

EXECUTIVE SUMMARY

TMC MM 1.1: Development and promotion of medium and long linted diploid cotton (*G. arboreum* & *herbaceum*)

- In common *arboreum* trial (conducted at eleven locations across three zones) the seed cotton yield ranged from 820 kg/ha to 1588 kg/ha. Only one genotype, RG 509 (1158 kg/ha) recorded higher seed cotton yield numerically than the quality check PA 255 (1103kg/ha).
- In south zonal trial of 18 entries over two locations (Mudhol and Dharwad), the highest seed cotton yield was recorded by MDL 2452 (1188 kg/ha) followed by JLA 0613 (1106 kg/ha) and PA 733 (1063 kg/ha). These entries were significantly superior to *arboreum* check (922 kg/ha) but cannot outyield common check PA 255 (1257 kg/ha) as well as *hirsutum* check (1399 kg/ha).
- The highest seed cotton yield was recorded by JLA 0613 (1500 kg/ha) which was higher than common check PA 255 (1251 kg/ha), *arboreum* check AKH 8401 (1225 kg/ha) and *hirsutum* check AKH 8828 (1361 kg/ha) in central zonal trial of 18 entries over six locations.
- In introgression trials (Central zone), the highest seed cotton yield was recorded by D1a-08-26 followed by PAIG 39 and PAIG 62 which was superior to two checks. For staple length, PAIG 325, PAIG 326, PAIG 62 (27.2 mm) & PAIG 39, for fibre strength, entries DLSA-8-26, PAIG 62, PAIG 325, PAIG 326, PAIG 39 and PAIG 12 had outperformed all the checks.
- Variety RG 42 has been recommended for adaptive trial in zone 1B of Rajasthan by the Zonal Research & Extension Advisory Committee.
- CISA 614 was released from CICR, Regional Station, Sirsa and notified for commercial cultivation in north zone (Punjab, Rajasthan & Haryana).
- In north zonal trial which was conducted over three locations none of the genotypes gave higher seed cotton yield than the local *arboreum* and *hirsutum* checks.

TMC MM 1.2: Development of extra long staple *G. barbadense* cotton with improved fibre qualities to meet the requirement of textile industry.

- Combined analysis of *G. barbadense* germplasm, accessions across five locations representing south and central zone indicated that the mean seed cotton yield ranged from 25.6 to 65.0 g/plant.
- Based on combined analysis, two entries NDGB 72 and NDGB 92 were identified as promising with moderate seed cotton yield and desirable fibre properties.
- Among the genotypes tested at UAS, Dharwad, ICB 125 recorded the highest seed cotton yield followed by ICB 134 which were distinctly superior to Suvin ICB 125 has fibre qualities as per the requirement of the textile industry.

- In common TMC trial, GSB 21, PCB 45 and DB 12 at UAS, Dharwad and CCB 9 At CICR, Coimbatore recorded more seed cotton yield compared to Suvin.

TMC MM 1.3: Identification of *G. hirsutum* genotypes suitable for machine picking and development of agronomic package

- Under evaluation of released/pre-released genotypes suitable for machine picking trial, highest seed cotton yield of 2065 Kg/ha was recorded in KC 3 followed by P 1750, F 2383 and NISC 50. Besides high yielding, these genotypes possess suitable characters for machine picking.
- Among the introgressed lines evaluated NISC 44 at IARI, New Delhi, RCH 134 Bt at PAU, NISC 40 at CICR, Nagpur and NISC 49 at TNAU, Coimbatore recorded highest seed cotton yield.
- Spraying of ethereal at 5000 ppm dose at 150 DAS was found suitable for achieving desirable level of leaf shedding and boll opening.
- Row to row spacing of 100 cm and plant to plant spacing of 10 cm was found to be suitable for machine picking.

TMC MM 1.4: Development and promotion of Bt transgenic cotton for bollworm resistance

- Seven, thirteen and twelve genotypes of *G. hirsutum* are in BC4, BC3 and BC2 generations of backcrossing, respectively at Dharwad. Similarly 20, 5,15 and 16 genotypes are in BC4, BC3, BC2, BC1 generations of backcrossing, respectively at CICR, Nagpur.
- Kanamycin resistant T1 Surabhi (*G. hirsutum*) plants for cry1 F and DLSa 17 (*G. arboreum*) T1 plants for cry2Aa have been recorded at Dharwad. Putative transgenic TO plants of PA225 and PA 402 of *arboreum* cotton have been recorded at Nagpur.
- Bt hybrids MRC 6029 Bt, RCH 314 Bt, NCS 138Bt for north zone; PRCH 31 Bt, AKKa Bt, RCH 138 Bt for irrigated conditions of central zone; ACH-11 BGII, MRC 7347Bt, MRC 7301 Bt, for rainfed condition of central zone and MRC 7201 BGII, Tulsi 1 IBt, PCH 205Bt, Tulsi 4, Tulsi 9 Bt for south zone have been found promising.

TMC MM 1.5: Molecular characterization of cotton germplasm using DNAmarkers

- One hundred three germplasm lines of *G. arboreum* were characterized using 26 STMS primer pairs and 104 germ plasm lines of *G. herbaceum* were characterized using 10 STMS primer pairs. Molecular characterization of 100 cotton (*G. hirsutum*) core collections using PCR based 28 STMS loci was completed.
- One hundred fifty-six (156) germplasm lines belonging to seven working groups (yield, variety, okra leaf, oil, boll weight, mean halo length (MHL) and bacterial blight resistance) were characterized using STMS 40 primers at NRC on DNA Fingerprinting.

- Accessions IC-357200 and IC-356527 showed the maximum similarity (98%), while IC-356975 and IC-357682 CY showed the least pair-wise similarity (36%). All the selected accessions of working collection could be grouped into six major clusters.
- At CICR Nagpur, hundred accessions of working collection of *G. hirsutum* were successfully discriminated on the basis of their banding pattern.
- At NRC on DNA Fingerprinting and CICR Nagpur, 256 germ plasm accessions were characterized out of which sixty were common in both the centres.

TMC MM 1.6: Exploitation of apomixis and TGMS system in hybrid cotton seed production

- After extensive screening six lines IS 244-4-1, IS 244-4-2-27, IS 181-7-1-19, AP 2-1, AP 3-2 and AP1-4 were found with a low frequency of apomixis were found, but their frequency was too low.
- Cytology was done on two lines AP 4-15 and AP 5-10 plants which showed the aneuploidy nature at metaphase and telophase of chromosome configuration. cytological studies revealed that in the lines namely, 1060 B, IS 244-4-1 and IS 244-4-2, abnormal behavior of chromosomes was observed which resulted in triad formation instead of tetrad and in metaphase I, univalents were seen.
- Out of 20 experimental hybrids evaluated at Agricultural Research Station, Mudhol, five hybrids were found statistically at par with check.
- The pollen grains were regular and stained in completely fertile flowers where as presence of irregular shaped and non stained pollen grains were observed in sterile flowers.

TMC MM 2.1: Development of production technologies for Bt cotton and improvement of water and nutrient use efficiency with precision farming techniques

- Intercropping of Bt cotton (NCS 145) with pulses/soybean in central zone, green gram/soybean in south zone found to be superior over other moisture conservation techniques of rain water.
- Soil test based RDF + micronutrient and 75% N through inorganic + 25% through organic manure found to be superior over 100% RDF (only inorganic) in central zone.
- Irrigation at 0.8 ETc with 100 % RDF (120:60:60) was found economically beneficial in in central and southern zones while irrigation at 0.6 ETc provided 40 % percent saving of water in north zone
- Three split application of N K nutrient with P as basal is recommended for rainfed Bt hybrid in central zone
- Mulching with straw in Bt (RCH - 134 Bt) at Sriganganagar was found to be better in achieving maximum seed cotton yield and WUE.

TMC MM 2.2: Identification of innovative Bt cotton based cropping systems

- Among the intercropping systems, Bt cotton + coriander system at CICR, Coimbatore, cotton +

green gram at UAS, Dharwad, CRS, Nanded, and CIP, Rahuri, cotton + baby corn under paired row at ANGRAU, Lam, Btcotton + soybean at JNKVV, Indore and cotton + pigeon pea at CICR, Nagpur were found superior.

- No intercropping system recorded additional net return than sole cotton under irrigated condition of Sirsa. But at PAU, Faridkot Bt cotton intercropped with mung bean and ground nut recorded on par yield with sole cotton, indicating the possibility of introducing leguminous.
- At Faridkot, the transplanted Bt cotton was on par with direct sowing suggesting that there is possibility to save crop and maintain the plant population through transplanting technique in case of seedling death due to aberrant weather.
- The soil analysis at CIP, Rahuri revealed that wherever leguminous intercrops were grown, the soil nutrient status has improved than under sole cropping.

TMC MM 2.3: Mechanization of cotton production

- Air assisted sprayer was found superior for cotton as it gave uniform droplet size among the sprayers under study.
- Results indicated that the solar operated sprayer sustain a pressure of 20+10% psi for a significantly longer time over the battery operated sprayer, thus generating uniform droplet size spectrum over a longer period of time.
- Flail type chopper cum loader in a single operation can harvest, chop and load the chopped crop material in the trailer attached to the machine with the field capacity varying from 0.25 to 0.35 ha/h.
- A self propelled weeder cum sprayer has been developed with weeding efficiency of 60-70 per cent, field capacity of 0.20 ha/hr and field efficiency of 83-88 %.

TMC MM 2.4: Physiological manipulation of Bt plant morpho-frame for enhanced productivity under varied agro climatic conditions

- Based on the three years experiments, it was confirmed that foliar application of ethrel @ 8.56 mM ethylene at square initiation stage brought about changes in the plant morpho-frame leading to synchronous squaring, flowering and boll bursting. There was an enhanced seed cotton yield of 25% across the genotypes and agroclimatic zones with no negative effect on fibre quality.
- Results of the three on-farm trial using RCH 708 Bt cotton, showed that there was enhanced sympodial growth and around 20-30 extra bolls produced per plant, with foliar application of ethrel @ 8.56 mM during square initiation stage. Uniform boll bursting was also observed with no harmful effect on fibre quality.

TMC MM 3.1: Emerging and key pests: Their characterization, taxonomy, genetic diversity and control

- The year 2009-10 saw the emergence of the gall midge, tea mosquito bug, spodoptera and the safflower caterpillar as pests on Bt cotton. However, their incidence and damage were restricted to specific locations.
- Directions were provided to minimize insecticide use against mealy bugs, emphasizing on the role of native natural enemies and use of ecofriendly insecticide for its management.
- Key pests on Bt cotton refer to whiteflies in North India, jassids and thrips across the country.
- Different methods of the application of insecticides with low ecotoxicity were tested. Acephate, amongst insecticides was the the molecule of choice for sucking pest management.
- Mealy Quit and Mealy Kill, both bio insecticidal products formulated at CICR were evaluated in multi location trials for their efficacy.
- Cotton leaf curl virus (CLCuV) In North India and tobacco streak virus disease in certain parts of Andhra Pradesh and Marathawada region of Maharashtra was observed.
- The cotton leaf curl virus has increased in intensity with a large number of Bt hybrids being susceptible to it. Grey mildew has also been recorded as an emerging pest in central and southern parts of India.
- Jasmine perfume (2.5ml/L), ocimene (3ml/L), limonene (3ml/L) can effectively be used against jassids in place of neonicotinoid sprays. Similarly Acephate 75 SP (1.0 g/L) was effective for management of mirid bugs.
- A novel non- phytotoxic, botanical bio- emulsifier (soap nut) was identified and evaluated in combination with limonene, ocimene and jasmine perfume as 5% spray.

TMC MM 3.2: Development and validation of IPM/IRM strategies for Bt cotton under different ecosystems

- Economic threshold level of *Helicoverpa* on Bt cotton in central India ranged from 1.12 to 2.03 while it was from 0.62 to 1.45 in south India
- Cry protein expression in Bt cotton was highest in irrigated cotton as compared to rainfed cotton.
- The toxicity to acephate ranged from LC_{50} 0.0001 % to 0.011 %. For monocrotophos it ranged from 0.0002% to 0.0113 %. The toxicity to thiomethoxam ranged from 0.0002% to 0.5% while for imidachlorprid it ranged from 0.00002% to 0.109%.
- The resistance was 110 fold for acephate, 54 fold for monocrotophos, 2500 fold for thiomethoxam and 5450 fold for imidachlorprid. Resistance to neonocotinoids was the highest in central India, including Gujarat and MP,
- Rasi genotypes, both BG and BGII were the only genotypes very susceptible to leaf reddening at 85 DAS. Rasi 2 non Btwas free from leaf reddening.

inoculants

MM3.3: Development, validation, utilization and/or commercialization of bio-pesticides and bio-inoculants

- Substitution of BSA and glycerol in PCR enhanced the efficacy of amplification and detection of pathogens in the infected plants and in soils.
- *Fusarium pallidoroseum* a new entomophagous fungus associated with cadavers of cotton mealy bug proved highly efficient for its control.
- Three entomophagus strains *Lecanicillium lecanii* (CBE), *Metarrhizium anisopliae* (MA4) and VL 5 of *Verticillium lecanii* (VLS) were found highly promising for biocontrol of cotton mealy bug and identified for registration with CIB.
- Three bacterial strains viz., *Pseudomonas fluorescens* (CICR Hia), *Phot rhabdus sp.* (Ngp), *Bacillus subtilis* (BsC₃) and two fungal antagonists viz., *Trichoderma harzianum*(Th-KSD) and *Trichoderma viride*(TV9) were proved efficient in biocontrol of cotton pathogens and pests.
- Biopesticidal formulations Mealy quit, Mealy kill and Biocidal formulation (NGP) proved efficient against sucking pests including mealy bug and are identified as potential candidates for CIB registration.

TMC MM 3.4: Development of farmer friendly diagnostic kits for transgenic event seed purity

- The Cry1 C and Cry1 B kits were developed, validated, stabilized and produced for use.
- Cry' 1 F antigen produced and purified.
- Cry 1 F protein qualified in putative GM plants through ELISA.

TMC MM 4.1 : Quality evaluation of cotton fibres

- During the reporting period 1552 samples were tested for fibre quality parameters under this project..Among these 107 samples were satisfying fibre quality norms and they could be promoted for further breeding programme. However, each project has a set of specific objectives and hence the quality data was analyzed accordingly.

TMC MM 5.1: Total factor productivity of cotton in India

- In Punjab total factor productivity of cotton showed positive growth in both the districts bhatinda and mansa for which the analysis was done.
- In Maharashtra out of ten districts analyzed eighth districts Amaravati, Beed, Buldhana, Jalna, Nanded, Parbhani, Wardha and Yevatmal showed positive significant total factor productivity growth during the period of analysis indicating that cotton output growth is sustainable. In Akola an Aurangabad districts total factor productivity growth was not significant this needs to be corrected to make cotton production sustainable.
- In Tamil Nadu total factor productivity index showed positive growth in southern zone and north western zone, negative growth in Cauvery delta zone and

north eastern zone while it was not significant in western zone indicating that cotton production growth is not sustainable in all the zones of Tamil Nadu.

TMC MM 5.2: Studies on social dynamics of cotton production in distress areas

- Large proportion of cotton growers from Eastern Vidarbha, Karnataka and Western Vidarbha had high alienation irrespective of situations as distress or non distress. The majority of cotton growers from Andhra Pradesh recorded medium level of alienation.
- Majority of cotton growers from both, distressed as well as non distressed districts from all the centres faced inadequacy of inputs like fertilizers, farm machinery and sprayers and dusters, irrigation facilities, electricity for farm operation and watershed development works were also inadequate.
- The information infrastructures like computer and internet, telephones, mobiles were not available with them. The post harvest infrastructures like warehouses, cold storage, rural agro-based

industries

TMC MM 5.3: Indian Cotton Portal

- With the collected datasets available with cotton information repository, developed new CD version of the information retrieval system with more user friendly tools with which the user with minimum interaction could retrieve complex information. The software developed with visual Basic.NET (2008) and for front end and Microsoft Access (2007) as backend.
- Prototype of the farmer forum prepared, Web contents have been reoriented as per ICAR norms and Cotton Portal was updated with many new information sets.

TMC MM 5.4: TMC MMI co-ordination and monitoring cell

- Coordinated the functioning of TMC MM I projects at various coordinating centres. The cell organized eighth meeting of ICAR Standing Committee for Technology Mission on Cotton Mini Mission -1 (TMC MM-1) and The Annual Review Workshop (2009-10) of Technology Mission on Cotton.

