategy based on strain identification.

- Technology is not for adoption by farmers but is an excellent tool for educating / guiding farmers in the management.

2) Development of diagnostic kit for fungal pathogens

i. Current approach in diagnosis of disease in cotton and other crops is symptom based. Descriptive aspect of symptom is documented and picturised to train field functionaries, farmers and to teach agricultural graduates. But, symptom expression by different disease either overlap or not highly dependable field tool.

ii. Employing molecular techniques, PCR protocols have been developed and recommended for five pathogenic fungi viz. *Alterneria macrospore, Rhizoctonia bataticola, R. Solani*, *Ramularia areola, Fusarium vasinfeetum and Myrothecium roridum.*

iii. Besides identification of pathogens, precise differentiation of closely related fungi like *R. bataticola* from *R. solani* has been made possible through use of differential primers developed based on sequences of ribosomal RNA genes.

iv. Ability to detect presence of pathogens in soil, seeds, plant tissue and other sources through PCR techniques has greater consequence to eliminate or restrict the disease spread. Healthy or pathogen free seed certification is made easy in the seed laboratories and seed producing agencies.

v. Time required for diagnosis through PCR amplification is 90 minutes only. Once sampling procedure is standardized, 20-25 samples can be processed for preparation of template and PCR processing in a day single handedly. Detection cost is estimated at about Rs 10-15 per sample.

Conclusions

- PCR protocols are not farmer friendly. The outcome of the programme is of practical significance in the advisory service. They may form a component of plant health clinic or can be practiced by plant protection specialists in the state Department of Agriculture and SAUs.
- Further, the tool enables reinforcement of seed technology / testing laboratories for supply of disease free seeds.

3) Detection of inter–specific variability & morphological markers for *Helicoverpa armigera*

i. *Helicoverpa armigera* is one of three species of bollworms that shake the cotton productivity to a great extent. A close relative of this insect, *Helocoverpa assulta* also co-exist in crop ecosystem. Each of these have differential biocontrol agent besides differential response to pesticides.

ii. Differentiation of species by field workers depends exclusively on morphological characters of adult moth. Appearance of insect on cotton is noticed by the presence of larva / caterpillar, the destructive stage of insect, and not on the moths. A time lag of a fortnight or more is generally required for emergence of moths from larva. Thus, pest recognition is delayed for 15 days. Further, larvae are to be reared separately to get the moths for identification.

iii. Through molecular technology, the PCR – RFLP kit has been developed to detect and differentiate *Helicoverpa armirgera* from *H. assulta* with 98% accuracy. Morphological markers effective in grouping insects into 3 categories but its utility is limited as it cannot relate to damage caused by each of these categories.

Conclusions

- The most significant contribution of practical utility is the development of PCR – RFLP kit for distinguishing the morphologically indistinguishable stages of the pest. This detection of species is possible at egg, larval and pupal stages, which was not possible hitherto. The protocol has been published for wider use by researchers & extension workers and consultancy service agencies. It takes about 3 hours to detect at an estimated cost of Rs. 40 per sample.
- Valuable contribution to resolve the confusion of identifying bollworm species and species tailored remedial suggestions can be offered in the management.
- Differentiation in the immature stages (egg, larva, pupa) helps in early diagnosis to prevent crop loss till adult emergence. Collection and submission of these stages to the diagnostic laboratories is also easy.

- However, the technique is neither accessible to extension worker nor farmer friendly as it calls for established molecular laboratory. Nevertheless, it can be most dependable technique at KVKs, SAUs & plant protection laboratories, etc.

4) Categorization of different groups / biotypes of whitefly vis-à-vis destructive nature and efficiency of cotton leaf curl virus (CLCV) disease transmission

i. Cotton leaf curl virus disease, a serious production constraint in Northern Zone, is transmitted by whitefly *Bemesia tabacci*. Besides cotton, the insect survives on many agricultural and horticultural crops and occurs alround the year.

ii. Whitefly types in different parts of India had remained uncharacterized with respect to its biotype until B-biotype was first reported to exist in Kolar, Karnataka in 2000. Detection and differentiation of biotypes through conventional means is time demanding and inference cannot be drawn instantly.

iii. Little or no information is available on the variability of biotypes/groups of whitefly in respect of biological traits. In the absence of the said information, misfitting of control measures is not ruled out.

iv. Primarily existence of two biotypes has been brought to light. The major biotype is type B–that is typical to Indian subcontinent and is not characterized with respect to already known biotypes. Other one is B like biotype of whitefly, typical of B–biotype prevalent in other parts of world (when compared to standard B–type from Australia and Israel) and is predominant in all south Indian states. However, north Indian states like Rajasthan Punjab and Haryana are totally free from B–like biotype. Significant genetic variability within whitefly population irrespective of region has also been observed due to type of the plant.

v. Host plant specific SCAR markers (8) have been developed in whitefly populations that were holding specificity for five different crops (potato, tomato, brinjal, cotton, soybean and weed *Sida* sp.). The sequence of these markers has been submitted to GenBank. The SCAR markers have been evaluated with test populations & validated with field collected populations.

Conclusions

- Establishment of existence of 2 biotypes is of great utility to formulate strategic approach to contain the biotype habitat. The North Indian biotype is of considerable economic concern as it transmits deadly leaf curl virus. At present the disease is confined to north western part of northern Zone and is not a threat to cotton elsewhere in other zones. Population on cotton is most efficient with 100% CLCuV acquisition as against 20% in population on tomato.
- This know-how will not benefit individual farmer but helps to formulate national strategy to curtail CLCV in Central & South zones. Further, the knowledge will serve as baseline for researchers in crop improvement programme to enhance yield capacity and disease suppression through induction of resistance to whitefly and virus.

5) Development of protocols for detection of cotton leaf curl virus (CLCV)

i. Detection of cotton leaf curl virus immediately after invasion of plant or at the earliest possible can save substantial crop loss. Prevention is the only best remedy till date as curative measures under high pressure are lacking or ineffective. Therefore, all out efforts may be taken to contain it through multipronged approach. Pre-requisite for this action is detection of virus in the plant before expression of symptoms.

ii. Protocol for detection of CLCV before symptom expression has been developed employing molecular technology. It takes about 90 minutes. DNA extraction time per sample various from protocol to protocol from 1-2 hours. For more number of samples, time does not add up cumulatively. Conveniently 10- 15 samples can be processed within an hour after DNA extraction with commercial kits at a cost of Rs 10 -15 per sample. Any technician once trained can perform procedure for PCR & detection.

Conclusions

- Simple, handy, assertive, less expensive and rapid molecular technique enable detection at early stage. Technology has greater impact in mapping and demarcating outer geographical boundaries of CLCV in North India. It is also of greater utility to monitor by Governmental agency from time to time before disease can take drastic form.

- The protocol is routinely used for detection. Besides, an immunodiagnostic procedure developed for detection of the virus is under improvisation to develop “farmer – friendly dipstick” protocol for easy detection. It will be of great utility to extension workers, KVK staff and plant health clinics to advice farmers.

C) Validation of crop simulation model “INFOCROP”

i. Estimation of production and productivity in space forms the basis for planning & policy decision making. Enumeration of data at ground level through physical means is not only cumbersome and inaccurate but also cannot be initiated well ahead of harvest season. Emerging technology through remote sensing satellite data has come handy to cut short time, labour and coverage of larger area with fair degree of accuracy.

ii. Using remote sensing GIS and simulation models, crop simulation model “INFOCROP” to predict cotton production has been developed under ongoing research activities of ICAR. Test verification or validation of model under diverse geographical & climatic regions was needed.

iii. Integrated prediction methodology has been validated in four districts over an area of 74.300 ha in Nagpur, 89,000 ha in Dharwar (Karnataka), 14,800 ha in Bharuch (Gujarat) and 19,200 ha in Sirsa (Haryana). Model was validated to simulate the effect of diverse weather, soils, agronomic management, varieties and hybrids under cultivation for 3 years.

iv. The genotypes involved in the validation process were two Bt hybrids besides conventional varieties and non–Bt hybrids. Total biomass and seed cotton yield showed an accuracy of 86% and 89%. For an indeterminate crop like cotton,

accuracy over 80% is adequate for regional level applications. The model and methodology are scale neutral and hence can be applicable to any location in any Zone.

v. The model prediction requires refinement with respect to soil water balance in vertisols. At present, the model is not calibrated to involve loss due to pests & diseases. Once the spatial distribution of cotton acreage is overlaid on pedo-climatic polygons and simulation units are demarked, district level prediction can be aggregated in 3-4 hrs.

Conclusions

- The technology proves to be timely and handy to predict cotton production at district level. It reduces time, man power and ensures accuracy. However, availability of cloud free imageries (spacial distribution) at a reasonable cost should be ensured.
- Further, the model needs to be calibrated to take account of losses due to biotic stress, an important production constraint in cotton. New genotype co-efficient for Bt hybrids need to be imbedded in the model to enhance accuracy / precision level of prediction model.

VII. To evaluate useful technological interventions/ innovations in various cropping systems to increase cotton production

A) Evaluation of technological innovations for increased cotton production in various cropping systems employing scientific tools and measures

i. Many promising technologies developed in all the disciplines have not reached to the farmers and are not widely adopted by the farmers due to unawareness in respect of technologies developed.

ii. The field survey has revealed that – (i) the rainfed farmers are slow in adoption of new technologies and follow the old conventional practices; (ii) irrigated farmers are following many recommended practices with some deviations though were found to be slow in adoption of interventions; (iii) Farmers accept the innovation at faster rate provided it is highly remunerative and productive; (iv) Availability of labour and inputs, cost involved and financial conditions are also playing role in wider adaptability of new innovations/interventions.

iii. A total of 384 on farm/verification trials have been conducted in the farmers' fields to demonstrate and assess the documented technologies (97) in cotton based cropping systems. Total area covered was 1993 ha in 481 villages involving 4993 farmers. The promising interventions tried were classified into hybrids and varieties/Bt cottons/foliar spray/sowing time/IPM/INM/IRM based interventions.

iv. Increase in cotton yields with interventions on cotton varieties/hybrids were in the range of 12.3 to 22.6, 10.8 to 25.9 and 17.5 to 18.5 per cent in Central, South and North zones, respectively over farmer practice. Whereas, B:C ratio improved from 1.2 to 2.25 in Central, 1.65 to 2.95 in South and 1.05 to 2.64 in North Zones due to interventions demonstrated in the farmers fields.

v. Interventions on Bt cotton cultivation upgraded the yields in the range of 6.3 to 46, 9.4 to 15.3 and 14.88 per cent in Central, South and North Zone, respectively over

farmers practice. B:C ratio with farmers practice was in the range of 1.04 to 2.19 and it increased to 1.47 to 2.81 with Bt cotton cultivation. In general, Bt cotton has given 3 to 6 qt per ha more yield over conventional hybrids.

vi. Per cent increase in yield due to IPM was 6.26 to 19.58 per cent as compared to non-IPM and it reduced the cost to the tune of Rs. 2647 per ha. Improvement in yield was to the extent of 2 to 4 qt. per ha due to adoption of IPM modules. The B:C ratio was in the range of 1.28 to 2.0 at non-IPM and it was in the range of 1.52 to 2.39 at IPM interventions.

vii. Yield improvement with INM interventions over farmers practice was in the range of 9.49 to 20.0 per cent, whereas improved B:C ratio was in the range of 1.31 to 2.64. Increase in yield due to INM modules was to the extent of 2 to 4 qt per ha.

viii. Seeding in dry soil produced 7.6 to 27.3 per cent more yield over conventional method of sowing (normal sowing after receipt of rain in the sowing season), besides it has improved the B:C ratio to the extent 0.25 as compared to normal sowing.

ix. Foliar spray of 2 per cent DAP or 2 per cent Urea has produced 8.38 to 31.38 per cent more yield over non-foliar spray and it has improved the B:C ratio at all the locations. Planting on flat bed and opening of furrows at last inter-cultivation improved the yield by 18 per cent.

Conclusions

- As most of the innovations have improved the yield to the extent of 15 to 20 per cent, the Indian cotton production can be improved to a greater extent without increasing the cost and expansion of the area under cotton by adopting new technologies.
- Bt cotton in combination with promising innovations can reduce the cost of cultivation drastically, besides improving the productivity and production. Thus, sustainability in cotton cultivation can be achieved in India and huge cotton export is possible.
- Field survey has revealed that the farmers would be keen to cultivate public bred Bt cotton hybrid/variety. Many promising technologies developed in all the disciplines have not reached to the farmers and are not widely adopted by the farmers due to unawareness in respect of technologies developed.
- Adoption of improved hybrids/varieties/desi hybrids Bt cottons, integrated weed/nutrient/water/pests/resistance management systems as well as IMC practices, precision farming systems, foliar sprays of nutrients and methods/scheduling of irrigations to improve WUE *etc.* have got more scope in upgrading the productivity and saving in cost of cultivation. Thus, popularization of these techniques through farmers' field schools, demonstrations and verification trials assists in wider adaptability in cotton based cropping systems.
- High cost of cotton seeds, limited availability of bioagents and FYM, lack of scientific knowledge for use of bioagents/ET based pesticide application, non-availability of certified/quality seeds of improved hybrids/varieties/Bt cotton, high capital and labour requirement, lack of financial assistance, susceptible genotypes for pests and diseases were some of the major constraints in adoption based on farmers perspectives.

B) To evaluate the development of commercially viable processes for value addition of cotton byproduce

(a) Designing and development of low cost bailing press for cotton stalks

i. Cotton lint and seed are products of high commercial value as raw materials for textile industry, animal feed and oil industry. Value addition to the cotton stalk would elevate the income level of cotton growers. Stalk containing high cellulose and fibrous material serves as a raw material for making wooden boards and paper. Because of the limitations of supply chain management and storage problem, cotton stalk is not used as raw material by Board Industry and thus the demand for byproduct is not fully realized.

ii. Hand-cum-power operated cotton stalk compacting machine has been fabricated from mild steel sheets employing hydraulic system. With this, it is possible to compact the stalks by 75-80 per cent (4-5 times). It is possible to make about 200 bales of 10 kg each in a day 6 hrs by two workers. Approximate cost is about Rs. 1.5 lakhs. This technology needs wider adoption. A company in Nagpur has taken the technology by paying royalty. Patents have been granted on farm models.

Conclusions

- Large by produce can be compressed to reduce transportation and storage cost helping farmers to get added income to enhance profitability from cotton cultivation.
- Further, enormous biological wealth can be appropriately used to reduce pressure on forest wealth for board/paper making.

(b) Preparation of boards with different surface finish

i. Technology generation to utilize the stalk assumes importance to use annual biological output for best purpose. Technology generation on utilization of cotton stalks for making boards has been in progress for quiet sometime at CIRCOT Mumbai.

ii. Commercial trial on preparation of hard board and particle board from cotton stalk showed that the process is technically feasible and good quality boards conforming to BIS specification can be prepared.

iii. A process has also been standardized to prepare absorbent cotton from non-spinnable cotton *viz.* Bengal desi. The biological process standardized at CIRCOT eliminates initial energy intensive process and makes it eco-friendly. .

Conclusions

- Preparation of hard board and particle board from cotton stalk was made known in late 1990s. But it did not create impact on board industry as viewed from either establishment of manufacturing units or from creation of demand for cotton stalk. Process of preparing boards appears to be same as done earlier. Therefore, impact of this programme is not visible.

XI PLAN PROGRAMMES

VIII. Development of Extra Long Staple *G. barbadense* cotton with improved fibre qualities to meet the requirements of textile industry

i. The Annual production of Extra Long Staple Cotton in India is 3.0 to 4.0 lakh bales as against the demand of 9.0 lakh bales. The requirement of ELS cotton is met through import from USA, Egypt and Sudan. At present SUVIN is the only ELS variety with fibre length 35 mm and above. Susceptibility of *G. barbadense* cotton to sucking pests as well as their low yielding nature and low ginning outturn necessitate the urgent need for its improvement.

ii. Four hundred nine germplasm accessions have been evaluated at five locations for their agronomic and fibre quality traits. Several promising lines were identified for further utilization in breeding programmes.

iii. Under screening of segregating materials, 160 plants were selected based on economic and fibre quality characters. Sufficient variability has been noticed in respect of yield and ginning outturn. However, as regards fibre length and strength, only few plants exceeded the check Suvin.

iv. Under multi-location evaluation of existing material, culture CCB 6 was found as the best recording 1444 kg/ha seed cotton yield and was superior to Suvin by 67 percent. Similarly, it recorded the highest ginning outturn of 35.2% as against 30.2 percent of Suvin. However, as regards fibre quality, the control variety Suvin was found to be the best.

v. Culture (SN x ICB 75)7-5-2 with a mean seed cotton yield of 126 g/plant, fibre length of 34.2 mm, micronaire of 4.0 and fibre strength of 34.1 g/tex is found to be promising.

vi. Under utilization of biotechnological tool (MAS) work has been initiated at TNAU, Coimbatore and NAU, Surat. Fifty germplasm accessions at TNAU, Coimbatore and 22 lines at NAU, Surat were screened for polymorphism.

Conclusions

- The project is running in the right direction. Genotypes with superior fibre quality equivalent to Suvin or better identified and are under different stages of testing. The results indicate that superior early maturing *G .barbadense* variety with desired level of yield, fibre quality coupled with resistance to pests (jassids) and diseases (Bacterial blight) will be available to the farmers by the end of the project.
- The programme aims at genetic enhancement of *G. barbadense* cotton for earliness, higher yield and ginning outturn maintaining acceptable fibre quality for additional revenue through value addition of ELS based textiles. The cultivated area under ELS cotton needs to be increased by promoting *barbadense* cotton in other potential areas such as M.P., Maharashtra, Gujarat, Orissa and Karnataka.

IX. Identification of *G. hirsutum* genotypes suitable for machine picking and development of agronomic package

i. The prevalent age old practice of picking cotton manually has been labour intensive. Current problems relating to rising labour costs and often lack of timely labour availability are posing a serious challenge to cotton cultivation thus deteriorating the fibre quality and making cotton cultivation less remunerative.

ii. Superior genotypes suitable for machine picking identified are-

North Zone – P 1752, RS2553; Central Zone – AKH 8828, CNH 28 I, KH 134, KH 139, NH 615, NH 635; South Zone – L 761, RACH 11, SCSBC 1001

iii. The results obtained after screening of released / pre-released and other available breeding materials under common trial are encouraging. Genotypes identified possess high yield and synchronous flowering and boll bursting up to certain level individually. So far, no genotype has been identified which can be termed as ideal plant type for machine picking.

iv. Identification of suitable spacing (100 x 10 cm) and correct / effective dose (5000 ppm) of defoliant (Etheral) suitable for achieving desired level of leaf shedding (95%) and boll opening (95%) are a good beginning and promising.

Conclusions

- In cotton growing countries like USA and Brazil, machine picking have been widely adopted for clean cotton production which in turn offers higher price in world market. Therefore, it is necessary to adopt machine picking in India to obtain quality cotton comparable with the cotton produced by these countries.
- Though suitable genotypes for machine picking have been identified but cannot be tested for want of mechanical picker.
- There is a need to step up research for evolving genotypes having suitable traits like dwarf and compact plant type suited for agronomic manipulations, short sympodia (mostly zero branch type), short inter-node in main stem, big boll size and early uniform maturity. Already promising lines with required characters are available from introgression which can be successfully used in development of genotypes with desirable degree of resistance to biotic stresses and amenable to machine harvesting.

X. Development and promotion of 'Bt' transgenic cotton for bollworm resistance

i. Till 2009, six events (Cry1Ac-Mon 531, Cry1Ac+2Ab-Mon 15985, Cry1Ac-Event 1, Cry1Ab+Cry1Ac-GFM Event), Cry1Ac-BN LA601 and Cry1Ac-MLS9124) have been approved by the GEAC for commercial release in India. Of the 621 Bt hybrids released upto 2009, more than 90% belong to intra-*hirsutum* category and the rest relate to the inter-specific (*G. hirsutum* x *G. barbadense*) category.

ii. The following General Events are under development and field trials are reportedly in progress:

a. Cry 1 Aa3, Cry1F (CICR);

b. VIP 3a (Cot 102 x Cot 67 B) [Deltopine India Seed (P) Ltd.]

c. Cry1Ac & Cry1F (Event 3006 – 210 – 23 & Event 281-24-236) [Dow Agro Sciences]

iii. Transfer of **Cry1Ac** gene from **BNBt**, the approved transgenic to other elite lines (Comprising released varieties and parental lines of hybrids) of Public research centres of India is under progress through back cross breeding. Genetic transformation of Cry2a and Cry 1f genes is also under progress.

iv. More than 80 genotypes are under back cross breeding at various stages of crossing (BC2, BC3, BC4 and F1). Currently there are 70 genotypes in BC1 stage, 29 in BC2 stage, 5 in BC3, 50 in BC4 and 4 in BC5 stage.

Conclusion

Transformation of new Bt genes has been completed. Testing of superior events is in progress.

XI) Evaluation of commercial Bt cotton Hybrids (Pvt. Sector)

i. Efforts are being made to evaluate all the released hybrids for different regions of the country and identifying the best ones for yield, fibre quality, maturity etc. for recommending to the farming community for commercial cultivation.

ii. Based on first year evaluation of GEAC approved Bt cotton hybrids (Pvt. Sector) under common trial, superior as well as inferior hybrids were identified. Five promising Private Bt hybrids identified for north, central and south zones are as shown below:

NORTH ZONE	CENTRAL ZONE	SOUTH ZONE
MRC 6029	ACH-11-2 BG II	NCHB992
RCH 134	JAYBT	MRCH7351BGII
NCS 138	Tulsi4	MRCH7201BGII
NECH 6R	MECH162	Kashinath
RCH 308	KDCHH9632	PCH205

iii. 34 Bt cotton hybrids recorded significantly inferior seed cotton yield than the non-Bt check hybrids.

Conclusions

- There appears to be a mad rush to increase Bt cotton area in the country in total disregard to the suitability of the area and the adaptability of the hybrids. Only hybrids with proven yield advantage and adaptability should be encouraged to be cultivated. The species composition needs to be maintained at least at the current level and the proportion of Bt and Non-Bt hybrids should be regularized to avoid dangers of genetic uniformity and the concomitant problems
- In view of large number of Bt cotton hybrids recommended for cultivation in the country, extreme confusion is prevailing among the cotton growers in the selection of hybrids. In such a situation, the results of this activity of the project will definitely help. It is necessary to profile the hybrids based on suitability for location / region for

enhancement in production and productivity of cotton thereby benefiting the cotton growers

- Large scale and continued use of Bt cotton genotypes may bring into focus the problem of insect resistance. Hence, adequate precautions are necessary to delay the development of resistance to Bt toxins through strict adherence to the planting of Refugia, encouraging the cultivation of other alternate host plant, gene stacking, use of alternate genes that do not share common resistance mechanism as that of Cry1Ac, reducing the Bt cotton surviving population of *H. armigera* by conventional methods of insect control, etc.

XII. Exploitation of Apomixis and TGMS system in hybrid cotton seed production

i. Under Xth Plan of TMC, few lines obtained from tri-species cross (*hirsutum* x *barbadense*) x *arboreum*) were showing apomictic behaviour producing uniform plants in spite of having abnormal chromosome number. This needed further confirmation for which the project was initiated. Similarly, a temperature sensitive male sterile mutant has been obtained from *G.arboreum* variety DS-5 as well as *G. hirsutum* variety Renuka which required to be confirmed and stabilized.

ii. Confirmed and stabilized five lines of TGMS in *G. arboreum.* Effected crosses of the lines with popular variety PA 255 and F2s developed

iii. A low frequency of apomixis were found, in IS 244-4-1, IS 244-4-1, IS 181-7-1, AP 2-1, AP 2-1, AP 3-2 and AP `-4.

Conclusions

- Thermosensitive Genetic Male Sterility (TGMS) system observed in both the species (*G. arboreum* and *G. hirsutm*) is a new line of work. Utilization of TGMS system in the hybrid seed production is to be worked out at a large scale.
- This programme has been initiated very recently. The confirmation of apomixis through boll setting after emasculation as well as removable of style and stigma is the first step towards achieving the goal. Results obtained are encouraging but it is too early to draw conclusions.

XIII. Development of production technologies for Bt cotton and improvement of water and nutrient use efficiency with precision farming techniques

i. Across the country, N, P and Zn are deficit in cotton growing areas. K, Fe and B are deficit in few locations. RDF + micronutrients (based on deficiency), INM and IMC practices were developed during X Plan and recommended for non-Bt cotton. However, farmers were found to be slow in adopting these practices.

ii. RDF + micronutrients (STB) was the best nutrient management system to get potential yield of Bt cotton.

iii. INM modules involving organic manures have got a potential to save fertilizer N in Bt cotton and these modules gave more yield as compared to RDF alone.

iv. Application of 75 per cent RDN + 25% N as organic manures or RDF + micronutrients integrated with IMC practice like intercropping with legumes/green manures as cover crops for moisture conservation as well as for incorporation of intercrop residues to build up organic carbon produce stable and higher yields of Bt

cottons. Nutrient management systems developed have potential to reduce the cost by reducing the fertilizer requirement to some extent over a period of time. These practices improve the soil fertility, productivity, soil health including organic carbon and take care of deficit nutrients.

Conclusions

- INM and IMC practices developed are acceptable and widely adaptable since techniques are easy and resources are also available.
- INM practices in conjunction with IMC practices and drip irrigation/fertigation/split application of nutrients have no significant effect on fibre quality. Marginal improvement has been noticed in few locations.
- Although drip irrigation and fertigation have got several benefits, yet most farmers are not adopting due to high initial investment, non-availability of good quality material, poor socio-economic conditions and lack of financial assistance.
- Innovations developed under the programme need popularization through FLDs for wider acceptability since they have greater impact on productivity, production and cost minimization. With adoption of these technologies in Bt cotton, another quantum jump in cotton production in India can be achieved.
- Although precision farming techniques have greater impact on productivity of cotton as well as increasing nutrient/moisture use efficiencies, yet adoption of these techniques requires training and sensitization of officials, farmers and traders.

XIV. Identification of innovative Bt cotton based cropping systems

i. Intercropping in cotton is restricted to South and Central cotton zones and it is followed by farmers having small holdings under rainfed conditions. Across the country, intercropping in cotton under irrigated situation is not in practice. Mono-cropping of cotton is still existing with many irrigated farmers and few rainfed farmers. With long experience, farmers have developed their own systems which are location specific and need based, remunerative cotton based inter/rotational cropping systems.

ii. Intercropping by paired row planting of cotton with soybean, blackgram, radish, spinach and green gram in 1:1 ratio, recorded significantly higher productivity.

iii. In North Zone, no intercropping system has been found to be beneficial as compared to sole cotton. Transplanted Bt cotton recorded only 5-7% increase as compared to normal sown cotton.

iv. The following double cropping systems are found to be profitable:

⇒ In North India, cotton-wheat.

⇒ In Central India, Cotton – Groundnut/ green gram/sunflower/wheat/okra.

⇒ In South India, Cotton – Sesamum/maize.

Conclusions

- Sole cotton cultivation under rainfed conditions is risky and non-profitable. Cotton being long duration and wide spaced crop, there is need to identify component crops

for intercropping in Bt cotton under different ecosystems to get higher income and to improve the socio-economic status of rainfed cotton growers.

- Intercropping is not so suitable and beneficial for irrigated ecosystem of Bt cotton. However, cotton-wheat double cropping system is the most suitable, remunerative, easily acceptable system in North Zone. In Central India, It has got greater impact on production of cotton in India since it is a sustainable system.
- Bt cotton based double cropping systems developed for each Zone have got more influence on increasing the production efficiency and income per unit time and land. It can be adopted easily and quickly by the farmers on wide scale since technologies are simple, sustainable and acceptable.

XV. Mechanization of cotton picking and cultivation

i. Indian made picking machines to suit presently cultivated genotypes and practices are not at all developed and available. In India, cotton is mostly hand picked involving huge man hours and cost. Hand picked cotton contains more trash and seed cotton quality is low. Mechanized equipments for field operations like ploughing/ harrowing are used by many farmers. But, planters, weeders, boom sprayers are used by few farmers who have got large holdings. Bullock drawn implements are used by many farmers especially for sowing and inter-cultivation.

ii. Imported two row spindle type mechanical picker was tested in existing varieties, hybrids and Bt cottons to ascertain its suitability in picking the Indian cottons. Imported machine picked 85 per cent cotton in one pick but contained 20 to 26 per cent trash which requires several stages of pre-cleaners. This facility does not exist with Indian ginning factories.

iii. The knapsack, petrol engine operated single nozzle pneumatic picker has been developed and tested. It requires more time to cover one ha. area and the cost also seems to be very high as compared to manual picking. Development of high efficiency pneumatic picker by redesigning the system of suction and separation is in progress.

iv. Due to inherent drawback of low rate of picking in pneumatic pickers, development of a small spindle type mechanical picker to suit Indian conditions is also in progress.

v. Equipments modified and developed during Xth plan period for land preparation, sowing, weeding, inter-culturing, earthing up, stalk uprooting/shredding /incorporation were also in further testing stage. Results appear to be promising and needs popularization for wider adoptability. Labour saving of 75 to 90 per cent and cost saving of 30 to 80 per cent is expected with these equipments. Besides, operational efficiency will also be much higher than traditional equipments.

vi. Patents have been filed for some of the developed equipments viz. Bullock drawn vertical rotor planter for vertisols; Solar powered knapsack sprayer with tilting arrangement and Cotton seed blower.

Conclusions

- Modification and development of machine picking equipments are in progress. Success of these equipments has got greater impact on cotton production in India.

- Equipments already developed and modified needs publicity, mass production, large scale testing in farmers' fields and financial assistance to procure the units. Many industries came forward to manufacture these equipments.
- Wider adoption of these new equipments by the farmers has got more influence on sustainability of cotton production since saving in cost, labour and time are expected.

XVI. Physiological manipulation of Bt plant morphoframe for enhanced productivity under varied agro-climatic conditions.

i. Plant type with good morphoframe would sustain more boll load with synchronous boll development and boll bursting which will help in enhanced yield and effective harvesting in one or two pickings. At present, high yielding compact genotypes are not under commercial cultivation. Manual methods and foliar spray of growth regulators/chemicals are available to reduce vertical and lateral growth of the cotton plant.

ii. Under the programme, two plant morphoframe manipulation options have been evaluated:

- Manipulation of plant morphoframe using ethylene (etheral) sprayed at square initiation stage
- Manipulation of morphoframe by arresting apical meristem growth through nipping (detopping) at grand growth stage (85 DAS) and also mimicking this action through action specific chemical (maleic hydrazide).

iv. Spray of etheral at 35-40 DAS was found to alter the morphoframe and enhance the yield of Bt cotton significantly compared to control.

Conclusions

- Bt cottons have got greater role to play in quantum jump of productivity and Indian cotton production on sustainable basis. Non-availability of mechanized picking equipments restricting the area under Bt cotton.
- Results appear to be very good in enhancing the productivity of Bt cotton upto 25 per cent. Thus, foliar application of etheral has got good scope in improving the yield by changing the morphoframe of Bt cotton and boll setting pattern. It helps in the machine picking method of cotton harvesting.
- Application of maleic hydrazide to check the growth has also got good scope in enhancing the yield by reducing vertical growth.
- Large scale testing in farmers' fields is required to popularize the technology and to confirm the results for wider adaptability.

XVII. Emerging and key pests – characterization, taxonomy, genetic diversity and control

i. The mealy bug was identified as *Phenacoccus solenopsis* through conventional taxonomy and DNA methods. The mirids have been identified as *Creontiades biseratense, Campylomma livida*, *Hyalopeplus lineifer.*

ii. Two new parasitoids *Promuscidea unfasciativentris* (Chalcidodea: Aphelinidae) and *Aenasius* bambawalee (Chalcidodea: Encyrtidae) were collected during field survey - parasitizing *P. solenopsis* on cotton and Parthenium.

iii. Most of the effective organophosphates are extremely to moderately toxic according to WHO classification and are detrimental to several important natural enemies. Bio-rationals such as Neem oil, Herbal product, *Verticillium lecani, Beauveria bassiana*, Buprofezin and slightly hazardous WHO class: III organophosphate insecticide Acephate was found effective for mealy bug management.

iv. A method for quantifying the degree of infestation of the mealy bug has been developed. Damage potential of jassids was estimated to be beyond 65 DAS and of mirids 90 DAS. Thirty isolates of grey mildew were isolated. Isolates from diploid cotton were more virulent than tetraploid and were morphologically different.

Conclusions

- Bt cotton is toxic only to bollworms and does not control any of the sucking pests. Over the past few years after introduction of Bt, cotton cultivators in India have been facing new problems with insect pest management in many parts of the country, mostly as a consequence of low insecticide usage. New sucking pests have emerged as major pests causing significant economic losses. Mealy bug and mirids are the emerging pests of importance in the country on cotton. There is imminent need to continue advanced research to develop new and innovative strategies to combat this menace.

XVIII. Development and validation of IPM/IRM strategies

i. IPM designed for conventional varieties/hybrids does not hold good for Bt cotton. Efforts have been made at consolidating all results into location specific effective IPM strategies with a special focus on insecticides resistance management besides refinement and validation of IPM strategies on conventional and Bt cotton under different ecosystems.

ii. Location specific IPM module was found superior on Bt cotton by recording lower sucking pest damage, bollworm incidence and higher seed cotton yield with maximum net profit.

iii. Efficacy of Cry1Ac expressed singly and in combination with Cry2Ab against Spodoptera litura on terminal leaves indicated 20-100% mortality dependent on the genotypes at 60DAS.

iv. Bioassay studies indicated Isolate Vl-5 of *Verticillium lecanii* recorded a maximum of 100% mortality of melybug nymphs

v. ETL for thrips, pink bollworm and American bollworm have been determined. Sucking pest damage was lower under location specific IPM module compared to chemical protection.

Conclusions

- Conventional insect pest control strategies rely heavily on insecticides. Cotton pest management is particularly affected due to insecticides resistance as a consequence of excessive use of insecticides on the crop. Several efforts were made all over the world to devise region specific IPM systems. However, poor efficacy of insecticides

due to insecticide resistance in insects and performance inconsistencies of bio-pesticides and biological control have been making them unsustainable.

- IRM strategies have been duly evaluated through TMC MM II. It has resulted in a reduction in insecticide consumption by 30% and reduced the number of sprays by 15%. IRM-IPM has significantly contributed in increasing production and productivity of cotton besides providing financial, environmental and social benefits to the farming community.

XIX. Development, validation, utilization and/or commercialization of bio-pesticides and bio-inoculants

i. List of biocontrol and bioinoculant in cotton ecosystem keeps on expanding with exploratory work taken up by researchers under various organizations. Currently, such exploratory work has been exhaustive against bollworms, but new agents are proving promising against new and emerging pests. New entrants like mealy bugs are to be countered by potential bioagents through recognition, exploitation and commercialization. A handful of bioagents are exploited largely amidst a treasure of natural biological control agents.

ii. Efforts are on to develop new mass production protocols of biocontrol agents of pests and pathogens like *Trichogramma*, microbial agents *viz.,* viruses (NPVs, GVs and CPVs), bacteria (*Bacillus thuringiensis*, *B. cereus*) and fungal pathogens (*Beauveria bassiana, Metarrhizium anispoliae, Verticillium lecanii, Nomuraea rileyii, Glicladium* spp., *Pseudomans* spp.) and commercialize them. The optimum conditions for storage, efficiency and increasing shelf life of these biocontrol agents was to be determined.

iii. Based on field trials, Bacillus subtilis Iso-5 and *Pseudomonas flourescence* Iso-16 have been found effective against Cotton Soil Borne Pathogens Out of 16, three bacterial isolates viz., *Xeno-1, Xeno-12* and *Photo -3* are found to be highly pathogenic against mealy bug.

iv. Maximum reduction in the population of crawlers has been observed with profenophos followed by *V. lacanii* formulations.

v. Bacterial symbionts of EPN (*Photorhabdus/Xenorhabdus*) have been found pathogenic to mealy bug colonized on potato sprouts.

vi. Two new parasitoids *Promuscidea unfasciativentris* Girault (Chalcidodea: Aphelinidae) and *Aenasius bambawalea* (Chalcidodea: Encyrtidae) were found parasitizing *Phenacoccus solenopsis* on cotton and Parthenium

Conclusions

- A number of research programmes have been carried out to identify and strengthen biological control in cotton. It is a continuous and everlasting process to widen the spectrum of bioagents against pest complex of cotton. Projects to identify new biocontrol organisms were implemented under X Plan programmes and are continued in the XI Plan with a view to utilizing the results of the previous exploratory work so that the products can be validated, utilized and commercialized.

XX. Development of farmer friendly diagnostic kits for transgenic event seed purity

i. Widespread adoption of Bt cotton in the country has brought in its wake an opportunity for unscrupulous dealers to exploit the situation by supply of spurious or non-genuine Bt seeds at an attractive price over expansive genuine seeds. Seed production companies also had no tool to ensure transgenic event seed purity as a quality test. Hence, development of diagnostic kits was most essential for purchase of genuine Bt seeds by farmers.

ii. Under the programme, PCR tests have been designed to detect any of the transgene events of GM cotton that would have been commercially released in India and elsewhere in the world.

iii. Antigens (Cry1C, VIP3A, Cry1F & Cry2Ab2 & NPT-II) have been purified. The Cry2Ab ELISA has been developed as quantification Bt-Express-2 commercial kits

iv. Farmer usable field kits (Immuno-chromatographic 'dipstick' kits which take just 10 minutes to complete under field conditions) have been developed to detect Cry1Ac, Cry2Ab, Cry1F and NPT-II in genetically modified GM seeds/plants. These have been validated and commercialized.

v. Real-Time PCR has been standardized for transgene events 'MON-531' and 'MON-15985'.

Conclusions

- Greatest impact of programme is noticed in this case. This accomplishment serves as strong,reliable and legally tenable tool to question genuity. While it helps to curb or eliminate sale of sub standard seeds, it gives confidence to farmers to get price worthy Bt cotton seeds. It also enables purchasing of genuine Bt by Government agencies under various incentive based programmes.

ON-FARM EVALUATION OF OUTPUTS OF MINI MISSION-I

In order to evaluate the outputs of Mini Mission-I programme and to understand the socio-economic implications of new technologies as well the constraints limiting the transfer of technology, the All India Coordinated Cotton Improvement Project (AICCIP) has been conducting Front Line Demonstrations (FLDs) in association with State Agriculture Universities (SAUs), State Departments of Agriculture and other agencies, in various cotton growing areas across the country. Similarly, the IRM and IPM strategies developed by Scientists have been well evaluated by CICR through SAUs, ICAR centers and other recognized agricultural organizations in collaboration with State Department of Agriculture.

(1) Front Line Demonstrations (FLDs)

The FLDs on cotton are aimed at disseminating the latest agricultural technologies developed by the scientists on new crop varieties/hybrids, pest control measures, effective water use, post harvest technology and other crop management practices. It enables the scientists obtain direct feed back from cotton farmers so as to suitably reorient their research programmes and develop appropriate location-specific technology packages.

Impact of FLDs

- Significant Yield enhancement in FLD fields as against Framer practices by adopting IPM and agronomy practices and improved cotton varieties/hybrids
- Adoption of Bt cotton hybrids and enhanced yield realization by FLD farmers
- Reduction in cost of cultivation
- Better Soil Health maintenance and reduction in environmental pollution
- Reduced chemical pesticide usage
- Increased use of biocontrol agents
- Implement demonstrations that bring about reduction in drudgery
- Commensurate price for the quality produce by FLD farmers

Impact analysis yield enhancement in Cotton FLD Plots over Farmer practices

Technologies Demonstrated	Zone	Mean Seed Cotton Yield (kg/ha)		% Increase in yield
		Demo Plot	Farmer Practices	
Introduction of new cotton varieties and hybrids	North Zone	1670	1403	19.03
	Central Zone	1106	933	18.54
	South Zone	1441	1208	19.29
	Average	**1406**	**1181**	**19.05**
Agronomic Management	North Zone	1664	1409	18.10
	Central Zone	1214	966	25.67
	South Zone	1642	1388	18.30
	Average	**1507**	**1254**	**20.18**
IPM Practice	North Zone	1770	1553	13.97
	Central Zone	1535	1433	7.12
	South Zone	1637	1308	25.15
	Average	**1647**	**1431**	**15.09**

Details of Technologies Demonstrated under FLDs

(i) Crop Improvement

- Demonstration for popularization of Improved varieties / Hybrids based on adaptability to different agro-eco regions with aim to obtain increased yields

  F 846, F 1378, LH 1556, LD 491, ID 694, HD 107, HD 123, RG 8 (*arboreum*), HS 6, H 1098, H 777, H 1117, H 1226, HHH 81, RS 810, RS 875, RS 2013, RST 9, G.Cot Hy.8, G.Cot.Hy.10, G.Cot.23, G.Cot 18, G.Cot.Hy.19, Phule 492, NHS 44, RHB 388, LAHH 4, Narasimha, Aravinda, NDL 1875, NA 1588, NA 1325, MCU 12, TCHB 213, F846, F1378, F1054, F505, LH 1556,LH 900 , LDH 491,LDH 327, AAH 1, Ganganagar Ageti, Vagad Kalyan,Bikaneri Nerma, Hybrid 8, Vikas, LRK 516(Anjali), CNH 36, NHH 44, PKV hybrid 3, DHH 11, SVPR 2, KC 2, K 11, Jayadhar, Dig Vijay, G.Cot DH 7, G.Cot.MDH-11, G.Cot.Hy.102, G.Cot 21, PKV Hy-4, PKV Hy-5 and AKA-7, JLA-794, HB.123, HHH.223 and HHH.287, HD.324, H.1117, Bunny hybrid, CISAA2 (CICR 2), G.Cot-13, Deviraj, Veena, Brahma, DHB-290, DLSA-17, Sahana, DDhc-11, RAHS-14, MCU 13, Surabhi, Sumangala, PA 255 , Jawahar Tapti , JK.4

- Demonstration for popularization of Bt cotton hybrids RCH2 Bt, Bunny Bt, Mallika Bt, MECH-162 Bt, MECH 12 Bt etc.
- Seed village concept

(ii) Crop Production

- Weed control, Maintenance of plant population, Balanced Nutrition, Yield maximization technologies like Plant density
- DAP application and thinning
- Integrated Nutrient Management (INM)
- Demonstration of intercropping of blackgram in rainfed cotton
- Soil moisture conservation techniques, Spraying of DAP, Time and method of basal dose of fertilizer application
- Spraying of $MgSO_4$ / $ZnSO_4$ on rainfed cotton for enhanced yields
- Intercropping of summer groundnut in cotton
- Intercropping of cotton in sugarcane ratoon crop
- Growing of cotton after harvest of surgarcane without preparatory tillage
- Relay cropping of cotton
- Balanced crop nutrition and Residue management including vermi composting and trench composting
- Leaf reddening management in cotton, Spraying of growth regulator NAA in cotton, Intercropping in cotton
- Intercropping of cotton-maize (H-8)

- Demonstration on advantage of dry sowing on yield potential of hybrid NHH-44 over Normal sowing
- Demonstration of effectiveness of recommended spacing (60cmx60cm) over wider spacing (90cmx90cm) for rainfed hybrid cotton (NHH-44)
- Demonstration of utility of Basal dose of fertilizer at the time of sowing Vs delayed application of basal dose of fertilizer (NHH-44)
- Demonstration on minimum tillage
- Application of organics like vermicompost, cow's urine and new product Panchakavya
- Popularization of improved agronomic practices for yield maximization– skipping basal dose in summer, Soil management practices
- Demonstration of suitability of AKH-081 for shallow soils
- Demonstration of compartmental bunding

(iii) Crop Protection

- Integrated Pest Management (IPM) module demonstration
- Border crops viz., Sorghum/Maize
- Trap crops viz., Marigold for *Helicoverpa*/Castor for *Spodoptera*
- Bird perches 10/acre
- Use of Pheromone traps for pest monitoring
- Clean cultivation- burning crop stubbles, trimming bunds, destruction of weeds
- Seed treatment for control of insect pests and diseases
- Chemical control of stem weevil
- Seed treatment with Imidacloprid / thiomethoxam @5g/ kg seed
- Stem application (1:4 Monocrotophos or 1: 20 Imidacloprid) at 20,40 and 60DAS
- Allowing farm animals into fields for grazing
- Hand picking of grown up larvae and destruction and handpicking of Rosette flowers and destruction
- Demonstration of improved Bt cotton hybrids for better control of bollworms

(2) IRM-IPM Programme

IRM program has covered 4325 villages spread in 201 districts since initiation in 2002-03. During the span of seven years, the program was organized in over 4.88 lakh ha area and a little over 2.28 lakh farmers participated in the IRM technology dissemination.

Impact of IRM

The IRM program is so far implemented in 10 to 11 cotton growing States including Orissa and West Bengal which has impacted on reduction in the number of sprays and increasing the average yield. The State-wise impact of the IRM technology has been studied and the two events compared with the non IRM farmers yield. It can be seen from the table that in all

States, the average yield has been more in the IRM covered fields than the non-IRM fields. Tamilnadu has recorded highest yield difference to the tune of 3.1qtls/ha (26.4%) followed by Gujarat (2.87 qtls/ha, 15.0%) and Rajasthan (2.36 qtls/ha, 11.7%). In Andhra Pradesh the IRM covered farmers recorded maximum reduction of 7 to 8 number of sprays for plant protection followed by Maharashtra (5 to 6) and Gujarat (4 to 5). In other States the IRM farmers could achieve reduction in number of spray by 1 to 4. At the aggregate level the IRM farmers gained in yield by 1.8 qtls/ha and could reduce 3 to 4 number of spray for plant protection.

State-wise Impact of IRM

S. No.	State	Avg. Yield (Q/ha)		No. of Sprays	
		IRM	NIRM	IRM	NIRM
1.	Punjab	18.21	16.46	11.97	15.88
2.	Haryana	24.80	23.84	10.40	12.84
3.	Rajasthan	22.47	20.11	10.10	12.72
4.	Maharashtra	23.91	22.21	6.54	12.38
5.	Gujarat	21.99	19.12	11.60	16.21
6.	Madhya Pradesh	16.00	14.39	5.65	7.86
7.	Tamil Nadu	14.85	11.75	4.14	6.12
8.	Karnataka	20.75	19.38	8.14	13.01
9.	Andhra Pradesh	34.09	33.70	11.87	19.33
10.	Orissa	12.78	12.18	2.50	3.85
11.	West Bengal	8.80	8.10	2.40	4.60
	Total	**23.08**	**21.28**	**8.61**	**12.25**

SECTION C - MINI MISSION II

INTRODUCTION

1. Cotton Scenario – India and World

Cotton accounts for 40% of the total global fibre production and is the most important fibre in the world. India is one of the major cotton producers in the world having largest acreage under cotton and also the second largest consumer of cotton. Cotton is the most important commercial crop contributing nearly 65% of total raw material needs of textile industry in our country.

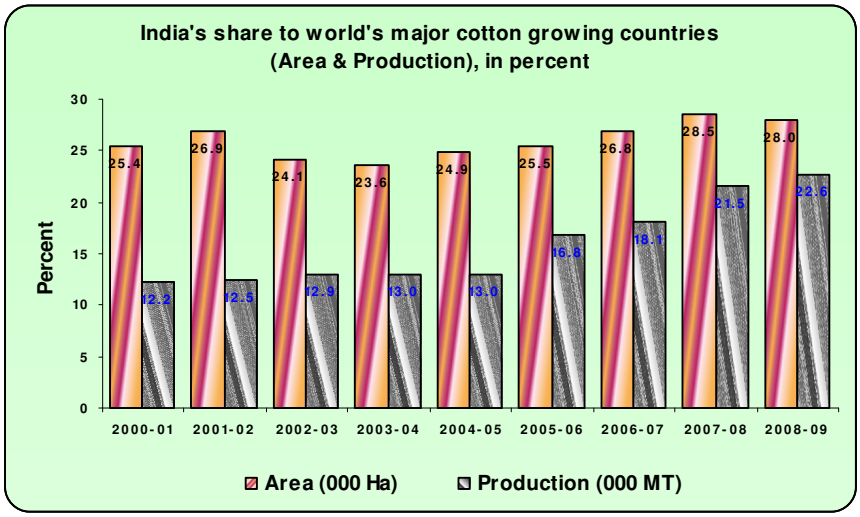
India ranks first in area in the world accounting for 28% of world coverage under the crop and occupies second position in production behind China contributing over 21% of world's cotton harvest. However, India stands far behind in yield as compared to major cotton producing countries in the world.

Area in Major Cotton growing Countries and World (2000-2009)

(000 Ha)

Country	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
China	4,921	5,187	4184	5110	5650	5060	5399	6450	5,534
India	**8535**	**9132**	**7,871**	**7598**	**8787**	**8677**	**9158**	**9585**	**9373**
United States	5,348	5,601	3,939	2,974	4,201	5586	5152	4246	4,835
Pakistan	2,108	2,215	2,263	2,221	2,242	3100	3100	3082	2,620
Brazil	2,998	2,779	3,030	3,107	3,707	587	1079	1149	2,229
Uzbekistan	1,878	1,873	1,885	1,888	2,021	1432	1432	1450	2,017
World Total	**33,631**	**33,969**	**32,593**	**32,151**	**35,223**	**33960**	**34115**	**33600**	**33521**
India (%) to World	**25.4**	**26.9**	**24.1**	**23.6**	**24.9**	**25.5**	**26.8**	**28.5**	**28.0**

Source: USDA (2004-05 to 2008-09), compiled data (2000-01 to 2003-04)



In the last few years, the world cotton harvested area declined at a sustained rate. The area under cotton cultivation shrank to 33.52 million ha in 2008-09 from 33.60 million ha in 2007-08 and 35.22 million ha in 2004-05.

About 75% of the global cotton area is covered in five countries – India (9.4 million hectares), China (5.5 million hectares), USA (4.8 million hectares), Pakistan (2.6 million hectares) and Uzbekistan (2.0 million hectares. The long-term trend in the USA cotton production has dramatically reversed after bumper crop in 2005-06. Diminishing local demand, lower subsidies and more areas going under biofuel crops resulted in further declining cotton output.

Production in Major Cotton growing Countries and World (2000-2009)

(**000 MT)**

Country	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
China	4420	5324	4916	5088	6600	6180	7730	8060	7950
India	**2380**	**2686**	**2500**	**2628**	**4140**	**4150**	**4750**	**5360**	**5220**
United States	3742	4420	3948	2690	5060	5200	4700	4180	2960
Pakistan	1816	1850	1747	1868	2430	2210	2160	1940	2050
Brazil	939	766	767	800	1290	1020	1520	1600	1260
Uzbekistan	975	1055	1015	1035	1130	1210	1170	1200	1090
Turkey	-	-	-	-	900	770	830	680	500
Others	-	-	-	-	4900	4630	3710	3250	680
World Total	**19438**	**21473**	**19294**	**20231**	**26440**	**25380**	**26260**	**26260**	**24290**
India (%) to World	**12.2**	**12.5**	**12.9**	**13**	**15.7**	**16.4**	**18**	**20.4**	**21.5**

Source: USDA (2004-05 to 2008-09), compiled data (2000-01 to 2003-04)

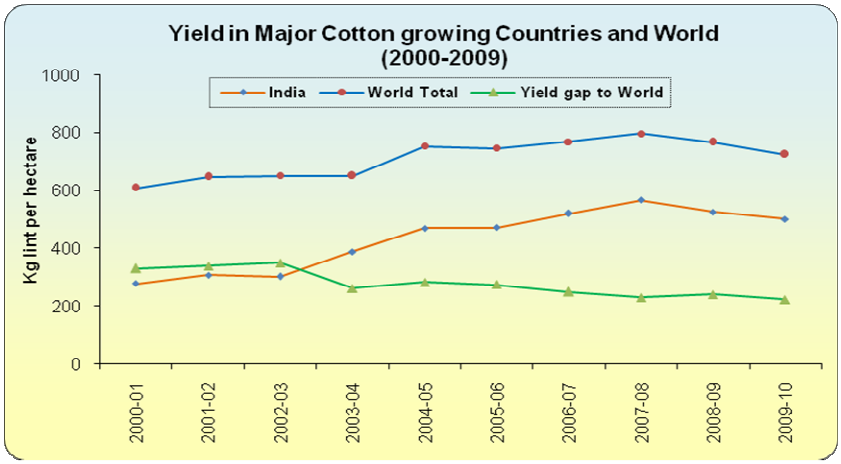
World cotton production has increased from 9.8 million tons in 1960-61 to 26.0 million tons in 2007-08 at an annual growth rate of 1.88% during 1961-2008 but it fell to 24.0 million tons in 2008-09. The reduction in world cotton area for the second consecutive season was one of the reasons for the fall in production; a significant area under cotton cultivation was shifted to grains and oilseed production because these earned more attractive prices than cotton. World cotton yield increased from 609 kg/ha in 2000-01 to 797 kg/ha in 2007-08. Nonetheless, the cotton yield reduced to 767 kg/ha in 2008-09. Factors responsible for the declining global production include high input prices at planting time, higher returns of competing crops and the current turmoil in world financial markets which is affecting the production.

Yield in Major Cotton growing Countries and World (2000-2009)

(**Kg /ha)**

Country	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
China	1,096	1108	1186	973	1132	1161	1286	1278	1270
India	**278**	**308**	**302**	**389**	**470**	**472**	**521**	**567**	**526**
United States	708	790	746	818	958	931	912	985	911
Pakistan	617	580	621	571	751	708	698	620	688
Brazil	1,081	1025	1153	1190	1101	1212	1389	1487	1446
Uzbekistan	676	727	719	641	800	845	818	831	769
World Total	**609**	**647**	**652**	**651**	**754**	**747**	**770**	**797**	**767**
Yield gap to World	**331**	**339**	**350**	**262**	**284**	**275**	**249**	**230**	**241**

Source: Cotton World Statistics, ICAC, September, 2009



Reasons for Low Yield in India:

- All the cotton growing States in the country, barring the non-traditional States of Uttar Pradesh, West Bengal and Tripura, have recorded growth in productivity to different extent depending upon the agro-climatic conditions.
- Fluctuations in the total land under cotton cultivation leading to low coverage and consequent low productivity. The area is subject to low-input cultivation of marginal lands and pest management complexities.
- Nearly 70 per cent cotton cultivation in the country is rain dependent and subject to heavy vagaries of monsoon rains while the remaining area (30%) is irrigated. The irrigated area is much lower in the Southern Zone (40 percent irrigated) and Central Zone (23 percent irrigated). About 60 percent of the total cotton area falls in the Central Zone.
- Continuous presence of cotton in the subcontinent also makes it easy for pests, diseases and other biotic stress agents which survive, multiply and cause frequent epidemics.
- The paucity of quality seeds, high cost of cultivation, multiplicity of varieties and indiscriminate use of pesticides are the other reasons for low productivity of cotton in the country.
- The downward trend in cotton yield in the northern region, particularly in Punjab, is because of increase in water table by way of excessive application of irrigation, canal seepage, etc., relatively higher intensity of insects and pests attack, and lack of availability of good quality hybrid cotton seeds.

Comparative Analysis of Growth in India and World

The annual growth in area and yield during the TMC period compared to world scenario is depicted in the table below, which is illustrated as under:

- Except in 2002-03 and 2008-09, the country ensured a positive growth in area during the period 2000 to 2009 under the TMC. Paucity of monsoon rains in 2002-03 and delayed monsoon in 2008-09 had caused negative growth in these years.
- The annual growth in area recorded by the country over the years has been better compared to global scenario.

- The annual growth in yield recorded by the country over the years has been better compared to global scenario with the exception of the years 2001-02 and 2008-09. In 2001-02, the crop suffered from biotic factors in a congenial climate. During 2008-09, the rainfall was received early during middle of June in most of the states. The sowing of cotton was also started early compared to previous year. But the rainfall ceased in early July and sowing was hampered. The rainfall was active again in last week of July which initiated further sowing and continued until mid-August. Therefore, late sowing was done during the year to the extent of 30% of the total sown area from where good harvest could not be expected.

Comparative Annual Growth in Area and Yield (2000-2009)

Year	Annual Growth (%)				Area	Yield
	Area		Yield		India to World (%)	Gap to World (Kg /ha)
	India	World	India	World		
2001-02	7.0	1.0	- 2.1	5.9	26.9	339
2002-03	-16.0	- 4.2	2.7	0.8	24.1	350
2003-04	-0.9	- 1.4	60.7	-0.1	23.6	262
2004-05	15.6	8.7	3.6	13.7	24.9	284
2005-06	-1.2	- 3.7	13.8	-0.9	25.5	275
2006-07	5.3	0.4	16.3	3.0	26.8	249
2007-08	2.9	- 1.5	10.9	3.4	28.5	230
2008-09	-0.4	- 0.2	- 10.3	-3.9	28.0	241

- Though the average productivity of the country is much lower as against major cotton growing countries of the world, the average yield of a few States in the country namely, Gujarat, Tamil Nadu, Andhra Pradesh and Punjab are at par with world average, ranging from 650 to 743 kg lint per ha.
- The coverage under the crop compared to the global cotton area in percentage terms has shown an increasing trend while the yield gap to world has recorded a declining trend.
- Overall scenario of cotton cultivation in the country has seen an improving trend since the program was brought under Technology Mission mode. India has fared better in reducing yield gap to world and over the years in increasing its contribution to global coverage of the crop.

2. Cotton in Indian Agriculture

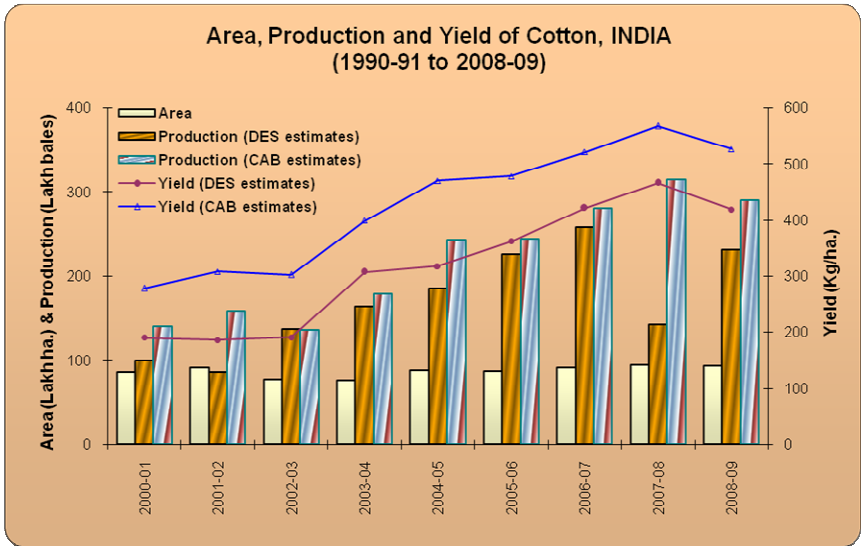
India is the only country which grows all the four species of cultivated cotton i.e. *Gossypium arboreum* and *Gossypium herbaceum* (Asiatic cotton), *Gossypium barbadense* (Egyptian cotton) and *Gossypium hirsutum* (American cotton) besides hybrid cotton. The cotton produced is of 4 different qualities: medium staple; superior medium staple, long staple and extra long staple. The ushering in of hybrid cotton era brought about a substantial increase in cotton production. Soon after the development of cotton hybrid in India during 1970, the cultivation of four species e.g., Hybrid 4, JKHY 1, NHH 44 and DCH 32 was undertaken that brought about a white revolution in cotton. Similarly, the development and release of varieties such as LRA 5166, MCU 5, Suvin and hybrids like DCH 32, H 6 and Savitha brought about a qualitative change in Indian cottons.

Area, Production and Yield (2000-2009)

(Area - Lakh Ha, Production – Lakh bales of 170 kgs. each, Yield - Kg./ Ha.)

Year	Area	DES	
		Production	Yield
2000-01	85.3	95.2	190
2001-02	91.0	100.0	186
2002-03	76.7	86.2	191
2003-04	76.0	137.3	307
2004-05	89.7	164.3	318
2005-06	86.8	185.0	362
2006-07	91.4	226.3	421
2007-08	94.3	258.8	467
2008-09	93.7	231.6	419

(Data Source: DES & CAB)



The Area, Production and Yield of cotton in the country during the period 2000-01 to 2008-09 are presented in the table above. As can be seen, after many years of stagnation, the productivity of cotton in the country has increased significantly during the last 3-4 years and it has been viewed as a major break through. It attained a level of 467 kg/ha during 2007-08 but declined to 419 kg/ha in 2008-09 due to late sowing in most cotton growing States.

While India has registered a notable increase in area from 85.3 lakh ha in 2000-01 to 93.7 lakh ha in 2008-09 and production from 95.2 lakh bales to 231.6 lakh bales, the low productivity is a matter of serious concern. This calls for concerted efforts towards improvement in performance of cotton genotypes in stress situations and coping with situations of deficit rainfall, widespread pests and diseases.

3. Trends in Growth Rates of Cotton

The cotton production in India has nearly doubled in the green revolution period from 57.8 lakh bales in 1967-68 to 100.0 lakh bales in 2001-02. The annual growth rate is 1.60 percent over these years, and most of the growth appears to have come from yield growth, which shows a growth rate of 1.21 percent.

However, during the 10 years starting 1991-92, the growth in production showed an increase of 0.29% while the growth rate in yields declined by 1.48%, indicating a problem with the then existing technology as also adverse effects of vagaries of climate. However, the growth rate in area has accelerated by 1.77% in this period indicating that the crop is finding favour with the farmers. The spectacular figures and growth rates during the three years prior to 2004-05 indicates revival in the yields and production in spite of a negative growth in area of cotton which may be related largely to the introduction of Bt cotton. During 2000-01 to 2008-09 the compound growth rate in area escalated from -1.66% to 1.18%, production from -9.56% to 11.69% and yield from -7.98% to 10.39%, which certainly shows that the mission mode approach adopted through the TMC has yielded positive results, as envisaged.

Trends in Growth Rates of Cotton

Year	Area (lakh ha)	DES		CAB	
		Production (lakh bales)	Yield (kg/ha)	Production (lakh bales)	Yield (kg/ha)
1967-68	80.0	57.8	123	--	--
1981-82	80.6	78.8	166	--	--
1991-92	76.6	97.1	216	--	--
2001-02	91.0	100.0	186	158.00	308
2004-05	89.7	164.3	318	243.00	470
Compound Growth Rate (%)					
1967-68 to 2001-02	0.38	1.60	1.21	--	--
1991-92 to 2001-02	1.77	0.29	-1.48	--	--
2001-02 to 2004-05	-1.24	17.80	19.36	15.26	14.96
1996-97 to 2000-01 (Pre-TMC period)	-1.66	-9.56	-7.98	-5.81	-4.19
2000-01 to 2008-09 (TMC period)	1.18	11.69	10.39	9.53	8.30

(Based on DES & CAB Data)

4. Annual Growth Rate of Cotton

Looking at the annual performance during the nine years since launch of the TMC, as is evident from table below, it may be seen that there has been a gradual improvement with some fluctuations. The performance has been excellent with all-round growth during 2001-02, 2004-05, 2006-07, and 2007-08 with the exception of three years during 2000-01, 2002-03 and 2008-09. The growth in yield despite a negative growth in area during 2003-04 and 2005-06 is indicative of adoption and dissemination of the improved technology propagated through the TMC program among cotton growing farmers and other stakeholders.

While there has been an impressive growth in area, production and yield upto 2007-08, a negative growth has been witnessed during the year 2008-09 which also corroborates with the findings of the field survey of beneficiary and non-beneficiary cotton growers in all the cotton growing states. The main reason attributable for the negative growth during 2008-09 is inadequate rainfall during critical period in many parts of cotton growing States.

Annual Growth Rate

Year	Growth rate (%)				
	Area	DES estimates		CAB estimates	
		Production	Yield	Production	Yield
1999-00	-6.74	- 6.18	0.44	-5.4	0.7
2000-01	-2.07	-17.43	-15.55	-10.2	-8.5
2001-02	7.03	5.04	- 2.10	12.8	10.8
2002-03	-16.00	-13.77	2.69	-13.9	-1.9
2003-04	-0.91	59.28	60.73	31.6	32.1
2004-05	15.66	19.66	3.58	35.7	17.8
2005-06	-1.25	12.60	13.83	0.4	1.7
2006-07	5.30	22.32	16.30	14.7	9.0
2007-08	2.95	14.36	10.92	12.5	8.8
2008-09	-0.42	-10.51	- 10.28	-7.9	-7.2

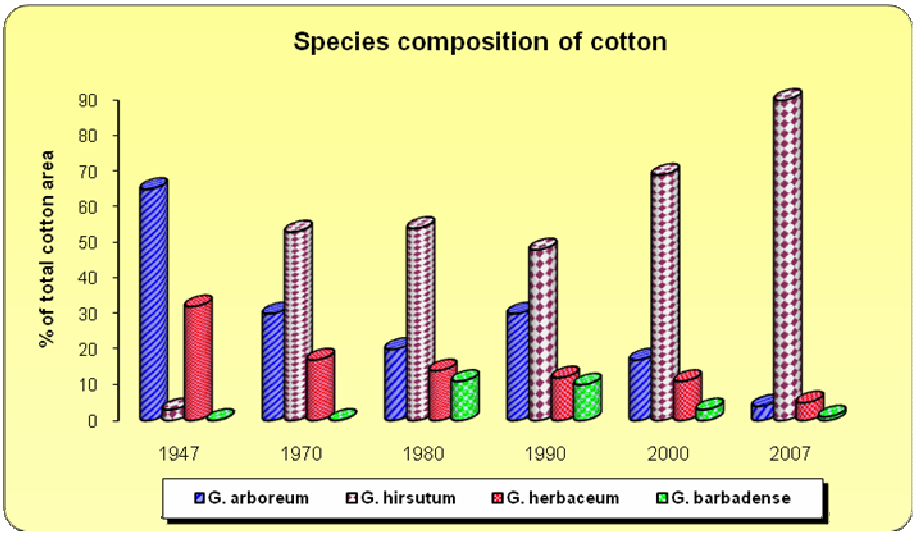
5. Species Composition in Indian Cotton

Species composition of cultivated cotton in India has changed over the years as shown in the table below. In 1947, 97 per cent area was sown to desi cotton viz., *Gossypium arboreum* and *G. herbaceum. G. hirsutum* (Tetraploid) contributed only 3 per cent. By 2000 *G. hirsutum* and interspecific hybrids occupied 69 per cent area, while desi cotton share declined to 28 per cent.

Species composition of cotton

Species	% of total cotton area					
	1947	1970	1980	1990	2000	2007
G. arboreum	65	30	20	30	17	4
G. hirsutum	3	53	54	48	69	90
G. herbaceum	32	17	14	12	11	5
G. barbadense	-	-	11	10	3	1
	100	**100**	**100**	**100**	**100**	**100**

(**Source** : DES upto 2000, State Department 2007-08)



The area under *G.hirsutum* has increased from 3% in 1947 to 90% in 2007 whereas the area under *G.arboreum* decreased from 65% to 4% and that of *G.herbaceum* decreased from 32% to 5%. The area of *G.barbadense* which was 11% in 1970 was just 1% of total area in 2007. The reversal in trend is mainly due to the ingress made by Bt Cotton which is mainly of the *G.hirsutum* specie. This kind of skewed production of cotton is certainly not in India's interest since cotton of all varieties is required by the end user. Hence, the extent to which this distortion has affected the availability of the other varieties has to be considered and steps taken to redress the situation so that adequate quantities of other species of cotton are also available.

6. State-wise Trends in Area, Production and Yield

6.1 Area: The area under Cotton was 85.76 lakh ha in 2000-2001 and thereafter it went down to 78.70 lakh ha in the year 2002-03 and again came up to the level of 87.87 lakh ha in 2004-05. Due to good monsoon in major cotton growing parts of the country and higher prices fetched by the farmers more acreages were covered in the year 2007-08, surpassing the highest area covered in 2006-07 (91.44), covering 94.33 lakh ha area.

State-wise Cotton Area (Lakh ha.) and Compound Growth Rate (%) (2000-2009)

State	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	Compound Growth Rate (%)
Haryana	6.30	5.19	5.28	6.21	5.83	5.30	4.83	4.56	- 3.95
Punjab	6.07	4.49	4.52	5.09	5.57	6.07	6.04	5.27	- 1.75
Rajasthan	5.10	3.86	3.44	4.38	4.72	3.51	3.39	3.02	- 6.34
Gujarat	17.49	16.36	16.41	19.06	19.08	23.90	24.22	23.54	3.78
M.P.	5.42	5.59	5.64	5.76	6.20	6.39	6.30	6.25	1.79
Maharashtra	31.06	28.00	27.62	28.40	28.75	31.07	31.94	31.42	0.14
A.P.	11.01	8.03	8.37	11.78	10.33	9.72	11.33	13.99	3.04
Karnataka	6.08	3.93	3.17	5.21	4.13	3.75	4.02	4.08	- 4.86
Tamil Nadu	1.88	0.76	0.98	1.29	1.41	1.00	1.19	1.09	- 6.59
Orissa	0.63	0.30	0.37	0.46	0.56	0.51	0.50	0.58	- 1.03
U.P. & others	0.05	0.05	0.04	0.05	0.11	0.05	0.04	0.26	22.88
All India	**91.32**	**78.70**	**75.98**	**87.87**	**86.77**	**91.44**	**94.33**	**94.06**	**0.37**

Source: Compiled from State DoA data

The area under cotton cultivation in India grew from around 56.5 lakh ha in 1950-51 to 94.33 lakh ha in 2007-08 and witnessed a marginal decline at 94.06 lakh ha in 2008-09. However, the rise in area under cotton cultivation over the years has not been on a sustained basis. Various factors such as variability in monsoon, returns from competitive crops, have played a significant role in influencing the cotton planting decision of farmers. For instance, during 2002-03, the drought conditions experienced in India to certain extent restrained the growers to take up cultivation of cotton; as a result, the area under cotton cultivation went down to 78.7 lakh ha from 91.3 lakh ha in 2001-02. Comparatively, the acreage under cotton increased by 5.4% (y-o-y) in 2006-07, primarily on account of a good monsoon in major cotton growing parts of India and higher prices fetched by farmers.

In the northern Zone, the cotton sown area has decreased to all time low of 12.85 lakh ha in 2008-09. The reduction was contributed by all the three states of the Zone. The decrease in area was maximum in Rajasthan, 12.2% over 2007-08, reducing from 3.39 lakh ha in 2007-08 to 3.02 lakh ha in 2008-09. The acreage in Punjab continued to grow through 2002 to

2007, but declined by about 15% over 2006-07 to 5.27 lakh ha in 2008-09. Irregular and less water supply in canal during sowing period in Rajasthan caused lower coverage during last few years. Water logging and rise in soil salinity forced farmers of Punjab to shift cotton area to paddy.

The increasing trend of coverage followed since 2002-03 till 2007-08 in the central Zone, have decreased by 2% in 2008-09. While main contributors to the decrease were Gujarat (-2.9%) and Maharashtra (-1.6%), Madhya Pradesh had decreased coverage by a marginal 0.8% over 2007-08.

Coverage under cotton has increased in south Zone by 11.8% over 2007-08 with all time high coverage of 19.16 lakh ha overshooting that of 2001-02 (18.97 lakh ha). While Andhra Pradesh and Karnataka recorded increased coverage, it shrunk in Tamil Nadu by more than 9% over 2007-08.The non-traditional and negligible cultivated states have maintained the increasing trend in acreage over the years, achieving 0.56 lakh ha in 2006-07 and ascending to 0.84 lakh ha in 2008-09 registering 33% increase in area over 2006-07.

Paucity of monsoon rains in 2002-03 and delayed monsoon in 2008-09 had caused negative growth in these years. Recently the area under cotton is declining owing to crop diversification and continuous failure of monsoon. The States of south Zone were once famous for long staple cotton but the same status has been lost and area under long staple group has declined drastically.

6.2 Production: In 2000-2001, cotton production in the country was 140 lakh bales but decreased in 2003-04 to 137 lakh bales. Thereafter, the production maintained an increasing trend over the years recording 164 lakh bales in 2004-05, 226 lakh bales in 2006-07 and 232 lakh bales in 2008-09 - recording almost 19% increase over 2005-06. The impressive increase in production since 2003-04 is a combined stimulation of farmers' adoption of improved production technology propagated through MM II of the TMC program and large scale embracing of Bt Cotton cultivation. The Production of cotton in north Zone has recorded negative growth during 2006-07 to 2008-09 almost continuously. In Central Zone, the production increased by 20.3% over 2005-06, main contributing state being Maharashtra with more than 56% growth. While Gujarat grew in production marginally, Madhya Pradesh showed 14.9% increase in production.

State-wise Cotton Production (lakh bales) and Compound Growth Rate (%) (2000-2009)

State	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	Compound GR (%)
Haryana	7.22	10.38	14.06	20.75	14.99	18.14	18.85	18.58	12.54
Punjab	13.07	10.83	14.78	20.67	23.95	26.78	23.56	22.85	7.23
Rajasthan	2.81	2.62	7.09	7.65	8.80	7.47	8.12	7.26	12.60
Gujarat	17.03	16.85	40.27	47.25	67.72	87.87	82.76	76.16	20.59
M.P.	3.94	3.90	6.39	6.26	7.45	8.29	8.65	8.56	10.18
Maharashtra	26.90	25.98	30.80	29.39	31.60	46.18	70.11	49.43	7.90
A.P.	18.77	10.96	18.90	21.90	21.08	21.27	34.52	35.72	8.37
Karnataka	6.12	3.31	2.65	6.88	6.64	4.40	6.96	9.12	5.11
Tamil Nadu	3.28	0.84	1.23	1.95	2.13	2.21	2.32	2.05	-5.70
Orissa	0.55	0.50	0.88	1.11	1.11	1.08	1.25	1.47	13.07
U.P. & Others	0.06	0.04	0.04	0.05	5.2	0.07	0.04	0..36	25.10
All India	**99.97**	**86.24**	**137.29**	**164.29**	**184.99**	**226.32**	**258.06**	**231.56**	**11.07**

Source: Compiled from State DoA data

6.3 Productivity: The Productivity of cotton, which has been ever increasing since 2000-01 has recorded a growth of about 13.4% in 2008-09 over 2005-06. Within the States, Rajasthan achieved maximum growth in yield of 46.8% followed by Karnataka (39.8%), Haryana (36.8%), Maharashtra (30.5%), Orissa (21.6%), Andhra Pradesh (20.1%), and Tamilnadu (19.4%). Negative growth in productivity is seen only in Gujarat by nearly (-) 9.8% over 2005-06.

It is noteworthy that during 2005-06 and 2006-07, the productivity of cotton in Gujarat was 600-625 kg lint/ha which was near to world average but it decreased to 581 kg lint/ha in 2007-08 due to mealy bug attack. The productivity in India has witnessed substantial improvement over the years. A confluence of factors such as adoption of Bt varieties, accelerated technology transfer to the farmers, efforts taken by the government and other agencies have been instrumental in increasing cotton productivity in India. The average cotton yield increased from 190 kg/ha in 2000-01 to peak at 468 kg/ha in 2007-08 and slipped to 418 kg/ha in 2008-09. The drop in cotton productivity in 2008-09 could be attributed to uneven monsoon which led to a dry spell in some areas and excessive rains in other areas coupled with high pest incidence.

State-wise cotton productivity (kg lint/ha) and Compound Growth Rate (%) (2000-2009)

State	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	Compound Growth Rate (%)
Haryana	195	340	464	568	437	582	683	692	17.15
Punjab	388	410	556	697	731	750	613	737	8.35
Rajasthan	94	111	150	297	217	363	397	408	20.14
Gujarat	165	175	417	421	604	625	581	550	16.24
M.P.	124	119	193	185	204	221	233	232	8.14
Maharashtra	147	158	190	178	187	253	373	269	7.85
A.P.	288	230	384	316	347	372	518	434	5.26
Karnataka	171	143	142	224	228	199	294	379	10.46
Tamil Nadu	295	188	213	257	257	378	312	319	0.98
Orissa	284	283	404	410	337	360	425	430	5.32
U.P. & others	310	136	170	170	201	138	170	235	- 3.40
All India	**186**	**191**	**307**	**318**	**362**	**421**	**468**	**418**	**10.65**

Source: Compiled from State DoA data

It can be construed that an increased growth in productivity level could be brought about only through accelerated transfer of technology and co-coordinated efforts in R & D for harnessing the full genetic potential for improved gains in the coming years.

6.4 **State-wise Compound Growth Rate:** The three northern States viz., Haryana, Punjab and Rajasthan as also the southern States of Karnataka and Tamil Nadu showed negative value in the compound growth rate in area of the crop. However, production and productivity both showed positive growth to diverse extent in Haryana, Punjab, Rajasthan and Karnataka.

It is noteworthy that the production of the crop in these States has shown positive growth in the face of a negative growth in area, signifying yield growth and an increased production.

State-wise Compound Growth Rate

State	Compound growth rate (%)		
	Area	Production	Productivity
Haryana	- 3.95	12.54	17.15
Punjab	- 1.75	7.23	8.35
Rajasthan	- 6.34	12.60	20.14
Gujarat	3.78	20.59	16.24
M.P.	1.79	10.18	8.14
Maharashtra	0.14	7.90	7.85
A.P.	3.04	8.37	5.26
Karnataka	- 4.86	5.11	10.46
Tamil Nadu	- 6.59	-5.70	0.98
Orissa	- 1.03	13.07	5.32
U.P. & others	22.88	25.10	- 3.40
All India	**0.37**	**11.07**	**10.65**

- Tamil Nadu, though had negative growth in production, its productivity, nevertheless, showed positive value, also signifying yield growth. These States had minimal area under Bt hybrids to have influence on production or productivity, thus dispelling the oft-repeated misconception that Bt hybrids contribute to yield enhancement.
- Andhra Pradesh had positive growth in area, production and productivity having relatively more contribution of Bt hybrids in production but no significant effect was seen in productivity. It is however notable that growth in productivity overshoots the area growth, also signifying yield growth.
- The compound growth rate in area of the crop in the three central zones States of Gujarat, Madhya Pradesh and Maharashtra have been at a very low level but the compound growth in productivity has been significant in Gujarat with significant contribution from Bt hybrids during the last three years. In Maharashtra, where more area was grown under Bt hybrids since 2005-06, no significant effect was seen on growth in production which nearly equated the growth in productivity. But in each case the growth in productivity overshoots the area growth, which point towards yield growth.

The above deliberations are indicative of a significant contribution of the state released varieties and hybrids on productivity which at all-India level has attained a healthy compound growth of 10.65% as against a nominal 0.37% growth in area. The data amply proves that the growth in productivity, with too little growth in area, is on account of yield growth

6.5 Reasons for Low Productivity

- All the States, barring the non-traditional States of Uttar Pradesh, West Bengal and Tripura, have recorded compound growth in productivity to different extent depending upon the agro-climatic conditions during the TMC period.

- The growth has been over 20% in Rajasthan followed by Haryana, Gujarat and Karnataka, all having achieved double digit growth, also seen at all India level (10.65%). The data amply proves that the growth in productivity, with too little growth in area, is on account of yield growth which can well be attributed to the efforts made under MM II of TMC.

- Among the States achieving less than 10% growth, Punjab is faced with soil salinity problems affecting production and productivity. Madhya Pradesh, Maharashtra and Tamil Nadu have large tracts under rain dependent cultivation leading to uncertain production and productivity.

6.6 Possible Remedial Measures

- In Punjab, land for cotton cultivation needs to be selected taking care of salinity level leaving saline soils for cultivation of other tolerant crops, especially rice. Few varieties of desi cotton tolerant to soil salinity have been recently released which can be tried.
- In Madhya Pradesh, Maharashtra and Tamil Nadu, the major factors affecting crop growth and development are radiation, temperature, water, nutrition and pests & diseases. In addition, productivity is also determined by many other factors such as type of cultivar, its physiology and crop management that interact with weather and soils to influence yield level.
- Supplementary irrigation, timely planting and improved nutrient management practices are key agronomic measures for better yield.
- A special scheme needs to be formulated for the rain-dependent cotton growing areas in Andhra Pradesh, Gujarat, Madhya Pradesh, Maharashtra Karnataka and Tamil Nadu.

7. Zone-wise State-wise Impact Assessment in sampled districts

NORTH ZONE

(i) Haryana

- Of the three districts studied, the area under cotton in Jind has increased with 2% compound growth rate but in Sirsa and Bhiwani, the cotton area has gradually decreased. The compound growth rate of area are (-) 2.8% and (-) 9.2% respectively.
- The production data and the compound growth rate of the districts selected for study reveal that Sirsa and Jind districts of the State, have recorded compound growth rate of production more than the State. Bhiwani recorded a negative compound growth rate.
- The production of cotton in the district is seen to grow till 2004-05 attaining the highest but started declining simultaneous to decline in area coverage, reaching the lowest in 2008-09.
- Congenial weather conditions during 2006-07 & 2007-08 favoured pest build up causing damage to the crop in the vegetative stage in Bhiwani district. Jassids, spotted bollworm & American bollworm continued through mid-July to1st fortnight of September, also affected production appreciably by damaging the crop at peak square & boll formation stage.
- The crop suffered from square shedding and boll rotting during 2005-06 in Bhiwani district due to continuous rain and humid conditions during mid-September.

- The yield data and the compound growth rate of the districts selected for study reveal that only Sirsa, out of the three districts of the State, has recorded compound growth rate more than the State.
- Bhiwani and Jind, also witnessed a positive growth but less than that of the State. Both districts failed to achieve State yield level during 2002-03 & 2004-05 to 2008-09.
- Climatic aberrations during 2002-03 and 2004-05 as well as prolonged excessive high temperature of above 47^{o}C and hot condition proved detrimental for the crop in these districts.
- Congenial weather conditions during 2006-07 & 2007-08 favoured pest build up causing damage to the crop in the vegetative stage. Jassids, spotted bollworm & American bollworm continued through mid-July to1st fortnight of September, appreciably damaging the crop at peak square & boll formation stage.
- The crop in Bhiwani district also suffered from square shedding and boll rotting during 2005-06 due to continuous rain and humid conditions during mid-September.

(ii) Punjab

- The area under cotton in Ferozepur & Muktsar districts have been gradually decreasing and the compound growth rate of area is negative 2.1% and 2.0% respectively. The cotton area had increased in all the districts to a peak before sliding to low coverage.
- Though the compound growth rate of area of Bathinda reflects a negative value (0.7%), factually speaking, the cotton area coverage remained almost stable, with minor variations, during 2001-02 to 2008-09.
- The production data reveals that the three selected districts Bhatinda, Ferozepur & Muktsar of the State recorded positive compound growth rate of production.
- The production of all the three districts continued to rise till 2006-07 but declined thereafter till 2008-09. The reason for the fall in production is traced to declining area coverage of cotton in these districts; the yield, however, remained static implying healthy yield growth in these years.
- The yield data reveals that while Ferozepur witnessed a positive growth less than that of the State, Bhatinda & Muktsar, the other two districts studied, has recorded compound growth rate more than the State.
- Ferozepur failed to equal the State yield in the years 2001-02 & 2006-07 to 2008-09. The plausible cause being growing soil salinity, delayed sowing in 2006-07, attack of bollworms, jassids and CLCV disease during 2001-02, and severe mealy bug attack in early stages of crop growth during 2007-08 and 2008-09.
- A drought-like situation in 2003-04 during June to August along with severe CLCV disease affected the crop in Bathinda and Muktsar leading to less than State yield.

(iii) Rajasthan

- In Hanumangarh, area of cotton continued to increase till 2005-06 but declined thereafter to an area above 2001-02 level recording a compound growth rate of 2.8%. In Jodhpur also, the area gradually increased to a maximum in 2004-05 but

declined steeply thereafter to a few thousand acres with a compound growth rate of area of (-) 15.9% respectively.

- Though Hanumangarh has the least productivity in the State, the data reflected a positive growth of area while Jodhpur with productivity level above both State and National averages, recorded negative compound growth rate with area coverage declining from 8800 in 2001-02 to 2200 in 2007-08.
- While Hanumangarh district has achieved positive compound growth rate of production, Jodhpur achieved compound growth rate of production in the negative.
- The reason for fall in cotton production in 2007-08 in Jodhpur is traced to abrupt dip in area coverage from 0.081 lakh ha to 0.022 lakh ha in the district.
- Both the districts studied have achieved a compound growth rate of yield more than the State.
- Average yield of Hanumangarh district during 2002-03 was less than State average yield level because of less monsoon rains and acute shortage of irrigation water in canals.

Conclusions

- High cost of cultivation, susceptibility to damage of insect & pest and a host of diseases, longer duration affecting sowing of following rabi crop are some of the acute concerns of the farmers influencing replacement of cotton area by equally remunerative other short duration kharif crops like maize, paddy, pulses etc.
- Six of the eight selected districts of the North Zone have achieved positive compound growth rate of production to various extent. Sirsa, Bathinda, Muktsar and Hanumangarh, are adjoining districts of the three States, whose achievements have been similar. The districts in these States have shown the potential to continued increase in production, though similarity in the climatic abnormality influenced the crop to different extent. Deficient technical advice on crop management at field level and decline in area coverage due to climatic aberrations are responsible for the variations in production.
- Compound growth rate of yield in five of the eight districts of the North Zone have been more than that of the respective State level position. Sirsa, Bathinda, Muktsar and Hanumangarh are bordering districts of the three States, whose achievements have been similar. The districts in these States have shown the potential to continued increase in productivity, though similarity in the climatic abnormality influences the crop to different extent. More than the climatic aberrations, unprofessional crop management at field level is responsible for the variation in productivity.

CENTRAL ZONE

(i) Gujarat

- Anand, Dahod, Panchmahal and Surendranagar districts recorded negative compound growth rate of area implying decline of area under cotton cultivation.

- Though the compound growth rate of area of Surendranagar reflects a negative value (1.0%), factually speaking, the cotton area coverage remained vacillating between 3.84 and 4.23 lakh ha area during 2001-02 to 2008-09.
- The districts of Kheda, Surat, Bhavnagar, Jamnagar, Junagarh and Rajkot witnessed positive compound growth rate in area.
- Except Anand the remaining nine selected districts of the State achieved positive compound growth rate of production.
- Production in Anand, district increased from 2001-02 to 2003-04 but started declining thereafter. The decline is traced to reduction in area coverage since 2004-05.
- Anand, Dahod, Kheda and Panchmahal districts achieved compound growth rate of yield lower than the State. These districts witnessed positive growth less than that of the State & failed to achieve State yield level during 2003-04, 2005-06 to 2008-09.
- During 2003-04, the crop was infested with sucking insects and the bollworms in Anand, Dahod, Kheda, Surat, Bhavnagar and Surendranagar districts leading to the crop yielding less than the State average.
- During 2005-06 to 2008-09 the crop in Anand, Dahod, Kheda, Panchmahal and Surendranagar yielded less than State. Plausible causes for low yield have been identified as cyclonic storm with heavy rains in 2005-06 inundated crops in
- Panchmahal and few other districts; during early August of 2006 there was heavy rains causing flood damaging cotton and other crops in Anand, Surat and some other south Gujarat districts.
- The crop in general was severely damage of mealy bug attack and poor performance of some Bt hybrids, leaf reddening wilting and sucking pest attack in BG II cotton in these districts leading to lowering of yield below the State average.
- Reason for yield lower than the State average is possibly because of poor performance of some Bt hybrids, cultivation of non-descript illegal Bt hybrids affected by mites and severe damage due to mealy bug.

(ii) Madhya Pradesh

- All three districts of Khargone, Ratlam & Khandwa achieved positive compound growth rate of area.
- Regardless of showing a positive compound growth rate in area, cotton area coverage in Khargone was almost stable, wavering between 1.75 and 2.02 lakh ha area.
- The three selected districts of the State achieved positive compound growth rate of production.
- With the exception of Khargaon, two other studied districts, Ratlam & Khandwa achieved positive compound growth rate of yield but failed to equate with the State.
- There is no reason for low yield other than unorganized crop management practiced in the State.

(iii) Maharashtra

- Nashik, Aurangabad, Buldana, Dhule, Jalgaon, Ahmednagar, Jalna, Beed, Nanded, achieved positive compound growth rate of area to different extent, highest being 20.7% in Nashik, next being 20.3% in Ahmednagar.
- Akola, Parbhani, Wardha & Nagpur Yavatmal & Chandrapur districts recorded compound growth rate of area in the negative. The data shows maximum decline in area was 9.3% in Wardha followed by 7.2% in Nagpur.
- The compound growth rate of area of Jalgaon, reflects a negative value (0.9%). In actuality, however, the coverage of cotton remained almost stable, the area fluctuating between 3.84 and 4.34 lakh ha area during 2001-02 to 2008-09.
- Parbhani, Wardha & Nagpur of the selected districts have recorded compound growth rate of production in the negative.
- Nashik, Akola, Aurangabad, Jalgaon, Dhule, Buldana, Yavatmal, Ahmednagar, Jalana, Beed, Nanded, & Chandrapur achieved positive compound growth rate of production.
- The area coverage in Wardha & Nagpur has been declining after 2006-07 and 2005-06 respectively leading to negative compound growth rate of production.
- The average yield of cotton in the State fluctuated over the years from 147 kg/ha in 2001-02 to 269 kg/ha in 2008-09 and thus recorded a compound growth rate of yield of 7.85 during the eight year period.
- Nashik, Akola, Aurangabad, Buldana, Yavatmal & Chandrapur achieved positive compound growth rate of yield above the State level. Jalgaon, Ahmednagar, Jalana, Beed, Nanded, Wardha & Nagpur witnessed positive compound growth of yield but stayed behind that of the State.
- Dhule & Parbhani recorded compound growth of yield in the negative. While the average yield in Dhule remained below the State average during 2001-02, 2002-03, 2005-06 and 2007-08, it was more than the State average yield in Parbhani all through the years under study.
- Exploring the probable causes for low and negative compound growth of yield in different districts identified are - delayed sowing in 2006-07, attack of bollworms, jassid and CLCV disease during 2001-02, and severe mealy bug attack in early stages of crop growth during 2007-08 and 2008-09. Congenial weather conditions during 2005-06 & 2007-08 favouring pest build up of aphids, Jassids, spotted bollworm & American bollworm continued through July to September, appreciably damaged the crop at peak square & boll formation stage.
- Climatic aberrations during 2001-02, 2005-06, less than normal rainfall and prolonged dry and hot condition in Jalgaon, Dhule & Aurangabad proved detrimental for the crop in these districts. The sowing operation was delayed in 12 districts due to delayed rainfall.
- The crop in Buldana, Yavatmal, Akola, Wardha, Nagpur and other districts also suffered from reddening of leaves, square shedding and boll rotting during 2007-08 due to excessive rainfall creating flood like situation with the crop remaining under submerged condition for a longer period resulting in stunted growth.

Conclusions

- Examination of the probable causes for negative compound growth of area in different districts of the Central Zone identified are - delay in onset of monsoon and subsequent dry spell at sowing period caused reduction in area sown. As delayed sowing of cotton leads to lower yields, farmers preferred to switch over to other short duration crops to some extent.
- Reduction in area sown was noticed in Gujarat and Maharashtra during 2002-03 & 2003-04. While climatic abnormality adversely affected cotton sowing, market price also played an important role in area coverage as farmers get Rs. 1700/- to 1800/- per qtl of seed cotton at APMC which was much lower than previous year's Rs 2200/- to 2500/- per qtl. Cotton area is replaced with other remunerative crops like maize, red gram, soybean sunflower and other pulses.
- Barring Anand, Parbhani, Wardha and Nagpur, the 24 other selected districts of the Central Zone have achieved positive compound growth of production, suggesting increase in production potential of these cotton growing districts. While the negative growth status of Anand, Wardha and Nagpur is influenced by diminishing area coverage, inept crop management at field level has been responsible for negative compound growth status in case of Parbhani district.
- Barring Dhule and Parbhani, the districts of the Central Zone have achieved positive compound growth of yield, suggesting the increase of yield potential of these cotton growing districts. Inept crop management at field level has been responsible for negative compound growth of yield in case of Dhule and Parbhani. While climatic variations played significant role in all the States, damage due to excessive pest build-up has added to the cause. The pest damage is the creation of slack and inept crop management which can well be avoided by taking help of the advanced technology.

SOUTH ZONE

(i) Andhra Pradesh

- Warangal, Khammam, Adilabad, Guntur and Krishna districts of the State have recorded positive compound growth rate of area to different extent, highest being 5.9% in Adilabad.
- Kurnool is the lone district in the State with negative compound growth rate of area. Cotton area in the district was 0.83 lakh ha in 2001-02 but the area declined continuously over the years to 0.23 lakh ha in 2008-09 recording compound growth rate of (-) 14.8%.
- Though Warangal and Krishna districts achieved compound growth rate of (-) 0.4% and 0.7% respectively, in fact, the coverage of cotton in these districts remained almost stable, the area fluctuating between 1.19 and 1.82 lakh ha area in the former and 0.31 to 0.48 lakh ha in the latter, during 2001-02 to 2008-09.
- Barring Kurnool, the other 5 selected districts of the State have achieved positive compound growth of production.

- The reasons for negative production growth status of Kurnool points to deficient rainfall & intermittent dry spell through the years 2001-02 to 2008-09 causing delayed sowing and created severe moisture stress & stunted growth.
- The yield data and the compound growth rate of the studied districts reveal that Warangal, Adilabad, Kurnool and Krishna districts of the State, have recorded compound growth rate more than the State. Khammam and Guntur districts have achieved positive compound growth rate of yield but less than that of the State.
- Though Adilabad & Kurnool achieved positive compound growth rate of yield, both, however, failed to equal the State average yield, the former during 2001-02 to 2004-05, 2006-07 & 2008-09 and Kurnool all through the years 2001-02 to 2008-09. The plausible reasons being deficient rainfall & intermittent dry spell between mid-June and August in 2002-03 and 2007-08 which caused delayed sowing and created severe moisture stress & stunted growth.
- The crop also suffered from cyclonic weather with excessive rain in 2005-06 & excess rains in August-end to Sept-end during 2007-08. The abnormal weather coincided with early crop growth and peak boll development stage leading to shedding of reproductive parts of the crop in extensive area affecting yield by 10-20% in Warangal, Adilabad and Kurnool.
- Despite Khammam and Guntur achieving lower compound growth rate of yield than that of the State, nevertheless, the average yield of the crop in these districts have been significantly in excess of the State average during the entire eight year period of study.

(ii) Karnataka

- According to the data, all three districts - Dharwar, Belgaum and Mysore of the State have recorded negative compound growth rate of area to different extent. The cotton area in these districts was fluctuating within a narrow span forming crest & trough every other year signifying the wavering mindset of farmers in respect of cotton cultivation.
- The data reveal that Dharwar, Belgaum and Mysore have achieved positive compound growth rate of production.
- The data reveal that Dharwar, Belgaum and Mysore have achieved positive compound growth rate of yield but less than that of the State. The average yield of the crop in Dharwar was less than the State average during 2003-04 to 2008-09.
- Climatic aberrations in 2003-04 and 2004-05, particularly delayed and deficit rainfall between mid June to end July and again first week of August to first week September severely affected the standing crop and its productivity in Mysore district.
- Excess water discharged from Maharashtra during 2007-08 in the adjoining rivers in Karnataka during July and excessive rains in August inundated the standing crop in some areas of Dharwar and Belgaum.
- The study depicted delayed sowing due to delayed and deficit rainfall, prolonged dry spell, drought & moisture stress as main of causes of low productivity in the State.

(iii) Tamilnadu

- Perambalur, the lone district studied in the State, achieved positive compound growth rate of area. The cotton area in the district dipped to a low of 809 ha in 2003-04, after which it gradually increased as the farmers were encouraged with introduction of Bt seed for sowing, increased procurement price and other factors that tilted the C:B ratio in favor of cotton.
- The study depicted area coverage of cotton in the State depended broadly on the receipt of south-west monsoon showers around September/October.
- The lone selected district achieved positive compound growth rate of production.
- The lone district studied showed a compound growth rate of yield more than the State. Average yield of Perambulur district was more than the State average yield level during the entire period of study.
- The study depicted cultivation and productivity of cotton in the State depended broadly on the receipt of south-west monsoon showers around September/October.

Conclusions

- Four of the ten districts of the South Zone have recorded negative compound growth of area. The cotton sowing in these States are influenced by the variations of south-west monsoon. Hence, the area sown fluctuates depending upon the quantum of monsoon showers received. The decline of cotton area leading to negative compound growth in Kurnool, Dharwar, Belgaum and Mysore is a combined effect of climatic reasons and significantly to the wavering mindset of farmers in respect of cotton cultivation and C:B ratio of cotton compared to other crops. The cotton area is generally replaced by concurrent competitive crops like maize, soybean, red gram, sunflower and other pulses.
- Barring Kurnool, the other nine selected districts of the South Zone have achieved positive compound growth of production, suggesting increase in production potential of these cotton growing districts. The cotton sowing in these States are primarily influenced by the variations of south-west monsoon. Cotton production thus depends upon the availability of rains for sowing and maintaining the standing crop.
- All ten districts of the South Zone have achieved positive compound growth of yield, suggesting the potential of increasing yield of these cotton growing districts. The cotton sowing in these States are primarily influenced by the variations of south-west monsoon. The productivity is thus related to the availability of rains for sowing but also affected by excess rain almost frequently, causing damage to the emerging or standing crop. The crop is generally not much damaged by pest and disease attack because of very efficient plant protection mechanism in these States. The lower compound growth of yield in Dharwar, Belgaum and Mysore is due to climatic reasons rather than to slackness in crop management.

OTHER STATES

(i) Orissa

- Rayagada, the lone district studied in the State, achieved positive compound growth rate of area. The cotton area in the district remained fluctuating between 0.10 to 0.17 lakh ha during 2001-02 to 2008-09 with a sharp decline to 0.07 lakh ha in 2002-03.
- During 2002-03, the State received low rainfall in the month of June – July which affected the sowing. The decrease in coverage of cotton area was mainly because of the moisture stress condition prevailing during sowing period.
- The lone district selected for the study showed a huge negative value of compound growth rate of production.
- Low production in the district is mainly on account of diminishing area coverage in the district and also influenced by the low average yield of the rainfed cotton due to delayed and deficit rainfall, prolonged dry spell, drought & moisture stress.
- The lone district studied showed a compound growth rate of yield more than the State. Average yield of cotton in Rayagada district was lower than the State average yield level during 2001-02 to 2004-05 & 2006-07.
- Going into the reason for lower average yields of the rainfed crop revealed delayed and deficit rainfall, prolonged dry spell, drought & moisture stress are the main of causes.

(ii) U.P, Tripura and West Bengal

- The lone district in each of the States i.e. Uttar Pradesh, Tripura and West Bengal have achieved positive compound growth rate of area.
- Cotton is suitable for semi-arid tropical climate but except Aligarh and some other western Uttar Pradesh districts, its cultivation is done in humid conditions in the eastern States.
- Cotton is still a crop of secondary importance in these States though the Agriculture departments of the respective States are taking steps to increase the area and yield level by exploring suitable pockets for cotton cultivation and adopting good crop management measures.
- In Tripura, varieties of only *Gossypium arboreum* species is cultivated mixed with paddy, maize, jute, mesta, sesamum and vegetables as a subsidiary rainfed crop in upland areas of West, South, North and Dhalai districts.
- The macro-constraints of cotton cultivation in the State like availability of suitable land and irrigated area for cotton cultivation, high soil temperature in April-May affecting germination, uncertain monsoon etc. are limitations for cotton area expansion.
- The lone district selected in each State have achieved positive compound growth rate of production implying the increasing production potential of the three districts.
- Though the districts achieved positive compound growth rate of yield but did not equate with the compound growth of State level.

- Cotton is suitable for semi-arid tropical climate but except Aligarh and some other western Uttar Pradesh districts, its cultivation is done in humid conditions in the eastern region. The crop thus struggles to grow to its capacity in not so congenial climate.

8. Extent of Bt Cotton Cultivation and Adoption in India

The Indian cotton scenario has changed dramatically in the last few years, largely due to the widespread adoption of Bt cotton. The area under Bt cotton reached 69 lakh hectares in 2008-09 constituting nearly 73% of the total cotton area in India as per the estimates received from the States, though in reality, the Bt Cotton acreage in the country is believed to have risen to over 90% of the total cotton area. The growth in Bt Cotton area during the period 2002-03 to 2008-09 is presented in Table 13.

Table 13: Bt cotton area (lakh ha) in India

Year	Total cotton area	Area under Bt cotton	Bt cotton to total cotton (%)	Growth rate over 2002-03 (%)
2002-03	73.90	0.29	0.39	-
2003-04	78.35	0.93	1.18	220.69
2004-05	89.70	4.98	5.55	435.48
2005-06	88.73	10.14	11.42	103.61
2006-07	91.58	34.61	37.79	241.32
2007-08	95.06	63.34	66.0	83.01
2008-09	93.73	69.00	73.0	8.94

(Source : State Dept of Agriculture)

Among the major Bt cotton-growing states, Punjab and AP leads the others with 90% Bt coverage. Bt cotton area in M'shtra is about 80% despite being a rainfed cotton area. In other States like Madhya Pradesh, Bt coverage is 71%, Gujarat 51% followed by Haryana (58%) and TN (46%). However, Bt adoption is still poor in Karnataka (37%). Rajasthan has increased the acreage under Bt hybrid to 49%- up from 10% in 2007-08 implying that the farmers have started to reap the benefits of Bt Cotton primarily despite lack of adequate irrigation facility. Bt. Cotton is sustainable as evident from the increase in area year after year from its commercial release in the year 2002-03 and it is well accepted by the farmers.

State-wise area under Bt cotton cultivation (lakh ha)

States	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Haryana	0	0	0	0.107	0.420	2.79	3.46
Punjab	0	0	0	0.704	2.810	5.57	4.76
Rajasthan	0	0	0	0.023	0.050	0.38	1.48
Gujarat	0.091	0.417	1.259	1.493	4.070	13.00	14.50
Madhya	0.014	0.133	0.861	1.362	3.020	4.71	5.14
Maharashtra	0.120	0.218	1.615	5.088	16.550	25.62	25.72
Andhra	0.038	0.054	0.0712	0.904	6.570	10.00	11.43
Tamil Nadu	0.003	0.076	0.120	0.170	0.320	0.60	0.12
Karnataka	0.021	0.030	0.343	0.293	0.800	1.46	1.57
Total	**0.294**	**0.931**	**4.985**	**10.148**	**34.610**	**63.34**	**68.81**

(Source: State Dept of Agriculture**)**

The present study has brought to the fore that the extent Bt cotton adoption has seen an increasing trend through the years in all the States with the exception of Rajasthan and Tamilnadu where the beneficiaries started Bt cotton cultivation from 2005-06 and 2006-07 respectively. In Andhra Pradesh and Tamilnadu, all the sample farmers started Bt cotton cultivation since 2003-04 and 2006-07 respectively. The farmers initiated Bt cotton cultivation in 2002-03 and continuously increased through the years.

Bt cotton cultivating farmers among the non-beneficiaries (89.0%) is slightly more than the beneficiaries (86.4%). According to the survey, though the cultivation has progressively increased in both beneficiaries and non-beneficiaries fields with fluctuations in coverage, more beneficiaries took up Bt cotton cultivation in 2002-03, 2004 to 2006 and 2008-09. In the intervening years more, non-beneficiaries took up Bt cotton cultivation. As per the feedback obtained from the farmers during field survey, high yield, high return and early maturity high yield, good market, high return and improved fiber quality are important attributes for preference of Bt cotton among cotton growers across the country.

GEAC has until now approved and released 621 Bt hybrids for commercial cultivation in India. During the years 2006-07 and 2007-08, GEAC released about 42 and 76 Bt hybrids respectively for cultivation in the three zones – North, Central and South as a result of which, the coverage under Bt hybrids got momentum. While GEAC released 143 Bt hybrids in 2008-09, the number raised to a record 340 Bt hybrids during 2009-10. Initially, the price of Bt hybrids was Rs.1700 per packet of 450 gm but it has drastically reduced to Rs. 750-800 per packet during recent times resulting in a reduced sale of illegal seeds.

All the Bt hybrids, however, are not found performing well except a few and farmers are much confused about the performance of too many hybrids.

Year-wise Bt hybrids released

YEAR	Cry 1 Ac (Mon 531)	Cry 1 Ac+2Ab (Mon 15985)	Cry 1 Ac (Event 1)	Cry 1 Ab+1Ac (GFM Event)	Cry 1 Ac (BN LA601)	Cry 1 Ac (MLS9124)
	Mahyco/ Monsanto	Mahyco/ Monsanto	JK Agri Genetics	Nath Seeds	UAS, Dharwar/ IARI	Metahelix India
	2002	2006	2006	2006	2008	2009
2002	3	-	-	-	-	-
2004	1	-	-	-	-	-
2005	16	-	-	-	-	-
2006	24	7	8	3	-	-
2007	56	13	4	3	-	-
2008	44	73	7	18	1	-
2009	55	220	17	45	1	2
Total	**199**	**313**	**36**	**69**	**2**	**2 (621)**

Since most of the seed distribution is now in the hands of the private seed industry, educational and awareness programs should be organized on a regular basis and quality assurance system should be monitored as per the Seed Act and seed policy to ensure supply of genetically pure seeds with high field performance for germination and vigour to farmers.

PROGRAMME IMPLEMENTATION

9. Utilization of Funds

The Government of India has provided substantial funds to State Governments and other agencies namely, ICAR, CCI, DOCD for implementing the Mini Mission II program of TMC in the shape of assistance on various components for increasing production and productivity of cotton in the country. The cumulative funds disbursed to various agencies during the period 2002-03 to 2008-09 are Rs. 31974.46 lakhs.

The program was implemented in all cotton districts of the thirteen States selected. With the exception of West Bengal, the fund utilization in all States has been over 90%. Haryana, Rajasthan, Madhya Pradesh, Maharashtra, Orissa and Uttar Pradesh have surpassed, to varying degrees, the utilization of the released fund. Punjab spending Rs. 517.51 lakh without any fund support from GOI is an exceptional feature. Overall utilization of released fund has been over 103% and is a good achievement. The State of Punjab, however, implemented the program during 2005-06 and 2007-08 only while in the remaining years under study the State Government did neither release funds nor provided the State's share of funds for program implementation.

The overall utilization of funds by the respective nodal agencies, against releases made for the central sector programs, has been over 90% but while the ICAR institutes had spent almost 98% of the releases, other organizations lagged in utilization, spending only a little over 65%. At cumulative level, the utilization of released fund by the 13 States, ICAR and other institutions and other organizations together is 102.51%.

The data reveals that the percentage of fund utilization to total available fund fluctuated rather widely over the years. It can be seen that utilization of fund is good in Karnataka and Tamilnadu. Although Rajasthan, Madhya Pradesh, Maharashtra and Orissa, have shown improvement during the last 3-4 years, the fund utilization in most States have been generally low, partly due to delayed receipt of communication on program implementation & fund supply and partly due to the States' trivial approach

The State-wise position of unspent central funds indicate considerable amount of central assistance remaining unspent, which are carried over to the next financial year. While some States like Gujarat, Maharashtra in 2001-02, 2002-03, 2003-04 spent in excess of the allocation, Punjab has spent a lowly around 60% only during 2005-06 and 2007-08, and has not implemented the program in remaining years as the State Government refused to release the funds in remaining years. Funds left un-utilized are the obvious result of an ineffectual implementation.

10. Awareness of the Program Components

The study has revealed that an overwhelming majority of beneficiary farmers in the States were well aware of the MM II program in force since 2000-01. Over half of the beneficiary farmers became aware from government departments and research institutions / KVKs. The share of awareness generation from the interaction with fellow farmers is 36%. Sources like ICAR institutions / SAUs and cooperative societies had not contributed much on generating awareness of the program under MM II of TMC. It transpired that while Government departments have obvious responsibility for dissemination of information of the program,

fellow farmers have proved to be a vital contributor in awareness generation among farmers irrespective of the zonal confines.

The program is rated good to average by majority of the farmers but the state of technical support received by the cotton farmers is reportedly scarce. The sample survey data indicated the inadequacy and ineffectiveness at the extension level to properly and satisfactorily guide the farmers.

Components mostly preferred by farmers are Farmers' Field School (FFS), supply of plant protection equipment & certified seed. Water saving devices is still not a preferred component due to their limitations. FFS is the first choice among the components, plant protection equipments and certified seed stand as second and third preferences respectively. It is worth noticing that a large section of beneficiaries are undecided on preferring any particular component. It indicates the need for wider publicity of the program components at the grass root level

IMPACT OF PROGRAM COMPONENTS

11. Seed Production & Distribution

Seed is an important component and included in the program to motivate farmers in the use of seeds of location specific new varieties / hybrids simultaneously ensuring seed replacement with quality seed thereby ensuring productivity increase. The State Governments are eligible to procure seed from any source including private sector and distribute the certified seed directly or through other seed agencies to eligible farmers under the program. In reality, however, certified seed is not much sought after component due to the wider acceptability of Bt cotton, except in Tripura and West Bengal where location specific Bt cotton has not been released. Certified seed component is availed by the beneficiary farmers, during the last three seasons more in Gujarat, Karnataka, Tamilnadu and Rajasthan with some fluctuations. In this changed situation, the State Governments have to plan seed production of the varieties/hybrids preferred by the farmers, ensure maintenance of seed multiplication chain and make available quality seed to the farmers at a reasonable cost particularly for the non-traditional & minor cotton growing States.

The Ministry of Agriculture, Govt. of India had allotted an amount of Rs.343.70 lakh for maintenance of nucleus and breeder seed program through CICR, Nagpur during the period 2001-02 to 2008-09. The fund allocation has increased over the years and individual centres were allocated in the range of Rs. 1 to 6 lakh depending on the number of varieties taken up for maintenance and the breeder seed required to be produced. Thirteen State Agricultural Universities and CICR, Nagpur and its Regional Stations at Coimbatore and Sirsa were involved in the program. Nucleus seed production in respect of varieties and parental lines of hybrids released from State Agricultural Universities and from ICAR centres were taken up at their respective locations. Adequate quantity of Nucleus seed was produced to take up breeder seed production each year.

To protect the interest of farmers from market forces, it is necessary to train the farmers for producing seed at their own farm. This will not only provide quality seed but also at a cheaper rate. The quality seed of released varieties and parents of hybrids is being supplied to the farmers to meet their seed requirement under "Produce Seed at Your Own Farms"

concept. This is reported to be quite successful in some locations particularly at Sirsa and Hisar (Haryana) and Guntur (A.P.).

11.1 **Maintenance of Nucleus Seed**

The number of varieties and parental lines of hybrids taken up for maintenance varied from 72 to 101, released from various centers viz., PAU, Ludhiana, CCS, HAU, Hisar, RAU, Sriganganagar, IARI, Pusa, CSAUAT Kanpur, JNKVV, Khandwa, GAU & NAU, Surat, PDKV Akola, MAU, Nanded, MPKV, Rahuri, LAM Guntur, UAS, Dharwad, TNAU, Coimbatore and CICR, Coimbatore & Hisar. The land allotted for nucleus seed production varied from 1.27 to 6.0 acres. The number of progenies selected was sufficient to constitute required quantity of Nucleus seeds.

11.2 **Breeder Seed Production**

Breeder seed production of National varieties is the mandate of the Indian Council of Agricultural Research (ICAR) and is being implemented through 14 AICCIP centres situated in various State Agricultural Universities (SAUs) and the ICAR Research Institutions.

In the initial years of the MM-II program, there was lot of demand from the farming community for the seeds of released varieties and parental lines of the hybrids which were duly met through proper seed chain. Every year 250-360 quintals of breeder seeds used to be produced for further multiplication and supply to the farmers as per demand. However, with the introduction of “Bt cotton”, and wide spread adoption by farmers across the country, the production and demand of breeder seed of public sector varieties/parental lines of hybrids has come down drastically and at present it is hardly between 60-80 qtl.

Total Breeder Seed Production of different cultivars, including parents of hybrids, often surpassed the indented quantity both in respect of hybrids and varieties in all the three zones. Over the years, the breeder seeds have been distributed as per the Government of India allotment order received and there were no major mismatches between the indent received from Government of India and the production at production centers.

11.3 **Supply of Breeder Seed**

The component has been implemented in Haryana, Rajasthan, Gujarat, Maharashtra and Tamilnadu and the non-traditional Uttar Pradesh in a limited scale. Gujarat and Tamilnadu have reasonably implemented the component during the four years, each exceeding targets thrice. Implementation has been moderate in Haryana, with reasonably good achievements, exceeding the targets in 2 years with big margin, while the target is surpassed in 2006-07 in Rajasthan with moderate achievement in the remaining years. It was a mediocre performance in Maharashtra, achieving 14.6% to a little over 61% during the four years under MM-II. Uttar Pradesh has implemented it only once during 2006-07 with 40% achievement.

The need for certified seed in Haryana and Rajasthan have declined during past few years due to reduction in coverage under cotton caused by untimely & less water supply in canals and severity of cotton leaf curl virus disease leading to diversion of area to other crops. In Gujarat and Maharashtra where Bt cotton is grown in around 14 and 25 lakh ha area

respectively leaving only about 9 and 6 lakh ha to be covered under certified seed, the breeder seed requirement has substantially diminished. In Uttar Pradesh, neither the agro-climatic condition is conducive to cotton seed production nor the State have necessary infrastructure. Use of breeder seed for further seed production is thus wastage. The State, therefore, purchases its requirement of seed from other States.

Overall status is a deficient implementation that speaks of slackness in the States particularly in Punjab, Madhya Pradesh, Andhra Pradesh and Karnataka.

11.4 **Foundation Seed Production**

In view of the need for maintaining seed chain of various varieties indented/allotted, it is necessary for the seed producing agencies to ensure lifting and using the allotted quantity of breeder seed varieties/parental lines of hybrids for further multiplication.

Haryana has achieved optimum SMR in respect of the hybrids HS-6, H-1098, & HD-123 in 2000-01 and varieties RG-8 and to some extent of H-1098 in 2005-06. In the rest of the cultivars, SMR has been appreciably low in all the years. It is noteworthy that the State has lifted the seed of 14 cultivars and parents of 4 hybrids but has multiplied only 7 cultivars for foundation seed production. Information on seed lifting of parents of hybrids was not provided by the State.

In Punjab, multiplication of LD-327 has been done during all the years except 2003-04 and LH-1556 during 2000-01 to 2006-07. Breeder seed of LD 694 & HD-107 have been used during 2000-01 & LD 694 in 2002-03 and 2003-04 but no production was obtained, implying that the crop might have failed. Similarly, foundation seed of H-1117 & H 1098 was not produced despite using breeder seed. The maintenance of seed multiplication chain is moderate in the State. The multiplication chain of parental lines of AAH-1 is maintained during 2002-03 to 2005-06, and the multiplication ratio is good in respect of the female parent though breeder seed quantity of male line has not been multiplied. Overall status of breeder to foundation seed production in the State in respect of seed chain and seed multiplication ratio is moderate.

In Maharashtra, optimum SMR could be achieved in most cases with a maximum 300 times production of AC-738 (male parent of NHH-44) and 200 time production in case of DHY 286-1 (male parent of PKV Hy-2). Among the varieties, though most of the lifted seed has been utilized, optimum SMR has been achieved to a limited extent. The SMR achieved is below 40% in most of the years for various varieties. Overall position of the extent of utilization of lifted breeder seed is not in favour of maintaining healthy seed multiplication chain.

Tamilnadu has utilized entire quantity of breeder seed cultivars lifted each year during 2000-01 to 2008-09 and thus maintaining seed multiplication chain each year for all cultivars though optimum SMR is limited to fewer cultivars in few years. It is noteworthy that the State has utilized entire quantity of Breeder seed of all the cultivars in the respective years.

11.5 **Certified Seed Distribution**

The production and distribution of certified seed is primarily the responsibility of the State Governments. Certified seed production is organized through State Seed Corporations, State Agricultural Farms, SFCI and Cooperatives etc.

The scope of certified seed production has diminished to a large extent because of extensive use of Bt cotton seed in almost all the main cotton growing States, accounting for more than 70% of total coverage under the crop. Thus, only about 30% of the area needed certified cotton seed of varieties and non-Bt hybrids for optimum seed replacement rate (SRR). Actual certified seed requirement, however, diminishes further because of the use of uncertified seeds of the State released or local varieties (farmers often use own seed or uncertified seed from market) for sowing. The States are, therefore, fixing smaller targets for certified seed production lest the left over seed is required to be carried over and needed safe storage.

The implementation of this component presented a rather average achievement in most selected States. The achievement was very erratic in Karnataka and Andhra Pradesh. The major causal factors reportedly inhibiting the pace of seed distribution are - (i) Bt cotton has gained tremendous popularity amongst farmers because of their potential resistivity to bollworm but again is not eligible for seed subsidy under the program, and (iii) the present rate of subsidy provided in the scheme is reported by the States and the farmers to be too small an amount to have any effect on certified seed use. However, the farmers' survey indicates that preferred variety seed is availed by 66% farmers which were received in requisite quantity under the program but lacked in getting quality rich cultivation aspects of the seed supplied.

11.6 **Reasons for not sowing preferred variety/hybrid of certified seed**

Majority of the beneficiary farmers have reported non-availability of their preferred variety/hybrid seed of cotton for sowing. Beneficiaries in Andhra Pradesh also reported about seed being affected by pest, indicating the inferiority of seed quality. In Tamilnadu and Orissa, all the beneficiaries could get the preferred variety / hybrid for sowing. Few Beneficiaries in Haryana (6.4%), Rajasthan (7.1%), Maharashtra (16.6%), Karnataka (2.13%), Tripura (5.5%) and West Bengal (17.4%) also reported on high seed cost. Lower price in market than the subsidized price under the program is also a reason for not sowing the preferred variety/hybrid reported by few beneficiaries in Karnataka (4.3%), Haryana (25.0%), and Uttar Pradesh (6.6%).

Non-availability of preferred variety/hybrid seed, inferior seed quality and high seed cost are the principal reasons for the farmers' inability to sow certified seed of variety/hybrid of their preference.

Possible remedial measures

This is a very tricky issue as the preference of farmers for seed changes from year to year. Proper coordination between all officials/staff involved right from field level workers to the DoA is necessary to identify farmers' preference of seeds and to suitably convey to the DoA for making a note of these and taking up with seed producing agencies for their supply.

11.7 **Farmer's response on Seed quality**

Overall status indicates 67% farmers are unsatisfied with the quality of seed supplied on subsidy under the program confined in ten States. Majority complained of poor germination, poor physical appearance of the seed and uneven growth of the crop. The States with percentage of farmer beneficiaries unsatisfied with the quality of seed are: 61% in Tripura,

50% in Andhra Pradesh, 42% in West Bengal, 26.7% in Uttar Pradesh, 25% in Haryana, 19% in Karnataka, 16.7% in Madhya Pradesh and Maharashtra, 14.5% in Rajasthan and 6.7% in Gujarat.

Possible remedial measures

The complaints indicate of keeping the seeds in unscientific storage condition. The storage condition has to be improved and seed should be carefully handled.

11.8 Seed Multiplication Chain

Breeder seed is the first stage for making available physically pure certified cotton seed variety / hybrid of known pedigree having improved genetic character to the cotton farmers. In order to maintain a continuous supply of certified seed to the cotton growers, it is essential that the breeder seed is used for multiplying in stages to foundation seed and certified seed. The States often fall short of maintaining the chain to avoid carry-over of surplus certified seed. The situation has aggravated since 2003-04 with increasing area being covered with Bt cotton resulting in less requirement of public-bred varieties. It is noted that the seed chain of public-bred hybrids is better maintained compared to varieties especially in Gujarat, Madhya Pradesh, Andhra Pradesh and Karnataka. It is necessary in the given situation, to maintain a minimum stock of the varieties according to farmers' preference and continue the multiplication process.

11.9 Seed Replacement Rate (SRR)

The seed replacement rate worked out on the certified seed of varieties/hybrids supplied by the State seed agencies including private seed growers producing and supplying public-bred varieties/hybrids highlighted better seed replacement rate achieved in Haryana, Punjab, Rajasthan, Gujarat, Tamilnadu, and Uttar Pradesh in most years. The seed replacement rate in these States has shown a gradual increase over the years since 2000-01. The farmers in Madhya Pradesh, Andhra Pradesh and Karnataka are regularly cultivating more Bt cotton than public-bred varieties/hybrids for obvious reasons. Consequently the SRR in these States is low. In general, the seed replacement rate in the selected States has shown an increasing trend lately which indicates that certified seed production and their supply are sustained. The average seed replacement rate of cotton varieties at national level ranged between 28 to 39 percent during last five years. It was high in Punjab (93), Uttar Pradesh (52), Rajasthan (51), Haryana & Tamilnadu (49), Andhra Pradesh (25), Gujarat (22), Maharashtra (19) and Orissa (11). Karnataka and Madhya Pradesh recorded SRR less than 10% the former having more area under non-Bt hybrids while Bt cotton is dominant in Madhya Pradesh.

Although hybrids are not counted for arriving at the SRR, both public-bred hybrids and Bt hybrids are grown with fresh seed thereby ensuring 100% seed replacement. The latter may not be certified as a quality seed in terms of Indian Seed Certification requirements but Bt cotton has proved its worth by contributing to increasing the country's cotton productivity. Taking an overall view of the situation, the seed replacement rate in different States is no mean an achievement.

12. Plant Protection Equipments

12.1 Manually Operated Sprayers

Supply of manual sprayers under the program for using in cotton plant protection revealed that, with few exceptions, all States have consistently implemented the component except Punjab. The State has implemented only during 2005-06 & 2007-08; the program could not be implemented in the remaining period of the present study on account of financial constraints caused by non-sanctioning of funds by the State Government. The component has proved extremely popular with the farmers resulting in the targets having been exceeded overwhelmingly in all the States in almost all the years since 2000-01. According to sample survey, more than 80% sample beneficiaries received hand sprayer in the surveyed States, while all farmers in the non-traditional and minor cotton growing States received hand sprayers.

12.2 Power Operated Sprayers

The component has been consistently implemented by seven States – Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Tamilnadu and Orissa though with a widely fluctuating achievement. Best among these States is Tamilnadu with more than 80% achievement in most years, followed by Madhya Pradesh and Maharashtra. Punjab has implemented in 2005-06 and 2007-08 with 100% achievements despite apathetic attitude of the State Government.

The achievement in the distribution of power operated sprayers was very satisfying in all the States in almost all the years. Power operated sprayers were not allotted to Haryana, Rajasthan Tripura, Uttar Pradesh and West Bengal.

12.3 Tractor Mounted Sprayers

The achievement in the distribution of tractor mounted sprayers was too little and confined to only six States mainly on account of the unaffordable high cost of the equipment. Haryana and Gujarat have distributed tractor mounted sprayers in five & four years respectively. The field survey has revealed that tractor mounted sprayers were supplied only in Haryana (23.6%), Punjab (5.1%), Rajasthan (16.6%), Gujarat (2.8%) and Maharashtra (4%). It is felt that the subsidy limit for the component may need to be suitably enhanced for motivating the farmers in its use.

12.4 Distribution of Plant Protection Equipments

The frequency of distribution shows the equipment has been distributed during all nine years in Maharashtra and Karnataka, 8 years in Gujarat 7 years in Haryana and Orissa, 6 years in Punjab and Tamilnadu, 5 Years in Madhya Pradesh and Andhra Pradesh, 4years in Rajasthan, Uttar Pradesh, West Bengal and during 2005-06 to 2008-09 (3years) in Tripura.

12.5 Timeliness and Preference of Plant Protection Equipments

- More than 80% beneficiary farmers in Haryana, Punjab, Gujarat, Karnataka, Tamilnadu and Orissa, 61 to 80% beneficiary farmers in Rajasthan, Madhya Pradesh, Maharashtra,

Tripura and Uttar Pradesh, 42% in Andhra Pradesh and 8% in West Bengal affirmed that the sprayers were made available in time.

- About 83% beneficiary farmers in Tamilnadu, 61 to 80% in Haryana, Gujarat and Karnataka and 20 to 50% in the remaining States reported to have got Sprayer of their choice.

- It is evident that not many of the beneficiaries were getting the Sprayer of their choice but had to accept whatever was made available.

Possible Remedial Measures

- The farmers' choice of sprayer should be gathered by the extension workers beforehand for supply at right time to the beneficiaries.

- The procedure of arbitrary promotion/distribution of sprayers should be stopped. The distribution should be based on farmers' choice.

13. Farmers' Field School

The concept of Farmer Field School (FFS) was introduced as a component of MM-II in 2005-06 for providing season long training to farmers, enabling them grow healthy crop adhering to right crop management practices. It has been in operation since 2005-06 in all States with the exception of Gujarat, Madhya Pradesh, Uttar Pradesh and Karnataka during 2007-08 & 2008-09. Achievement has been good in most States in the four years of the components' introduction with average performance in few years in Madhya Pradesh, Andhra Pradesh, Uttar Pradesh and West Bengal. FFS has gained popularity with farmers who seem to be much convinced about the training module and innovative method of 'learning by doing' approach.

The study has brought out that only few farmers availed the component in the initial years but as the perception of its utility increased, more and more farmers have opted for the component in the later years. Thus, the extent of beneficiaries rapidly increased to almost 50% in just four years. It has been gathered that all topics under training are not covered in different FFS. Looking to the significance of the component, all technologies propagated in the three types of front line demonstrations need to be included in the curriculum of these schools and precisely followed.

Since its introduction under MM II of TMC in the year 2005-06, the FFS on cotton was operative in all the cotton growing States. 105 beneficiary farmers got organized farmer field school in their own field during the four years. 9.1% to 54.5% beneficiaries in Gujarat and about 11.0% to 40.6% in Maharashtra got organized farmer field school in their own field in the four years. 37.5% in 2007-08 and 25.0% each in 2005-06 and 2008-09 in Karnataka, 16.6% beneficiary farmers in 2007-08 & 66.6 % in 2008-09 in Haryana, 66.6% in 2005-06 & 33.3% in 2006-07 in Tamilnadu and 50% beneficiaries in West Bengal also got organized farmer field school in their own fields.

Management Parameters of FFS

- 95.6% beneficiary farmers in Karnataka, 40% in Maharashtra and 29% in Tamilnadu affirmed that benchmark survey was conducted before starting of FFS in their area. Less

than 10% farmers affirmed in other States, implying that benchmark survey of the village is not done as per requirement.

- Affirmation by beneficiary farmers on conduction of evaluation study at the end of the training program at the FFS was highest - over 95% in Karnataka, 38% in Maharashtra and 35.3% in Tamilnadu. In the remaining States the affirmation was less than 14.3% (Tripura)

- Overall affirmation by beneficiary farmers has been 31.6% and 30.6% respectively for bench mark survey before start of the FFS and evaluation study at the end of the season to ascertain impact. Maharashtra, Karnataka and Tamilnadu are the three States where there is a semblance of systematic approach.

- This implies, with the exception of Karnataka, that the FFS are not systematically managed and grooming of farmers to function as facilitators and scouts is not coming about even though the program is under implementation for considerable period**.**

Possible Remedial Measures

- FFS to be set up in the field of outstanding and progressive cotton growers or in a Government / Non-Government Institution
- FFS once setup should continue at least for a min. period of 3 yrs with some limited financial assistance so as to ensure due stability, subject, however, to their satisfactory performance
- An expert scientist, preferably from KVK or an agripreneur should be appointed as "Coordinator" for periodic monitoring of functioning of the schools.
- Performance of all the FFS in each block should be reviewed at the FIAC meetings on a half-yearly basis. Knowledge and skills of facilitators should be upgraded on a continuous basis through training at district / State level institutions and exposure visits, etc.

The level of adoption among sample farmers and sharing of knowledge appears reasonably good wherein more than 75% farmers adopted and shared with other farmers the knowledge gained from the training and a little over 50% of the latter have adopted most of the knowledge acquired from the beneficiaries. The situation is encouraging but still needs to be vigorously followed up for the whole exercise to bear the desired result**.** The entire Central sector Schemes are also included FFS in their program. The object to scale down the pesticide consumption, cost of production and to opt for higher production of quality cotton were fulfilled by the implementation of FFS. Under MM-I,I annually 2.0 lakh farmers are being trained through season long FFS program.

Overall situation, though, do not reflect a satisfactory image of conducting FFS in all States. FFS are plagued with irregular conduction, old technology dissemination and low proficiency of the facilitators conducting the schools. A major drawback noticed during field survey was that the Farmer Field Schools were not well-structured and were functioning in a hap-hazard manner without a continuous control mechanism. Further, the much needed grooming of farmers to function as farmer facilitator is not coming about even though the program is under implementation for considerable period. The schools are reportedly not functioning in accordance with the stipulated guidelines making the whole exercise futile and failing to

deliver. It is, therefore, imminent that these schools are run in a professional way since these have become prime centers of technology dissemination.

14. Setting up of Bio-agent Laboratories

Looking to the importance of IPM technology, bio-agents and bio-pesticides should be more easily available in sufficient quantity to effectively replace the eco-destructive effect of chemical insecticides. The effectiveness of bio-agents is already established and this should be exploited to the maximum extent possible. There is welcome trend of increased share of farmers using bio-agents / bio-pesticides for bio-control of cotton pest & insects.

The component has been implemented very sparingly by 12 States in few years except Uttar Pradesh and Madhya Pradesh. Karnataka is by far the best performing State, implementing the component in 5 years (2000-01, 2001-02, 2003-04, 2005-06 and 2006-07) while Tamilnadu implemented in 2003-04, 2005-06 & 2006-07 (3years) and West Bengal in 2007-08,2008-09 (2years). Maharashtra has not reported any physical achievement in terms of number of labs setup though it has spent funds allocated possibly for strengthening existing units, capable of producing bio-agents for an area of about 10000 ha.

15. Surveillance and Monitoring of Pests and Diseases

Surveillance is an essential pre-requisite for effective crop pest/disease management by identifying occurrence of hot spots of pest and disease and to keep a watch on the pest/ disease situation for taking timely control measures, preventing insects from reaching damaging proportions. Managing the incidence below ETL pest management has to begin right from the beginning i.e. before eggs are laid. Control measure is taken only if pest build-up crosses ETL. Pest scouting is done at weekly intervals on randomly selected 20 plants per acre in early stage of crop growth. The weekly surveillance and monitoring report on the situation of insect, pest and disease forms the basis for taking proper decision on remedial measures.

The adoption of surveillance and monitoring exercise by States is observed to be slow. The performance of Maharashtra, Tamilnadu and Orissa are consistently good, achieving 80% to over 100% in most years while that of Haryana, Rajasthan, Gujarat, Karnataka and Tripura are moderate. The data indicates that the States are yet to organize themselves to recognize the importance of surveillance and field scouting and thus fail to take full technological advantage of the exercise.

16. Distribution of Bio-agents / Bio-pesticides

Bio-agents/Bio-Pesticides are crucial inputs of IPM technology, based on the inbuilt eco-mechanisms of bio-control through predators, pathogen and parasitoids. Though the concept of bio-agent use has become popular among cotton farmers, inadequacy in availability of bio-agents in the market and non-synchronization with the pest/disease surveillance mechanism has been an impediment in wider and effective use of this vital method of cotton pest control. During the TMC period, 54 bio-agent production units have been sanctioned to various commercial agencies with expected large area coverage. The production of bio-agent, bio-pesticides, trico card, Bt formulations etc. have been started by the public sector.

The States have been found to be still lacking in giving required thrust to enhance supply of bio-agents/bio-pesticides. Despite bio-agent/bio-pesticides being crucial inputs for plant protection today, feedback from the sample survey on various parameters of supply does not provide a bright enough picture and points to shortage in quantity, compromise in quality and delay in availability. Above all, quality technical support is also not forthcoming from government departments or few others supplying bio-agents/bio-pesticides. Such a situation is not going to sustain effective execution of IPM technology.

- 80 to 100% beneficiary farmers in Haryana, Gujarat, Karnataka, Tamilnadu, Tripura and 60 to 79% beneficiary farmers in Punjab, Madhya Pradesh, Maharashtra, Andhra Pradesh, Orissa, Uttar Pradesh and West Bengal reported the bio-agent/bio-pesticides received in time.
- Only 25% beneficiary farmers in Rajasthan reported the bio-agent/bio-pesticides received in time.
- 80 to 100% beneficiary farmers in Punjab, Gujarat, Andhra Pradesh, Karnataka, Tamilnadu and 60 to 79% beneficiary farmers in Haryana, Rajasthan, Madhya Pradesh and Maharashtra found satisfactory quality of the bio-agent/bio-pesticides, supplied under the program.
- 40 to 59% beneficiary farmers in Orissa, Uttar Pradesh and West Bengal reported the quality of the bio-agent/bio-pesticides, supplied under the program as satisfactory

Possible Remedial Measures

For improvement in the timeliness of supply and satisfactory quality of bio-agent/bio-pesticides the State governments has to promptly arrange and distribute the inputs to the districts and ensure their availability at the field level in time. Rajasthan, Orissa, Uttar Pradesh and West Bengal appear to have faltered on this count. The feedback points to shortage in quantity, compromise in quality and delay in availability of bio-agent/bio-pesticides.

Impact of using Bio-agents/Bio-pesticides

- It is revealed that more than 80% beneficiary farmers in Punjab, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Tamilnadu and Tripura have benefited from use of bio-agent/bio-pesticides.
- In Haryana, Rajasthan, Madhya Pradesh, Orissa, Uttar Pradesh and West Bengal 60 to 80% beneficiary farmers affirmed savings in plant protection chemicals.
- The reduction on average number of spraying with chemicals is 2 to 3 in Haryana, Gujarat, Maharashtra, Tamilnadu and Tripura. In other states the average reduction is 1 to 2.
- Average cost of plant protection chemicals saved is more than 20% in Gujarat, Maharashtra, Karnataka, Tamilnadu, Orissa and Tripura.
- In Haryana, Punjab, Rajasthan, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh and West Bengal the average cost of chemicals saved is 11 to 20%.
- More than 80% beneficiary farmers in Tamilnadu and Orissa, 60 to 80% beneficiary farmers in Haryana, Punjab, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Uttar

Pradesh and West Bengal and about 47% in Madhya Pradesh and Karnataka viewed the bio agent/ bio pesticides safe for health.

- More than 80% beneficiary farmers in Rajasthan, Maharashtra, Andhra Pradesh, and West Bengal, 60 to 80% beneficiary farmers in Madhya Pradesh and Orissa, 40 to 60% in Punjab, Gujarat, Karnataka and a lesser section in Haryana and Uttar Pradesh viewed these as cheaper compared to the traditional plant protection chemicals.
- 40 to 61% beneficiary farmers in Punjab, Gujarat Maharashtra, Andhra Pradesh and Karnataka, 20 to 40% in Haryana, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh and West Bengal and fewer beneficiary farmers in Rajasthan, Tamilnadu and Orissa found the bio-agent/bio-pesticides very effective.
- There is no doubt that the bio-agents and bio-pesticides have become very useful inputs with the cotton farmers for insect/pest control in cotton. The impact is more or less uniform in all the States as visible in the feedback obtained on various aspects of these inputs.

17. Reduction in Pesticide Consumption & Number of Spray

The study has revealed that there has been a substantial savings on plant protection chemicals use by way of reduced spray of chemicals against cotton pests and insects, some of which cause deadly disease like CLCV. It is revealed that more than 80% beneficiaries in Punjab, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Tamilnadu and Tripura have benefited from use of bio-agents/bio-pesticides. The reduction on average number of spraying with chemicals is 2 to 3 in Haryana, Gujarat, Maharashtra and Tamilnadu. In other States, the average reduction is 1 to 2. In the process, the farmers also registered a cost savings on plant protection chemicals. Average chemical cost saved, at aggregate level is about 17% in North Zone, slightly more than 26% in Central and South zones; in remaining Zone States the saving is about 19%, biggest saver being Gujarat (29.0%) , followed by Karnataka (28.7%) and Maharashtra (26.5%).

Due to popularization of IPM & IRM strategies, the pesticide consumptions has been reduced by more than 30-40% especially in the States of Andhra Pradesh, Haryana, Maharashtra, Gujarat and Tamilnadu. Sufficient number of Cotton Master Trainers has been generated through season long ToF program in all the States for running large number of FFS. Pesticide consumption has been declined from 46.20 thousand tones to 41.02 thousand tones due to popularization of IPM/IRM and FLDs. Maximum reduction of pesticide was noticed in Andhra Pradesh followed by M.P., Karnataka, Rajasthan and Tamilnadu.

Cotton consumed nearly 52% of total pesticide consumption in India during 1979 which further increased to 54% during 1996. But during 2007, only 35% of total pesticide consumption was used in cotton.

Year	**1979**	**1988**	**1996**	**2007**
% Pesticide Consumption	52	38	54	35

The number of spray of pesticide by the farmers has been reduced from 15 to 8 numbers. The IRM module has been popularized to reduce the resistance to insecticides in 28 districts where pesticide consumption was more. 58 bio-agent production units have been

established in different States to strengthen the availability of quality bio-agents and bio-pesticides in proper time.

The study reveals that 43% farmers reduced quantity of pesticides use by 25-50%, 14.9% farmers reduced quantity of pesticides use by 50-75%, 36.80% farmers reduced quantity of pesticides use by 50-75%, 36.80% farmers reduced quantity of pesticides use by less than 25% and there was 41.40% saving in expenditure on plant protection. Use of neem based pesticides, MSKE, bio-pesticides, organic chemicals, pheromone traps; bio-agents etc. have increased significantly. Decline in pesticides spray from 15 to 6 numbers in North, 20 to 8 in South and 12 to 6 in Central Zone showed the significant impact in pesticide use reduction.

18. Water Saving Devices

Water saving technologies have been devised to enhance cotton area under irrigations and to improve water use efficiency, consequently effecting reduction in cost of cultivation and increase in yield. Sprinkler irrigation and drip irrigation are such that are particularly beneficial in areas where irrigation water is scarce.

18.1 Distribution of Sprinkler Irrigation Sets

The component has been implemented by 10 States including Orissa (in 2004-05 to 2008-09) and Uttar Pradesh (in 2005-06 & 2008-09). Among the main cotton growing States, Madhya Pradesh implemented during all the nine years. The sprinkler irrigation is widely accepted by the farmers particularly in Madhya Pradesh, Maharashtra, Karnataka and Tamilnadu, as found during field survey. Enough planning is, however, necessary to supply this water saving device based on land holding size, cropping system and irrigation potential of the area. This device of water saving in irrigation has, thus, not really been exploited to its potential.

Information on quantum of irrigation water saved was gathered through sample survey of sprinkler irrigation set beneficiaries. The data showed that highest section of sprinkler set beneficiaries responded to above 35% saving in water for irrigation. Noteworthy is the difference of over 53 percentage points between the section of beneficiaries saving water by 20 to 35% and above 35%. It is apparent that the savings in irrigation water is on account of using sprinkler irrigation for irrigation provided under MM II of TMC. Benefits received by the sample farmers due to use of the sprinkler irrigation sets are on an average 1.12 ha. area of additional coverage under irrigation, and over 6% increase in the number of irrigations with increase in yield to the extent of slightly over 176kg/ha.

- Beneficiary farmers in Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh and Orissa received sprinkler irrigation sets.
- In others, particularly the three northern States and the minor and nontraditional cotton growing States (except Orissa), the beneficiary farmers were not keen to receive the sets for irrigation for obvious reason.

Beneficiaries' perception of advantages of Sprinkler irrigation sets

- Beneficiary farmers affirmed average additional area coverage under sprinkler irrigation by over 2.00 ha in Gujarat, 1.00 to 2.00 ha in Maharashtra, Andhra Pradesh, Karnataka and less than 1.00 ha in Madhya Pradesh and Orissa

- Beneficiary farmers were able to increase average number of irrigation by 4 to 7 in Gujarat, Andhra Pradesh and Karnataka, 7 to 10 in Madhya Pradesh and Maharashtra and over 10 in Orissa.

- The achievement in average additional yield as reported by beneficiary farmers are more than 200 Kg/ha in Gujarat and Maharashtra, 100 to 200 Kg/ha in Madhya Pradesh, Andhra Pradesh and Orissa; in Karnataka it is least - 59.2 Kg /ha.

Possible Remedial Measures

The advantages gained from sprinkler irrigation set use depended on various biotic factors prevailing in a particular location and cannot be equated or compared. However there is always scope for improvement by adopting appropriate recommendations of research institutions.

Irrigation water saving by sprinkler irrigation set

State	% of beneficiary farmers			
	No water saving	10-20% saving	20-35% saving	above 35% saving
GUJARAT	0.00	0.00	4.00	96.00
MADHYA PRADESH	0.00	18.75	31.25	50.00
MAHARASHTRA	0.00	2.04	22.45	73.47
ANDHRA PRADESH	0.00	1.96	25.49	72.55
KARNATAKA	0.00	0.00	33.33	66.67
ORISSA	0.00	0.00	0.00	100.00

- The impact of sprinkler irrigation set use in irrigation water saving, as shown in above table, reveals that all beneficiaries have been able to save irrigation water.

- 80 to 100% beneficiary farmers in Gujarat and Orissa, 60 to 80% in Maharashtra, Andhra Pradesh and Karnataka and 50% in Madhya Pradesh saved more than 35% irrigation water.

- 22 to 33% farmer beneficiaries in Madhya Pradesh, Maharashtra, Andhra Pradesh and Karnataka saved 20 to 35% irrigation water.

- Fewer farmer beneficiaries in Madhya Pradesh, Maharashtra and Andhra Pradesh also saved 10 to 20% irrigation water.

- Noteworthy is the difference of over 53 percentage points between the section of beneficiaries saving water by 20 to 35% and above 35%. It is apparent that the savings in irrigation water is on account of using sprinkler irrigation for irrigation provided under MM II of TMC

18.2 Distribution of Drip Irrigation System

Under MM II, the drip irrigation system was supplied in eight States for various periods with widely fluctuating achievements. There was steep increase in beneficiaries' response in 2006-07 and 2007-08 in all States of Central Zone. Andhra Pradesh (2006-07) and Rajasthan (2007-2009) have implemented the component in the selected districts. Gujarat and Madhya Pradesh are the only two States that have implemented the component in 8 years signifying that implementation of the component is not consistent as per the water availability status of the States and that high cost of the device and its installation is a hindrance in its wider use. The present day need is to identify the farming and cropping systems as are suitable for drip irrigation with due consideration on water availability and irrigation potential of the area. This equipment of irrigation water saving has thus not really been exploited to its potential.

- Beneficiary farmers in Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, and Orissa received drip irrigation systems for cotton irrigation.
- Beneficiary farmers in other States did not prefer getting the drip irrigation systems for irrigating cotton crop.

Beneficiaries' perception of advantages of drip irrigation system

- Beneficiary farmers affirmed average additional area coverage under drip irrigation system by over 1.00 ha in Rajasthan, Gujarat, Maharashtra and Andhra Pradesh and less than 1.00 ha in Madhya Pradesh and Orissa
- Beneficiary farmers were able to increase average irrigation cycle by 20 to over 45 times in Rajasthan, Gujarat, Madhya Pradesh, Maharashtra and Andhra Pradesh, while it was 6 times in Orissa
- Average additional yield obtainable from drip irrigation system is more than that of sprinkler irrigation set. The achievement in average additional yield affirmed by beneficiary farmers are more than 300 to 400 Kg/ha in Gujarat, Madhya Pradesh and Andhra Pradesh, over 400 Kg/ha in Rajasthan and Maharashtra and 200 Kg /ha in Orissa. Maharashtra farmers affirmed receiving average additional yield to the extent of 569 Kg /ha.

Irrigation Water saved by drip irrigation system

The survey data on quantum of irrigation water saved by using drip irrigation system showed that most (72.6%) drip irrigation beneficiaries saved on irrigation water by more than 35%. Noteworthy is the difference of over 49 percentage points between the section of beneficiaries saving water by 20 to 35% and above 35%. It is apparent that the savings in irrigation water is on account of using drip system for irrigation provided under MM II of TMC. Beneficiaries also reported average coverage of additional area to the extent of 1.2 ha by using the device. Though the farmers get sprinkler / drip irrigation sets at 50% subsidized price, yet the high cost of these devices is a deterrent in their use by farmers.

State	% of Responses			
	No water saving	10-20% saving	20-35% saving	Above 35% saving
RAJASTHAN	0.00	0.00	0.00	100.00
GUJARAT	0.00	5.26	21.05	73.68
MADHYA PRADESH	0.00	0.00	37.84	62.16
MAHARASHTRA	0.00	6.67	20.00	71.11
ANDHRA PRADESH	0.00	0.00	13.64	86.36
ORISSA	0.00	100.00	0.00	0.00

- The impact of drip irrigation system in irrigation water saving, as shown in above table, reveals that all beneficiaries have been able to save irrigation water.
- 80 to 100% beneficiary farmers in Rajasthan and Andhra Pradesh, 60 to 80% in Gujarat, Madhya Pradesh and Maharashtra saved more than 35% irrigation water.
- 20 to 40% farmer beneficiaries in Gujarat, Madhya Pradesh and Maharashtra, and less than 20% in Andhra Pradesh saved 20 to 35% irrigation water.
- 100% beneficiary farmers in Orissa and fewer in Gujarat and Maharashtra also saved 10 to 20% irrigation water
- Noteworthy is the difference of over 49 percentage points between the section of beneficiaries saving water by 20 to 35% and above 35%.

19. Front line Demonstrations (FLDs)

The Front Line Demonstration (FLD) is an extension program for disseminating new technologies developed by the scientists on crop production, pest control, efficient water use, post harvest management and other crop management practices. The All India Coordinated Cotton Improvement Project (AICCIP) and Cotton Corporation of India (CCI) act as the Nodal Agencies for conducting the Cotton FLD Programmes in the country with 100% financial assistance provided under Mini Mission II of TMC.

During the pre-TMC and TMC period upto 2005-06, there was no separate categorization of Front Line Demonstrations. Subsequently, from the year 2006-07, the pattern of the program was spread into three exclusive categories namely, FLD on Production Technology (PT), FLD on IPM Technology (IPM) and FLD on Farm Implements (FI) so as to give complete thrust and focus to each of them in view of their vital significance in increasing production and productivity of cotton in the country.

Major technologies transferred through FLDs include popularization of new cotton varieties and hybrids, integrated plant nutrient management practices, integrated pest management strategies, disease management practices, cotton hybrid seed production, intercropping, drip irrigation system, seed treatment with bio-fertilizers for sustainable yields, soil moisture conservation techniques, residue management including vermi-composting and foliar nutrition. The main emphasis in all these demonstrations was to enhance the production of cotton in low productivity areas / problematic areas with an improved package. The important farm implements demonstrated have largely been – Tillage (rotovator, furrow maker, harrow, plough, tiller, stalk up-rooter, stalk shredder); Sowing / Planting (dibbler,

seed treatment drum, planter and seed drills); Weeders; Sprayers; Ginning and Delinting Machine.

19.1 FLDs on Production Technology

- FLDs on production technology was organized in beneficiary farmers' field during 7years in Haryana, 5 years in Maharashtra, 4 years in Madhya Pradesh and Tamilnadu, 3 years in Punjab, Rajasthan, Gujarat, Karnataka and Orissa and lesser in remaining States.

- The front line demonstrations organized covered use of high yielding varieties/ hybrids and approved transgenic cotton seed, use of bio agent/ bio pesticides, use of micro nutrients and secondary nutrients, inter cropping system in cotton, use of water saving devices and water management technology, and IPM/ IRM technology.

Extent of adoption of knowledge gained

- Demonstrations were found useful by over 80% beneficiary farmers in Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Tamilnadu, Orissa, Tripura and West Bengal, 60 to 80% in Haryana, Madhya Pradesh and Uttar Pradesh and a lowly 53% in Punjab, signifying a marginal impact.
- The extent of adoption of the knowledge of technologies followed in the front line demonstrations by most fellow farmers have been 60 to 80% in Karnataka, Tamilnadu, Orissa, Tripura and West Bengal, 40 to 60% in Gujarat, Maharashtra and Andhra Pradesh and upto 40% in Haryana, Punjab, Rajasthan, Madhya Pradesh and Uttar Pradesh where the adoption has been low among fellow farmers.

Possible Remedial Measures

- The front line demonstrations in Punjab were held in 2002-03, 2007-08 and 2008-09 covering, use of high yielding varieties/ hybrids and approved transgenic cotton seed and IPM/IRM technology. The demonstrations were fewer and left out many important topics. This has been the reason for marginal impact and will improve once the State organizes regular front line demonstrations on the proposed Integrated Crop Management.
- Adoption of technologies followed in the front line demonstrations have been low among fellow farmers in the States where the demonstration had been fewer and organized after a long gap which defeats the very purpose of the FLDs. It is vital for continuous dissemination of the latest technology the States should take-up organizing front line demonstrations every year.

Increase in yield of fields under FLD (Production technology) over farmers practice

- An exercise was done for comparing the average yields in fields under FLDs and fields under farmers' practice. It revealed that the yield obtained in FLD demonstration fields is generally higher than those of farmers' practice in all the 13 States to varying degree. The average yield is more than 40% in Karnataka; 20 to 40 % in Rajasthan, Orissa and West Bengal; 10 to 20% in Maharashtra and Andhra Pradesh. In the remaining States the yield difference is less than 10%.
- Increase in average yields of demonstration plots over farmers practice implies impact of the component by proving superiority of production technology propagated through FLD.

19.2 FLDs on Integrated Pest Management (IPM) Technology

- The FLD on integrated pest management was organized in beneficiary farmers' field during 6 years in Rajasthan, 5 years in Maharashtra, 4 years in Haryana, Gujarat and Uttar Pradesh, 3 years in Punjab, Karnataka, Tamilnadu and West Bengal, twice in Orissa and once in Andhra Pradesh.
- Seven among the selected non-beneficiary farmers have used IPM technology for plant protection in cotton on their own field after getting awareness through IPM demonstrations and from fellow farmers. These farmers have used the IPM technologies in Gujarat during 2006-07 to 2008-09 and in Karnataka and Punjab in 2008-09.

Extent of adoption of knowledge gained

- 80 to 100% beneficiary farmers in Haryana, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Tamilnadu, Orissa, Uttar Pradesh and West Bengal, and 71% in Punjab termed the FLD on integrated pest management useful.
- The extent of adoption of the knowledge of technologies followed in the front line demonstrations by most fellow farmers have been 80 to 100% in Karnataka and West Bengal, 60 to 80% in Gujarat, Maharashtra, Andhra Pradesh and Orissa, 40 to 60% in Haryana, Punjab, Rajasthan and Tamilnadu, and 28% in Uttar Pradesh.
- The adoption in Haryana, Punjab, Rajasthan, Tamilnadu, and Uttar Pradesh has been low among fellow farmers.

Possible Remedial Measures

- Adoption of technologies followed in the front line demonstrations have been low among fellow farmers in the States where the demonstration had been fewer and organized infrequently which defeats the very purpose of the FLDs. It is crucial for consistent dissemination of the latest technology the States should be serious in organizing front line demonstrations every year.

Advantages of FLDs on IPM/IRM technology perceived

- It is revealed that more than 80% beneficiary farmers in Haryana, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Tamilnadu, Orissa and West Bengal, 60% in Punjab and 56% in Uttar Pradesh have been benefited from savings on plant protection chemicals to different extent.
- The reduction in average number of spraying with chemicals is reported by beneficiary farmers more than 3 in Gujarat and Tamilnadu, 2 to 3 in Haryana, Rajasthan, Maharashtra and Orissa and 1.5 to 2 in Punjab, Andhra Pradesh, Karnataka, Uttar Pradesh and West Bengal.
- According to the beneficiary farmers, the average cost of plant protection chemicals saved is highest – over 41% in Gujarat, 33% in Rajasthan, 20 to 30% in Haryana, Maharashtra, Karnataka, Tamilnadu, Orissa and West Bengal, 10 to 20% in Punjab, Andhra Pradesh and Uttar Pradesh.
- Seven among the selected non-beneficiary farmers who have used IPM technology for plant protection in cotton on their own field confirmed having been benefited from

savings on plant protection chemicals, gained from reduction of spraying with chemicals to 3 sprayings in Gujarat and 2 sprayings in Punjab and Karnataka.

- The extent of advantages gained by farmers in Punjab, Andhra Pradesh and Uttar Pradesh is generally at a low level.

Possible Remedial Measures

- The agro-climatic situation in the three States is different and so are the cultivars under cultivation. Thus no common remedy can be prescribed. It is however apparent that the agriculture department and the extension wing in these States are not alive to the limitations.
- The reduction in average number of spraying with chemicals, the average cost of plant protection chemicals saved have been least in these States signifying the need for a thorough examination.

Increase in yield of fields under FLD (IPM/IRM technology) over farmers practice

- An exercise was done for comparing the average yields in fields under FLDs and fields under farmers' practice. It revealed that the yield obtained in the FLD fields are generally higher than those in farmers' practice in all the States to varying degree, except in Uttar Pradesh, where the average yield showed a slight negative value (0.006%). In Tamilnadu average yield is higher in FLD fields by 30% and about 19% in West Bengal; the average yield is higher by 5 to 6 % in Andhra Pradesh, Karnataka and Orissa and by 1 to 2% in Haryana, Punjab, Rajasthan, Gujarat and Maharashtra.
- Increase in average yields of demonstration plots over farmers practice implies impact of the component by proving superiority of production technology propagated through FLD.

19.3 FLDs on Farm Implements

- The FLD on farm implement was very sporadically organized by eight of the 13 States during the four years of its initiation.
- In beneficiary farmers' fields the FLDs were organized during 2 years in Haryana and Punjab, and during one year in Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Karnataka and West Bengal.
- The FLDs on farm implement are organized in too few States in too few years. It was implemented in one State in 2005-06, none in 2006-07 and in four States each in 2007-08 & 2008-09.

Possible Remedial Measures

- Accessibility to the technology gets wider coverage among farmers if FLDs are conducted by the State Departments of Agriculture. It is therefore suggested to conduct the FLD on farm implements by all State Department of Agriculture in increased numbers to cover more farmers. Enhanced funds as required should be allocated accordingly

Implements under use in the FLD on Farm Implements

- 100% beneficiary farmers in Maharashtra and Karnataka and 40 to 60% in Punjab and Rajasthan used tillage implements; 100% beneficiary farmers in Haryana, Rajasthan, Madhya Pradesh, Maharashtra, Karnataka and West Bengal used implements for sowing; implements for inter-culture are used by 100% beneficiary farmers in Rajasthan, Madhya Pradesh, and Karnataka, and 75% farmers in Haryana; Sprayers are used by 100% farmers in Madhya Pradesh and Maharashtra, 40 to 60% in Punjab and Rajasthan, and by 25% in Haryana; While implements for post-harvest technology is used by Haryana only, Gujarat has used other implements like land leveler, water saving devices etc.

Beneficiaries' perception on usefulness and adoption of technology

- 80 to 100% beneficiary farmers in Punjab, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra and Karnataka, and 75% in Haryana termed the FLD on farm implements useful.
- Sharing of the knowledge of technologies followed in the front line demonstrations by fellow farmers have been 80 to 100% in Punjab, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra and Karnataka, and 75% in Haryana and 75% in Haryana.
- The extent of adoption of the knowledge of technologies followed in the front line demonstrations by most fellow farmers have been 100% in Gujarat, Maharashtra and Karnataka 50% in Rajasthan, about 67% in Haryana and 25% in Punjab.
- The adoption of the knowledge of technologies has been good to satisfactory among fellow farmers in the few States where FLDs on farm implement are organized barring Punjab.

Possible Remedial Measures

Adoption of technologies followed in the front line demonstrations can be low among fellow farmers in Punjab where the demonstration had been organized infrequently which defeats the very purpose of the FLDs. It is crucial for consistent dissemination of the latest technology that the States should seriously organize front line demonstrations as per schedule every year.

Perception of beneficiary farmers on advantages gained though FLDs on farm implements

- Beneficiary farmers of FLDs on farm implement affirmed having saved average time in field operation with the implements in one hectare area by 2 to 5.8 hours.
- Least time saving of 2 hours is reported in Maharashtra, 3.5 hours in Rajasthan, 4 hours each in Madhya Pradesh & Karnataka, 5 hours in Haryana and 5.80 hours in Punjab.
- In monetary terms the savings ranged between Rs.50.00 and Rs.537.00 reported by beneficiaries in different States.
- Least amount saved is Rs.50/- per ha in Maharashtra and Haryana, Rs.150/- per ha in Karnataka, Rs.344/- per ha in Punjab, Rs.400/- per ha in Madhya Pradesh and a maximum of Rs.537 /- per ha in Rajasthan.

Increase in yield of fields under FLD (farm implements) over farmers' practice

- An exercise was done to compare the yield gains by following technology demonstrated in the FLDs on farm implements with the average yields obtained in fields under farmers' practice. It revealed that the yield obtained in the fields under FLD is generally higher than those in farmers' practice in all the implementing States under study to varying degree. The highest yield increase, slightly over 14%, is seen in West Bengal; minimum is about 3 %, (2.70% to be precise), in Rajasthan. 5 to 10% increase is seen in Haryana, Punjab, Maharashtra and Karnataka while Gujarat and Madhya Pradesh showed relatively lower increase of 4.20% & 4.76% respectively.
- Increase in average yields of demonstration plots over farmers practice implies impact of the component by proving improved operation of the farm implements propagated through FLD.

19.4 State-wise Impact of FLDs

The data obtained from an exercise done to compare the yield gains by adopting technologies demonstrated under FLDs with the average yields obtained in fields under farmers' practice revealed that the demonstration plot yields are generally higher than the farmers practice ranging from 6% to 41% in different States. The increase in yield over farmers' practice was recorded highest in Rajasthan (23%) in North Zone, in Orissa in Central Zone and in Andhra Pradesh in South Zone. At all India level, the FLDs on production technology recorded an increase in the mean average yield of 18% over farmer practice with the average yields in FLDs and in farmer practice being 2029 kgs/ha and 1722 kg/ha respectively. Overall percentage increase in average yields of demonstration plots over farmers' practice have been 18% implying superiority of production technology propagated through FLD.

The State-wise average yield of FLDs conducted on IPM Technology show that the increase in mean yield of demonstration field over the mean average yields obtained in fields under farmer practice varied from 4.8% (Karnataka) to 31.5% in the various States. The increase in yield over farmers' practice was recorded highest in Rajasthan (27.3%) in North Zone, in Madhya Pradesh (25.8%) in Central Zone and in Tamilnadu (31.5%) in South Zone. At all India level, the FLDs on IPM recorded an increase in the mean average yield of 14% over farmer practice with the mean average yields in FLDs and in farmers' practices being 2081kgs/ha and 1818 kg/ha respectively.

19.5 Overall Impact of FLDs

In majority of the crop technology demonstrations organized in farmers' fields under FLDs, the yield realization was better and higher increase was seen over control practices. It is noteworthy that the increase in mean average yield of the FLDs in the total demonstrations on introduction of new cotton varieties and hybrids over the mean average yields obtained in all check fields under farmer practice was 19.05% and ranged around 18.5% to 19.3% between the Zones. For agronomic management, it was 20.18% over the check fields and ranged from varied from 18.1% to 25.7% (Central Zone).

For demonstrations on IPM practices, the increase in mean average yield of the FLDs in the total demonstrations over the mean average yields obtained in all check fields under farmer

practice was 15.09% and ranged from 7.12 in Central Zone, 13.97 in North Zone and 25.15 in South Zone.

20. Insecticide Resistance Management (IRM) Program

The Insecticide Resistance Management program was initiated during 2002-03 and is being implemented by CICR through SAUs, ICAR centers and other recognized agricultural organizations in collaboration with State Department of Agriculture. IRM modules have been developed by CICR, Nagpur and disseminated in 28 cotton-growing districts of 10 states, which utilize 85% of the total insecticides used on cotton in India. All Plant protection related sub components under MM-II are coordinated in the IRM villages of selected districts and, therefore, surveillance of pest and diseases component is not implemented.

The Government of India, Ministry of Agriculture has provided funds to the tune of Rs.1312.67 lakhs to CICR for implementing IRM program during the period 2002-03 to 2008-09 against which Rs. 1267.63 lakh was utilized. The fund utilization has been over 90% all through the years, except in the initiating year of the program, which is obvious. Overall fund utilization in the seven years is a satisfying 96.6%. The program was started with an overall fund support of Rs. 120 lakh which was gradually increased over the years with increasing coverage.

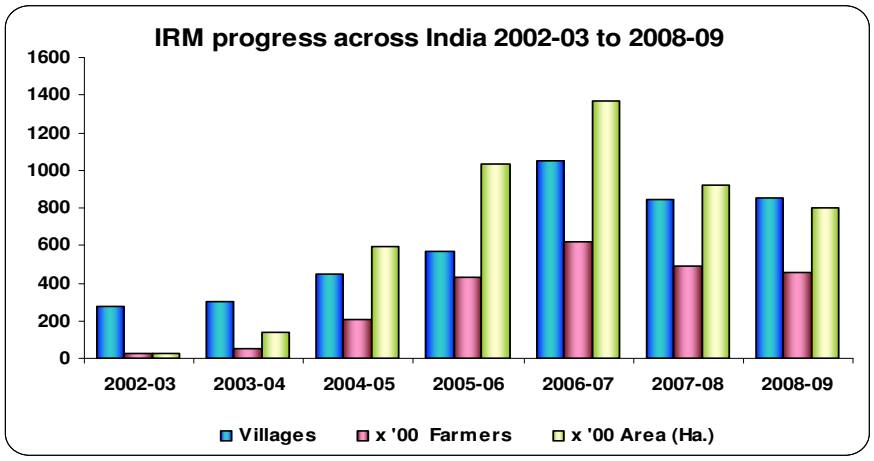
20.1 Coverage of IRM Programme

The coverage of IRM technology program since launch of the scheme i.e. during the period 2002-03 to 2008-09 is presented in the table below. As may be seen therefrom, IRM program covered 4325 villages spread in 201 districts since initiation in 2002-03.

During the span of seven years, the program was organized in over 4.88 lakh ha area and a little over 2.28 lakh farmers participated in the IRM technology dissemination. It may also be seen from the Table, the coverage increased from a modest 2781 ha in 2002-03 to highest coverage of 13684 ha in 2006-07.

Physical Coverage of IRM Program (2002-2009)

Year	States	Districts	Villages	Farmers	Area (Ha.)
2002-03	10	26	273	2801	2781
2003-04	10	26	300	5372	13816
2004-05	11	27	444	20525	59232
2005-06	11	26	570	43282	102886
2006-07	10	33	1047	62289	136844
2007-08	10	31	840	49149	92191
2008-09	10	32	851	45557	80124
TOTAL :	**72**	**201**	**4325**	**228975**	**487874**



The program has been widespread in 2005-06, covering almost 1.37 lakh ha area, spread in highest number of 1047 villages and maximum number of participating farmers (0.62 lakh). Overall fund utilization under the program during the seven years of its operation is a satisfying 96.6%.

20.2 IRM Impact on Farmers - Pre TMC Vs TMC Period

The table below shows the changes brought on various aspects of cotton cultivation on account of the IRM technology.

IRM Impact on Farmers – Pre-TMC and TMC Period

Items	After IRM adoption	Before IRM practice
Sucking pest complex	**Nil**	**2-3**
Protection of natural enemies	**40 %**	**10%**
No. of sprays up to 60 DAS	**Nil**	**4-5**
No. of sprays up to final stage	**3-5**	**6-12**
Yield (q/acre)	**20 (1q @ Rs/.1800)**	**12**
Gross income (Rs)	**20,000/-**	**18,000/-**
Cost of plant protection (Rs)	**4,000/-**	**5,000/-**
Total cost of Cultivation (Rs)	**6,000/-**	**9,000/-**
Net income	**14,000/-**	**9,000/-**
C: B ratio	**1 : 3**	**1 : 2**

On the basis of the cost of cultivation and the net income of the farmers, both IRM adopted and without IRM adoption, the C:B ratio has been worked out that clearly shows that adoption of IRM technology has been extremely beneficial for the cotton growing farmers.

20.3 Economic Benefits from IRM

Over the years, the IRM program has resulted in economic benefits in terms of yield increase and insecticide reduction and is directly related to the area coverage and crop yield with few variations. The total benefit is estimated to be Rs. 198.26 crores from yield increase and Rs. 96.80 crores from savings on pesticides. Total benefit value on account of both factors together comes to Rs. 295.06 crore.

The IRM-IPM program resulted in a reduction in insecticide consumption by 30%, and reduced the number of sprays by 15%. The IRM program has, thus, significantly contributed

in increasing production and productivity of cotton besides providing financial, environmental and social benefits to the farming community.

The study has noted that considerable efforts have been made to reach out to farmers in villages through innovative extension approaches such as street plays, live phone-in-radio programme to solve farmers' problems, involvement of women and school children in awareness generation, etc. In view of such concerted efforts, IRM is gaining popularity among the cotton farmers and the participation is also voluntarily increasing. The project has created enormous awareness not only in the participating villages but also in the neighboring villages. Since the programme is being implemented through Universities, State departments, KVKs, ICAR institutes and NGOS, the level of acceptability seems too high.

The field survey has revealed the following:

- Farmers appear to be highly trained for identification of insect-pests and their damage, predators and their significance in the management of insect-pests.
- Farmers were found to be trained for identifying the different stages (egg, nymph, pupa etc.) of insect-pests.
- Farmers were convinced to realize the disadvantages of mixing of insecticides and hence they avoided the practice of mixing and repetition of the same brand in subsequent sprays.
- Farmers were found to be very much convinced on the use of insecticides only after observing of ETL of key pest and hence they could minimize the tendency of blanket spray to a greater extent.
- Farmers were unanimously found to be highly motivated for the reduction in no. of insecticidal sprays and so to cost of cultivation without any compromise with the seed cotton yield.
- A large number of farmers of Non-IRM villages were found to be ready to participate voluntarily in the extension of IPRM programme.
- Participatory farmers of IPRM project were of the opinion that effective components of IPM like Neem based insecticide and organic manure, pheromone traps and bio-agent conservation crop must be taken into practice on priority in the IRM programme so as to reduce the load of pesticides and ultimately the environmental hazards.

21. On-Line Pest Monitoring under NISPM (Bt cotton)

Though Bt cotton has led to increased yields and improved socio-economic position of the farmers in the recent past, the sudden emergence of new pests, particularly mealy bug in Gujarat and Punjab, coupled with the high cost of seed cotton, is having a strong impact on socio-economic condition of the farmers. Thus, considering the need for regular monitoring of cotton pests, using ICT and formulation of suitable location-specific IPM strategies, the Government of India launched the "National Information System for Pest Management (Bt Cotton)" under the nodal responsibility of NCIPM during 2008-09 on a pilot basis in 12 cotton growing districts across India.

The on-line pest monitoring for Bt cotton involved selection of 20 maximum cotton growing villages in each district across the country, thus selecting 240 villages in 12 districts. Two fixed fields of most popular Bt cotton hybrids with proper plant population and two random fields in each village were selected for noting the GPS points on the website to implement GIS mapping system in viewing the pest population. The observations were taken repeatedly at weekly intervals in fixed fields and the data collected on insect pests, diseases and natural enemies is uploaded to NCIPM website by the respective centres.

The targeted 240 village was fully achieved and 92.3% of the 1200 farmers were selected. Recording of data have been low at 75.8% and it transpires that the data recording has been a weak point in the on-line pest monitoring system.

21.1 **IPM dissemination activities carried out under NISPM**

In different districts, around 1108 farmers were selected & trained in all the IPM strategies in cotton for technology dissemination. Around 48 village group meetings, 73 field visits and 27 farmers' training programs were organized by different centres besides publishing popular literatures, folders, leaflets, IPM books, etc. and dissemination through news paper, TV, radio talks, video films, etc.

22. Flexibility to States under New Intervention Component

Under MM-II, funds have been earmarked to the extent of 10% of total allocation under the component of new interventions so as to provide flexibility to State Governments to implement certain programmes keeping in view their own area specific requirements essential to boost the productivity of cotton.

The States have implemented this component to varying extent utilizing the financial provisions on various items of local need. Farmer's training tops the list implemented by all the 13 States. Next widely implemented item is supply of farm implements that included Bt detection kits, local manual ginning machines, fertilizer broadcaster, intercultural plough etc. The items consisting of six different implement / agri-equipments have been supplied by all States barring West Bengal. It also included demonstration on farm implements carried out in Maharashtra during 2005-06 & 2006-07. Other agri-inputs supplied through this component by various States are supply of organic manure (Gujarat), micronutrients (Andhra Pradesh & Tamilnadu), bio-fertilizers (Tamilnadu) and weedicide (Orissa). A few States have also taken up innovative programmes like organic cotton cultivation (CICR & ITK method) in Maharashtra and setting up of vermi-compost unit in Andhra Pradesh and Madhya Pradesh. Intercropping with pulses and demonstration & training on IPM technology have been carried out in Tamilnadu, West Bengal and Maharashtra.

Though the States have undertaken an array of activities under the component, very few can be termed "new intervention" as most of them are covered under the existing components of MM-II. Foliar spray of fertilizers / micronutrients at appropriate stages of crop growth, utilization of fertigation during drip / sprinkler irrigation, use of post emergent weedicides through irrigation water are some of the innovative methods, hitherto not widely followed and farmers lack awareness of their benefits which the States can attempt under this component.

As is evident from the present study, though the States have undertaken an array of activities under the component fully utilizing the funds for the purpose, very few can be

termed as “new intervention” as most of the activities are already covered under the existing components of MM-II. Although activities like vermi-compost unit and organic cotton cultivation have been undertaken by a couple of States, it appeared that the States have no conceptual clarity or innovative ideas for better utilization of the component for improvement of cotton production and productivity. Foliar spray of fertilizers / micronutrients at appropriate stages of crop growth, utilization of fertigation during drip / sprinkler irrigation, using post emergent weedicide through irrigation water are some of the innovative methods, hitherto not widely followed and farmers lack awareness of their benefits. It may be necessary to hold an in-depth discussion among scientists, progressive framers, officials of allied Government departments and NGOs as well and call for their suggestions based on local situations in order to facilitate enhanced productivity.

23. Comparative Analysis of Cotton Cultivation - Pre and Post Bt Cotton Era

(i) Type of seed used

Foundation and certified seed beneficiaries have been only 16.6% in 2008-09 (decrease of 63%); also truthful level seed users increased to over 80% (increase of 67%). Increase in use of truthful level seed for cotton cultivation supports the wider use of Bt cotton seed.

Among sample non-beneficiary farmers, during 2002-03, foundation seed was used by 4.5% only in Rajasthan. More than 80% sampled farmers in Punjab, Rajasthan, Gujarat and Madhya Pradesh and 60% to 79.3% in Haryana, Andhra Pradesh, Orissa and Uttar Pradesh have used certified seed; during this period a little over 10% non-beneficiary farmers also used truthful level and about 6% used own seed or market seed – all being non-certified seeds. Thus, certified category seed use declined by about 63 and 73 percentage points over 2002-03, and simultaneously TL seed use increased by 67 and 77 percentage points respectively among beneficiaries and non-beneficiaries.

(ii) Use of various inputs

In 2002-03, less than 1% beneficiaries have used all inputs for plant protection, Methylotroph, and bio-fertilizer azophosmat. A little over 14% used seed treatment chemicals and less than 3% used phosphorous solubilizing bacterial (PSB) fertilizer.

In 2008-09, seed treatment chemical users halved and manifold increase seen in users of PSB, slight increase in use of Methylotroph and users of Azophosmate remained slightly more than 2002-03, showing a marginal increase in 2008-09 over 2002-03.

It may be concluded that through various measures for awareness generation under MM II and depending on the availability of the various inputs, the extent of usage of PSB and methylotroph has substantially increased among the farmers. The scenario in 2008-09 may, therefore, be attributed to the impact of MM II of TMC. The reduction in the use of seed treatment chemicals may be attributed to the increased availability of treated seed of certified seed as also the Bt-cotton seed.

(iii) Use of secondary nutrients

Secondary nutrients sulphur and magnesium have beneficial effect on cotton and are recommended for use in different locations. The sample survey data shows the percentage

of users of secondary/micronutrient has increased from about 2.5% in 2002-03 to 9.5% in 2008-09. The usage of both has shown about four fold increase in usage in 2008-09 over 2002-03. In regard to average quantity of use of these nutrients while use of sulphur witnessed an increase of 1.25 times, in case of magnesium it is insignificant.

Among non-beneficiary farmers, average quantity of sulphur and magnesium was used by over 2% and 1% respectively in 2002-03 while in 2008-09, the share of farmers using these secondary nutrients were nearly 13% and over 16% respectively. The share of non-beneficiary farmers using both secondary nutrients increased during 2008-09 to 4.12 from less than 1% - an increase of over 3 percentage points.

It is clear that there is perceptible improvement in use of secondary nutrients in cotton cultivation which have been inculcated among the farmers in general through concerted efforts under MM-II of TMC.

(iv) Methods of sowing

Line sowing was followed in 2002-03 by 51.6% beneficiaries; in 2008-09 line sowing decreased from 51.6% to about 31.6%, highest reported by all beneficiaries in Orissa and least (5.4%) in Karnataka.

While broadcasting was followed by 3.1% beneficiaries in 2002-03, it declined to less than 2% in 2008-09. Seed drilling is reported by 6.9% in 2002-03 which in 2008-09 was followed by an increased section (10.6%) of beneficiaries, establishing about 4 percentage point increase. From the feedback, the changes seen in the methods of sowing indicate the impact of awareness generated through numerous training, demonstration and exposure visits.

(v) Stages of irrigation application

Most beneficiaries reported applying irrigation after sowing and at the vegetative stage during 2002-03. The trend remained the same during 2008-09 but the share of beneficiaries applying irrigation after sowing and at vegetative stage is less compared to 2002-03, while significant increase in share is seen in application at flowering and boll initiation stages over 2002-03.

Among the non-beneficiaries, the trend of stage-wise irrigation to the crop was the same in 2002-03 and 2008-09. The share of non-beneficiaries applying irrigation at flowering and boll initiating stage were more during 2008-09 over 2002-03. It can be construed that with increased awareness, both beneficiary and non-beneficiary farmers have learnt the importance of irrigation at these two crucial stages that impact the production of the crop.

(vi) Foliar application of fertilizers and micronutrients

According to responses, about 34% during 2002-03 and 30.5% during 2008-09 of sample farmers applied fertilizers and micronutrients through foliar spray at vegetative stage; foliar spray at flowering stage was done during 2002-03 and 2008-09 by about 71% and 74% and at boll formation stage by 37.8% and over 50%.

Among non-beneficiaries, foliar application of both fertilizers and micronutrients followed the same trend as that of the beneficiaries. More emphasis is given in the application during flowering and boll initiation stage in comparison to the vegetative stage when the basal dose fertilizers and top dressing almost suffice to the crop requirement during that period. Non-beneficiaries, like beneficiaries, have also become aware of the right stage of foliar application of fertilizers and micronutrients.

(vii) Fertilizer and minor nutrients applied through foliar spray

Comparison of data during the two years reveals increased foliar application of all the inputs during 2008-09 by the beneficiaries. The non-beneficiaries have also adopted foliar application of fertilizers and micronutrients more in 2008-09 compared to 2002-03.

Overall status reflects that the principle of foliar application of major and minor nutrients is well conceived by the beneficiaries and non-beneficiaries alike. This has been a positive impact of the program under MM II of TMC whereby advanced and effective technological improvements are disseminated through various components which is also accessed by non-beneficiary farmers mainly through interactions with fellow farmers and also other sources.

(viii) Inter-cropping in cotton

A host of crops are used for cultivating in the inter-row spaces of cotton during 2002-03 & 2008-09. The changes during 2008-09 over 2002-03 in inter-cultivation have reportedly declined in black gram (4.5% to 3.1%), green gram (9.1% to 4.4%), and maize (15.8% to 13.2%) and increased in soybean (2.2% to almost 7%), pigeon pea (62.3% to 63.7%) and others including groundnut, sunflower etc (5.9% to 8.5%).

Non-beneficiary farmers have undertaken intercropping mostly with black gram, pigeon pea and other crops more in 2008-09 over 2002-03. Intercropping with green gram, soybean and maize are less in 2008-09. Intercropping of black gram, green gram, maize and pigeon pea is more in 2008-09 compared to the beneficiaries.

Intercropping has been adopted by significant section of farmers depending upon choice of crops which is the impact of the program under MM II of TMC, as disseminated through the demonstration, exposure visits etc. for the beneficiaries and through fellow farmers and improved extension services in the case of non-beneficiaries.

(ix) Methods of pest control used in cotton

Use of PP chemicals was the most common method of plant protection in 2002-03 which declined in 2008-09 by about 6 percentage points corroborating the reduction in use of PP chemicals discussed earlier. Instead, use of bio–chemicals increased over 2002-03 by over 19 percentage points, use of bio-agents from about 2% to 12.5%, increase of over 10 percentage points, use of IPM technology increased by over 7 percentage points, IRM technology was reportedly used by 0.37% against 0.23% in 2002-03, and pheromone traps usage also increased by over 2 percentage points. Overall status of methods used by sample farmers during 2002-03 and 2008-09 revealed a marginal to impressive increase in usage of bio-chemical methods for control of pest and disease in cotton simultaneous to reduction in use of chemicals.

Methods used for plant protection by non-beneficiaries reveals that most common method has been use of chemicals, during 2002-03 and 2008-09. Other methods had been minimally used during 2002-03. In 2008-09, the use of chemicals for pest control reduced by about 3.5 percentage points over 2002-03. Simultaneously the use of bio-chemicals, bi-agents, and IPM technology increased by over 5.43, 0.78 and 0.11 percentage points over 2002-03. Pheromone traps for monitoring pest build up has also been increasingly used during 2008-09 over 2002-03. Similarly, principles of IRM technology have also been increasingly used during 2008-09.

The pace of shift from chemical measures to biological measures for pest and insect control in cotton is slow which indicates that the mindset of majority of farmers is still traditional. Inadequacy of the bio-inputs also appears to be a severe constraint leading to large section of farmers still using chemicals.

(x) Type of cotton used

The coverage under different types of cotton shows that share of area under desi, American and non-Bt State hybrids have declined drastically in 2008-09 over 2002-03. While large scale area has been diverted to Bt cotton during 2008-09 in all states replacing mainly State hybrids and to some extent desi & American cotton grown in 2002-03. Overall situation in the States taken together show large scale area under non-Bt cultivars during 2002-03 are replaced by Bt cotton in 2008-09, indicating popularity and advantages of Bt cotton over State non-Bt cultivars including Desi and ELS cotton. The worrying point is the reduction in area under ELS cotton which is imported to meet the requirement of the textile industries.

(xi) Average yield of cotton

Though, the average yield has grown over 2002-03 in respect of all types of cotton except Desi varieties, the decline in average yield of Desi and ELS cotton is a matter of serious concern that need to be looked into. Among non-beneficiaries, the yield level has shown a negative growth over 2002-03 for all types of cotton except Bt cotton. This supports swift shift to Bt. Cotton cultivation among non-beneficiaries.

The data also points to the plight of non-beneficiary cotton farmers in general and particularly in Gujarat, Madhya Pradesh, and Tripura where the yield level has dropped in most type of cotton cultivated, which need a critical / thorough appraisal for ensuring growth in yield of non-beneficiary farmers also.

24. Adaptation of Rainfed Technology in Cotton Cultivation

The two major impediments to cotton cultivation in India are the predominance of rain-fed areas and the high level of pests. About 65% of India's cotton is grown under rainfed conditions and 35% is grown on irrigated land. The Northern Zone is almost totally irrigated, while the irrigated area is much lower in the Southern Zone (40% irrigated) and Central Zone (23% irrigated). The Central Zone is home to about 60% of the total cotton area of our country.

In the rain-fed growing areas, rainfall ranges from 400 to 1000 millimeters per year. Coupled with an aberrant precipitation pattern over the years, this leads to large-scale productivity

gap. In the irrigated tract, canal and well irrigations are available. These areas are mostly covered by hybrids, upland cotton and diploid species.

In cotton, the mean yield gap between simulated rain-fed potential yield and state average yield is high in Gujarat and Maharashtra, modest in Andhra Pradesh and relatively low in Karnataka and Madhya Pradesh. This gap essentially refers to the gap that can be bridged if appropriate crop management practices are followed. Several rainfed production technologies are available which need to be tested, refined and transferred to the growers.

In the rain-fed areas, the cotton yield is strongly dependent on the date of onset of monsoon, and its subsequent distribution which affects planting date and ultimately the crop performance. There could be several approaches that can be used to bridge yield gaps.

24.1 Approaches to bridge yield gaps

i) Supplementary irrigation: The yields were generally better in those years when rainfall was well distributed and adequate to meet crop water requirements. A comparison with the mean rain-fed potential yields indicates the gap can be bridged by additional water availability. Water from external source (if available) or harvested rainwater can be used either to ensure early crop establishment or to provide critical life saving irrigation during the reproductive phase.

ii) Ensuring timely planting: Farmers of rain-fed areas have a problem in sowing seeds on time due to delay in onset of monsoon. A comparison of the mean yields over different years with the mean rain-fed potential yields (this considers timely planting all the times) indicates the gap can be bridged by providing irrigation at the sowing time to ensure timely planting.

iii) Improved nutrient management practices: In addition to nitrogen management, existence of widespread deficiencies of micronutrients such as zinc and boron and secondary nutrients such as sulfur in 80-100% farmers' fields in rain-fed areas of different states in India need to be tackled. Application of balanced nutrients (micro-and macro nutrients) in farmers' fields may increase crop yields up to 100 per cent Nutrient management based on soil testing may be advised so as to prevent deficiency of either macro or micro nutrient.

iv) Water management: To boost the crop production under dry farming, water resources in the respective areas have to be efficiently managed as dry land farming gets more complex and intractable when droughts occur frequently. An efficient soil and water conservation system plays a vital role in boosting the crop yield in dry farming.

v) More efficient use of rainfall: In-situ conservation of water can be achieved by reduction of runoff loss and enhancement of infiltrated water and reduction of water losses through deep seepage and direct evaporation from soil. Runoff is reduced either by increasing the opportunity time or by increasing infiltrability of soil or both. Opportunity time can be manipulated by land shaping, tillage, mechanical structures and vegetative barriers of water flow and the infiltrability can be increased through suitable crop rotations, application of amendments, tillage, mulching etc. Water loss by deep seepage can be reduced by increasing soil water storage capacity through enlarging the root Zone of crops and

increasing soil water retentivity. Direct evaporation from soil can be controlled with shallow tillage and mulching.

24.2 The different interdisciplinary approaches which are recommended for dry land farming are categorized into four major groups e.g. engineering, physiological, genetic and agronomic approaches as discussed hereunder:

i) **Engineering approaches**: These approaches are aimed at soil and moisture conservation through regulation of run-off, collection of surplus rain water checking evaporation and seepage losses of water and recycling of collected water as irrigation in times of critical need. This is facilitated by:

a. Contour bunding across the slope,
b. Scooping of land
c. Opening or ridges and furrows
d. Compartmental bunding
e. Bedding system
f. Broad-based bunding
g. Deep summer Ploughing followed by surface tilling
h. Water harvesting System

For cotton, on lands having slope up to 1 to 2 per cent, field bunding, land levelling, contour ditching or cultivation along contour is recommended while on lands having 2 to 6 per cent slope, graded contour bunds can be constructed to conserve water in the profile and check runoff and soil losses. In-situ rainwater conservation can be carried out either through land configuration or adoption of suitable tillage practices or through mulching.

ii) **Physiological approaches**: The extent of transpiration can be greatly influenced by using certain chemicals. These chemicals reduce transpiration, encourage root growth and protect the cytoplasmic proteins of the plants. These chemicals bring about more drought resistance in the plants. These compounds, according to their role, are classified as given below:

1. Anti-transpirants like Phenylmercuric Acetate (PMA), Hydroxy Sulphonates (HS), Alkenyl Succinic Acid (ASA), Aldol:-52, and S-600.
2. Chemicals for improved cell membrane permeability of water like Alkenyl Succinic Acid (ASA) and Decenyl Succinic Acid (DSA), when applied, penetrate into the root and increase its water absorption power 8 times. Therefore, these chemicals are applied in the root Zone for increased water absorption along with some chemicals to retard the transpiration from foliage
3. Use of plant hormones and growth retardants - Plant hormones like Indole acetic acid (IAA) and Abscissic acid (ABA) may be used for reducing the frequency and period of stomatal opening thereby minimizing the water loss from the plant body.
4. Use of chemicals- There are certain chemicals which are used for seed treatment to bring about drought resistance in plants right from seedling stage.

iii) **Genetic approaches:** As nearly 70% of our total agricultural land is rainfed and 45% of rainfed area is dryland, there is no way out but to adopt suitable varieties as well as appropriate technology for getting the most from our rainfed areas.

For central Zone the following varieties have been recommended based on extensive trails by the AICCIP: PKV DH-1, PKV Hy 3, PKV Hy.4, PKV Rajat, PKV Hy.5, AKA-8, AKA-7,NH.545, NH-615, NH-630, PH-348, PA 141,PA 183, PA-255, PA-402, Parbhani Turab, PHA 46, Renuka ,JK Hy 2, Jawahar Tapti, JK-4, JK Hy 2, G.Cot.Hy-10 (New), G.Cot 17, G.Cot 19, G.Cot.21, G Cot 23, Phule 492, Phule 388, Pratima and Arogya

Transgenic Bt cotton hybrids have been suggested for commercial cultivation in different States of the country based on the recommendations of the Standing Committee on Event Based Approval Mechanism (constituted by GEAC). The details are available in the IGMORIS website http://igmoris.nic.in/files/Recommendations_of_Standing_Committee.pdf)

iv) **Agronomic approaches:** Effective management of moisture would be crucial in consolidating the productivity gains offered by the introduction of Bt cotton in rainfed areas. Contour bunding is an effective soil and water management system to reduce run off and soil erosion, while increasing infiltration of rain water. Other soil moisture conservation practices include graded, narrow or broad ridges or beds separated by furrows. Forming beds (120-180 cm wide) and furrows on a gradient for in situ water harvesting is found to be efficient in deep black soils with a rainfall of 700-850 mm

Ridges and furrow method of water harvesting is a proven method to increase cotton yield under rainfed condition by improving the soil moisture availability. Among other techniques, there was a significant increase in seed cotton yield with black polythene mulch (25 µ) as compared to non mulched cotton. Opening of furrows using a bullock drawn harrow after every row of cotton (modified by tying a rope around the harrow after the first run) between 30 to 75 DAS and spreading of crop residue mulch between 75 to 90 days were found to be promising in Maharashtra. In Bt hybrids, straw mulching and bio–mulching with sunhemp are promising.

a) **Tillage requirements of the crops:** Deep ploughing during summer helps in destroying weeds and suppressing insect pests and diseases. It also helps in an efficient root penetration very deep into soil.

b) **Sowing of crops:** Sowing of crops deals with several associated factors namely sowing time, method of sowing, depth of sowing etc. It is important in the sense that once the ideal plant population is achieved the crop is bound to give yield. Sowing time can markedly influence the production and productivity of dry land crops. Broadcasting of seeds should be avoided; placing the seed at about 5 cm depth through pore or seed drill is desirable.

c) **Fertilizer management:** Use of fertilizers in dry lands is limited as compared to irrigated areas. Resorting to deep placement of fertilizers followed by foliar application results in extensive rooting up to deeper soil layers where the plants extract moisture to meet their demands.

24.3 **Cropping systems**

Inter-cropping with short duration, water requiring crops with cotton is a better idea for the farmers to harvest without the risk of losing the crop if sown as sole crop. Farmers should grow only short duration varieties/hybrids, which will require less water to complete their life cycle or which can stand or yield under protective irrigation. In addition, plants can be grown only where some water is available to sustain the growth of plants. Some of the intercropping systems which can be adopted are as follows:

State	Intercrop
Madhya Pradesh	Cotton + Black gram (1:1 or 2:1) Cotton +Soybean (2:1)
Gujarat	Hy Cotton + Groundnut Desi Cotton + Black gram
Maharashtra	Cotton + green gram, black gram Cotton + Soybean Cotton + Groundnut Mixed cropping with red gram
Karnataka	Cotton+ Chilly/Onion (irrigated) Cotton (DCH-32) + Rice (high rainfall area)
Tamilnadu	Cotton + Onion Cotton + Groundnut Cotton + Blackgram (paired row) Mixed cropping with horse gram & minor millets
Andhra Pradesh	Cotton + Blackgram (1: 2) Cotton + pigeon pea Cotton+ Chilli Mixed cropping with Soyabean

24.4 **Weed control**

Presence of weeds in the crop field, especially in case of dry lands, cause a severe crop weed competition for water, nutrients and light The reduction in yield due to weeds varies from 30-75% depending upon the crop and nature and extent of weed infestation. Weeds may be controlled by hand weeding, intercultural operations and herbicidal application or by adopting an integrated approach. Use of weedicides like fluchloralin @ 1 Kg a.i./ha, Pendimethalin @ 1.5 Kg a.i./ha (preemergence) with interculture at 35 - 50 days after sowing is recommended as a substitute for manual/ mechanical weeding alone.

25. Economics of Cotton

(i) Cost of Cultivation:

The cost of cultivation of various types of cotton grown by the sample beneficiaries in the States selected for study has been worked out considering all major items of expenditure viz. cost of seed, fertilizer including FYM, irrigation, labour (including family labour), picking cost and marketing.

The average of cost of cultivation in all the thirteen cotton growing States put together, both under irrigation and under rainfed conditions, is presented below.

Average Cost of Cultivation of Irrigated & Rainfed Cotton

Particulars	Irrigated		Un-Irrigated	
	Bt.	Non Bt.	Bt.	Non Bt.
Total Cost per ha (Rs.)	30168.50	25634.39	22647.44	17806.25
Total Value of per ha (Rs.)	55072.16	41004.44	38772.84	24864.71
Profit per ha in (Rs.)	24903.66	15370.06	16125.41	7058.46
B:C Ratio	**1.83**	**1.60**	**1.71**	**1.40**

Looking into the cost of cultivation data in totality in the States under study, the information reveals that Bt cotton bears highest cost of cultivation except in Desi cotton, on account of extra expenses on mechanical operations; the crop, sown in rain dependent condition, required repeated overturning of the soil for moisture conservation. There is no appreciable variation in the cost of cultivation of various types of non-Bt cotton that ranged around Rs. 18000 to Rs.26000 as against about Rs.23000 to over Rs.30000 in case of Bt cotton.

(ii) Benefit Cost Ratio (B : C Ratio) of Cotton

The B:C ratio of cotton in different States is found to vary from 2.16 to 1.46 thereby implying the impact of agro-climatic situation, soil & location factors. However, cotton has proved quite profitable with adoption of proven & improved scientific technologies. The B:C ratio worked out from the values of income from produce and cost of cultivation in the selected States does not follow any trend as it is based on a number of widely differing variables. It is, however, seen that except in Andhra Pradesh and Tamilnadu, the B:C ratio for Bt cotton is generally higher than Non Bt hybrid and American cotton obviously because of higher production and lesser input cost for plant protection in Bt cotton.

(iii) Benefit Value of Investments

In view of the huge investments made by the Government of India for promotion and development of cotton in the country, an attempt has been made to analyse the actual benefits derived in terms of increase in yield as well as increase in income from the perspective of sampled beneficiary farmers. The purpose is to analyse how far the investments have resulted in creating the desired impact and to see the extent to which objectives of Mini Mission II have been fulfilled in its nine years of operation under mission mode.

The component beneficiaries in the States have gained advantage by registering higher productivity and higher value of cotton produce at the prevailing market rate / MSP compared to non-beneficiaries. The benefit value is about Rs.2100 per ha. in favor of the investment made on supply of pheromone traps, about Rs. 2526 per ha. in favor of the investments made on the FFS, about Rs. 6727 per ha. in favor of bio-agent/bio-pesticides, Rs.11496 per ha. in support of the investments made on plant protection equipments (sprayers). In respect of water saving devices, the benefit value is about Rs.4997 per ha. for sprinkler irrigation systems and about Rs.12549 per ha. for drip irrigation sets conveying a clear mandate in support of the investments made on the component.

In respect of Front Line Demonstrations, the benefit value is a massive Rs.13499 per ha. for FLD on PT and Rs. 11406 per ha. for FLD on IPM technology, conveying a positive impact and support of the investments made under the program.

At the aggregate level, considering the assistance provided under all the components put together, it is noteworthy that except Orissa, which has a negative growth of productivity, beneficiaries of all the States gained advantage by registering higher productivity and higher value of cotton produce compared to non-beneficiaries. The beneficiaries in Karnataka could register an impressive benefit value topping among all the other States.

Overall Benefit Value and Impact of All Program Components

Sample category	All program components						
	No.	**Area (ha.)**	**Yield (qtls.)**	**Yield increase (kg/ha.)**	**%**	**Average. sell price (Rs./ha.)**	**Total benefit value (Rs./ha.)**
Beneficiary farmers	3809	7139	21.17	2.91	13.8	2839	8260
Non-beneficiary farmers	925	1453	18.26				

Thus, the cumulative benefit value for all components put together is about Rs.8260 per ha. which brings out in no uncertain terms that the huge investments made by the Government of India have resulted in a positive outcome in the form of benefits to farmers in increasing production and productivity of cotton.

Strategies for New Pest Management in Bt Cotton

Since introduction of Bt-cotton", the cotton cultivators in India have been facing new problems with insect pest management in many parts of the country, mostly presumed to be a consequence of low insecticide usage. New sucking pests have emerged as major pests causing significant economic losses. The reduction of pyrethroids and several conventional insecticides on Bt Cotton is believed to have led to an enhanced infestation of several non-target species such as mired bugs, mealy bugs, thrips and *Spodoptera litura.* Apart from judicious implementation of IRM strategies such as refugia, gene stacking, high toxin dosage and IPM, the under mentioned strategies have been recommended by CICR for meeting these emerging pest problems:

Window Based IRM Strategies

Early sucking Pest Window-Upto 60 DAS

i) Cultivation of sucking pest tolerant genetypes to help in delaying the first spray, thereby conserving the initial build-up of natural enemies

ii) Using dual genes such as the 'Bollgard-II' (Cry1Ac+Cry2Ab) will help in delaying resistance development

iii) Illegal Bt-cotton proliferation should not be allowed

iv) Mealybug affected plants should not be disturbed since mealybug crawlers spread through human interventions such as spraying, irrigations, frequent movement through the infected area, etc.

v) Inter-cropping and border rows with cowpea, soybean and blackgram may be done to encourage predators of sucking pests in the cotton eco-system.

vi) Insecticides should not be applied all over the field to manage mealybugs.

vii) Early detection and initiation of interventions to control stages of infestation is essential since mealybugs are initially restricted to a few plants along the border rows adjacent to the source of infestation. The infested plants should be removed and destroyed to prevent further spread. Insecticide application should start first on the neighbouring plants and then as spot application near the root Zone, base of the plant and other infested parts.

viii) Since mealybugs multiply on weeds on field bunds, water channelts and wastelands, it is necessary to destroy the weed hosts (Parthenium weed) by using Zygogramma beetles.

ix) It is important to avoid the use of Confidor and related chloronicotinyl as foliar sprays so as to prevent further additional selection pressure as these strongly disrupt the natural enemy populations.

x) Stem application or soil application of Dimethoate or "Acephate at 30-40 DAS and 50-60 DAS for effective eco-friendly control of thrips, miridbugs, mealybugs and other sucking pests.

xi) Neem oil 2.5 loit/ha mixed with 0.1% detergent powder can be used for the management of jassids, whitefly or aphids.

xii) Verticillium lecanii can be used for sucking pest control wherever good formulations are available from reliable manufacturers.

Window 1: 60-90 DAS-Initial bollworm infestation

i) Using HaNPV on Bt cotton at 50% bollworm infested plants followed by the application of 5% NSKE a week later.

ii) Spraying against minor lepidopteran insects should be avoided as the larvae serves as hosts for parasitoids.

iii) Trichogramma can be used on non-Bt genotypes at 70-80 DAS.

iv) Optimizing INM and nutrient management for macro and micro nutrients.

v) Using Spinosad or Emamectin benzoate on only non-Bt cotton at ETLs of 50% infested plants. It is necessary to avoid these insecticides on Bt cotton so that their efficacy can be preserved for bollworm control in non-Bt cotton.

Window 2: 90-120 DAS-Peak bollworm infestation

i) Using Indoxacarb once only on non-Bt cotton for bollworm control at ETLs of 90-100% plants showing flared up squares. These are expensive insecticides which may be used only where yields and are affordable.

ii) Using one applicationh of an insecticide such as thiodicarb or quinalphos or chlorpyriphos during 90-120 DAS on conventional or Bt cotton at ETLs of 90-100% plants showing flared up squares to effectively reduce the population of bollworm larvae that survive on Bt cotton.

Window 3: Above 120 DAS-Bollworms and Mealybugs

i) The application of pyrethroids (8 moths per trap per night for 3 nights consecutively) as late season sprays would be effective for pink bollworm management.

ii) Handpicking of surviving bollworm larvae from Bt cotton fields during peak bollworm infestation and destruction of residual pupae by deep ploughing immediately after final harvest will help immensely in resistance management.

iii) Insecticides are not advised for meanlybug management. Proper precautions and ecological compatible methods must be preferred.

iv) If plants are infested severely, the affected stems can be drenched with a systemic insecticide.

KEY ISSUES AND RECOMMENDATIONS

A) MINI MISSION I

1. Before TMC, the emphasis was mainly on high yield rather than fibre quality. Therefore, under TMC major emphasis has been towards fibre quality improvement with desired level of seed cotton yield. During the TMC period till now, thirteen high yielding (12-18 q/ha) varieties with desired fibre quality coupled with resistance / tolerance to pests and diseases have been released so far. These are - HD 432, CISA 614, LD 694, PA 402, JLA 794, GBhv 226, Pratap Kapi 1, MDL 1875 and DLSA 17.

All these varieties are high yielding but all of them do not possess the required fibre quality, except a few. Therefore, more emphasis is required to incorporate better fibre quality especially fibre length and strength.

Large number of superior genotypes (donors) possessing most of the desired fibre quality besides high yield identified should be extensively utilized, so as to develop and release superior varieties / parents of hybrids for the farmers.

2. In India, several varieties of upland cotton have been released for commercial cultivation for different agro-climatic zones. However, the fibre strength of the presently available varieties varies from 16-22 g/tex (at 3.2 mm gauge). As a result, they are not suitable for high speed spinning such as Rotobar and Jet spinning. The GOT of present varieties is also low and varies from 32-35 per cent. Hence, with the low fibre strength and GOT, the fibre from currently cultivated varieties are not competing with global marketing. Since Bt cotton area is increasing every year and due to farmer's preference for the same, it is evident that non-Bt cotton will not be in demand. In the circumstances, transfer of Bt gene in the newly developed or future varieties is recommended.

3. Four *G.hirsutum* varieties viz. MCU 13 (TCH 1452), Aurobindo (PSS 2), Suraj (CCS 510-4) and Anusaya (NH 615) have been released for commercial cotton cultivation for different agro-climatic conditions of the country. These varieties out yielded the checks in respect of seed cotton yield by 16-27 per cent and also possessed desired fibre quality and medium to high degree of resistance / tolerance to diseases and pests.

Considering the number of centres (15) involved in the project, the number of *G. hirsutum* varieties released during the TMC period appears to be less.

In the case of diploid cotton, there is a tremendous improvement in the yield and fibre quality. The genotypes with these traits have to be cultivated on large scale which is only possible if Bt technology is brought into these genotypes. This is imminent because, in India, the cotton requirement varies from 6s to 120s counts which can be met only by cultivation of diploid cottons, provided the Bt technology comes in these species (*arboreum* and *herbaceum*).

4. From the introgressed materials developed, resistant / tolerant genotypes for Bollworms, Jassids, Aphids, Whitefly, CLCuV, Root rot and drought have been identified, evaluated and exchanged among the centres / breeders for utilizing in their breeding programmes. It is recommended for their utilization in the breeding programmes. Resistant genotypes identified include –

- GISV 206, GISV 216, GISV 248, GISV 253 (Drought)
- 14MH 8, AKH 8828, TCH 1653, JK 276XTCH1699 & many more (Bollworm)
- DQRH1R2, TCH 1648 (Jassids)
- 14RM1R, IH35, GISV 206, Rai7B2……..many (Whitefly)
- I4MH8, GISV-33, GISV-6, TCH 1693……....many (CLCuV)
- GISC 17, GISC 185, GISC 218, GISC 246……many (Root Rot)
- Segregants of crosses Abhadita x IV – 3F3 and Abhadita x TCH – 2F3 (Bacterial Blight)

Some other superior introgressed genotypes identified are:

LAS 10, L 799, RAC 024, D1 x 57-1, NISC 36, RHRHC 601 AND LAIHH10 having 2.5% span length=27-32 mm, strength=21-24 g/tex, MIC=3.8-5.4. They had the yield potential of 10-25 q/ha of seed cotton and percent increase over the checks ranged from 31-40 %. These genotypes also had very low sucking pest population as compared to the checks. Hence, these must be included in the breeding programmes at all locations.

For fibre quality attributes also, superior genotypes have been identified. The range for 2.5 % SL was 27.5 to 32.5 mm; for fibre strength, it was 20.5 to 24.6 g/tex and for fibre fineness (micronaire), it was between 3.2 to 4.0. These superior introgressed material identified will be good sources for various desired characters though they may not possess very high yield potential. Hence, it is recommended that these sources must be utilized at all the centres by the breeders.

5. Availability of pure seed of varieties to the farmers is very important for realizing the full potential of technology for achieving enhanced and sustainable productivity. Therefore, the multiplication and supply of breeder and nucleus seed need to be suitably improved. In this context, it is imminent to provide skill based training to farmers for producing quality seeds at their own farm. Hence, the aspect of “produce seed at your farm” needs to be suitably supported, strengthened and enlarged by Government of India and the State Governments. The interaction of research institutions / SAUs with that of National / State seed corporations may also be attempted to ensure large scale production and supply of quality seed to the farmers.

6. The concept of developing and popularizing Integrated Nutrient Management approaches for efficient nutrient management, sustaining productivity, low cost and maintaining eco-friendly environment, maintaining productivity and fertility of the soil has been recommended through MM-I multi-location efforts and findings. In the above context, application of micro and secondary nutrients ZnSO4 @ 20-25 Kg/ha and Sulphur @ 25 Kg/ha along with RDF is an important recommendation for improving the cotton productivity.

7. INM technologies should include application of available organic manures such as wheat straw/*pressmud*/crop residues/green manures/compost/FYM to compensate the recommended level of fertilizer application, thus saving chemicals to an extent of 20.0 per cent. INM technologies should also manage the new and emerging problems such as leaf reddening which is prevalent on Bt cotton grown in rainfed areas.

8. For achieving enhanced and high productivity (yield) of cotton crop, appropriate combination of chemical fertilizers (RDF and organic manures is recommended for all eco-zone (North, Central and South). Apart from soil application, potassium (K) may also be supplemented through foliage spray during the post flowering period.

9. Rainwater harvesting and its recycling as well as fertilizer application through drip irrigation/fertigation at critical stages to improve cotton productivity, Water Use Efficiency (WUE), Fertilizer Use Efficiency (FUE) have been well documented and, therefore, recommended as improved production technologies.

10. Technologies like opening furrows in every/alternate row, in-situ rain water harvesting and moisture conservation, adoption of inter-cropping, irrigation at 0.8 IW/CPE (Irrigation water/cumulative pan-evaporation) ratio irrigation at critical stages e.g flowering stage, boll development stage, are advocated to realize high yield with improved fibre qualities and higher WUE.

11. Adoption of drip irrigation and fertigation will save 25 per cent of fertilizer, 30-40 per cent of irrigation water, besides reducing the requirement of electricity and manpower, etc. Hence, drip irrigation needs to be widely promoted and propagated.

12. Application of one irrigation at boll development stage using harvested rainwater is suggested to equate rainfed cotton yields to assured irrigated situations. In rainfed areas more efforts should be attempted for efficient rain water harvesting technologies for irrigation at critical stages.

13. Introduction and popularizing IPM modules including planting of resistant varieties, seed treatment with Trichoderma, inter-cropping with pulses and cereals, bird perches, trap crops, parasitoids, microbial pesticides, pheromone / light traps, hand collection, botanical and chemical pesticides in conjunction with IRM practices reduced the incidence of sucking pests (thrips, aphids and white fliers) by 26-40 per cent in non Bt and 22-67 per cent in Bt cotton. These practices must form an integral part of extension technologies for increasing productivity of cotton. The validated IPM modules shall also be published in package of practices / crop production guides of State Agricultural Universities or State Department of Agriculture for further dissemination.

14. Cotton spraying is one of the most expensive and labour intensive and yet less effective activity involving multiple and continuous spraying schedules. Thus, a major breakthrough is needed in improving distribution system to suit plant genotype canopy with advance in age of plant. Maximum spray coverage on the canopy is needed so as to avoid run off and increase the efficiency of pesticide.

15. In view of increasing cost and scarcity of labour, the use of power operated equipments e.g. (i) Tractor mounted sprayer; (ii) Aeroblaster sprayer; (iii) Air assisted sprayer; and (iv) Rotary battery operated sprayer have been found useful and are, therefore, recommended to overcome the shortfalls and to enhance cost effectiveness. These equipments are likely to lead to labour saving to the extent of 30 per cent and savings in operational cost upto 20 per cent.

16. Under WTO Regime, there is a need to protect the genotypes and germ plasm in the public institutes. Therefore, Molecular characterization through approaches e.g, RAPD (Randomly Amplified Polymorphic DNA), ISSR (Inter Sample Sequence Repeats), SSR (Sample Sequence Repeats) have been found quite useful to the confirmation of hybridity and seed purity of hybrids and their parents. Hence, it is

recommended for molecular characterization of all the released varieties and hybrids along with the parental lines of hybrids to ensure their purity and protection.

17. Invasion of plant pathogens is to be detected as early as possible so as to ensure that remedial measures are effective thereby reducing the crop losses. Thus, employing molecular techniques, PCR protocols have been developed and recommended for pathogenic fungi e.g. leaf blight, root rot, grey mildew, *Myrothesium* spots and wilt etc. Results of MM I have shown that PCR protocols are not suitable for farmers as these need sophisticated techniques. However, they may form an important component of plant health clinics or can be successfully practiced by plant protection specialists of the Department of Agriculture and experts and scientists of State Agricultural Universities. PCR protocols can be achieved in 1 Hr 30 minutes. The cost would not be prohibitive and may cost Rs. 10-15 per sample.

18. Another significant contribution of practical utility is the development of 'PCR-RFLP' KIT for detecting and differentiating *Helicoverpa armirgera* from *H.assulta* with 98% accuracy. Thus, detection of species is possible at egg, larval and pupal stages, which was not possible hitherto. The protocol has been published for wider usage by the researchers and extension workers and consultancy service agencies. It takes about 3 hours to detect it at a cost of Rs.40.00 per sample and is recommended for wider adoption under location specific situations of different eco-zones.

19. Cotton leaf curl virus (CLCuV) disease is a serious production constraint in northern zone rather than southern and central. It is transmitted by whitefly *Bemisia tabaci* . Experimental results have indicated that population of whitefly on cotton crop is most efficient with 100 % CLCuV acquisition as against 20% acquisition in tomato crop. These types of know-how may not benefit the individual farmer but definitely helps to formulate a National policy to curtail the impact of CLCuV in southern and central zones of the country, where at present CLCuV is not a very serious threat for cotton crop. Further, this knowledge can be effectively utilized as a baseline for researchers to enhance yield capacity and timely disease suppression through induction of resistance to whitefly and virus disasters.

20. Many promising and proven technologies have not reached out to farmers and are not widely adopted due to lack of proper awareness in respect of location specific technologies. Hence, adoption of improved hybrids / varieties / desi hybrids, Bt cottons, integrated weed / nutrient / water / pests / resistance management systems as well as IMC practices, precision farming systems, foliar spray of varieties (fertigation) and methods/scheduling of irrigations to improve WUE etc. have got more scope in enhancing the productivity and savings in total cost of cultivation. Thus, popularization of these techniques through Front Line Demonstrations, kisan melas, etc. may prove more beneficial for wider dissemination, acceptability and adaptability of cotton based cropping systems for achieving enhanced productivity per unit area. Therefore, it is suggested that a field of around one acre shall be earmarked "TMC Technology Demonstration" at all the participating institutions / SAUs which may aid in imparting on-farm practical training to the farmers / extension functionaries for further dissemination of the technologies evolved through MM-I.

21. High cost of cotton seeds, limited availability of bio-agents and FYM, lack of scientific knowledge for the effective use of bio-agents / ET based pesticides application, non-availability of certified / quality seeds of improved hybrids/varieties/Bt cotton, high labour & capital investment/requirement, lack of timely financial assistance, susceptible genotypes to pests and diseases are some of the major constraints for

quick adoption by the farming community. This aspect requires a critical appraisal by the scientists, SAUs and State Departments of Agriculture for achieving the desired and targeted results and level of success at village / farmers' level.

22. Cotton lint and seed are products of high commercial value as raw materials for textile industry, animal feeding and oil industry. Cotton stalks containing high cellulose and fibrous material serves as important raw material for making wooden boards and paper. Hence, by using the Hand-cum-Power operated cotton stalk compacting machine, it is possible to compact the cotton stalks by 70-80 percent (4-5 times) . In case of power / electricity failure, this machine can be operated manually by rotating a wheel. It is possible to make about 200 bales of 10 kg each in a day of 6 hours engaging two labourers/workers. This machine is reported to be costing about Rs. 1.5 lakh. The equipment needs wide popularity and adoption by providing suitable subsidy as a post harvest component of technology.

23. Commercial trial on preparation of hard boards and particle board from cotton stalks have shown that the process is technically feasible and good quality boards conforming to BIS specification can be prepared as advocated by CIRCOT. This needs suitable refinement and standardization for wider adoption to ensure effective utilization of cotton stalks.

24. Though Bt cotton has led to increased yields and improved socio-economic position of the farmers in the recent past, the sudden emergence of new pests, particularly mealy bug in Gujarat and Punjab, coupled with the high cost of seed cotton, is having a strong impact on socio-economic condition of the farmers. Thus, considering the need for regular monitoring of cotton pests, using ICT and formulation of suitable location-specific IPM strategies, the "National Information System for Pest Management (Bt Cotton)" (NISPM) was launched under the nodal responsibility of NCIPM during 2008-09 on a pilot basis in 12 cotton growing districts across India.

    While the initial efforts in this regard are appreciable, the system is yet to fully stabilize. The observations on pest population are being taken periodically in fixed fields and the data collected on insect pests, diseases and natural enemies is uploaded to NCIPM website by the respective centres. However, the recording of data have been low at 75.8% and it transpires that the data recording has been a weak point in the on-line pest monitoring system, which needs to be strengthened.

KEY ISSUES AND RECOMMENDATIONS (contd…)

B) MINI MISSION II

1) FLD on Integrated Crop Management

In lieu of the present three types of FLDs viz. production technology, integrated pest management and farm implements, a comprehensive FLD on Integrated Crop Management is recommended for introduction by integrating the three types into one single component covering an area of about 50 acres. Such FLDs should cover every aspect of technologically proven cultivation practices including use of location specific seeds of high yielding varieties and hybrids; INM, IPM, IRM, bio-agents/bio-pesticides, surveillance & monitoring of pests/diseases, use of improved spraying machines, water saving devices- particularly drip irrigation system etc. These components should be integrated into the new FLD format with enhanced cost for inputs. All technological advancements under MM-I should be included in the new FLD on ICM so that they trickle down to farmers.

Prerequisites for the proposed FLD on ICM may broadly be stated as under:

- FLD should be organized in at least 50 acre area whereby operation of various farm implements can be amply demonstrated.
- FLD should be organized for the whole season – sowing to harvest which will facilitate demonstration of all cultivation practices ensuring sequence and timeliness of each operation.
- All essential inputs to be integrated and the FLD on ICM should follow the most recent production technologies developed under MM I like:
    - Site specific nutrient management for Bt cotton
    - Site specific soil moisture conservation
    - Drip irrigation schedules for Bt cotton / Morphoframe manipulation in Bt cotton by etheral spray
    - Farm machinery developed and tested
- An expert scientist (KVK/Research Institution) or an agripreneur may be appointed as “Coordinator” in each State who would carry out periodic visits of the FLDs and ensure proper conduction of the FLDs.
- Organizing FLDs in different villages every year to facilitate taking part by maximum number of farmers.
- New technologies under MM-I that transpires thru FLDs should invariably be included in the package of practices prepared by State DoA.

2) Farmers’ Field Schools (FFS)

The Farmers’ Field School is conceived as a platform which brings farmers, extension workers and experts at one platform and provides an opportunity to have a direct interface among them. Though FFS has gained popularity among farmers, the overall situation as regards functioning of the schools leaves much to be desired. The schools appear to be plagued with irregular conduction, old technology dissemination and low proficiency of the

facilitators conducting the schools. A major drawback noticed during field survey was that these schools were not well-structured and were functioning in a hap-hazard and adhoc manner without a continuous tracking or control mechanism. Further, the much needed grooming of farmers to function as farmer facilitators is not coming about even though the program is under implementation for a considerable period. The schools are also reportedly not functioning in accordance with the stipulated guidelines making the whole exercise futile. It is, therefore, imminent that these schools are run in a professional way since these have become prime centers of technology dissemination. The following suggestions could, therefore, be considered for restructuring the FFS:

i. Farmers' Field Schools should be set up in every village, in the field of outstanding and progressive cotton growers or in a Government / Non-Government Institution.

ii. Training should be flexible and non-lecture based with more emphasis on observation, analysis and discussions.

iii. Selection of farmers should be made in consultation with Farmers' Advisory Committee (FAC) and Farmers' Organisations at the block level.

iv. An expert scientist, preferably from KVK or an agripreneur trained by MANAGE, should be appointed as "Coordinator" of the farm school and entrusted with the responsibility of managing and coordinating the farm school activities.

v. The Coordinator so appointed shall periodically monitor the activities of farm schools under his jurisdiction and act as a mentor, philosopher and guide to the Farmer Facilitator or Official Facilitator running the school. He shall make atleast one visit to the FFS every fortnight to oversee and monitor its functioning. A record of his visits to the school, important activities undertaken during the period and his comments on the functioning of FFS, must be invariably entered in a register maintained for the purpose.

vi. A course module for the FFS with a well-structured curriculum and week-by-week training plan should be prepared by the Coordinator.

vii. The performance of all the FFS in each block should be reviewed at the Farm Information Advisory Centre (FIAC) meetings on a half-yearly basis. Similarly, the performance of all the FFS schools functioning in the district may be reviewed on an annual basis by the ATMA Governing Board at the district level.

viii. A few Farmer Facilitators could be selected from amongst the farmers trained under FFS and given further orientation training so as to involve them in dissemination of technologies and extension activities in their respective villages or neighboring village, on a specified honorarium. In each village 3-5 representative farmers (Elite Farmers) may be selected and trained in all aspects of production / protection technologies, who shall act as Farmer Facilitators of technology dissemination for the respective villages.

ix. Knowledge and skills of Facilitators should be upgraded on a continuous basis through training at district / State level institutions and exposure visits, etc.

x. FFS once setup should continue at least for a minimum period of 3 years with some limited financial assistance particularly, for operational expenses, so as to ensure due stability, subject, however, to their satisfactory performance.

xi. KVK may be entrusted with the responsibility to set up atleast one Model FFS in each district which would operate under their complete supervision and control to serve as a replicable model for other fellow farmers.

xii. This apart, the technologies demonstrated in the three types of FLDs should be a major part of technology propagated in the FFS.

3) Restructuring of IRM Program

The IRM-IPM program launched during 2002-03 has significantly contributed in increasing production and productivity of cotton besides providing financial, environmental and social benefits to the farming community. It has resulted in a reduction in insecticide consumption by 30% and reduced the number of sprays by 15%. Over the years, the IRM program has resulted in economic benefits estimated at Rs.198.26 crores from yield increase and Rs.96.80 crores from savings on pesticides.

The IRM program presently implemented by CICR through SAUs, ICAR centres in collaboration with State DoA. The time is now ripe to bifurcate IRM into 2 components –

i) Insecticide Resistance Monitoring & Refinement of Protocols

ii) Dissemination of IRM Protocol

The first component namely, Insecticide Resistance Monitoring & Refinement of Protocols may be retained for implementation by CICR in collaboration with SAUs. The second component relating to Dissemination of IRM Protocol may be entrusted to the Department of Agriculture of the cotton growing States for implementation. The Protocols shall, however, be issued by CICR which may be modified from time to time based on resistance monitoring data.

The following measures, in this regard, are also suggested for successful adoption and implementation:

- Efforts must be made to enroll all the farmers in a village to impart IRM / IPM techniques. Farmers may be assisted throughout the season in managing cotton pests efficiently with minimum insecticides use. Field workers must be oriented to have direct interface with the farming community to propagate advanced crop production and pest management technologies
- Training should be field oriented and participatory. Farmers should be encouraged to undertake scouting and should be able to decide the best option of pest management by themselves
- IRM strategies may be propagated through innovative tools such as folk theatre, street plays, dramas, song & dance etc. relevant to the IRM/IPM theme to attract farmers and keep them engrossed
- Wide publicity through local print and electronic media may be ensured before conducting pest management awareness & education campaigns to reach out to all farmers of the selected villages
- Insecticide dealers may also be involved in awareness generation and training programs being in close proximity and in constant touch with farmers. Similarly, involvement of women farmers in such campaigns may prove much beneficial

- District level Centers for 'monitoring of Pest incidence' and 'Insecticide / Bt toxin resistance levels in both sucking pests as well as bollworms' could serve as an 'On-the-Spot forewarning and pest management advisory service' with flow of expertise and guidance from scientists of CICR and the SAUs
- Due to the large scale cultivation of Bt cotton and the consequent change in pest scenario experienced during the last 2-3 years, a constant monitoring of emergence of new / secondary pests on Bt cotton as well as monitoring of resistance against Bt toxin will aid in alleviating the occurrence of pest epidemics
- The IPM / IRM strategies may be included in the package of practices / crop production guides of SAUs / State Department of Agriculture of cotton growing states so as to facilitate its spread and dissemination among the farmers

4) Seed Production and Supply

The level of foundation seed production in the States has been moderate and so is the production level of certified seed. With the advent of Bt cotton, the requirement of certified seed of public sector varieties/hybrids declined. The States have restricted certified seed production to a manageable level confining to those varieties and hybrids most preferred by the farmers.

Fewer beneficiaries in Gujarat, Andhra Pradesh and Tripura reported availability of required quantity of certified seed showing a chronic inadequacy in seed availability. In other States, the beneficiary farmers affirmed getting adequate quantity of certified seeds. Beneficiary farmers from only Punjab, Rajasthan, Gujarat, Maharashtra and Tamil Nadu affirmed receipt of seed of choice.

Availability of pure seeds of varieties to the farmers is very important for realizing the full potential of a technology (variety) and simultaneously increasing the production and productivity of the crop. The *desi* cotton produced earlier in India was fit for spinning 10s to 30s only. The improved quality genotypes developed through the project indicated the spinnability upto 20s to 50s counts. However, to see the impact of these genotypes, there is need to adopt Bt technology either by the public institutes or parting the genotypes to the private sector so that the improved genotypes with quality can see the light of the day and benefit the farming community. Thus, the production and distribution of certified seed component should be retained in the next plan period also in order to popularize public bred Bt cotton varieties / hybrids.

The extension department has to play an important role in finding the best performing varieties/hybrids in their location and the varieties / hybrids most preferred by the farming community. This feedback should regularly be provided suitably to the nearest research center or to the State Agriculture Department.

Special emphasis is needed to maintain continuity of Seed multiplication chain in case of seed of all categories, and particularly the varieties of farmers' preference. Seed multiplication ratio at each stage must be attained for proper utilization of breeder and foundation seeds and improvement in the seed replacement rate.

Seed production program of varieties in demand for organic cotton growers should be taken up by public sector organizations. Further, there is need for providing R&D support to organic cotton growers for tackling the location specific problems

5) Promotion and Development of ELS Cotton

The Annual production of Extra Long Staple Cotton in India is 3.0 to 4.0 lakh bales as against the demand of 9.0 lakh bales. The requirement of ELS cotton is met through import from USA, Egypt and Sudan. Further, a big chunk of area of cotton in India is under *hirsutum* species (90%) leaving 4 to 5% under *arboreum* & *harbaceum* species and negligible area under *barbadense* specie. As a result shortage of short & ELS cotton has been realized by the textile Industries in recent years. These issues need to be addressed by launching a special scheme for promotion and development of ELS Cotton so as to enable India achieve desired levels of cotton productivity, quality and competitiveness in the world textile and apparel market.

The cultivated area under ELS cotton can also be increased by promoting *barbadense* cotton in other potential areas such as M.P., Maharashtra, Gujarat, Orissa and Karnataka.

Varietal demonstration is one of the important components in the FLD on production technology under MM II program. Special emphasis may be laid for ELS cotton production and the scope of FLD program should be enlarged to cover maximum number of demonstrations on cultivation of ELS varieties / hybrids in potential areas. There is also a felt need for enhancing the quantum of subsidy from Rs.2000 to at least Rs.4000 due to longer duration of the crop and the special efforts to be put in by farmers. Such demonstrations will act as a catalyst for expanding the area under ELS cotton and increase the yield besides ensuring higher revenue to the farmers. Considering the scope for export potential, employment potential for the handloom community and enhanced income to the farmers, budgetary allocation may also be suitably increased.

6) Special Scheme for Improving Cotton Production in Rainfed Areas

Even though India ranks first in area in world accounting for 28% of world coverage under cotton and occupies second position in production behind China contributing over 22% of world's cotton harvest, the low productivity as compared to other major cotton growing countries in the world, is a cause for major concern. Main reasons for such low productivity are nearly 70 per cent cotton cultivation in the country is rain dependent and subjected to vagaries of monsoon rains and excessive pest and disease infestation of the crop. It is, therefore, appropriate that concrete steps are initiated to improve cotton productivity in the vast tracts of semi-arid region in the States of Maharashtra, Andhra Pradesh and Gujarat followed by Punjab, Haryana, Karnataka and Madhya Pradesh. The following measures may be considered:

- Identifying location specific, abiotic stress resistant, seeds of high yielding varieties and hybrid essentially of desi cotton; provision of seed and bio-agents for IPM to farmers at an enhanced subsidy, more than that given under the certified seed component of MM II;
- Organizing FLD on Integrated Crop Management covering various components and undertaking various operations like:
    - ✓ seeds of location specific varieties/hybrids emphasizing on desi cotton
    - ✓ micro-irrigation (drip irrigation system) for better water management and fertigation
    - ✓ protective irrigation by alternate furrow method at critical growth stages of peak flowering and boll development; the practice of opening of ridges and furrows at last hoeing across the slope should be followed for rain water conservation

- ✓ intercropping with green gram/ black gram
- ✓ maintaining optimum plant density and crop geometry
- ✓ Integrated Nutrient Management; application of micronutrients and secondary nutrients;
- ✓ intercultural operations for weeds removal, aeration and restricting evaporation losses;
- ✓ IPM technology for pest and disease control;

- State Department of Agriculture should facilitate spread and dissemination of IRM program among the farmers in these areas.

7) Special scheme for promotion of Desi Cotton (G. *Herbaceum* and G. Arborium species) under MM-II

The area under *G.hirsutum* has increased from 3% in 1947 to 90% in 2007 whereas the area under *G.arboreum* decreased from 65% to 4% and that of *G.herbaceum* decreased from 32% to 5%. The area of *G.barbadense* which was 11% in 1970 was just 1% of total area in 2007. The reversal in trend is mainly due to the ingress made by Bt Cotton which is mainly of the *G.hirsutum* specie. This kind of skewed production of cotton is certainly not in India's interest since cotton of all varieties is required by the end user. Hence, the extent to which this distortion has affected the availability of the other varieties has to be considered and steps taken to redress the situation so that adequate quantities of other species of cotton are also available.

In the recent past, several cases of Bt varieties being susceptible to bollworm have been reported in different cotton growing areas. Hence, public sector research needs to be given greater impetus to come out with alternatives in a given time frame which may be fixed in consultation with the scientists of the concerned research institutions. Similarly, efforts should be made to implant the Bt gene into the long fibre length, high strength fibre varieties developed by the public sector institutions since that alone would ensure acceptability by the farmers. There is an urgent felt need for public sector intervention to Btfy varieties / hybrids, evaluating their performance & suitability across various regions and profiling them zone-wise.

100% coverage of farmers in non-Bt states and non-Bt farmers in Bt states may have to be ensured in XI Plan in the implementation of various components such as supply of breeder/foundation seed, FSS, FLDs, IPM/IRM etc. besides stepping up production of desi varieties and introduction of newly developed varieties of *G.arboreum, herbaceum* and *barbadense* species, whose production is getting affected due to large scale acceptance of Bt cotton. This would ensure reduction in distortion on account of extensive production of *G.hirsutum* specie which is now 90% of the total cotton production.

8) Enhancement of Subsidy on Components

The present rate of subsidy for different components was last revised about five years back. In the intervening period the prices of agri-inputs have gradually increased. Steep price escalation has been seen during the last couple of years but the subsidy rate remained unchanged. The subsidies, therefore, have no influence on choice of components and farmers do not find the program attractive from the viewpoint of subsidy.

Certified seed is provided under the program at a subsidy of a mere Rs.20 per kg on variety and hybrid alike. Similarly, though sprayers, sprinkler irrigation system and drip irrigation sets are provided at a subsidy of 50% of their cost, the subsidy is limited to Rs.800 to Rs.10000 for various types of sprayers, Rs.10000 for sprinkler irrigation system and Rs.25000 for drip irrigation sets. Therefore, considering the fact that the existing subsidy rates have not been revised for quite some time, in the best interest of the farmers and in the interest of improving production / productivity, the following measures are suggested:

- The limits set for these inputs need to be revised upwardly so that a farmer is required to bear only a bare minimum of actual cost from his own resources. No social category-wise differentiation may be needed.
- For general farmers not entitled for any subsidy, the cotton growing States may initiate a separate scheme wherein a certain percentage of the cost be borne by the States to facilitate purchase of the equipments like power operated and tractor operated sprayers and water saving devices at an affordable price.
- The study has observed that a substantial section of the cotton growers were unable to use hybrid seed because of its high cost as compared to varieties. The beneficiaries of seed component were inclined to use market seed along with the certified seed instead of spending almost 50% of seed cost of varieties. The subsidy structure for seed component, therefore, needs upward revision to 60% for varieties 75% for hybrids.
- The present level of assistance for the pheromone traps may not need any enhancement but the maximum limit of assistance in respect of the lures may be increased to Rs.1500 per trap in view of the escalated market cost.
- In respect of the three types of sprayers, the beneficiaries of MM II program are eligible for assistance to the extent of Rs.800, Rs.2000 and Rs.10000 respectively. They have to shell out an additional amount of Rs.800 to 1000 for manual, Rs.3500 to Rs.11500 for power operated and about Rs.16000 for tractor operated sprayers. In the given situation, it is proposed to raise the assistance to 50% of the cost of manual sprayers (to enable purchase of high–tech sprayers), 50% of the cost of power operated sprayers (60% of the cost for the Taiwan makes) and 50% of the cost of tractor operated sprayers. The enhanced assistance would encourage more farmers to use the technologically improved spraying systems that can provide uniform spraying over the crop canopy and also save in time.
- For sprinkler irrigation systems and drip irrigation sets, the present subsidy structure under MM II provides assistance limited to Rs.10000 per ha and Rs.25000 per ha to beneficiary farmers of general category. The present market rates for the two devices are Rs.14700 for sprinkler system and about Rs.45000 for drip sets. Considering the ever increasing cost of the devices and tremendous benefits farmers receive on using these devices, it is suggested that the maximum limit of quantum of assistance may be revised to Rs.18000 for sprinkler system and to Rs.35000 for drip irrigations sets.
- The present level of assistance for bio-agents & bio-pesticides is 50% of cost, limited to Rs.900 per ha. The present market rate for various bio-inputs has escalated during the last 5-6 years and, therefore, the assistance requires upward revision. In the interest of cotton beneficiaries, the proven impact of the bio-inputs of cotton should be fully exploited. Accordingly, the assistance is proposed for enhancement as 50% of the cost of bio-agents /bio-pesticides with maximum limit enhanced to Rs.1200 instead of the present Rs.900 per ha.

9) Other Recommendations

(i) Utilization of Funds

Slow pace of implementation and wavering execution is reflected in the under utilization of funds bringing to fore the need for better utilization of program components and synchronization of component-wise fund utilization. Gujarat, Maharashtra, Andhra Pradesh and Karnataka are singled out for low fund utilization as a consequence of wavering program execution. Needless to emphasise, the States must exhibit utmost sincerity in program execution by way of complete utilization of the allocated funds. In any event, if the unspent balance exceeds 20% of total allocation for the 75:25 cost sharing components, fund allocation (first installment) in the following year may be restricted to the unspent (balance) amount to start with and further funds could be released restrictively on the basis of submission of utilization certificate. This system can be followed in respect of all the defaulting States to make them deliver and inculcate a sense of discipline in program implementation.

The timeliness in release of funds to implementing agencies well before the commencement of sowing season being the essence, the State Governments may be advised to issue necessary notification and guidelines for implementation of the program immediately on receipt of administrative approval of the scheme from Government of India and also make available funds to their field units.

The States should also make separate budgetary allocation of funds for SC, ST and women farmers to enable benefit flow from the program to these sections of farmers. It may be 10% to 15% among SC/ST farmers and 15% to 20% among women farmers.

(ii) Awareness Generation

The state of technical support received by the cotton farmers is reportedly too little. There is indication of inadequacy and ineffectiveness at the extension level to properly and satisfactorily guide the farmers. The field survey has noted that the district agriculture departments in most of the sampled districts are overburdened with multifarious activities under multiple schemes of the Centre/State and hence the desired focus and attention to extension activities in the district is certainly lacking.

In order to improve awareness about the MM-II programme, the following measures are suggested:

i) Effective involvement of Panchayati Raj Institutions for creating awareness among farmers and in selection of beneficiaries for various components under MM-II, particularly, FFS, FLDs, etc.

ii) Launching a wide publicity campaign through audio-visual and other aids at the district, block level and village level for creating awareness about various components under MM-II with active participation and involvement of all the line departments, KVKs, SAUs, Farmers' Organisations and NGOs.

iii) Preparing a time bound and well-structured HRD plan for providing capacity building/training to all the field functionaries and stake holders.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