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ICAR-CENTRAL INSTITUTE FOR COTTON RESEARCH
NAGPUR

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2021

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ICAR- CENTRAL INSTITUTE FOR COTTON RESEARCH, NAGPUR

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ICAR-Central Institute for Cotton Research, Nagpur

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PREFACE

Cotton was sown in 120.55 lakh hectares during 2021-22 season across 11 major cotton growing states. The institute coped well with the pandemic situation and pursued its research and outreach programmes which led to significant achievements during the year under report.

In 2021, 4 Bt varieties namely ICAR-CICR Bt 9, ICAR-CICR Bt 14, ICAR-CICR Bt 21, ICAR-CICR Bt 25 were released by CVRC and Gazette notified. Four non-Bt varieties namely, CICR-A Cotton 46 (CNA 1054) *of G. arboreum,* CICR-H Cotton 47 (CNH 1111) and CICR-H Cotton 48 (CNH 1128) of *G. hirsutum* and for the first time a naturally dark brown coloured cotton *G. hirsutum* variety CICR-H-NC Cotton 53 (16301 DB) were identified for commercial cultivation and released during the 87th CVRC meeting and notified in the Gazette vide S.O. 8(E) dated 24th December, 2021. Also, an Extra Long Staple (ELS) variety - CICR B Cotton 45 (CCB 143B) was released and notified for the states of Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu.

ICAR-CICR, Nagpur has more than 12,336 germplasm accessions covering all the cultivated species including wild species, interspecific derivatives, perennials and landraces of Gossypium. Two tetraploid wild species *viz., G. mustelinium and G. ekmanianum were* added to the existing collection. Added 21 exotic accessions from USDA during the year. A total of 152 cultivated cotton germplasm was distributed.

Roving surveys carried out in 30 different locations spread across North, Central and South cotton growing zones of India revealed pink bollworm infestation above ETL at all the locations with green boll infestation ranging between 26.25% (Nagpur) and 100% (Nasik and Amreli). IRM: Dissemination of Pink Bollworm management strategies was implemented in 105 villages covering 21 districts of 8 major cotton growing states through financial support under NFSM-CC. Among the eight different vegetable oils tested for their oviposition deterrent properties, maximum reduction (74%) was observed in blend of ground nut with safflower. Six pathogenic bacterial internal boll rot isolates belonging to *Erwiniaceae, Enterobacteriaceae, Pseudomonadaceae* and *Sphingobacteriaceae* were characterized.

Deep sub-soiling and rotation with deep rooted crops such as pigeon pea, radish, sesbania, and sunnhemp had a positive effect on cotton yield. Seed cotton yield was significantly higher under zero tillage - permanent narrow raised bed with residue retention as compared to the other treatments of zero tillage and conventional tillage. Twelve short-listed microbial-based volatiles as seed treatment and foliar application were found to significantly enhance cotton seedling vigour, plant defense enzyme activities and soil biological properties. Under e-communication programme, advisories through voice messages were sent to 2.65 lakhs registered farmers during the year.

During the period, a total of 64 research papers of which 25 research papers with >6 NAAS Score and 39 research papers with <6 NAAS Score 29 popular articles were published. Fifty-nine training programmes in virtual, hybrid and physical mode were organized. Linkages were fostered with sister ICAR Institutes, SAUs, other public sector Institutes, private companies, NGOs and farmer producer groups to commercialize and upscale varieties and technologies developed. Seven MoUs were inked during January to December 2021.

Guidance and constant encouragement received from Dr Trilochan Mohapatra, Secretary, DARE and Director General, ICAR and Dr T.R. Sharma, DDG (Crop Sciences) is gratefully acknowledged. I am indebted to Dr S.A. Patil,

Chairman and esteemed members of the Research Advisory Committee for their valuable guidance and direction. I am grateful for the guidance extended by Dr R.K. Singh, ADG (CC), ICAR and research support received from my colleague's Dr A.H. Prakash, Head, Regional Station, Coimbatore and Project Coordinator, AICRP on Cotton; Dr S.K. Verma, I/c Head, Regional Station, Sirsa. Heads of Divisions *viz.* Dr Blaise D'Souza, HoD, Crop Production; Dr V.N. Waghmare, HoD Crop Improvement; and Dr Nandini Gokte, HoD, Crop Protection and Dr M.V. Venugopalan, Head, PME. The unstinted efforts of the Editorial Committee members in bringing out this publication in time is commendable.

(Y.G. Prasad)
Director, ICAR-CICR, Nagpur

1. EXECUTIVE SUMMARY

Crop Improvement Division

- ICAR-CICR, Nagpur has more than 12,336 germplasm accessions covering all the cultivated species including wild species, interspecific derivatives, perennials and landraces of *Gossypium*. A total of 52 *G. herbaceum* lines multiplied at Surat and 565 accessions multiplied at Nagpur were deposited in medium term storage (MTS). A total of 152 cultivated cotton germplasm was distributed.
- Two tetraploid wild species *viz., G. mustelinium and G. ekmanianum were* added to the existing collection. The available *Gossypium* species and derivatives namely *G. aridum, G. armourianum, G. barbadense, G. arboreum, G. hirsutum x G. triphyllum* and *G. hirsutum* unconfirmed species are conserved and have been morphologically and cytologically characterized.
- CLCuV immune accessions namely GVS 8 and GVS 9 were evaluated at ICAR-CICR, Regional Station, Sirsa. A total of 2025 new crosses were attempted using the cultivars and races of *Gossypium* and wild species. More than 450 introgressed derivatives (*G. arboreum* and *G. hirsutum*) and 50 colour cotton entries were evaluated at Nagpur for yield, fibre traits, biotic and abiotic stress tolerance.
- Embryo culture mediated accelerated introgression of Tg2E13 event (*cry1Ac* gene) into three genotypes (Suraj, NH615 and CISH3178) was accomplished through BC_4 under contained facility of ICAR-CICR, Nagpur. The studies revealed that Tg2E13 carrying plants had delayed maturity compared to non-Bt counterpart both in the background of Coker310 and CISH3178.
- Incidence of whitefly on Tma 12 and LPS141 (resistant check) was similar while the incidence on non-Tma 12 plants and HS6 (highly susceptible check) was comparable but significantly higher than in Tma12 and LPS141 genotypes.
- Four Bt varieties namely ICAR-CICR Bt 9, ICAR-CICR Bt 14, ICAR-CICR Bt 21, ICAR-CICR Bt 25 were released by CVRC and Gazette notified.
- Conversion of several non-Bt varieties/genotypes (LRA 5166, Anjali, MCU 5-VT, Suraj, Surabhi, Supriya, Sumangala, CCH 2623, Subiksha, Sunantha, CCH 15-1, BB 6 and BB 7) is in progress
- Four non-Bt varieties namely, CICR-A Cotton 46 (CNA 1054) of *G. arboreum* CICR-H Cotton 47 (CNH 1111) and CICR-H Cotton 48 (CNH 1128) of *G. hirsutum* and for the first time a naturally dark brown coloured cotton *G. hirsutum* variety CICR-H-NC Cotton 53 (16301 DB) were identified for commercial cultivation by CVIC and released during the 87th CVRC meeting and notified in the Gazette vide S.O. 8(E) dated 24th December, 2021.
- CICR B Cotton 45 (CCB 143B)has been released and notified vide Gazette notification dated 24th December 2021; S.O. 8 (E) for the states Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu.
- Evaluation of 31 F_4 generation of single, double, six and eight parental crosses along with three checks for seed cotton yield and other important traits showed that DTS 518 was the best performer. DTS 519, DTS 509, DTS 524 and DTS 502 were other promising cultures recording more than 20 per cent increase over the check NH 615. For improving the fibre quality of drought tolerant line, culture 28I was backcrossed with four high fibre strength lines. F5 generation (2972 progenies) of ten parents MAGIC population was advanced to F6 generation.

- The introgression lines (Gh × Gb) exhibited higher ginning outturn (39.2–43.1) and lint index (6.5-8.2%). The introgression lines CNH 204710 (43.9%), CNH 20378, CNH 20387 (43.4%) and CNH 204910 (43.3%) were identified for higher ginning outturn.
- The highest activity of pink bollworm (moth catches per trap) was observed in third week of November. An early maturing variety (150 days) sown in early/mid-June can potentially escape pink bollworm damage.
- Genetic transformation using Coker 312 with *CICR-cry2Ab1Ac::chitinase* gene constructs through *Agrobacterium* mediation and regeneration through somatic embryogenesis was carried out and 45 putative transgenic plants were regenerated.
- Isolation, cloning and transformation of Wnt3A like gene into cotton (Suraj) was attempted for its functional validation through over-expression.
- The *cry1D* nucleotide sequence coding for active toxin was custom synthesized, cloned in bacterial expression vector pET28, expressed in bacterial host *E. coli* Rosetta gami and BL21 strains. Recombinant proteins expressed in *E. coli* BL21cells were isolated and utilized for testing the efficacy of target Cry1D protein against *P. gossypiella, H. armigera* and S. *frugiperda* through diet incorporation method. The preliminary bioassay results were found promising against pink bollworm *P. gossypiella*.
- Chimeric callus cultures for the presence of sgRNA::Cas9 using vector and sgRNA specific primers was established. This methodology helps to shortlist the putative callus cultures. Agrobacterium mediated transformation of Coker 312 hypocotyls was carried out with sgRNA3GhPHYA1 ::CRISPR / Cas9 cassettes. Somatic embryogenesis has been achieved from the Coker 312 callus cultures harboring sgRNA3GhPHYA1::CRISPR/Cas9 cassette.
- For development of mapping population, two accessions each of most diverse water-logging tolerant and susceptible were characterized and subjected to diversity analysis using SSR markers.
- The yield trial of nine high yielding long staple cultures with Surabhi and Suraj as the check varieties revealed that culture YLS 21-2 yielded 1528 kg/ha having the highest boll weight of 4.9 g/boll. The culture YLS 21-4 was the best for fibre quality with 34.1 mm length and 33.8 g/tex tenacity.
- Forty-five genotypes from different AICRP centres were screened for leafhopper tolerance in glass house. NDLH 2010 (R) and LRA5166 (S) were identified and used as resistant and susceptible lines and F_1 hybrid was produced for proteomic analysis.
- Among the four cultivated species, seed protein content determined by Bradford method was lowest in diploid varieties (20-30mg/g seed) than
- in tetraploids (35-45 mg/g seed). Among the 16 wild species, soluble seed protein content was highest in *G. anomalum* (30mg/g seed) and lowest in *G. aridum* (10mg/g seed).
- Seed coating (on hydro primed seeds) with DAB + Bio NPK and halo-priming with KH_2PO_4 (@ 0.5%) was found be a viable seed treatment for quality enhancement.
- Germination studies of the seeds kept under different packaging containers after four years revealed that each of the treatments have maintained seed viability with germination (>65%) above Indian Minimum Seed Certification Standards (IMSCS) in refrigerated conditions (5°C).
- Maintenance breeding and characterization of 183 extant cotton varieties was carried out in tetraploid and diploid cotton viz., 138 in *G. hirsutum*, 35 in *G. arboreum, 3 in G.herbaceum and 7 in G.barbadense.*
- 7.17 q breeder seed of non-Bt varieties of cotton, 5.90 q breeder seed of different Bt cotton varieties released by ICAR-CICR was produced.

Crop Protection Division

- Significant reduction in the number of sprays for the control of cotton pests in IRM fields (5.19 sprays) with significant reduction in cost of pesticide use by 40% was observed compared to non-IRM fields (8.08 sprays) through management strategies implemented under IRM-PBW project.
- Among the eight different vegetable oils tested for their oviposition deterrent properties, Palm oil 3% gave maximum reduction in the egg laying (69%) of *Helicoverpa armigera* compared to control. Maximum reduction (74%) was observed in blend of ground nut with safflower.
- The order of preference for pink bollworm female for egg laying was in order of *G. hirsutum>G. barbadense > G. arboreum > G. herbaceum.* Higher proportion of γ terpinene in *G. herbaceum* might account for deterrent effect against pink bollworm.
- Fourteen pathogenic fungal boll rot isolates belonging to *Pleosporaceae, Botryosphaeriaceae, Nectriaceae, Glomerellaceae, Sporocadaceae* and *Trichocomaceae* from different geographic locations of Maharashtra, Telangana and Madhya Pradesh states were characterised. Six pathogenic bacterial internal boll rot isolates belonging to *Erwiniaceae, Enterobacteriaceae, Pseudomonadaceae* and *Sphingobacteriaceae were characterized*.
- *Corynespora cassicola* leaf spot samples from 35 different cotton growing locations of Maharashtra, Gujrat and Telangana, States were characterized based on morphological and molecular parameters and ITS sequences deposited to NCBI database.
- Bio-priming of cotton seeds (CV. Suraj and Phule Dhanwantary) with *endophyte strains Diaporthe* sp. CFL-34 and CFR-1 registered highest seed germination (93.33%) followed by *F. solani* CEP-20 (90.0%) and CFL-27 (83.33%). Seed treatment of talc-based formulation of endophytes viz., CEL-41, CEL-48, M_1-4, CFS-5 and CFL-34 resulted in reduced wilt/ root rot incidence (2.66 – 4.16%) compared to control (12.61%) under field condition.
- Roving surveys carried out in 30 different locations spread across North, Central and South cotton growing zones of India revealed pink bollworm infestation above ETL at all the locations with green boll infestation ranging between 26.25% (Nagpur) and 100% (Nasik and Amreli).
- The 19 different populations of pink bollworm subjected to bioassays revealed that the folds of resistance against Cry 1Ac ranged between 113.0 to 828.62 while resistance to Cry 2Ab was between 130.22 and 1961.78.
- Dominant endosymbiotic gut bacteria from pink bollworm larval midgut was *Burkholderia* which are gram negative, rod shaped bipolar bacteria.
- Individual pheromone septa targeting the *Pectinophora*

gossypiella, *Spodoptera litura*, *Helicoverpa armigera* and *Earias vittella* are housed in a modified delta trap and smart trap imaging and transmission system coupled with weather sensor system is developed for investigating the real-time trap catch with corresponding weather data.

- The relative tolerance values of insecticides for cotton leaf hopper in comparisons to thiamethoxam (1.0) were clothianidin (1.22) > fipronil (1.52) > acetamiprid (3.15) > Imidacloprid (3.56) >flonicamid (4.74) > thiacloprid (5.32) >spiromesifen (5.68 >diafenthiurons (7.15) > chlorpyrifos (18.39) and profenofos (29.21). The Nagpur population of leafhopper was more susceptible to imidacloprid (0.037 mg.ai/L) followed by flonicamid (LC_{50} = 0.052 mg.ai/L) and clothianidin (LC50 = 0.053 mg.ai/L). Less effective insecticides for leafhopper were thiodicarb (LC50 = 0.693 mg.ai/L), diafenthiuron (LC50 = 1.080) and chlorpyrifos (LC50 = 1.145 mg.ai/L)
- Six different cotton genotypes (Bt and non-Bt) were evaluated for tolerance against stem weevil with Mallika Bt hybrid and MCU5VT recorded more susceptible while Bahubali and MCU 3 were found to be tolerant to stem weevil.
- Morphological and molecular characterization of *Pochonia chlamydosporia (Goddard)* Gams and Zare, isolated from the Reniform nematode, *Rotylenchulus reniformis*, was carried out and a liquid-based formulation of *P. Chlamydosporia* was developed with storage viability of 540 days.
- Molecular characterization of a native nematode antagonistic fungus, *Purpureocillium lilacinum*, isolated from the cotton rhizosphere was carried out and submitted to GenBank (Accession No. OK189590.1).
- At, CICR Sirsa and CCS HAU Hisar 0-58 % and 0.0-5.0% pink bollworm larval recovery from green bolls of Non- Bt cotton at 160DAS was recorded. In BG-II cotton, during 2021-22, severe infestation of PBW is recorded in the entire North zone where maximum larval recovery (20.0-38.0%) was at Bathinda (Punjab).

Crop Production Division

- Deep sub-soiling and rotation with deep rooted crops such as pigeon pea, radish, sesbania, sunnhemp produced greater yield than the non-sub soiled control. Among rotation crops, sesbania was followed by sunnhemp, soybean and pigeon pea.
- Doubles and multiples were almost negligible with the Gaspardo pneumatic planter. Skip and doubles studies with BGII hybrid indicated that skips up to 15% was compensated without significant yield penalty when 10% doubles were present. Significant yield reduction was observed at 20 and 25% skips without doubles.
- The cumulative, seasonal values for Net Ecosystem CO_2 Exchange, Gross Primary Productivity, Ecosystem respiration and evapotranspiration were -391.8 gC m^{-2}, 1063.9 gC m^{-2}, 672.0 g Cm^{-2} and 545.3mm respectively. During the crop season 2020-21, around 3.92 t/ha carbon was sequestered in the rainfed cotton ecosystem.
- New conceptual design for tractor mounted spindle type picker was finalised in order to accommodate the prototype into 90 cm row to row spacing. The PGR based chemical defoliant's application to cotton leaves at the time of 60-70% boll opening resulted in more than 90% leaf defoliation without any adverse effect on the fibre quality parameters.
- Drainage practice by adopting ridges and furrows followed by foliar application of salicylic acid @ 0.5 mM had lowered the incidence of *Alternaria* and improved the uptake of total N, total Ca, total Fe and total Mn significantly. Water logging resulted in decreased concentration of nitrate reductase (NR) activity across treatments as compared to control. But effect of melatonin @ 100 µM, Fe_2 SO_4 (0.5%) and urea 1% treatments stabilized the NR.
- After two years continuous adoption of cotton-maize cropping system, the highest values of available N, P and K in surface soil (0-30 cm) was noticed with combined application of inorganic and organic sources of nutrients.
- The epigenetic regulating chemicals (ERCs) like Sulfamethazine 10 µM (68.3%) and 5 Azacytidine 10µM improved the relative water content over control in Suraj and 5 Azacytidine 40 µM recorded higher RWC in LRA 5166. Higher total soluble sugars (TSS) content was recorded by 5 Azacytidine 40 µM treated plants in case of Suraj and Epigallocatechin gallate 100 µM treated plants of LRA 5166.
- Seed cotton yield was significantly higher under zero tillage - permanent narrow raised bed with residue retention as compared to the other treatments of zero tillage and conventional tillage. Total system productivity was higher under cotton-berseem cropping system and second best total system productivity was under cotton - wheat cropping system.
- In North-west India, early sowing (in 4th week of April) of Bt cotton variety, non-Bt cotton variety as well as Bt cotton hybrid gave significantly higher seed cotton yield. Application of Mepiquat chloride @ 20 g ai / ha at 60 and 75 DAS significantly improved the seed cotton yield over control.
- For qualitative and quantitative estimation of cotton metabolites through GC-MS, single solvent extraction followed by combination of solvents was found the most suitable method. Mid polar column followed by non-polar column was found the best to identify cotton metabolites. Additionally, among identified 50 GLP (Germin Like Proteins) isoforms, nine GLP isoforms were found to show more than four-fold expression under drought.
- Out of seven best native PGRs selected, *Sphingomonas* sp. treated cotton plants showed better drought stress tolerance than control. While evaluating their *In-vitro* growth promotion activity, three bacterial isolates; *Micrococcus luteus*, *Agrococcus* sp and *Solibacillus isronesis* exhibited higher activity in terms of IAA (1, 3 Indole Acetic Acid). Also, maximum ACC deaminase activity was found in drought tolerant bacterial isolate *Micrococcus luteus*.
- Increase in soil $CaCO_3$ content due tocalcium carbonate solubilizing bacteria (CSB) affected the root and shoot attributes. Significant enhancement in root characteristics and yield attributes were observed in plants inoculated with CSB consortia and CSB-1 compared to the uninoculated plants (RDF).
- Twelve short-listed microbial-based volatiles in 150 combinations were tested using yellow (YST), white (WST), and blue (BST) sticky traps. Overall, YST was found to trap more sucking pests compared to WST and BST. These 12 microbial-based volatiles as seed treatment and foliar application was found to significantly enhance the cotton seedling vigour, along with improvements in plant defense enzyme activities and soil biological properties.
- Under conventional ridges and furrow irrigation system, foliar spray of mepiquat chloride (60ppm), at flowering stage

followed by the second dose 30 days after the first spray significantly reduced plant height and increased seed cotton yield in RCHB 625 BGII vis-a-vis untreated plants. Under drip fertigation system, planting of Suvin with fertigation and foliar spray of mepiquat chloride followed by subsequent dose of 30 ppm produced highest seed cotton yield of 2182 kg ha^{-1} (significantly higher than that of farmer's practice).

- Available soil K at 30 days after sowing recorded higher K availability in soils treated with potassium solubilising microbial (KSM) isolates compared to control in black and red soils. These isolates were deposited in ICAR-NBAIM, Mau for conservation of genomic material and accession numbers were obtained for the same.
- Under e-communication programme, more than 5000 users downloaded Integrated Cotton Mobile App. A total of 1,08,21,782 pre-recorded automatic phone calls (75,17,218 in Marathi, 5,84,704 in Tamil; 2,07,062 in Hindi languages from Nagpur, Coimbatore and Sirsa, respectively) were made for benefit of the registered farmers during the year.
- Study on Farmers Producer Organization (FPO) based Agribusiness model for cotton marketing in Maharashtra revealed that the FPOs face many constraints due to which they were unable to expand their activities. Lack of capital, lack of storage facilities, lack of professional marketing skill, low business volume of many FPOs rendering manpower employment uneconomical, non-payment of salary or incentives to those who participate in the activities of the FPO, price risk were the major problems extricated from the study.
- The secondary data collected regarding the cotton value chain in Tamil Nadu shows that the State has more than 959 cotton man-made fibre textile mills and 40 composite mills in the non-SSI sector. Coimbatore cluster has around 919 spinning units contributing around 387 Million kgs yarn which is 25% of Tamil Nadu's Production. European countries are the major importers of Tiruppur Textile Products (majorly Knitted variety).
- Extension Model for promoting the production of Extra Long Staple cotton in India revealed that the knowledge gap index was more regarding usage of refuge crops in ELS Bt cotton hybrids, available ELS cotton varieties and hybrids, suitable weedicides and chemicals for managing pests. Technology gap index was more in areas pertaining to nutrient management, planting methods, disease and pest management.

General

- During the period, a total of 64 research papers of which 25 research papers with >6 NAAS Score and 39 research papers with <6 NAAS Score as well as 29 popular articles were published.
- 59 training programmes including virtual training programmes were organized where a total of about 4800 beneficiaries including farmers, students, field trainees and extension functionaries participated.
- Linkages were fostered with sister ICAR Institutes, SAUs, other public sector Institutes, private companies, NGOs and farmer producer groups to commercialize and upscale varieties and technologies developed. Seven MoUs were inked during January to December 2021.
- A patent was granted on "CICR Whitefly Adult Suction Trap" on 6th September 2021 vide patent no. 376517.

2. INTRODUCTION

2.1 : Brief History

The ICAR-Central Institute for Cotton Research (CICR) was established at Nagpur, in 1976. The two regional stations of IARI located at Sirsa (Haryana) and Coimbatore (Tamil Nadu) were transferred to ICAR-CICR to cater needs of north and south India, respectively.

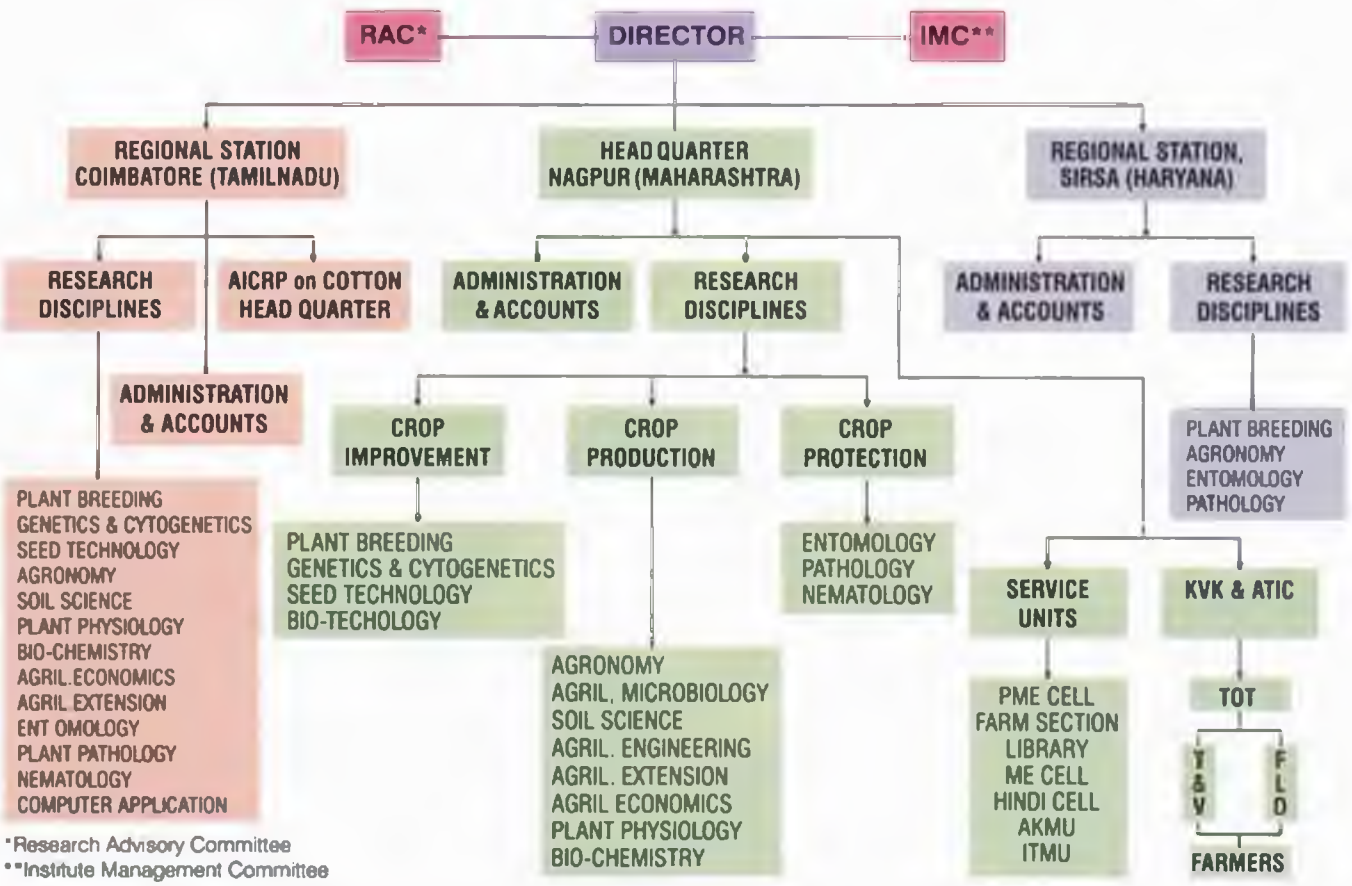
2.2 : Mandate

- Basic, strategic and adaptive research on production, protection, fibre quality and by-products of cotton
- Creation of new genetic variability for location-specific adoption in cotton-based cropping systems.
- Coordination and monitoring of applied research on national and regional issues to develop improved varieties and technologies
- Dissemination of technologies and capacity building

Location of the of ICAR-CICR Institute

Center	Latitude (0N)	Longitude (0E)
ICAR-CICR, Head Quarters, Nagpur, MH	21.037	79.058
ICAR-CICR, Regional Station,Coimbatore, TN	11.014	76.929
ICAR-CICR, Regional Station, Sirsa, Haryana	29.543	75.038

ORGANOGRAM OF CICR



*Research Advisory Committee
**Institute Management Committee

2.3 : Staff Position (as on 31st December, 2021)

Category	Sanctioned Cadre Strength				Post Filled Up			
	NGP	CBE	Sirsa	Total	NGP	CBE	Sirsa	Total
Director (RMP)				1	1	--	--	1
Scientific				77	41	19	5	65
Technical				72	38	12	8	58
Administrative				46	15	4	3	22
Skilled Support Staff				44+31	29	11	17	44+13
Krishi Vigyan Kendra								
Training Organizer	1	--	--	1	--	--	--	1
Technical	11	--	--	11	10	--	--	10
Administrative	2	--	--	2	--	--	--	--
Skilled Support Staff	2	--	--	2	2	--	--	2

NGP – Nagpur; CBE - Coimbatore

2.4 : Financial Statement

The budget grant and actual expenditure for the year 2021 are furnished below:

(Rs. in Lakhs)

Name of Scheme	2020-21		2021 (Jan-Dec 2021)	
	Sanction	Expenditure	Sanction	Expenditure
Plan Scheme	2679.25	1648.52	3063.07	1753.09
Deposit Scheme	1306.63	1225.4	1206.64	1181.21
Revolving Fund	12.08	11.86	14.01	4.23
Govt. Grants	4763.19	4641.89	3931.01	4867.11
Total (in lakhs)	**8761.15**	**7527.67**	**8214.73**	**7805.64**
Revenue Generation (Revenue Receipts)	**50.32**		**48.37**	

3. RESEARCH ACHIEVEMENTS

Theme 1: Accelerating genetic gains for productivity enhancement, fibre quality, stress tolerance and climate resilience using transgenics, genome editing and pre breeding technologies

1.1 Project Name : Development of elite Bt cotton varieties using potential non-deregulated transgenic events

Dr. V.N. Waghmare (PI); Co-PI's: Dr G Balasubramani, Dr Vinita Gotmare, Dr J Amudha, Dr KP Raghavendra, Dr M Saravanan, Dr HB Santosh, Dr Vivek Shah, Dr Rakesh Kumar, Dr Rishi Kumar, Dr VS Nagrare

Importance of the study : Development of transgenic cotton varieties for sustainable bollworm management using available deregulated and non-deregulated indigenous new events available from Indian Research Institutions.

Salient findings :

Introgression and Evaluation of Tg2E13 event : Embryo culture mediated accelerated introgression of Tg2E13 event (*cry1Ac* gene) into three genotypes (Suraj, NH615 and CISH3178) was accomplished through backcross breeding under contained facility of ICAR-CICR, Nagpur. From the BC_1F_2 populations of three crosses *viz.*, Suraj × Coker310 (Tg2E13), NH615 × Coker310 (Tg2E13) and CISH3178 × Coker310 (Tg2E13) homozygous plants carrying Tg2E13 event were identified in the previous generation and seeds were multiplied. Comparative evaluation of Tg2E13 and Mon531 events for toxin expression and bio-efficacy was studied during 2020-21 in the following combinations *viz.*, CISH 3178 - Mon531 (*cry1Ac*), CISH 3178 - Tg2E13 (*cry1Ac*), CISH 3178 - Tg2E13 (*cry1Ac*) + Mon531 (*cry1Ac*), Coker 310 - Non-Bt, Coker 310-Tg2E13 (*cry1Ac*) and BGII hybrid check (*cry1Ac + cry2Ab*).

Leaf bioassays were conducted at 60 DAS using two days old neonate larvae of *H. armigera* under laboratory condition with assay period of seven days. Insect mortality of Mon531 was comparable to Tg2E13 event. Both the events achieved more than 90% mortality on/before 4th day of assay (Fig. 1.1.1). CISH3178 (Tg2E13/*cry1Ac* + Mon531/*cry1Ac*) and Ankur 3028 BGII (*cry1Ac* + *cry2Ab*) event had similar efficiency with more than 95% mortality on/before 4th day of assay. All transgenic events yielded 100% mortality on 7th day. Protein expression was studied through ELISA at 60 DAS. Tg2E13 event (5.08 ppm) had higher toxin expression compared to Mon 531 (3.61 ppm). Tg2E13 + Mon531 events (6.02 ppm) together had very high toxin expression than BGII check (5.19 ppm). The studies revealed that Tg2E13 carrying plants had delayed maturity compared to non-Bt counterpart both in the background of Coker310 and CISH3178 under contained facility. To confirm the protein expression, bioefficacy and agronomic performance of the Tg2E13 introgressed plants, a Confined Field Trial was proposed in the crop season (2021-22).

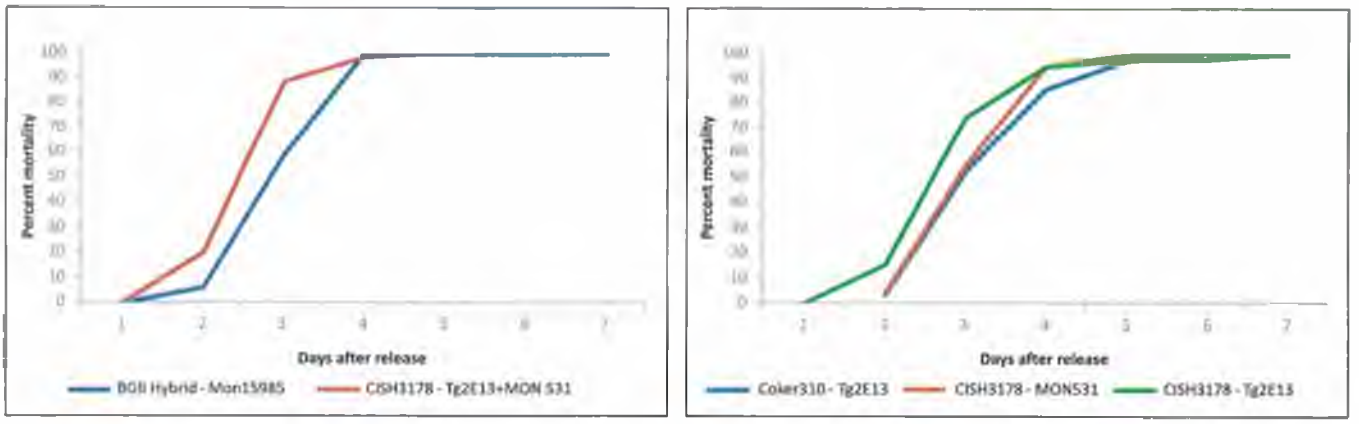


Fig. 1.1.1 Leaf bioassay of Tg2E13 and Mon531 events against *Helicoverpa armigera*

Introgression of CH12 event (cry2Ax1): BC_3F_1's of three crosses (Suraj, NH615 and CISH3178) were made, F1's will be selfed to produce BC_3F_2. It is proposed to study homozygous plants in BC_3F_2 generation and shall be further evaluated.

Evaluation of Event UASD 78 (cry1Ac): The event UASD 78 has been characterized and the report was submitted to the Council.

Evaluation of Tma12 (Event 403):

Effect of Tma12 on whitefly incidence 2020-21: Comparative evaluation of Event 403 (Tma-12), non-Event, HS-6 (susceptible genotype) and LPS-141 (resistant genotype) was carried out in 2020-21. Each genotype was sown separately under contained conditions in separate compartment of muslin cloth with insect proof entry doors. After 40DAS, 30 pairs of whitefly adults were released in each compartment having 30 plants and again at 60DAS, 30 more pairs of whiteflies were released to intensify the studies. Ten plants were tagged in each genotype and fixed for further data recording and data recording started at 60 DAS (43rd SMW). Observations were recorded on whitefly adults and nymph from upper, middle and lower leaves from each tagged plant. Data on appearance of sooty mould was also recorded. Results (Table 1.1.1) indicated similar incidence of whitefly nymphs and adults/ 3 leaves, respectively, on Tma 12 (11.81, 13.99) and LPS141 (12.03, 16.40) while the incidence on non-Tma 12 plants (22.24, 27.41) and HS6 (21.91, 29.0) a highly susceptible check was similar but significantly higher than in Tma12 and LPS141 genotypes.

Table 1.1.1 Incidence of Tma 12 event on whitefly incidence

Genotype	No of whitefly Nymphs /3 leaves	No of whitefly Adults/3 leaves
Tma -12	11.81	13.99
N-Tma -12	22.24	27.41
LPS 141 (*resistant check*)	12.03	16.40
HS 6 (*susceptible check*)	21.91	29.00

Comparative biology of cotton whitefly on event 403 (Tma 12) and non-event : To study the whitefly establishment, plants of Tma12 (Event 403) along with non-event (Coker 312), resistant (LK861) and susceptible check (RCH-2) were grown under contained conditions (under whitefly free conditions). Separate cages were maintained for event and control checks. Fixed number of whiteflies were released and observations on establishment were taken on top, middle and lower part of cotton plants canopy. The results indicated that whitefly established in higher number at upper portion than middle and lower portion in all the genotypes.

To study biology of the whiteflies, plants of Tma12 (Event 403) along with checks were exposed to whitefly for a period of 48 h for egg laying. Individual eggs were marked (75-100 no.) on five plants with three leaves per plant for observations on biology of whitefly. Biology of whitefly was studied for three generation and observation on developmental stages were taken. The data indicated that no visual difference was observed on total developmental period.

1.2 Project Name : Development of elite Bt cotton varieties / hybrids using deregulated transgenic events

Dr Suman Bala Singh (PI); Co-PI's: Dr Santosh HB, Dr VN Waghmare, Dr MV Venugopalan, Dr.Balasubramani G, Dr Raghavendra KP, Dr Vivek Shah, Dr GI Ramakrushna, Dr. D.V. Patil, Dr S. Manickam, Dr K. Rameash, Dr A. Sampath Kumar, Dr. K. Baghyalakshmi, Dr SK Verma, Dr Rishi Kumar and Dr SK Sain

Importance of the study : Bt cotton technology was developed as an alternate strategy to the previously used hazardous insecticides to circumvent bollworm problem in cotton. Productivity enhancement in India can come from yield improvement in rainfed ecosystems through development and deployment of Bt cotton varieties which are amenable to High Density Planting System (HDPS). Bt varieties provide higher yields with an option of high-density planting, provide better protection against bollworms owing to presence of transgene in homozygous conditions with no further segregation, are less input demanding and more climate resilient. This project aims to develop Bt varieties using deregulated transgenic events.

Salient findings :

Release and notification of Bt varieties by CVRC : Two Bt varieties were identified for release in the Annual Meeting of ICAR-AICRP on Cotton held on 09 April 2021. Four Bt varieties (ICAR-CICR Bt9, ICAR-CICR Bt14, ICAR-CICR Bt21, ICAR-CICR Bt25) were released for commercial cultivation during the 87th CVRC meeting held on 22nd September and 18th October 2021 and notified in the Gazette vide S.O. 8(E) dated December 24, 2021.

Nucleus seed production of released and notified Bt varieties: Nucleus seed for seven Bt varieties *viz.,* ICAR-CICR Suraj Bt (159 kg), ICAR-CICR GJHV 374 Bt (209 kg), ICAR-CICR

Rajat Bt (216 kg), ICAR-CICR PKV 081 Bt (127 kg), ICAR-CICR 16 Bt (45 kg) and ICAR-CICR 23 Bt (15 kg) was produced.

Evaluation of sponsored entries in ICAR-AICRP on Cotton: During the crop season, 22 Bt genotypes and one Bt hybrid were tested in Initial Evaluation Trial, 12 in Advance Evaluation Trial I and 6 in Advance Evaluation Trial II in different zones. CICR 18 Bt was promoted to AET I in central zone under both rainfed and irrigated condition. CICR 20- 31Bt an early maturing, compact, jassid tolerant Bt cotton entry for high density planting system performed well in central and south zone under rainfed and irrigated conditions (Table 1.2.1) and was promoted for testing in AET I in both central and south zone (rainfed and irrigated). Bt 183059-4, Bt 183059-5, CICR 19-32 Bt and CICR Bt 19-33 were promoted for evaluation in AET II in central zone (rainfed) while CICR Bt 19-31 and Bt 183059-2 was promoted to AET II in central zone (rainfed) while CICR Bt 19-31 and Bt 1830592 was promoted to AET II in south zone (rainfed).

Table 1.2.1 Performance of the entry CICR Bt 20-31 in ICAR-AICRP trials during 2020-21

Zone / Condi-tions	Rank	Yield (Kg/ha)	GOT (%)	UHML (mm)	Mic (µg/in)	UI (%)	FS (g/tex)
CZ (R)	5	1281	37.6	25.3	4.9	82.8	26.6
CZ (I)	2	1694	36.8	25.1	4.8	83.0	25.0
SZ (R)	1	1093	38.5	25.2	5.1	82.6	24.1
SZ (I)	4	1838	37.3	25.3	4.9	82.6	25.2

Performance of converted Bt genotypes in Institute trial : Thirty-five genotypes converted into Bt background were tested for their performance (Fig. 1.2.1) in the Institute trial. Seed cotton yield ranged from 1247 to 2941 kg/ha. Eighteen

Fig 1.2.1 A promising genotype CICR 861 Bt

Fig. 1.2.2 Late maturing genotype G Cot 12 Btand early maturing CNH 29I Bt genotypes

genotypes were at par to the check CICR 23 Bt and 27 were at par to CICR 16 Bt which recorded seed cotton yield of 1740 kg/ha and 1556 kg/ha respectively. Six genotypes recorded more than 15% increase in yield over the check. CICR 28I Bt recorded highest SCY of 2941.35 kg/ha followed by CICR 56-1 BT, CICR29I Bt (Fig. 1.2.2), CICR 56-2 Bt, CICR 789 Bt, CICR 93 Bt. Some of the genotypes has recorded >40% GOT.

Comparative evaluation of early maturing, compact Bt entries under HDPS : The early maturing, compact, jassid tolerant genotypes for high density planting system (HDPS) were identified for testing in ICAR-AICRP on Cotton. Few compact genotypes (compact, early maturing and jassid tolerant) were tested along with BG II check hybrid Ankur 3028, released Bt varieties (Suraj Bt and PKV 081 Bt) and non-Bt variety (NH 615). The check hybrid was sown at two spacing 60x15 and 90x60 cm while all other entries were sown at 60x15 cm spacing. The treatment showed significant difference for plant height, monopodia, days to maturity (calculated based on boll bursting at 150 DAS), boll weight and seed cotton yield. Several genotypes out yielded the BGII hybrid check sown at 90x60 cm spacing (Fig 1.2.3). Two entries CICR Bt 19-31 and CNH 191165 out yielded the BGII hybrid sown at 60x15 cm.

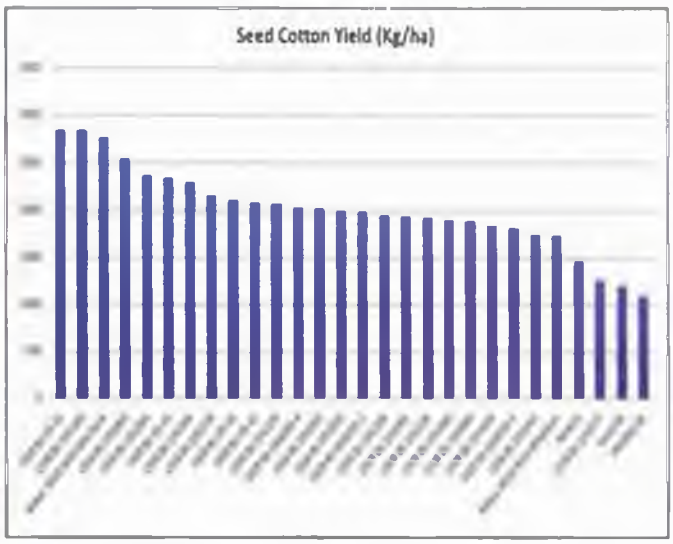


Fig. 1.2.3 Yield of early maturing Bt entries of ICAR-CICR under HDPS

Development of Bt hybrids : To identify promising intra-*hirstuum*(H x H) hybrids, 124 Bt hybrid combinations were evaluated in two trials. The hybrids showed significant difference for seed cotton yield but none of the hybrids performed better than the BG II check hybrid Ajeet 155 (seed cotton yield of 25q/ha). However, few hybrids recorded seed cotton yield upto 21 q/ha. These hybrids had boll weight almost equivalent to Bt check hybrids.

Interspecific Bt hybrids (HxB) : 28 crosses involving four *Bt hirsutum* female parents (Suraj Bt, Rajat Bt, PKV 018 Bt and GJHV 374 Bt) and seven *barbadense* male lines (ICB 39, ICB 183, CCB 141, SUVIN, ICB 34, ICB 28, ICB 207) were evaluated at Regional Station, Coimbatore. Rajat Bt x Suvin, Suraj Bt x ICB 194 (Fig. 1.2.4) and PKV 081 Bt x ICB 284 were better than the BGII H x B check hybrid for seed cotton yield, boll weight and GOT. These hybrids also

Fig. 1.2.4 Suraj Bt x ICB 194

possessed good fibre quality. Two hybrids GJHV 374 Bt x ICB194 and PKV 081 Bt x ICB 255 had short stature.

Conversion programme at Coimbatore and Sirsa : At Coimbatore, Cry1Ac positive plants were identified from donor parent (F 1861 Bt& PAU Bt1) and 13 female parents *viz.,* LRA 5166, Anjali, MCU 5-VT, Suraj, Surabhi, Supriya, Sumangala, CCH 2623, Subiksha, Sunantha, CCH 15-1, BB 6 and BB 7 were used for crossing. BC2 and F3 generations were raised in field for backcrossing and generation advancement respectively. About 1531 plants were screened for presence of Bt and positive plants (1081) identified in different generations. At Sirsa, single plant progenies in F4 and F5 generations were screened and Bt positive plants were identified which were also free from cotton leaf curl virus disease.

Agronomic evaluation of released Bt varieties and hybrids for yield maximization: For optimizing plant geometry four Bt varieties i.e., Suraj Bt, Rajat Bt, PKV 081 Bt and GJHV 374 Bt were evaluated at four spacing 60 x 15, 60 x 30, 90 x 30, 90 x 15 cm in split plot design with spacing as main plot and varieties as sub-plots. This was the second year of testing and based on pooled analysis both spacing and varieties recorded significant effect on seed cotton yield, boll weight, bolls per square meter, plant height, leaf area index at 110 days after sowing, monopodia and earliness except it was non-significant for LAI in case of varieties.

The best average performance was recorded for spacing of 90 x 15 cm and was the most appropriate one. In case of varieties, Rajat Bt and PKV 081 Bt were superior to Suraj Bt and GJHV 374 Bt. Boll weight was higher in 90 cm R-R than 60 cm R-R for all varieties, highest being 3.67 g in PKV 081 Bt at 90x15 cm. Bolls/sq.m was significantly higher in Rajat Bt and PKV 081 Bt than Suraj Bt and GJHV 374 Bt. Monopodia increased with increase in within and between row spacing. Spacing x variety interaction was significant and closer spacing did not induce earliness.

MoU for Bt variety Seed Production : MoU was signed with Nairuthi Seeds Pvt. Ltd. for seed production of two Bt varieties ICAR-CICR 23 Bt and ICAR-CICR PKV 081 Bt.

1.3 Project Name : Development of broad-based high yielding varieties of diploid and tetraploid cotton through recurrent selection

Dr. V. N. Waghmare (PI); Co-PI: Dr. SK. Verma

Importance of the study : The project involving several parental lines aimed at development of broad-based *G. arboreum* and *G. hirsutum* varieties with improved fibre traits and high seed cotton yield through cycles of selection and intercrossing. It also envisages development of high yielding spinnable as well coarse type *G. arboreum* varieties and GMS based hybrids for north zone.

Salient findings :

GMS based recurrent selection: From the GMS based trait specific populations of *G. arboreum* and *G. hirsutum*, 3269 single sterile plants (1244 of *G. arboreum* and 2054 of *G. hirsutum*) harvested in prior season were grown as plant to row progeny for evaluation. At flowering, all sterile and fertile plants were tagged. Seed cotton from the sterile plants from each trait specific groups were separately harvested and grown as plant to row progeny in 2021-22. Seed cotton from sterile plants in each progeny bulk harvested while observations on economic traits and fibre quality were recorded on 3 fertile plants of each progeny.

Evaluation of single plant selection : About 1722 Superior single plants selections were planted for evaluation as plant to row progenies. Based on the performance, uniformity and fibre quality traits, 42 plant progenies (33 of *G. arboreum* and 9 of *G. hirsutum*) were identified for evaluation in replicated trial. Superior single plants were selected from the segregating progenies for further evaluation as plant progenies.

Evaluation of advance cultures : The results of evaluation of advance cultures of *G. arboreum* 174 and 52 of *G. hirsutum* during 2020-21 indicate overall good performance of *G. hirsutum*. The seed cotton yield ranged from 1222 to 2883 kg/ha., boll weight ranged from 2.95 to 4.54 and GOT ranged from 27.8 to 37.6%. Cultures with average above mean seed cotton yield (1929 kg/ha) were retained for further evaluation. The overall performance *G. arboreum* cultures during 2020-21 was very poor, the seed cotton yield ranged less than a quintal to 1123 kg/ha., due to heavy rain during the season. It was difficult to identify promising lines and had risk of losing good material, hence the trials were vitiated and decided to re-evaluate all selections during 2021-22. *G. arboreum* 207 cultures and 41 of *G. hirsutum* were evaluated in 9 replicated trials (4 rows plots in 2 replications)during the crop season 2021. In all, 7 trials of *G. arboreum* and 2 of *G. hirsutum* were conducted following spacing of 60 x 45 cm.

Crosses attempted during 2021:

a) **Crosses attempted in RMP Cycle:** GMS 16 A x (GVS 8 x CSH 3075),GMS 16 A x (GVS 8 x CSH 3129), GMS 16 A x (GVS 9 x CSH 3129),GMS 16 A x (GVS 9 x F 2228),GMS 16 A x (GVS 9 x HS 6),GMS 16 A x (GVS 9 x CSH 3075),GMS 16 A x (CSH 3075 x GVS 9),GMS 16 A x (HS 6 x GVS 9),GMS 16 A x (CSH 3129 x GVS 9),GMS 16 A x [(GVS9xHS6)xHS6].

b) **Backcrosses attempted using GVS lines**: (GVS 9 x F2228) x F2228,(*GVS 9 x CSH 3129) x CSH* 3129, (GVS 9 x HS 6) x HS 6, (GVS 9 x HS 6) x GVS 9, (GVS 8 x CSH 3075) x CSH 3075, {(F2228 x GVS 9) X F2228}x F 2228.

Identification and release of variety : Three varieties namely, CICR-A Cotton 46 (CNA 1054) of *G. arboreum* (Fig. 1.3.1) CICR-H Cotton 47 (CNH 1111) (Fig. 1.3.2) and CICR-H Cotton 48 (CNH 1128) of *G. hirsutum* were tested in Agronomy trial in Central and South Zone during 2020-21. These three varieties

Fig. 1.3.1 CICR-A Cotton 46 (CNA 1054)

Fig. 1.3.2 CICR-H Cotton 47 (CNH 1111)

were identified for commercial cultivation by Central Varietal Identification Committee and released during the 87th CVRC meeting and notified in the Gazette vide S.O. 8(E) dated 24th December, 2021.

Varieties identified & released during the year 2020

S. No.	Characters	CNA 1054	CNH 1111	CNH 1128
1	Seed cotton yield potential (Kg/ha.)	1432	1407	1399
2	Boll weight (g)	2.50	3.05	4.00
3	Ginning Outturn (%)	34.87	33.80	34.50
4	Days to maturity (days)	150-160	150-160	150-160
	Fibre characteristics			
5	Fibre length (at 2.5% SL) (mm)	26.9	27.3	26.9
6	Micronaire	4.9	4.5	4.5
7	Bundle strength (g/tex)	28.3	28.7	27.1
8	Zone of cultivation	Central Zone	Central Zone	South Zone

SMVT Trial

A SMVT trial of *G. arboreum* and *G. hirsutum* comprising of 6 and 5 entries contributed by Dr. PDKV, Akola and ICAR-CICR, Nagpur was conducted during 2021 in RBD with 3 replications, 4 rows plots, 12 dibbles and spacing of 60 x 45 cm. All recommended package of practices were followed for raising the normal crop that included interculture, weeding and plant protection measures. In *G. arboreum* AKA-2016-3 out yielded with seed cotton yield of 1285 kg/ha followed by CNA1031 (1255 kg/ha) compared to control AKA-7 (745.5 kg/ha). In *G. hirsutum*, seed cotton yield of AKH-2016-13 was highest i.e.1580 kg/ha followed by AKH-1514 (1270 kg/ha) compared to control variety AKH-09-5 (923 kg/ha).

S.No	Name of entry	SCY Kg/ha	Boll Wt	GOT (%)
G. arboreum				
1	AKA-20091	1213.1	2.6	37.44
2	AKA-20163	**1284.9**	**2.7**	36.70
3	CNA-1031	1255.7	2.5	35.90
4	CNA-1084	1052.1	2.3	**38.18**
5	CNA-1032 (ch)	1196.0	2.4	36.83
6	AKA-7 (ch)	745.5	2.1	39.87
	Mean	**1124.5**	**2.4**	**37.5**
G. hirsutum				
1	AKH-1514	1269.5	3.34	**36.68**
2	AKH-201613	**1580.4**	**3.44**	36.62
3	CNH-1137	1139.0	2.79	36.07
4	CNH-1140	1214.2	3.02	34.19
5	AKH-09-5 (ch)	922.5	2.83	34.71
	Mean	1225.1	3.1	35.7

1.4 Project Name : Development of compact plant types with improved quality traits through selective mating system in *G. hirsutum L.*

Dr. Suman Bala Singh (PI), Co-PI's : Dr. Jayant Meshram, Dr. J. Amudha

Importance of the study : Sustainable cotton production is severely challenged by climate change and water scarcity. It is therefore imperative to develop cotton lines that can grow on minimum water availability.

Salient findings :

Third year testing of twenty-one advance cultures along with two checks in replicated trial revealed that 13 genotypes were at par to the check Suraj which recorded seed cotton yield of 1331 kg/ha. The seed cotton yield ranged from 1061 (DTS 422) to 1698 kg/ha (DTS 405). Highest seed cotton yield was recorded for DTS 405 followed by DTS 412, DTS 413, DTS 420, DTS 410. These genotypes recorded more than 15% increase over the check. Boll weight ranged from 2.62 (DTS 404) to 3.54g (DTS 405) while ginning percentage ranged from 33.8 (DTS 410) to 38.5 % (DTS 404). DTS 405 has been among the top ten consecutively for three years and was the most stable entry. It recorded UHML of 29.4 mm, fibre strength of 30.3 g/tex, micronaire of 4.1 µg/in, UI of 83% and GOT of 36.2%.

Evaluation of 31 F_4 generation of single, double, six and eight parental crosses along with three checks for seed cotton yield and other important traits showed that DTS 518 was the best performer. DTS 519, DTS 509, DTS 524 and DTS 502 were other promising cultures which recorded more than 20 per cent increase over the check NH 615. Nineteen crosses were at par to the check NH 615 which recorded seed cotton yield of 1369.78 kg/ha. Seed cotton yield ranged from 920.82 (DTS 514) to 2017.82 kg/ha (DTS 518). DTS 524, DTS 530, DTS 517 and DTS 503 recorded GOT of >40%. In general, the boll weight was low as the first set bolls were damaged due to continuous rains in the month of September – October. Boll weight of 4.28 g was recorded for culture DTS 506.

For improving the fibre quality of drought tolerant line, culture 28I was backcrossed with four high fibre strength lines. Advance generation of seven backcrosses were evaluated during the period under report and seed cotton yield ranged from 1865.92 (DTS-BC 112) to 2764.22 kg/ha (DTS-BC 102). DTS-BC 101, DTS-BC 113, DTS-BC 109, DTS-BC 114, DTS-BC 108 were other promising entries than the check Suraj. Boll weight ranged from 3.3 (DTS-BC 108) to 4.5g (DTS-BC 107). DTS-BC 102, DTS-BC 106 recorded more than 4.0 g boll weight. GOT ranged from 39 (DTS-BC 112) to 44 % (DTS-BC 109). DTS-BC 105, DTS-BC 108, DTS-BC 110, DTS-BC 113 recorded >42 % GOT.

Developing compact plant types with good seed cotton yield and fibre quality is one of the objectives of the project. Nineteen intercross lines in F3 generation were evaluated in replicated trial with two replications and plot size of 7.2 sq. m. The seed cotton yield ranged from 807.18 (IC 15) to 1994.43 kg/ha (IC 11 sel.). IC 12, IC 4, IC 14, IC 11, IC 3 recorded > 10 q/ha seed cotton yield. Boll weight ranged from 2.32 (IC 2) to 3.56g (IC 18). IC 4, IC 17, IC 8 and IC 6 also recorded boll weight of >3 g. GOT ranged from 34.02 (IC 16) to 44 % (IC 14). IC 17, IC 10 and IC 13 showed GOT of >40%.

F5 generation of Multi-parental advance generation cross was raised for ten parental cross and F6 seeds were harvested. This population comprised of 2972 progenies. All the 2972 progenies were observed for morphological parameters associated with compact plant type. Based on the plant type they have been grouped into compact, semi-compact and spreading type. 396 lines from this population was evaluated for proline content. Proline content ranged from 0.5-1.03 µmoles/gm. Proline content was also estimated for parental lines which ranged from 0.010 to 0.119 µmoles/gm. There was not much difference in proline content in control and stress condition.

1.5 Project Name : Breeding of upland cotton for improved fibre yield, quality and resistance to biotic stress (jassid)

Dr. S. M. Palve (PI); Co-PI's: Pradeep Mandhyan ICAR-CIRCOT, Mumbai

Importance of the study : In this project, the breeding lines were developed with improved seed cotton yield, fibre quality and resistance to jassid. In addition to this, utilization of interspecific crosses between *G. hirsutum* and *G. barbadense* in the breeding programme was taken up in order to increase genetic variability for fibre quality traits in the generated populations.

Salient findings :

The advanced breeding lines developed were evaluated in replicated trials for seed cotton yield, fibre properties and tolerance to jassid. The entry CNH 3169 had highest seed cotton yield of 1611 kg/ha followed by CNH 3055 (1424 kg/ha) and CNH 6356 (1292 kg/ha). In another yield trial, entry CNH 6461 recorded seed cotton yield of 1425 kg/ha followed by CNH 5923 (1420 kg/ha) and CNH 6356-5 (1342 kg/ha). Entries CNH 5856, CNH 5923, CNH 6461 and CNH 6464 were tolerant to jassid. Entry CNH 119310 exhibited seed cotton yield of 1165 kg/ha followed by CNH 76-97 (1048 kg/ha) and CNH 7337 (1018 kg/ha). Entry CNH 2451 recorded seed cotton yield of 1224 kg/ha followed by CNH 76216 (1172 kg/ha) and CVNH 21186 (1111 kg/ha). Most of the entries evaluated in different yield trials were tolerant to jassid.

For fibre properties, twelve entries were identified with improved yield and tolerance to jassid. Entries CNH 11937-2 recorded fibre length of 30.6 mm and fibre strength of 29.4 g/tex. Entries CNH 11937-3 (29.0 mm, 28.8 g/tex), CNH 11937-6 (28.8 mm, 28.9 g/tex), CNH 11930-6 (29.5 mm, 29 g/tex), CNH 6037-4 (29.2 mm, 28.1 g/tex) and CNH 5846-11 (29.6 mm, 28.1 g/tex) were identified as promising lines for fibre properties and tolerance to jassid.

In interspecific crosses of *G. hirsutum* × *G. barbadense* (Gh × Gb), promising introgression lines (ILs) for specific traits like high ginning outturn, cluster bolls and round bolls were developed. The introgression lines (Gh × Gb) exhibited higher ginning outturn (39.2–43.1) and lint index (6.5-8.2%). For ginning outturn, entry CNH 20357 recorded 43.1% followed by CNH 20395 (42.5%) and CNH 20378 (42.7%). The cluster boll bearing lines, CNH 2010, CNH 2011, CNH 2012 and CNH 2013 were identified for better fibre length of 28.5 mm, 28.1 mm, 29.4mm, and 28.8 mm respectively. Round boll bearing lines, CNH4810, CNH 4813, CNH 4836, CNH 4837and CNH 4838 were identified for fibre length of 28.2 mm, 29.9 mm, and 28.0 mm, respectively.

The introgression lines CNH 20378, CNH 20378, CNH 204710 and CNH 204910 were identified for higher ginning outturn. CNH 204710 had ginning outturn of 43.9 % followed by CNH 20378, CNH 20387 (43.4%) and CNH 204910 (43.3%).

1.6 Project Name : Harnessing the potential of wild and unadapted germplasm in cotton improvement- A pre-breeding approach.

Vinita Gotmare (PI); Co-PI's: Dr Santosh HB, Dr M Saravanan, Dr Rachna Pande, Dr Neelkanth Hiremani, Dr Chandrashekhar N, Dr S K Verma

Importance of the study : Wild species of *Gossypium* are the reservoir of many useful genes governing different economic traits including lint yield, fibre quality and resistance to biotic and abiotic stress. In view of narrow genetic base of cultivated cotton, the available wild species, races of cultivated species and synthetic polyploids of *Gossypium* are conserved and utilized in introgression breeding to broaden the genetic base and to create newer genetic variations for various traits of interest.

Salient findings :

Conservation of wild and unadapted germplasm : 25 wild species, 12 races of cultivated species and more than 45 synthetic polyploids are conserved in the wild species garden. Plants of *G. nelsonii* – a diploid species were established and selfed seeds were collected for its multiplication. The seeds of two tetraploid wild species *viz., G. mustelinium* and *G. ekmanianum* procured from Rasi Seeds Pvt Ltd *were* added to the existing collection and efforts were being made to establish them in pot conditions.

The available *Gossypium* species & derivatives namely *G. aridum, G armourianum, G. barbadense, G. arboreum, G. hirsutum x G. triphyllum* and *G. hirsutum* x unconfirmed species are conserved and have been morphologically and cytologically characterized at ICAR-CICR, Regional Station, Coimbatore. CLCuV immune accessions namely GVS 8 and GVS 9 were evaluation at ICAR-CICR, Regional Station, Sirsa during the cropping season 2020-21. (Table 1.6.1)

Table 1.6.1 Plant, yield and fibre quality traits of CLCuV immune accessions

S. No.	Name of Entry	Plant ht (cm.)	Monopods	Sympod	No. of Boll	Boll wt.(gm)	UHML	UI	Strength	Mic.
1	GVS8	98	4	7	20	1.5	24.3	80	26	4.5
2	GVS9	106	6	9	17	1.4	24	79	27	4.5

Conservation of wild species in Medium Term Storage (MTS) and Long-Term Storage (LTS) : 84 introgressed derivatives and twelve species (*G. anomolum, G. triphyllum, G. barbosanum, G. capitis viridis, G. thurberi, G. raimondii, G. stocksii, G. somalense, G. australe, G. bickii, G. mexicanum* and *Thespesia lampas*) were conserved in MTS at ICAR-CICR, Nagpur and LTS at ICAR-NBPGR, New Delhi.

Hybridization and selection : A total of 2025 new crosses were attempted using the cultivars and races of *Gossypium* (LRA5166, LRK 516, MCU5, MCU5VT, Arogya, Suvin, KH3, Moco, Suraj, MCU10, Africanum, Jawahar Tapti, AK5, AK7, PA255, PA402, CNA1003, Digvijay, AK8401, Gcot23, DLSA17, Latifolium, Palmeri, Richmondii, Sinense, Indicum, Burmanicum, Bengalense, Cernuum, Soudanense) and wild species (*G. raimondii*, *G. australe, G. klotzschianum*, *G. capitis viridis*, *G. trilobum*, *G. thurberi*, *G. triphyllum*, *G. anomolum*, *G. barbosanum*, *G. somalense*, *G. stocksii*, *G. davidsoni*, *G. longicalyx*, *Thespesia lampas*, *G. mexicanum*). Promising single plants were selected from F6 generation plant to row progenies of the following crosses *viz.,G. arboreum* x *G. longicalyx; G. arboreum* race indicum x *G. davidsonii; G. arboreum* x *G. thurberi and* AK 8401 x *G. davidsonii.* Thirty-five single plants were selected from Jawahar Tapi x *G. longicalyx* for fibre length (22.4-26.6mm) and fibre strength (24.9–28.8g/tex). Five F1 crosses were established in pot culture during the cropping season 2020-21 (Fig. 1.6.2).

Fig 1.6.2 : 1. LRK x *G. capitis virides* (F1) 2. Arogya x *G. raimondii* (F1) 3. LRK x *G. mexicanum* (F1) 4. KH3 x *G thurberi*(F1) 5. MCU5VT x *G. barbosanum* (F1)

Introgression and evaluation of introgressed derivatives : More than 450 introgressed derivatives (*G. arboreum* & *G. hirsutum*) were evaluated at Nagpur for yield, fibre traits, biotic and abiotic stress tolerance. The yield levels were low both in *G. hirsutum* & *G. arboreum* based introgressed derivatives. All the wild species are devoid of PBW attack, and infestation of whitefly and American bollworm was below ETL. Grey mildew and *Corynespora* leaf spot were the major diseases whereas bacterial blight and root rot were negligible on introgressed derivatives. *G. arboreum* race Cernuum A4 (19025) was free from grey mildew disease. High incidence of grey mildew was seen in the Wild species garden especially in the F1 hybrids G.Cot21 × *G. barbadense*, PA-255 × *G. anomalum* and also on all the *G. arboreum* introgressed derivatives evaluated in field. Severity of grey mildew ranged from 12% to 39.9%. *Corynespora* leaf spot was observed in most of the entries and bacterial blight was also present in some of the cultivars to some extent. High incidence of sooty mould was seen in Serido, Exotic 3, *G. triphyllum*, *G. anomalum*, *G. arboreum* race Soudanense and G. barbadense var Suvin while *G. hirsutum* race Richmondi and Mexicanum were free from infection. Morphologically, the mold was identified as *Leptoxyphium* sp. Species identification through ITS sequence analysis was being done.

Exploration of unadapted germplasm (Exotic Collections) for GOT improvement : Promising Exotic Collections (EC143506, EC343624, EC700403, EC128340, EC141725, EC137596, EC344076, EC344803 and EC344541) having higher GOT (upto 43%)procured from published 'Germplasm catalogues' of the National Cotton Gene Bank, ICAR-CICR, Nagpur were raised in both field and pot conditions. Of the nine exotic accessions evaluated, three accessions *viz.*, EC143506 (GOT-43.3%), EC141725 (GOT-41.2%) and EC137596 (GOT-41.7%) were selected based on GOT, jassid tolerance and plant populations available for selfing/crossing. The seed of six exotic accessions were multiplied for their detailed characterization for traits of interest including GOT (%) in the ensuing season.

Colour cotton : Fifty colour cotton entries were evaluated in field for their fibre traits during the cropping season 2020-21. F1 crosses between cleistogamous MSH-345 and Dark Brown linted genotype Vaidehi-95 were evaluated and backcrosses were attempted. The colour cotton lint from harvested produce of Vaidehi-95 (approx. 205 kg) was sold to Ethical Clothing India. Mehsana, Gujarat. Selection among the introgressed derivative for green colour lint (Fig. 1.6.3) was successful.

Fig. 1.6.3 a. opened boll; b. green colour lint; c. green colour fuzz.

1.7 Project Name : Development of heterotic pools in *hirsutum* cotton

Name of PI: Dr. D. V. Patil

Importance of the study : Cotton is the best example to exploit practical heterosis as evident from cultivation of intra and inter-*hirsutum* hybrids covering more than 90% area under cotton cultivation in India. In order to break the yield plateau and realize heterotic yield potential of hybrids, it is essential to develop genetically diverse parental lines. The project envisages development of heterotic pools to develop genetically diverse parental lines to be used in hybrid development programme.

Salient findings :

Ninety-one F1's hybrids developed through half-diallel mating design using 14 *G. hirsutum* parents were evaluated in 2 replications. Grouping and data compilation for base height (ground to the first branch), days to maturity, plant type, boll number and boll weight and GOT is in progress. A set of 50 *G. hirsutum* germplasm were collected from germplasm unit and crossing program was carried out. Six crosses recorded highest yield ranging from 55 – 80g / plant.

1.8 Project Name : Breeding for early maturity, compact plant type and jassid tolerance in cotton

Dr HB Santosh (PI); Co-PI's: Dr S Manickam, Dr KP Raghavendra

Importance of the study : High density planting system (HDPS) and use of compact plant type is recognized for higher productivity of cotton across the countries. This project envisages to develop cotton varieties having potential to produce higher yield per unit area and per unit time along with resilience to jassids and fibre quality attributes. Early maturing cotton variety can also help escaping pink bollworm damage.

Salient findings :

Three early maturing, compact and jassid tolerant entries (CNH 20-31, CNH 20-32 and CNH 20-33) were sponsored to Br 06 (a/b) of the 'ICAR-AICRP on Cotton' and One entry CNH 20-34 was sponsored to State Multi-location Varietal Trial (SMVT) of *G. hirsutum*. Stringent selection for early maturity has led to trait penalty on fibre quality. The progenies and single plant selections having early maturity (150 days) with better fibre quality (medium to long staple) were identified for advancement and further evaluation (Table 1.8.1).

Table 1.8.1 Promising compact single plant selections with earliness, yield and fibre quality

Single plant selections	Plant height (cm)	Plant Width (cm)	Monopodia	Percent boll bursting at 150DAS	Boll Weight (g)	Plant Yield (g)	Fibre length (mm)	MIC (µg/in)	Fibre strength (g/tex)
SPS191-152	93	22	0	100.00	5.00	80	23.7	4.9	22.3
SPS191-234	95	25	0	100.00	5.33	120	26.8	4.5	26.8
SPS191-036	91	27	0	93.94	4.33	94	28.0	3.8	27.6
SPS191-023	92	27	0	88.24	4.67	53	26.8	4.3	26.4
SPS191-027	118	27	0	78.95	4.33	116	27.4	3.8	27.0
SPS191-163	103	28	0	100.00	4.67	122	25.3	5.3	24.0
SPS191-239	116	28	0	100.00	5.33	115	26.4	5.2	27.3
SPS191-149	132	30	0	100.00	5.33	108	23.1	5.3	23.7
SPS191-185	131	30	1	100.00	4.33	110	29.3	3.9	30.9
SPS191-291	122	31	0	100.00	5.00	140	29.3	3.1	29.0

A total of 484 progenies were evaluated for jassid tolerance through grading system (1-4) at 60 DAS of which 222 were categorized as tolerant (Grade I) while 242 were grouped as Grade II. Promising progenies and single plant selections were evaluated for earliness, plant type, jassid tolerance, boll size, seed cotton yield and fibre quality. Single plant selections among the segregating populations were selected for advancement and further evaluation (Table 1.8.2).

Table 1.8.2. Single plant selections during 2020-21

Single plant selections	Plant height (cm)	Plant Width (cm)	Monopodia	Sympodia	Percent boll bursting at 150DAS	Boll Weight (g)	Plant Yield (g)
SPS201-010	100	30	-	20	95.83	3.71	82.61
SPS201-021	118	30	-	20	87.50	4.38	81.92
SPS201-023	97	30	-	21	88.89	3.55	93.53
SPS201-011	98	32	-	18	100.00	3.22	84.12
SPS201-002	96	35	-	17	90.91	4.01	54.25
SPS201-020	110	35	1	20	86.36	3.25	84.10
SPS201-025	102	35	-	15	95.24	3.68	51.16
SPS201-006	93	38	2	17	91.67	3.83	75.93
SPS201-009	115	38	-	20	100.00	4.54	101.90
SPS201-024	111	38	-	22	89.29	4.12	93.73
SPS201-008	90	40	1	20	76.19	3.40	52.55
SPS201-007	113	51	1	18	95.00	3.83	76.20
SPS201-014	135	55	1	27	100.00	3.41	133.60

To understand the relation between earliness and pink bollworm damage, 8 genotypes (non-Bt and Bt) having differential crop maturity were evaluated under replicated trial with two dates of sowing (timely sown; 27 June 2020 and late sown; 05 August 2020) along with BGII hybrids. The seed cotton yield was higher in timely sown crop across the groups (non-Bt, Bt and BGII) compared to late sown crop. The experiment revealed that the crop maturity (earliness measured as percent boll bursting) had profound influence on damage by pink bollworm (measured as open boll damage). The highest activity of pink bollworm (measured as moth catches per trap) was observed in third week of November. The study indicated that an early maturing variety (150 days) sown in early/mid-June can potentially escape pink bollworm damage.

At Coimbatore, 106 progeny rows of compact plants and 110 progeny rows of zero branching compact plants were evaluated and promising single plants from the segregating populations were selected. Eight early maturing compact plant progenies were multiplied for further evaluation.

1.9 Project Name: Seed characterization based on protein quantification and profiling in cotton

Dr. V. Santhy (PI); Co-PI: Dr. Pooja Verma

Importance of the study : Seed protein content among the present-day cotton genotypes, species, germplasm accessions and seeds of different seed quality etc. needs to be understood. It is also essential to understand the change in protein content or profiles during the process of seed storage and subsequent deterioration so that there could be a possibility to develop a protein-based marker to determine seed quality.

Salient findings :

Among the four cultivated species, seed protein content determined by Bradford method was lowest in diploid varieties (20-30mg/g seed) compared to tetraploid species (35-45 mg/g seed). Among the 16 wild species soluble seed protein content was highest in *G. anomalum* (up to 30mg/g seed) and lowest in *G. aridum* (10mg/g seed). Among the seed storage protein fractions, albumin and globulin fractions were highest (30-40 mg/g seed) that equals to tris-soluble protein content compared to prolamine and glutelin fractions (10-15 mg/g seed). The values were higher for varieties of *G. hirsutum* and lower for varieties of *G. arboreum*. The seed protein content from early picked bolls showed lower seed protein content than from the later opened bolls as determined in 4 *G. hirsutum* and 4 *G. arboreum* varieties. revealed No variation for seed protein content was observed in both bigger and smaller sized seeds in varieties of *G. hirsutum* and *G. arboreum*.

The seed of CICR2 desi hybrid along with its male and female parent was profiled for tris soluble, albumin and globulin fractions by SDS-PAGE. The profile for male and female parent were different for both albumin and globulin fraction. Profiles of F1 hybrid for albumin and globulin were similar to the profiles of female parent.

1.10 Project Name: Collection, conservation, evaluation, documentation and maintenance of germplasm of cultivated species of *Gossypium*

Dr. Sunil S. Mahajan (PI); Co-PI's : Dr. Saravanan. M., Dr. NS Hiremani, Dr. Rachana Pande, Dr. S. Manickam, Dr. K.P.M. Dhamayanthi, Dr. A.H. Prakash, Dr. K. Rameash, Dr. A. Manivannan, Dr. P. Valarmathi, Dr. Rishi Kumar, Dr. Debashis Paul, Dr. S.K. Sain, Dr. Anjali Kak (ICAR-NBPGR, New Delhi)

Importance of the study : The ICAR-CICR has been entrusted with the responsibility to plan, conduct, promote and coordinate the collection, characterization, evaluation, conservation, exchange, documentation and sustainable management of diverse germplasm of cotton and its storage (ex-situ at 5°C temp and 35% RH) with a view to ensuring their availability for use over time to breeders and other researchers.

Salient findings :

Status of cotton germplasm : ICAR-CICR, Nagpur maintains one of the largest cotton germplasm collection of the world with more than 12,336 accessions covering all the cultivated species including wild species, interspecific derivatives, perennials and landraces of *Gossypium*. (Table1.10.1). The *G. barbadense* (536) germplasm lines are being maintained at ICAR-CICR, Regional Station Coimbatore.

Table 1.10.1: Germplasm collections at ICAR-CICR, Nagpur

Species	Base Collection
G. hirsutum	8851
G. barbadense	536
G. arboreum	2053
G. herbaceum	585
Wild species	25
Interspecific derivatives	40
Perennials and land races	254
Races and derivatives of all 4 species	12
Total Collection	12336

Enrichment and Evaluation of Cotton Genetic Stocks: 52 *G. herbaceum* lines multiplied at Surat centre and 565 accessions multiplied at Nagpur were deposited in medium term storage (MTS). Similarly, 756 lines including GMS (27), CMS (18+18), A & B lines (73+73), *desi* GMS lines (22+18), drought tolerant lines (12), big boll lines (23), parental lines (10), CMS (A & B) Lines (113+113), restorer lines (47+36) and 153 cotton variety groups have been deposited in MTS. Besides this, 25

high GOT advanced cultures, 13 whitefly resistant accessions and 84 introgressed derivatives have been deposited in MTS. Morphological and fibre quality data along with seeds of core collection (541), base collection (1143) and wild species (11) have been deposited in long term storage at ICAR-NBPGR, New Delhi.

Multiplication and characterization of germplasm : A part of base collection, 5797 cotton germplasm including *G. hirsutum* (1277), *G. arboreum* (1587), core collection (780), registered lines (49), developed cultures (106), working collection (402), imported accessions (263), AICRP on cotton lines (570), variety group (35) and ICAR-NBPGR lines (218) were rejuvenated/multiplied in the field and pot house. Thirty-six Coker lines including 2 accessions of CLCuD resistant (GVS) multiplied in the field were evaluated and characterised. Exotic accessions (472) were multiplied in the field and data on morphological traits and fibre quality were recorded.Cotton germplasm (*G. arboreum* 60, *G. herbaceum* 15, *G. hirsutum* 32 and *G. barbadense* 27) collected from different regions of India were characterised, evaluated and multiplied. Germplasm accessions of *G. barbadense* (336) were maintained and 27 new lines rejuvenated at ICAR-CICR Regional Station, Coimbatore. The variability recorded for yield characters of registered lines (49), core collection (780) and exotic materials (248) is given in Table 1.10.2.

Table 1.10.2 : Variability of yield characters in cotton germplasm:

Registered Line (49)		
S. No.	**Characters**	**Range**
1	No. of sympodia/plant	11-32
2	No. of bolls /plant	13-45
3	Seed cotton yield/plant (g)	17.28-67.78
4	Ginning outturn (%)	26.0-41.30
5	Seed index (gm)	5.2-9.6
Core Collection (780)		
S. No.	**Characters**	**Range**
1	Seed cotton yield/plant (g)	8.08-156.0
2	Ginning outturn (%)	25.91-45.15
3	Seed index (g)	5.2-13.9
Exotic *G. hirsutum* accessions(248)		
S. No.	**Characters**	**Range**
1	No. of sympodia/plant	8-26
2	No. of bolls /plant	7-45
3	Boll weight (g)	1.26-6.8
4	Seed cotton yield/plant (gm)	6.61-131.0
5	Ginning outturn (%)	18.67-43.78
6	Seed index (g)	5.0-13.9

Crossing of GVS lines (CLCuD resistant) with advanced lines and their reciprocal crosses were carried out to generate BC_1F_1 population. Similarly, one way cross with CMS lines were attempted to convert into CMS lines.

Distribution of cotton germplasm : A total of 152 cultivated cotton germplasm requested for use in research, breeding, crop improvement was distributed to the cotton breeders/scholars, scientists from different SAU's, government institutions, ICAR institutes and private seed agencies.

1.11 Project Name: Strategies to augment quality and storability of cotton seed under different environmental conditions

Dr. Sunil S. Mahajan, (PI); Co-PIs: Dr. V. Santhy, Dr. PR Vijayakumari

Importance of the study : The knowledge of cotton seed storability is essential to avoid loss of valuable genetic stocks, unsold commercial seed stocks, carry over seed stock and unused breeding cultures to be sown in subsequent sowing season. The information from such studies will help all stakeholders such as small holding farmers, researchers, gene bank custodians and commercial seed suppliers to maintain quality seeds without much loss in viability.

Salient findings :

Freshly harvested seeds of *G. hirsutum* (var. Suraj) and *G. arboreum* (var. Phule Dhanwantari) produced during 2016-17 were kept under different packaging containers, *viz.,* waterproof orange, brown paper packet, aluminum foil and polythene bag for four years. The germination studies after four years revealed that each of the above treatments have maintained seed viability with germination (>65%) above Indian Minimum Seed Certification Standards (IMSCS) in refrigeration conditions (5°C). Another set of seed lot of *G. hirsutum* (var. Suraj) and *G. arboreum* (var. Roja) produced during 2018-19 and packed in vacuum packets, zeolite beads, modified gases and polythene bags and kept under cold conditions (5°C) for two years have maintained seed germination above IMSCS. Seed stored without zeolite beads, non-vacuum packets, cloth bags or polythene bags showed lower seed germination (<65%) when kept under ambient conditions.

1.12 Project Name : An efficient regeneration system for transformation studies with CICR cry2Ab1Ac and fiber strength genes in cotton (*G. hirsutum*)

Dr. G. Balasubramani (PI); Co-PI's: Dr. J. Amudha, Dr. K. P Raghavendra, Dr. N. Chandrashekar, Dr. Joy Das

Importance of the study : The project aims to develop an efficient regeneration system and development of transgenic cotton using indigenously made gene construct *CICR-cry2Ab1Ac::chitinase*.

Salient findings :

Genetic transformation was carried out using *Gossypium hirsutum* genotype Coker 312 with *CICR-cry2Ab1Ac::chitinase* gene constructs through *Agrobacterium* mediation and regeneration through somatic embryogenesis. Around 45 putative transgenic plants carrying *CICR- cry2Ab1Ac::chitinase gene* were

regenerated (Fig. 1.12.1) and roots were induced (Fig. 1.12.2). New putative plantlets (Approx. 55) are in test tube conditions. In addition, more numbers of hypocotyl explants were subjected to transformation to generate large number of events.

Fig. 1.12.1. Putative transformants in MS selection medium

Fig. 1.12.2. Root induction and establishment of putative plants

1.13 Project Name : Unveiling the potential of cotton WNT-like gene in somatic embryogenesis through genetic engineering

Dr. N. Chandrashekar (PI)

Importance of the study : Development of reproducible somatic embryogenesis in cotton has been a long-time research goal. Therefore, characterization of *WNT*-like gene(s) in plants and functional validation may lead to unveiling their potential role in somatic embryogenesis of cotton. Such basic studies may provide clues for the signaling cascades of *Wnt*-like pathways to uncover other upstream or downstream players in plants.

Salient findings :

Indigenous Suraj cultivar *(G. hirsutum)* is not amenable for stable transformation and regeneration. The genotype is the major determinant for successful somatic embryogenesis, though other factors viz., explants tissue, media composition, plant growth regulators, initiation and development of embryonic calli, maturation of somatic embryos and their germination are important. This is the first report on isolation, cloning and transformation of Wnt3A like gene into cotton (Suraj) and attempted for its functional validation through over-expression.However, over expression of Wnt3A like gene may not be the single factor/player(s) for converting non-responsive genotypes into responsive genotypes for somatic embryogenesis. Hence, knockdown approach may be attempted in Coker312 for conclusive evidence on functional attributes of Wnt3A like gene in somatic embryogenesis. Identification and functional validation of candidate genes expressed during somatic embryogenesis is desirable through transcriptome profiling of highly responsive Coker 312 and least responsive genotypes to identify differentially expressed genes. Suraj genotype may be explored for final validation of candidate genes through over expression after establishing conclusive proof of concept through knockdown approach.

1.14 Project Name : Exploration of genomic resources for identification of candidate genes and promoters for cotton improvement

Dr. KP Raghavendra (PI); Co-PI's: Dr Pooja Verma, Dr N Chandrashekar, Vivek Shah

Importance of the study : Biotechnological advances such as genome sequencing, functional genomics, RNA interference, genome editing, new molecular markers for economically important traits have provided an enhanced scope for accelerated cotton improvement. The deployment of biotechnology tools for cotton crop improvement necessitates the discovery of novel genes associated with economical important traits and unveiling the possible role of engineered Cry toxin for enhanced toxicity against *cotton bollworms*.

Salient findings :

Genes for bollworm management : Cloning, expression and bio-efficacy studies were conducted to evaluate the efficacy of Cry1D protein against cotton bollworms. The *cry1D* nucleotide sequence coding for active toxin was custom synthesized, cloned in bacterial expression vector pET28, expressed in bacterial host *E. coli* Rosetta gami and BL21 strains. Recombinant proteins expressed in *E. coli* BL21cells were isolated and utilized for testing the efficacy of target Cry1D protein against *P. gossypiella, H. armigera* and S. *frugiperda* through diet incorporation method. The preliminary bioassay results were found promising against pink bollworm *P. gossypiella*. Purification of Cry1D protein for probit analysis to study the dose response is being carried out. To develop transgenic events in cotton, the codon optimized cry1D nucleotide sequence was synthesized and is being used in preparation of plant expression vector and transformation.

Isolation of stress (drought and salt) responsive genes for functional validation : Isolated full length coding sequence of *GaDAR1* (1.5kb) and *GhNAC9* (861bp) from *G. arboreum* Cv Roja and *G. hirsutum* respectively. GaDAR1 belongs a member of plant specific LIM family protein, possess high molecular weight (57.84kD) with single LIM domain, presence of DUF3633 domain at C-terminal was identified based on their enhanced expression in response to salt treatment

(200mM) compared to the other plant specific LIM members. *GhNAC9* is a stress inducible transcription factor, identified for its significant higher expression in drought tolerant genotypes during water stress.

1.15 Project Name : Targeted mutagenesis of *ghPHYA1* through *CRISPR/Cas9* in Cotton

Dr. N Chandrashekar (PI); Co-PI: Dr. Raghavendra K.P.

Importance of the study : PHYA1 is one of the known major potential negative regulator of PHYA2, PHYB PHYC and PHYE genes and RNAi cotton lines of PHYA1 showed vigorous vegetative growth, flowering and early maturity, higher root mass, higher germination, more flowers and bolls, and increase in fibre staple length as compared to their controls (Abdurakhmonov et al. 2014). ghPHTA1 gene is being targeted through CRISPR/Cas9 technology to generate mutant stocks with enhanced fibre quality parameters. Development and standardization of protocol for CRISPR/Cas9 in cotton will be useful to generate further CRISPR/Cas9 constructs for some of the candidate genes for cotton improvement.

Salient findings :

Methodology developed : Chimeric callus cultures for the presence of sgRNA::Cas9 using vector and sgRNA specific primers has been established (Fig. 1.15.1). This methodology is important to shortlist the putative callus cultures harbouring CRISPR/Cas9::sgRNAPHYA1 cassettes to carry forward the candidate callus cultures in limited stocks to derive somatic embryogenesis and establishment of putative cotton plantlets with CRISPR/Cas9::sgRNAPHYA1 cassettes.

Fig 1.15.1: Screening of chimeric callus cultures for the presence of sgRNA::Cas9 using vector and sgRNA specific primers

Somatic embryogenesis : *Agrobacterium* mediated transformation of Coker 312 hypocotyls was carried out with sgRNA3GhPHYA1::CRISPR/Cas9 cassettes. Somatic embryogenesis has been achieved (Fig. 1.15.2) from the Coker 312 callus cultures harbouring sgRNA3GhPHYA1::CRISPR/Cas9 cassette and establishment of plantlets is in progress.

Fig 1.15.2: Somatic embryogenesis in *sgRNA3GhPHYA1::CRISPR/ Cas9 callus cultures*

1.16 Project Name: ICAR Seed Project Seed Production in Agricultural Crops

Dr. P. R. Vijaya Kumari (PI); Co-PI's:Dr. K. Rathinavel, Dr (Mrs.) V. Santhy, Dr. Debashis Paul.

Importance of the study: The project aims to produce sufficient quantity of breeder, foundation, certified and TFL seeds of released, notified varieties of cotton as well as other major popular crops so as to fulfill the partial requirement of quality seeds in the region.

Salient findings :

During 2020-21 breeder seed of 7.17 q of non-Bt varieties of cotton were produced. Similarly, 5.90 q breeder seed of different Bt cotton varieties released by ICAR-CICR were produced. A total 56.84 q seed of different classes of seed of Red gram, Gram, Linseed and Lakhori Dal were produced under the project (Table 1.16.1).

Table 1.16.1. Seed Production of cotton and other crop varieties:2020-21

Name of Crop	Name of Variety	Class of Seed	Production (q)
Cotton	**Non Bt Varieties :** Suraj, Surabhi, LRA5166, LRK516, CNA1003, CNA1028, CNA1032, CSH 3075, CSH 3129, CICR 1, CICR 3 and Parental lines of hybrid CICR 2.	Breeder Seed	7.17
	Bt Varieties : ICAR-CICR Suraj Bt, ICAR -CICR PKV -081 Bt, ICAR -CICR PKV Rajat, ICAR - CICR Bt-6 and ICAR-CICR GJHV 374 Bt	Breeder Seed	5.90

Name of Crop	Name of Variety	Class of Seed	Production (q)
Other Crops			
Red Gram	BSMR-736	Certified Seed	50 85
Gram	Jaki-9218	Certified Seed	5.09
Linseed	NL-260	Foundation Seed	0.74
Lakhodi Dal	Mahativra	Certified Seed	0.16

1.17 Project Name : Marker Assisted Breeding for Waterlogging in Cotton

Dr. Vinita Gotmare (PI); Co-PI's:Dr. Saravanan, M, Dr Jayant Meshram, Dr Annie Sheeba

Importance of the study: Cotton, in India, is grown in different agro-climatic conditions and it experiences waterlogging at one or other stages of its life cycle because of recent climate change scenarios. Information on the genetic variation for waterlogging tolerance in cotton is meager. This project is aimed to derive insights on waterlogging tolerance in *G. hirsutum* germplasm.

Salient findings :

Two accessions each of most diverse tolerant and susceptible were characterized and subjected to diversity analysis based on SSR markers. These were utilized in the development of First filial (F_1) generation, which will be advanced to F_2 generation. Genetic diversity among tolerant and susceptible accessions was established using SSR markers.

The Sucrose synthase activity in roots was higher in susceptible varieties both under control and water-logged conditions. However, when compared to susceptible ones, the tolerant genotypes LRA5166 and IC63998 recorded almost 2-fold increase in sucrose synthase activity under waterlogged conditions compared to other genotypes (Table 1.17.1). The lactate dehydrogenase and Nitrate reductase activity in roots was higher in tolerant varieties both under control and water-logged conditions. Thus, the plants can cope up with nitrogen assimilation under hypoxic conditions.

Water logging tolerant (T) & susceptible (S) lines	Sucrose Synthase Activity (µg/g/hr)		Lactate dehydrogenase Activity (µg of pyruvate reduced/min/g)		Nitrate Reductase Activity (µg N02/g/h)	
	Control	Water logging	Control	Water logging	Control	Water logging
IC356708 (S)	283	306	1262.3	1118	440.7	341
IC357607(S)	317	402	1082	1118	603.3	414.4
LRA5166(T)	169.8	391	1526.8	1406.6	687.2	529.9
IC563998(T)	175.5	272	1466.7	1382.5	786.9	587.6

1.18 Project Name : Development of high strength cotton genotypes by reducing the short fiber content

Dr. S. Manickam (PI); Co-PIs: Dr. A. H. Prakash, Dr. J. Gulsar Banu, Dr. K. Rameash, Dr. A. Sampath Kumar

Importance of the study : The identification and development of high strength culture will be useful for further breeding programmes. By working out suitable geometry and agronomy, yield maximization can be achieved in the high strength cultivars which may be released as variety for the benefit of both the farmers and the end users, the textile mills.

Salient findings :

Confirmatory yield trial was conducted with nine high yielding long staple cultures with Surabhi and Suraj as the check varieties. The highest seed cotton yield was noted in the culture YLS 21-2 with 1528 kg/ha, which has also recorded the highest boll weight of 4.9 g/boll. The culture YLS 21-4 was the best for fibre quality with 34.1 mm length and 33.8 g/tex tenacity.

In another replicatory trial with 16 long staple cultures having big boll and high bundle strength with Surabhi and Suraj as the check varieties, the fibre quality analysis with Advanced Fibre Information System (AFIS) indicated that the culture BB 1-1-1 was the best in terms of Upper

CCH 19-2

CCH 19-2

CCH 19-2

Quarter Length with 34.3 mm. For short fibre content, the culture BB 16-1-1 recorded the least value in terms of both weight (4.3) and number (15.9). For immature fibre content, the culture BB 10-1-2 was the best with 6.4 %. These cultures may be exploited for further utilization in breeding programme.

The long staple high strength cultures CCH 19-2 and CCH 19-4 were tested in preliminary variety trial in All India Coordinated Research Project on Cotton in both Central and South Zone States during kharif 2020-21 in irrigated and / or rainfed conditions and the fibre quality performance of these cultures indicated that in most of the trials, they topped in terms of length and / or strength.

CCH 19-4

CCH 19-4

CCH 19-4

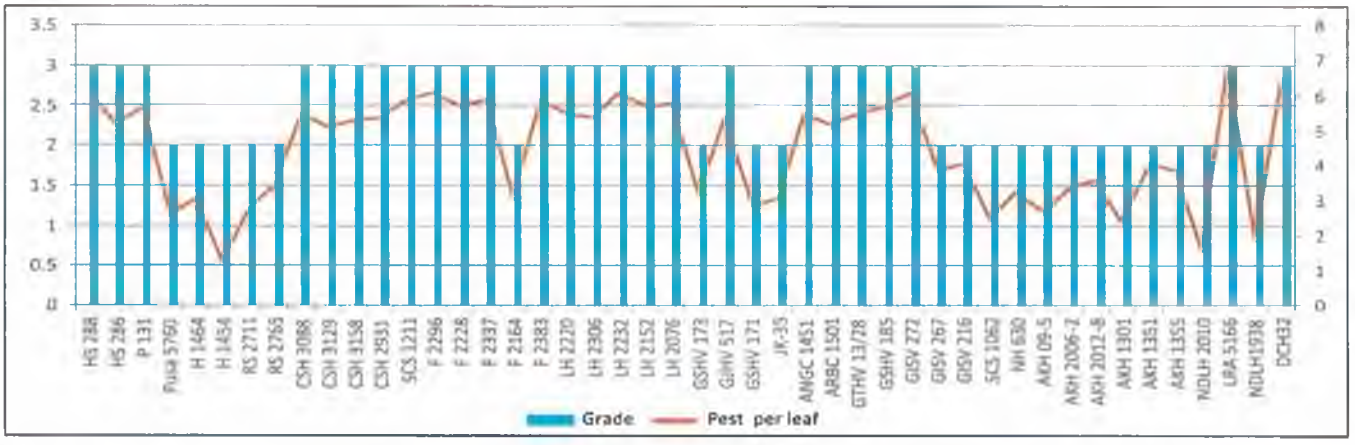
1.19 Project Name : DST CRG Project - OXX5197: Unraveling the Differential Expressed Proteins (DEP) in cotton genotypes with contrasting resistance to leafhopper and development of the protein biomarkers / functional markers for leafhopper resistance

Dr. A. Manivannan (PI) ; Co-PI: Dr K. Shankarganesh

Importance of the study : Differential Expressed Proteins (DEP) leads to identification of the key peptides involved in resistance. This helps in identification of resistance genes and development of functional markers for marker assisted selection for leafhopper resistance in cotton.

Salient findings :

Forty-five genotypes from different AICRP centres were screened for leafhopper tolerance in glass house. At 45 days after sowing, the following 18 genotypes, Pusa 5760, H 1464, H 1454, RS 2711, RS 2765, F 2164, GSHV 173, GSHV 171, JK-35, GISV 267, GISV 216, SCS 1062, NH 630, AKH 09-5, AKH 2006-2, AKH 2012-8, AKH 1301, AKH 1351, AKH 1355 and NDLH 2010 were performing on par with leaf hopper resistant check (NDLK 1938) with injury gradient score of 2. Among them LRA 5166 was highly susceptible, with highest pest load of 6.9 and injury gradient of 3. In order to study the differential expression studies, the two contrasting parents were selected. Based on the results two genotypes namely, NDLH 2010 (R) and LRA5166 (S) were sown as resistant and susceptible lines and hybrids are produced for proteomic analysis.



Leafhopper infestation on cotton genotypes in green house condition

1.20 Project Name : National Seed Project (Crops)

Dr. K. Rathinavel (PI), CCPI: Dr. P. R. Vijayakumari

Importance of the study : Experiments were conducted to study the planting values of seeds to examine the prescribed periods of validity of fresh and revalidated certified seed lots of some major field crops and also for the Development of priming technologies for enhanced planting value of seed under sub-optimal conditions in field crops

Salient findings :

In the laboratory experiments conducted to validate the validity periods of certified seeds, NH 615 (*G. hirsutum*) and Roja (*G. arboreum*) variety seeds were packed and stored in gunny bags and polythene bags after initial evaluation. Seed moisture content (ISTA), germination % (ISTA), vigour index- (I & II) and speed of emergence and final plant stand establishment (%) were recorded at bimonthly interval under ambient condition.

The data on germination revealed a progressive decline from June 2019 to February 2021, in both varieties (NH 615 and Roja) stored in gunny bag and poly bag (700 gauge) under ambient conditions over a period of 20 months. The seed quality decline due to period of storage across varieties and containers was 31.6%. Between varieties, the rate of quality decline was high in Roja (from 90.1% to 46.1%) and less in NH 615 (from 90.9% to 71.8%). The germination percentage recorded after 9 months of storage was 89.0%, 78.5%, respectively in gunny bag and poly bag stored seeds of NH615 and 74.5%, 75.3% of Roja, suggest that seeds may safely be stored as per the IMSCS standard. During the extended storage period of 20 months, NH615 seeds are capable of maintaining viability over and above as per the IMSCS standard of 65%, whereas, in Roja, the viability was maintainable up to 12 months of storage.

In the experiment on the physiology studies and development of priming technologies for enhancing planting value of seed in field crops under optimal and sub-optimal conditions, two seed lots of Surabhi and Suraj (2019-20 (L1); 2018-19 (L2)) were used and treated with different priming agents/biocontrol agents. Treated seeds were observed for Moisture content (ISTA) before and after treatment i.e. Before sowing First count %, Germination % (ISTA), Vigour index-I & II, Speed of emergence and Final plant stand establishment (%) after 3 weeks.

The results revealed that seed moisture content recorded initially was 6.4% and 7.0%, respectively in L1 and L2 of Surabhi. This was 6.8% and 6.3% in Suraj. The moisture content recorded after seed treatment revealed that an increase of 1.6% due to halo-priming with KH_2PO_4 (@ 0.5%) and 2.4% due to halo-priming with KNO_3 (@ 0.3%) in L1 of Surabhi and 0.97% increase due to hydro-priming (12h @ 25°C) and 1.4% due to halo-priming with KH_2PO_4 (@ 0.5%) in L1 of Suraj. In low vigour seed lot the increase in seed moisture was 3.32% in surabhi due to hydro priming (12h @ 25°C) and 2.54% in Suraj due to halo-priming with KH_2PO_4 (@ 0.5%). The treatment response was observed significantly in Surabhi than Suraj cotton seeds. In surabhi, in the high vigour seed lot, the germination improvement was noticed to the tune of 9.75% due to Seed coating (on hydro primed seeds) with DAB + BioNPK. Similarly in the low vigour seed lot it was 10.5% due to the same treatment. The same treatment did not improve germination in high vigour seed lot of suraj, however, it was 6.5% in the low vigour seed lot. The next best seed treatment observed in Surabhi was seed coating with *Trichoderma harzianum* (15g/kg) and halo-priming with KH_2PO_4 (@ 0.5%) with germination improvement of 4.8% in high vigour seed lot of surabhi, whereas in low vigour seed lot, the numerical increase of 6.0% and 3.5%, respectively.

Root length has shown on par response of best treatments with control in surabhi and suraj in high and low vigour seed lots. Significant increase in shoot length of 1.44 cm and 1.43 cm respectively was observed due to seed coating with *Trichoderma harzianum* (15g/kg) and Halo-priming with KNO_3 (@ 0.3%). The same treatments have promoted the shoot growth of 1.33cm and 1.02 cm, respectively in Suraj. A vigour index of 448 and 361, respectively was recorded by seed coating (on hydro primed seeds) with DAB + Bio NPK and halo-priming with KH_2PO_4 (@ 0.5%) in the high vigour seed lot of Surabhi, however their contribution to vigour improvement in low vigour seed lot of surabhi was found to be meager. In Surabhi, seed coating with *Trichoderma harzianum* (15g/kg) have recorded the highest field emergence of 78.3% in high vigour seed lot, whereas in low vigour seed lot, 78.3% field emergence was observed in hydro priming seeds treated with DAB + Bio NPK . In Suraj it was 73.8% and 78.8%, respectively in high and low vigor of hydroprimed seeds treated with DAB + Bio NPK. The mean data of other parameters recorded viz., vigour index II, speed of germination and final plant stand depicted more or less similar pattern. Hence seed coating (on hydro primed seeds) with DAB + Bio NPK and halo-priming with KH_2PO_4 (@ 0.5%) would be a viable seed treatment for quality enhancement.

1.21 Project Name : Implementation of PVP legislation 2001 and DUS testing of cotton under ICAR-SAU system

Dr. K. Rathinavel (PI); Co-PIs : Dr.V. Santhy, Dr. P.R.Vijayakumari

Importance of the study: The project is aimed for the establishment and maintenance of database on extant

cotton varieties, conduct of DUS test of new, VCK and farmers varieties, and maintenance breeding of reference cotton varieties, morphological characterization of cotton varieties and registration of extant cotton varieties.

Salient findings :

At ICAR-CICR, Regional Station Coimbatore during the year 2021, the cotton varieties notified through CVRC were included in the data base on extant cotton varieties. Maintenance breeding and characterization and of 183 extant cotton varieties were carried out in tetraploid and Diploid cotton viz.,138 in *G. hirsutum*, 35 in *G. arboreum, 3 in G.herbaceum and 7 in G.barbadense.*

The field trial on DUS test of candidate varieties include new and VCK category and they are 2877/4088, 2880/3220, 2880/3220F1SMG, 2884/2112, 2884/2112 F1SMG, 2884/2088, 2884/2088 F1SMG, 2884/2089, 2884/2089 F1SMG, 2884/2111, 2884/2111 F1SMG, 2884/2113, 2884/2113 F1SMG, 2870/2100, 2870/2100 F1SMG, 2870/2107, 2870/2107 F1SMG, TC-H-1, TC-H-1 F1SMG, TC20SH, TC20SH$_2$ TC20ST, TC20ST$_2$ 2879/3887. The F1 seeds produced at Shimoga were grown along with candidate hybrids for stability testing. Along with candidate varieties, the reference varieties NC-61, MCU10, MCU13, Sumangala, Surabhi, Sujatha, Suvin, TCB 209, JK4, GSHV112, MRC7351 BGII and RCH 659 BGII were also grown for the establishment of distinctiveness.

Field sowing was taken up on 28.8.2020 in randomized block design with 3 replications. Germination count at 12 DAS in corresponding plot was recorded in all the entries. Morphological characters such as Hypocotyl: Pigmentation, Leaf: Colour, Leaf: Hairiness, Leaf: Appearance, Leaf: Gossypol glands, Leaf: Nectaries, Leaf: Petiole pigmentation, Leaf: Shape, Plant: Stem hairiness, Plant: Stem pigmentation, Bract: Type, Flower: Time of flowering, Flower: Petal colour, Flower: Petal spot, Flower: Stigma, Flower: Anther Filament colouration , Flower: Pollen colour, Flower: Male Sterility, Boll: Bearing habit, Boll: Colour, Boll: Shape, Boll: Surface, Boll: Prominence of tip were recorded in 10 plants of all varieties. Monitoring of DUS trials at the participating centres (RRS Bathinda, ICAR-CICR, Nagpur and MPKV, Rahuri, UAS, Dharwad and ICAR-CICR, Coimbatore) were done through virtual mode.

At ICAR-CICR, Nagpur centre, seven new hybrids were grown in the first-year trial and they are 2020 TC H1, 2020 TC OP2, 2020 TC H4, 2020 TC H5, 2020 TC H6, 2020 TC T6, 2020 TC H7. In the second-year trial five new hybrids such as C14Q2 x 1895B2, C15Q2 x 0184B2, C16Q2 x 0588B2, PC-P 3812 BG-II and NCS-854 Bt2; five varieties of common Knowledge 25D55 BG II, ZCH 511 BG II, SRCH-55 BG II, 25D51 BG II and CFL (DH-904) were grown and evaluated for DUS traits. The data on DUS traits from the nodal centre (ICAR-CICR, Regional Station, Coimbatore) and the received verified data from co-nodal centres were compiled and provided to PPV&FRA for the issue of plant variety protection certificate.

1.22 Project Name : Development of varieties of upland cotton having better fibre traits and tolerance to CLCuD

O. P. Tuteja, S. K. Verma (PI); Co-PIs: Dr V.N. Waghmare, and Rishi Kumar

Importance of the study : CLCuD is a major problem in case of cotton production. As it is a vector transmitted viral disease its management is very difficult. With this regard the present project has advance cultures of cotton in four separate experiments with local checks evaluated for yield potential and CLCuD resistance.

Salient findings

Based on yield potential three advance cultures namely CSH 2924 (2556 kg/ha), CSH 1628 (2278 kg/ha) and CSH 2931 (2185 Kg/ha) were found superior over check varieties. CSH 1628 had lowest incidence of *CLCuV (7%).*

In the 2nd trial out of 22 advance cultures only a single genotype; CSH 1926 (1648 Kg/ha) was found with higher yield potential. CSH 2931 (PDI 11%) was most preferred entry for *CLCuD* resistance.

In the 3rd trial the culture CSH 1607 with average yield 1796 kg/ha and lower *CLCuV* incidence (16%) was one of the most promising entries of this experiment.

In this experiment two advance culture namely CSH 1910 (3037 kg/ha) and LH 900 (2407 kg/ha) were found superior over local check. Both of these entries had PDI less than 20%.

Evaluation of *G. hirsutum* genotypes for seed cotton yield and CLCuD resistance

Entry	Bolls/ plant	SCY (Kg/ha)	PDI (%)
CSH-2924	25	2556	23
CSH-1628	28	2278	7
CSH-2931	17	2185	11
CSH-1926	44	1648	22
CSH-1607	22	1796	16
CSH-2902	24	1685	23
CSH-3836	22	1676	18
CSH-88	22	1407	14
CSH-1910	40	3037	18
LH-900	36	2407	17
SASA-1647	26	1481	13
CSH-3088	35	1444	14
CSH-3075 ©	34	1593	23
RCH 773BGII©	21	1620	36
RS 2013©	31	1648	9
CSH-3129©	18	1333	10

Theme 2 : Development of ecologically compatible integrated pest management strategies for existing and emerging pests under conventional and niche area cotton production systems

2.1. Project Name : Investigations on bioefficacy of entomopathogens against cotton Pink bollworm, *Pectinophora gossypiella* Saunders

Dr. V. S. Nagrare (PI), Co-PIs: Dr. V. Chinna Babu Naik, Dr. S.P. Gawande, Dr. D.T. Nagrale, Dr. J. Gulzar Banu

Importance of the study: In recent years, the pink bollworm (PBW), *Pectinophora gossypiella* (Saunders) has re-emerged as a serious pest of cotton in India. The chemical control for PBW is very difficult as the larvae are internal feeders, living inside the green bolls. Entomologists are exploring the possibility of using entomopathogens as biological control agents, and the researchers are working towards possible exploitation of entomopathogens (bacteria, fungi, virus, EPN and protozoa) for the control of many insect pests. The project aims to explore potential of entomopathogens for management of pink bollworm in field conditions.

2.2. Project Name : Crop pest surveillance and advisory project (CROPSAP) in Maharashtra

Dr. V. S. Nagrare (PI)

Importance of the study: Government of Maharashtra has formulated and implemented an innovative project e-pest surveillance and advisory based on Information and Communication Technology (ICT) in plant protection from 2009-10. The project involves multi-stakeholders like ICAR Institutes and State Agriculture Universities besides Government agencies/ institutes like NIPHM, MAIDC etc. Consistent pest monitoring and adoption of appropriate pest management strategies at proper growth stages of the crop have been implemented under the project and thus has led to lower pest damage in crops as soybean, cotton, rice, tur and gram. The work assigned to ICAR-CICR was: i) To formulate IPM strategies for cotton, ii) To develop pest specific advisory capsules, iii) To visit hot-spots for imparting guidance to farmers and field functionaries and iv) To get feedback for future research and developing IPM Strategies.

Salient findings :

Pre-sowing and in-season advisories were formulated and provided to the State Agriculture Department. Wide publicity of pest management advisories was given through newspapers and electronic media. Advisory was issued to dealers regarding sale of cotton seeds to in view of COVID pandemic and lockdown, weekly cotton advisories as well as mid-course advisories were issued, weekly pest data was analysed. Data on population dynamics of cotton pests were generated at station trial. Morpho-variational studies of cotton jassid were done.

Pest status in Maharashtra

Pest status was monitored in 12,584 villages across the state of Maharashtra.

Pink bollworm : During 31 standard meteorological week (SW), total 42 villages out of 12,584 villages surveyed showed infestation of pink bollworm above ETL from all cotton growing districts of Maharashtra during 2020-2021. The number increased to 67 villages in 32 SW and for short period remained low. Starting from 43 SW, the infestation of PBW crossed ETL in more than 100 villages and remain unchanged till 50SW. Thereafter the number of villages went down. The maximum infestation of PBW has recorded during 44SW and 47SW showing 269 and 268 villages crossed ETL, respectively whereas, the minimum infestation was recorded during 52SW, showing only 19 villages crossed ETL (Fig.2.2.1).

Fig. 2.2.1. Number of villages across Maharashtra during crop season 2020-21 where pink bollworm infestation crossed ETL

Cotton jassid : During 31 SW, jassid infestation was recorded above ETL in a total of 61 villages. Thereafter, the highest infestation of jassid was noticed during 32 SW recording 88 villages above ETL from all cotton growing districts of Maharashtra. The infestation of jassid lowered down from 39 SW to 41 SW, recorded 27-41 villages above ETL. During 42-44 SW, the number of villages were in the range of 13-20, which indicates a decrease in the infestation of cotton jassid. From 45SW onwards, the infestation of cotton jassid was recorded in a very few villages, ranging from 1-5 only (Fig 2.2.2).

Fig 2.2.2. Number of villages across Maharashtra during crop season 2020-21 where jassid infestation crossed ETL

Other pests

Other targeted pests like whitefly, thrips and other bollworms hardly crossed ETL in cotton growing districts of Maharashtra.

Other research works carried out at the Institute level under CROPSAP

Population dynamics of sucking pests

Sucking pests viz., cotton jassid, whitefly and thrips population were slightly higher in number during the initial period of the season however, decreased with the progress of season and remained below ETL subsequently (Fig.2.2.3). As like the previous year (2020), where the peak aphid population was recorded (62 aphids/3leaves) at 45SW (05-11 Nov), but during 2021 on such peak was recorded and remained <10 aphids/3 leaves throughout the crop season (Fig.2.2.4).

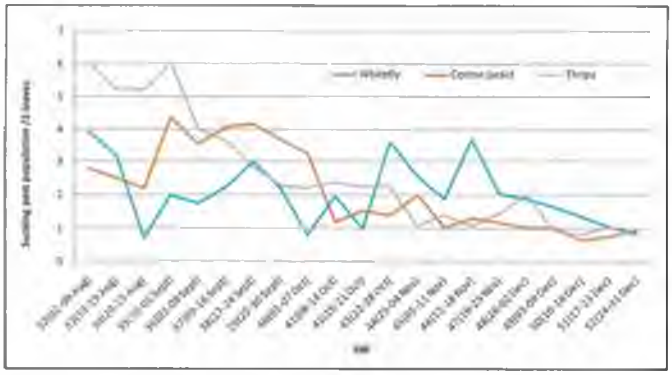


Fig.2.2.3. Population dynamics of sucking pests over the season in RCH 2 during 2021

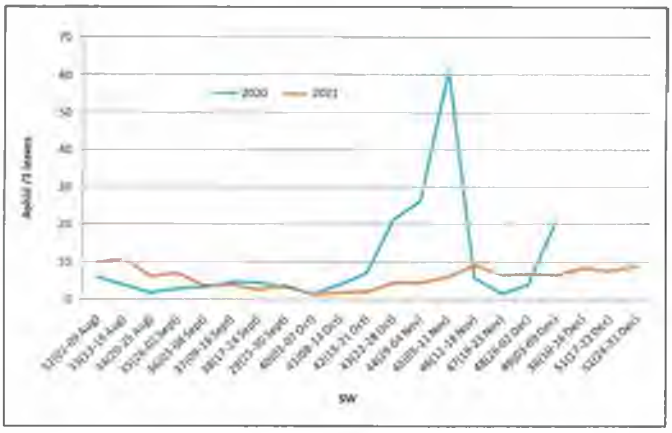


Fig.2.2.4. Population dynamics of aphid over the season in RCH 2 during 2021

Pink bollworm infestation in green bolls of non-Bt and Bt cotton

In non-Bt cotton (Suraj) pink bollworm infestation was recorded above ETL (>10% green boll infestation) starting from 35SW (02-07 Sept) and was highest during 48 SW (29-08 Dec). While in Bt cotton (RCH 2 BGII) pink bollworm infestation was started during 41SW (11-21Oct) and peak period was recorded at 47SW (25-28 Nov). Comparatively, the pink bollworm infestation was higher in non-Bt cotton than Bt cotton (Fig 2.2.5).

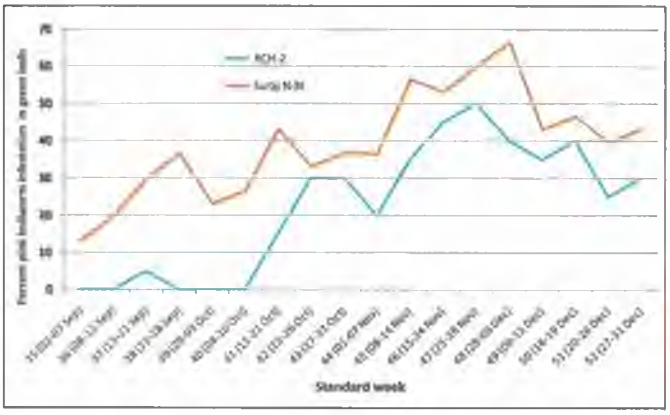


Fig 2.2.5. Pink bollworm infestation in Bt and non-Bt cotton during 2021

Pheromone trap catches

During 2021, weekly moth catches of cotton bollworm and spotted bollworm were recorded during the season. Maximum moth catches of cotton bollworm *Helicoverpa armigera* (6 moths /trap/week) was recorded at 47 SW (22-28 Nov) while of spotted bollworm moth catches were (13 moth /trap/week) at 50 SW (13-19 Dec). Pink bollworm moth activity was seen starting from 41SW (11-17 Oct); thereafter increased and maximum moths were captured (123 moths/ trap/ week) at 48 SW (29-05 Dec) and thereafter started decreasing. Higher number of moth catches of Tobacco caterpillar (30 moths /trap/week)was recorded during 46SW (15-21 Nov) (Fig.2.2.6).

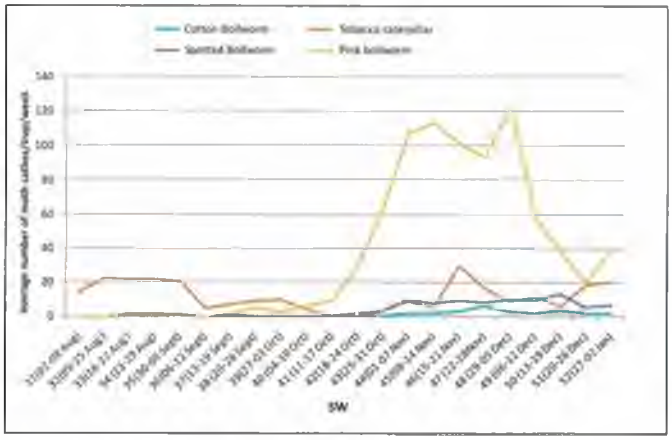


Fig.2.2.6. Pheromone trap catches during 2021 (Nagpur)

Yellow sticky trap catches of Whitefly and Jassid

Cotton jassid population at the initial period was low (86 cotton jassid/trap/week) at 32 SW (9-15 Aug), but with the progress of the season, trap catches increased (273 cotton jassid/trap/ week) at the mid of the season 39 SW (27 -03 Oct). Populations of whitefly fluctuated over the season, peak (225 whitefly/trap/ week) was recorded at 48 SW (29-05 Dec) (Fig. 2.2.7).

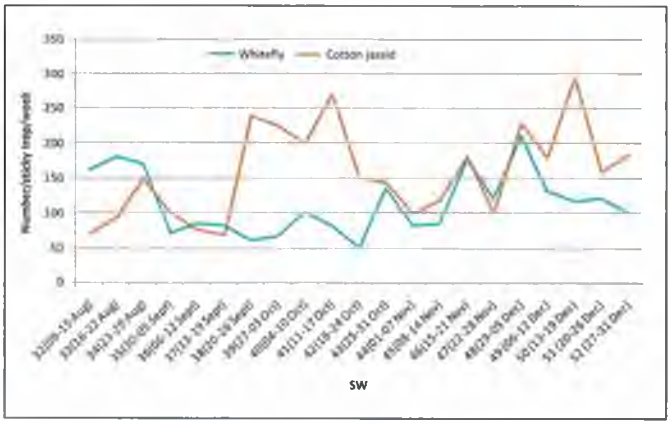


Fig.2.2.7. Sticky trap catches of Jassid and whitefly during 2021 (Nagpur)

2.3 Project Name : Insecticide resistance management: Dissemination of pink bollworm management strategies

Dr. V. S. Nagrare (PI); Co-PIs: Dr. V. Chinna Babu Naik, Dr. S.P. Gawande, Dr. S. M. Wasnik, Dr. B.B. Fand, Dr. D.T. Nagrale, Dr. S.S. Patil, Dr. K. Rameash, Dr. Rishi Kumar, Rachna Pande, Nilkanth Hiremani

Importance of the study: Pink bollworm, *Pectinophora gossypiella* (Saunders) has emerged as a serious threat to the

cotton in all the three cotton growing regions of India causing widespread losses in the cotton yield. In the year 2017-18, pink bollworm was found at epidemic levels in major cotton producing states -Maharashtra, Telangana, Andhra Pradesh, Karnataka, Gujarat and Madhya Pradesh of central and southern cotton growing zones. These states incurred heavy yield losses ranging from 10 to 30%. Till 2017-18, in north India, pink bollworm infestation was under control however, since 2018-19, pink bollworm crossed ETL especially in the state of Haryana. The necessity of the hour was to manage the pest with existing management strategies and their dissemination in wide area in major cotton producing states (Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu and Haryana). This project is funded by Department of Agriculture, Cooperation and Farmers' Welfare (Crops Division), Ministry of Agriculture and Farmers' Welfare, Govt. of India.

Salient findings :

Through demonstrations of the pink bollworm strategies, it was possible to bring down the number of sprays for the control of cotton pests during the season to an average of 5.19 in IRM field as compared to 8.08 in non-IRM fields. Reduction in pesticide usage in IRM vs non-IRM fields was 40% in terms of cost, while 39.31% in terms of volume. Reduced sprays resulted in saving the cost of unnecessary insecticide sprays, thus increasing the margin of profit to the cotton farmers. The overall benefit cost ratio was 1.89:1. Comparatively, seed cotton harvested was more in IRM fields (1881 kg/ha) *vs* non-IRM fields (1585 kg/ha). The reduced pink bollworm infestation has improved the quality of lint and seed.

2.4. Project Name : Identification of oviposition deterrents for ethological management of cotton bollworm *Helicoverpa armigera* (Hübner)

Dr. Rachna Pande(PI); Co-PI:Dr. Vivek Shah

Importance of the study : Semiochemicals are the acceptable alternatives for the management of insects as they alter the behaviour of insects. In recent years, among the semiochemicals, oviposition deterrent was the most explored field. In the present study the oils containing the fatty acids as a component were evaluated both under laboratory and field conditions. Selection of oils was based on the oviposition deterrent compounds identified in previous year through GC-MS.

Salient findings :

Vegetable oils (groundnut, sunflower, rice bran, soybean, safflower, sesame, palm oil and shea butter) containing these fatty acids viz., linoleic acid (9,12-octadecadienoic acid), palmitic acid (hexadecanoic acid), myristic (Tetradecanoic acid) and stearic acid (Octadecanoic acid) at different proportion were selected after confirmation by GC-MS studies. In laboratory evaluation all the oils were effective except shea butter. In the experiment more than 50% reduction was observed in Sunflower, soybean, Palm oil at 1% and in ground nut, rice bran, safflower and sesame at 2% conc. Maximum % reduction in egg laying i.e. 69% was on Palm oil 3%. Oils were sprayed (@1%, 2% and 4%) in cotton field and compared with insecticides (chlorantriniliprole 18.5 SC and emamectin benzoate 5%SG). Oils performed better than control and sometimes at par with insecticides at higher concentration. Among the oils groundnut, soybean, rice bran, palm oil (2% and 4 %), sunflower (4%) were effective. On chick pea crop oils were sprayed (@ 0.5%, 1% and 2%) and compared with insecticides (chlorantriniliprole 18.5 SC and emamectin benzoate 5% SG). Oils performed better than control and but not in comparison of insecticide. Among the oils rice bran 2% was effective in reducing the number of eggs of *H. armigera*. In another set of experiment blends of oils was evaluated under laboratory condition at 1%. All the blends were effective in deterring the female from laying eggs from 61 to 74% reduction in egg laying. Maximum reduction was observed in blend of ground nut with safflower which is 74%. In continuation of laboratory evaluation total 21 blends of oils were sprayed in cotton field at 3% concentration. In case of blends all the blends were effective however, performance of blends was not consistent in both the sprayings across the days. In first spraying 5 blends viz., groundnut + safflower, sunflower + sesame, ricebran + palmoil, safflower + sesame, sesame + palmoil and in second spraying groundnut + sunflower, safflower + palmoil, groundnut + ricebran, sunflower + safflower, soybean + palmoil were best among the blends tested in field condition.

2.5. Project Name : Studies on chemical cues mediating natural enemy and sucking pest interactions in cotton ecosystem

Dr. Shah Vivek (PI); Co-PIs: Dr. K. Shankarganesh, Dr. Rishi Kumar, Dr. K Rameash, Mr. Madhu T.N.

Importance of the study: After introduction of Bt cotton in India although there was reduction in sprays for bollworms but with gradual increase in sprays for sucking pests. Whitefly and jassids are the major sucking pests in cotton in Indian context. Present study aims in identifying volatiles from sucking pests that play role in attracting natural enemies that can be deployed in eco-friendly pest management.

Salient findings :

Compounds were identified from body wash extracts of sucking pests. Based on identified compounds vegetable oils were selected and evaluated under field conditions at Nagpur, Coimbatore and Sirsa.

Field evaluation conducted at all three centers showed no significant difference either in attracting natural enemies and/or on population of sucking pests.

This may be attributed to presence of natural enemies restricted to brief period of around 14-21 days only at crop stage between 45-90 DAS.

2.6. Project Name : Push-Pull strategy for management of pink bollworm in cotton

Dr. Shah Vivek (PI); Co-PIs: Dr. Pooja Verma, Dr. Rachna Pande

Importance of the study: Present study aims to identify oviposition deterrents from pink bollworm (push component) and plant-based volatiles attractants (Pull component) that can be deployed for ecological pest management against pink bollworm.

Salient findings :

Vegetable oils (groundnut, sunflower, rice bran, soybean, sesame, safflower) containing palmitic, oleic and linoleic acid were evaluated both under laboratory and field conditions, were found promising.

Compounds identified from square extracts of cotton, higher proportion of pinene over caryophyllene as found in American cotton, Pinene: caryophyllene in the ratio of 2:1 (*G. hirsutum*) and 5:2 (*G. barbadense*) gives higher preference of pink bollworm for egg laying.

Higher proportion of caryophyllene over pinene as present in *G. arboreum.* Pinene, carene, caryophyllene (2:2:5) cotton with presence of γ terpinene reduces oviposition preference of pink bollworm.

The ratio of pinene, carene, caryophyllene, humulene and γ-terpinene is 2:5:4:2:5 found in *G. herbaceum.* Higher proportion of γ terpinene in *G. herbaceum* might attribute to deterrent effect.

The order of preference for pink bollworm female for egg laying based on volatile blend was in order of *G. hirsutum*>*G. barbadense* > *G. arboreum* > *G. herbaceum*

2.7. Project Name: Studies on boll rot in cotton – Etiology and Management

Dr. Dipak T. Nagrale (PI); Co-PI: Dr. Babasaheb B. Fand

Importance of the study : In recent years emerging diseases in climate change scenario are increasingly assuming major challenges in limiting the cotton production. Boll rot disease complex has emerged as an important disease in cotton in most of cotton growing areas and not only reduces the yield but also affects the quality of lint and seed. Most of the times, boll rot has been recognised as a complex problem involving damage and injury symptoms produced by bollworms, principal pathogen (s) and secondary invaders causing damage at boll development stages with abiotic factors as precipitation also playing a significant role.

Salient findings :

Isolation, purification and polyphasic characterization of boll rot pathogens from different geographic locations from Maharashtra, Telangana and Madhya Pradesh states were carried out

Total fourteen pathogenic fungal boll rot isolates including five isolates from *Pleosporaceae*, three isolates from *Botryosphaeriaceae*, three isolates from *Nectriaceae* and each one isolate from *Glomerellaceae, Sporocadaceae* and *Trichocomaceae* were characterized (Table 2.7.1)

Total six pathogenic bacterial internal boll rot isolates including three strains from *Erwiniaceae* and each one strain from *Enterobacteriaceae*, *Pseudomonadaceae* and *Sphingobacteriaceae* were characterized (Table 2.7.2)

Studied the symptomatology of boll rot disease complex caused by fungal (Fig. 2.7.1) and bacterial pathogens (Fig. 2.7.2)

Proved the pathogenicity of boll rot isolates on Bt cotton hybrid and non Bt variety

Table 2.7.1: Fungal boll rot pathogens from different geographic locations of India

Sr. No.	Name of organism	Isolate ID	Location	Nos. of isolate	GPS co-ordinate	GenBank Accession no.
1	*Lasiodiplodia theobromae*	ICBF-MS	Nagpur, Maharashtra	03	21°02'14.6"N 79°03'31.2"E	MW750583
2	*Lasiodiplodia theobromae*	ECBR-MS-1	Nagpur, Maharashtra		21°02'14.5"N 79°03'31.5"E	MW750584
3	*Lasiodiplodia theobromae*	ECBR-TS-2(A)	Adilabad, Telangana		21°02'16.2"N 79°03'09.8"E	MW750585
4	*Colletotrichum gossypii*	ECBR-MS-3(A)	Nagpur, Maharashtra	01	21°02'15.0"N 79°03'17.7"E	MW750586
5	*Curvularia* lunata *(Cochliobolus lunatus)*	ECBR-TS(2)	Adilabad, Telangana	01	19°43'26.4"N 78°43'01.2"E	MW750587
6	*Aspergillus nidulans*	ECBR-TS-3(A)	Adilabad, Telangana	01	19°43'26.4"N 78°43'01.2"E	MW750588
7	*Fusarium proliferatum*	ECBR-TS-3(B)	Adilabad, Telangana	03	19°43'26.4"N 78°43'01.2"E	MW750589
8	*Fusarium proliferatum*	ECBR-MP7-C	Chhindwara, Madhya Pradesh		21°38'11.4"N 78°49'11.9"E	MW750590
9	*Fusarium proliferatum*	ECBR MS2-B	Nagpur, Maharashtra		21°02'15.0"N 79°03'17.5"E	MW750592
10	*Pestalotiopsis* sp.	ECBR MS9-A	Nagpur, Maharashtra	01	21°02'16.1"N 79°03'09.8"E	MW750593
11	*Alternaria macrospora*	ECBR MP8-A	Chhindwara, Madhya Pradesh	04	21°38'11.4"N 78°49'11.9"E	MW750594
12	*Alternaria macrospora*	ECBR MS9-B	Nagpur, Maharashtra		21°02'14.5"N 79°03'31.5"E	MW750595
13	*Alternaria macrospora*	ECBR TS6-C	Adilabad, Telangana		19°37'46.5"N 78°27'33.0"E	MW750596
14	*Alternaria macrospora*	ECBR-MS5-A	Nagpur, Maharashtra		21°02'16.2"N 79°03'09.8"E	MW750591

Table 2.7.2. Bacterial boll rot pathogens from different geographic locations of India

Sr. No.	Name of organism	Isolate ID	Location	Nos. of isolate	GPS Co-ordinate	GenBank accession no.
1	*Pantoea dispersa*	BBF-TS	Adilabad, Telangana	03	19°27'17.3"N 78°24'43.2"E	MW751673
2	*Pantoea dispersa*	BBR-MS-AM	Amravati, Maharashtra		21°04'54.8"N 78°03'11.7"E	MW751674
3	*Pantoea dispersa*	BBR-TS3-C	Adilabad, Telangana		19°26'52.8"N 78°19'18.1"E	MW757341
4	*Enterobacter* sp.	BBR-TS3-A	Adilabad, Telangana	01	19°26'36.6"N 78°19'57.4"E	MW757342
5	*Pseudomonas* sp.	BBR-MP-CH	Madhya Pradesh	01	21°38'11.4"N 78°49'11.9"E	MW751676
6	*Sphingobacterium* sp.	BBR-MS-AM1	Amravati, Maharashtra	01	21°02'51.7"N 77°58'32.7"E	MW751675

Fig. 2.7.1. Fungal boll rot infection to developing green bolls and symptomatology in field condition

Fig. 2.7.2 Bacterial boll rot with point of infection (1), lint discolouration (2), seed rot and swelling (3) and hard lock symptoms

2.8. Project title : Studies on target leaf spot of cotton caused by *Corynespora cassiicola*

Dr. S.P. Gawande (PI); Co-PIs: Dr S.K. Sain, Dr Chandrashekhar N.

Importance of the study : Present investigation is proposed to gather the information about target leaf spot of cotton an emerging disease for location specific management, which is presently lacking. More data about distribution across Indian cotton acreage disease onset and diversity are needed to understand disease development and potential impact on yield.

Salient findings :

Survey and collection of *Corynespora* leaf spot samples from different cotton growing district of Maharashtra, Gujrat and Telangana states has been done (Table 2.8.1).

Isolations of collected diseased samples on PDA/SDA were carried out.

Pathogenicity of isolates on susceptible cotton host was done.

Potato Dextrose agar (PDA) and Streptocycline agar (SA) were found excellent among all the media tested for the growth and sporulation of *C.cassicola*.

Morphological and molecular characterization of isolates has been carried out and ITS sequences has been deposited to NCBI database.

Phylogenetic correlation between submitted sequences and their close relatives of *C. cassicola* was done using Mega 6 using Taimura Nei model.

Table 2.8.1. Survey, collections and Molecular Characterization of *Corynespora cassicolla by* ITS-Sequencing

Sr. no.	Specimen voucher no.	Location	District	State	GPS	NCBI accession no.
1	CICR-ARF1	Arvi	Wardha	Maharashtra	20° 35' 24.00" N 79° 08' 24.00" E	MW426359
2	CICR-SAF2	Samudrapur	Wardha	Maharashtra	20°38'59.99" N 78°57'59.99" E	MW426360
3	CICR-SUF2	Navsari	Surat	Gujrat	20°56'60.00" N 72°55'48.00" E	MW426361
4	CICR-AKF5	Dapura	Akola	Maharashtra	20° 43' 46.7076" N77° 22' 4.4004E	MW426362
5	CICR-PARF6	Parshivni	Nagpur	Maharashtra	21°22'59.99" N 79°08'60.00" E	MW426363
6	CICR-JUF7	Junagarh	Junagarh	Gujrat	21.515471N 70.456444E	MW426364
7	CICR-NAGF8	Panjri	Nagpur	Maharashtra	21.03631N79.05601E	MW426365
8	CICR-AMTF9	Shendola	Amravati	Maharashtra	21.06.123N 77.99.154NE	MW426366
9	CICR-BHF10	Bhadravati	Chandrapur	Maharashtra	20.10187N79.11575E	MW426367
10	CICR-KAF11	Roshankheda	Nagpur	Maharashtra	21.28.220N78.53.711E	MW426368
11	CICR-CHF12	Shembal	Chandrapur	Maharashtra	20.177.84N78.98.872 E	MW426369
12	CICR-YAF13	Chaparda	Yeotmal	Maharashtra	20.25.20N 78.16.14E	-
13	CICR-ADF14	Boraj	Adilabad	Telangana	19.45.48 N78.41.20E	-
14	CICR-GUNF15	Penuganchiprola	Guntur	Andhra Pradesh	16.9017° N, 80.2475° E	MW630050
15	CICR-GADF13	Chamorshi	Gadchiroli	Maharashtra	19° 33' 0.00 N 79° 31' 12.00" E	MW630051

Fig. 2.8.1. Isolation of infected samples on PDA medium and their morphological studies. 550 bp

Fig. 2.8.2 Growth of *Corynespora cassicola* on different medium

Table 2.8.2. Growth of *C. cassicolla* on different media

Sr. No.	Growth Medium	Mycelial growth (mm) 5th DAI (Mean of 3 repl.)	Mycelial growth (mm) 10th DAI (Mean of 3 repl.)	Sporulation on 7 DAI
1	SDA	39.67	71.33	+
2	PDA	44.67	85.00	++
3	SA	43.00	82.00	++
4	NA	42.33	54.00	-
5	CZA	38.33	76.33	+
6	VJA	34.67	53.67	-
7	RA	29.33	70.33	-
8	KA	41.33	80.00	+
9	CA	29.37	76.33	-
10	YDCA	51.33	71.00	+
11	WA	38.67	47.33	-

Where **SDA** - Soubords dextrose agar, **PDA** - Potato dextrose agar, **SA** - Streptomycin agar, **NA** - Nutrient agar, **CZA** - Czapex dox agar, **VJA** - V8 Juice agar, **RA** - Richards Agar, **KA** - Kirchoffsagar, **CA** - Coons agar, **YDCA** - Yeast dextrose chalk agar, WA - Water agar

2.9. Project Name : Identification of endophytes from cotton with special reference to *desi* cotton and evaluation of biocontrol activity against major diseases

Dr Neelakanth S Hiremani (PI); Co-PIs: Dr S.P. Gawande, Dr Pooja Verma and Dr S.K.Sain

Importance of the study : This study was taken up to identify and utilize potential fungal endophytes from cotton as biocontrol agents against diseases. During the previous years, endophytes were evaluated and nine were shortlisted for in vivo studies. The pathogenicity and cross-pathogenicity of these endophytes has been studied previously and none caused any infection in cotton as well as non-host crops.

Salient findings :

Effect of endophyte treatment on germination in cotton : Two cotton cultivars *viz.*, Suraj and Phule Dhanwantary were treated with spore suspension of nine different fungal endophytes and it was evident from the germination paper study that, bio-priming of seeds with endophytes had positive effect on seed germination. Germination percentage for each endophyte and

cultivar was calculated after 10 days (Fig. 2.9.1). As compared to control, seed germination was high in all the endophyte treatments in both the cultivars. Seed germination was highest for *Diaporthe* sp. (CFL-34) and CFR-1 (93.33%) in Suraj followed by *F. solani* (CEP-20-90.0%). Whereas, CEP-20 and CFL-27 resulted in high seed germination (90.0% and 83.33% respectively) as compared to control (which was only 46.67%) in Phule Dhanwantary. Among others, *D. melonis* (CFS-5) and *D. longicolla* (CEL-41) were also responsible for higher germination in Phule Dhanwantary. Further, endophyte seed bio-priming had a positive effect on root length and shoot length in both the cotton cultivars. In comparison to untreated control, root and shoot length increased in endophyte treated plants (Fig. 2.9.2). In case of Suraj, maximum root length was seen in CEL-41 (10.04 cm) followed by CEL-19, whereas max. root length was seen in M_1-4 (8.39 cm) in Phule Dhanwantary.

Effect of endophytes on natural incidence of wilt/root rot diseases during 2020-21: Field trial was taken up during 2020-21 to evaluate the efficacy of endophytes against natural incidence of diseases. Seeds of Suraj and Phule Dhanwantary were treated with five endophytes (talc-based formulation) viz., CEL-41, CEL-48, M_1-4, CFS-5 and CFL-34 along with untreated control and *Trichoderma harzianum* (Trichocash) and carbendazim as standard check. The results indicated that the wilt/ root rot incidence was less in endophyte treated Suraj and Phule dhanwantary plants as compared to control (Fig. 2.9.3). Minimum disease incidence was seen in *Diaporthe longicolla* CEL-48 (2.66%) followed by CFS-5 in Suraj whereas, in Daldinia eschscholtzii M_1-4 (4.16%) followed by CEL-48 in Phule Dhanwantary. Maximum disease incidence (12.61%) was seen in untreated control (P Dhanwantary). Thus, endophytes proved beneficial in reducing wilt incidence in the field.

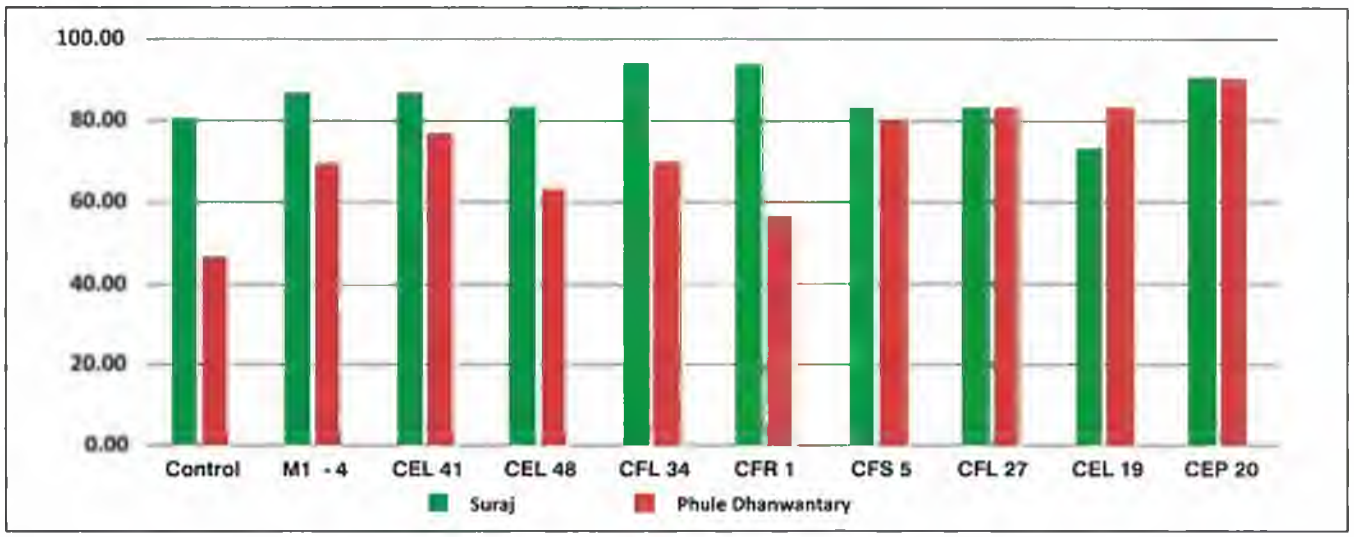


Fig 2.9.1. Germination percentage in different endophyte bio-primed cotton cultivars Suraj and Phule Dhanwantary. Error bars are SE of the mean (n=3).

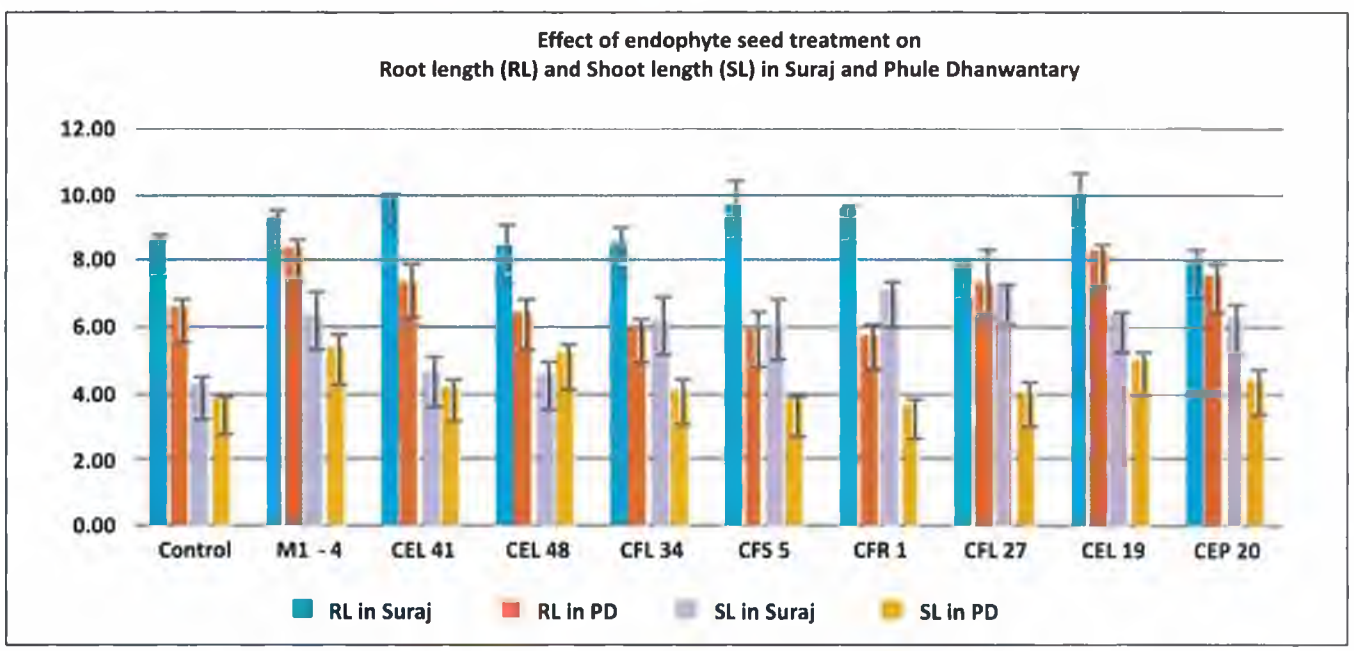


Fig. 2.9.2 Effect of endophyte seed treatment on Root length (RL) and Shoot length (SL) in cotton cultivars Suraj and Phule Dhanwantary. Error bars are SE of the mean (n=3).

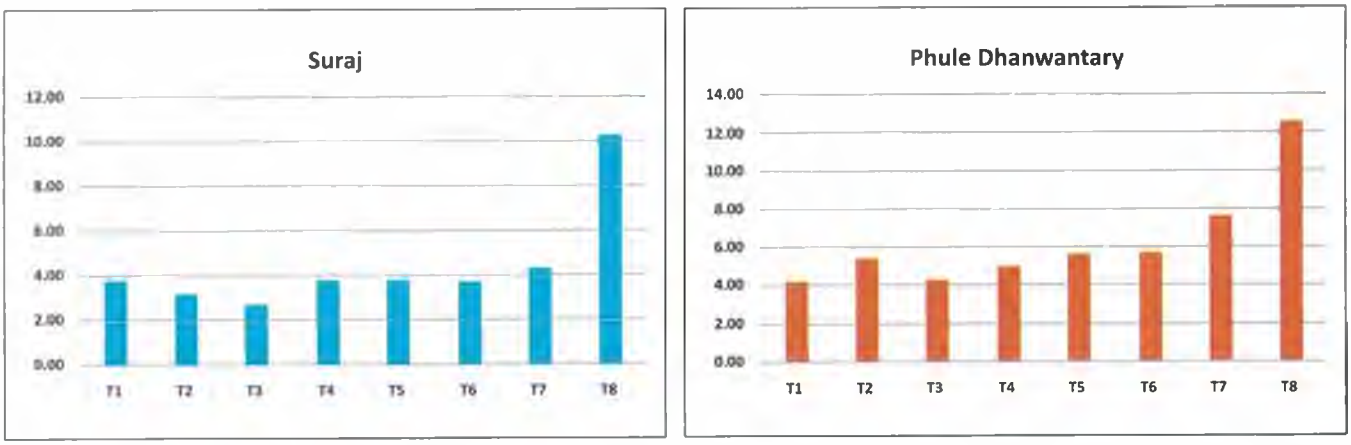


Fig. 2.9.3 Effect of endophyte seed treatment on natural disease incidence in Suraj (left) and Phule Dhanwantary (right) during 2020-21 crop season. Seed treatment as *T1-Daldinia eschscholtzii (M1-4), T2- Diaporthe sp (CFL-34), T3- D. longicolla (CEL-48), T4- D. longicolla (CEL-41), T5- D. melonis (CFS-5), T6- Trichoderma harzianum, T7- Carbendazim* and *T8- Untreated control.*

2.10. Project Name : DST-SERB-EMR : Pink bollworm, *Pectinophora gossypiella* (Saunders): Resistance Monitoring, Fitness Costs, Inheritance of Resistance to Cry toxins expressed in Bt cotton

Dr V. Chinna Babu Naik (PI)

Importance of the study: Resistance of pink bollworm to Cry toxins had threatened the efficacy of genetically modified Bt cotton. Sound understanding of the extent, mechanisms and genetic basis of resistance to Bt toxins is needed to monitor the build-up of and counter the pest resistance with alternate strategies.

Salient findings :

A roving survey was carried out in 30 districts spread across three different zones *viz*, North, Central and South . The surveys were conducted at crop stage of 60-120 DAS to assess the levels of pink bollworm (PBW) infestation on BG II and non Bt cotton crop and collection of PBW larvae for research work. The highest green boll infestation was observed in Nashik (100%) and Amreli (100%) districts of Central India. The lowest green boll infestation was observed in Nagpur dist. (26.25%) of Central India. Whereas in all the locations PBW infestation was above ETL.

Nineteen and twenty-nine populations of pink bollworm were subjected to bioassays against Cry 1Ax and Cry 2Ab toxins, respectively for resistance monitoring studies. In the populations from Guntur, Amreli, Chandrapur, Bhavnagar, Vadodara, Surendranagar and Anand resistance to Cry 1Ac over susceptible check were 828.62, 514, 359, 312.12, 244.5, 113- fold respectively. Similarly, the folds of resistance to Cry 2 Ab over susceptible check were 1961.78, 1572.33, 893.44, 763.00, 690.11, 383.56, 294.89, 241.78, 190.67, 151.33, 150.44, 131.33, 131.33 and 130.22 for Warangal, Beed, Akola, Anand, Khandwa, Adilabad, Dhule, Guntur, Nanded, Jalgoan, Bhavnagar, Nashik, Surat and Parbhani, respectively.

Insecticides resistance monitoring against Pink bollworm :

The Pink bollworm insecticides resistance monitoring was conducted in Jalgaon, Amreli and Adilabad population were subjected to bioassay with five insecticides namely, Thiodicarb, Spinosad, Fenvalerate, Spinotoram, Emamectin Benzoate at CICR, Nagpur. The results indicated that, the lowest LC_{50} was observed in Spinotoram as compared to other insecticides under laboratory condition.

2.11. Project Name : DST-SERB-EEQ : "Genetic diversity in geographical population of Pink bollworm *Pectinophora gossypiella* (Saunders) in India"

Dr V. Chinna Babu Naik (PI)

Importance of the study: The main purpose of this study was to reveal the genetic diversity in geographical population of pink bollworm *Pectinophora gossypiella* (Saunders) infesting cotton across the North, Central and South cotton growing zones of India. It was also aimed to investigate the microbial community from the larval midgut which might be responsible for imparting resistance to PBW against Bt endotoxins.

Salient findings :

Distribution and characterization of endosymbionts in different geographical populations of Pink bollworm (*Pectinophora Gossypiella*)

Endosymbiotic gut microbiota in pink bollworm populations collected from 12 different districts of India was studied. Insects were surveyed for bacterial gut microbes (endosymbionts) that may influence their biology and their interaction with other organisms or the environment. The larval stage of pink bollworm used to isolate DNA and amplification of DNA in polymerase chain reaction done by using universal 16s rRNA primers. The amplified products were sequenced and BLAST analyzed to determine the bacterial identification by similarity with existing sequences in NCBI (http://www.ncbi.nlm.nih.gov). Based on PCR, cloning, sequencing, and BLAST analyses of bacterial 16S rRNA genes *Burkholderia* strains were identified in most of the locations as endosymbionts. Also, some of the sequences were similar to *Pluralibacter gergoviae*, *Enterobacter* sp. and *Citrobacter youngae* bacteria . The core microbial community existing in gut might be responsible for resistance of insect to *Bt* cotton as well as for host physiology and food. Dominant bacteria isolated from larval midgut belonged to *Burkholderia* which are gram negative, rod shaped bipolar bacteria. Confirmation of identity was done by polymerase chain reacton with *Burkholderia* specific primer (gltB forward primer CTGCATCATGATGCGCAAGTG and Reverse Primer CTTGCCGCGGAARTCGTTGG) with annealing temperature of 58° c and amplicon size of 652 base pairs.

2.12 Project Name : Development of wireless smart trap for automated monitoring of lepidopterous pests in cotton

Dr K. Rameash (PI); Co-PIs: Dr K. Shankarganesh

Importance of the study : The conventional pheromone trap technology has many intrinsic limitations, though it is being widely used for monitoring and mass trapping of key insect pests in cotton. The trap catch data only gives the information of the number of insects trapped between two consecutive surveys, usually between 7-15 days. With poor temporal resolution measurement, the dynamics of pest population density in an area cannot be accurately monitored. To circumvent the limitations of the conventional trapping system, a wireless smart trap is developed to target multi species lepidopterous pests of cotton.

Salient findings :

Individual pheromone septa targeting the *Pectinophora gossypiella*, [7,11-hexadecadienyl acetate]; *Spodoptera litura* [(Z,E)-9,11-Tetradecadienyl acetate]; *Helicoverpa armigera*, [Z-9-Hexadecenal] and *Earias vittella* [(E,E) - 10, 12-hexadecadienyl] are housed in a modified delta trap, and the trap catch is recorded as images and transmitted to a remote server at hourly intervals for a real time pest monitoring.

The smart trap imaging and transmission system is developed by integrating a single board computer (Raspberry Pi / Arduino ESP 32); camera module and GSM / wi-fi modules. The standalone system is powered by 10 w solar panel with a rechargeable battery. A control unit will trigger the camera module at specific time intervals to record an image of trapped insects (presently tested at every one-hour interval). The recorded image is being saved in a memory card kept inside the single board computer and simultaneously being transmitted to a remote server via GSM / wi-fi modules. A weather sensor module is also integrated with the smart trap that sends the information on the temperature, relative humidity, atmospheric pressure and altitude along with the image. The combined data is optimised and transmitted via 4G GSM and or thorough wi-fi module and delivered to a remote server and via e-mail (Gmail) and mobile application (Telegram Bot). By investigating the real-time trap catch with corresponding weather data, the pest dynamics in cotton is comprehended in a better way, to establish a more reliable pest forewarning system and better pest management practices in cotton.

Multi Species pheromone septa and camera unit in the modified delta trap

2.13 Project Name : Investigation on the susceptibility status and possible detoxification mechanism for neonicotinoids and newer molecules against cotton leafhopper

Dr. K. Shankarganesh(PI); Co-PIs: Dr. VS Nagrare

Importance of the study : To understand the variation in the level of susceptibility of leafhopper to most commonly used insecticides in cotton ecosystem.

Salient findings :

Out of the eleven insecticides tested, thiamethoxam was found to be more toxic followed by clothianidin and fipronil. The insecticides such as profenofos and chloropyrifos were found to be less toxic. The relative tolerance values of insecticides in comparisons to thiamethoxam (1.0) were clothianidin (1.22) > fipronil (1.52) > acetamiprid (3.15) > Imidacloprid (3.56) > flonicamid (4.74) > thiacloprid (5.32) > spiromesifen (5.68 > diafenthiurons (7.15) > chlorpyrifos (18.39) and profenofos (29.21). The survived individuals of leafhopper bioassay were selected for estimating the detoxification enzyme (Esterase (EST), Mixed Function Oxidases (MFOs) and Glutathione S transferases) level. Insecticide exposre induces the activity of detoxification enzymes in leafhopper. This was very evident in case of profenofos and chlorpyrifos, where the activity of mixed function activity was 3 fold higher than that of the control (unexposed to insecticide). The esterase activity was increased upon exposure to neonicotinoids such as imidacloprid, acetamprid, thiamethoxam.

Nine insecticides were tested against Nagpur population of leafhopper by leaf residue method, the results revealed that the imidacloprid (0.037 mg.ai/L) was found to be more toxic followed by flonicamid (LC_{50} = 0.052 mg.ai/L) and clothianidin (LC50 = 0.053 mg.ai/L). The insecticides such as thiodicarb (LC50 = 0.693 mg.ai/L), diafenthiuron (LC50 = 1.080) and chlorpyrifos (LC50 = 1.145 mg.ai/L) were found to be less effective against leafhopper.

2.14 Project Name : Identification of semio-chemicals associated with host plant cotton and insect pest stem weevil *Pempheres affinis*

Dr. K. Shankarganesh(PI)

Importance of the study: Screening for source of tolerance against stem weevil under field conditions.

Salient findings :

Six Cotton varieties such as MCU-5 VT, Sumangala, Suraj, Surabhi, LRA 5166, MCU-3 (Non -Bt cotton) and three Bt hybrids viz., Mallika, Bahubali, RCHB 625 BGII were sown and the percent incidence of stem weevil was observed at 45, 60, 75, 90, 120 and 150 Days after sowing by destructive sampling method. The results revealed that the stem weevil incidence (damage) varied from 30 to 90 %. The Mallika Bt hybrid and

MCU5VT were found to be more susceptible whereas, Bahubali and MCU 3, were found to be tolerant to stem weevil. The GC EAD analysis was carried out to understand the effect of plant derived semiochemicals on behavior of cotton stem weevil. The females of cotton stem weevil were exposed to extracts (Dichloromethane extracts) of Mallika Bt hybrid and MCU 3. The results revealed that the presence of 14 different compounds (1R – α -Pinene, β- Myrcene, D-Limonene, 2,6-Dimethyldecane, 2,6-Nonadienal, (E,Z)-, 2-Nonenal, (E)-,2,6,11-Trimethyldodecane, α-Copaene, β-Caryophyllene, α-Guaiene, 2-Methyltetradecane, 2,6,10-Trimethyltetradecane, Patchouli alcohol, Tetradecanoic acid, propyl ester) in Mallika BT in comparison to MCU 3 (α-Pinene, 2,6-Nonadienal, (E,Z)-,n-Tridecane, 4,6-Dimethyldodecane,n-Tetradecane, β-Caryophyllene, n-Hexadecane, β-Bisabololn-Heptadecane) were found to elicit the response from the female stem weevil. In comparison to other cotton varieties, presence of one or more secondary metabolites in Mallika Bt may be responsible for high susceptibility to stem weevil. Apart from the plant extracts, head space volatiles were collected from the cotton varieties and they were subjected to behavioral assay. Head space volatiles collected from the female stem weevil was exposed to male stem weevil and it was observed that the presence of four different compounds (1, 3, 5-Cyclooctatriene, Phenol, Isopinocarveol and Hexyl cyclohexane carboxylate) elicited the response from male stem weevil. Further studies were aimed to characterize the behavior of stem weevil to synthetic analogue of metabolites.

2.15 Project Name : Biology and holistic management strategies for emerging pest Tea mosquito Bug (*Helopeltis sp.*) in Cotton.

M. Amutha (PI)

Importance of the study : *Helopeltis* is the emerging pests on cotton. Occurrence and epidemics of *Helopeltis* have been documented on various hosts. But on cotton not yet recorded. Life history and damage potential of an insect may vary in its different host plants. Hence, studies on these parameters have become essential in cotton.

Salient findings :

There are two species of Tea mosquito Bug (TMB) recorded in cotton. Dominant species is *Helopeltis theivora.* Rarely *Helopeltis antonii is* also observed in cotton. Population dynamics was observed and correlated with weather factors. From 42nd standard week onwards TMB incidence observed. Highest population and damage was observed in month of December and January and then declined. Temperature and Relative humidity had negative correlation with TMB incidence. Life cycle of Tea mosquito bug carried out in laboratory condition. TMB consist of five instars and adult stage. The life cycle period were as follows, Egg period- 4.17±0.19, 1st instar- 2.3±0.17, 2nd instar- 2.9±0.23, 3rd instar- 3.1±0.20, 4th instar- 2.1±0.17 and 5th instar- 1.1±0.12 days respectively. Life cycle period of 15.8±1.48 and 21.6±2.30 days observed for male and female respectively. A single 1st instar, 2nd instar, 3rd instar, 4th instar, 5th instar nymph and female and male adult of *H. theivora* could make as many as 63, 80, 71, 59, 51, 96 and 56 feeding punctures in 24 hours respectively. Cotton leaf area damaged by individual per day for 1st instar, 2nd instar, 3rd instar, 4th instar, 5th instar nymph and female and male adult of *H. theivora* were 25, 62, 119, 173, 186, 229, 526 mm^2 respectively. A cumulative feeding spots was recorded as 1659.13 and 2847.53 for male and female respectively (Table 2.15.1). Data on total area damaged by individual/day showed that, among the nymphal stage 5th instar nymph and among the adults female found to be voracious feeder. From field collected TMB cadavers, two fungi were isolated *viz.*, *Aspergillus* sp. and *Fusarium* sp.

Table 2.15.1. Damage potential of different stages of *H. theivora* on cotton

Stage of the Insect	Feeding spot/individual /day (Nos.)	Area of feeding spot (mm^2)	Total leaf area damaged /individual/day (mm^2)	Total feeding spots/stage	Cumulative feeding spot /stage
1st instar	63.4±1.21	0.39±0.04	24.62±1.92	145.22±7.57	145.22
2nd instar	80.8±2.78	0.77±0.03	61.58±2.36	230.72±2.79	375.93
3rd instar	71.8±2.28	1.68±0.05	118.72±2.85	220.40±11.84	596.33
4th instar	59.6±1.56	2.94±0.12	173.39±8.51	123.61±3.78	719.94
5th instar	51.2±1.24	3.64±0.21	185.7±12.39	55.98±2.61	775.93
Male	56.4±1.69	4.10±0.19	228.52±7.31	883.20±41.24	1659.13
Female	96.2±1.68	5.48±0.21	526.36±24.01	2071.60±96.43	2847.53
S.Ed	0.165	0.039	0.392	0.721	
CD	0.342	0.082	0.814	1.497	

Helopeltis theivora

Helopeltis antonii

***Helopeltis theivora* egg**

2.16 Project Name : Molecular characterization, virulence and genetic diversity analysis of *Alternaria* leaf spot disease of cotton

Dr A. Sampathkumar (PI)

Importance of the study : *Alternaria* leaf spot causes 20-30% seed cotton yield loss in India (Chauhan *et al*. 1997, Mayee and Mukewar, 2007). Under favourable environmental conditions it can cause yield losses up to 26.59% (Monga *et al*. 2013) and 38.23% (Bhattiprolu and Prasada Rao, 2009). Two *Alternaria* species *viz. A. macrospora* and *A. alternata* are causing leaf spot and leaf blight symptoms. Species identification and genetic diversity analysis are required for study of dynamic change in the pathogen population distribution and its virulence. ISSR markers are widely used for genetic diversity analysis of Alternaria species. Hyper-variable SSR primers designed from whole genome sequences produce very high allelic variations among closely related isolates also.

Salient findings :

Morphological identification of *Alternaria* isolates

Ninety six *Alternaria* isolates were selected from samples of Karnataka, Telangana, Tamil Nadu, Andhra Pradesh, Maharashtra, Gujarat and Madhya Pradesh. Morphological identification was performed based on beak length of the obclavate conidia. Out of 33 *Alternaria* isolates from Tamil Nadu, 27 found to be *A. macrospora and* 6 as *A. alternata (Fig.2.16.1)* based on conidial characters. Out of 25 isolates from Karnataka, 20 found to be *A. macrospora* and 5 as *A. alternata (Fig.2.16.2).* Out of 22 isolates from Telangana, 19 isolates found to be *A. macrospora* and 3 as *A. alternata (Fig.2.16.3). Isolates from Andhra Prasdesh (9), Maharashtra (4), Gujarat (2) and Madhya Pradesh (1) were found to be A. macrospora based on conidial character.*

Fig.2.16.1. **Microscopic images of Conidia of *Alternaria* isolates (400 x magnification) from Tamil Nadu**

Fig.2.16.2. **Microscopic images of Conidia of *Alternaria* isolates (400 x magnification) from Karnataka**

Fig.2.16.3. **Microscopic images of Conidia of *Alternaria* isolates (400 x magnification) from Telangana**

Molecular identification and genetic diversity of *Alternaria* isolates

Fifteen isolates from Karnataka (KA1 to KA5), Telangana (TG1 to TG5) and Tamil Nadu (TN1 to TN5) were selected for molecular identification and genetic diversity analysis. Alternaria species specific primers for *A. macrospora* (AmF5'-CGG TAC TAC TGT CAT CTT CG-3' and AmR 5'-CTT ACG GTA CCT GAG TTG AC-3') and *A. alternata* (Aa F2 5'-TGC AAT CAG CGT CAG TAA CAA AT-3' and Aa F 35'- ATG GAT GCT AGA CCT TTG CTG AT-3') were used for species identification. Both the primers invariably amplified 442 bp (Fig.2.16.4) and 320 bp (Fig. 2.16.5) amplicon for all the isolates. These primers may not be suitable for identification of Alternaria at species level. ITS primers namely ITS1 and ITS4 amplified 560 bp (Fig. 2.16.6) amplicon for all isolates. Sequencing of ITS region and blasting at NCBI showed that all isolates were belonging to *A. alternata.* Five different clusters were formed among isolates based on ITS sequences. Conidial morphology showed that most of these isolates were belonging to *A. macrospora.* NCBI itself contains very few sequences of *A. macrospora* and flooded with *A. alternata* sequences. Further, amplification and sequence analysis of housekeeping genes such as Alt a1, GAPDH, Plasma membrane ATPase, TEF 1 alpha and Calmodulin will be useful to confirm the isolates at species level as *A. macrospora.*

Figure .*2.16.4.* PCR amplification of *Alternaria* isolates (442 bp) using *A. macrospora* specific primers (AmF and AmR)

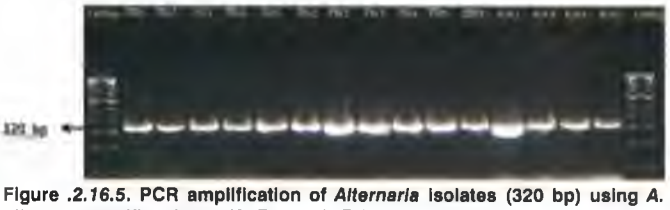


Figure .*2.16.5.* PCR amplification of *Alternaria* isolates (320 bp) using *A. alternata* specific primers (AaF2 and AaF3)

Figure.*2.16.6.* PCR amplification of ITS region of *Alternaria* isolates (560 bp) using ITS1 and ITS4 primers

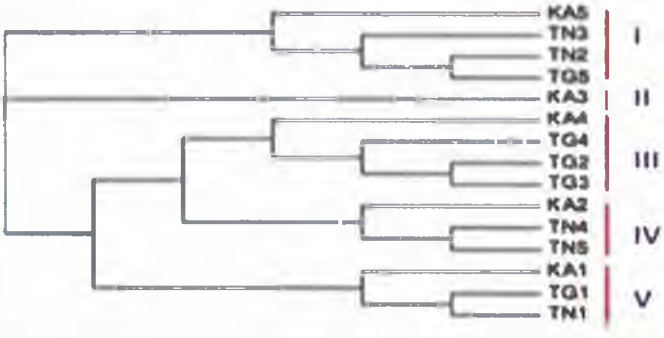


Figure.*2.16.7.* Phylogenetic tree constructed using ITS sequences of *Alternaria* isolates

Thirteen hyper-variable SSR primers (SSR 1 to SSR 13) specific to *A. alternata* were designed based on the whole genome sequences retrieved from NCBI and used for diversity study. Two primers namely SSR 1 and SSR 5 found to be effective in amplification and showing variability among the isolates. SSR1 primer amplified expected 179 bp amplicon for KA1 isolate only. Other isolates showed presence of approximately 150 bp amplicon. SSR5 primer amplified expected 224 bp amplicon for KA2 isolate only. Other isolates showed presence of 200 bp amplicon. Non-specific amplification of these SSR primers showed that most of these *Alternaria* isolates were not belonging to *A. alternata* and it must be belonging to *A. macrospora* only. Based on the literature survey, six ISSR primers namely UBC 807, UBC 809, UBC 834, UBC 835, UBC 842 and UBC 856 were used for genetic diversity study. Six different clusters were formed at 71 percent genetic dissimilarity among the 15 isolates.

2.17 Project Name : Studies on symptom expression, host range, transmission and spread of *Tobacco streak virus* (TSV) infecting Cotton

Dr. P. Valarmathi (PI); Co-PIs: Dr. M. Amutha; Dr. Shailesh P Gawande, Dr. S. K. Sain

Importance of the study : Screening of germplasm to explore resistant source is a basic step towards the solution of this hazardous virus problem. The same can be utilized in the breeding programme for evolving TSV tolerant/resistance varieties of cotton. Evaluation of the susceptible/resistant *G. barbadense* lines to TSV/thrips in separate plot.

Salient findings :

Susceptible lines (94), Resistant lines (14) of *G. barbadense* were sown with control Suvin in augmented design (Fig. 2.17.1, 2.17.2). ICB 84, ICB 85, ICB 86, ICB 87, ICB 90, ICB 91, ICB 122, ICB 124, ICB 125, ICB 127, ICB 153, ICB 161, ICB 162, ICB 163 (14) were resistant lines. ICB 184, ICB 185, ICB 188, ICB 189, ICB 190, ICB 191, ICB 192, 193, ICB 194, ICB 195, ICB 196, ICB 198, ICB 199, ICB 200, ICB 201, ICB 202, ICB 203, ICB 204, ICB 205, ICB 207, ICB 208, ICB 209, ICB 210, ICB 211, ICB 212, ICB 213, ICB 214, ICB 215, ICB 216, ICB 217, ICB 218, ICB 219, ICB 220, ICB 222, ICB 223, ICB 224, ICB 225, ICB 226, ICB 227, ICB 231, ICB 233, ICB 235, ICB 237, ICB 238, ICB 240, ICB 241, ICB 242, ICB 244, ICB 247, ICB 248, ICB 249, ICB 250, ICB 251, ICB 254, ICB 256, ICB 257, ICB 258, ICB 259, ICB 260, ICB 261, ICB 262, ICB 263, ICB 264, ICB 265, ICB 266, ICB 267, ICB 268, ICB 269, ICB 270, ICB 271, ICB 272, ICB 273, ICB 274, ICB 275, ICB 276, ICB 278, ICB 280, ICB 283, ICB 284, ICB 287, ICB 288, ICB 290, ICB 299, ICB 300, ICB 303, ICB 306, ICB 308, ICB 310, ICB 313, ICB 317, ICB 318, ICB 320, ICB 323, ICB 325 (94) were the susceptible lines. One row each of Bhendi (Hybrid CO 4), Blackgram (CO 6) and Chilli (Variety Bullet) were sown. Parameters like mean per cent TSV disease incidence and mean thrips population were observed. Biometric parameters like Plant height, No. of monopodial branches, No. of sympodial branches, No. of bolls/plant and Boll weight were observed both in the susceptible and resistant lines. The symptom expression in *G. barbadense* was very distinct with dark purple necrotic spots and drying of squares. The disease incidence ranges from 11.5 to 27.5 %.in susceptible lines. The disease incidence ranges from 3.2 to 10.0% in resistant lines. The mean thrips population ranges from 1.3 to 11.3 in both susceptible and resistant lines. Significant negative correlation of -0.07 was derived. There is no significant difference in the biometric parameters like plant height, no. of monopodial branches, no. of sympodial branches and boll weight in both susceptible and resistant lines. The parameters such as no. of bolls/plant were found to be more in resistant lines when compared to the susceptible lines. This is due to drying of squares in susceptible lines which in turn reduced the no. of bolls in the plants and hence the yield.

Fig. 2.17.1 Fig. 2.17.2

Evaluation of the susceptible /resistant *G. barbadense* lines (94 lines)

2.18 Project Name : Studies on plant parasitic nematodes of cotton

Dr. J. Gulsar Banu (PI); Co-PI : Dr. Nandini Gokte-Narkhedkar

Importance of the study : This study aims to identify and develop a formulation of native nematode antagonistic fungal based formulation for the eco friendly management of plant parasitic nematodes in Cotton.

Salient findings :

Morphological and molecular characterization of *Pochonia chlamydosporia (Goddard) Gams and Zare, isolated from the Reniform nematode, Rotylenchulus reniformis, was carried out and submitted to GenBank (Accession No. OK179069.1)*. This isolate was able to colonise the eggs of root-knot nematodes, *Meloidogyne incognita*, *Meloidogyne enterolobii*, reniform nematode, *Rotylenchulus reniformis,* and cyst nematode, *Heterodera cajani,* under *in vitro* conditions. When biomass production was studied, malt extract broth supported maximum biomass production and sporulation, which was followed by Sabouraud Dextrose Broth with Yeast Extract. A liquid-based formulation of *P. chlamydosporia* was developed and tested for shelf life and virulence. The liquid formulation was able to support the survival of spores for up to 540 days without any loss in virulence. Three substrates (Farm Yard Manure, Neem Cake, and Vermicompost) were tested for the survival of *P. chlamydosporia* under field conditions. All these three substrates at 1:1, 1:2, and 1:5 ratio could not support the multiplication of *P. chlamydosporia* under *in vitro* conditions, but when used at the field recommended dose, the survival of fungal propogule was recorded for up to six months under field conditions. Among different solid substrates tested, maize grains supported the maximum production of 13.67 x 10^8 spores/g of the substrate, followed by pearl millet grains. This isolate could not be multiplied on oil cakes. Molecular characterization of a native nematode antagonistic fungus, *Purpureocillium lilacinum,* isolated from the cotton rhizosphere was carried out and submitted to GenBank (Accession No. OK189590.1).

3.1 Project Name : Alleviating soil compaction – a production constraint in cotton

Dr. Blaise (PI), Co-PIs: Er. G Majumdar, Dr A. Manikandan, Dr S. Santosh

Importance of the study : Soil compaction is a process of compression of soil particles into a smaller fraction, reducing pore spaces leading to an increase in bulk density. This is coupled with a decline in soil hydraulic conductivity, deteriorating soil health and consequently a decrease in crop yield. Thus, it was hypothesized that the root growth probably gets affected due to the hard pan developed by traffic or natural causes. Therefore, alleviating soil compaction either by mechanical or biological means could improve crop growth and yield.

Salient findings :

Deep sub-soiling vs. shallow sub-soiling was evaluated along with deep rooted crops grown in rotation such as pigeon pea, radish, sesbania, sunnhemp. A control treatment without sub-soiling and a legume fixer with shallow rooting (soybean) were also included in the study. At the end of the fifth year of study, the sub-soiling treatment effects were clearly visible. The magnitude of yield increase over the control was the greatest with the deep sub-soiled (+676 kg/ha) followed by the shallow sub-soiling (+148 kg/ha). Shallow sub-soiling every row and in alternate rows did not differ. Comparing the rotation treatments, rotation with sesbania produced the maximum yield (2788 kg/ha) followed by sunnhemp (2488 kg/ha), soybean (2379 kg/ha) and pigeonpea (2240 kg/ha) while the non-rotated plots without any sub-soiling had the least seed cotton yield (1774 kg/ha).

Physical properties that were assessed during the crop season indicated that the sub-soiled and the rotation plots had the least penetration resistance and greater infiltration rate. Resistance was the greatest during the November sampling and was inversely correlated with the soil moisture. Soil biological properties were also assessed during the season. The enzyme activitiesas well as the soil microbial biomass carbon (SMBC) were greater in the rotation plots than the sub-soiled or the control. Data for the SMBC is provided in the figure 3.1.1.

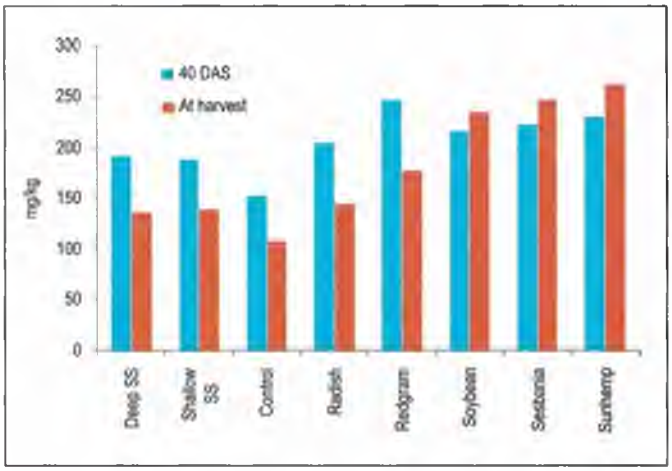


Figure 3.1.1 Soil microbial biomass C as affected by sub-soiling and crop rotation treatments

3.2 Project Name : Investigation on the effect of skips and multiples on the productivity of machine planted cotton

Dr MV Venugopalan (PI); Co-PIs: Er. G Majumdar, Dr Ramkrushna GI, Dr R Raja

Importance of the study : Picking, weeding and sowing are the main labour-intensive field operations in cotton cultivation. Precision pneumatic planters are now available to plant a single cotton seed at desired spacing thereby, reducing the expense on seeds and labour for planting. The project aims to evaluate the precision planters for better plant stand and uniformity and also to evaluate the productivity of cotton under different simulated regimes of skips and multiples in order to identify the extent to which cotton can compensate for skips and multiples in machine planted cotton

Salient findings :

Performance of Gaspardo pneumatic planter was evaluated at 3 within row spacing (150, 200 and 300 mm) on Vertisol at ICAR-CICR farm, Nagpur. The results indicated that, doubles and multiples were negligible. The Miss Index ranged from 13.9 to 21.4% and quality of Feed Index ranged from 76.9 to 86.1%. The precision in spacing decreased at closer spacing. It ranged from 10.6 at 300 mm spacing to 24.1 mm at 150 mm spacing.

Performance of New Holland Pneumatic Precision Planter was evaluated at 167 mm within row spacing on clay loam soil at ICAR-CICR, Regional Station farm, Coimbatore. The values for Miss Index, Multiple Index, Quality of Feed Index and Precision of Spacing were 34.1, 5.1, 60.8 and 16.3, respectively.

Field experiment using BG II hybrid with 12 treatments was laid out in on rainfed vertisol with 90x 30 cm spacing at ICAR-CICR, Nagpur. Treatments comprised of 5, 10, 15, 20 and 25% skips (S) and 5, 10, 15, 20 and 25 percent skips in combination with 10% doubles (D),along with two checks viz. all single and all double plants. Preliminary results indicated that skips up to 15% was compensated without significant yield penalty when 10% doubles were present (Figure 3.2.1). Significant yield reduction was observed at 20 and 25% skips without doubles. Provision of 10% doubles could only partially compensate the loss in yield when the skips were 20 or 25%.

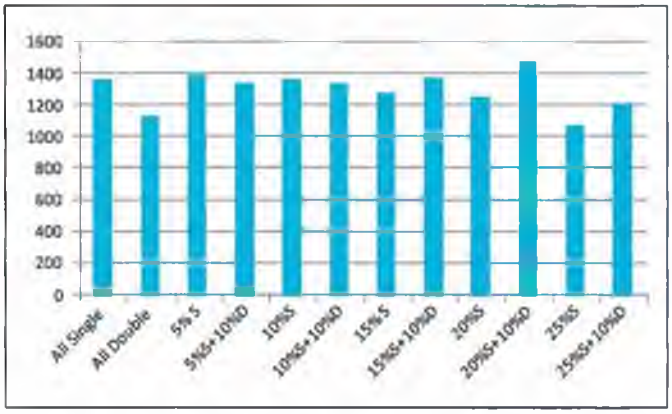


Figure 3.2.1: Seed cotton yield of Bt Hybrid under various proportions of skips (S) and doubles (D)

Field view of cotton seedlings sown using Gaspardo pneumatic precision planter

3.3 Project Name : Evaluation and refinement of spindle type header prototype and development of a cotton picker

Er. Gautam Majumdar (PI); Co-PIs: Dr Ramkrushna G.I., Dr Jayant Meshram, Dr Blaise Desouza, Dr R. Raja, Dr Amarpreet Singh

Importance of the study : Limitations of the commercial cotton pickers are their huge size and power requirement catering to very large farms. The cost of operation is high because of the large initial cost of these imported cotton pickers. Use of such sophisticated equipment also needs trained manpower coupled with repair and maintenance facilities at village level, especially in case of available cotton harvesting systems. Often, spares are not available within reach. Under these situations it is necessary that suitable pickers be developed to cater to the small holder cotton farms in India.

Salient findings :

Design details of conveying, suction, storage systems and spindle, doffer manufacturing worked out and 3-D models have been made for a tractor mounted spindle type picker. Kinematic analysis of picker head was done. New conceptual design was finalised with space reduction from 1525×600 to 900×900 mm in order to accommodate the prototype into 90 cm row to row spacing. The PGR based chemical defoliant formulated in the institute to facilitate mechanical harvesting was evaluated. Its application to cotton leaves at the time of 60-70% boll opening resulted in more than 90% leaf defoliation without any adverse effect on the fibre quality parameters.

3.4 Project Name : Quantitative estimation of carbon and moisture fluxes over the cotton based agro-ecosystem : Integrating ground observations, satellite data and modeling

Abhishek Chakraborty NRSC, ISRO (PI); Co-PIs: CCPI -MV Venugopalan, A Manikandan

Eddy-covariance (EC) based estimation of carbon exchanges is ideally suited for addressing the magnitude and variability of the terrestrial carbon sink and moisture fluxes over terrestrial ecosystems. The project aimed to assess the seasonal and diurnal dynamics of CO_2, H_2O fluxes over rainfed cotton crop grown central India using EC system.

Salient findings :

EC flux tower with a suite of meteorological sensors was established at the experimental farm of ICAR-CICR, Nagpur. Both, CO_2 and moisture fluxes, between the terrestrial rainfed cotton ecosystem in the Black Soil Region and the atmosphere were measured throughout the cotton season. Crop biometric parameters and yield were also measured in the catchment area of the EC flux tower.

In the catchment area, peak LAI value for cotton was 3.3±0.25 and this occurred at 130-135 days after sowing (DAS). The height of the crop was found to increase till 135-140 DAS and the maximum height at this stage was 144±12.8 cm. The maximum above ground dry biomass was 6097±1766 kg ha^{-1} at 145 DAS. The mean seed cotton yield was 1613±661 kg ha^{-1}.

Cotton crop behaved as net carbon source during night time due to respiration. Whereas, it acted as a net carbon sink during day time as photosynthesis rate was more than respiration rate.

The rainfed cotton crop was found to be a strong net CO_2 sink. The cumulative, seasonal values for Net Ecosystem CO_2 Exchange, Gross Primary Productivity, Ecosystem respiration and evapotranspiration were -391.8 gC m^{-2}, 1063.9 gC m^{-2}, 672.0 gC m^{-2} and 545.3mm respectively. The data at different phenophases are depicted in figure 3.4.1

The ratio of cumulative (season long) ecosystem respiration to gross primary productivity was 63%.

During the crop season 2020-21 around 3.92 t/ha carbon was sequestered in the rainfed cotton ecosystem.

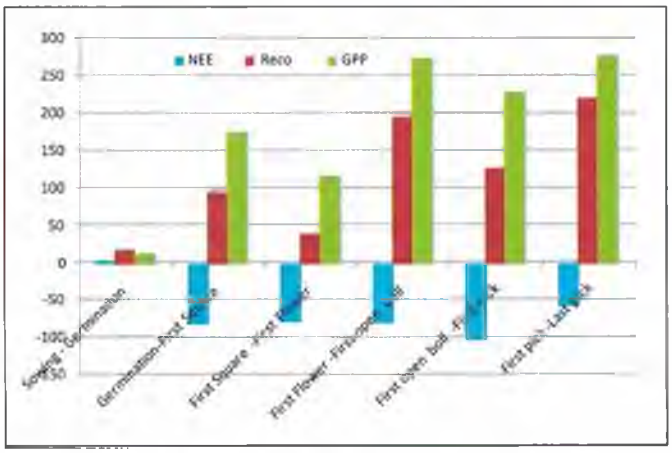


Figure 3.4.1 Net Ecosystem CO_2 Exchange (NEE), Gross Primary Production (GPP), Ecosystem Respiration (R_{eco}) in (g C m^{-2})during different phenophases of cotton crop during 2020-21 season

3.5 Project Name : Crop – weed interactions under ambient and elevated CO_2

Dr. P. Nalayini (PI); Co-PIs: Dr. A.H. Prakash and Dr. M. Amutha

CO_2 in atmosphere is currently around 419 ppm and is expected to reach 550 ppm in the next 30 to 80 years and such changes will alter the dominance weed species, crop weed interaction and herbicidal efficacy. Prediction of future damage by weeds due to climate change is very important for sustainable weed management. Experiment conducted at regional station, Coimbatore, to study the crop weed interactions due to elevated CO_2, revealed changes in relative density among weed species, DMP accumulation by weeds and crop, physiological and biochemical changes under elevated CO_2

At 60 DAS, the relative density of broad leaved weeds was 87 % in ambient and reduced to 73 % under elevated CO_2 while, the grass weed was just 12 % in ambient and enhanced to 27 % due to elevated CO2 and among weed species, the RD of *Trianthema portulacastrun* was 59.7 per cent in ambient and reduced to 39.9 % under elevated CO_2. However, the RD of *Digera arvensis* was just 3.09 % in ambient and enhanced to 20.77 % due to elevated CO_2. At 90 DAS, the RD of broad leaved weeds reduced from 90 % at ambient to 40.5 % under elevated CO_2 while the RD of grass weed enhanced from 5 % at ambient to 58.9 % due to elevated CO_2 clearly indicating the dominance of grass weeds due to elevated CO_2. The same trend of reduction in RD of broad leaved weeds and enhancement in RD of grass weeds was observed at 120 DAS, where the RD of broad leaved weeds reduced from 83.6 % in ambient to 57.6 % under elevated CO_2. While the RD of grass weed enhanced from 10.9 % in ambient to 41.5 % due to elevated CO_2 (Table. 3.5.1).

The SEM images has shown the reduction in stomatal density, trichome density and partial closure of stomata due to elevated CO_2 indicating the possibility of higher water use efficiency (associated with lesser stomatal density and partial closure) and higher pests problems associated with lesser trichome density with enhanced soluble sugars due to elevated CO_2 The soluble sugars (μg/gm) in cotton were enhanced from 54.1 in ambient to 113.9 under elevated CO_2. The enhanced photosynthetic efficiency of 18.3 to 19.6 μmol m^{-2} sec^{-1} was recorded due to elevated CO_2. The healthy plants due to elevated CO_2 recorded higher root CEC of 28.86 (m.eq/100 g roots) as against 26.1 under ambient conditions. The crop Growth rate (CGR) between 75 - 90 DAS was enhanced from 10.82 g per m^2 in ambient to 12.78 under elevated CO_2, while the CGR during 90-120 DAS enhanced from 3.01 g per m^2 in ambient to 5.39 g per m^2 under elevated CO_2 and thus the overall yield enhancement in cotton due to elevated CO_2 was 21 % (Table. 3.5.2). Among the sucking pests viz., aphids, jassids, thrips and whitefly, population of aphids and jassids were significantly high in elevated CO_2 treated plants compared to plants in ambient CO_2.

Table 3.5.1. Relative density of major weed groups as influenced by elevated CO_2

Weeds group	Ambient			Elevated CO_2 (480 ppm)		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Broad leaved weeds	86.84	90.01	83.62	72.67	40.46	57.64
Sedge weed	1.26	4.99	5.40	-	0.57	0.86
Grass weeds	11.58	5.00	10.98	27.35	58.97	41.50

Table 3.5.2. Yield attributes and seed cotton yield as influenced by elevated CO_2

Treatments	Bolls/plant	Boll weight (g/boll)	Seed cotton yield (kg/ha)
Elevated CO_2 (IWM)OTC	28.0	4.49	2610
Elevated CO_2 (un weeded)OTC	13.8	3.70	1091
Ambient (IWM)OTC	23.8	3.82	2155
Ambient (un weeded)OTC	10.3	3.79	889
Weed free open field	25.8	4.38	2358
SEd	1.378	0.253	152.3
CD (P=0.05)	3.00 **	0.553 *	331.6 **

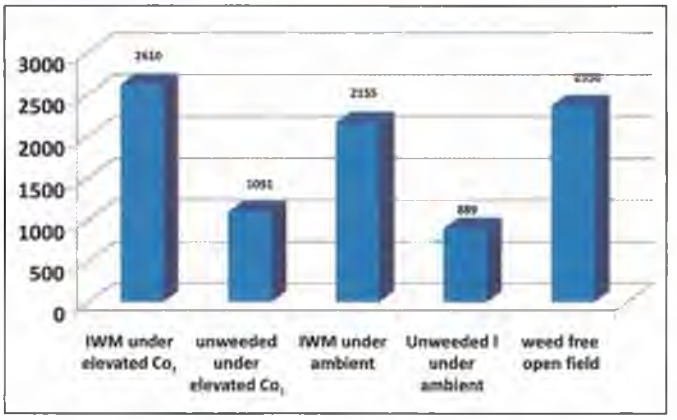


Fig.3.5.1. Seed Cotton Yield (Kg/ha) as influenced by elevated CO_2 and weed control treatments

3.6 Project Name : Evaluating of agro techniques for overcoming weather aberrations of drought and water logging in cotton

Dr. K. Sankaranarayanan (PI); Co-PI: Dr J. Annie Sheeba, Dr M. Amutha, Dr P. Valarmathi, Dr J.H. Meshram, Dr B. Bhargavi

Importance of the study : Cotton is a forced annual crop and is susceptible to climate changes. The expected erratic distribution of rainfall leads to frequent wet and dry spell. Continuous dry/wet or both spells during critical crop growth periods of squaring, flowering and boll development may affect the yield of the crop. Water logging coupled with drought leads to poor performance of crop. The contingent measures identified from this project could be useful for managing low and excess moisture stress.

Salient findings :

Drainage practice by adopting ridges and furrows followed by foliar application of salicylic acid @ 0.5 mM (single spray three days after water logging) had significantly lowered the incidence of *Alternaria* and improved the uptake of total nitrogen (1.4%) , total calcium (2.5 %), total Fe (201.6 mg/kg) and total Mn (96.0 mg/kg). In Nagpur, pot culture experiment on water logging revealed that foliar spray of melatonin @ (100 μM), kinetin (50 ppm) and urea (1%) had improved physiological parameters such as leaf area and chlorophyll contents. Water logging resulted in decreased concentration of nitrate reductase activity across treatments as compared to

control. But effect of melatonin @ 100 μM, Fe_2SO_4 (0.5%) and urea 1 % treatments stabilized the nitrate reductase activity. Sucking pest population of aphids, jassids, thrips, whitefly recorded one week after first and second spray were not significantly influenced by drought management treatments viz., PPFM @ 1%, glycine betaine 100 ppm, KNO_3 at 2%, salicylic acid @ 100 ppm and urea @ 1% as compared to control. Incidence of *Alternaria* was noticed and graded in water logged plot, which was significantly lower with salicylic acid @ 0.5mM single spray three days after water logging.

Fig. 3.6.1.Field experiment on water logging

3.7 Project Name : Effect of long term application of organic and inorganic sources of nutrients on continuous cultivation of Bt and non Bt cotton cropping system under irrigated conditions

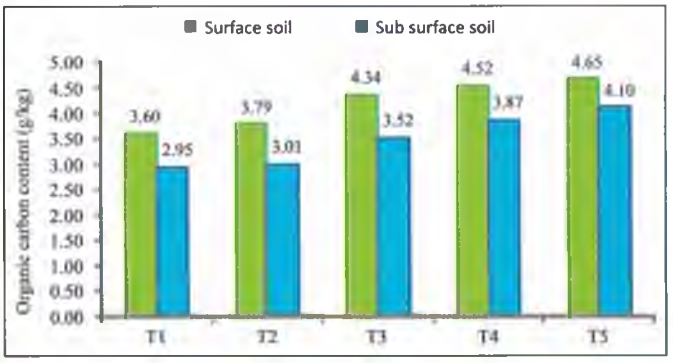
Dr. D. Kanjana (PI); Co- PI: Dr.K. Sankaranarayanan, Dr. Amarpreet Singh

Importance of the study : Long term fertilizer experiment under continuous cotton – maize cropping system is an essential study to realize the importance of integrated sources of nutrients other than sole application of chemical fertilizers or application of nutrients only through organics on sustaining the soil nutrient availability and building up of soil organic carbon in both surface and subsurface soil.

Salient findings :

After two years continuous adoption of cotton-maize cropping system, available nutrients like N, P and K in surface (0-30 cm) and sub surface (30-60 cm) soils significantly differed due to continuous application of different sources of nutrients however it was not significantly different among the cropping systems. The highest value of available nitrogen (185 and 183 kg/ha), available phosphorus (21 and 21 kg/ha) and available potassium (773 and 785 kg/ ha) in surface soil (0-30 cm) was noticed in application of combined sources of nutrients and organic sources of nutrients respectively whereas the lowest value of major available nutrients (150 kg N ha^{-1}, 15 kg P ha^{-1} and 720 kg K ha^{-1}) was registered in absolute control treatment which might be due to continuous omission of nutrients. In sub surface soil, available nitrogen (158 and 154 kg/ha) and available phosphorus (22 and 22 kg/ha) content were improved by organic sources of nutrients and integrated sources of nutrients than sole application of inorganic fertilizers (151 kg N ha^{-1} and 18 kg P ha^{-1}).

Two years average of organic carbon content was increased by 29.2 and 22.7 in surface and 39.0 and 36.2 per cent in subsurface due to application of nutrients through organics over no fertilizer and 100 % NPK, respectively (Fig.3.7.1). Similarly, application of integrated source of nutrients NPK + Mg + Zn + B + FYM (5 t/ha) once in two years and balanced form of inorganic nutrients (NPK + Mg +Zn + B) increased the average value of organic carbon content by 19.3 and 14.5 percent in surface soil and 28.6 and 16.9 per cent in sub surface soil, respectively over 100% NPK i.e., imbalanced use of fertilizer.



T1 - Control T2 - NPK (100 %) T3 - NPK + MgSO4 + ZnSO4 + Borax
T4 - NPK + MgSO4 + ZnSO4 + Borax + FYM (once in two years)
T5 - FYM (every year) + Azophos + Neem cake + Sunhemp incorporation

Fig.3.7.1. Organic carbon content (g/kg) in surface (0-30 cm) and subsurface (30-60 cm) soil under cotton-maize cropping system (average of two years)

Fig. 3.7.2. Visual difference of maize crop (second rotation of cotton-maize cropping system) in integrated nutrient management (T_4) and organic sources of nutrient (T_5) plots

3.8 Project Name : Exploiting the epigenetic transgenerational inheritance of stress responsive traits for imparting abiotic stress tolerance to cotton

Dr J. Annie Sheeba (PI)

Importance of the study : An experiment was conducted to demonstrate the epigenetic transgenerational inheritance of abiotic stress tolerant traits in cotton. Epigenetic inheritance is important for the understanding of phenotypic variations in nature. Variations in methylation are of immense value in breeding for stress tolerance.

Salient findings :

The epigenetic regulating chemicals (ERCs) treated plants of Suraj and LRA 5166 were subjected to drought stress in the fourth generation and screened for drought tolerance. Screening is being done based on physiological and

biochemical parameters such as relative water content, total soluble sugars, peroxidase activity, chlorophyll contents and other morphological characters. ERCs like Sulfamethazine 10 μM (68.3 %) and 5 Azacytidine 10μM (63.9 %) improved the relative water content over control in Suraj and 5 Azacytidine 40 μM recorded higher RWC in LRA 5166 (59.3 %) (Fig. 3.8.1). Higher total soluble sugars (TSS) content was recorded by 5 Azacytidine 40 μM (53.4 mg/g FW) treated plants in case of Suraj and in LRA 5166 higher TSS were recorded by Epigallocatechin gallate 100 μM (47.1 mg/g) (Fig. 3.8.2). Higher peroxidase activity was recorded by Epigallocatechin gallate 100 μM (5.7 430 nm/min/g of sample) treated plants in case of Suraj and plants treated with Sulfamethazine 10 μM and Epigallocatechin gallate 100 μM (5.3 430 nm/min/g of sample) exhibited higher peroxidase activity in LRA 5166. The chlorophyll contents are not significantly affected by ERCs.

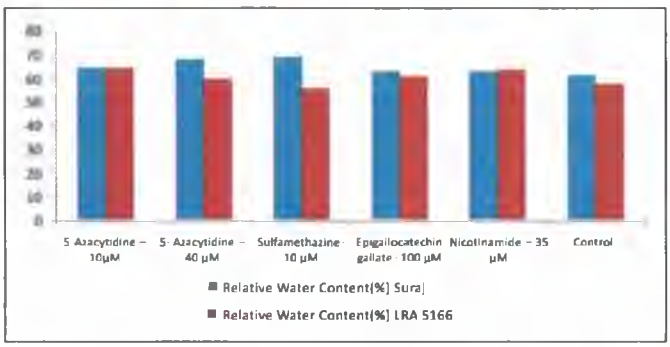


Fig 3.8.1. Effect of ERCs on Relative Water Content (%) in Suraj and LRA 5166 varieties of Cotton in fourth generation

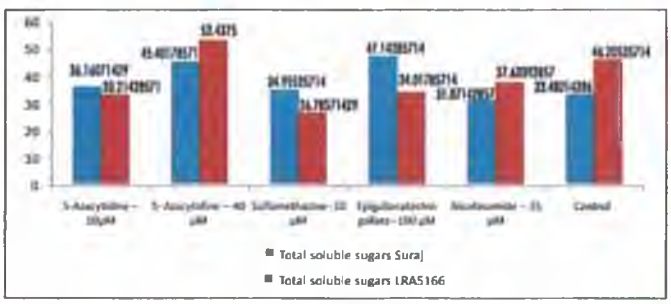


Fig 3.8.2. Effect of ERCs on Total Soluble Sugars (mg/g FW) in Suraj and LRA 5166 varieties of Cotton in fourth generation

3.9 Project Name: Development of Cotton based cropping systems under Conservation Agriculture for North- Western Indian conditions

Dr. Amarpreet Singh (PI)

Importance of the study : Cotton based cropping systems in the northwestern India are accompanied by intensive, yearly soil tillage leading to soil quality degradation and reduction in productivity. The need for conservation agriculture practices has become necessary for long-term resource conservation and for improvement of soil health. A trial with fixed lay out plan were being conducted under split plot design with six tillage and land configuration treatments (as main plots) and seven cropping systems (as sub plots).

Salient findings :

Seed cotton yield was significantly higher under Zero tillage - permanent narrow raised bed (2,595.3 kg/ha) with residue retention [over Conventional Tillage - Flat Bed (no residue incorporation), Conventional Tillage - Flat Bed (with residue incorporation), Zero Tillage - Flat Bed (no residue retention on surface) and Zero tillage - permanent narrow raised bed (37.5 cm bed top) no residue retention on surface] and in Cotton - Chickpea (Bengal gram) cropping system (2,790.0 kg/ha) [over Cotton - Wheat, Cotton - Mustard (Raya), Cotton - Barley, Cotton - Winter Maize (Spring Maize), Cotton - Sunflower and Cotton - Berseem (Fodder) cropping systems].

The total system productivity was higher under Cotton - Berseem (Fodder) cropping system (6,193.1 kg/ha cotton equivalent yield) and second best total system productivity was under Cotton - Wheat cropping system (4,381.2 kg/ha cotton equivalent yield).

With respect to Rabi crops (harvested in 2020) grain yield of wheat, barley, mustard, chickpea, sunflower and spring / winter maize was significantly higher under Zero tillage - permanent narrow raised bed with residue retention (5,322.7; 3,152.3; 1,641.0; 1,655.0; 2,223.6; 6,273.7 kg/ha, respectively) over Conventional Tillage - Flat Bed without residue incorporation (4,483.7; 2,413.3; 1,477.0; 1,282.7; 1,751.3; 4,674.0 kg/ha, respectively) but was at par with Zero Tillage - Flat Bed with residue retention (4,992.0; 2,988.3; 1,135.3; 1,457.6; 1,993.0; 5,925.3 kg/ha, respectively). Highest berseem (green fodder) yield was obtained under Conventional Tillage - Flat Bed with residue incorporation (107,790.3 kg/ha) and it was significantly higher over Conventional Tillage - Flat Bed without residue incorporation (83,403.3 kg/ha).

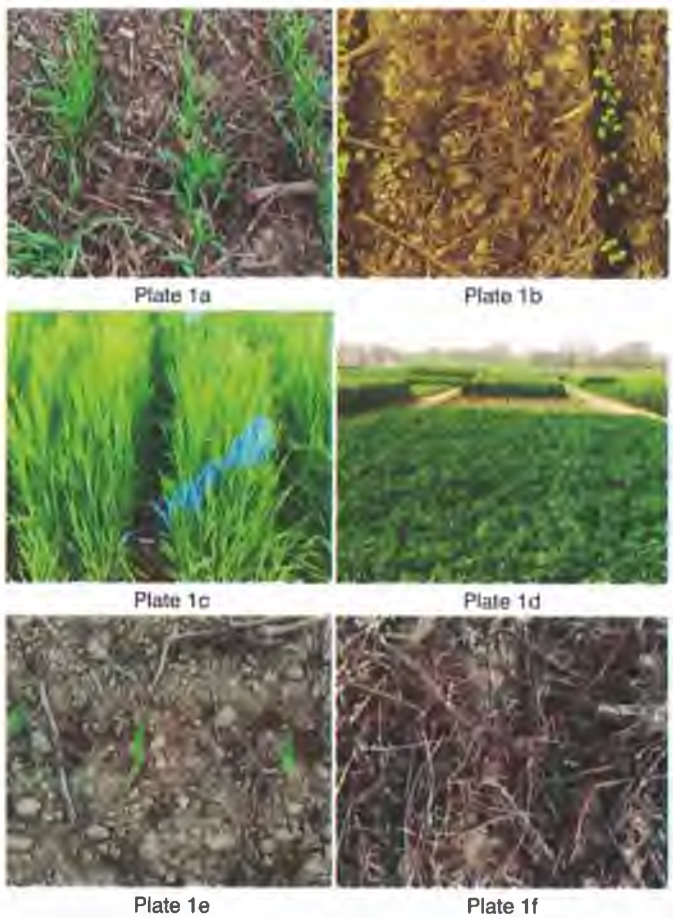


Fig.3.9.1: Plates 1a: Wheat in Zero Tillage - Flat Bed with residue retention; 1b: Mustard in Zero Tillage - Flat Bed with residue retention; 1c: Barley in Zero tillage - permanent narrow raised bed

with residue retention at ear emergence stage; 1d: Field view of Cotton based cropping systems during the Rabi season (Berseem fodder in foreground); 1e: Winter / spring maize in Conventional Tillage - Flat Bed with residue incorporation; 1f: Berseem fodder seedlings emerging in Zero Tillage - Flat Bed with residue retention; under Conservation Agriculture Experiment

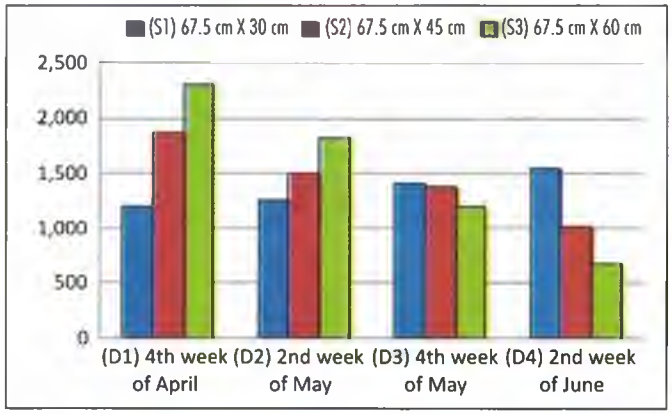
3.10 Project Name : Enhancement in productivity of cotton through improvement in agrotechniques under North-Western Indian conditions

Dr Amarpreet Singh (PI)

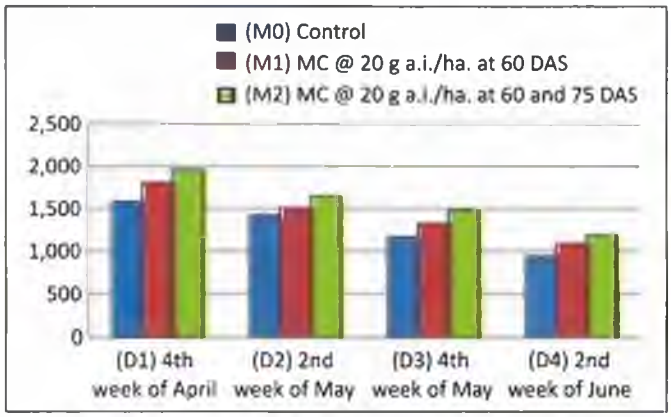
Importance of the study : Enhancement in cotton productivity through improvement in agrotechniques such as sowing time, spacing and use of growth regulators under North-Western Indian conditions are of immediate need. Therefore, under this project three separate experiments were conducted with (a). Bt cotton variety (b) non-Bt cotton variety and (c) Bt cotton hybrid under split-split plot design by keeping four dates of sowing as main plots, three plant spacings as sub-plots and three levels of mepiquat chloride application as sub-sub plots.

Salient findings :

Under North-Western Indian conditions early sowing (in 4th week of April) of Bt cotton variety, non-Bt cotton variety as well as Bt cotton hybrid gave significantly higher seed cotton yield (1,528.5; 1,469.9; and 1,787.3 kg/ha, respectively). When sowing was delayed till second week of June, closer spacing gave higher yield than wider spacing. Application of Mepiquat chloride @ 20 g ai / ha at 60 and 75 DAS significantly improved the seed cotton yield over no Mepiquat chloride application (Fig. 3.10.1a&b).



Figures 3.10.1a: Effect of dates of sowing and plant spacing on seed cotton yield of Bt cotton hybrid;



3.10.1b: Effect of dates of sowing and mepiquat chloride application on seed cotton yield of Bt cotton hybrid

3.11 Project Name : Efficient nitrogen fixing legumes for cotton cropping systems

Dr. A. Manikandan (PI); Co-PIs- Dr. D. Blaise, Dr. P. Nalayini, Dr. V. S. Nagrare

Importance of the study : Though, profitability of rainfed sole cotton is low, intercropping cotton with legumes ensures additional income. Nitrogen (N)fixing capacity of these legumes supplements 20- 30 kg of Nha^{-1} and also reduces the sucking pests and bollworm infestation in cotton. Although cotton + legume intercropping systems improve land use efficiency, their system productivity is poorly understood with high density and row cropping patterns. Thus, the shortlisted legumes were tested with alternate row of cotton.

Salient findings :

The shortlisted legumes when intercropped with cotton had a complementary effect. This in turn influenced the cotton equivalent yield (CEY) significantly when intercropped with *G. hirsutum* var Suraj and *G. arboreum* var Phule Dhanwantary, compared to the sole cotton. Among the six legumes tested, intercropping Suraj with greengram had maximum CEY (up to 27%) as well as gross monetary return (GMR), net monetary return (NMR) and B:C ratio than other legume intercrops. Similarly, intercropping of Phule dhanwantary with soybean produced maximum CEY (up to 31%) compared to other legume intercrops with additional benefits of GMR, NMR and B:C ratio.

Cotton + green gram intercropping

Cotton+soybean intercropping

3.12 Project Name : Metabolite Exploration of Drought stress in Cotton

Pooja Verma (PI); Co-PIs: Ramkrushna G I (Co-PI)

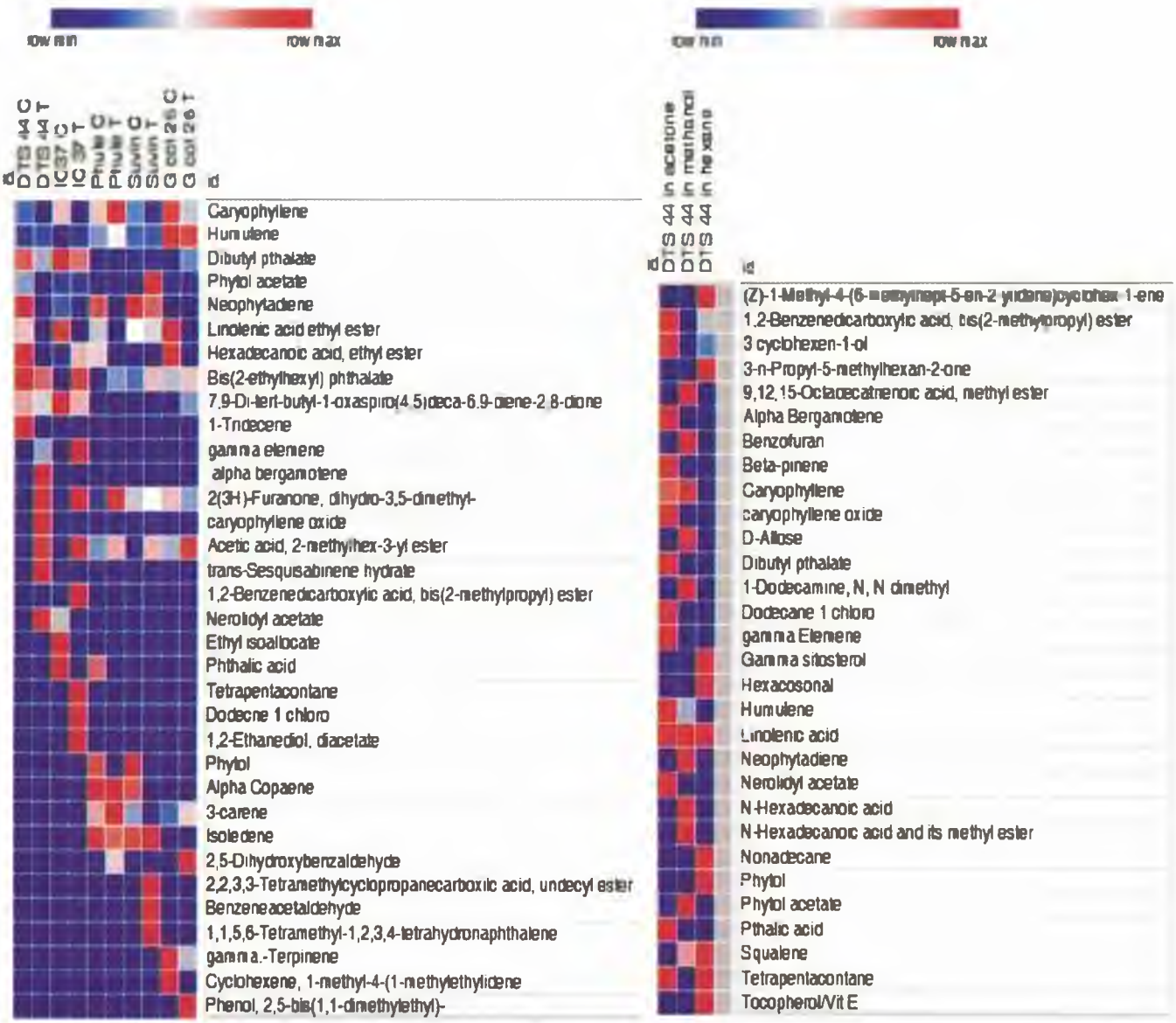
Importance of the study: Alarm photosynthesis, a newly discovered pathway was explored and validated in cotton. It enriches our knowledge and understanding of the additional mechanisms undergoing in cotton plants, which help cotton to sustain under drought stress. Also, how calcium oxalate crystals can be functionally utilized in calcium oxalate-carbon cycling in cotton for stress tolerance. On the other hand, metabolic changes under the drought stress condition in cotton will improve our understanding of the mechanisms to support the above as well as to identify new metabolic indicator(s) for drought in cotton.

Salient findings :

A study on existence of "Alarm Photosynthesis" metabolic pathway was first time performed and validated in cotton along with characterizing the effect of drought stress on metabolites at different stages of growth in cotton.

Standardization of GC-MS method for qualitative and quantitative estimation of cotton metabolites was completed. Single solvent extraction followed by combination of solvents was found the most suitable method to extract the maximum number of metabolites. More than 50 metabolites could be identified with major abundance of caryophyllene, humulene, pinene, carene, γ terpinene, copaene, humulene and fatty acids with their methyl esters (Figure 3.12.1). Mid polar column followed by non-polar column was found the best to identify cotton metabolites.

Additionally, identified 50 GLP (Germin Like Proteins) isoforms were characterized for differential expression through qRT-PCR under drought in cotton (Phule Dhanwantary, leaf tissue). Among 50, nine GLP isoforms were found to show more than four-fold expression under drought.



a. Differential Expression under drought

b. Under Different Solvents

Figure 3.12.1 Heat maps representing differential expression of metabolites with respect to drought stress (a) and solvents (b) in different cotton genotypes

Theme 4 : Genetic improvement and development of production and protection technologies tor desi, organic, ELS and naturally coloured cotton

4.1 Project Name : Breeding to improve performance of *Gossypium herbaceum* for adaptation to climate change in central India

Dr. D. V. Patil (PI)

Importance of the study : Cotton productivity in Central zone is very low due to abiotic and biotic stresses and climate change. *Gossypium herbaceum* can grow under adverse conditions and low fertility soils. The project aims to identify suitable early maturity genotypes to fit in the double cropping systems.

Salient findings :

Evaluation of advanced generation populations of *G. herbaceum*:

Advanced generation of 10 inter- as well as intra-*herbaceum* selections (Heb -11, Heb - 22, Heb - 33, Heb - 44, Heb - 55, Heb - 66, Heb -77, Heb - 88, Heb - 99 and Heb - 00) were supplied to the Regional Cotton Research Station (RCRS), Viramgam, Gujarat for the evaluation along with standard checks (GDAC-3 and GDAC- 4). The station trial with 3 replications was conducted at RCRS, Viramgam and also at ICAR – CICR, Nagpur.

4.2 Project Name : Development of high yielding, early maturing Asiatic cotton *(G. arboreum)* genotypes suitable to south and central zone

Dr. Saravanan, M (PI); Co-PI's: Dr. V.N. Waghmare, Dr. A. Manivannan

Importance of the study: Due to robustness and adaptive features, *desi* cotton can withstand abiotic (drought, heat, salinity, sodicity) and biotic (sap sucking pests and diseases particularly vector borne Cotton Leaf Curl Virus Disease) stresses. They are suitable to combat climate change effects in the cotton ecosystem. The project envisaged to develop high yielding and superior fibre quality traits in *G. arboreum* genotypes.

Salient findings :

A total of 330 promising single plant selections from the segregating populations were selected for yield and fibre quality traits. Data on some of the superior single plant selections is given in the table (Table 4.2.1) those shall be further evaluated.

Table 4.2.1. Single plant selections of *desi* cotton identified for better yield traits

Selections	Plant Height (cm)	No. of Monopodia	No. of Sympodia	Boll weight (g)	Seed Index (g)	GOT %	Yield/ Plant (g)
SPS-20-4	96	3	15	1.6	4.90	39.49	46.41
SPS-20-9	115	4	15	1.85	6.68	33.03	47.62
SPS-20-11	126	7	16	2.28	6.55	31.23	50.74
SPS-20-13	78	4	10	1.67	6.32	29.07	53.52
SPS-20-14	126	4	20	2.36	6.98	28.27	65.86
SPS-20-15	192	6	24	1.56	6.56	35.15	64.03
SPS-20-27	106	7	16	2.8	5.27	36.03	49.51
SPS-20-31	188	2	28	2.16	5.95	34.37	62.02
SPS-20-38	210	2	28	2.09	7.23	35.86	63.68
SPS-20-39	138	3	12	2.15	5.78	29.7	79.69
SPS-20-43	90	7	16	1.74	5.62	34.71	59.57
SPS-20-67	154	4	24	2.68	6.54	36.64	53.18
SPS-20-102	86	0	14	2.27	6.15	28.74	75.6
SPS-20-130	90	4	20	2.51	6.32	29.7	56.45
SPS-20-141	60	0	10	2.53	5.61	33.27	58.42
SPS-20-154	100	1	16	1.95	5.84	35.00	59.91
SPS-20-162	83	0	13	2.25	6.18	38.55	57.94
SPS-20-163	150	4	22	2.08	5.40	38.35	59.32
SPS-20-231	168	1	24	1.64	5.38	34.28	60.78

Evaluation of entries of ICAR-CICR in ICAR-AICRP on Cotton during 2021-22

The list of non-Bt entries sponsored during 2021-22

Trial	Entry
IET of *G. hirsutum* Colour cotton trial Br 02 (a/b) CC	CCH 20449, CCH 20452, CNH 21198
IET of *G. arboreum* Br 22 (a/b)	CISA 7, CISA 33-7, CNA1076, CNA1077, CNA1080, CNA1081
Br 25 (a) PHT *G. arboreum*	CISAA 20-1, CISAA 20-2

The list of entries (non-Bt) sponsored in Institute Common Trial during 2021-22

Trial	Entry
Institute Common Trial of *G. hirsutum*	CNH 1140, CNH 1147, CNH 1149, 201-611, 201-767, 201-772, 201-778, 201-814, 201-856, 201-936, 201-948, 201-1005, CNH 2121, 2921, CNH 3176, CNH 1810, CNH 2010, CNH 2010 -9, CNH 2310, CNH 2410, CNH 2524, CNH 3058, CNH 2863, CNH 6461, CNH 6464, CNH 1576, CNHN 1676
Institute Common Trial *G. arboreum*	CNA 1065, CNA 1069, CNH 1077, CNA 1082, CNA1083, CNA1084, CNA20178

The list of entries (non-Bt) promoted and retained in ICAR- AICRP on Cotton during 2020-21

Trial	Entries promoted	Entries retained
North zone		
Br.04(a) CVT irrigated	CSH 90	-
Br 25 (a)	CISAA 19-3	-
Central zone		
Br.03(a/b) CC	CNH 19325, CNH 19480	CNH 17395, CNH 18529, DHCC 1901, CNH 18528
Br.04(b) CVT	CNH 119	-
Br.24(b) CVT- *G. arboreum*	CNA 1071, CNA 1072, CNA 1075	-
Br.24(b) CVT- Coloured Cotton trial of *G. arboreum*	-	CNA 19475, CNA 18562, CNA 1092, CNA 18563
South zone		
Br.03 a/b (CC) Colour Cotton irrigated	-	CNH 18529
Br-04a – CVT - Irrigated	CCH 19-2	-
Br-04b – CVT - Rainfed	CNH 119, CCH 19-2	-
Br.14(a) CVT *G. barbadense*	CCB 26	CCB 6, CB 51, CCB 29,
Br. 24 (b) CVT *G. arboreum*	CNA 1071, CNA 1072, CNA 2034, CNA 1075	-

The entries (non-Bt) proposed for Agronomy trial during 2020-21

Zone	Species	Variety / Hybrid	Irrigated / Rainfed	Entries
Central Zone	*G. barbadense*	Variety	Irrigated	CCB 51-2
	G. arboreum	Variety (Coloured Cotton)	Rainfed	CNA 17522
South Zone	*G. hirsutum*	Variety (Coloured Cotton)	Irrigated / Rainfed	CNH 17395
	G. barbadense	Variety	Irrigated	CCB 51-2
	G. arboreum	Variety (Coloured Cotton)	Rainfed	CNA 1091

Bt entries sponsored to ICAR-AICRP on Cotton during 2021-22

Zone	Condition	Trial		
		IET	AET 1	AET 2
North	Rainfed	-	-	-
	Irrigated	CICR Bt 21-33	-	-
Central	Rainfed	CICR 30 Bt, CICR 31 Bt, CICR 32 Bt, CICR 33 Bt, CICR 34 Bt, CICR 35 Bt, CICR Bt 21-31, CICR Bt 21-32	CICR 18 Bt, CICR Bt 20-31	Bt 183059-4, Bt 183059-5, CICR Bt 19-32, CICR Bt 19-33
	Irrigated	CICR 30 Bt, CICR 31 Bt, CICR 32 Bt, CICR 33 Bt, CICR 34 Bt, CICR 35 Bt, CICR Bt 21-33	CICR 18 Bt, CICR Bt 20-31	-
South	Rainfed	CICR 31 Bt, CICR 32 Bt, CICR 33 Bt, CICR 34 Bt, CICR 35 Bt, ICAR-CICR PKV081 Bt, ICAR-CICR GJHV 374 Bt, ICAR-CICR Rajat Bt, ICAR-CICR Suraj Bt	CICR Bt 20-31	CICR Bt 19-31, Bt 183059-2
	Irrigated	CICR 31 Bt, CICR 32 Bt, CICR 33 Bt, CICR 34 Bt, CICR 35 Bt CICR 61 Bt, ICAR-CICR PKV081 Bt, ICAR-CICR GJHV 374 Bt, ICAR-CICR Rajat Bt, ICAR-CICR Suraj Bt, CICR Bt 21-33	-	-

4.3 Project Name : Breeding for high yielding, early maturing sucking pest tolerant extra-long stable *G. barbadense* genotypes with improved fibre properties

Dr. A.Manivannan (PI); Co-PI: Dr. K.Ramaesh

Importance of the study : Genetic improvement of *G. barbadense* genotypes for early maturing, sucking pest tolerance, high yielding with improved fibre quality properties

Salient findings :

ELS Variety released: CICR B Cotton 45 (CCB 143B) has been released and notified vide Gazette notification dated 24th December 2021; S.O. 8 (E) for the states Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu.

Promising ELS genotypes in AICRP trials during 2020-21: CCB51-2(Agronomy trail), CCB26 (CVT Br 14a); CCB 6, CCB 15, and CCB 29(CVT Br 13a); CCB1, and CCB 2 (IET Br12a)

CCB 12 Cleistogamous mutant in *G. barbadense* : A mutant from the *barbadense* intra cross Suvin x Giza-45, a single plant, bearing flowers of cleistogamous in nature different from that of the parents was isolated.

Evaluation of Advanced Progenies for sucking pest tolerance : A set of 10 advanced progenies with high yielding and sucking pest tolerance were evaluated namely H_1 Suvin x (ICB-241 x CCB-29), H_2 Suvin x(EC-18 x CCB-3), H_3 Suvin x (ICB85 x CCB-29), H_5 Suvin x(ICB126 x CCB-29), H_6 Suvin x(ICB124 x CCB-29), H_7 Suvin x(ICB124 x CCB-6), H_8 Suvin x (ICB-124 xCCB-5), H_9 Suvin x (ICB-27 xCCB-12), H_{10} Suvin x (ICB-214 xCCB-6), H_{11} Suvin x (EC18 xCCB-29). In case of leafhopper infestation lines *viz.*, H_1, H_2, and H_9 for white fly H_2, H_5, H_7, H_{10} and H_{11} showed lesser infestation than other lines.

Germplasm: A set of 327 *G. barbadense* germplasm is being maintained. Spontaneous mutations namely brown lint from EA 203, big boll from (EA 159) and naked seeds (EC 959057) were observed.

Seed multiplication: Mass multiplication of seeds of advance cultures (CCB 3, CCB 4, CCB 5, CCB 7, CCB 8, CCB 12, CCB 13, CCB 28, CCB 64, CCB 64B, CCB 129, CCB 141, CCB 142) and AICRP trials cultures (CCB 51-2, CCB 26, CCB 6, CCB 15, CCB 29, CCB 1, CCB 2) and released varieties CICR B Cotton 37 and 45 were done.

Fig.4.3.1. CICR B Cotton 45 (CCB 143B) High yielding variety of *G. barbadense* identified for South Zone

4.4 Project Name : Induced Mutagenesis for Improvement of ELS cotton (*G. barbadense)*

Dr. A. Manivannan (PI); Co-PI: Dr. K. Rathinavel, Dr. K. Shankarganesh, Dr. A. Sampath kumar

Importance of the study : Induced mutagenesis in Suvin (*G. barbadense*) variety through Fast Neutron (FN) for identifying of novel mutants with high ginning out turn (GOT).

Salient findings :

Potential mutant fast neutron was tried to induce mutagenesis in Suvin variety. There were five sets of doses been used for irradiation *viz.*, 10 Gy, 20 Gy, 30 Gy, 40 Gy and 50 Gy. Probit analysis been done to fix the LD50 value for Fast neutron. LD50 was fixed with dose of 30 Gy. When measured in laboratory, germination per centage was higher when compared with field emergence with 90% germination. M_1 population (10,000 plants) been raised under field condition to observe the variability among the populations. Intensity of mutation was determined based on the appearance of potential mutants in different categories namely albino, chlorina and sectoral chlorina. It was evident that full chimeras as well as partial, as sectoral chimera, appeared in the field.

Analysis of the quantitative traits showed that genotypes had a wide range of variations. Days to flowering ranged from 70 to 93 DAS with a mean of 75.14; plant height ranged from 77 to 140 cm with a mean of 113.47; monopodia ranged from 3 to 6 with a mean of 3.6; sympodia ranged from 12 to 26 with a mean of 20.9; number of bolls ranged from 45 to 80 with a mean of 60.92; yield ranged from 50.8 to 284g with a mean of 150.4; GOT ranged from 28 to 35.4 with a mean of 32.29. Among the traits, morphologically observed variation shows distinct pattern of petal spot of dark to light red colors. In case of pollen fertility, it was found three distinct groups namely 100% fertility, 75% fertility and 50% fertility. From this selected 5000 plants will be advanced to M_2 generation.

4.5 Project Name : Development and evaluation of ELS interspecific hybrids with better yield and fibre quality

Dr. K. Baghyalakshmi (PI); Co-PI: Dr. M. Amutha , Dr. A. Sampath Kumar

Importance of the study: Although, Indian cottons have very wide quality spectrum, the right combination of fibre length (33-37mm), fibre strength (25 to 37 g per tex) and micronaire (4- 4.5) is however absent in many of the popular varieties and hybrids. There is an urgent need to promote these cottons that could come closer in quality to the most sought by modern textile mills for which H x B address the need.

Salient findings :

Fifty *barbadense* lines were evaluated and two sets of 28 L x T crosses were attempted for further evaluation. One set of 28 hybrids obtained earlier (Rabi 20-21) with 4 female *hirsutum* lines and seven *barbadense* male lines was evaluated, among which 18 germinated during the season. G x E interactions were analysed for the 50 *barbadense* genotypes for two seasons namely 2019-2020 and 2020-2021.

The results from the biplot were extracted and are given in the table 1 below. Among the 50 parental genotypes, genotype with highest boll weight was CCB 143 B (5.35 g), Ginning percent ICB 176 (37.5), Fibre length CCB 11A (39.4), fibre strength CCB 28 (44.1). Weather data showed that there were changes in rainfall pattern. Due to this, traits like number of bolls, single plant yield and fibre Strength, the environment that classify

better to the genotypes is environment 1 when compared to environment 2. Similarly for traits like single boll weight and micronaire the environment 2 is better for the genotypes (Fig.4.5.1). When considering the traits like ginning percentage and fibre length both the environments were better suited and their expression mainly depends on genotype itself. Crosses MCU VT5 x CCB 64 (88 nos) and MCU VT5 x ICB 1 (83.5 nos) had significantly higher number of bolls than the check used DCH 32 non bt (59 nos) and Baghubali Bt (62 nos).

Similarly, hybrids CCH 15-1 x CCB 64 (5.08 g), Suraj x Suvin (4.79 g), had significantly highest single boll weight than the check DCH 32 (4.05 g). Hybrids CCH 15-1 x CCB 64 (229 g/plant), MCU VT5 x ICB 53 (209 g/plant), MCU VT5 x CCB 64 (207 g/plant), Surabhi x CCB 64 (205 g/plant), recorded significantly higher single plant yield than the checks (0.01*). Hybrid CCH 15-1 x ICB 290 had the higher GOT of 36 per cent. The hybrids MCU VT5 x ICB 1 and Surabhi x CCB 64 had a fibre length of 39.9 mm and fibre strength of 39.2 g/tex and 40.9 g/tex respectively. The hybrid CCH 15-1 x Suvin exhibited fibre length of 39.6 mm and fibre strength of 40.4 g/tex.

The characters related to pest and disease resistance was studied and it was found that leaf trichome density was higher in ICB 124 (135/sq cm), ICB 264 (126/sq cm) had higher gossypol gland per sq cm of leaf area. During 2019-20 disease incidence of TSV ranged from 1.32 to 8.33 PDI and 1.25 to 4.35 PDI during 2020-21 which affected only few genotypes. Alternaria leaf spot ranged from 3.60 to 9.05 PDI (2019-2020) and 2.65 to 5.40 PDI (2020-21). Grey mildew affected very few genotypes and ranged from 4.72 to 7.34 PDI during 2019-2020. Rust emerged as major disease at the end of the season (2019-20) and PDI ranged from 5.36 to 12.27. However, CCB143B, ICB1, ICB75, ICB99, ICB124 ICB16, ICB28, ICB273 and ICB264 found to be free from all the diseases.

Eight lines namely Suraj x ICB 1, CCH 15-1 x ICB 290, MCU VT 5 x ICB 53, Surabhi x suvin, MCU VT5 x CCB 64, Suraj x Suvin, Surabhi x ICB 46 and CCH 15-1 x CCB 64 based on the number of bolls and boll size has been selfed for next generation for varietal development. Weather parameters for two seasons (Kharif 2019-2020 and Kharif 2020-2021) are listed in the table 4.5.2.

Table 4.5.1. List of genotypes showing stability for various traits for two environments

Characters	Stable genotypes	Season I	Season II
Number of Bolls	ICB 13, ICB 16, ICB 35, ICB 184, ICB 220, CCB 141, ICB 255, CB 264	ICB 28, ICB 177	ICB 273, ICB 73
Single Boll Weight	ICB 39, ICB 46, ICB 96	CCB 141, CCB 64, ICB 161, CCB 26	ICB 35, CCB 11 A, ICB 40
Single plant Yield	ICB 129, ICB 244, ICB 16, ICB 273, ICB 194	ICB 28, CCB 64	ICB 262, ICB 177, ICB 35
Ginning Percentage	ICB 176, ICB 39, ICB 99	ICB 177, ICB 194	4ICB 290, CCB 143 B, CCB 141, ICB 77, ICB 28
Fibre Length	ICB 262, ICB 177, ICB 194, ICB 61, CCB 29	CCB 28, CCB 11A, ICB 198, CCB 25	ICB 176, ICB 77, CCB 26, ICB 220
Fibre Strength	CCB 141, ICB 262, CCB 29, ICB 40, ICB 73, ICB 258	CCB 28, CCB 25, ICB 53, ICB 143, ICB 40	ICB 174, ICB 77, ICB 198, CCB 26, CCB 11A
Micronaire	ICB 194, ICB 207, ICB 46, ICB 273, ICB 258. ICB 244, CCB 25, CCB 143 B	ICB 39, ICB 184, ICB96, ICB 177, ICB 28, ICB 75	ICB 73, ICB 199, CCB 141, ICB 99, ICB 290, ICB 161

Table 4.5. 2. Weather parameters for two seasons (Kharif 2019-2020 and Kharif 2020-2021)

Month	Temperature (°C)		RH	Rainfall (mm)	Crop Stage
	Max	Min		Sowing	
			2019-2020		
July 19	31.8	23.7	70	8.5	Sowing
August 19	29.9	23.0	75	221.3	
September 19	30.9	23.4	74.5	57.3	Square formation
October 19	30.7	22.7	74.5	246.9	Flowering
November 19	29.6	22.2	73.5	167.1	Boll Formation
December 19	27.8	21.2	74	36.0	
January 20	30.4	22.6	69.5	0.5	Harvesting
			2020-2021		
July 20	31.7	23.3	68.5	109.5	Sowing
August 20	29.9	23.1	71	26	
September 20	31.4	23.4	74	105.5	Square formation
October 20	32.2	22.4	68	36	Flowering
November 20	33.2	22.8	65	103	Boll Formation
December 20	27.7	22.1	77.5	32	
January 21	27.6	21.0	74.95	141.5	Harvesting

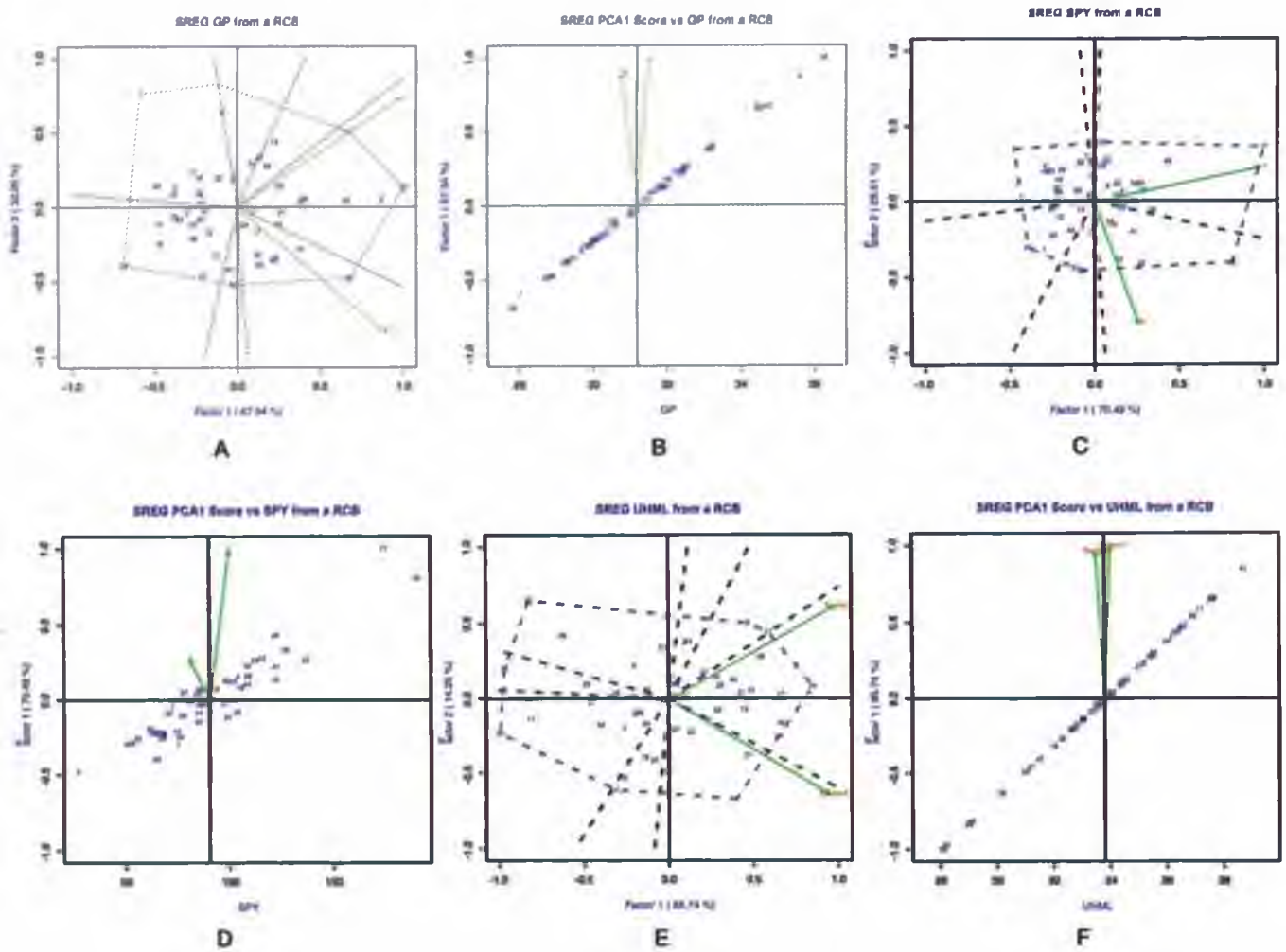


Fig 4.5.1. Polygon views of the GGE biplot based on symmetrical scaling for pattern of barbadense genotypes in two environments. (A, C, E), Polygon view of Ginning Percentage, single plant yield and Fiber length. (B, D, F), which-won-where plot Ginning Percentage, single plant yield and Fiber length.

4.6 Project Name : Evaluation of PGPR and microbial inoculants to alleviate drought stress in cotton (*G.hirsutum* L.)

Dr. J H Meshram (PI); Co-PIs: Dr S.Gawande, Dr D.Nagrale, Dr K.Velmourougane, Dr Pooja Verma

Importance of the study : The bio stimulants like PGPR play significant role in alleviation of drought stress. This project aims toevaluate the PGPRs collected from cotton rhizosphere for their potential to improve the drought tolerance in cotton.

Salient findings :

Total 34 native PGPRs were tested in preliminary experiments and the seven best inoculants were shortlisted based on plant growth promotion and drought stress tolerance. Out of these, *Sphingomonas* sp. treated cotton plants showed better drought stress tolerance than control in terms of plant height, leaf chlorophyll content (37.4 SPAD) and relative water content (85 %). While evaluating their *In-vitro* growth promotion activity, three bacterial isolates; *Micrococcus luteus*, *Agrococcus* sp. and *Solibacillus isronesis* exhibited higher activity in terms of IAA (1,3 Indole Acetic Acid). Also, maximum ACC deaminase activity was found in drought tolerant bacterial isolate *Micrococcus luteus*. Under field evaluation, significant difference was observed between control and bacterial isolates treated cotton plants in terms of enhanced root and shoot traits. Of the seven bacterial isolates evaluated in the field, *Micrococcus luteus* showed better yield attributes and root traits under drought stress condition.

4.7 Project Name : Development of microbial biofilm formulations for cotton : effects on yield, pests, diseases and soil health

Dr. K. Velmourougane (PI); Co-PIs: Dr Savitha Santosh, Dr Rachna Pande, Dr Dipak Nagrale

Importance of the study : This project aims to develop multi-species microbial biofilm formulation to enhance cotton root colonisation, thereby expected to enhance plant innate immunity against pest and diseases, apart from enhancing plant and soil health attributes

Salient findings :

A replicated field trial was conducted to evaluate the effects of microbial biofilm-based formulations (MBF) on cotton growth, yield and soil health in an RBD design with Ajeet 155 BG II in calcareous soil. The treatment includes Control (no nutrients), 75% recommended dose of fertilizers (RDF), 100% RDF

(90:45:45 NPK kg ha^{-1}), seed treatment with MBF + 75% RDF, soil application of MBF along with FYM (25 DAS) and 75% RDF, foliar application of MBF (squaring) + 75% RDF, seed treatment + soil application (25 DAS) of MBF + 75% RDF, seed treat + foliar application (squaring) of MBF + 75% RDF, soil application (25 DAS) + foliar application (squaring) of MBF + 75% RDF, seed + soil + foliar application of MBF + 75% RDF. Observations on plant roots & shoots (at harvest), root and shoot antioxidant enzymes, SPAD, leaf area index (at squaring), yield attributes, soil nutrients, and soil health properties (at harvest) indicated a significant enhancement in above mentioned parameters in seed + soil + foliar application treatment (An additional 10 quintals SCY/ha; 87% yield increase) followed by soil + foliar treatment (70% yield increase) compared to the 75% RDF treatment (Table 4.7.1). MBF inoculation as seed + soil + foliar application also enhanced seed and lint index, apart from enhancing cotton root attributes (Fig. 4.7.1).

Table 4.7.1 Field inoculation of microbial biofilm on cotton root, shoot and yield attributes

Plant attributes	Control	75% RDF	100% RDF	Seed	Soil	Foliar	Seed+ Soil	Seed+ Foliar	Soil+ Foliar	Seed+ Soil+ Foliar	$LSD_{0.05}$
Root length (cm)	29.09^{g}	31.77^{f}	46.18^{cd}	39.07^{e}	46.19^{cd}	44.86^{d}	47.18^{bc}	48.08^{bc}	48.23^{b}	51.27^{a}	2.873
Root girth (cm)	4.33^{h}	5.09^{g}	7.33^{d}	6.80^{e}	8.05^{c}	6.36^{f}	7.22^{d}	8.04^{c}	8.38^{b}	8.56^{a}	0.161
Root density (cm^3)	1.029^{g}	$1.110f^{g}$	1.418^{bc}	1.274^{de}	1.449^{bc}	1.205^{ef}	1.477^{bc}	1.354^{cd}	1.490^{b}	1.626^{a}	0.188
Root surface area (mm^2)	395.7^{h}	508.0^{g}	1063.1^{d}	834.5^{f}	1167.9^{c}	896.2^{e}	1070.7^{d}	1215.0^{c}	1269.6^{b}	1378.5^{a}	75.79
Root dwt (g)	23.41^{h}	26.91^{g}	41.95^{d}	35.27^{f}	42.73^{d}	40.00^{e}	45.31^{bc}	44.31^{d}	46.22^{b}	55.69^{a}	2.111
Secondary root no.	20.5^{h}	22.5^{g}	31.5^{c}	28.0^{e}	30.5^{cd}	25.5^{f}	31.5^{c}	29.5^{de}	33.5^{b}	39.0^{a}	2.834
Sec. root length (cm)	20.17^{f}	26.11^{e}	34.12^{c}	28.87^{d}	35.23^{bc}	33.90^{c}	35.66^{b}	34.03^{c}	36.62^{ab}	37.57^{a}	2.148
Shoot length (cm)	94.10^{e}	97.75^{e}	135.7^{ab}	114.3^{d}	132.7^{b}	124.7^{c}	135.2^{ab}	136.7^{ab}	135.3^{ab}	137.9^{a}	6.378
Shoot girth (cm)	4.77^{g}	5.59^{f}	7.39^{d}	6.91^{e}	7.33^{d}	7.26^{d}	7.58^{bc}	7.40^{cd}	7.59^{b}	8.77^{a}	0.258
Shoot dwt (g)	104.5^{h}	113.5^{g}	234.5^{c}	168.1^{f}	235.5^{c}	185.2^{e}	192.9^{d}	236.8^{c}	262.3^{b}	391.5^{a}	9.852
Root:shoot ratio	0.309^{g}	0.325^{f}	0.340^{e}	0.342^{de}	0.348^{cde}	0.360^{b}	0.349^{cde}	0.352^{bcd}	0.356^{bc}	0.372^{a}	0.014
Boll numbers	15.6e	21.8^{d}	32.0^{b}	28.2^{c}	30.9^{bc}	30.2^{bc}	32.5^{ab}	30.1^{bc}	32.2^{ab}	35.5^{a}	4.442
Boll wt. (g)	3.00^{d}	3.25^{cd}	3.51^{bcd}	3.33^{bcd}	3.36^{bcd}	3.36^{bcd}	3.65^{bc}	3.45^{bcd}	3.80^{ab}	4.26^{a}	0.549
SCY (kg/ha)	934.8^{f}	1180.5^{e}	1909.7^{bc}	1580.2^{d}	1890.5^{bc}	1778.6^{cd}	1929.8^{bc}	1903.6^{bc}	2009.0^{ab}	2206.6^{a}	310.0
Seed index (g)	7.636^{f}	7.875^{e}	8.257^{c}	7.984^{de}	8.355^{bc}	8.087^{d}	8.442^{ab}	8.403^{ab}	8.418^{ab}	8.491^{a}	0.192
Lint index (g)	3.681^{e}	4.101^{d}	5.312^{c}	5.284^{c}	5.349^{bc}	5.267^{c}	5.612^{a}	5.258^{c}	5.574^{ab}	5.722^{a}	0.340

Figure 4.7.1. Field inoculation of microbial biofilm on cotton root characteristics (length, girth, density, dry weight etc.)

4.8 Project Name : Microbial dissolution of carbonate to ameliorate soil sodicity in Black Soil Regions of Maharashtra

Dr K. Velmourougane (PI); Co-PI's: Dr A. Manikandan, Dr D. Vasu (NBSS & LUP)

Importance of the study : The present study aims to isolate calcium dissolving bacteria, and to develop consortia of calcium dissolving bacteria for dissolution of pedogenic $CaCO_3$ in soils through exogenous application to improve soil properties enhancing soil and plant productivity.

Salient findings :

A replicated pot experiment was laid out in a two-factorial design with Ankur 3208 BGII to evaluate the effects of calcium carbonate solubilizing bacteria (CSB) on cotton plant attributes, soil nutrients, and soil biological properties in a graded level of calcareousness (5-20%) along with non-calcareous soil. The main treatment (4) includes Non-calcareous soil, calcareous soil with 5% $CaCO_3$, calcareous soil with 10% $CaCO_3$, and calcareous soil with 20% $CaCO_3$. The sub treatments (6) include 100% RDF with no microbial inoculation, CSB-1 (seed treatment) + 75% RDF, CSB-2 (seed treatment) + 75% RDF, CSB-4 (seed treatment) + 75% RDF, CSB-5 (seed treatment) + 75% RDF, and CSB-Consortia (seed treatment) + 75% RDF. Observations were made on plant roots, shoots, root and shoot antioxidant enzymes, SPAD, leaf area index, yield attributes, soil nutrients, $CaCO_3$ fractions, and soil health properties. Overall, the increase in soil $CaCO_3$ content affected the root and shoot attributes. Among the sub treatments, inoculation with CSB

consortia followed by CSB-1 helped the cotton plants to overcome the $CaCO_3$ stress. Significant enhancements in root characteristics (Fig. 4.8.1) and yield attributes (Table 4.8.1) were observed in plants inoculated with CSB consortia and CSB-1 compared to the uninoculated plants (RDF).

Table 4.8.1. CSB inoculation on cotton plant attributes in calcareous and non-calcareous soils

Treatments	Root length (cm)	Root girth (cm)	Root density (cm cm3)	RSA (mm2)	Root dwt (g)	Shoot length (cm)	Shoot dwt (g)	R:S ratio	Boll nos.	Boll wt. (g)	SCY/ plant
Main treatments											
Non-Calcareous	26.65	2.653	0.463	204.20	3.39	70.39	29.379	0.382	13.52	2.831	44.138
Calcareous -5%	25.76	2.671	0.551	187.28	3.35	78.65	28.492	0.332	16.72	3.131	56.788
Calcareous -10%	25.20	2.227	0.540	146.6	3.03	74.39	20.753	0.344	11.38	3.160	44.746
Calcareous -20%	23.24	1.709	0.584	121.69	2.62	59.50	12.734	0.397	10.05	2.939	36.999
$LSD_{0.05}$	**1.186**	**0.233**	**0.114**	**21.74**	**0.226**	**4.135**	**3.222**	**0.027**	**0.887**	**0.111**	**2.072**
Sub treatments											
100% RDF	25.14	2.087	0.460	159.11	2.67	70.87	21.689	0.334	11.08	2.981	39.734
75% RDF + CSB-1	25.47	2.329	0.524	164.50	3.61	73.47	25.314	0.376	14.50	3.135	51.333
75% RDF + CSB-2	24.49	2.385	0.515	167.73	3.39	73.35	22.049	0.364	12.87	3.061	45.274
75% RDF + CSB-4	25.11	1.938	0.452	139.25	2.74	65.01	18.825	0.372	11.66	2.777	38.333
75% RDF + CSB-5	25.50	2.670	0.695	175.28	2.83	70.61	22.913	0.362	12.79	2.954	43.355
75% RDF + Consortia	25.57	2.480	0.559	183.42	3.35	71.07	26.248	0.373	14.62	3.184	55.978
$LSD_{0.05}$	**1.453**	**0.285**	**0.139**	**26.62**	**0.227**	**5.065**	**3.946**	**0.033**	**1.087**	**0.136**	**2.537**
Interaction $LSD_{0.05}$	**2.905**	**0.570**	**0.278**	**53.25**	**0.554**	**10.13**	**7.891**	**0.066**	**2.173**	**0.272**	**5.074**

Figure 4.8.1: CSB inoculation on cotton root characteristics in calcareous and non-calcareous soils

4.9 Project Name : Bioprospecting microbial volatiles for plant growth promotion and sucking pest (Whitefly and Jassids) management in Bt cotton (DST-SERB Project)

Dr. K. Velmourougane (PI)

Among the sucking pests, whitefly (*Bemisia tabaci*) and green leafhopper (Jassids) (*Amrasca biguttula biguttula*) cause significant yield loss in Bt cotton. Microbial volatile organic compounds (mVOCs) are semiochemicals that can attract or repel the insects, stimulate oviposition, mimic plant hormones, or even induce plant resistance. The aim of this project was to develop eco-friendly and cost-effective microbial volatile formulation for field application to enhance plant growth promotion and management of whiteflies and jassids in Bt cotton.

Salient findings:

12 short-listed microbial-based volatiles in 150 combinations (single compound to four compounds combinations; multi-choice assay) were tested along with respective controls under replicated field conditions to study their effects on attraction/repulsion of major sucking pests of cotton (whiteflies, jassids, aphids, thrips) and other beneficial insects (predators, parasitoids) using yellow (YST), white (WST), and blue (BST) sticky traps. The field trials were conducted in 40 days sucking pest window *i.e.* 40, 50, 60 and 70DAS (Plates 1-6). The volatiles were used in 5 ppm concentration along with sticky traps similar to that of commercial lures. Overall, YST was found to trap more sucking pests compared to WST and BST. The promising microbial volatiles and their combinations involved in attraction or repulsion of sucking pests of cotton are presented in Tables 4.9.1 and 4.9.2. Further, some of the volatile combinations were also found to attract beneficial insects such as coccinellids with concomitant repulsion of sucking pests (Table 4.9.3). A separate pot experiments with these 12 microbial-based volatiles as seed treatment and foliar application was found to significantly enhance the cotton seedling vigour, along with improvements in plant defense enzyme activities, and soil biological properties, indicating no risk involved in their usage.

Table 4.9.1. Field evaluation of microbial based volatiles on attraction and repulsion of whiteflies and jassids

	Whiteflies- Attraction	Mean	% Increase	Fold		Jassids- Attraction	Mean	% Increase	Fold
1	TPC X TC X BHT X HTC	756	232	3.32	1	EC X HC X TPC	776	3133	32.33
2	EC X HDC	724	218	3.18	2	DBP X HDC	736	2967	30.67
3	PD X PY X TPC X HDC	696	205	3.05	3	TD X PD	692	2783	28.83
4	BHT X DBP X TPC	688	202	3.02	4	TD X BHT	692	2783	28.83
5	HC X HTC	680	198	2.98	5	DCT X PY	656	2633	27.33
6	PD X TPC	676	196	2.96	6	TC X DBP	648	2600	27.00
7	PY X TPC X TC X HDC	676	196	2.96	7	PD X BHT	636	2550	26.50
8	EC X HC X DCT X TC	668	193	2.93	8	PD X TC	570	2275	23.75
9	TD X PD X PY X TPC	668	193	2.93	9	EC X BHT	560	2233	23.33
10	EC X BHT	656	188	2.88	10	PD X HDC	560	2233	23.33
	Control + Solvent	**228**				**Control + Solvent**	**24**		
	Control	**408**				**Control**	**105**		
	Whiteflies-Repulsion	**Mean**	**% Decrease**	**Fold**		**Jassids- Repulsion**	**Mean**	**% Decrease**	**Fold**
1	BHT X HDC	168	-26	0.74	1	PD X PY X TPC X HDC	2	-92	0.08
2	DCT X PY	173	-24	0.76	2	HC X BHT	3	-88	0.13
3	EC X PY	176	-23	0.77	3	EC X HC X DCT X TC	3	-88	0.13
4	PY X TC	218	-4	0.96	4	DCT X BHT	5	-79	0.21
5	HC X TC	224	-2	0.98	5	TD X PD X PY X DBP	7	-71	0.29

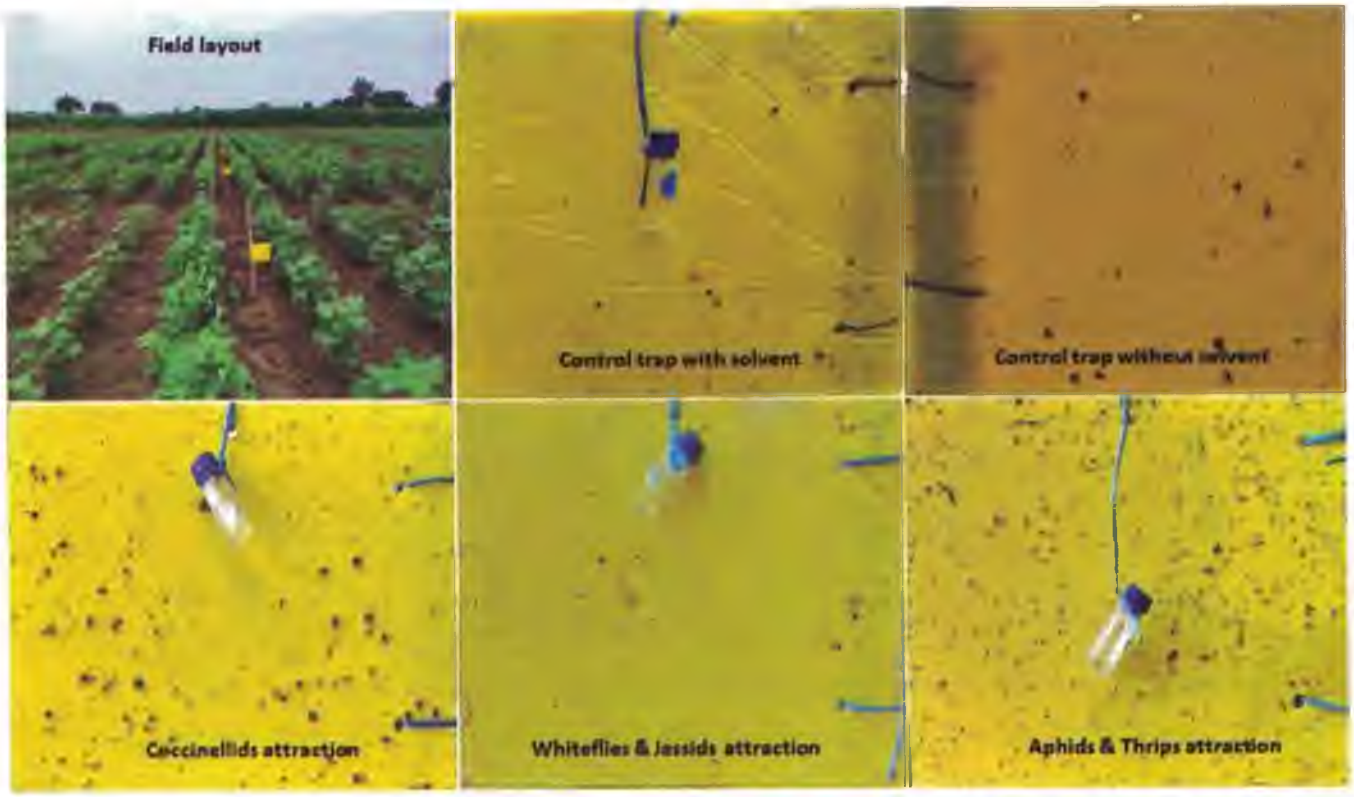
Table 4.9.2. Field evaluation of microbial based volatiles on attraction and repulsion of aphids and thrips

	Aphids- Attraction	Mean	% Increase	Fold		Thrips- Attraction	Mean	% Increase	Fold
1	PD X TPC	696	709	8.09	1	HC X TPC	472	237	3.37
2	PD X PY X TPC X HTC	656	663	7.63	2	TD X BHT	396	183	2.83
3	DCT X TC	623	624	7.24	3	DCT X PD X PY	348	149	2.49
4	TD X PD X PY X DBP	596	593	6.93	4	DCT X PY	240	71	1.71
5	DCT X TD X PD	562	553	6.53	5	TC X DBP	236	69	1.69
6	HC X BHT	540	528	6.28	6	TD X PD	224	60	1.60
7	EC X HTC	520	505	6.05	7	HC X TD	220	57	1.57
8	EC X HC X DCT X TC	520	505	6.05	8	PY X DBP	208	49	1.49
9	EC X HC X DCT X TD	496	477	5.77	9	PD X PY	204	46	1.46
10	PY X HDC	444	416	5.16	10	HC X TC	168	20	1.20
	Control + Solvent	**86**				**Control + Solvent**	**140**		
	Control	**232**				**Control**	**13**		
	Aphids- Repulsion	**Mean**	**% Decrease**	**Fold**		**Thrips- Repulsion**	**Mean**	**% Decrease**	**Fold**
1	EC X HDC	18	-79	0.21	1	EC X HC X DCT X PY	3	-98	0.02
2	TD X PY	52	-40	0.60	2	DCT X BHT	6	-96	0.04
3	EC X DCT	56	-35	0.65	3	PD X PY X DBP	6	-96	0.04
4	EC X TPC	56	-35	0.65	4	EC X HC X DCT X TD	6	-96	0.04
5	PY X BHT	60	-30	0.70	5	PD X TPC	9	-94	0.06

Table 4.9.3. Volatiles on coccinellid beetle's attraction with concomitant repulsion of sucking pests

Code	Whiteflies % decrease	Coccinellids % increase	Code	Jassids % decrease	Coccinellids % increase
BHT X HDC	-26.3	425	TD X PD X PY X DBP	-70.8	50
DCT X PY	-24.1	675	PY X TPC X TC	-45.8	175
EC X PY	-22.8	50	EC X HC X PD	-4.2	225
HC X TC	-1.8	650			
Code	**Aphids % decrease**	**Coccinellids % increase**	**Code**	**Thrips % decrease**	**Coccinellids % increase**
EC X HDC	-79.1	350	PD X PY X DBP	-95.7	300
HC X DCT X TD	-44.2	425	DCT X PD	-91.4	425
EC X DCT	-34.9	200	HTC X HDC	-90.7	275
EC X TPC	-34.9	150	TD X TPC	-90.0	125

Plates 1 - 6



4.10 Project Name : Sustainable Intensification of Extra Long Staple Cotton Production in South Zone

Dr R. Raja (PI); Co-PIs: Dr JAnnie Sheeba, Dr K. Rameash and Dr K. Rathinavel

Importance of the study : Field experiments are being conducted at ICAR-CICR Regional Station, Coimbatore to study the effect of increased plant density and use of growth regulators on the productivity of ELS cotton under conventional ridges & furrow irrigation system and drip fertigation system.

Under conventional ridges and furrow irrigation system, foliar spray of Mepiquat chloride @ 60ppm, given at flowering stage (around 60 DAS) when height to node ratio (HNR) reached 1.5 followed by the second dose at 30 days after the first spray has significantly reduced the plant height vis-à-vis untreated plants and significantly increased seed cotton yield in RCHB 625 BG II. Increased plant density through adoption of 90 x 30cm spacing has increased the number of bolls produced per unit area and in turn increased the seed cotton yield compared to conventional 90 x 60 cm spacing (Fig 4.10.1).

Under drip fertigation system, planting of Suvin at 120 x 25 cm spacing with fertigation and foliar spray for canopy management (Mepiquat Chloride @ 60 ppm) given, when height to node ratio (HNR) reached 1.5 followed by subsequent dose of 30 ppm twice at 15 days interval after first spray) produced highest seed cotton yield of 2182 kg ha^{-1} (Table 4.10.1) which was significantly higher than that of farmer's practice (1413 kg ha^{-1}). In case of MRC 7918 BG II hybrid, application of Mepiquat Chloride as mentioned above has significantly reduced the plant height and registered significantly higher seed cotton yield than farmer's practice.

For optimization of dose and frequency of plant growth regulator application in G. barbadense cv. Suvin for canopy management, Mepiquat chloride and Lihocin under different combinations of low dose multiple sprays under three spacings 90 x 45, 90 x 30, 90 x 25 were tested. Foliar spray of Mepiquat chloride @ 60ppm, 30ppm and 30 ppm at 50, 75, and 95 DAS has reduced the plant height and maintained a Height to Node ratio of 1.5 when compared to control (1.9) and other treatments at 90 x 60, 90 x 45 and 90 x 25 cm spacing. At 90 x 60 cm, the above treatment increased the boll yield per square metre. Spraying of Mepiquat chloride has reduced the days to physiological maturity by 3 to 4 days when compared to control as evidenced from the number of nodes above cracked bolls and nodes above white flower. There is no significant difference in SPAD values among treatments.

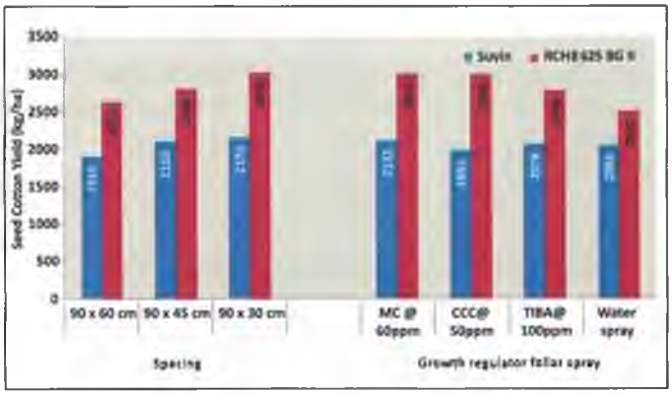


Fig 4.10.1. Effect of plant density and growth regulator application on yield of ELS cotton cultivars

Table 4.10.1: Plant height, number of bolls and seed cotton yield of Suvin and MRC 7918 BG II

Treatment	Suvin			MRC 7918 BG II		
	Plant height (cm) at 150 DAS	No. of bolls m^2 at Harvest	Kapas Yield (kg/ha)	Plant height (cm) at 150 DAS	No. of bolls m^{-2} at Harvest	Kapas Yield (kg/ha)
T_1: 90 x 60 cm	108.8	70	2093	135.6	102	3960
T_2: 90 x 45 cm	108.2	89	1918	114.7	98	3932
T_3: 90 x 30 cm	100.3	84	1991	104.8	108	3932
T_4: 120x 45cm	103.5	71	1747	137	102	3773
T_5: 120 x 30 cm	102.9	84	2056	102.7	96	3640
T_6: 120 x 25 cm	102.3	98	2182	107.9	98	3963
T_7: Farmer's practice (90 x 60 cm: R&F)	144.1	52	1413	151	90	3074
S Ed	*7.89*	*13.0*	*292.6*	*5.93*	*7.92*	*385.2*
CD (P=0.05)	*17.18*	*28.2*	*637.5*	*12.91*	*17.27*	*839.3*

Plate 1: Suvin crop (120 x 25 cm spacing) at boll bursting and maturity stage (150 DAS)

Plate 2: MRC 7918 BG II crop (90 x 30 cm spacing) at maturity stage (150 DAS)

4.11 Project Name : Development of biocontrol consortia with multifaceted fungi for the management of important pests and nematodes of cotton

Dr. J.Gulsar Banu (PI); Co-PI: M.Amutha

Importance of the study : This study aims to identify and develop biocontrol consortia of novel microbes for the eco-friendly management of important pests and nematodes of cotton

Salient findings :

A total of 644 entophytic fungal strains were recovered from 2170 tissue segments collected from 434 cotton roots. Of those, 62 per cent of the samples were positive for endophytic fungal colonisation. Root samples were collected from cotton hybrids and varieties, Bt and Non-Bt cotton, *G. hirsutum* and *G. barbadanse*. In *G. hirsutum*, *G. barbadanse*, Bt, Non-Bt, Variety, and hybrids, the percent endophytic colonisation was 57.89, 67.76, 67.51, 75.68, 72.97, and 75.0, respectively. A total of 71 and 228 endophytic fungal strains were isolated from *G. hirsutum* and *G. barbadanse,* respectively, whereas 67 and 577 strains were isolated from Bt and non-Bt cotton.

Fungal strains belonging to *Pencillium, Aspergillus, Alternaria, Colletotrichum, Phomopsis, Cladosporium, Trichoderma, Fusarium,* etc. were identified. Out of 644 endophytes, 50 strains were screened for nematicidal activity against the Reniform nematode, *Rotylenchulus reniformis,* infecting cotton. Inhibition in nematode egg hatching ranged from 11 to 90 per cent, and more than 50 and 70 per cent inhibition in hatching was recorded in 34 and 8 samples, respectively. Juvenile mortality ranged from 13 to 85 percent, with more than 50 and 70 percent mortality recorded in 25 and 10 samples, respectively. Among them, EF 11, EF-41, and EF 42 recorded maximum inhibition in hatching and juvenile mortality.

Compatibility studies were carried out among entomopathogenic and nematode antagonistic fungi to develop consortia for the management of pests and nematodes in cotton. None of the nematode antagonistic fungi (*Pochonia chlamydosporia, Purpureocillium lilacinum,* and an unidentified fungus) were compatible with each other. Among five entomopathogenic fungi, *viz., Lecanicillium lecanii, Metarhizium anisopliae, Cladosporium cladosporioides, Fusarium pallidoroseum, and Beauveria bassiana,* tested, *L. lecanii* and *B. bassiana* were found to be compatible with each other.

4.12 Project Name : Collection, characterization and evaluation of beneficial fungal microorganisms from North, Central and South Cotton growing zones

Dr S.K. Sain (PI); Co-PIs: Dr Nandini Narkhedkar, Dr S.P. Gawande, Dr P. Valarmathi, Dr Savitha Santosh

Importance of the study : Rhizospheric microorganisms play a key role in the agricultural ecosystem for plant growth and health. They act as phytostimulators, produce phytohormones, promote plant development through altering root architecture and induce tolerance in plants to biotic stress. Until now, research on isolation and characterization of the rhizosphere fungi from cultivated cotton in India is lacking. The beneficial fungal strains reported in this research can used for developing bioformulation or consortia for improving the plant health, and ultimately cotton productivity in integrated and organic farming system.

Salient findings :

Survey and collection of rhizosphere soil samples from different cotton cropping systems in North (NZ), Central (CZ) and South(SZ) India were conducted. More than eighty cotton rhizosphere soil samples were collected. Fungal colony in the sample ranged from 1-16 with an average of 5.5 c.f.u. $x10^4$ Among 100 rhizospheric fungi isolated, purified, and characterized, 17 prominent ones were further evaluated *in vitro* against soil borne and foliar fungal pathogens for their antagonistic activity using dual culture technique. At 7 day-after inoculation and incubation at 28±2°C, mycelial growth inhibition of fungal pathogens by rhizospheric fungi was recorded for comparison. Regardless of all rhizospheric fungi, the mycelial inhibition of pathogen ranged from 23.5 to 90.6%. Comparatively, rhizospheric fungi, Rf-b (>65%), Rf-16-5 (>62%), Rf-28-2 (>51%), Rf-10-1 (>50%), Rf-3-3 (>42%), and Rf-29-1 (>37%) were found to be better antagonistic to *Rhizoctonia solani, Macrophomina phaseolina, Alternaria alternata,* and *Corynespora cassiicola* than others (Fig. 4.12.1 and Table 4.12.1).

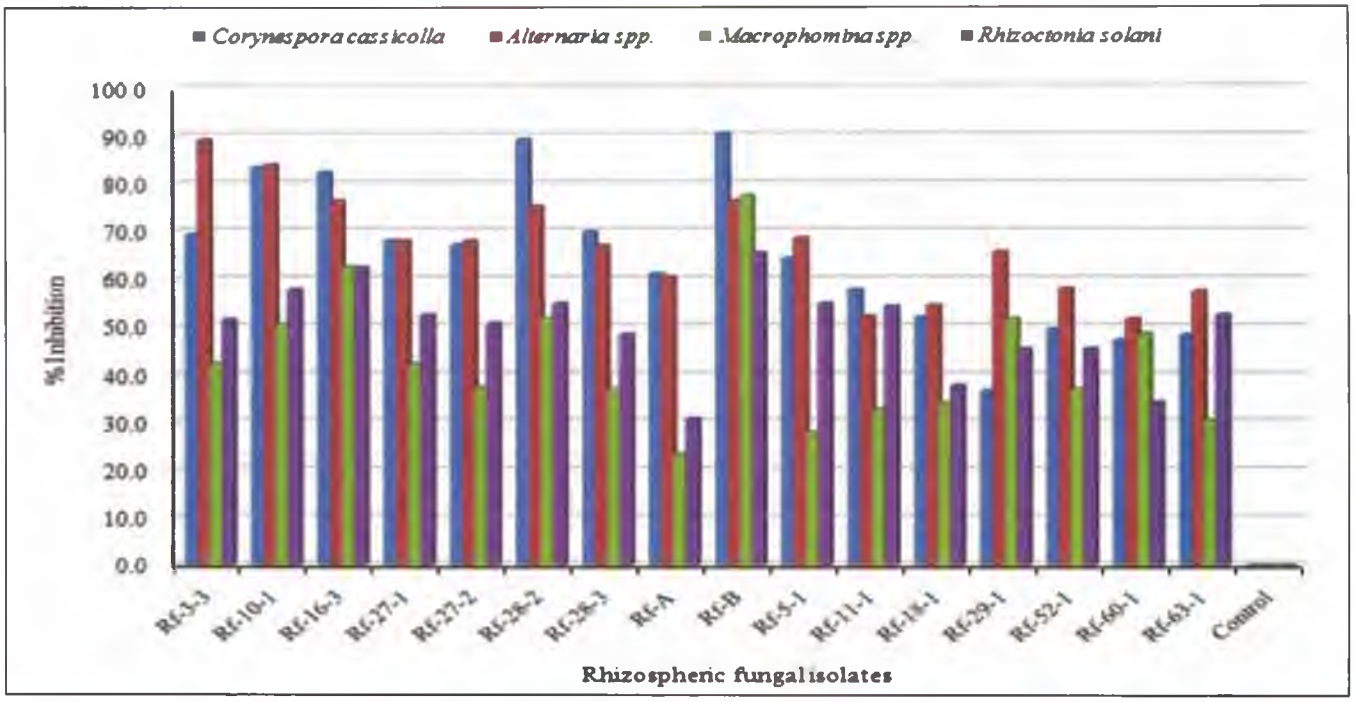
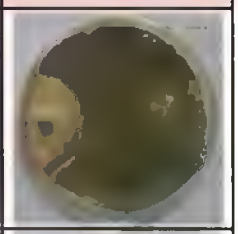
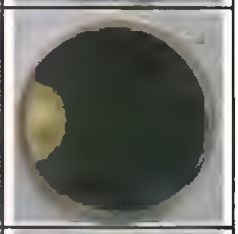
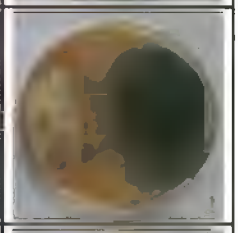
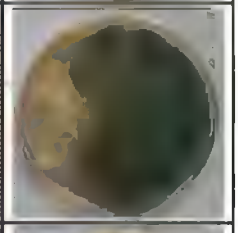
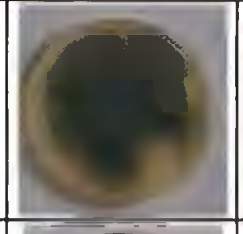
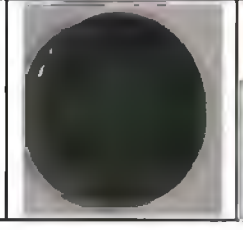
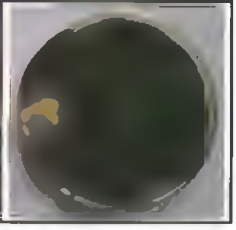


Fig.4.12.1. Precent *in vitro inhibition* activity of soil borne and foliar fungal pathogen (dual culture) by rhizospheric fungal isolates (Rf).

Isolates	Rf - control/ Pathogen control	*Corynespora cassiicola*	*Alternaria* spp.	*Macrophomina* spp.	*Rhizoctonia solani*
					
Rf-3-3					

Isolates	Rf - control/ Pathogen control	*Corynespora cassiicola*	*Alternaria* spp.	*Macrophomina* spp.	*Rhizoctonia solani*
Rf-10-1					
Rf-16-3					
Rf-27-1					
Rf-27-2					
Rf-28-2					
Rf-28-3					
Rf-A					
Rf-B					

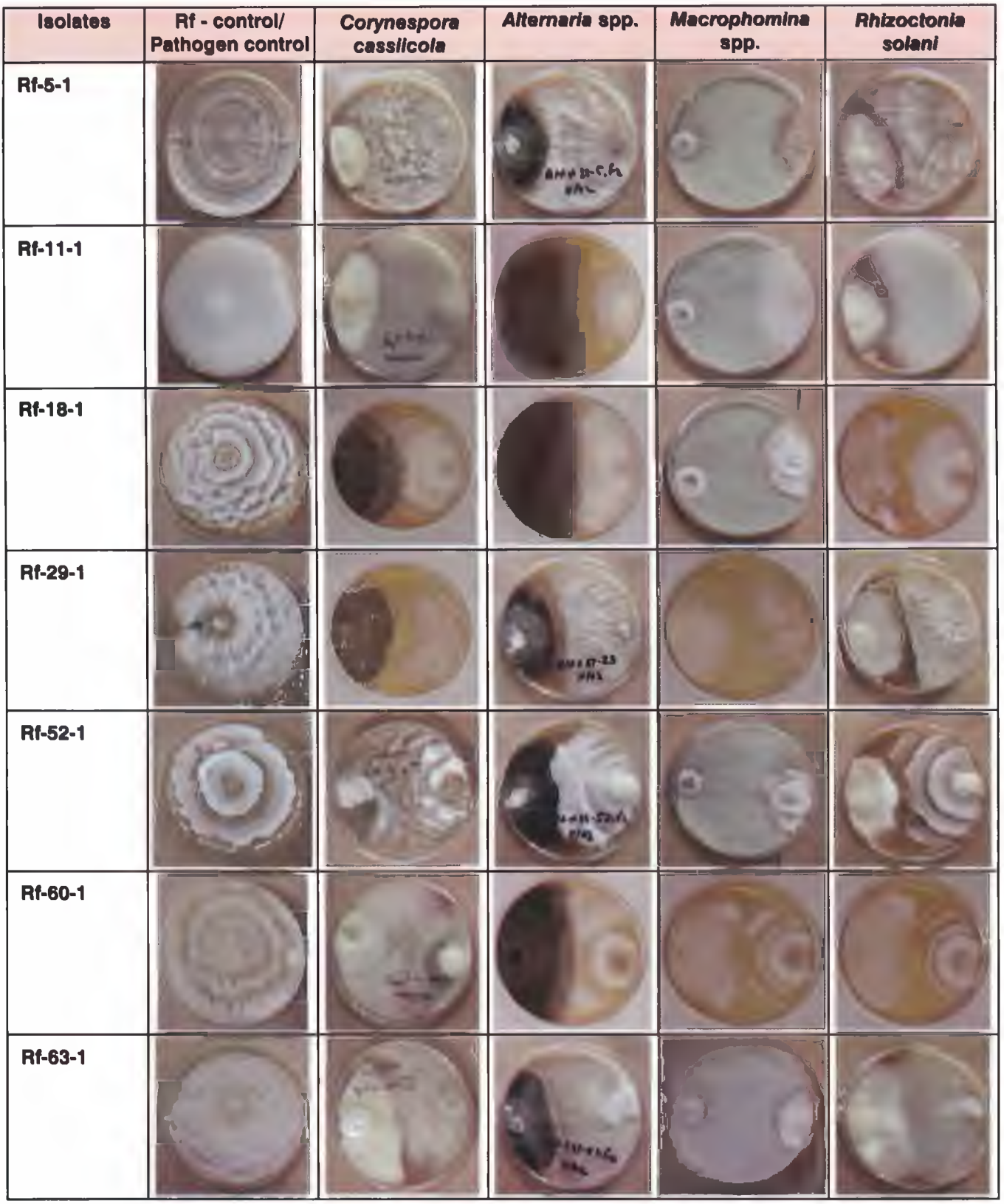


Fig.4.12.2 Antagonistic activity of rhizospheric fungi (Rf) against soil borneand follar fungal pathogen of cotton using dual culture technique

4.13 Project Name : Microbial interventions for potassium nutrition in cotton

Dr Savitha Santosh (PI); Co-PIs: Dr Ramkrushna, G.I., Dr A. Manikandan

Importance of the study : Potassium (K) is the third major macronutrient after nitrogen (N) and Phosphorous (P), which plays a key role in various biochemical and physiological processes in plants. In India, fertilizer K demands are met by importing the entire amount as there are no exploitable reserves

of potassic minerals in India, causing extensive foreign exchange outflow. Thus, there is a need for alternative native K source to maintain K status in soils for sustainable crop production. Despite soil being rich in K in India, the available soil K fraction is only 1-2% and the rest is bound to other minerals and thus is unavailable to plants. Microorganisms play a significant role in the mineralization of nutrients from insoluble minerals. The microbial solubilization of unavailable K can substitute significant part of crop's K requirement and which in turn can help to reduce import of K fertilizers.

Salient findings :

Six efficient potassium solubilising microbial (KSM) isolates were shortlisted based on their growth promotional activity and quantitative estimation of K released under laboratory conditions. Based on 16S rRNA gene sequencing, the efficient isolates were identified and the gene sequences of the selected isolates have been submitted to NCBI database. These isolates were deposited in ICAR-NBAIM, Mau for conservation of genomic material and accession numbers were obtained for the same. List of submitted isolates with their accession numbers-

Lysinibacillus fusiformis KSM1- NAIMCC-B-02844

Enterobacter spp. KSM2- NAIMCC-B-02843

Brucella intermedia KSM3- NAIMCC-B-02840

Enterobacter cloacae KSM4- NAIMCC-B-02841

Alcaligenes faecalis KSM5–NAIMCC-B-02839

Enterobacter hormaechei KSM6- NAIMCC-B-02842

Soil incubation experiment was conducted under laboratory conditions by using different types of soil (Black and red soils). Based on this, three efficient isolates were shortlisted for pot culture studies. Pot experiment was conducted for three efficient KSM isolates with different level of recommended dose of K (50% (15 kg/ha) and 75% (22.5 kg/ha)) in black vertisols and Red soil with cotton. The available soil K estimated by flame photometry at 30 days after sowing recorded higher potassium availability in soils treated with KSM isolates compared to control in black and red soils (Figure 4.13.1). The pathogenicity of the strains was tested by haemolytic activity (on blood agar base with 5% sheep blood) and DNase activity. The colonies without any zone will indicate no hemolytic activity and DNase activity is visualized as clear zones around colonies when the plates were flooded with 1 N hydrochloric acid. All the isolates tested showed negative results hence confirmed to be non-pathogenic.

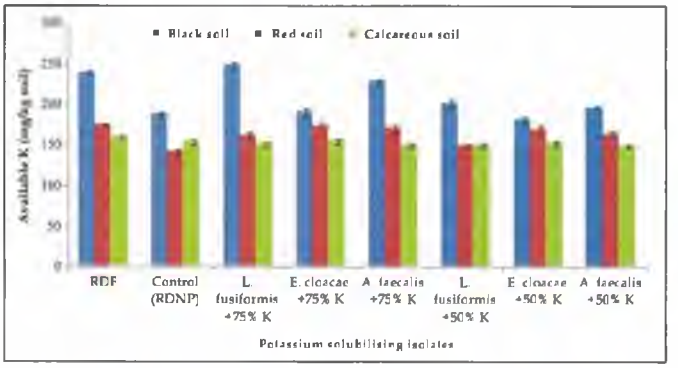


Fig 4.13.1: Influence of KSM isolates on available K in Black and Red soil @30 days after sowing under pot culture conditions

Theme 5 : Socio-economic dimension of cotton production system, technology dissemination, outreach, impact assessment and industrial linkages

5.1 Project Name : e-Communication Dissemination of Cotton Technology

Dr S. M. Wasnik (PI), Co-PI: Dr Usha Rani, Dr O. P. Tuteja (Up to March 2021)

Importance of the study : Extensive use of modern technology and mobile phones in recent times seems to have great influence on farming too. Therefore, information and communication technologies (ICTs) have a possibility of strengthening the linkages among research, extension and farmers. An initiative by ICAR-CICR, e- Communication project aims to deliver the cotton production technologies to majority of the farmers across large population in less time. The relevant, understandable and need based information in local languages provided to farmers help them to take timely and appropriate crop management decisions.

Salient Findings :

Collaboration with teleservice industries for delivering bulk voice messages

IT firm Tube light Communications Ltd, Mumbai was engaged up to August 17, 2021 for sending the voice messages to already registered cotton farmers of Nagpur, Coimbatore and Sirsa. It also covered the farmers under various IRM centres across the country. Afterwards, the new IT firm Go 2 Market India Pvt Ltd, New Delhi took up and continued the task of sending bulk voice messages to the registered farmers.

Farmer's Registration and e- Communication beneficiaries' *database*

3307 new farmers were registered from Nagpur centre and more than 99,000 farmers were registered from various IRM centres. e- Communication farmers' database was developed using information of total 2,65,374 registered farmers from all the three centres of ICAR-CICR.

Delivery of voice messages

Around 18- 52 messages in different local languages covering various aspects including mitigation measures for tackling extreme weather conditions like rains, agro-practices, pest attack, pink bollworm in cotton, etc. were recorded as noise free and clear voice calls/alerts by the centres. A total of 1,08,21,782 pre-recorded automatic phone calls (75,17,218 in Marathi, 5,84,704 in Tamil; 2,07,062 in Hindi languages from Nagpur, Coimbatore & Sirsa, respectively)were pushed for benefits of the registered farmers during the year.

Integrated Cotton Mobile App

Integrated Cotton Mobile App, developed in 2019in English is now also available in Hindi, Marathi, Kannada and Gujarati languages. The app includes information about the varieties & hybrids, production technology, protection technology, farmers outreach, news, weekly advisories etc. Content in the app is

available as per north zone, south zone, and central zone in respective modules for better user interface. More than 5000 users have already downloaded this app. Farmers can also use the discussion forum, which enables them to interact with one another, and to share general problems, ideas, and solutions. Guest Login is available to users who do not want to register.

5.2 Project Name : FPO based Agribusiness Model for Cotton Marketing in Maharashtra

Dr. Sundaramurti Y (PI); CCPI : Dr. A.R. Reddy, Dr Ramkrushna G I

Importance of the study : Existing market mechanism for cotton in Maharashtra was assessed under the project,'An Inclusive Agribusiness Model for Sustainable Cotton Marketing in the State of Maharashtra to identify and assess agri-business model to improve the profitability of cotton farmers and mechanism(s) needed for implementation with the financial assistance of NASF.

Salient Findings :

The study was conducted in six cotton growing districts of Maharashtra during 2018-19 to 2020-21. It was found that cotton farmers are selling their produce mainly to three agencies; village merchants, traders in the nearby towns and ginning mills. Cotton Corporation of India is another agency to which farmers sell their produce in the event of prices falling below the MSP.

About 30 percent of the respondents sold their produce to the village merchants while another 46 percent sold to the traders in the nearby town. Remaining 24 percent farmers sold their cotton to the ginning mills directly. Farmers got highest price (Rs. 5225/q) when they sold to ginners directly and lowest when they sold to village merchants (Rs. 5087/q). Seed cotton when ginned and sold separately as lint and seed fetched a price of Rs. 6200/q. Commercial utilization of the cotton stalks was not found. About 70-80 % of the cotton stalks are burnt in the field, 10-15 % is used as household fuel and less than 5% cotton stalks are ploughed back into the field with the help of rotavator. Farmers incur additional cost of Rs.800-1000/ per acre for removal of the stalks.

Farmers Producer Organization (FPO) based marketing model is proposed to overcome the bottlenecks in marketing and utilization of cotton stalks. As an FPO, farmers can overcome the issues of quantity, transportation, rejection and benefit from collective bargaining power. They can enter into contract with the ginners/traders with regard to price. In the study area FPOs are active in conducting marketing activities on small scale. Generally, FPOs are involved in input supply and custom hiring of implements and machinery. Output marketing was limited to Arhar, Gram, Soybean and Wheat. The produce thus collected are converted into dal and flour with the help of processing machinery provided by the government on subsidized rates. The study also revealed that these FPOs are facing many constraints due to which they are not able to expand their activities. Lack of capital and lack of storage facilities are the two top most constraints faced by all the FPOs in the study area. Capital is very crucial as they have to pay for the produce they purchased from the farmers. There is a time gap between processing the produce and sale in the market. Due to urgent cash needs farmers often resort to distress sale to agencies who pay without delay.

Similarly, warehouses are needed to store the produce purchased from the farmers until they get higher price. In the absence of storage facility, they are forced to sell the produce procured from the farmers immediately, thus unable to make good profits. Lack of professional marketing skill is another constraint expressed by the FPOs. Most of the FPOs are managed voluntarily by some of the members who are functioning as directors. To engage skilled manpower is beyond the capacity of the FPOs. Maintaining records/ registers, online filling of GST forms etc needs trained persons. As the business volume of many FPOs is very less, employing manpower becomes uneconomical. Lack of interest on the part of members as well as directors is another problem faced by the FPOs. Still many of the members are not sure about the benefits of the FPOs. Most of the FPOs do not pay any salary or incentives to those who participate in the activities of the FPO. Price risk is another problem as most of the FPOs are in their initial stages of development and work with limited capital; their risk bearing ability is less. Hence, they are unable to venture into output marketing in a big way. FPOs need to be supported with capital and storage facilities as well as technical support. This model can be implemented to improve the profitability of the cotton farmers.

5.3 Project Name : Economic Analysis of Value Chain of Cotton Market in Tamil Nadu

Dr. Isabella Agarwal (PI)

Importance of the study: Farmers who primarily grow cotton in their fields perform various practices right from sowing of cotton to picking, storing and finally selling the cotton. With a large number of small and uneducated growers, it is difficult to manage quality since many intermediary marketing agents are involved from farm to the ginning factories. Cotton produced by farmer is mostly marketed through this local intermediaries /commission agent. These agents purchase the seed cotton from growers and after weighing and loading it transport to ginning factory. Ginners are the third important component in the marketing channel of seed cotton. The lack of an efficient feedback system at all levels of the cotton chain hinders information flow and scope for change in practices needed to improve the quality of cotton. In this situation, it is the mills that bear the brunt of poor quality cotton as it impacts the production of quality yarn and fabrics. Knowing the commercial importance of cotton at the country and state levels, it is felt that there is need to map the cotton chain (consisting of producer and various processors) and study the same through functional and financial analysis.

Salient findings :

The secondary data collected regarding the cotton value chain in Tamil Nadu shows that the State has more than 959 cotton man-made fiber textile mills (919 spinning mills (SSI units) and 40 composite mills in the non-SSI sector) In nonSSI sector, there are 18 exclusive weaving mills and four 100 per cent of export oriented mills. Coimbatore cluster has around 919 spinning units which are more than 40 % of total units in Tamil Nadu. Total Yarn production in Coimbatore is around 387 Million kgs which is 25% of Tamil Nadu's Production. Tiruppur is known as the Knitting City of India. European countries are the major importers of Tiruppur Textile Products (majorly Knitted variety). The type of Units in Tirupur encompasses Knitting 24%, Dying & Bleaching 11%, Fabric Printing 8%, Garment Making 40%,

Embroidery 4%, Other Ancillary Units 8% and Compacting and calendaring 5%. Global Companies that sourcing from Tiruppur: are NIKE, ADIDAS, GAP, TOMMY HILFIGER, KATZENBERG, VAN HEUSEN, FILA, ARROW, WALMART, SEARS, MOTHER CARE, H & M.

Interview schedule has been designed to collect data from the stakeholders viz., farmers including details on their main occupation, education, land holding details, cropping pattern, input costs, farm operations and labour employed/ acre, marketing details and storage costs, constraints etc. In case of Ginning / Spinning / Weaving Units, details on Investment on Processing Unit, Fixed and Variable cost parameters. Employment of labour details in the unit, Procurement of raw material (Cotton/ lint/ yarn), Processing of cotton and their value added products, Disposal of the products and returns, problems encountered – procurement, processing, marketing and financial aspects, constraints etc. are to be collected. A total of ten cotton growing districts have been selected for the study comprising of 300 sample cotton farmers in total. Due to pandemic situation, primary data is yet to be collected.

5.4 Project Name : Ex Ante Analysis of the Impact of COVID 19 on Cotton Economy in India

Dr. Isabella Agarwal (PI); Co-PI: Drs. A.R. Reddy, Amarpreet Singh

Importance of the study : The impact of COVID-19 on the economy is no doubt devastating and its impact on agriculture is complex and varied across diverse segments that form the agricultural value chain. The migration of workers from few parts to their native places has also triggered panic buttons, as they are crucial for both harvesting operations and post-harvest handling of produce in storage and marketing centers.

Salient findings :

Global Cotton Scenario during the pandemic period

Indian cotton scenario was not deterred by the pandemic as the production was 6.3 mill MT when compared to 6.4 mill MT during 2019 but at the world level, there was seven per cent decline. Brazil and India showed marked increase in export during the same period. At world level, cotton export was registered at 7.78 per cent increase, 8.9 per cent increase in cotton imports and no effect on the cotton consumption scenario in almost all the major cotton consuming countries like China, India, Pakistan, Bangladesh, Turkey, Vietnam etc. in 2020 as that of the previous year.

Domestic Cotton Scenario during pandemic period

There was a decline of 2.79 per cent in cotton area planted in cotton growing States of India, 1.64 per cent increase in cotton production and 4.91 per cent increase in cotton yield during 2020-21 as that of previous year 2019-20. There was a drastic reduction in the cotton arrivals to the tune of 31.6 per cent during the pandemic period as a result of lockdown resulting in labour and transport problems combined with fewer prices for cotton. There has been an increase in cotton price to the tune of 11.25 per cent during 2020-21 as compared to 2019-20.

District wise Cotton Scenario during pandemic period

In North Zone, a total of 317 cotton farmers were contacted in person for the data collection from 77 cotton farmers of six districts in Punjab, 167 farmers of five districts in Haryana and 73 farmers of three districts in Rajasthan. In case of Central Zone, 120 farmers from four districts in Maharashtra, 250 farmers from eight districts of Andhra Pradesh and Telengana, 40 from Dharwad district of Karanataka and 90 from four districts of Tamil Nadu in South Zone. Analysis confirmed that though the area sown had decreased, there was no impact on cotton production or marketing due to lockdown. In North Zone, inputs were sufficient and easily available to 100 per cent of the famers excepting for irrigation wherein 5.39 per cent of the farmers faced shortage not due to pandemic but the dependability on canal irrigation (Nehri Pani) water. In Central Zone, most of the cotton farmers expressed that there was no difficulty in getting seed for sowing during 2020-21. There was a little difficulty in getting fertilizer and their transportation due to Covid 19. Labour availability for loading and unloading and its transport was the major impediment in the Southern Zone. It is to be stressed at this juncture that in the Covid-19 pandemic year, the cotton value-chain, like others, had faced unprecedented disruptions.

5.5 Project Name : Development of Extension Model for Promoting the Production of Extra Long Staple Cotton in India

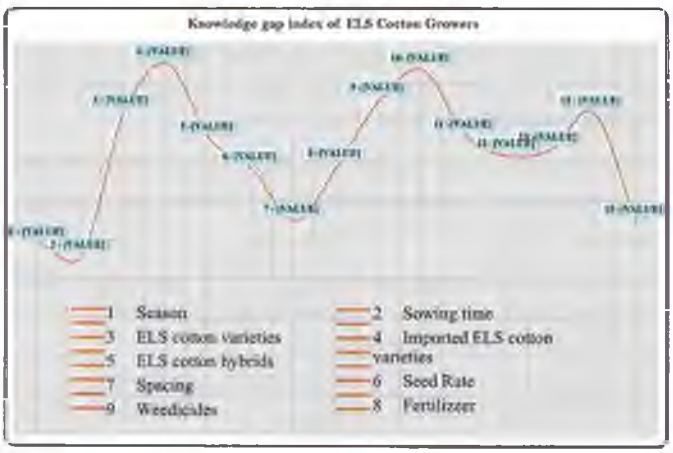
Dr. (Mrs) S. Usha Rani (PI); Co-PI: Dr. S. Manickam, Dr K. Sankaranarayanan, Dr M. Sabesh, Dr M. Amutha, Dr P. Valarmathi and Dr S. M. Wasnik

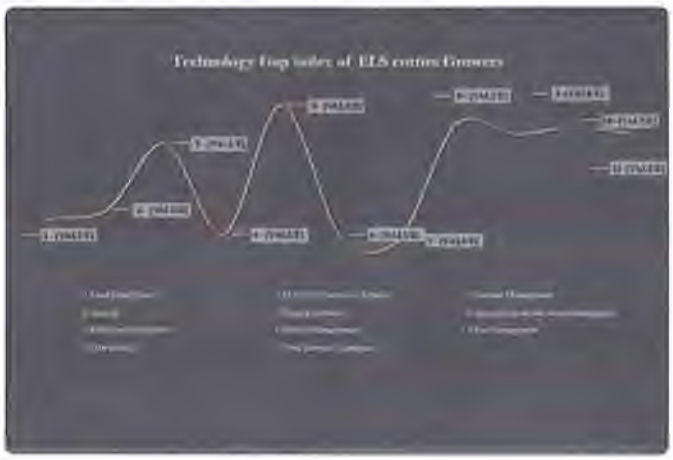
Importance of the study : India is the second-largest producer and the largest consumer of ELS cotton in the world. Indian production of ELS during 2020-21 was 5 lakh bales of 170 kg, and consumption was 10.2 lakh bales with a deficit of 5.2 lakh bales. To meet the above requirement, India has to import significant quantities of ELS Cotton namely Supima from USA, Giza cotton from Egypt as well as some quantities of CIS and Sudan cotton. The textile industries in the country fear that the current international rates of ELS cotton and market resistance to increase the price of super fine yarn would pose great challenges. Considering the demand of ELS cotton and the challenges faced by its stakeholders, the cotton research system has to find out means to foster the domestic production of ELS cotton. In view of that an extension research project has been in operation with the institute since 2020.

Salient findings :

The project aims at analysing the cultivation behaviour of ELS cotton growers and for that primary data were collected from 120 ELS cotton growers from Tamil Nadu and Karnataka. The analysis on collected data revealed that almost half of the respondents (49.00%) had positive towards cultivation of ELS cotton. Analysis on knowledge level revealed that the knowledge gap index was more in knowledge about usage of refuge crops in ELS Bt cotton hybrids, available ELS cotton varieties and hybrids, suitable weedicides, suitable intercrops, chemicals for managing sucking pests / Pink Boll worm and adoption possibility of drip irrigation in ELS. The analysis on technology gap revealed that technology gap index was more in technologies about nutrient management, planting methods, disease management, pest management, harvesting and post-harvest techniques. The range of average seed cotton yield obtained by the respondents in study area was 500-1500kg/ha (61.67%), 1500-2000kg/ha (31.67%) and 2000-2500 kg/ha

(6.67%). The range of average cost of cultivation incurred by the respondents for cultivating ELS cotton per hectare in the study area was Rs. 45000 – Rs. 60000 (70.85%), Rs.60000 – Rs.80000 (16.67%) and Rs. 80000 – Rs.100000 (12.50%). The perceived opinion of the respondents about potential yield that can be obtained per hectare was 2500 to 3000 kg/ha. The perceived opinion of the respondents about expected price per kg of ELS cotton was Rs. 80 to Rs. 100 per Kg (intra specific hybrids) and Rs.150 – Rs. 200 per kg for pure *G. barbadense* varieties. Analysis on the marketing behaviour of respondents revealed that majority of them sold the produce at farm gate to the village merchants immediately after harvest for ready cash. Cent percent of the respondents opined that out of their own interest and tradition, they cultivated ELS cotton and so far no promotion methods implemented for promotion of ELS cotton cultivation in the study area. Pre sowing rate contract with CCI, forming FPC, Forming FPO/ CIG / FIG for bargaining power and contract with private companies were the future promotion methods suggested. Low yield, long duration, high susceptibility to pests and diseases, climate change impacts, high labor requirements, sensitivity to water logging and nutrients deficiency, competition from high value crops, high production cost, low and non-stable market price and lack of policy support were the major constraints encountered by the respondent in cultivation of ELS cotton. Based on the FGD and survey results, a model was "Pluralistic Extension Model for Fostering the Production of ELS cotton" was conceptualized. The support extended by the ICAR-AICRP on cotton centre at UAS, Chamarajanagar in collecting the primary data at Study area is duly acknowledged.



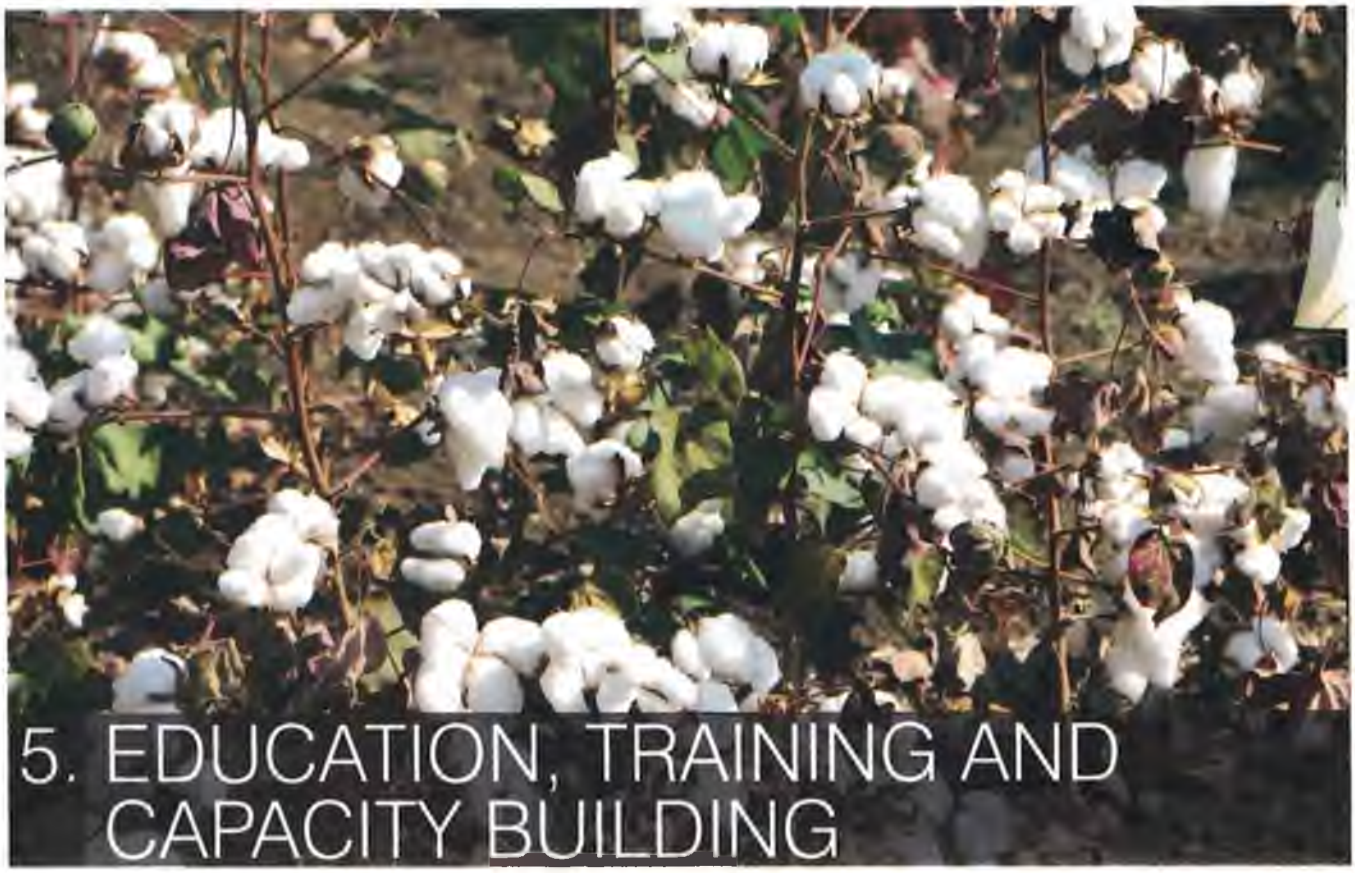


4. TECHNOLOGIES ASSESSED AND TRANSFERRED

Egg parasitiod, *Trichoderma bactrae* (NBAIR strain) was evaluated under field condition to standardise the dosage and frequency of application in the management of pink bollworm in cotton. The most effective schedule was found to be the release of 60,000 parasitized eggs/ acre in three equal doses (@20,000/release) with first release at flowering stage (50-60 DAS) and second and third release at boll formation stage (75-90 DAS) at 15 days interval. The mass production technology for Trichocards of *T. bactrae and T. chilonis* were also standardized under laboratory condition at ICAR-CICR, Nagpur.

Front Line Demonstrations (FLD) under the National Food Security Mission (NFSM) (Commercial Crops)

Front Line Demonstration is a proven extension mechanism with the objectives of demonstrating the usefulness of the latest improved crop production and protection technologies to the farmers as well as extension workers with a view to reduce the time gap between technology generation and its adoption. This novel programme was implemented in 1996 for cotton crop to demonstrate cotton production technologies through the networking centres of All India Coordinated Research Project (AICRP) on Cotton. Since then, AICRP on cotton has been conducting FLD on cotton through its network centers and by the ICAR- Central Institute for Cotton Research, Nagpur and its regional stations in Coimbatore and Sirsa. Until 2013, these demonstrations were conducted on Production Technology, Integrated Pest Management and on Farm implements under Technology Mission on Cotton, Mini Mission II. Since 2014-15, FLDs have been conducted under the National Food Security Mission on Cotton (NFSM) – Commercial Crops. During the year 2020-21 under NFSM-Commercial Crops, a total of 500 FLDs on Integrated Crop Management (ICM), 296 FLDs on Desi / ELS cotton / ELS cotton seed production and 130 FLDs on intercropping with cotton were allotted to ICAR-AICRP on Cotton with a budget outlay of INR 77.00 lakh. Out of the allotted FLDs, a total of 514 FLDs on Integrated Crop Management on cotton, 271 FLDs on Desi / ELS cotton / ELS cotton seed production and 128 FLDs on intercropping with cotton were conducted by nineteen centers of All India Coordinated Research Project on Cotton.



5. EDUCATION, TRAINING AND CAPACITY BUILDING

5.1: Training and Capacity Building

5.1.1: Training Received

International

Scientist

Name of Scientist	Name of the Training	Place/Organized by	Period
Dr A. Manivannan, Dr K. Baghyalakshmi	Seed Quality Enhancement under the aegis of Indo-German Cooperation on Seed Sector Development	TNAU Coimbatore	23-25, June 2021

National

Scientist

Name of Scientist	Name of the Training	Place/Organized by	Training Date
Dr G.I.Ramkrushna, Dr. Amarpreet Singh	Integrated Nutrient Management and Nutrient Budgeting through Advanced Models to Improve Crop Productivity	ICAR-IISWC Research Centre, Udhagamandalam, Tamil Nadu	18-22, January 2021
Dr R. Raja	Geo-informatics in agriculture using open-source data and analysis platforms (Online mode)	Division of Agricultural Physics, ICAR-IARI, New Delhi	01-05, March 2021
Dr M.V. Venugopalan	Implementation and Use of Agricultural Research Management System (ARMS)	ICAR-IASRI, New Delhi	08 June 2021
Dr. D.V. Patil	16th Generic Online Training of Government Personnel of Central Government Ministries / Department in Cyber Security	CDAC, Hyderabad	29 July 2021

Name of Scientist	Name of the Training	Place/Organized by	Training Date
Dr S. Usha Rani, Dr K. Baghyalakshmi	Climate Change: Challenges and Response for Women Scientists, (Virtual platform)	Centre for Disaster Management (CDM), LBSNAA, Mussoorie, DoPT, GOI	09-13, August 2021
Dr K. Sankaranarayanan	Strategies for climate risk management and resilient farming	MANAGE &CRIDA, Hyderabad	20-24, September 2021
Dr K. Velmourougane, Dr H. B. Santosh	E-training programme on Emotional Intelligence at Workplace for Scientists and Technologists	Centre for Organization Development, Hyderabad Sponsored by: DST, MOST, GoI	20-24, September 2021
Dr A. R. Reddy	Data Analysis in Social Sciences Research (online)	ICAR-NAARM, Hyderabad	04 October 2021
Dr A.R.Reddy Dr G. Balasubramani	Online course on Parliament Question and Answers	PARI, New Delhi,	08 November 2021
Dr. K. Velmourougane	NABL Assessors Training course on ISO/IEC 17025:2017 (Level 2 Onsite) at Chennai	NABL, New Delhi	21-23, October 2021
Dr Rishi Kumar	Management Development Program (MDP)on Priority Setting, Monitoring and Evaluation (PME) of Agriculture Research Projects	ICAR-NAARM, Hyderabad	25-30, October 2021
Dr S. Manickam , Dr H. B. Santosh	Analysis of Multi-location experiment	ICAR- NAARM, Hyderabad	28-30, October 2021
Dr A .Manivannan	DST sponsored Proteomics advanced winter school 2021	IIT Bombay	08-19, November 2021
Dr. A. Manikandan	Integrated Nutrient Management and Nutrient Budgeting through Advanced Models to Improve Crop Productivity	ICAR-IISWC Research Centre,Udhagamandalam, Tamil Nadu	29 November -03 December, 2021
Dr. Amarpreet Singh	Advances in Weed Management for Sustainable Agriculture	ICAR-Directorate of Weed Research, Jabalpur & Indian Society of Weed Science	13-18, December 2021
Dr. V.N. Waghmare, Dr V. S. Nagrare	Management Development Programme on Leadership Development (A pre-RMP)	ICAR-NAARM, Hyderabad	13- 24, December 2021
Dr Saravanan M	SNP mining, GWAS and Genomic selection	ICAR-IASRI, New Delhi	16-21 December 2021

Technical Staff:

Name of Technical	Name of the Training	Organized by	Training Date
Sh. Paresh Bhoyar	16thGeneric Online Training of Government Personnel of Central Government Ministries/ Department in Cyber Security	CDAC, Hyderabad	29 July 2021
Sh. Rohit Katiyar, Smt. Anisha V, Sh. Kopulla Suresh, Sh. Chandrashekhar Mundafale	Appropriate sampling techniques including sample preparation and preservation for soil, water, plant and air samples for various analysis	ICAR-IARI, New Delhi	02-07, August 2021
Sh. Sanjay Kushwaha	Online training Programme towards Making a Secure & Resilient workplace	ICAR-CPRI, Shimla	01-03, September 2021
Smt. Chetali S. Rodge	E-Governance Applications in ICAR for Technical Staff	ICAR-IASRI, New Delhi	06-10, September 2021
Smt. Pooja B Ghonge, Dr Vrushali Deshmukh, Sh. Homraj Mundafale	Statistical techniques for data analysis in Agriculture	ICAR-IASRI, New Delhi	04-13, October 2021
Smt. Swati Dixit	National Level Capacity Building Workshop for Agricultural LIS professionals	PJTSAU, Hyderabad	22-27, November 2021
Smt. Vandana Satish	Advances in Web and Mobile Application Development	ICAR-NAARM, Hyderabad	06-10, December 2021

Administrative Staff:

Name of Administrative staff	Name of the Training	Place/Organized by	Training Date
Mr. A. A. Goswami, Mr. Yashwant Sorte, Mr. Rakesh Tiwari, Mrs. R. R. Kulkarni, Mr. EAM Ismail, Mrs. D. N. Gudhane, Mr. N. P. Tupte, Mr. V. D. Bende, Mrs. S. P. Kharche, Mr. Manas Aswal, Mr. V. M. Waghmare, Mr. K. B. Nandeshwar, Mr. A. M. Kawale, Mr. Saurabh Patil, Mr . Sheetal Kumar Sharma, Mrs. R. G. Iyer, Mr. M.C. Tiwari, Mr. S. S. Chalkhure, Mr. P. P. Ambade,	Training program on Skill Upgradation of Administrative Staff of ICAR-CICR, Nagpur	ICAR-CICR, Nagpur	12 February 2022
Mrs. R. Kulkarni, Sh. N.P. Tupte, Mr. Kapil Nandeshwar	Accrual Accounting	ICAR-NRRI, Cuttack	26-30 July, 2021

Student Education Tour/field visit to ICAR-CICR Nagpur

Sl.No.	College / Institute Name	No. of Students	Course	Date of Visit
1	Shri Sewakbhau Waghaye Patil College of Agriculture, Kesalwada	6	B. Sc. Agri. 8th Semester	26.08.2021
2	Late R.G. Deshmukh College of Agriculture, Tiwsa	2	B. Sc. Agri. 2nd Semester	02.11.2021

List of Colleges and Universities signed MoU with ICAR –CICR, Nagpur

Sl. No.	Name of University /College	Date of Signature
1.	Chaudhary Devi Lal University (CDLU) Sirsa, Haryana	2021
2.	Department of Biosciences and Bioengineering, Indian Institute of Technology, Roorkee	2021

Student Research

Sl No.	Name of student	Name of advisor	Thesis title
1.	Ms. Shrishti Roy	Dr. K.P.Raghavendra	Screening of *Bacillus thuringiensis* isolates for insecticidal genes and plant growth promoting parameters
2.	Mr. Piyush Ghukse	Dr. N. Chandrashekar	Morphological and biochemical studies in drought tolerance of cotton
3.	Ms.Ritika Waghmare	Dr. K. Velmourougane	Investigations on biochemical, soil biological, antioxidant and defense enzyme activities of wild species of cotton
4.	Mr. Paras Jangade	Dr. J. H. Meshram	Isolation and characterization of native rhizobacteria from cotton rhizosphere for osmotic stress tolerance
5.	Ms.Anamika Pandagre	Dr.J.Amudha	Gene expression in drought tolerant cotton (*Gossypium hirsutum*) genotypes
6.	Ms. Apurva Dange	Dr. G. Balasubramani	Molecular analysis of putative transgenic cotton
7.	Diksha Ramteke	Dr. Savita Santosh	Screening for potential lignocellulolytic and plant growth promotional microbial isolates and to assess their role in cotton stalk valorizations

5.1.2: Training Imparted

Students Training Imparted

Name of Training	Place/Organized by	No. of participants	Period
In-Plant Training/ Hands -on Training on Food Processing; Seed Production and Technology ; Production Technology for *Trichogramma* and Bio-agents ;Pheromone T rap Production ; Soil, plant, water Testing ; Vermicomposting ; Organic cotton Production and Tissue Culture.	ICAR-CICR, Nagpur	4(B. Sc. Agri.) SHUATS, Naini Prayagraj	01.10.2021 to 12.11.2021

5.2: Trainings organized for farmers and extension functionaries

Name of the Training	Organized by	Place & Date	Participant Category	Number of participant (Male)	Number of participant (Female)
FLDs					
Training on cotton production technology & seed distribution	ICAR-CICR RS, Sirsa	KVK-CCSHAU, Bawal, Rewari (Haryana) 27 April 2021	Farmers	30	0
Field Survey for observing the cotton -field problems and providing advisory to the farmers in Haryana	ICAR- CICR RS, Sirsa	Village Shahuwala, Randhawa, Kanwarpura, Nirban (Haryana) 17 July 2021	Farmers	20	0
Field Survey of the affected cotton crop in Village Kanwarpura, district Sirsa (Haryana)	ICAR- CICR RS, Sirsa	Village Kanwarpura, Sirsa (Haryana) 28 August 2021	Farmers	15	0
Training on cotton production & protection technologies cum CICR cotton -variety exo programme	ICAR- CICR RS, Sirsa	ICAR- CICR RS, Sirsa 17 September 2021	Farmers	20	0
Institute					
Virtual orientation session cum training on long linted desi cotton production	ICAR - CICR, Nagpur	Nagpur 26 June 2021	Field team of BCI	50	10
Online state level training progr am on advanced technology for enhancing cotton production for the cotton growers of North India	ICAR-CICR,RS, Sirsa & GSP Crop Science Ltd.	ICAR-CICR Regional Station Sirsa 28-30, June 2021	Farmers	800	0
Recent advances in sucking pest management in cotton	ICAR-CICR Nagpur	Nagpur 30, June 2021	Staff of Bayer Crop Sciences Pvt Ltd	90	10
Training Programmes Series on "Advanced Cotton Production Technologies" for North India in collaboration with RIGS Sustainable Solutions Pvt. Ltd.	ICAR-CICR, RS, Sirsa	Sirsa 15-19, July 2021	Farmers	200	0
Interactive session cum exposure visit of post graduate students of CDLU	ICAR- CICR RS, Sirsa	ICAR- CICR Regional Station, Sirsa 22-23, July 2021	Student	25	20
Training Programme on "Recent Advances in Cotton Crop Pro duction and Protection Technologies for North India" with the sponsorship of Better Cotton initiative (BCI) & Ambuja Cement Foundation (Bathinda). (Virtual mode)	ICAR-CICR, RS, Sirsa	Sirsa 24 July 2021	Farmers	127	0
Training on safer cotton production & p rotection technologies	ICAR- CICR RS, Sirsa	ICAR- CICR RS, Sirsa 13 August 2021	Farmers	20	0

Name of the Training	Organized by	Place & Date	Participant Category	Number of participant (Male)	Number of participant (Female)
In-season one day training on *desi* cotton production for IPs of BCI	ICAR-CICR, Nagpur	ICAR-CICR, Nagpur 07 September 2021	Extension Functionaries	26	2
Interface meeting on enhancing cotton productivity in North Zone: Way Forward (Hybrid mode)	ICAR-CICR, RS, Sirsa	Sirsa 07 September 2021	CICR Employees	106	0
Campaign on Nutri-Garden and Tree Plantation	ICAR- CICR RS, Sirsa	ICAR- CICR RS, Sirsa 17 September 2021	Farmers, Students, employees etc	150	20
Web Training Program on "Recent Advances in Cotton Crop Protection with Emphasis on Pink Bollworm"	ICAR- CICR RS, Sirsa & Nuziveedu Seeds Ltd.	ICAR- CICR RS, Sirsa 08 October 2021	Farmers	200	0
Training Program for Agro-Input Dealers	HAMETI (Jind) and ICAR- CICR RS, Sirsa,	Krishi Bhawan Sirsa 09 October 2021	Agro Input Dealers	40	0
Training programe for agro-input dealers	HAMETI (Jind) and ICAR- CICR RS, Sirsa,	ICAR- CICR Research Regional Station, Sirsa 17 October 2021	Agro Input Dealers	45	0
Training to manage diseases in cotton (virtual)	Division of Crop Protection, ICAR-CICR Nagpur	ICAR-CICR Nagpur 22 October 2021	Field personnel/ Representatives from BCI	50	10
IRM					
Sensitization workshop on pink bollworm to gin ning mill owners, input dealers and other stakeholders	ICAR - CICR, RS, Coimbatore	Coimbatore 19January 2021	Ginning mill owners, input dealers and State Department Officials	126	72
Kisan Mela organized at ICAR - CICR Regional Station, Sirsa	ICAR-CICR, RS, Sirsa	Sirsa 26 March 2021	Farmers	360	0
IPM in cotton		Warora, Chandrapur 05 August 2021	Farmers	48	8
Field demonstration on monitoring of pink bollworm using pheromone traps	ICAR - CICR, RS, Coimbatore	Sokkanur and Kallapuram villages of Coimbatore District 28 August 2021	Farmers	42	8
One day Farmers Field training and Inputs Distribution	ICAR-CICR, Nagpur	Bhadravathi, Chandrapur 31August 2021	Farmers	44	6
Farmers training cum awareness campaign on pink bollworm	ICAR-CICR, Nagpur	ICAR-CICR, Nagpur 16 September 2021	Farmers	66	22
Farmers Field Training	ICAR - CICR, RS, Coimbatore	Kinathukadavu, Coimbatore 27 November 2021	Farmers	48	12

Name of the Training	Organized by	Place & Date	Participant Category	Number of participant (Male)	Number of participant (Female)
"Krishi Kirtan" for creating mass awareness and providing guidance to the cotton farmers on pest and diseases managemen t in cotton	ICAR-CICR, Nagpur	Girad Tah. Samudrapur Dist. Wardha 01December 2021	Farmers	140	35
MGMG					
Training on cotton production & protection technologies	ICAR- CICR RS, Sirsa,	VillageKhedi Kagdaana, Sirsa 08 July 2021	Farmers	20	0
Training on cotton production & protection technologies	ICAR- CICR RS, Sirsa	Village Chaaharwala Sirsa 08 July 2021	Farmers	60	0
Diagnostic field visit -cum- on farm guidance to the cotton farmers	ICAR-CICR, Nagpur	Adasa,Varoda and Sonapar Tah. Kalmeshwar, Dist. Nagpur 13 July 2021	Farmers	30	10
Farmers' training programme in Chaaharwala, Khedi Kagdaana, Hanjira and Chadiwal, Sirsa	ICAR-CICR, RS, Sirsa	Chaaharwala, Khedi Kagdaana, Hanjira and Chadiwal villages 26 August 2021	Farmers	110	0
Visit and Farmers Training Progra mme on cotton production & protection	ICAR- CICR RS, Sirsa	Village Chadiwal, Sirsa 26 August 2021	Farmers	30	0
Visit and Farmers Training Programme on cotton production & protection	ICAR- CICR RS, Sirsa	Villages Hanzira, Sirsa 26August 2021	Farmers	20	0
Training on cotton production & protection technologies cum CICR Cotton -Variety Exo program	ICAR- CICR RS, Sirsa, MGMG	ICAR- CICR RS, Sirsa, 17 September 2021	Farmers	20	0
Farmers training on Clean Picking of Cotton and PBW management strategies	ICAR- CICR RS, Sirsa	Villages Chaharwala, Sirsa 02 October 2021	Farmers	25	0
NFSM (CC)					
State -level training on latest cotton technologies under NFSM (CC) scheme for Extension officials of Haryana	ICAR-CICR RS, Sirsa, NFSM (CC)	ICAR-CICR RS, Sirsa 14-15 January 2021	Farmers	80	0
Farmers training on latest cotton technologies under NFSM (CC)	ICAR-CICR RS, Sirsa, NFSM (CC)	ICAR-CICR RS, Sirsa 20 January 2021	Farmers	23	0
Farmers training on latest cotton technologies under NFSM (CC)	ICAR-CICR RS, Sirsa, NFSM (CC)	ICAR-CICR RS, Sirsa 22 January 2021	Farmers	50	0
Farmers training on latest cotton technologies under NFSM (CC)	ICAR-CICR RS, Sirsa, NFSM (CC)	ICAR-CICR RS, Sirsa 28 January 2021	Farmers	50	0
Farmers training on latest cotton technologies under NFSM (C C)	ICAR-CICR RS, Sirsa, NFSM (CC)	ICAR-CICR RS, Sirsa 29 January 2021	Farmers	50	0

Name of the Training	Organized by	Place & Date	Participant Category	Number of participant (Male)	Number of participant (Female)
State-level training on latest cotton technologies under NFSM (CC) scheme for Extension officials of Haryana	ICAR-CICR RS, Sirsa, NFSM (CC)	ICAR-CICR RS, Sirsa 08 March 2021	Farmers	50	0
State-level training on latest cotton technologies under NFSM (CC) scheme for Extension officials of Haryana	ICAR-CICR RS, Sirsa, NFSM (CC)	ICAR-CICR RS, Sirsa 09 March 2021	Farmers	50	0
Farmers training cum field day	ICAR-CICR RS, Sirsa, NFSM (CC)	ICAR-CICR RS, Sirsa 10 March 2021	Farmers	50	0
SCSP					
Training cum input distribution to SC cotton farmers of Wardha district under SCSP	ICAR-CICR, Nagpur	Pimpalgaon and Durgada Tah. Deoli Dist: Wardha 11 June 2021	Farmers	60	25
Training cum input distribution to organic cotton farmers of Girad cluster of Wardha district under SCSP	ICAR-CICR, Nagpur	Girad Tah. Samudrapur, Dist. Wardha 16 June2021	Farmers	20	5
Farmers training cum input distribution under SCSP	ICAR-CICR, Nagpur	Welsakhra Tah. Umred Dist. Nagpur 16 July 2021	Farmers	20	10
Poshan Vatika Maha Abhiyan & Tree plantation and training on integrated pest management in cotton	ICAR-CICR, Nagpur	Dhurkheda, Tah. Umred Dist: Nagpur 17 September-2021	Farmers	180	40
TSP					
One day farmers training and groundnut seeds distribution program	ICAR-CICR, Nagpur	ICAR-CICR, Nagpur 28 January 2021	Farmers	43	7
Farmers training cum workshop program on cotton & summer mung cultivation	ICAR-CICR, Nagpur	KrishiVigyan Kendra, Gadchiroli 10 February 2021	Farmers	186	14
One day farmers training and groundnut seeds distribution	ICAR-CICR, Nagpur	KVK, Nagpur 11February 2021	Farmers	48	2
One day farmer's training on production and protection techniques on cotton	ICAR-CICR, Nagpur	KVK, Nadurbar 04 June 2021	Farmers	80	0
Farmers training cum seed distribution	ICAR-CICR, Nagpur	KVK, Gadchirolli 10 June 2021	Farmers	188	12
One day training cum seed distribution under TSP	ICAR-CICR, Nagpur	ICAR-CICR, Nagpur 15 June 2021	Farmers	29	5
Farmers training and inputs (vegetable seed kit, cotton picking bag and pheromone trap) distribution programme	ICAR-CICR, Nagpur	Boath, Adilabad, Telangana 08 July 2021	Farmers	48	2
One day farmers field training cum inputs distribution and demonstration of mass trapping under TSP	ICAR-CICR, Nagpur	Bela, Adilabad, Telangana 21 August 2021	Farmers	80	20

Name of the Training	Organized by	Place & Date	Participant Category	Number of participant (Male)	Number of participant (Female)
Farmer's training –cum-exposure visit and input distribution under TSP	ICAR-CICR, Nagpur	ICAR-CICR, Nagpur 30 September 2021	Farmers	25	0
Farmer's training –cum-exposure visit and input distribution under TSP	ICAR-CICR, Nagpur	ICAR-CICR, Nagpur 05 October 2021	Farmers	10	35
Farmers training cum input distribution	ICAR-CICR, Nagpur	KVK, Sonapur, Gadchiroli 30 November 2021	Farmers	87	12
One day farmers training and groundnut seeds distribution program	ICAR-CICR, Nagpur	ICAR-CICR, Nagpur 28 January 2021	Farmers	43	7
Farmers training cum workshop program on cotton & summer mung cultivation	ICAR-CICR, Nagpur	KVK, Gadchiroli 10 February 2021	Farmers	186	14

6. AWARDS AND RECOGNITIONS

Name of the officer	Name of the Award/Recognition	Awarded by	Conferred on
Dr A. Sampathkumar	Best Poster Award	International conference on "Industrial perspective, challenges and strategies in the development of novel bio-pesticides : Its implication in sustainable pest and disease management" at TNAU Coimbatore	12-03-2021
Dr P. Nalayini	Foreign visit grant of INR 25,000/- for participation as invited speaker in 78th plenary meeting of ICAC, Brisbane, Australia Dec 2-5, 2019	Indian Society of Agronomy	15-03-2021
Dr Satish Kumar Sain	Best oral paper presentation award	Indian Phytopathology Society, New Delhi	27-03-2021
Dr Amarpreet Singh	Best Oral Presentation Award	Astha Foundation, Meerut, U.P., India	21-07-2021
Dr Amarpreet Singh	Excellence in Research Award	Society for Scientific Development in Agriculture & Technology (SSDAT)	21-07-2021
Dr Saravanan M.	Bharat Ratna Mother Teresa Gold Medal Award	Global Economic Progress and Research Association	24-07-2021
Dr A. Manikandan	ICAR-Post Doctoral Fellow	ICAR-Indian Agricultural Research Institute, New Delhi	11-10-2021
Dr A. Manivannan	Agricultural Scientist Award 2021	Dr Vasantharaj David Foundation, Chennai	17-10-2021
Dr M. Amutha	Agricultural Scientist Award-2021	Dr Vasantharaj David Foundation, Chennai	17-10-2021
Dr J.Gulsar Banu	Scientist of the Year 2021 Award	National Conference on Agricultural Sciences - 2021	29-10-2021
Dr M. Amutha	Excellence in Research Award -2021	Indian Society for the Promotion of Agricultural Sciences	30-10-2021
Dr A. Manivannan	First prize in oral presentation	CPBG, TNAU, Coimbatore	07-11-2021
Dr V. Chinna Babu Naik	Awarded AZRA, Avvaru Seethamma Memorial Award-2021	Applied Zoologists Research Association (AZRA), Cuttack, India	12-11-2021
Dr Blaise Desouza	ISA Gold Medal	Indian Society of Agronomy	25-11-2021
Dr M. Amutha	Best oral presentation Award-2021	Centre for plant protection studies, Tamil Nadu Agricultural University, Coimbatore	10-12-2021

Dr. Blaise Desouza receiving ISA Gold Medal from Indian Society of Agronomy

7. LINKAGES AND COLLABORATIONS

Areas of Linkages	Institution
Refinement of spindle type header prototype for development of a cotton picker	CSIR-CMERI-CoEFM, Ludhiana
Crop pest surveillance in Maharashtra.	CROPSAP, Maharashtra
Insecticide Resistance Management (IRM): Dissemination of Pink bollworm Management Strategies.	DAC, Govt of India and SAUs (Dr PDKV Akola, VNMKV Par bhani, MPKV Rahuri, NAU Surat, JAU Junagarh, RVSKVV Gwalior, UAS Dharwad, UAS Raichur, PITSAU Hyderabad and ANGRAU Guntur)
Development of consensus genetic linkage map for *Gossypium* spp.	DBT, Ministry of Science and Technology, Govt of India
Development of thermal tolerant strain of biocontrol agent, *Acerophagus Papaya* for sustainable management of papaya mealybug,	DST-SEED, Ministry of Science And Technology, Govt of India
Pink bollworm: Resistance Monitoring, Fitness Costs, Inheritance of Resistance to Cry toxins	DST-SERB, Ministry of Science And Technology, Govt of India
Genetic diversity pink bollworm in India	DST-SERB, Ministry of Science And Technology, Govt of India
Implementation of PVP legislation 2001 and DUS testing of cotton.	Protection of Plant Varieties and Farmers' Rights Authority, Govt of India
Evaluation of insecticide combinations against insect pest complex of cotton	M/s Gharda Chemicals Ltd, Thane Mumbai
Monitoring changes in baseline susceptibility to Cry toxins in cotton bollworms	MAHYCO, Jalna
ICAR project on Seed Production in Agricultural Crops and Fisheries.	ICAR, New Delhi
An Inclusive Agri -Business Model for Sustainable Cotton Marketing in the State of Maharashtra.	NASF, New Delhi
Quantitative estimation of carbon and moisture fluxes over the cotton based agro-ecosystem.	National Carbon Project, ISRO, Hyderabad
IPM strategies to combat whitefly and other emerging pests of cotton.	NICRA, Hyderabad
National Seed Project (Crops)	ICAR, New Delhi
Transgenic research plant protection	CSIR and NBRI, Lucknow
Pheromone technology	CSIR and IICT, Hyderabad
Molecular mapping	TNAU, Coimbatore and UAS, Dharwad
Value addition Naturally colored cotton	Dr. PDKV, Akola and ICAR -CIRCOT, Mumbai
Student collaboration for research	RTMNU, Nagpur
Production and commercialization of Bt cotton varieties.	Maharashtra State Seeds Corporation Ltd. (Mahabeej), Akola
Seed production and commercialization of Bt cotton varieties (Suraj Bt, Rajat Bt, GJHV 374 Bt and PKV 081 Bt)	Farmer Shri Raju Gotmare, Beed- Borgaon, Hingna
Seed production/ multiplication and commercialization of cotton varieties (Suraj , Surabhi, CNA 1003 (Roja) & CNA 1028) developed by ICAR- CICR	Group of tribal farmer, Beed -Borgaon, Hingna
HRD of implementation partners of BCI programme in India	Better Cotton Initiative, New Delhi
Whitefly management	PAU, Ludhiana, HAU, Hisar RAU, Sriganganagar
Dissemination of weekly advisories and HRD of officials on BMPs for cotton	State Agricultural Departments of cotton growing states
Strengthening Bt referral lab for BT/HT tests	DAC, GoI

8. ICAR-AICRP ON COTTON

Bt cotton identified during 2020-21

Eight Bt varieties, 69 Bt hybrids and 22 conventional cotton varieties/ hybrids were identified during the year, in the VIC meeting held under the Chairmanship of Hon'ble Deputy Director General (Crop Science)on 09/04/2021 through virtual mode. Similarly, 8 Bt varieties, 56 Bt hybrids and 27 conventional varieties & Hybrids were notified.

Review Meeting of ICAR-All India Coordinated Research Project on Cotton

The review meeting of ICAR-All India Coordinated Research Project (ICAR-AICRP) on Cotton was held on 9th January 2021 at ICAR- CICR, Regional Station, Coimbatore under the Chairmanship of Dr. C.D. Mayee, Chairman-Program Advisory and Monitoring Committee for ICAR-AICRP on cotton. Dr. B.M. Khadi, Former Director, ICAR-CICR, Dr. T.M. Manjunath, Former Director, Monsanto Research Centre, Dr. A. R. Sharma, Director of Research, Rani Lakshmi Bai CAU and Dr. Y.G. Prasad, Director, ICAR-CICR, Nagpur participated in the event as members of the Program Advisory and Monitoring Committee. The status report of ICAR-AICRP on Cotton was presented by Dr. A. H. Prakash, Project Coordinator (Cotton Improvement) and Head, ICAR-CICR RS, Coimbatore which was followed by presentation of progress reports by Principal Investigators. The Principal Investigators, Drs. S. Manickam, K. Sankaranarayanan, Rishi Kumar, Satish Kumar Sain, Pradeep Kumar Mandhyan and S. Usha Rani presented the progress reports of Plant Breeding, Agronomy, Entomology, Pathology, Quality Evaluation and NFSM-FLD, respectively. The honourable members and the Director, ICAR-CICR expressed their suggestions and the chairman offered concluding remarks. The meeting concluded with the vote of thanks proposed by Dr. S. Usha Rani.

9. KRISHI VIGYAN KENDRA

Trainings

On campus and Off campus training

One hundred thirty six short duration (1 to 3 days) on-campus and off-campus training courses were conducted in different disciplines for practicing farmers, rural youth and extension functionaries. In all 6181 participants including 1741 SC/ST participants benefited from the training programs. No. of female beneficiaries were 2803

Sponsored training programme

Nine sponsored training programmes were organized in the field of Crop Production, Horticulture, Plant Protection, Veterinary Science and Home Science for farmers and extension functionaries, deputed by State Agriculture Department of Maharashtra, ATMA, CIPMC, Nagpur, RCF, MAFSU Nagpur, MCED & ICDS Nagpur, NGOs. In all 737 participants attended these courses. In all 423 participants including 171 women benefitted.

Cluster Front Line Demonstrations on Oilseed and Pulses

Four CFLDs on oilseeds soybean (MAUS-158), groundnut (TAG-24)) & pulses pigeon pea(BDN-716), chickpea (Rajvijay-203) were conducted in the adopted villages of Nagpur district viz., Bendoli, Bothli, Nagazari, Amgaon, Chargaon & Surabardi. These demonstrations were conducted on 150 farmers field covering 80 ha. area.

Front Line Demonstrations

1. Horticulture

High yielding variety of Onion Bhima Shakti

Thirty six demonstrations on high yielding variety of Onion Bhima Shakti were conducted. The average yield in the demo plots was 2650 kg/ha as against 2000 kg/ha in check plots. the cost of cultivation was lower (Rs. 22, 500 per ha) in demo plots as against Rs. 23,300 in check plots.

Imparting training to the participating farmers

High yielding variety of Onion Bhima Shakti

2. Plant Protection Integrated management of defoliators in Soybean & Chickpea

Crop	No. of farmers	Area	Yield	Check	% increase	Parameters of			
						Demo plots		Check plots	
			Avg.			No. of defoliator /MRL	B:C Ratio	No. of defoliator / MRL	B:C Ratio
Soybean (MAUS-158)	13	5.2	19.5	15.25	27.87	2.48	3.20	3.59	2.59
Chickpea (Digvijay)	13	5.2	22.6	18	25.55	2.61	3.20	3.79	2.6

3. **Livestock Production**

1) **Supplementation of Probiotic to cross bred cows**

20 gm of Probiotic powder was supplemented in the daily diet of 15 crossbred cows of 15 farmers for 90 days. There was 13.04% increase in milk yield with an average daily milk yield of 7.9 l/cow and 6.9 l/cow in demonstration and local check, respectively. An increase of 13.51% was also observed in milk fat content in demonstration group (4.2%) over local check (3.7%).

2) **Scientific cultivation of Hybrid Napier variety BHN-6**

Hybrid Napier variety BHN-6 (BAIF Variety) was cultivated on 15 farmers field on 3 hectares of area. There was an increase of 6.42% in green fodder yield in demonstration plot (235.40 q/ha) as compared to local check variety CO4 (221.20 q/ha). On feeding greens, the average milk yield in demo group was observed as 7.85 lit/cow/day over local check i.e. 7.50 l/cow/day with 4.67% change in parameters.

3) **Supplementation of mineral lick blocks to the local goats**

Hanging mineral lick block were provided adlibitum to 30 local goats for the period of 90 days. Reproductive performances and milk yield of local goats supplemented with mineral blocks were improved as compared to local check. All of the 30 goats in demonstration group conceived when supplemented with mineral blocks, whereas, 27 goats conceived in local check. Average daily milk yield increased by 10% in demonstration group (0.550 kg/goat) as compared to local check (0.500 kg/goat).

4. **Home Science**

Performance of soymittens in harvesting soybean crop

While harvesting soybean crop using of VNMKV, Parbhani Soymitten covers 19% more area with less increase (33) in ΔHeart Rate as compared to check (39).

On Farm Trials (OFT)

Summary

For management of leaf reddening in Bt cotton, application of NPK @ 90:45:45 Kg/ha with alternate spray of 2% Urea and 2% DAP along with1% $MgSO_4$ was beneficial. This practice increased yield (17.65 q/ha as against 13.37 q/ha in farmers practice) and B:C ratio (3.22 as against 2.26 in farmers practice).

1. For **weed management in soybean**, post emergence application of Imazelhapyr 35% and Imazimix @ 40 g/acre was beneficial. This practice gave higher weed control efficiency (67.1 as against 58.7 in farmers practice), higher yield and higher B:C ratio.
2. **Bt cotton varieties** viz., ICAR-CICR PKV081 Bt and ICAR-CICR Rajat Bt were found promising for HDPS under rainfed conditions.
3. **Short duration marigold varieties**-Pusa Basanti and Arka Bangara gave higher yields than farmers practice (variety Suvan). The B:C ratio were 3.6:1for Suvan, 6.2:1 for Pusa Basanti and 5.4:1 Arka Bangava.
4. **Tomato hybrids** Arka Rakshak (350 t/ha) and Arka Samrat (210 t/ha) gave higher yield compared to local check Abhinav (195 t/ha).Highest B:C ratio (3.5:1)was with Arka Rakshak as against 3.1:1 with Abhinav.
5. **Integrated management of pink bollworm (PBW) in Bt cotton hybrid**: Among the technologies assessed the following integrated management gave better control of PBW. The yield also increased by 28.3% over farmers practice.
   i. Installation of pheromone traps @2/acre for monitoring at square formation
   ii. Spray azadiractin 300 ppm @ 50ml/10 l at flower initiation
   iii. 6 to 7 inundative releases of *Trichogramma chilonis* 60,000 per acre
   iv. Plucking of rosette flowers.
   v. ETL based application of Thiodicarb 75 WP 20 g per 10 l water at boll formation followed by Deltamethrin 2.8 EC 10 ml per 10 l water

6. **Integrated management of pod borer complex in Pigeon pea :** Among the technologies assessed the schedule comprising of 1st spray Azadirachtin 300 ppm 50 ml /10 l water 2nd Spray Emamectin Benzoate 5 SG 3 g/10 l water 15 days after 1st spray . 3rd spray Lamda cyhalothrin 5 EC 10 ml/10 l water based on ETL gave best control of pod borer and improved yield by 25%over farmers practice.
7. **Assessment of performance of new breeds of Chicken under Back Yard System :** A total of 130 birds (6 weeks old) of each improved varieties i.e. CARI-Nirbheek and Giriraja were distributed to 13 farmers of Panjari village of Nagpur Tahsil. These birds were reared under free range system with minimum inputs. The details of the parameter of evaluation were as follows :

Sr. No.	Parameters	Farmer's Practice (TO1) Local chicken	Technology Option (TO2) CARI-NIRBHEEK	Technology Option (TO3) GIRIRAJA
1	Mean body weight kg/bird	1.10	1.78	1.77
2	Age at sexual maturity days	185.71	170.42	160.26
3	Gross cost (Rs/bird	315.00	315.00	315.00
4	Gross return (Rs/bird)	688.00	995.00	820.00

Thus, CARI-Nirbheek birds may be recommended for rural back yard poultry system instead of local breed to fetch more income.

Backyard Poultry birds of breed CARI-Nirbheek

8. **Evaluation of fodder hybrid Napier varieties under scientific management** was conducted at Umred tahsil, Nagpur district. Two multi-cut perennial varieties - Super Napier and BNH-10 were compared with local prevalent variety CO4 on 4.68 ha area on 13 farmer's field. Both Super Napier and BNH-10 showed better performance in terms of green fodder yield, number of tillers, number of leaves and milk yield on feeding of greens than locally grown CO4 variety. Green fodder intake was more when Super Napier was fed to the cows. That might be due to less serration, high succulence and good palatability of Super Napier.

9. **Assessment of different models of Nutrition Garden for small land holders for Nutritional Sustainability at farmers backyard :** Area under production of vegetables in Nutrition Garden in all trials is 21 sq m. for four family members. Quantity of Green leafy vegetables (GLV) , cucurbitaceous vegetables & other vegetable produced through improved practice in T3 is 96 kg in Rabi season which is higher and better as compared to T2 (71 kg) & T1 (32 Kg) .Thus it helps to save Rs. 1003/ month /family.

10. **Assessment of cultivation of Cole crops in Nutrition Garden through IPM Model with Organic input**

    Cultivation of Cabbage and cauliflower (cole crops) along with trap crop such as marigold, Coriander, mustard, sorghum using organic input jivamrut, Panchgavyapulse seed based micronutrients and Dashparni, waste decomposer result excellent quality produce with increased yield of Cole crops in T3 .The BC Ratio of T3 is 2.68.

Attracting and retaining rural youth in Agriculture (ARYA)

Under ARYA, KVK-CICR, Nagpur is focusing on two enterprises to improve the lively-hood of rural youth under this project. 1) Production of disease free sampling Nagpur mandarin 2) Fruits and vegetable processing.. During the year 2021-2022, the KVK trained 375 rural youths on the production of disease-free seedlings of Nagpur mandarin and 485 rural youth on custard apple processing, its value addition, and preparation of pickles, citrus juice and solar drying of vegetables. Additionally, KVK provided technical support to rural youth of Katol block for the multiplication of Nagpur mandarin seedlings. 15 rural youth beneficiaries developed their own nursery after successfully completing the training. Five Green shade net houses are built at the farms of rural youth for developing diseases free citrus nursery. Three units of pickle processing; two units of sugarcane processing, one unit each of custard apple pulper, solar drying unit for chilli processing are running successfully at Besa, Beltarodi, Chichbhuvan, Gondbori, Wakodi, Bhiwapur. A total of 2000 citrus plants are being raised in nursery for budding process at KVK, Nagpur. Ten rural youths from Ladgoan, Kukadipanjara villages of Katol Tahsil have established disease-free nurseries of citrus and Nagpur mandarin after acquiring training under ARYA.

Integrated Farming System (IFS) for Doubling Farmer's Income

Krishi Vigyan Kendra, Nagpur has developed an Integrated Cotton based IFS module in 2021 covering one hectare area. This IFS is having three components *viz.*, crop component (Cotton + Soybean), Horticulture component (vegetable & fruits) and animal components (Goat, cow, fish) and allied enterprise (mushroom cultivation).

- In Horticulture Component all seasonal vegetables of Kharif and Rabi crop are grown organically.

- Organic waste is also converted into manure using Waste Decomposer.
- 179 Mango plants of Amrapali was planted in March 2021 in high density method and 56 Guava of L-49 variety are planted in June 2021 on mulch
- Nearly 750 Dignitaries, Tribal & Schedule Caste farmers, Farm Women, RAWE students, SHG were visited. Skill training on Nursery raising, Seedling transplanting on mulch, Operation of drudgery reduction tools were provided.
- A model of Cole Crops with Bio Control was demonstrated.
- A low cost, Outdoor, Mobile Oyster Mushroom Unit was established
- A model shade for a family of 2-4 person for care and maintenance was established. A low cost shades for goat and Desi Cow were also constructed
- A fish pond having Rohu, Katla, Mrigal was established.

Events

Installation of Agro Automatic Weather Station

The India Meteorological Department has installed an Agro Automatic Weather Station at the Agromet observatory of KVK, ICAR- CICR, Nagpur on 07thMarch, 2021. Observations on the air temperature, humidity, rainfall, wind speed and direction at 3 and 10 meter height, duration of sunshine, soil moisture and temperature at depth of 10, 30, 70 and 100 cm at 15 minute interval are being recorded. Data is used for the preparation of

Agromet Advisory Service. The weather data recorded from the observatory is available at http://aws.imd.gov.in/

International Women Day on 8th march-2021

International women's day was celebrated at KVK, ICAR-CICR, Nagpur with great zeal and enthusiasm on 8th March 2021.

Dr. Y.G. Prasad, Director ICAR-CICR, Nagpur graced the occasion as chief guest while A. A. Goswami, Sr. Administrative Officer, Dr. Nandini Gogte, Head Crop Protection Division, Dr. Suman Balasingh, Principal Scientist, Division of Crop Improvement, were present. During the event, staff who are superannuating in the coming months were felicitated for their excellent contribution and dedicated service to the institute. To showcase the talent of women, various competitions like essay writing on topic "Strong Women for a Strong Nation", rangoli competition, fancy dress competition and singing competition were organized. The winners were honoured with cash prizes.

National Campaign on Poshan Abhiyan and Tree Plantation on Sept. 17, 2021

The programme was jointly organized by KVK, ICAR-CICR, Nagpur and IFFCO to create awareness amongst the stakeholders about importance of millets in our diet and their beneficial role in providing good health.

Hon'ble Union Minister for Agriculture and Farmers Welfare, Shri Narendra Singh Tomar ji inaugurated the Mega Convention through video conferencing. At CICR-KVK, the key note address on the "Importance of millets in human diet" was delivered by Dr. Renuka Mainde, Professor (Food and Nutrition), LAD college, Nagpur. The SMS (Home Science) and SMS (Horticulture) also delivered lectures on the importance of tree planting. Around 100 seed packets and 1000 plants supplied by IFFCO, Nagpur were distributed to the women of self help group, girl students and farm women.

World Soil Day

The"World Soil Day" Programme, organised at Chargaon village on 05-12-2021, was attended by 140 participants including 110 farmers and 20 Students. The Guest of Honour, Mrs Shalutai Parteki, Member Gram Panchayat, urged the farmers to take full advantage of information given by the Scientists. Dr Subhash Patil explained the causes of ill health of soil and urged the farmers to follow good agronomic operations for maintenance of soil health. Dr Ulhas Galkate urged the farmers to use organic manures to improve the physical condition of soil. Dr Sachin Wankhede spoke on effect of climate change on soil health.

Swachhta Pakhawada - Under this program various activities related to cleanliness were carried out from 16/12/2021 to 31/12/2021.

Meetings/ Workshop/Conference/Training attended

Name of the officials	Name of event	Location	Date
Meetings			
Smt. Sunita Chauhan	Hortalk-55 International Year of Fruits and Vegetables	Webinar	03.01.2021
Dr. S. N. Rokde	Israel's Agriculture best practices	Webinar	12.01.2021
Dr. S. N. Rokde	Identification of Thrust Areas & State Training Needs in Agriculture & Allied Sectors	Online Workshop	18-19.01.2021
Dr. S. N. Rokde	Government's New Initiatives in Agriculture	National Webinar	22.01.2021
Dr. P.B. Deulkar	Know your Milk Food: Facts & Myths of A1 &A2 Milk	Webinar	23.01.2021
Dr. S. N. Rokde	Inaugural session of National Horticultural Fair 2021	Online	08.02.2021
Dr. S. N. Rokde	State Level Annual Action Plan Workshop	Online	09-10.02.2021
Dr. S. N. Rokde	VAMNICOM & CNRI's Global Conclave on Structural changes required for Innovative Agriculture Value Chain: Opportunities ahead for Collectives	Online	12-13.02.2021
Dr.S.N. Rokde, Dr. U. V. Galkate	Sensitizing Extension Professional for Successful Livestock Farming Models to Develop *Atamnirbhar Kisan*	Webinar	19-20.02.2021
Dr. S. N. Rokde	Agriculture Research through Knowledge Discovery	Webinar	23.02.2021
Dr. S. N. Rokde, Dr. S. S. Patil	KVKs as Leaders in Natural Farming Education	Webinar	25.02.2021
Dr. S. N. Rokde	Agricultural Extension and Advisory Services: Innovations to Impact	Online MANAGE International Conference 2021	25-27.02.2021
Dr. S. N. Rokde, Dr. S. S. Patil	Enterprise Solutions for FPO Management Experiences from Agri-Startups	Webinar	27.02.2021
Dr. S. N. Rokde, Dr. S. S. Patil	FPO Orientation Workshop for KVKs	Webinar	05.03.2021
Dr. S. N. Rokde, Dr. S. S. Patil	Block chain – Disrupting the Agriculture Sector	Webinar	06.03.2021

Name of the officials	Name of event	Location	Date
Dr. S. N. Ro kde, Dr. S. S. Patil	Agri-Startups driving Agri-Input Sector	Webinar	13.03.2021
Dr. S. N. Rokde, Dr. S. S. Patil	MANAGE-Centre for Innovation and Agripreneurship: Offerings and Opportunities for Agri-Startups	Webinar	03.04.2021
Dr. S. N. Rokde	*Bhoomi Suposhan Jan Jagran*	Webinar	15.04.2021
Dr. S. N. Rokde, Dr. S. S. Patil	DFI Network Project	Sensitization Workshop	22.04.2021
Dr. S. N. Rokde	Agri-Startups and Contract Farming Models	Webinar	22.05.2021
Dr. S. S. Patil	Strengthening Community Based Organisations through KVKs	Webinar	03.06.2021
Dr. S. S. Patil	Virtual Conference on New Innovations & Digital Technologies for Agriculture	Online	17-18.06.2021
Dr. S. S. Patil	Role of weed biology in improving weed management strategies	Webinar	22.06.2021
Dr. S. N. Rokde	Rodent Management	Online	01.07.2021
Dr. S. N. Rokde	Emerging IoT Technologies and Application in Farming	Webinar	09.07.2021
Dr. S. S. Patil, Dr. U. V. Galkate	Training programme on *Kisan Sarathi*	Online	24.07.2021
Dr. S. N. Rokde	Annual Review Workshop of DAMU	Online	29.07.2021

Technical bulletins

i. *Fale va Bhajipala Prasanskran Papai Jam va Papaiche Cheri* [Fruits and Vegetables Processing - Papaya Jam and Papaya Cherry] by Dr Deepa Lal. Editor: Dr S.N.Rokde, PS & Head, KVK, ICAR, CICR, Nagpur. Publisher 'Dr Y.G. Prasad, Director, CICR,Nagpur

ii. Mixed Fruit Jam [by Dr Deepa Lal. Editor: Dr S.N. Rokde. PS & Head, KVK, ICAR-CICR, Nagpur. Publisher 'Dr Y.G. Prasad, Director, CICR, Nagpur

Popular articles

i. Rokde, S.N. (2021) "*Shetkaryancha Devdut : Aaj Aahe Bhartiy Kisan Diwas* [God's Messenger for Farmers : Today is Indian Farmer's Day] Published in Vichakshan e-weekly . dated 23.12.2021

ii. Rokde S.N., (2022) "*Utpann wadhisathi pratyek shelyanche shastriy padhtine vyawsthapan*"[Scientific Management of Goats for enhancing production] Published in Vichakshan e-weekly dated 31.1.2021

iii. Rokde, S.N., Pundalik Deulkar and U.V. Galkate (2022) "*Vidarbhatil Shetkaryanchasathi Chalta Firta* Demand Draft" [Walking Demand Draft for Farmers in Vidarbha- Goat] Published in Vichakshan e-weekly dated 14.2.2021

iv. Rokde, S.N., Pundalik Deulkar and U.V.Galkate (2022) "*Sankarit Gaiche dudhutpadan wadhvinyasathi uapay*" [Scientific ways to enhance milk production of crossbred cows] Published in Vichakshan e-weekly dated 14.2.2021

Radio Talks (AIR, Nagpur) delivered

i. Smt. Sunita Chauhan, SMS (Home Sci.), - "Oyster Mushroom Production and its marketing - 24.02.2021

ii. Dr. P. B. Deulkar (Farm Manager) -"Care and Management of Animals in Summer" broadcasted - 17.03.2022

TV Talks (Krishi Darshan, DDK Sahyadri channel)

Dr. Ulhas Galkate, SMS (Veterinary Science) - "Cultivation of Perennial fodder crop" - 17.03.2021

10. GENERAL

10.1 : Research papers published in refereed journals

10.1.1 Research Papers

10.1.1.1 Research papers (NAAS rating > 6)

1. Kumar, M., Tomar, M., Punia, S., Grasso, S., Arrutia, F., Choudhary, J., Singh, S., Verma, P., Mahapatra, A., Patil, S. and Dhumal, S. (2021). Cottonseed: A sustainable contributor to global protein requirements. *Trends in Food Science & Technology*., DOI: 10.1016/j.tifs.2021.02.058. **(NAAS rating: 17.08)**
2. Desouza Blaise, Kulandaivelu Velmourougane, Savitha Santosh, Angamuthu Manikandan. (2021). Intercrop mulch affects soil biology and microbial diversity in rainfed transgenic Bt cotton hybrids. *Science of the Total Environment*, 794 (2021) 148787 https://doi.org/10.1016/j.scitotenv.2021.148787 **(NAAS rating: 12.55)**
3. Patil, P. G., Singh, N. V., Bohra, A., Raghavendra, K. P., Mane, R., Mundewadikar, D. M., Babu, K. D., & Sharma, J. (2021). Comprehensive Characterization and Validation of Chromosome-Specific Highly Polymorphic SSR Markersfrom Pomegranate (*Punicagranatum* L.) cv. Tunisia Genome. *Frontiers in Plant Science*,12, 645055. https://doi.org/10.3389/fpls.2021.645055 **(NAAS rating: 10.11)**
4. Fand, B. B., Nagrare, V. S., Bal, S. K., V. Chinna Babu Naik, Naikwadi, B. V., Mahule, D. J., & Waghmare, V. N. (2021). Degree day-based model predicts pink bollworm phenology across geographical locations of subtropics and semi-arid tropics of India. *Scientific Reports*, 11 (1), 1-18. **(NAAS rating: 10.01)**
5. Raghavendra K P, Das J, Kumar R, Gawande S P, Santosh H B,SheebaJ A, Kranthi S, Kranthi K R &Waghmare V N.(2021). Genome-wide identification and expression analysis of the plant specific LIM genes in Gossypium arboreum under phytohormone, salt and pathogen stress. *Nature Portfolio Scientific Reports*, 11:9177 | https://doi.org/10.1038/s41598-021-87934-0 April 2021. **(NAAS rating: 10)**
6. Velmourougane K, Thapa S, Prasanna R. (2021). Prospecting microbial biofilms as climate smart strategies for improving plant and soil health: A review. *Pedosphere*,in press. **(NAAS rating: 9.91)**
7. Velmourougane K, Manikandan A, Blaise D, Mageshwaran.(2021). Cotton stalk compost as a substitution to farmyard manure along with mineral fertilizers and microbials enhanced Bt cotton productivity and fibre quality in rainfed Vertisols. *Waste and Biomass Valorization*, https://doi.org/10.1007/s12649-022-01689-x. **(NAAS rating: 9.70)**
8. Thapa S, Prasanna R, Ramakrishnan B, Mahawar H, Bharti A, Kumar A, Velmourougane K, Shivay YS, Kumar A. (2021). Microbial inoculation elicited changes in phyllosphere microbial communities and host immunity suppress *Magnaportheoryzyzae* in a susceptible rice cultivar. *Physiological and Molecular Plant Pathology*. doi.org/10.1016/ j.pmpp.2021.101625. **(NAAS rating: 8.75)**
9. Desouza Blaise, Keshav R. Kranthi, Chandragiri D. Ravindran & Kamlesh Thalal. (2021). High plant density can improve the productivity of rainfed Asiatic cotton

(*Gossypium arboreum* L.). *Archives of Agronomy and Soil Science*, 67:5, 607-619, DOI:10.1080/03650340.2020.1741553. **(NAAS rating: 8.14)**

10. Sain Satish Kumar, Monga Dilip, Hiremani Neelkanth S, Nagrale Dipak T, Kranthi Sandhya, Rishi Kumar, Kranthi Keshav Raj,Tuteja O P,Waghmare Vijay N.(2021). Evaluation of bioefficacy potential of entomopathogenic fungi against the whitefly (*Bemisiatabaci*Genn.) on cotton polyhouse and field conditions. *Journal of Invertebrate Pathology*, 0022-2011, 183, 107618 https://doi.org/10.1016/j.jip.2021.107618 **(NAAS rating: 8.07)**
11. V. ChinnaBabu Naik, Subbireddy, K. B., Kranthi, S., Nagrare, V. S., Kumbhare, S., Gokte-Narkhedkar, N. & Waghmare, V. N.(2021). Pink bollworm, *Pectinophoragossypiella* (Saunders) (Lepidoptera: Gelechiidae) survival on transgenic cotton in India. *Egyptian Journal of Biological Pest Control*,30 (1), 1-7. **(NAAS rating: 8)**
12. Madhu, T.N. and Mohan, K.M.(2021). Effect of host plants on the oviposition preference of pink bollworm, *Pectinophoragossypiella* (Lepidoptera: Gelechiidae). *Animal Biology*, 1(aop), pp.1-11.,in press. **(NAAS rating: 7.2)**
13. Monga D and Sain S K.(2020). Incidence and severity of cotton leaf curl virus disease on different BG II hybrids and its effect on the yield and quality of cotton crop. *J. Environ. Biol.*, 42, 90-98 (2021).p-ISSN: 0254-8704 e-ISSN: 2394-0379 **(NAAS rating: 6.78)**
14. Manivannan, A., Kanjana, D., Dharajothi, B. Meena, B.(2021). Evaluation of resistance in cotton genotypes against leafhoppers *Amrascabiguttulabiguttula* (Ishida), (Homoptera: Cicadellidae). *International Journal of Tropical Insect Science*, 41: 2409–2420. **(NAAS rating:6.77)**
15. DesouzaBlaise.(2021). Nitrogen loss from plants – an ignored aspect. *Current Science*, 121, (5), 10 **(NAAS rating: 6.73)**
16. Verma Pooja, D. Blaise, J. Annie Sheeba and Manikandan A.(2021). Allelopathic potential and allelochemicals in different intercrops for weed management in rainfed cotton. *Current Science*, VOL. 120, NO. 6, 25 March 2021. **(NAAS Rating: 6.73)**
17. Velmourougane K, Blaise, D. Manikandan A, Savitha S, Waghmare, VN. (2021). Environmental impacts of herbicide tolerant crops and glyphosate-based herbicides. *Applied Ecology and Environmental Research*. ,19(5):3481-3504. **(NAAS rating: 6.71)**
18. Shah, V,Pande, R.,Fand, B.B. Gokte-Narkhedkar N. and Waghmare V.N.(2021). Innovative on plant bioassay method for selection of superior genotype/cultivar/event against pink bollworm, *Pectinophoragossypiella* (Saunders) in cotton in protected screen house condition. *International Journal of Tropical Insect Science* ,https://doi.org/10.1007/s42690-021-00512-9. **(NAAS rating: 6.54)**
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2. Madhu T N, Muralimohan K, Arunkumara C G and Nagaraju M C.(2021). Effect of different nutrient diets on developmental and reproductive fitness of Pink bollworm, *Pectinophoragossypiella* (Lepidoptera: Gelechiidae. *J. Entomological Research* ,45 (4): 641-646 (2021) DOI: 10.5958/0974-4576.2021.00100.6. **(NAAS rating: 5.89)**
3. W Jessie Suneetha, Kumar Hemanth J,Chaitanya V, Rao Jagan Mohan P and Prasad Y G.(2021). Low-Cost Farm Implements for Enhanced Work Efficiency Amongst Farm Workers. *Journal of Community Mobilization and Sustainable Development*,16(3), 633-636. **(NAAS rating: 5.67)**
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14. Saravanan M, Misra R C, Mahajan S S, Patil D V and Waghmare V N.(2021). Morphological and molecular characterization of desi cotton (*Gossypium herbaceum* L.) land races collected from different states of India. *Electronic Journal of Plant Breeding* ,12(1):142-150. **(NAAS rating: 5.14)**

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18. Agale SV, Rangarao G V, Gupta Rajeev, Wani S P,V. Chinna Babu Naik. (2020). Population dynamics of *Helicoverpa armigera* with Pheromone traps in relation to weather Parameter in Pigeon pea. *Indian Journal of Plant Protection*. ,48(4), 87-89. **(NAAS rating: 5.07)**

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36. Prasad Y G, Venugopalan M V and Reddy A R.(2021). India Cotton Outlook. *Cotton: Review of the World Situation*, 74 (3), March 2021.
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10.1.2 Other Publications

10.1.2.1Book Chapters

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2. T N Madhu, B Doddabasappa. (2019). Electroantennogram for recording olfactory responses of an insect to plant volatiles. *Experimental techniques in Host-Plant resistance*. A K Chakravarthy, V Selvanarayanan. Edited by 53-56.Pp.English
3. S.K.Sain, Gulsar Banu, P. Valarmathi, S.P. Gawande, D.T. Nagrale, N.S. Hiremani, D. Monga, Mujeebur Rahman Khan and Rahul Kumar Sharma.(2021). COTTON: Important Disease and Nematode Problems. *Diseases of Nationally Important Field Crops*. M.R. Khan, Z. Haque and F. Ahamad. Edited by 501-537.Pp.English
4. Pratibha Sharma, P PJambhulkar, M Raja, S K Sain, S Javeria.(2020). *Trichoderma* spp. In consortium and their rhizospheric interactions. *Trichoderma Rhizosphere Biology* A K Sharma, P Sharma. Edited by 267-292.Pp.English
5. W. Jessie Suneetha, J.Hemanth Kumar, P.Jagan Mohan Rao and Y.G. Prasad. (2021). Recent Advancement on Climate Resilient Millets for Food and Nutrition Security: Time to Promote for All Seasons. *Current Perspectives on Chemical Sciences* Vol. 9 DOI: 10.9734/bpi/cpcs/v9/2179E Print ISBN: 978-93-90768-66-0, eBook ISBN: 978-93-90768-68-4 Fahmida Khan. Edited by 24-31.Pp.English
6. V.Chaitanya, J.Hemantha Kumar, B.R. Madhushekar, P. Jagan Mohan Rao, P. Sri Ranjitha , K. Ravi Kumar and Y. G. Prasad.(2021). Determining the Effect of Front Line Demonstrations on Trellis Method of Cultivation in Tomato (*Solanum lycopercicum* Mill.) in Khammam District of Telangana, India. *Current Topics in Agricultural Sciences* Vol. 5 DOI: 10.9734/bpi/ctas/v5/15034D Print ISBN: 978-93-5547-300-4, eBook ISBN: 978-93-5547-308-0.Edited by 31-38.Pp.English
7. V.N. Waghmare, M.V. Venugopalan, V.S. Nagrare, S.P. Gawande and D.T. Nagrale. (2022).Cotton Growing in India. Pest management in cotton: a global perspective LCCN 2021023836 (print) | LCCN 2021023837 (ebook) ISBN9781800620216 (hardback) | ISBN 9781800620223

(ebook) | ISBN 9781800620230 (epub) G. A. Matthews, T Miller. Edited by 30-52.Pp.English

8. Bharathi Raja Ramadoss, Usharani Subramanian, ManivannanAlagarsamy and Manu Pratap Gangola.(2021).Non-Enzymatic Antioxidants' Significant Role in Abiotic Stress Tolerance in Crop Plants.Organic Solutes, Oxidative Stress, and Antioxidant Enzymes Under Abiotic Stressors (first edition) (ISBN 9781032040523). *Arafat Abdel Hamed Abdel Latef*.Edited by 365-392.Pp.English
9. Velmourougane K, D. Blaise. (2021). Rhizoengineering: A Strategy to Enhance Soil and Crop Productivity. *Omics Science for Rhizosphere Biology*, Rhizosphere Biology, R.N. Pudake et al. (Eds.),.Edited by 235-262.Pp.English
10. Velmourougane K, Blaise D, Savitha S, Waghmare VN.(2021).Valorization of cotton wastes for agricultural and industrial applications: present status and future prospects.*Valorization of Agri-Food Wastes and By-Products: Recent Trends, Innovations, and Sustainability Challenges*, Bhat R.Edited by 665-692.Pp.English
11. Velmourougane K, Prasanna R. (2021).Microbial Management of Phosphorus in Agroecosystems: Recent Concepts and Developments. Biological Approaches to regenerative and resilient soil systems. Norman Uphoff et al. (Eds.). Edited by in press. Pp.English
12. Blaise D, Velmourougane K, Manikandan A. (2021).Conservation Agriculture in Cotton-Based System: Impact on Soil Properties. Conservation Agriculture: A Sustainable Approach for Soil Health and Food Security. Jayaraman S., Dalal R.C., Patra A.K., Chaudhari S.K. (eds).Edited by 87-115.Pp.English
13. Nalayini,P., Sankaranarayanan, K and A. H.Prakash.(2021). Climate Smart Agro Techniques for Yield Enhancement and Sustainability of Cotton Based System. *Physiological Interventions for Developing Climate Resilent Commercial crops*. 978-93-90660-53-7 E-ISBN : 978-93-90660-54-4.English
14. G Balasubramani, KP Raghavendra, Joy Das, Rakesh Kumar, HB Santosh, J Amudha, Sandhya Kranthi, KR Kranthi. (2021). Critical Evaluation of GM Cotton.*Cotton Precision Breeding*. Rahman M., Zafar Y., Zhang T. Edited by Springer, Cham. https://doi.org/10.1007/978-3-030-64504-5_16.Pp.English
15. Usha Rani, S. and Vijayalakshmi, B.(2021).Utility of Social Media for Knowledge Dissemination. Digital Technologies in Agriculture Surya Rathore, Vijayalakshmi, B and Sumanth Kumar V.V., Edited by Biotech Books, New Delhi. ISBN:978-81-7622-470-3.Pp.English

10.1.2.2 Technical Bulletins/leaflets:

1. ChinnaBabu Naik V, Dipak T. Nagrale, Shailesh P Gawande, V.S Nagrare, B BFand, Nandini Gokte-Narkhedkar and Y. G. Prasad (2021). Pink bollworm and Boll rot management in cotton. ICAR-CICR, Nagpur,.Pp6 (English)
2. O.P.Tuteja, S.K.Verma, Debashis Paul, Amarpreet Singh, V.N. Waghmare. (2021). Achievements in Cotton Improvement at ICAR-CICR,ICAR- Central Institute for cotton Research, (English)
3. Dilip Monga, Satish Kumar Sain(2020). Integrated Disease Management in Cotton. AICRP on Cotton-ICAR CICR Regional Station Coimbatore- 641003 Tamilnadu.Pp38 AICRP on Cotton Technical Bulletin No 1/2020(English)

10.1.2.3 Popular Articles:

1. A Manivannan (2021). CICR B COTTON 37 – A promising Extra Long Staple Cotton Variety. *Cotton Innovate*,Pp. 3(1):1-2., (English)
2. A Sampathkumar (2021).Cotton bacterial blight pathogen *Xanthomonas citri* pv. malvacearum: Overview on its virulence, races and genetic diversity. *Cotton Innovate* Pp. 9(1):1-3., (English)
3. A. Manivannan (2021).Relevance of semigamy for in vivo haploid induction in Cotton. *Cotton Innovation* Pp. 1(7): 26. (ISSN 2788-6611)., (English)
4. D Monga and Sain S K(2021).Threats from Emerging and New Diseases in Indian Cotton with Required Pest Risk Analysis. *Cotton Statistics & News* Pp. 38: 1-4, 21-12-2021 (English)
5. KPM. Dhamayanthi, A. Manivannan and K. Rathinavel. (2021). Cleistogamy in *Gossypium barbadense* cotton- A mechanism for self-pollination. *Cotton Innovate*, Pp. 4(1):3-4.(English)
6. M V Venugopalan (2021).Intercropping in cotton for self-sufficiency in pulses and oilseeds. *Cotton Statistics and News*Pp. 7: 1-5, 18-05-2021 (English)
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8. MV Venugopalan (2021). A century of cotton improvement research in India- looking back to move ahead-Part I. *Cotton News and Statistics* Pp. 2021, Nov 16, 33(1-3), (English)
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10. MV Venugopalan (2021).Diversity of cotton in India- a bane or boon. *Cotton Innovations* (ICRA) Pp. March 2021, 1(1) 3, (English)
11. MV Venugopalan (2021).HDPS in cotton where we are and what next. *Cotton Innovate* Pp. Jan 2021, 1(1)2, (English)
12. MV Venugopalan, KS Baig, VN Chinchane. (2021).Era of long linted *G. arboreum* cotton has begun. *Cotton Innovations (ICRA)* Pp. March 2021, 1(1)4, (English)
13. Nalayini,P., Sankaranarayanan, K and AH Prakash (2021). Agrotechniques for enhancing the yield potential of ELS cotton. *Cotton Innovate* Pp. 2021, 2(1), (English)
14. Nalayini, P., Sankaranarayanan, K and A.H. Prakash (2022).Water smart hi-tech agrotechniques for cotton cultivation in changing climate. *Cotton Innovations (ICRA)*Pp. 2022, 1(2), (English)
15. Pooja Verma and D. Blaise (2021). An insight into metabolomics for cotton improvement. *Cotton Innovate*, Pp. 2021, 8(1), 1-2, (English)
16. S. Usha Rani and A.H. Prakash (2021). Front Line Demonstration – A Good Extension Practice for bridging the yield and knowledge gaps in Cotton – Part I & II. *Cotton Statistics and News*, Pp. 2021- 22, 24 & 25, (English)

17. S. Usha Rani(2021).The incredible and inevitable technologies that Unlocked the Milestones in Indian Cotton Production – Part I &II.*Cotton Statistics and News*, Pp. 2020-21, 35-36 (English)
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19. Sheeba, JA, (2021).Virus induced flowering in cotton: an option for speed breeding in cotton. *Cotton Innovate*,Pp. 2021, 9(1), (English)
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21. V. ChinnaBabu Naik and Rajasekhar (2021).Mass trapping of pink bollworm in cotton. *Eeenadu Annadata*, Pp. December, 2021., (Telugu)
22. Valarmathi, P.(2021). Flavonoids: Defensive role in cotton. AGROBIOS Newsletter. Pp. Vol. XX (07):33-34., (English)
23. Valarmathi, P.(2021).Mechanical transmission for Tobacco Streak Virus (TSV) – local lesion assay on cowpea. *Cotton Innovate*, Pp. 5(1): 5-6., (English)
24. Velmourougane K, Blaise D, Pooja Verma. (2021). Bioprospecting microbial volatiles for plant growth promotion and pest management in cotton. *Cotton Innovate*, Pp. 7(1): 3-4.,
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10.2: List of on-going projects

Sl. No.	Project title and Investigators	Type & duration
1	**Accelerating genetic gains for productivity enhancement, fibre quality, stress tolerance and climate resilience using transgenics, genome editing and pre breeding technologies**	
Crop Improvement Division		
Nagpur		
1.1	Development of elite Bt cotton varieties using potential non-deregulated transgenic events. **VN Waghmare (PI),** Vinita Gotmare, G Balasubramani, J Amudha, Santosh HB, Raghavendra KP, Saravanan M, Shah Vivek, Rishi Kumar, V.S. Nagrare, Rakesh Kumar	Institute (2018-2023)
1.2	Development of elite Bt cotton varieties using deregulated transgenic events. **Suman Bala Singh (PI),** Santosh HB, V.N. Waghmare, MV Venugopalan, D.V. Patil, Raghavendra KP, Shah Vivek, S, Ramkrushna GI, Manickam, K. Baghyalakshmi, K. Rameash, A. Sampath kumar, S.K. Verma, Rishi Kumar, S.K. Sain	Institute (2018-2023)
1.3	Development of broad based high yielding varieties of diploid and tetraploid cotton through recurrent selection. **V.N. Waghmare (PI), S.** K Verma	Institute (2020-2026)
1.4	Development of compact plant type with improved quality traits through selective mating system. **Suman Bala Singh (PI),** J.H. Meshram, J. Amudha	Institute (2017-2022)
1.5	Breeding of upland cotton for improved fibre yield, quality and resistance to biotic stress (Jassid). **S.M. Palve (PI),** Mandhyan P (CIRCOT)	Institute (2005-2022)
1.6	Harnessing the potential of wild and unadapted germplasm in cotton improvement-A pre-breeding approach. **Vinita Gotmare (PI),** SK.Verma, Santosh HB, Chandrashekar N, Rachna Pande, Neelkanth Hiremani, AH Prakash, M. Amutha, A. Sampath Kumar, K. Baghyalakshmi	Institute (2018-2023)
1.7	Development of heterotic pools in *hirsutum* cotton. **D.V. Patil(PI)**	Institute (2020– 2025)
1.8	Breeding for early maturity compact plant type and jassid tolerance in cotton. **H.B. Santosh (PI),** S. Manickam	Institute (2014-22)
1.9	Seed characterization based on protein quantification and profiling in cotton. **V. Santhy (PI),** Pooja Verma	Institute (2019-2022)
1.10	Collection, conservation, evaluation, documentation and maintenance of germplasm of cultivated species of Gossypium. **Vinita Gotmare (PI),** Sunil S. Mahajan, M. Saravanan, Neelkanth Hiremani, S. Manickam, A.H. Prakash, A. Manivannan, K. Rameash, Debashis Paul, Anjali Kak	Institute (2018-2023)
1.11	Strategies to augment quality and storability of cotton seed under different environmental conditions. **Sunil.S. Mahajan (PI),** V. Santhy, P. R. Vijayakumari	Institute (2017-2022)
1.12	An efficient regeneration system for transformation studies with *CICRcry2Ab1Ac* and fiber strength genes in Cotton (*G. hirsutum*) **G. Balasubramani (PI), J.** Amudha, K.P. Raghavendra, Chandrashekar N.	Institute (2017-2022)
1.13	Validation of molecular markers and genes linked to drought tolerance in cotton. **J. Amudha (PI),** Suman Bala Singh, Jayant Meshram, M. Saravanan	Institute (2021-2024)
1.14	Exploration of genomic resources for identification of candidate genes and promoters for cotton improvement. **Raghavendra KP (PI),** Chandrashekar N, Pooja Verma, Joy Das	Institute (2020-2025)
1.15	Targeted mutagenesis of ghPHYA1 through CRISPR/Cas9 in Cotton. **Chandrashekar N. (PI),** Raghavendra, K. P	Institute (2017-2023)
1.16	Molecular Characterization of EPSPS Gene in Cotton Germplasm for the Development of Herbicide Resistant Cotton Through CRISPR/Cas9. **Chandrashekar. N (PI)**	Institute (2021-2024)
1.17	Identification, Cloning, and functional validation of genes/enzymes involved in chitin biosynthesis pathway of Cotton Pink Bollworm (*Pectinophora gossypiella*). **Joy Das (PI),** Raghavendra KP	Institute (2021-2024)
1.18	ICAR project on Seed Production in Agricultural Crops and Fisheries. **P.R.Vijayakumari, (Nd Officer),** V. Santhy, Sunil Mahajan, K. Rathinavel, Debashis Paul	MSP, ICAR (2007-2022)
Coimbatore		
1.19	Development of high strength cotton genotypes by reducing the short fiber content. **S. Manickam (PI),** A.H. Prakash, J. Gulsar Banu	Institute (2017-2025)

Sl. No.	Project title and Investigators	Type & duration
1.20	Unraveling the Differential Expressed Proteins (DEP) in cotton genotypes with contrasting resistance to leafhopper and development of the protein biomarkers/functional markers for leafhopper resistance. **A Manivannan (PI),** K.Shankarganesh	DST-CRG (2021-24)
1.21	National Seed Project (Crops). **K. Rathinavel (PI),** P.R.Vijayakumari	NSP, ICAR (1999-2022)
1.22	Implementation of PVP legislation 2001 and DUS testing of cotton under ICAR-SAU system. **K. Rathinavel (PI),** P.R. Vijayakumari, V. Santhy	DUS, ICAR (2003-2022)
Sirsa		
1.23	Development of varieties of upland cotton having better fibre traits and tolerance to CLCuD. **S. K. Verma (PI)**, V. N. Waghmare	Institute (2017-2025)
1.24	Physiochemical traits determining genotypic response towards Accelerated Ageing process in Cotton.**Debashis Paul (PI),** V Santhy, Sunil Mahajan	Institute (2021-24)
2	**Development of ecologically compatible integrated pest management strategies for existing and emerging pests under conventional and niche area cotton production systems**	
Crop Protection Division		
Nagpur		
2.1	Investigations on bioefficacy of entomopathogens against cotton Pink bollworm, *Pectinophora gossypiella (*Saunders). **V. S. Nagrare (PI),** ChinnaBabu Naik, Shailesh P. Gawande, Dipak T. Nagrale, J. Gulzar Banu	Institute (2020-2023)
2.2	Multi-pronged bio-rational management of Pink bollworm (PBW), *Pectinophora gossypiella* (Saunders) on cotton in India. **V. ChinnaBabu Naik (PI)**, YG Prasad, BB Fand, Rishi Kumar, K Rameash	Institute (2021-2024)
2.3	Identification of oviposition deterrent for ethological management of cotton bollworm *Helicoverpa armigera* Hubner. **Rachna Pande (PI)**	Institute (2017-2022)
2.4	Revisiting the ETLs and yield loss assessment for cotton pink bollworm. **Babasaheb B Fand (PI)**, Vivek Shah, Dipak Nagrale	Institute (2021-2024)
2.5	Evaluation of biocidal activity of Gossypol against cotton pink bollworm. **Babasaheb B Fand (PI),** Pooja Verma	Institute (Adhoc) (2021-2022)
2.6	Monitoring insecticide resistance in American bollworm, *Helicoverpa armigera* Hubner populations from cotton growing regions of Maharashtra and Gujarat. **Shah Vivek(PI)** , Rachna Pande	Institute (2021-2026)
2.7	Studies on inner boll rot of cotton caused by *Pantoea* spp. and other pathogens. **Dipak T. Nagrale(PI)**, B.B. Fand	Institute (2020-2025)
2.8	Studies on target leaf spot of cotton caused by *Corynespora cassiicola.* **S.P. Gawande(PI)**, S.K.Sain, Chandrashekhar N.	Institute (2020-2025)
2.9	Studies on prevalence of *Xanthomonas citri* pv. *malvacearum* races of cotton and breeding for BLB resistant varieties. **S. P. Gawande (PI),** VN Waghmare, Dipak Nagrale, Neelkanth Hiremani, S.K.Sain, Sampathkumar	Institute (2018-2022)
2.10	Studies on grey mildew disease of cotton caused by *Ramularia areola.* **Neelkanth Hiremani (PI)**, P. Valarmathi	Institute (2020-2025)
2.11	Crop pest surveillance and advisory project (CROPSAP) in Maharashtra. **V. S. Nagrare (PI)**	CROPSAP (2010 onwards, annual basis)
2.12	Insecticide Resistance Management (IRM): Dissemination of Pink bollworm Management Strategies. Zone/State/ District Coordinators: V.S. Nagrare, V. Chinnababu Naik, Rachana Pande, Neelkanth Hiremani, S.P. Gawande, S. M. Wasnik, B.B. Fand, D.T. Nagrale, S.S. Patil, K. Rameash, Rishi Kumar.	IRM-DAC (2018 onwards, annual basis)
2.13	Monitoring for shifts in susceptibility in populations of cotton bollworms to Bt cry toxins. MAHYCO I: *Helicoverpa armigera* and *Pectinophora gossypiella* against Cry 1Ac protein in various cotton growing regions of the country. **Vivek Shah (PI),** V. ChinnaBabu Naik (Co-PI) MAHYCO II: *Helicoverpa armigera* and *Pectinophora gossypiella* and leaf eating caterpillar (*Spodoptera litura*) against Cry 2Ab and Cry 1Ac+ Cry 2Ab protein in various cotton growing regions of the country. **V. ChinnaBabu Naik (PI)** , Vivek Shah (Co-PI)	MAHYCO -BCS

Sl. No.	Project title and Investigators	Type & duration
Coimbatore		
2.14	Development of wireless smart trap for automated monitoring of lepidopterous pests in cotton. **K. Rameash** (PI), K. Shankarganesh, Babasaheb B Fand	Institute (2019-2022)
2.15	Biologyand holistic management strategies for emerging pest Tea mosquito Bug (*Helopeltis*) in Cotton. **M. Amutha(PI)**	Institute (2020-2023)
2.16	Identification of semiochemical associated with host plant cotton and insect pest stem weevil *Pempheres affinis*. **K. Shankarganesh (PI)**	Institute (2019-2022)
2.17	Investigation on the susceptibility status and possible detoxification mechanism for neonicotinoids and newer molecules against cotton leaf hopper. **K. Shankarganesh (PI),** VishleshNagrare	Institute (2019-2022)
2.18	Identification and genetic variability of *Alternaria* and *Cercospora* isolates of cotton using molecular markers. **A. Sampathkumar (PI)**	Institute (2021-2024)
2.19	Studies on rust disease of cotton caused by *Phakopsora gossypii* and its management. **P. Valarmathi (PI)**	Institute (2021-2024)
2.20	Studies on plant parasitic nematodes of cotton. **J. Gulzar Banu (PI),** Nandini GokteNarkhedkar	Institute (2020-2025)
Sirsa		
2.21	Whitefly: Studies on ecology and host plant resistance. **Rishi Kumar (PI),** S.K. Sain, Prabhulinga	Institute (2020-2023)
3	**Development efficient resource management technologies for precision farming, smart cotton production, mechanical harvesting and high-density planting**	
Crop Production Division		
Nagpur		
3.1	Alleviating soil compaction – a production constraint in cotton. **Blaise D esouza (PI),** Gautam Majumdar, A Manikandan, Savitha Santosh	Institute (2017-2022)
3.2	Investigation on the effect of skips and multiples on the productivity of machine planted cotton. **M.V. Venugopalan(PI),** G. Majumdar, Ramkrushna GI, R. Raja	Institute (2020-2023)
3.3	Validation and refinement of organic cotton production technology. **Ramkrushna G.I (PI),** Rachna Pande, Neelakath S. Hiremani, Savitha Santosh	Institute (2021-2027)
3.4	Development of decision support system for precision water and nutrient management in cotton. **Bhargavi. B. (PI),** Blaise Desouza, Pooja Verma, P. Nalayini, MSS Nagaraju (ICAR-NBSSLUP), S. Chattaraj (ICAR-NBSSLUP)	Institute (2021-2024)
3.5	Estimating water footprint in cotton production system. **B. Bhargavi (PI),** Blaise D, P. Nalayini	Institute (2019-2022)
3.6	Phytohormone profiling by targeted metabolomics in cotton. **Pooja Verma (PI),** Joy Das	Institute (2021-2024)
3.7	Evaluation and Refinement of spindle type header prototype for development of a cotton picker. **G. Majumdar (PI) ,** Blaise D, Ramkrushna GI, J.H.Meshram, A. Raja, Amarpreet Singh	ICAR-CICR, Nagpur & CSIR-CMERI-CoEFM, Ludhiana. (2019-2022)
3.8	ICAR Programme on Network Project on Precision Agriculture (NePA). **Dr. Blaise (PI)**	ICAR-IARI, New Delhi (2021-2026)
3.9	Quantitative estimation of carbon and moisture fluxes over the cotton based agro - ecosystem: Integrating ground observations, satellite data and modelling. **M.V. Venugopalan (PI),** A. Manikandan	National carbon project (2017-June 2021)
3.10	Land resource inventory of Pench National Park for ecological restoration (NBSS & LUP, Pench Tiger Reserve Project). **K.Velmourougane(Co-PI)**	Pench project, Maharashtra Forest Dept. (2020-22)
Coimbatore		
3.11	Crop-weed interaction under ambient and elevated CO_2 conditions. **P. Nalayini(PI),** A.H.Prakash, M. Amutha	Institute (2020-2023)
3.12	Evaluation of agro techniques to overcome the impact of weather aberrations (drought, water logging) in ELS cotton. **K Sankarnarayanan(PI),** M. Amutha, J. Annie Sheeba, P. Valarmathi, J.H.Meshram, B. Bhargavi	Institute (2020-2023)

Sl. No.	Project title and Investigators	Type & duration
3.13	Active Optical Sensors based Nitrogen Management and Yield Prediction in Cotton using Unmanned Aerial System. **R. Raja (PI),** D. Kanjana, T. Arumuganathan (SBI, Coimbatore)	Institute (2021-2024)
3.14	Effect of long-term application of organic and inorganic sources of nutrients on continuous cultivation of Bt and non Bt cotton with maize cropping system under irrigated conditions. **D. Kanjana (PI)**, K. Sankaranarayanan, Amarpreet Singh	Institute (2017-2022)
3.15	Fertilizer optimization and formulation of customized fertilizers for HDPS cotton. **D Kanjana(PI),** R. Raja, Usha Rani	Institute (2021-2025)
3.16	Development of a nutrient and plant hormone - enriched foliar formulation for cotton. **Annie Sheeba(PI),** D Kanjana	Institute (2021-2024)
3.17	Exploiting the epigenetic transgenerational inheritance of stress responsive traits for imparting abiotic stress tolerance to cotton. **J Annie Sheeba (PI)**	Institute (2016-2022)
Sirsa		
3.18	Development of Cotton based cropping sys tems under Conservation Agriculture for North-Western Indian conditions. **Amarpreet Singh (PI)**	Institute (2018-2023)
3.19	Enhancement in productivity of cotton through improvement in agro - techniques under North-Western Indian conditions. **Amarpreet Singh (PI)**	Institute (2019-2022)
4	**Genetic improvement and development of production and protection technologies tor *desi*, organic, ELS and naturally coloured cotton**	
Crop Improvement Division		
Nagpur		
4.1	Breeding to improve performance of *Gossypium herbaceum* for adaptation to climate change in central India. **D.V. Patil (PI)**	Institute (2015-2022)
4.2	Development of high yielding, early maturing Asiatic cotton (*Gossypium arboreum*) genotypes suitable to south and central zone. **M. Saravanan(PI)**, A. Manivannan, V.N. Waghmare	Institute (2015-2023)
Coimbatore		
4.3	Breeding for high yielding, early maturing sucking pest tolerant extra -long staple G. barbadense genotypes with improved fibre properties. **A. Manivannan (PI)**, K. Rameash	Institute (2017-2025)
4.4	Induced Mutagenesis for Improvement of ELS (*G.barbadense*) cotton. **A. Manivannan (PI),** S. Manickam, K. Rathinavel, K. Shankarganesh, A. Sampathkumar	Institute (2020-2025)
4.5	Development and Evaluation of ELS interspecific hybrids with better yield and fiber quality. **K. Baghyalakshmi (PI),** M. Amutha, A. Sampathkumar	Institute (2019-2024)
Crop Production Division		
Nagpur		
4.6	Evaluation of PGPR and microbial inoculants to alleviate drought stress in cotton (*G. hirsutum* L). **J.H.Meshram (PI),** Pooja Verma, Dipak Nagrale	Institute (2019-2022)
4.7	Development of microbial biofilm formulations for cotton: effects on yield, pests, diseases and soil health. **K. Velmourougane (PI)**, Savitha Santosh, Rachana Pande, Dipak Nagrale	Institute (2017-2022)
4.8	Microbial dissolution of carbonate to ameliorate soil sodicity in Black Soil Regions of Maharashtra. **K. Velmourougane (PI)**, A. Manikandan, D. Vasu (NBSS & LUP)	Institute (2019-2022)
4.9	Bioprospecting microbial volatiles for plant growth promotion and sucking pest (Whitefly and Jassids) management in Bt cotton. **K. Velmourougane (PI)**	SERB-DST (2019-2022)
Coimbatore		
4.10	Sustainable Intensification of Extra Long Staple Cotton Production in South Zone. **R. Raja (PI),** J Annie Sheeba, K. Rathinavel	Institute (2019-2023)
Crop Protection Division		
Nagpur		
4.11	Mass multiplication of CICR - Trichocash (*Trichodrma harzianum*) and validation of their efficacy under MGMG fields. **S.P. Gawande(PI),** D.T. Nagrale	Institute (2020-2025)

Sl. No.	Project title and Investigators	Type & duration
Coimbatore		
4.12	Development of biocontrol consortia with multifaceted fungi for the management of important pests and nematodes of cotton. **Gulsar Banu (PI),** M. Amutha	Institute (2020-2025)
Sirsa		
4.13	Collection, characterization and evaluation of beneficial fungal microorganisms from North, Central and South Cotton growing zones. **S.K. Sain (PI)**, Nandini Gokte Narkhedkar, S.P. Gawande, P. Valarmathi, Savitha Santosh	Institute (2020-2025)
5	**Socio-economic dimension of cotton production system, technology dissemination, outreach, impact assessment and industrial linkages**	
Crop Production Division		
Nagpur		
5.1	e-Communication: Dissemination of Cotton Technology. **S.M. Wasnik (PI)**, S. Usha Rani, M. Sabesh	Institute (2017-2022)
5.2	An Inclusive Agri-Business Model for Sustainable Cotton Marketing in the State of Maharashtra. **A.R.Reddy (CCPI),**Ramkrushna GI	NASF (2018- Nov 2021)
Coimbatore		
5.3	Economic Analysis of Value Chain of the Cotton Market in Tamilnadu. **Isabella (PI)**	Institute (2020-2022)
5.4	Ex Ante analysis of the impact of COVID 19 on cotton economy in India. **Isabella (PI)**, A.R.Reddy, Amarpreet Singh	Institute (2020-2022)
5.5	Development of Extension Model for Promoting the Production of Extra Long Staple Cotton in India. **S. Usha Rani (PI)**, K. Sankaranarayanan, M.Sabesh, M. Amutha, P. Valaramathi, S. M. Wasnik	Institute (2019-2022)
5.6	Development of web-based Cotton data query system. **M. Sabesh(PI),** A R Reddy, Sunil Mahajan, Isabella	Institute (2021-2026)

10.3 : Consultancy, Patents, Commercialization of Technology

10.3.1 Contract Research / Revenue generation :

Items	Amount (Rs. In lakh)
Monitoring for shift in susceptibility in population of the cotton bollworms *viz Helicoverpa armigera* and *Pectinophora gossypiella* and leaf eating caterpillar *Spodoptera litura* against *Cry2Ab* and *Cry1Ac + Cry2Ab* protein in various cotton growing region of the country.	30
Monitoring for shift in susceptibility in population of the cotton bollworms *viz. Helicoverpa armigera* and *Pectinophora gossypiella* against *Cry1Ac* protein in various cotton growing country.	10
Evaluate Nectariless Rasi Cotton Hybrids against pink bollworms on Cotton.	15

10.3.2 Patents

Title of Patent	Patent Number for Granted Patent	Patent Application Number	Date of Grant	Name of Applicant	Name of Inventor	Present Status of Patent
"CICR Whitefly Adult Suction Trap"	376517	1724/Del/2015	06.09. 2021	CICR, Sirsa	Dr. Rishi kumar, Dr. Dilip Monga, Dr.SandhyaKranthi, Dr. K.R.Kranthi, Sh. Madan Lal	Patent Granted

10.3.3 MoU Signed :

Sr. No.	ICAR-CICR signed MoU/ MTA with Institutions	Date	Area of work
1.	M/s. Nairuthi Seeds Pvt. Ltd, Hyderabad	27 January 2021	Seed production and commercialization of Bt cotton varieties developed by ICAR-CICR.
2.	Solidaridad Regional Expertise Centre (SREC), New Delhi	23 February 2021	Collaboration and Association as a Knowledge Partner to Promote Sustainable Agricultural Production.

10.3.3 MoU Signed :

Sr. No.	ICAR-CICR signed MoU/ MTA with Institutions	Date	Area of work
3.	Cottonguru MAHAFPC Limited, Mumbai	19 April 2021	Establishing sustainable organic cotton production ventures in selected Farm & Pilot trials of CCB 51 A and CCH 15-1 in the state of Tamil Nadu and Karnataka.
4.	Agrovision Foundation, Nagpur	27 May 2021	Leveraging the joint expertise for conceptualization, development, sourcing and implementation of new initiatives and interventions (including projects, programmes, events, trials, proof-of-concept studies etc.) in cotton production technologies in Maharashtra.
5.	M/s. Rasi Seeds Pvt. Ltd, Maharashtra	27 May 2021	Evaluate Nectariless Rasi Cotton Hybrids against pink bollworms on Cotton.
6.	M/s. Rasi Seeds Pvt. Ltd Coimbatore	27 May 2021	High Density Plant System (HDPS) pertaining to canopy and nutrient management through collaborative agronomy trail / Demonstrations.
7.	Tripartite Agreement with BCI, New Delhi and VNMKV, Parbhani	8 June 2021	Conducting good quality field trials for long linted *Gossypium arboreum* (*Desi* cotton) varieties.

10.4 : Significant decisions of RAC Meeting

10.4.1: Research Advisory Committee (RAC) meeting

The second meeting of the current Research Advisory Committee (RAC) of ICAR-Central Institute for Cotton Research (CICR), Nagpur held during 17 to 18th November 2021 under the Chairmanship of Dr. S.A. Patil, Former Chairman, Farmers' Commission of Karnataka, Former Director ICAR-IARI, New Delhi and Former Vice Chancellor UAS, Dharwad. Dr. P.A. Kumar, Prof. S. S. Siwach, Dr. A. R. Sharma, Dr. A.J. Shaikh in physical mode and Dr. R.K. Singh attended through virtual mode. Dr. Y.G. Prasad, Director; Dr. V.N. Waghmare, Dr. D. Blaise, Dr. Nandini Narkhedkar Gokte, Dr. AH Prakash, Dr. S.K.Verma, Dr. M.V. Venugopalan, Dr AR Reddy, Dr. K.P. Raghavendra and Dr. K. Velmourougane also participated in the meeting.

Dr. M.V. Venugopalan, Member Secretary, welcomed the Chairman and the other members of the RAC Dr. Y.G. Prasad, Director, ICAR-CICR also extended a formal welcome and underlined the importance of the RAC meeting.

The Chairman Dr. S.A. Patil in his introductory remarks recalled the significant milestones in the history of cotton improvement and recollected the contributions from various Cotton Research Stations-Coimbatore, Surat, Dharwad, Khandwa, Guntur, Hisar, and Ludhiana.

Dr. M.V. Venugopalan presented the Action Taken Report on the recommendations of the previous RAC meeting held on 27th & 28th Nov, 2020.The Chairman and members expressed satisfaction that despite hardships caused due the Covid pandemic, most of the recommendations made in the last RAC meeting were adequately addressed.

Dr. Y.G. Prasad appraised the RAC about the salient research achievements for the period during 2020-21 and highlighted the recent R&D initiatives. Later, he explained the reorientation of the research projects on the lines of programmes outlined in the EFC document.

In the prolonged meeting during November 17-18,2021, the Heads of the Divisions and Regional stations presented the salient achievements of the research undertaken by their divisions/stations. The Chairman and Members of the RAC also visited the experimental fields, polyhouse and laboratories. The scientists interacted with the experts and explained the objectives of the work being undertaken and the research findings that are emerging.

Dr. S. A. Patil addressed all the scientists through hybrid mode (physical and virtual). He appreciated the conduct of RAC meeting and urged the institute to include the valuable suggestions been made by the members during the meeting in the research programmes of the institute. The RAC meeting concluded with the vote of thanks been proposed by the Dr. D Blaise, Head Division of Crop Production, ICAR- CICR, Nagpur.

The committee proposed the following recommendations and the same were subsequently approved by the Council.

1. Efforts must be further intensified to upscale seed production and coverage under public sector Bt varieties developed by ICAR-CICR in the targeted agro-ecological environments with a complete package of practices. Results of demonstrations conducted during 2020-21 and 2021-22 must be clearly documented and analyzed.
2. Work on pre-breeding, plant architecture, and development of promising parental lines with Bt background may be intensified at headquarters and regional stations for developing high yielding intra and inter-specific Bt cotton hybrids with higher boll weight and better fibre quality.
3. For generating next-generation Bt cotton, *cry1D* gene is promising for pink bollworm management, but, it may need higher expression in plants. The *cry1D* gene should be driven under suitable promoter, which sustains the expression throughout the boll development stage. Multiple transgenic events with cry1D may be developed to select the best one. Stacking with deregulated events may be taken up in a phased manner. Transgenic with non-deregulated events developed elsewhere may be critically examined before introgression.
4. The project on the characterization of EPSPS gene for glyphosate herbicide tolerance may be expanded. Cotton seeds can be sent to BARC for irradiation. Irradiated seeds may be raised, and the seedlings can be checked for point mutation for glyphosate resistance.
5. A long-term field experiment on conservation agriculture may be laid out with limited treatments (minimum tillage, residue management, cover crop/ cropping systems,

mulching, etc.) to study in detail the long-term effects on the dynamics of weed flora, soil biology and soil / plant health parameters.

6. The yield maximization plot at CICR technology park is a good initiative. The yield levels can be further enhanced by introducing validated CICR technologies (plant architecture management, drip and polymulch and other compatible strategies), so that the potential yield can be demonstrated. Innovative technologies developed by farmers can also be showcased in the technology park. The potential benefits of microbial inoculants including PGPR's and salicylic acid on abiotic stress management in cotton may be validated on large plots.
7. An end-to-end project on short duration, compact genotypes under HDPS with canopy management, defoliant technology for mechanical harvesting may be pursued. During defoliation, mechanical harvesting, and pre-cleaning stages, the fibres are repeatedly subjected to mechanical stresses. Hence, fibre quality of mechanically picked, pre-cleaned cotton fibre can be compared with conventional manually picked cotton to understand if fibre quality is compromised.
8. India is the largest cotton producer and exports 50-70 lakh bales of raw cotton annually. Scope exists to convert our raw cotton into value-added products. For this purpose, a study may be undertaken to create database (national/international) in collaboration with the ICAR-CIRCOT to understand the existing cotton value chain and identify potential segments where the production of value-added products upto garment / made ups can be increased.
9. The project on "IRM-Dissemination of pink bollworm management strategy" is in operation since 2018. A comprehensive analysis of the results obtained should be done, and the impact of the programme should be quantified. The success story of the project must be documented. Strategies for managing pink bollworm in the North zone must be finalized and passed on to the line departments, so that preventive measures can be taken to minimize the same during 2022-23 season.
10. Work on use of AI, robotics, and drones may be initiated and sensor-based applications to be developed and validated in PPP mode for precision crop protection and production. Such technologies to be adopted and demonstrated in the research farms.

10.5: Other Important Meetings/Events

10.5.1: Meetings

Project Monitoring and Evaluation Committee visit to ICAR-CICR Regional Station, Coimbatore

The Project Monitoring and Evaluation Committee (PMEC) visited the ICAR-CICR Regional Station (RS), Coimbatore during 8-10th January, 2021 to evaluate the implementation of research projects and to monitor the progress of the technical programmes (2020-21) being operated at the centre. Dr. Y.G. Prasad, Director, ICAR-CICR, Nagpur; Dr. C.D. Mayee, Chairman, Programme Advisory Committee for AICRP-Cotton; Dr. B.M. Khadi, Member, Programme Advisory Committee for AICRP -Cotton; Dr. A.H. Prakash, Project Coordinator and Head, ICAR-CICR Regional Station, Coimbatore; Dr. M.V. Venugopalan, Head, PME Unit; Dr. Suman Bala Singh, Principal

Scientist (Plant Breeding); Dr SM Palve, Principal Scientist (Plant Breeding); Dr HB Santosh, Scientist (Plant Breeding), ICAR-CICR, Nagpur and Scientific staff of ICAR-CICR RS, Coimbatore participated in the deliberations. Dr. K. Rameash, Internal IRC Secretary delivered the welcome address. Dr. A.H. Prakash highlighted activities of the station and briefed on the yearly progress and achievements of the research programmes during the current season 2020-21. The scientists of the regional station presented a brief account of ongoing laboratory and field trials and highlighted their significant findings. The committee also visited the well laid out field experiments at the station.

Institute Research Committee (IRC) meeting - 2021

The Annual Institute Research Committee (IRC) - 2021 meeting of ICAR-CICR was conducted as a combined IRC for ICAR-CICR, Nagpur, ICAR-CICR, Regional Stations, Coimbatore and Sirsa during 22nd-27th March, 29th April, and 5th May 2021 in a virtual mode. Dr. Y.G. Prasad, Director and Chairman, IRC chaired the meetings. All the Heads of Divisions/Regional Stations, Head, PME Cell, Secretary, IRC, and the Scientists of ICAR-CICR participated in the deliberations. Dr. K. Velmourougane, Secretary, IRC presented the Action Taken Report (ATR) of the previous IRC (2020). In the IRC 2021, a total of 19 concluding projects were approved for closure, and 18 new projects were approved. After the project matrix finalization on the last day of IRC, a total of 82 (71 institute & 11 externally funded) projects were listed as on-going projects. Dr. K. Velmourougane, Secretary IRC and Dr. Dipak Nagrale, Joint Secretary IRC coordinated the meeting.

Interface Meeting on Enhancing Cotton Productivity in North Zone: Way Forward

An 'Interface Meeting on Enhancing Cotton Productivity in North Zone: Way Forward' was organized at ICAR-Central Research Institute for Cotton Research (CICR) Regional Station, Sirsa, Haryana on September 07, 2021 on the occasion of "Azadi Ka Amrit Mahotsav" under the Chairmanship of Dr. B. R. Kamboj, Hon'ble Vice Chancellor, CCS HAU, Hisar, Haryana. Dr. S. K. Verma, Head (I/c), ICAR-CICR, Regional Station, Sirsa welcomed the participants and presented the cotton scenario of north zone including the constraints in cotton production. Dr. Y. G. Prasad, Director, ICAR-CICR, Nagpur discussed about 'Holistic cotton production and way forward'. Dr. Rajbir Singh, Director, ICAR-ATARI, Ludhiana (Zone-I), Dr. A. H. Prakash, PC-AICRP on Cotton, ICAR-CICR, Regional Station, Coimbatore, Dr. N. S. Bains, Director of Research, PAU, Ludhiana, Dr. S. K. Sehrawat, Director of Research, CCS HAU, Hisar, Dr. P. S. Shekhawat, Director of Research, SKRAU, Bikaner, Dr. S. S. Siwach, Member of RAC, ICAR-CICR also expressed their views on increasing cotton productivity in North Zone. Dr. R.K. Singh, ADG (CC), ICAR, New Delhi made a special address about 'How to fill yield gap of cotton and problem of pink boll worm in North

Zone'. Dr. Hardeep Singh, Director General, Dept. of Agriculture and Farmers' Welfare, Govt. of Haryana made a special address about problems in cotton cultivation through online mode. A keynote address on cotton was presented by the chief guest of the programme, Dr. B. R. Kamboj, Hon'ble Vice Chancellor, CCS HAU, Hisar. A total of 106 participants from various stakeholders like CCS HAU, SKRAU, KVKs, State Agriculture Departments of Punjab, Haryana and Rajasthan, progressive farmers and seed companies have attended the programme in physical as well as online mode. The Chairman emphasized to constitute a high-powered interstate committee for enhancing cotton productivity with strategic district level planning and recommendation to state governments.

Farmers'-Scientists'-Interface Meeting on "Climate Resilient Varieties, Technologies and Practices"

Under Azadi Ka Amrut Mahotsav, a Farmers-Scientist Interaction meet was organized on Cotton production and

protection technologies on 28th September 2021 in the Training Hall of ICAR-CICR, Nagpur. Dr. Vikas Mahatme, Member of the Parliament in Rajya Sabha was the chief Guest for the occasion. This was followed by the address by the Hon'ble Prime Minister of India - "Dedication to the Nation of 35 Crop Varieties and ICAR – National Institute of Biotic Stress Management, Raipur" witnessed by 100 participants. The ICAR-CICR, Regional Station, Coimbatore, Tamil Nadu, organised Farmers Meet at Vadapudur Village in Coimbatore, Tamil Nadu in which 40 farmers participated. The ICAR-CICR, Regional Station, Sirsa organized the program involving 45 participants.

World Cotton Day Celebrations at ICAR-CICR, Nagpur on 7th October, 2021

World Cotton Day on 7th October, 2021 was celebrated at ICAR-CICR, Nagpur with gaiety and grandeur. Forenoon saw a visit of Director alongwith Scientists and Technical staff to Institute cotton fields and picking cotton manually. This was followed by a Panel Discussion "Towards Mechanization of Cotton Picking" in hybrid mode, which was one in a series of events being held under the aegis of Azadi Ka Amrut Mahotsav commemorating 75 years of India's independence. The event was chaired by Dr. T.R. Sharma, Deputy Director General (Crop Science), ICAR,

WORLD COTTON DAY

7th October

New Delhi. Dr. C.D. Mayee, Former Chairman, Agricultural Scientists Recruitment Board (ASRB), presided over and moderated the discussions. The event was attended by more than a hundred distinguished scientists and Directors from Public and Private Organisations. Host Dr. Y.G. Prasad, Director ICAR-Central Institute for Cotton Research, Nagpur, in his welcome address, highlighted the importance of celebrating World Cotton Day and stressed the need to expedite the process of mechanizing the cotton picking operation.

Dr.Trilochan Mohapatra, DG (ICAR) visit to farmer's innovative agro-technique plots in Jalna district of Maharashtra

Dr. Trilochan Mohapatra, Director General (ICAR), New Delhi with a team of senior officials- Dr Suresh Kumar Chaudhari, Deputy Director General (Natural Resource Management & Agricultural Engineering), Dr AK Dhawan, Vice Chancellor, VNMKV, Parbhani, Dr VM Bhale, Vice Chancellor, Dr PDKV Akola, Dr R.K. Singh, ADG (CC), Dr Y.G. Prasad, Director, ICAR-CICR, Dr A.H. Prakash, PC AICRP on Cotton, Dr D.P. Waskar, Director of Research, VNMKV, Shri Dinesh Kulkarni, Secretary, Akhil Bharatiya Kisan Sangh visited the demonstration (Farmer's Innovative Agro-Technique-popularly called Dada Lad Cotton Production Technology) Plots of Shri Rameshwar Ambhore and Shri Kishore Chavan in Sipora Ambhora Village, Jaffrabad Tehsil, Jalna District, Maharashtra on 14th Oct 2021.

Shri Dada Lad explained and demonstrated the innovative technology of – removal of monopodia, detpopping, higher plant density, drip and polymulch.. The DG, ICAR appreciated the demonstrations and applauded the potential of the "Dada Lad" Technique for increasing cotton yields.

An inter-institutional team (ICAR-CICR & SAUs) visited Nimkheda Bk and Sipora villages in Jafferabad Tehsil of Jalna District on 22nd October 2021 and studied the Dada Lad technology in detail.

10.5.2: Events

***Azadi Ka Amrut Mahotsav* Lecture Series:**

Sl No.	Name of the Speaker	Date	Topic	Number of Participants
1.	Dr. Kuldeep Singh, Director, ICAR -National Bureau of Plant Genetic Resources, New Delhi	05.02.2021	Management of plant genetic resources	63
2.	Dr P K Chakrabarty, Member ASRB & Ex-ADG (PP), ICAR, New Delhi	01.04.2021	Need for disruptive cotton technologies for breaking yield barriers	190
3.	Dr. B. M. Khadi, Former Director, ICAR -CICR, Nagpur	03.04.2021	Revisiting cotton breeding strategies in Bt era	190
4.	Dr. S.S. Patil, Former Director of Research, UAS ,Dharwad,	09.04.2021	Breeding strategies for varietal development in cotton	140
5.	Dr. Rajvir Rathi, Head -Agricultural Policy & Stakeholder Affairs, BAYER Crop Science	09.04.2021	Role of Seed Industry in Cotton Cultivation in the country	145
6.	Dr TR Sharma, DDG Crop Science, ICAR, New Delhi	08.11..2021	New gene technologies for cotton crop improvement	205
7.	Dr CD Mayee, Former Chairman, ASRB, New Delhi	29.11.2021	Bt cotton: current status in Asia and what next for India (looking beyond Bt cotton through biotech mirror)	140
8.	Dr Dilip Monga, Former Head, ICAR-CICR, Regional Station, Sirsa	22.12.2021	The story of cotton leaf curl virus disease	95

Glimpses of celebrations

Celebration of New Year 2021

Republic Day 2021

Shivaji Maharaj Jayanti 2021

National Science Day 2021

International Women's Day 2021

45th ICAR-CICR Foundation Day on 1st April 2021

International Yoga Day 2021

Tree plantation on ICAR Foundation

Independence Day 2021

World Cotton Day 2021

Germplasm Day 2021

Constitution Day 2021

World Soil Day 2021

Swacchata Abhiyan 2021

Live webcasting of Natural Farming Summit

10.6 : Participation of Scientists in Symposia/ Conference/Seminars/ Webinar

Name of Scientist	Name of Seminar/Webinar/Conference/Symposia/	Place/Organized by
Symposia		
Dr. P. Nalayini	International Plant Physiology virtual Symposium on Physiological Interventions for Climate Smart Agriculture (11 March 2021)	Sugarcane Breeding Institute, Coimbatore
Conference		
Dr. A Sampathkumar	International conference on Industrial perspective, challenges and strategies in the development of novel bio-pesticides: Its implication in sustainable pest and disease management (11 March 2021)	Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore
Dr. Neelakanth S Hiremani, Dr. Satish Kumar Sain	National e-Conference on Plant Health and Food Security: Challenges and Opportunities (25-27, March 2021)	Indian Phytopathological Society, New Delhi
Dr. Amarpreet Singh, Dr. Satish Kumar Sain	International Web Conference on Innovative and Current Advances in Agriculture and Allied Sciences" (ICAAAS-2021)(19-21, July 2021)	Astha Foundation, Meerut, U. P., India
Dr. A Manivannan, Dr. S Manickam, Dr. J. Amudha, Dr. K. Baghyalakshmi	International Conference on Future Challenges & Prospects in Plant Breeding (FCPPB 2021) (6-7 October 2021)	CPMB, TNAU Coimbatore
Dr. M.Amutha	International conference on Insect and Plant Biology (7-8 October 2021)	Hansraj College, University of Delhi, Delhi.
Dr. M. Amutha	National conference on Agricultural Sciences (29-30 October 2021)	The Indian Society for promotion of Agriculture Science, Nagaland
Dr. J.Gulsar Banu	National Conference on Agricultural Sciences- 2021 (29-30 October 2021)	Faculty of Agriculture, Raja Balwant Singh College, Bichpuri, Agra
Dr. A. Manikandan	XV Agricultural Science Congress & ASC Expo (13-16 November 2021)	Banaras Hindu University, Varanasi
Dr. K. Baghyalakshmi	Virtual 2nd International Agrobiodiversity Congress (15-18 November 2021)	Biodiversity International And International Centre for Tropical Agriculture
Dr. D. Kanjana	85th Annual Convention of the Indian Society of Soil Science (16-19 November 2021)	PalliSiksha Bhavana, Institute of Agriculture, Visva-Bharati (Central University), Sriniketan, Birbhum, West Bengal
Dr. Blaise Desouza, Dr. K. Sankaranarayanan, Dr. P. Nalayini, Dr. R Raja, Dr. Ramkrushna G. I, Dr. Amarpreet Singh Dr. A. Manikandan	5th International Agronomy Congress "Agri Innovations to Combat Food and Nutrition Challenges" (23-27 November 2021)	PJTSAU, Rajendra Nagar, Hyderabad
Dr. Rachna Pande, Dr Ramkrushna G.I.	Integrated Agriculture, Natural Farming, Biodiversity Conservation and Rural Bio-Entrepreneurship under Changing Climate Scenario (07-09 December 2021)	College of Agriculture, Kyrdemkulai (Central Agricultural University, Imphal)
Dr. M. Amutha	International conference on Global perspectives in crop protection for food security (08-10 December 2021)	Centre for plant protection studies, Tamil Nadu Agricultural University, Coimbatore
Dr. J Gulsar Banu	Golden Jubilee International Conference "Global Perspectives in Crop Protection for Food Security (08-10 December 2021)	Tamil Nadu Agricultural University, Coimbatore

Name of Scientist	Name of Seminar/Webinar/Conference/Symposia/	Place/Organized by
Dr. MV Venugopalan	Challenges facing rainfed cotton farming and its solution (10-11 December 2021)	Mission Samriddhi, Chennai and Gram Sewa Mandal, Wardha
Dr. Shailesh P. Gawande	Transforming Agriculture through Technology Innovations: Agrovision 2021 (24-27, December 2021)	Agrovision Foundation, Reshimbagh Ground, Nagpur.
Webinar		
Dr. S. Manickam	Webinar on Extra Long Staple (ELS) Cotton (29 April 2021)	Sardar Vallabhbhai Patel International School of Textiles & Management
Dr. V.ChinnaBabu Naik	Furtherance in Integrated Pest Management (IPM) approaches (10 June2021)	NCIPM, New Delhi
Dr. MV Venugopalan	ICAC WCRC 7 Webinar plenary lecture series (07 July 2021)	ICAC Washington
Dr. Shailesh P.Gawande	RAMETI Nagpur Workshop (18 August 2021)	RAMETI, NAGPUR
Dr. Shailesh P. Gawande	Integrated Pest Management in Cotton Crop. (24 August 2021)	VANAMATI, Nagpur
Dr. Babasaheb B Fand	National webinar on "Integrated Pest Management : A Paradigm Shift" (27-28, August 2021)	ICAR-NCIPM, New Delhi
Dr. Shailesh P. Gawande	Cotton- Pink bollworm and Boll rot Management (30 September 2021)	Agriculture Commissionerate, Pune
Seminar		
Dr. A Manivannan	Agricultural Genomics: Progress and Prospects – Ag'Omics (21-23 October 2021)	CPBM TNAU COIMBATORE

10.7: Distinguished Visitors

Visitors	Date of Visit
Dr. Kuldeep Singh, Director, ICAR -NBPGR, New Delhi and Dr. Ashok Kumar, Head, Division of Germplasm Evaluation, ICAR-NBPGR	February 5, 2021
Shri. J. C. Madhuswamy, Hon'ble Minister for Law, Parliamentar y Affairs, Legislation and Minor Irrigation, Government of Karnataka and Mr. M Shivanna, Former minister (Sericulture) visited to ICAR-CICR Regional Station, Coimbatore	August 24, 2021
Dr. S. K. Chaudhari, Hon'ble DDG (NRM), ICAR	September 16, 2021
High Commissioner of Uganda H.E. (Ms) Grace Akello	September 20-21, 2021
Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR) visited to ICAR-CICR Regional Station, Coimbatore	November 1, 2021
Dr. Rossitza Krueger, Deutsche Gesellschaft fur I nternationa Zusammenarbeit (GIZ), Mr Shivaprasad Shetty, Consultant – ELS cotton along with Dr. P. Alli Rani, Director - Sardar Vallabhbhai Patel International School of Textiles & Management (SVPISTM), Mr. Jayakumar, General Manager Cotton Corporation of India, Coimbatore	November 23, 2021
Dr. T.R.Sharma, Hon'ble DDG (CS), ICAR	November 8, 2021

Distinguished visitors at ICAR-CICR









Director

- Dr. Y. G. Prasad Director

Project Coordinator (Cotton)

- Dr. AH Prakash, PC (Cotton) & Head (Acting)

CROP IMPROVEMENT DIVISION

Genetics& Plant Breeding

Nagpur

- Dr. V N Waghmare, Head (Acting)
- Dr. (Mrs.) Sumanbala Singh, Pr. Scientist
- Dr. S M Palve, Pr. Scientist
- Dr. (Mrs.) Vinita Gotmare, Pr. Scientist
- Dr. DV Patil, Pr. Scientist
- Sh. M Saravanan, Scientist
- Dr. H B Santosh, Scientist
- Dr. Rahul Phuke, Scientist (Joined on 12.10.2021)

Coimbatore

- Dr. S Manickam, Pr. Scientist
- Dr. Manivannan A, Scientist
- Dr. (Mrs.) K Baghyalakshmi, Scientist

Sirsa

- Dr. O P Tuteja,I/c Head & Pr. Scientist, (Retired. on 31.03.2021)
- Dr. SK Verma, Pr. Scientist

Agril. Biotechnology

- Dr. G Balasubramani, Pr. Scientist
- Dr. (Mrs.) J Amudha, Pr. Scientist
- Dr. KP Raghavendra, Sr. Scientist
- Dr. Chandrashekar N, Scientist
- Mr. Joy Das, Scientist **(Rejoined after Study leave on 27.12.2021)**
- Mr. Rakesh Kumar, Scientist**(Rejoined after Study leave on 27.12.2021)**
  (Study Leave w.e.f. 27.12.2018 to 26.12.2021)

Seed Science &Technology

Nagpur

- Dr. (Mrs.) PR Vijayakumari, Pr. Scientist
- Dr. (Mrs.) V Santhy, Pr. Scientist
- Dr. SS Mahajan, Pr. Scientist

Coimbatore

- Dr. K Rathinavel, Pr. Scientist

Sirsa

- Mr. Debashis Paul, Scientist

CROP PRODUCTION DIVISION

Agronomy

Nagpur

- Dr. Blaise Desouza, Pr. Scientist& Head (Acting)
- Dr. MV Venugopalan, Pr. Scientist
- Dr. AR Raju, Pr. Scientist
- Dr. Ramkrushna I Gandhiji, Senior Scientist
- Dr. B. Bhargavi, Scientist

Coimbatore

- Dr. (Mrs.) P Nalayini, Pr. Scientist
- Dr. K Sankaranarayanan, Pr. Scientist
- Dr. R Raja, Pr. Scientist

Sirsa

- Dr. Amarpreet Singh, Scientist

Soil Science

Nagpur

- Dr. A Manikandan, Scientist **(Rejoined after Study leave on 12.10.2021)**
  (Study Leave w.e.f. 12.10.2020 to 11.10.2021)

Coimbatore

- Dr. (Mrs.) D Kanjana, Scientist

Farm Machinery & Power

Nagpur

- Er. G Majumdar, Scientist

Plant Physiology

Nagpur

- Dr. JH Meshram, Pr. Scientist

Coimbatore

- Dr. AH Prakash, Pr. Scientist & Head (Acting) RS Coimbatore
- Dr.(Mrs.) Annie Sheeba, Scientist

Plant Biochemistry

- Dr. (Mrs.) Pooja Verma, Scientist

Agricultural Microbiology

Nagpur

- Dr. K Velmourougane, Senior Scientist
- Dr. (Mrs.) Savitha Santosh, Scientist

Agricultural Extension

Nagpur

- Dr. SM Wasnik, Pr. Scientist

Coimbatore

- Dr. (Mrs.) Usha Rani, Pr. Scientist

Agricultural Economics

Nagpur

- Dr. AR Reddy, Pr. Scientist

Coimbatore

- Dr. (Mrs.) Isabella Agarwal, Pr. Scientist

Computer Application in Agriculture

Coimbatore

- Dr.M Sabesh, Sr.Scientist

CROP PROTECTION DIVISION

Agricultural Entomology

Nagpur

- Dr. V S Nagrare, Pr. Scientist

- Dr. Chinna Babu Naik V, Sr. Scientist
- Dr. (Mrs.) Rachna Pande, Sr.Scientist
- Dr. Babasaheb Fand, Scientist
- Mr. Prabhulinga Tenguri, Scientist **(Rejoined after Study leave on 27.08.2021) (Study Leave w.e.f. 27.08.2018 to 26.08.2021)**
- Mr. Madhu TN, Scientist **(Rejoined after Study leave on 04.09.2021) (Study Leave w.e.f. 11.09.2018 to 10.09.2021)**
- Dr. Shah Vivek Hanskumar, Scientist

Coimbatore

- Dr. K Rameash, Pr. Scientist
- Dr. (Mrs.) M Amutha, Sr. Scientist
- Dr. K Shankarganesh, Sr. Scientist

Sirsa

- Dr. Rishi Kumar, Pr. Scientist

Plant Pathology

Nagpur

- Dr. SP Gawande, Scientist
- Dr. DT Nagrale, Scientist
- Dr. Neelakanth Hiremani, Scientist

Coimbatore

- Dr. A Sampath Kumar, Scientist
- Dr. P Valarmathi, Scientist

Sirsa

- Dr. Satish Kumar Sain, Sr. Scientist

Nemotology

Nagpur

- Dr. (Mrs.) N Narkhedkar, Pr. Scientist & Head (Acting)

Coimbatore

- Dr. (Mrs.) J Gulsar Banu, Pr. Scientist

KVK

- Dr. S. N Rokde, Head KVK

ADMINISTRATION

- Sh. A.A. Goswami, Sr. Administrative Officer
- Sh. Yashwant Sorte, Finance & Accounts Officer (Additional Charge from 23.07.2019)
- Sh. Ashwani Garg, Senior Finance & Accounts Officer (Additional Charge from 16.10.2021)

10.9 : Other Information

10.9.1: Mera Gaon Mera Gaurav

During the year 2021, new teams were constituted for MGMG program and adopted villages in Nagpur, Coimbatore and Sirsa.

The scientists in each team visited the MGMG adopted villages regularly and extended technical support to the farmers for profitable and sustainable farming. Seeds of cotton varieties developed at ICAR-CICR were distributed to MGMG beneficiaries and demonstrations were conducted in selected fields. Mobile based advisories were sent to the cotton growers with the support of the institute project "e-Communication". Literature support was provided to the farmers in the adopted villages on various aspects of cotton cultivation. Training programs on cotton production and protection technologies were organized in the adopted villages. Group discussions with farmers were held in all adopted villages to create awareness about effective management of insect pests and diseases of cotton in particular and other crops in general. Consistent field visits were organized to understand the biotic and abiotic problems and crop conditions. **In two MGMG villages Waroda and Adasa of Kalameshwar cluster, a farmers' participatory project on "Integrated Cotton Management" has been implemented by Agrovision Foundation, Nagpur in collaboration with South Asian Biotechnology Centre, Jodhpur with technical partnership of ICAR-Central Institute of Cotton Research, Nagpur.**

10.9.2: Development Action Plan for Scheduled Caste

The central government sponsored and funded scheme, "Development Action Plan for Scheduled Caste (DAPSC -- formerly Scheduled Caste Sub Plan SCSP)" was implemented by the ICAR-CICR, Nagpur with the main aim of emphasizing the developmental programmes for the Scheduled Castes, in relation to their agribusiness pattern and the need to increase productivity and income from their limited resources. The objective of the scheme was to increase the income levels of the targeted population through various income generating schemes, skill development and infrastructure development. The scheme was implemented in the selected PMAGY and other Non- PMAGY villages in four Districts of Maharashtra namely Nagpur, Wardha, Chandrapur and Bhandara, where the Scheduled Caste population is 50% or more by identifying the beneficiary families with the help of State Government Agencies. The program planning was done at the institute level and executed by the committee members in the adopted villages. The poor families were targeted to directly use the various agricultural related inputs provided by the Institute. The scientific inputs in terms of technology dissemination, technological interventions, capacity building, showcasing technologies, exposure visits, interface meetings and trainings, skill up gradation, timely solutions of the farmers problems, cleanliness of public premises, sanitization and providing information of various schemes implemented by state agricultural departments.

Various activities were carried out in the adopted villages to provide direct benefit to the scheduled caste beneficiaries under the SCSP Scheme. These includes, organization of skill development programmes, trainings and workshops, distribution of Goat & Goat Feed, improved Cotton cultivation practices, ICAR-CICR Bt varieties, Paddy seed, Red Gram seed, Gram seed, Wheat seed, Fertilizers, vegetable seed kits, bio-fertilizer kit, Power weeder and printed cotton cultivation practices. The farmers were sensitized on round the year for Cotton production and its scientific cultivation, with complete package of practices and seeds. The programme was implemented with involvement of the following team members of SCSP committee constituted by the authority.

The details of various activities carried out under SCSP schemes for the period given below:

Sr. No.	Name of activities	Venue and Date	No of SC beneficiaries	Input distributed/ skill imparted
1.	Entrepreneurship development along with various input distribution	Godhani village, Ta. Umred, Dist. Nagpur 4 February 2021.	100	• One day training cum farmers meets on 'Agri-based business management' & various critical input distributions. • Power weeder handed over to the Grampanchyant, Godhani.
2.	'Poshan Vatika Maha Abhiya n' and one day workshop on Integrated Pest and Disease Management in Cotton.	Dhurkheda, Ta. Umred, Dist. Nagpur 17 September 2021.	200	• Workshop on "Integrated pest and disease management in Cotton". • PoshanVatikaMahaAbhiyan
3.	Training program on Scientific Goat Farming cum Female Goat & Goat Feed distribution.	Parsodi, Aptur, Jogithana, Kalmana, Khairi Buti, Makardhokada, Paradgaon, Thombara, Tirkhura, Salebhatti, Saleshahari, Dhurkheda, Champa, Godhani, Sonpur, Bondri, Kesalwada, Chakara, Bandar Shivapur, Amati, Kanheri Dongarmoh, Sawarkheda, Khobna, Bodakipeth, Amboli January, March, April, November 2021	179	• Training program on Scientific Goat Farming & livestock management • Vaccination of female goats & distribution of two goats to each Scheduled Caste Beneficiaries. • Distribution of 50 Kg Goat Feed to each Scheduled Caste Beneficiaries.
4.	Demonstrations of ICAR-CICR Bt varieties.	Pipmalgaon Lute, Durgada, Kavtha, Welsakhara, Bandar June & July 2021	58	• Seeds of ICAR-CICR Suraj Bt and ICAR-CICR Rajat Bt variety distributed to SC farmers for the demonstration purpose.

Sr. No.	Name of activities	Venue and Date	No of SC beneficiaries	Input distributed/ skill imparted
5.	Tur Seed Distribution	Kawatha,Nandpur; Shekapur, Chitki Pimplagaon Lute, Durgada, Welsakhra, Thombra, Godhani, Dhurkheda, Amboli, Dhanla, Kuhi, Bandar, Kesalwada June & July 2021	625	• Tur seed and bio-Fertilizer kit distributed for intercropping to Scheduled caste farmers for Kharif season. • PKV – TARA variety of tur having packing 2 kg (4 Kg to each) distributed to the farmers.
6.	Paddy Seed Distribution	Dhanala, Bandar, Kesalwada, KVK-PDKV Sakoli June & July 2021	183	• Paddy seed distributed CO-51 & PDKV–Tilak variety of paddy distributed to Scheduled caste farmers for Kharif season.
7.	Bio-fertilizer Kit Distribution	Amboli, Amti, Bandar, Chitki, Dhanla, Dhurkheda, Durgada, Girad, Godhani, Kawatha, Kesalwada, Khapri, Khobna, Bodkhi Peth, Kuhi, Nandpur, Pauni, Pipardol, Pimplagaon Lute, Sawarkheda, Sillori, Shekapur, Sonapar, Sonpur, Tekari, Thombra, Tirkhura, Wadegaon, Welsakhra June, October & November 2021	1020	• Bio-fertilizer Kit Contain 4 items namely Rhizobium, PSB- Phosphate Solubilising Bacteria, Azotobacter and Trichoderma were distributed.
8.	Fertilizers – NPK (10:26:26), Urea, DAP, MOP Distribution	Kavtha, Nandpur, Chitki, Pauni, Shekapur, Amti, Pimpalgaon Lute, Durgada, Welsakhara, Thombara, Godhani, Dhurkheda, Amboli, Kuhı, Bandar, Tekari, Khobna, Bodakipeth, Khapari, Pipardol, Sillori, Sawarkheda, Tirkhura, Sonapar, Wadegaon July, October & November 2021	NPK - 680 Urea - 228 DAP - 395 MOP - 140	• Distributed to Scheduled caste farmers for Kharif and Rabi crop & to create awareness among the farmers for balanced use of fertilizers for higher yield & good quality crop produce.
9.	Gram Seed (Chickpea) Distribution	Durgada, Welsakhara, Thombara, Amboli, Tekari, Khobna, Bodakipeth, Khapari, Amti, Sawarkheda, Sillori, Pipardol, Tirkhura, Pauni, Sonapar, Wadegaon. October & November 2021	450	• Gram seed and bio-Fertilizer kit Distributed to Scheduled caste farmers for Rabi season. • Gram Variety, Jaki-9218 having packing 30 Kg& Rajvijay- 202 having packing 20 Kg distributed to 300 & 150 farmers respectively.
10.	Wheat Seed Distribution	Durgada, Tekari October & November 2021	75	• Wheat seed and bio-Fertilizer kit Distributed to Scheduled caste farmers for Rabi season. • Wheat variety PhuleSamadhan having packing 40 kg one bag to each distributed to the farmers.

Sr. No.	Name of activities	Venue and Date	No of SC beneficiaries	Input distributed/ skill imparted
11.	Skill up gradation programme on improved methods of vegetable cultivation & vegetable seed kit distribution.	Kawatha, Durgada, Pimplagaon Lute, Welsakhra, Thombra, Godhani, Dhurkheda, Amboli, Pipardol, Pauni, Tirkhura, Wadegaon, Khobna, BodkhiPeth, Sawarkheda, Amti, Kuhi, Sonapar, Sillori, Sonpur, Khapri, Tekari, Bandar, Girad June, October & November 2021	726	• Sensitisation on scientific Management of vegetable crops and off-season vegetable production. • Seeds of various vegetables like cucumber, hybrid bottle gourd, hybrid brinjal, cowpea, cluster bean, chilli, ridge gourd and other critical inputs.

Entrepreneurship development & various input distribution at Godhani village Tah. Umred, Dist. Nagpur

Poshan Vatika Maha Abhiyan activities to the farmers at. Dhurkheda, Ta. Umred, Dist. Nagpur

Female Goat distribution to beneficiaries under SCSP scheme

Cotton Seed distribution to SC beneficiaries ICAR- CICR Bt Cotton demonstrations

10.9.3 : Tribal Sub Plan

The "Tribal Sub Plan" programme runs by the Government of India with the main objective to promote Scheduled tribes' economic development through family-oriented schemes by providing resources to the Scheduled tribes family. Planning Commission set up an Inter-Ministerial Committee under the Chairpersonship of Secretary, Planning Commission, to effectively implement TSP as an essential instrument for accomplishing socio-economic growth of tribal farmers. The main objective of TSP scheme is focusing on the empowerment of Tribal farmers through trainings, exposures, education and providing resources. The activities carried out during 2021 include capacity building on improved production and protection techniques of cotton, paddy, green gram, vegetable seeds (kit) and groundnut cultivation. Exposure visits and awareness training about new technologies in agriculture and allied activities were also organized. Similarly, vocational trainings on agribusiness, skill up gradation, integrated pest management (IPM) programmes, reduced tillage or conservation tillage farming and created awareness on personal protection while spraying and use of agrochemicals among scheduled tribe (ST) farmers.As women farmers play important role in agriculture, the aim of project was to mobilize women farmers from ST families to form self-help groups (SHGs) through awareness programmes, provide them technical assistance through capacity building and motivate them to generate income round the year through vegetable

cultivation, nutri-gardens and other various activities. As part of the TSP programmes, inputs like improved seeds of cotton, paddy, green gram, Bengal gram and groundnut varieties, vegetable seeds (kit), fungicides & pesticides (IPM in cotton kit), CICR KVK cotton picking bags, pink bollworm pheromone traps and yellow sticky traps for sucking pests management were distributed to the ST farmer beneficiaries from the project areas and adopted villages under TSP programme.

The details of various programmes carried out under the TSP schemes :

Sr. No	Conducted programs	Venue and Date	No. of ST beneficiaries	Input distributed/ skill imparted
1.	One Day Farmers training and groundnut seeds distribution program	KVK CICR, Nagpur 28th Jan, 2021	50	• Summer groundnut seeds of variety TAG-24 to the tribal farmers of Umred tehsil, Nagpur district @ 20kg/ farmer
2.	Farmers Training cum Workshop Program on Cotton & Summer Green Gram Cultivation	KVK, Sonapur, Gadchiroli 10thFeb, 2021	200	• Green gram variety IPM 410-3 (Shikha)
3.	One Day Farmers training and groundnut seeds distribution program	KVK CICR, Nagpur 11thFeb, 2021	50	• Summer Groundnut seeds of variety TAG-24 to the tribal farmers of Umred and Hingana tehsil @ 20kg/ farmer.
4.	Distribution of vegetable seeds kit programme	Arvi, Taluka - Samudrapur, Dist. Wardha 1stJune, 2021	15	• Distribution of vegetable seeds kit
5.	One day Farmers Training on "Production and Protection Techniques on Cotton"	Video conferencing, In collaboration with KVK, Nandurbar 4thJune, 2021	80	• Resource persons from the Central Institute for Cotton Research, Nagpur provided detailed technical guidance to the farmers on various topics by providing detailed information and discussion
6.	Farmers Training on cotton cultivation programme, paddy seed and vegetable seed distribution	KVK, Sonapur, Gadchiroli 10thJune, 2021	200	• Distribution of paddy seeds and vegetable seeds kit
7.	One day "Tribal farmer's training workshop program cuminput distribution" programme	ICAR-CICR, Nagpur 15thJune, 2021	34	• Distribution of cotton seeds (cv. SurajBt and cv. PKV-081) and vegetable seed kits
8.	Paddy seed & vegetable seed kit distribution programme	Khapa(Khurd), Taluka-Tumsar Dist.- Bhandara 17thJune, 2021	110	• Distribution of 25 Kg bags of Paddy seeds variety (Kishan, Tilak) • Distribution of vegetable seedskit
9.	Vegetable Seeds Distribution Programme	Taluka-Bhadravati Dist.- Chandrapur 17thJune, 2021	16	• Distribution of vegetable seeds kits
10.	Field Demonstrations in Tribal farmers' fields and vegetable seed distribution programme	Ghatpendhari, Taluka-Parsheoni Dist.-Nagpur 18thJune.2021	134	• Seeds of ICAR-CICR Bt cotton varieties *viz.*, SurajBt (20), RajatBt (20) and PKV 081Bt (10 bags of 2 kg each) along with pigeon pea seeds (50 bags of 2 kg each) • Vegetable seeds kit were distributed
11.	Farmers Training and Inputs (Vegetable seed kit, Cotton	Patnapur, Taluka - Botha	50	• Distribution of 30 Vegetable seed kit

Sr. No	Conducted programs	Venue and Date	No. of ST beneficiaries	Input distributed/ skill imparted
	picking bag and Pheromone trap) Distribution programme	Dist. Adilabad 8th July, 2021		• Distribution of 50 Cotton picking bags • Distribution of 30 Pheromone trap for PBW
12.	Distribution of pheromone trap for mass trapping of pink bollworm	Muradpur, Taluka-Umred Dist.-Nagpur 12th Aug, 2021	12	• Distribution of 1000 pheromone traps and lures
13.	Distribution of pheromone traps for Field demonstration of mass trapping of pink bollworm in cotton	KVK, Sonapur, Gadchiroli 13th August, 2021)	50	• Distribution of 1000 pheromone traps and 2000 lures
14.	One day farmers field training cum inputs distribution and demonstration of mass trapping	Masala-K Taluka - Bela Dist.-Adilabad 21st August, 2021	100	• Distribution of 1000 pheromone traps and Lures • Distribution of 100 Cotton picking bags • Distribution of 100 yellow sticky traps.
15.	Demonstration of Integrated pest management and inputs distribution	Sitagondi, Taluka-Gudihatnur, Dist. Adilabad 21st August, 2021	2	• Distribution of cotton IPM kit
16.	Farmers training and Inputs distribution to the famers for cotton IPM	Dhannur Taluka-Mulchera Dist.-Gadchiroli 31st August, 2021	2	• Distribution of cotton IPM kit
17.	Farmers training and Inputs distribution Program under MGMG and TSP	Ghatpendhari Taluka-Parsheoni Dist.-Nagpur 24th September, 2021	50	• Distribution of pheromone traps 150 traps and 150 lures • Yellow sticky trap • Thiamethoxam (5 kg) • Lambda cyhalothrin (25 litres)
18.	Farmer's training cum-Exposure visit and input distribution	KVKCICR, Nagpur 30th September, 2021	25	• Distribution of 25 tarpaulins
19.	Farmer's training cum-Exposure visit and input distribution	KVK CICR, Nagpur 5th October, 2021	45	• Distribution of 45 Cotton picking bags • Yellow sticky traps
20.	Farmers training-cum-Inputs distribution Program	KVK, Sonapur, Gadchiroli 30th November, 2021	99	• Distribution of 99 Gram seed bags
21.	Farmer's training –cum-Exposure visit and input distribution	KVK CICR, Nagpur 13th December, 2021	15	• Distribution of mango and papaya seedlings

Glimpses of various activities undertaken in TSP, ICAR-CICR, Nagpur

10.9.4: Library

In the year 2021, the Library purchased 26 new books and procured the e-book version of ICAC Cotton Databook. The Library also procured the *e-book series of Advances in Agronomy 2021* thus adding to its existing e-book collection.

25 Hindi books were procured. The Library also subscribed to 12 Indian Journals. Off-campus activation was done for all e-books and journals for scientists, taking into account the Covid situation. Annual Report and CICR Newsletter was distributed to ICAR Institutes and dignitaries.

DOCUMENTATION SERVICES

- The Library started a monthly documentation service from August 2021 to highlight the worldwide ongoing research and development in Cotton science by the name "Gleanings in Cotton Research". Five issues of this publication were compiled and e-mailed to all scientists.
- Library has developed computerized bibliographic database on Cotton to provide comprehensive and updated information on cotton. About 5400 bibliographic references along with abstracts have been stored in it. Based on this bibliographic database the Library publishes a current awareness bulletin namely "COTTON RESEARCH ABSTRACTS". The Bulletin is circulated to all the scientists of the Institute and to all AICCIP Centers in India. In the reported period, two issues of COTTON RESEARCH ABSTRACTS (V35, January – December 2021) were published and circulated.
- Articles appearing in newspapers on Cotton are digitally scanned and the copy is emailed to all scientists for information. A collection of all news items appearing in 2020 was compiled and published by the name "CICR in News 2020".
- The Library is actively participating in the e-Journal Consortium by responding regularly through E-mails and thus also receiving updates. More than 2000 on-line journals on agriculture and crop science are made available over the network through this consortium. Library provides E-Reference Service by virtue of which, important information vital for research such as, alerts, bulletins, articles and circulars received by the Library in electronic format are immediately circulated to all scientists by sending regular E-mails.
- Four User Terminals installed in the Library have facilitated the library users to access the databases uploaded in the Library Server. Users can also access the Internet on these terminals. Similarly, the entire catalog of the library has been downloaded on these terminals for ease of use.
- The Web OPAC version of the Library software SLIM21 was updated and by using this Library Application Software, the

entire catalogue of holdings of the Library (books and bound volumes) is available on all terminals within the Institute. By its virtue, the entire holdings and the catalogue of the Library are visible on the LAN terminals within the Institute by clicking on the following link. Library Catalogue Web-OPAC Link http://cicrslim/w27/

10.9.5 : Progressive Use of Hindi

राजभाषा (हिंदी) : प्रचार प्रसार

भा.कृ.अनु.प.– केन्द्रीय कपास अनुसंधान संस्थान, नागपुर में वर्ष 2021 के अंतर्गत भारत सरकार, गृह मंत्रालय, राजभाषा विभाग एवं भारतीय कृषि अनुसंधान परिषद, नई दिल्ली से प्राप्त निर्देशानुसार संस्थान में राजभाषा (हिंदी) के सक्रिय प्रचार–प्रसार हेतु राजभाषा (हिंदी) संबंधित विभिन्न गतिविधियां का आयोजन किया गया, जिसका संक्षिप्त विवरण निम्नानुसार हैं :

राजभाषा कार्यान्वयन समिति की त्रैमासिक बैठक का आयोजन

संस्थान में राजभाषा हिंदी के सक्रिय प्रचार–प्रसार के हेतु राजभाषा कार्यान्वयन समिति (वित्तीय वर्ष 2021) की त्रैमासिक बैठकों का आयोजन निम्नानुसार किया गया।

क्र.	दिनांक	विषय
1	27 मार्च, 2021	वर्ष–2021 की राजभाषा कार्यान्वयन समिति की प्रथम बैठक
2	26 जून, 2021	वर्ष–2021 की राजभाषा कार्यान्वयन समिति की द्वितीय बैठक
3	17 अगस्त, 2021	वर्ष–2021 की राजभाषा कार्यान्वयन समिति की तृतीय बैठक
4	20 नवम्बर, 2021	वर्ष–2021 की राजभाषा कार्यान्वयन समिति की चतुर्थ बैठक

हिंदी सप्ताह 2021

भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर में बडे ही उत्साह पूर्ण वातावरण में 'हिंदी सप्ताह (दिनांक : 07 – 14 सितबर, 2021) समारोह' का विधिवत् उद्घाटन दिनांक : 07 सितम्बर, 2021 को डॉ. ब्लेज डिसूजा, प्रभारी निदेशक, भा.कृ.अनु.प –केन्द्रीय कपास अनुसंधान संस्थान, नागपुर के शुभहस्त दीप प्रज्ज्वलित कर किया गया। इस सुअवसर पर संस्थान में 'हिंदी सप्ताह समारोह' के अंतर्गत विभिन्न हिंदी प्रतियोगिताओं (हिंदी निबंध प्रतियोगिता, सामान्य ज्ञान प्रतियोगिता, चित्र आधारित कहानी लेखन प्रतियोगिता, शब्दानुवाद प्रतियोगिता एवं हिंदी शुद्ध लेखन प्रतियोगिता) की जानकारी अधिकारियों एवं कर्मचारियों को देते हुए उनसे यह आग्रह किया कि वे इन विभिन्न हिंदी प्रतियोगिताओं मे अधिक–से–अधिक संख्या में भाग लेकर इस आयोजन को सफल बनाए ।

'हिंदी सप्ताह : समापन समारोह' का आयोजन दिनांक : 14 सितम्बर, 2021 को राजभाषा कार्यान्वयन समिति के अध्यक्ष डॉ. वाय. जी. प्रसाद, निदेशक, भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर की अध्यक्षता में किया गया। डॉ. वाय. जी. प्रसाद ने अपने अध्यक्षीय सम्बोधन में कहा कि हिंदी से राष्ट्रीय एकता को बल मिलता है। हिंदी हमारे लिए केवल एक भाषा ही नहीं अपितु राष्ट्रीय अस्मिता की प्रतीक है जिसे राष्ट्र हित में मजबूत करना हम प्रत्येक भारतीय नागरिकों का कर्तव्य है। अतः इस दृष्टिकोण से राष्ट्रीय हित में अपने कार्यालयीन कार्यों में राजभाषा (हिंदी) का अधिक–से–अधिक उपयोग करना हमारा संवैधानिक उत्तरदायित्व है।

तदोपरांत इस समारोह के कार्यक्रमाध्यक्ष एवं मंचासीन मान्यवरों के शुभहस्ते संस्थान में हिंदी सप्ताह समारोह–2021 के अंतर्गत आयोजित हिंदी संबंधित विभिन्न प्रतियोगिताओं के विजयी प्रतिस्पर्धी अधिकारियों एवं कर्मचारियों को नकद पुरस्कार वितरित किए गए। इस कार्यक्रम का कुशल संचालन डॉ. महेंद्र कुमार साहू, सहायक मुख्य तकनीकी अधिकारी (रा.भा.) ने किया और आभार डॉ. पूजा वर्मा, वैज्ञानिक, भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान, नागपुर ने माना।

कार्यशालाएं : 2021

केन्द्रीय कपास अनुसंधान संस्थान, नागपुर कार्यालय में वैज्ञानिक/प्रशासनिक/तकनीकी अधिकारी संवर्ग हेतु एक दिवसीय कार्यशालों का आयोजन किया गया। संस्थान में इस वर्ष निम्नलिखित विषयों पर कार्यशालाओं का प्रस्तुतीकरण किया गया।

क्र.	दिनाक	विषय
1	30 मार्च, 2021	कोविड–19 महामारी सतर्कता एवं अनुपालन
2	26 जून, 2021	योग मिटाए रोग
3	08 सितबर, 2021	जन जन की भाषा हिंदी
4	30 दिसबर, 2021	"किसानो की आय दोगुनी करने हेतु उपाय

पुरस्कार :

भा.कृ.अनु.प.–केन्द्रीय कपास अनुसंधान संस्थान को 'ख' क्षेत्र के अतर्गत वर्ष 2019–20 के लिए राजभाषा (हिंदी) कार्यान्वयन के क्षेत्र में उल्लेखनीय कार्य करने हेतु दिनांक : 16 जुलाई, 2021 को भारतीय कृषि अनुसंधान परिषद, नई दिल्ली के 93 वें स्थापना दिवस एवं पुरस्कार वितरण के आभासी समारोह में संस्थान को परिषद का प्रतिष्ठित 'राजर्षि टंडन राजभाषा पुरस्कार (प्रथम)' प्रदान किया गया। संस्थान को लगातार तीसरी बार राजभाषा (हिंदी) कार्यान्वयन के क्षेत्र में उल्लेखनीय कार्य करने हेतु परिषद का यह गौरवान्वित 'राजर्षि टंडन राजभाषा पुरस्कार (प्रथम)' लगातार तीसरी बार प्राप्त हुआ है।


भारतीय कृषि अनुसंधान परिषद

प्रशस्ति पत्र

राजर्षि टंडन राजभाषा पुरस्कार

10.10 : Weather

Nagpur

Month	Temperature (°C)		Relative Humidity (%)		Rain fall (mm)	No. of Rainy Days
	Max	Min	Max	Min		
January, 2021	29.4	15.3	81.3	48.3	12.8	1
February, 2021	31.3	14.4	73.4	36.4	13.8	3
March, 2021	36.6	19.2	61.8	26.3	19	6
April, 2021	40.5	22.5	49.3	20.6	8.4	3
May, 2021	40.1	25.6	59.9	28.9	34.1	4
June, 2021	34.6	24.6	80.3	54.5	282.7	20
July, 2021	32.0	24.8	85.5	64.6	382.7	20
August, 2021	31.6	24.4	85.2	67.1	181	15
September, 2021	31.4	24.4	84.8	69.4	355.8	26
October, 2021	33.1	21.1	83.0	52.8	21.6	6
November, 2021	31.1	18.1	82.5	48.8	8.20	2
December, 2021	28.0	14.0	82.1	38.1	1.8	1
Total					**1321.9**	**107**

Coimbatore

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
January, 2021	27.6	21.0	86.8	63.3	141.5	9.0
February, 2021	31.0	20.1	84.8	40.8	2.9	0.0
March, 2021	35.0	22.5	80.4	36.6	0.0	0.0
April, 2021	35.1	24.3	82.8	47.8	34.0	3.0
May, 2021	33.5	24.4	82.5	55.5	70.1	5.0
June, 2021	32.7	23.7	80.4	53.4	15.0	4.0
July, 2021	31.0	23.6	80.8	60.8	30.5	4.0
August, 2021	30.9	24.3	84.0	59.0	50.5	9.0
September, 2021	31.9	23.4	84.0	57.0	57.5	7.0
October, 2021	30.1	23.1	86.0	66.0	268.0	10.0
November, 2021	28.5	22.3	87.0	69.0	203.0	8.0
December, 2021	28.7	21.2	85.0	58.0	75.3	6.0

Sirsa

Month	Temperature (°C)		Relative Humidity (%)		Rain fall (mm)	No. of Rainy Days
	Max.	Min.	Max.	Min.		
January, 2021	18.5	6.5	89.4	61.5	7.2	1
February, 2021	25.4	10.8	79.9	45	0	0
March, 2021	31.3	15.7	76.7	38.2	0	0
April, 2021	36.9	19.5	54.8	22.3	4.5	1
May, 2021	39.7	25.4	55.2	31.6	14.5	2
June, 2021	39.5	28.4	62.8	37.4	150.5	4
July, 2021	37.2	28.2	73.5	54.8	53.3	5
August, 2021	36.5	27.3	76.5	56	33.1	2
September, 2021	32.7	24.3	84.9	68.4	93.5	7
October, 2021	33.1	20.6	76	42.4	10	2
November, 2021	28.9	13.2	78.4	32	0	0
December, 2021	22.0	7.9	86.9	45.8	0	0
Total					**366.6**	**24**

10.11 : Cotton Scenario

Area: in Lakh Hectares
Production: in Lakh bales of 170 kg.
Yield: Kg per hectare

State	Area		Production		Yield	
	2020-21	2021-22*	2020-21	2021-22*	2020-21	2021-22*
Punjab	2.52	2.56	10.23	6.51	690.12	432.30
Haryana	7.40	6.36	18.23	13.16	418.80	351.76
Rajasthan	8.07	7.56	32.07	24.81	675.58	557.90
Total North Zone	***17.99***	***16.48***	***60.53***	***44.48***	***571.99***	***458.83***
Gujarat	22.70	22.46	72.18	75.57	540.56	571.99
Maharashtra	45.44	39.54	101.05	71.18	378.05	306.03
Madhya Pradesh	5.88	5.63	13.38	14.27	386.84	430.89
Total Central Zone	***74.02***	***67.63***	***186.61***	***161.02***	***428.58***	***404.75***
Telangana	23.58	20.69	57.97	66.45	417.93	545.99
Andhra Pradesh	6.06	5.48	16.00	15.18	448.84	470.91
Karnataka	8.20	6.77	23.20	19.52	480.98	490.16
Tamil Nadu	1.12	1.38	2.43	2.80	368.84	344.93
Total South Zone	***38.96***	***34.32***	***99.60***	***103.95***	***434.60***	***514.90***
Odisha	1.71	1.93	5.51	5.70	547.78	502.07
Others	0.17	0.19	0.23	0.28	230.00	250.53
All-India	***132.85***	***120.55***	***352.48***	***315.43***	***451.05***	***444.82***

Source: Cotton Advisory Board, Ministry of Textile, Govt. of India.
* Provisional as estimated by CAB in its meeting

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