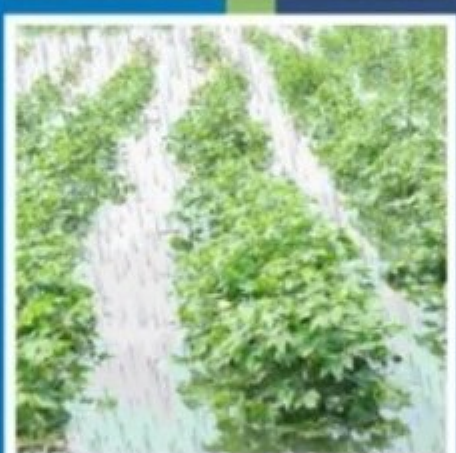


2020
Annual Report

GOLDEN JUBILEE CELEBRATIONS

CENTRAL COTTON RESEARCH INSTITUTE MULTAN

1970 - 2020

**CENTRAL COTTON RESEARCH INSTITUTE,
MULTAN - PAKISTAN.**

EXECUTIVE SUMMARY

i). Introduction

Central Cotton Research Institute (CCRI), Multan, the prime research facility of Pakistan Central Cotton Committee was established in 1970. By the grace of God, the Institute has completed 50 years of establishment during the year 2020. The Institute is equipped with different research disciplines i.e., Agronomy, Breeding & Genetics, Cytogenetics, Entomology, Plant Pathology, Physiology/Chemistry, Fibre Technology, Transfer of Technology and Statistics. The research work has been focused on the following main aspects:

i. Study the cotton plant from botanical, genetical, production, physiological, chemical, entomological, pathological and other relevant facets in a coordinated manner.
ii. Undertake research work of national importance, handle problems of inter-regional nature.
iii. To develop cost-effective cotton production technology.
iv. Advance knowledge on the cotton plant responses to environment with a view to better cope with the adverse impacts in the changing climate scenario.
v. Provide education and training on cotton production technology to the agriculture research, extension, teaching staff and other stakeholders.
vi. Identify problems of cotton growers and advocate remedial measures.
vii. Promote mechanization in cotton production system.
viii. Transfer production technology to the cotton growers.
ix. Educate and motivate cotton growers and monitor research outcomes.
x. Provide technical support to the Pakistan Central Cotton Committee in coordinating and developing a national programme for cotton research and development.
xi. Training manpower across the country and other cotton growing countries on "cotton research and development".
xii. Facilitation and research guidance to students at graduate and higher level degree courses.

The Institute has so far developed 30 elite cotton varieties since its inception. Developments have been made in earliness, heat tolerance, drought tolerance, disease resistance and fibre quality traits. CCRI Multan pioneered in developing cotton leaf curl virus (CLCuV) resistant varieties when the country suffered a huge loss in cotton production during 1993-94. In addition to the varietal development, the scientsts of the Institute developed water saving planting techniques, pest scouting models and economic threshold levels (ETLs) for various pests, evaluate nutritional requirement of cotton varieties, addressing soil health issues. Since its establishment, CCRI Multan has made tremendous progress in cotton R&D in various aspects of cotton crop. Some of which are given below:

- Hosting World Cotton Gene Pool comprising 6143 entries in medium and long term storage facilities, and characterizating them for heat, drought and CLCV tolerance.
- Developed short-duration varieties (210 to 150 Days; CIM-506).
- Developed CLCuV resistant varieties (CIM-1100 & CIM-443), high lint percentage (34% - 45%) and staple length (27.0 - 33.0 mm) varieties.
- Developed 11 Genetics Male Sterile (GMS) lines at Breeding & Genetics.
- Maintaining live herbarium of 33 species of Gossypium germplasm.
- Hosting facility for Karyotypic analysis of interspecific hybrids (21 hybrids).
- Established a Biotechnology Lab with limited resources.
- Developed 30 varieties (20 Non Bt. & 10 Bt.)
- Developed production technology for various regions and IPM strategies for different pests.
- Providing Fibre Testing Services at Faser Institute, Germany recognized standards.
- Providing Training of farmers, extension workers, academia and industry.

In addition to the above mentioned achievements, the ongoing research work carried out by the scientists of the Institute is as summarized below:

- Characterization of germplasm (CLCuV resistance, insect-pest and disease resistance, heat tolerance and fiber quality traits)
- Endeavoring to break photo period sensitivity of 52 accessions identified as CLCuV resistance during screening.
- Development of extra-long staple (ELS) strains through introgression of fiber linked genes.
- Development of Mapping population for fibre quality
- Preliminary lab work in progress for transformation
- Ideotype varietal development for mechanical cotton picking
- Screening of advanced material for heat, drought, duration inputs response, and adaptability
- Development and improvement of natural color cotton varieties

At the international fronts, CCRI Multan has been nominated as “Center of Excellence in Cotton Research and Development” by the Ministry of National Food Security & Research, Government of Pakistan under the China-Pak-Economic Corridor (CPEC)’s Agricultural Development Projects.

The Institute, since its establishment, remained associated with various international organizations for cotton research and development programs as mentioned below:

- Asian Development Bank (ADB)
- CERA USA (Biosafety Research in Pakistan Grant Program)
- Common Fund for Commodity (CFC) UK
- Economic Cooperation Organization (ECO)
- Faser Institute (Bremen Fibre Institute), Germany
- Food & Agriculture Organization (FAO) of the United Nations
- International Cotton Advisory Committee (ICAC) USA
- International Cotton Researchers Association (ICRA)
- Japan International Cooperation Agency (JICA)
- Natural Resources Institute UK
- Organization of the Islamic Conference (OIC)
- Overseas Development Agency UK
- South Asian Association for Regional Cooperation (SAARC)
- United Nations Development Program (UNDP)
- University of Hubei, China
- USDA (USAID PL-480, Pak-US ICARDA Cotton Project)
- Fellowships & Trainings
  - Borlaug Fellowships
  - Chinese Government Trainings
  - Islamic Development Bank Fellowship

ii) Staff Position

A total of 112 staff members including 30 officers and 82 other staff members remained at the Institute during the period under report. The position of technical staff during the year 2020-21 is given in **Annexure-I**.

iii) Budget

The sanctioned budget from the year 2017-18 to 2020-21 is given below:

(Rs. Million)

Sr. #	Detail	2017-18	2018-19	2019-20	2020-21
1.	Pay & Allowances	66.891	65.567	58.703	27.129
2.	Medical	0.027	0.106	0.077	--
3.	Traveling Allowance	1.983	1.206	0.827	--
4.	Group Insurance	0.650	0.683	0.550	0.264
5.	Utility Bills*	6.861	10.711	10.726	7.656
6.	Contingencies	24.126	24.273	22.532	5.406
	Total	**100.538**	**102.546**	**93.415**	**40.455**

* Include Electricity, Gas, WASA, Phone, Internet, and electricity charges for new building

iv) Income

The income of the Institute from the year 2017-18 to 2020-21 is given below:

(Rs. Million)

Sr. #	Head	2017-18	2018-19	2019-20	2020-21
1.	Farm Produce	4.479	6.838	3.378	1.190
2.	Non-Farm Produce	1.268	1.275	1.328	1.380
	Total	**5.747**	**8.133**	**4.706**	**2.570**

* Period from 1st July to 28th February

II RESEARCH ACTIVITIES

i) Research Experiments

The research experiments conducted during 2020-21 along with estimated cost for each experiment, carried out by various sections are as follows:

Name of Scientist	Experiment	Approx. Cost (Rs.)
	AGRONOMY	
Dr. M. Naveed Afzal	Effect of time of sowing on productivity of advanced genotypes	67,240
Dr. M. Ahmad	Effect of time of sowing on productivity of transgenic cotton	67,240
Muhammad Tariq	Yield response and nitrogen use efficiency of transgenic and conventional cotton cultivars to nitrogen application	65,250
Muhammad Tariq	Modeling cotton genotypes performance at temporal variations	17,790
Dr. M. Ahmad	Cotton yield response to residues management and tillage systems in cotton-wheat cropping system	60,150
Muhammad Tariq	Cotton yield and fiber quality response to high density planting system	65,300
Dr. M. Ahmad	Agro-economic feasibility for cotton-based intercropping system.	70,800
Dr. M. Naveed Afzal	Effect of planting and picking time on cotton seed quality.	10,000
Muhammad Tariq	Weed diversity survey in cotton growing areas of Punjab.	150,000
Dr. M. Naveed Afzal	Screening of pre- and post-emergence weedicides in cotton	50,550
	PLANT BREEDING & GENETICS	
Dr. M. Idrees Khan **Saeed Muhammad**	VT- 1:Evaluation of medium long staple Bt. and Non Bt. strains against commercial varieties	45,300
Dr. M. Idrees Khan **Dr Khadim Hussain**	VT-2: Evaluation of medium long staple Bt. and Non Bt. strains against commercial varieties	45,300
Dr. M. Idrees Khan **Hafiz Abdul Haq**	VT-3: Evaluation of medium long staple Bt. and Non Bt. strains against commercial varieties	45,300
Dr. M. Idrees Khan **Dr. Fazl-I-Dayim Shehzad**	VT-4: Evaluation of medium long staple Bt. and Non Bt. strains against commercial varieties	45,300
Hafiz Abdul Haq	MVT-1: Evaluation of medium long staple Bt. and Non Bt. strains against commercial varieties	27,500
Saeed Muhammad	MVT-2: Evaluation of medium long staple Bt. and Non Bt. strains against commercial varieties	27,500

Dr Khadim Hussain	MVT-3: Evaluation of medium long staple Bt. and Non Bt. strains against commercial varieties	27500
Dr. Fazl-I-Dayim Shehzad	MVT-4: Evaluation of medium long staple Bt. and Non Bt. strains against commercial varieties	27,500
Dr. Fazl-I-Dayim Shehzad	MVT-5: Evaluation of medium long staple Bt. and Non Bt. strains against commercial varieties	27,500
Muhammad Akbar	MVT-6: Evaluation of medium long staple Bt. and Non Bt. strains against commercial varieties	27,500
Muhammad Akbar Dr. Fazl-I-Dayim Shehzad	Standard Varietal Trials (1 & 2)	35,000
Dr. M Idrees Muhammad Akbar Dr Khdim Hussain Hafiz Abdul Haq, Dr. Fazl-I-Dayim Shehzad Saeed Muhammad	Testing of Promising Strains of Cotton Breeders under National Coordinated Variety Testing Program (Set A-D)	150,000
Muhammad Akbar Dr Khadim Hussain Hafiz Abdul Haq Dr. Fazl-I-Dayim Shehzad Saeed Muhammad	Raising Hybrids (Filial generations)	850,000.
Muhammad Akbar Dr Khadim Hussain Hafiz Abdul Haq Dr. Fazl-I-Dayim Shehzad Saeed Muhammad	Performance of Promising Strains in Bigger Block	665,000
Hafiz Abdul Haq,	Ratooning of ICARDA materials for screening of against CLCuD	170,000
Hafiz Abdul Haq,	Maintenance of Genetic Stock of World Cotton Collection	255,000
Dr. M. Idrees Khan Hafiz Abdul Haq	Preservation and maintenance of Cotton germplasm in Cold Chambers	600,000
Muhammad Akbar Dr Khadim Hussain Hafiz Abdul Haq Dr. Fazl-I-Dayim Shehzad Saeed Muhammad	Maintenance of Glass house for generation enhancement	250,000
	CYTOGENETICS	
Farzana Ashraf	Collection and maintenance of *Gossypium* germplasm in permanent herbarium Block & Glass house	250,000
Farzana Ashraf, Khizer Hayyat, Muhammad Imran & Rashida Aslam	Species hybridization & Search for *Bt* homozygous resistance against CLCuD under field conditions	340,000
Khizer Hayyat & Rashida Aslam	Development of auto-tetraploid	50,000
Farzana Ashraf & Rashida Aslam	Chromosomal studies of Species hybrids in Lab.	50,000
Farzana Ashraf, Khizer Hayyat, Muhammad Imran & Rashida Aslam	Testing of Cyto-material in Micro Varietal Trials (1-4)	85,000
Farzana Ashraf, Khizer Hayyat, Muhammad Imran & Rashida Aslam	Testing of Cyto-material in Micro Varietal Trials (1-3)	63,000
Dr. Khizer Hayyat	Mapping population development for fibre quality	45,000

Farzana Ashraf, Khizer Hayyat, Muhammad Imran & Rashida Aslam	Early generation System for pre basic seed	170,000
Farzana Ashraf, Khizer Hayyat, Muhammad Imran & Rashida Aslam	Seed multiplication	170,000
	ENTOMOLOGY	
Dr Rabia Saeed	Impact of sowing period on the PBW infestation	57,000
Dr Rabia Saeed Junid Ali Khan	Pink bollworm infestation in green bolls in major cotton growing area	60,500
Dr Rabia Saeed	Monitoring of population dynamics of different lepidopterous pests	64,450
Mrs. Shabana Wazir Junaid Ali Khan	Studies on tolerance level of cotton genotypes to insect pest complex National Coordinated Varietal Trials	58,500
Junid Ali Khan	Screening of insecticides	57,000
Dr Rabia Saeed Junid Ali Khan Mrs. Shabana Wazir	Monitoring of insecticide resistance	63,500
Dr. Rabia Saeed Mrs. Shabana Wazir	Rearing of cotton insect pests and natural enemies in labs.	219,310
Dr Rabia Saeed Mrs. Shabana Wazir Junid Ali Khan	Projects on Pink bollworm, Whitefly, Dusky Bug	---
	PLANT PATHOLOGY	
Ms Sabahat Hussain	Survey on Prevalence of Diseases and Collection of Diseased Plant samples	--
--do--	Evaluation of Breeding Material against CLCuD	--
--do--	Epidemiological Studies of CLCuD	--
--do--	Evaluation of Advanced Strains in NCVT in tolerance to Cotton Diseases	--
	PLANT PHYSIOLOGY/CHEMSITRY	
Asia Perveen	Adaptability of cotton genotypes to high temperature stress	85,000
Asia Perveen	Evaluation of stress alleviating chemicals in cotton under heat stress conditions	125,000
Dr. Noor Muhammad	Screening of gene pool germplasm for HT	25,000
Dr. Fiaz Ahmad	Long term effects of minimum tillage on soil health and cotton-wheat productivity	68,000
Dr. Noor Muhammad	Does phosphorus application time affect root development and cotton productivity?	80,000
Dr. Fiaz Ahmad/ Dr Noor Muhammad	Adaptability of cotton genotypes to water stress conditions	75,000
Dr. Fiaz Ahmad	Evaluation of selected-K cotton cultivars for drought tolerance characteristics	80,000
Asia Perveen	Exploring the role of antioxidants, growth hormone in cotton plant growth, cottonseed health and productivity	120,000
	FIBRE TECHNOLOGY	
Muhammad Ilyas Sarwar Danish Iqbal	Testing of Lint Samples	235,000
--do--	Testing of Commercial Samples	60,000
--do--	To study the effect of different moisture levels on fibre characteristics of cotton cultivars	70,000
--do--	To study the effect of Potassium fertilizer & water stress on quality characteristics of cotton fibre	20,000
--do--	The role of stress alleviating chemicals on cotton fibre characteristics under heat stress conditions	20,000
--do--	Saw & Roller Ginning Comparison for Cotton Fibre Quality	30,000

--do--	Quality survey of lint collected from ginning factories	60,000
--do--	ICA-Bremen Cotton Round Test Program, Faser Institute, Germany	15,000
	TRANSFER OF TECHNOLOGY	
Sajid Mahmood	Integrated Multi-Media Publicity Campaign	--
--do--	TeleCotton SMS	15,87,730
	STATISTICS	
Mubashir Islam Gill	Experimental Design Layout, Statistical Analysis of NCVT	--
--do--	Maintenance of Cotton Statistics	--
--do--	Study of factors effecting the cotton lint rate in Pakistan	--
	FARM MANAGEMENT	
Muhammad Azam Mian	POL	18,60,041
--do--	Daily Paid Labour	22,02,638
--do--	Fertilizer	17,99,065
--do--	Pesticides	16,50,000
--do--	Repairs of Tractor & Machinery	371,580

ii) Approval of Cotton Varieties

The 54th meeting of the Punjab Seed Council approved one cotton varieties Bt.CIM-663 for general cultivation in the Punjab. The meeting was held under the chairmanship of Minister of Agriculture Punjab for approval of crop varieties on 28th January 2021 at Lahore. While, Bt. CIM-343 recommended for further testing of fibre quality traits. Both of these varieties are high yielding, heat tolerance, big boll, with high lint %age will boost Punjab cotton production. The cotton variety Bt.CIM-343 have excellent qualitative characteristics with 40.3 lint percentage, 28.8 mm staple length, 4.03 micronaire value (µg inch^{-1}) and 101.9 fibre strength (tppsi). Similarly, cotton variety Bt.CIM-663 also bears excellent qualitative characteristics with 38.8 lint percentage, 29.2 mm staple length, 4.4 micronaire value (µg inch^{-1}) and 103.7 fibre strength (tppsi).

iii) Promosing Interspecific and Intraspecfic Lines

	Lint (%age)	Staple Length (mm)	Micronaire (µg inch^{-1})	Strength (tppsi)
CIM-678	38.5	28.7	4.4	103.1
CIM-303	38.9	28.9	4.3	102.6
Bt.Cyto-19	39.8	34.7	4.1	104.3
Cyto-511	40.5	28.2	4.4	99.8
Bt.Cyto-533	39.5	28.3	4.1	101.1
Bt.Cyto-535	40.1	29.1	4.1	103.1
Bt.Cyto-536	40.3	28.5	4.3	103.5
Bt.Cyto-537	39.8	28.5	4.2	104.3

iv) Cotton Biotechnology

The Cotton Biotechnology Lab has been established to develop local cultivars with export quality lint yield and also resistance to drought stress and bollworms. Apart from lab work, the impact of abiotic & biotic stresses on cotton fibre quality are also studied. The lab is equipped with basic instruments that are necessary to carry out genetic transformation and GMO testing of cotton genotypes. The genes of different traits synthetically synthesized for transformation in local cotton cultivars:

Name of Gene	Function
Cry2A	Pink Bollworm Resistance
DREB2	Abiotic stresses including drought tolerance
MYB (Family Gene)	Fibre Improvement

Milestones Achieved

Genetic transformation of Cry1Ac, Vip3A and Gt Gene for glyphosate resistance genes into commercial cultivars and now under evaluation for gene stability and other molecular analysis to develop resistance against pests and herbicides.

Future Prospects

Working on challenging issues of cotton crop. Genetic Manipulation of cotton crop to improve abiotic stress tolerance abilities such as water scarcity is the major factor in future that effect the cotton yield. To cope with this situation, biotechnology lab currently working on genetic transformation of synthetically developed drought resistance gene in commercial cultivar. Dehydration responsive element binding proteins (DREB) are members of a larger family of transcription factors, many of which have been reported to contribute to plant responses to abiotic stresses in several species. A sequence of 438bp transcribe the mRNA that translate 146 amino acids. The other one (Cry2A) transcribed insecticidal proteins. The gene sequence got from NCBI, the origen of this protein is from *Bacillus thuringiensis* that constitute the active ingredient in many biological insecticides and biotech crops expressing *B. thuringiensis* genes (Bt crops). For the control of lepidopteran pests, *B. thuringiensis* Cry1 and Cry2 class proteins are being used either in sprayable products or in transgenic plants. A sequence of 1905bp transcribe the mRNA that translate 1635 amino acids.

v) Cold Room for Storage of Cotton Germplasm

The Institute has developed sub-zero cotton seed storage facility for long term storage that comprises of more than 6143 accessions (Local: 1290 and Exotic: 4853) collected from various national and international resources. The seed of different varieties is preserved for short (25 years), medium term (50 years) and long term (100 years) basis and to be used by researchers to develop new varieties. The germplasm is shared with various local / international organizations / universities for breeding purpose.

vi) Intercropping Experiment

The cotton growing communities are not satisfied with the current profitability scenarios of cotton. However, intercropping may be opportunity to tackle the issue as it contributes more returns per unit area and time. The objective of intercropping is to obtain a maximum yield of cotton crop along with additional returns from intercrops. In intercrops, at least two or even more crops are grown together; it improves biodiversity and attracts predators to make the integrated pest management possible. The Agronomy Section of the institute is conducting the plenary experiments to evaluate the compatibility of intercropping of fodder maize, mung bean and sesame for improving farmer's profitability.

Mulching involves the covering of soil surface through plastic sheet and crop residues etc. The basic objective of mulching is to discourage weed growth along with moisture conservation and soil health improvement. In either ways, it improves the cotton yield and minimizes the cost of weed control and reduces the amount of irrigation water. The significant amount of crop residue is available which may be utilized for mulching. The experiment is in process to evaluate the feasibility of wheat, rice and maize residue as mulch material.

Cotton and Mung bean

Cotton & Maize Fodder

vii) Installation of Yellow Sticky Traps

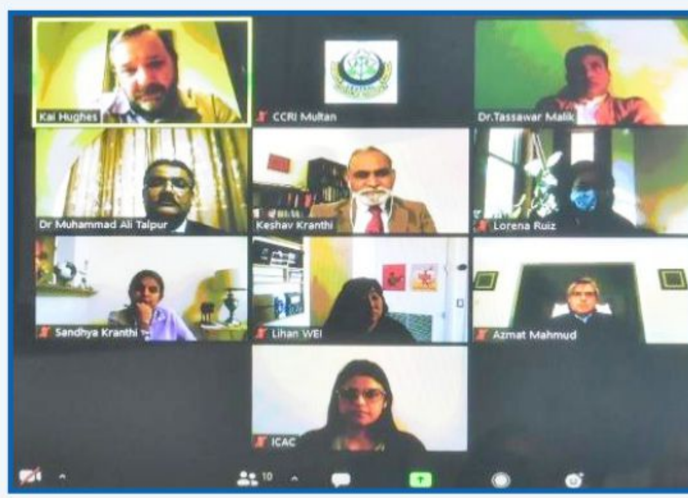
Bemisia tabaci, is difficult to control because of its high resistance to many insecticides, wide range of hosts, and rapid rate of development and reproduction. Besides chemical control measures, some non-chemical methods are also explored to control this pest which also helps to significantly reduce the spray of chemical insecticides. Yellow sticky traps are a commonly used method for population monitoring of many pests. These traps are installed to monitor populations of pest species. While, in recent years, these have now been used as a method for the control of some pests, especially whitefly. Research studies have shown that yellow sticky traps can significantly reduce the population of *B. tabaci* in field. During the experiments, the traps (8-10 per acre) were installed on 06-08-2020 about 30 cm above the crop canopies and were adjusted vertically as the crop attained additional growth.

viii) Installation of Sex Pheromone Traps

Sex pheromone traps were also installed for the management of Pink bollworm in the experimental fields of CCRI Multan during the cotton season under report.

ix) Meeting with ICAC Team

The International Cotton Adivsory Committee (ICAC) team team comprising Mr. Kai Hughes, Executive Director, Dr. Keshav Kranthi, Chief Scientist, Ms Lorena Ruiz, Economist; Dr Sandhiya Kranthi, Project Consultant; Ms Lihan Wei, Statistician, Parkhi Vats, Research Assistant; Mr Azmat Mahmood, Pakistan Embassy in USA held an online meeting with scientists of CCRI Multan and PCCC on 08.02.2021. Dr. Muhammad Ali Talpur, Vice President PCCC; Dr. Tassawar Hussain Malik, Director Research; Mr. Gul Hassan, Director Marketing; Dr. Zahid Mahmood, Director CCRI Multan, Dr. Muhammad Naveed Afzal, Dr. Fiaz Ahmad, Dr. M. Idrees Khan, Mr. Ilyas Sarwar, Mr. Azam Mian, Mr. Kamal Hassan, Mr. Zahid Khan participated in the meeting.



The ICAC team inquired about the causes of continuous production decline in Pakistan and offered to assist measures for improving cotton productivity. Small groups can be formed on key issues of Pakistan cotton (Pink bollworm, Whitefly, Climate Change, Technologies) to address cotton crop of 2021. Meeting of such group may be convened before cotton sowing for implementation of decisions. ICAC lauded research contributions from Pakistan and consider an important country having substantial presence in cotton production and spinning as well. ICAC team intends to visit CCRI Multan / Pakistan shortly for a week for detailed analysis of cotton production and marketing system in Pakistan and possible cooperation among ICAC and Pakistan. Dr. Keshav Kranthi is keen to visit CCRI Multan, though planned last year but due to COVID, could not come.

ICAC team appreciated very much the development of indigenous Mechanical Boll Picker (Pink bollworm Manager) machine developed by CCRI Multan for eradicating leftover bolls. Emphasized such localized technologies be promoted for pest control and crop production.

It was also proposed to hold country-specific webinars involving local cotton experts for consultation with ICAC researchers or other international researchers to solve local production problems of country.

It was also suggested that Pakistan must also join Global Promotion Campaign for Cotton. Moreover, collaborative regional / local cotton projects could also be initiated through funding from international organizations like GIZ, Lauds Foundation, USAID, etc.

x) Activities under Cotton Research & Development Projects

Pink bollworm Project : Cotton Productivity Enhancement through Eco Friendly Pink bollworm Management and Capacity Building in Punjab under PM Emergency Program

In order to manage Pink bollworm, cotton project was initiated with an objective to manage Pink bollworm through PB Rope technology, monitoring of PBW population, resistance studies through bioassay technique, farmers training, demonstrate performance of Mechancial boll picker and dissemination of insect management strategies. For this purpose, advertisement in local newspapers were floated for the announcement of subsidy of Rs.1000 per acre for the purchase of PB Ropes. A total of 1500 farmers registered by the Agriculture Extension Department Punjab under this program upto January, 2021. In addition, tenders were invited from manufacturer / suppliers for the manufacture and supply of 10 Cotton Boll Picker Machines and other laboratory equipments (Spectro-photometer, QPCR, Centrifuge, Solar Panel). Tender evaluation committee formed and successful bidders have been ordered for supply of equipments.

Survey was conducted in whole of the cotton areas of Punjab to check the performance of cotton varieties and infestation of Pink bollworm. Artificial diet has been prepared. Rearing of Pink bollworm has successfully been completed on this artificial diet. Now 9th generation of the Pink bollworm is present in lab to make it susceptible generation. Efforts for the mass rearing are being made to conduct resistance studies.

Training programs on “Pink bollworm Management” were organized for registered farmers of CABI on 12.10.2020, Lok Sangh (BCI) on 15.10.2020, FairTrade/SAS on 28.10.2020, Sangtani on 03.11.2020, RBDC/BCI on 13.11.2020.

A national seminar on “Pink bollworm Management” was organized on 16.11.2020. Syed Fakhar Imam, Minister NFSR chaired. More than 250 stakeholders (farmers, researchers, seed/pesticide representatives, textile and ginning industry) attended the seminar. Moreover, meetings were held with Secretary Agriculture South Punjab Secretariat on the management of Pink bollworm in the South Punjab.

Report on “History and Current Status of Pink Bollworm Management through PB-Ropes and Sex Attractants in the World” have been prepared. Moreover, Compendium of research papers on Management of Pink bollworm and other publications and training manual are in progress. Advisory disseminated among farmers on fortnightly basis through Farmers Advisory Committee meetings. Printed material / leaflets published about management of Pink bollworm. Electronic, print and social media was aggressively involved for dissemination of cotton production technologies and Pink bollworm management.

BCI Project: Better Cotton Initiative (BCI) for Sustainable Cotton Production in Pakistan

The project “Better Cotton Initiative (BCI) for Sustainable Cotton Production in Pakistan” is in operation in Punjab and Sindh province for management of cotton on the BCI principles. The project objvectives include emphasizing the use of quality seed of approved varieties, adoption and promotion of better management practices (BMPs), implementation of Integrated Pest Management (IPM) practices, optimized use of pesticides, fertilizers, irrigation water, soil health improvement, and adoption of descent work practices by farm and farmers and promotion of Clean Cotton production and picking practices through training of women pickers. The project aims to reduce the cost of production upto 20-25% by ensuring the sustainability of production resources (soil, water and environment).

The Punjab Component (Multan & DG Khan) have registered 9001 farmers in Multan covering an area of 14,832 acres while 3132 farmers in DG Khan area covering 10,733 acres under this program. Similarly, the Sindh Component (Shaheed Benazir Ahmad and Noushero Feroze) have registered 1498 farmers in Shaheed Benazir Abad district covering an area of 8768 acres while 1177 farmers in Nausher Feroze covering an area of 4858 for the program. Moreover, extensive farmers training programs were also carried out for the management of cotton crop.

Pak-US-ICARDA Cotton Project "Screening and maintenance of US cotton germplasm for the development of CLCuV resistant/tolerant genotypes by using traditional breeding approaches at CCRI Multan"

A total of 47 single plant selected from the last year sown (25 accessions received year from USDA) were also screened in field condition for CLCuV. All the plants were found susceptible for CLCuV. Similarly 123 promising single plants were selected from different generations (F_2 to F_6). Screening of more than 1200 genotypes in field condition and their seed were also preserved in cold Room Chamber. Beside this, 6143 cotton germplasm were preserved at Cold Room for short, medium and long term. A total of 46 accessions out of 3277 which were imported during the Pak-US- ICARDA cotton project were found to be resistant against CLCuV. These 46 accessions were ratooned at CCRI Multan from the last 5-7 years. Out of these 46 accessions square formation and flower induction were started in only few accessions in the month of December 2020 as detailed in Table 2.30. In Set-D accessions USG-1087/13 one boll was formed. While in Set K only one accession USG-618/14 having flowers and bolls formations were observed. In Set N in only one accession i.e. USG-2269/14 buds formation and flower induction were observed. The seed formed in all bolls were found non-viable due to the harsh climatic condition of this year.

Besides the above facts Breeding and Genetics were made successes by developing to high yielding strains i.e. *Bt*.CIM-775 (second year) and *Bt*.CIM-875 (First year) were tested in NCVT of Pakistan Central Cotton Committee trails. While four other advance lines which were also developed using these accessions of US Germplasm are in their advance varietal trial. Moreover, the US cotton germplasm, resistant/tolerant to CLCuV are also included in regular cotton breeding program of Plant Breeding & Genetics Section of CCRI Multan.

III COTTON PROMOTION & DEVELOPMENT ACTIVITIES

I) World Cotton Day

The year 2019 led to launch the initiative of declaring World Cotton Day by the ICAC and WTO, followed by events and celebrations around the world commemorating the importance of cotton crop. Hopefully, the 7^{th} October will soon be declared as the UN World Cotton Day. Pakistan being a leading cotton producing country holds responsibility to showcase solidarity with world cotton community. Cotton is not only the lifeline for Pakistan's economy but also has a unique association with mankind.

CCRI Multan celebrated the World Cotton Day on October 07, 2020. Mr. Saqib Ali Ateel, Secretary Agriculture, South Punjab Secretariat; Dr. Khalid Abdullah, Cotton Commissioner MNFS&R; Dr. Zahid Mahmood, Director CCRI Multan; Dr. Jasomal, Chairman PCGA, Dr. Shafiq Ahmad, BCI; Mr. Asif Majeed, CEO Kanzo, Mr. Khalid Khokhar, President Kisan Itehad and Mr. Suhail Mahmood Harral, PCGA chaired the program. The speakers highlighted the importance of cotton crop in the economy of Pakistan. Cotton production problems were discussed and measures were suggested for its enhancement and revival in the country. More than 500 participants from various stakeholders, NGOs and farmers attended the program.

Cotton Walk

A walk was also arranged in commemorating the importance of cotton for the economy of Pakistan. Mr. Saqib Ali Ateel, Secretary Agriculture, South Punjab Secretariat, Dr. Khalid Abdullah, Cotton Commissioner MNFS&R; Prof. Dr. Asif Ali, Vice Chancellor MNSUAM, Dr. Zahid Mahmood, Director CCRI Multan; Mr. Khalid Khokhar, President Kissan Itehad along with other participated in the walk.

Installatin of Stall

Installation of stall by various pesticide & seed companies, NGOs (ICI Pakistan, Artistic Milliners, CropLife Pakistan, WWF Pakistan, Fair Trade / SAS, Lok Sanjh (RBDC), Engro Fertilizer, SunCrop, 4-Brothers, CABI Rawalpindi, VectraCom). The Chief Guests along with other participants visited the stall and reviewed products of various companies.

ii) Provision of Cotton Seed at Farmers' Doorstep

Central Cotton Research Institute (CCRI) Multan extended facility for providing of cotton seed at the farmer's doorstep amid prevelance of the COVID-19 disease. The farmers were advised to get recommended seeds of cotton varieties. The farmers made call and text their address and demand of variety for obtaining seeds. The farmers submitted their complete address and the seeds was delivered on the government's price to the farmers. The farmers appreciated this activity for the facilitation of farmers.

iii) Mechanical Boll Picker

Central Cotton Research Institute Multan has fabricated/designed a Cotton Boll Picker Machine which picks the left over and Pink bollworm infected bolls. The machine is designed keeping in view the present planting system of cotton i.e line to line spacing of 75 cm. The mechanical boll picking machine could help not only eliminate Pink bollworm but could also help in saving over one billion dollars annually. By using this machine, farmers will be able to vacate fields for timely sowing of wheat crop. Moreover, seedcotton gained from leftover bolls will add a minimum of three maunds per acre production to the farmers; providing an extra income of

Rs.9000 per acre at least. Experiments showed that larvae of Pink bollworm remain inside the dried or unripe cotton bolls after the last picking, which if not controlled, could harm the cotton crop during next season.

Cotton farmers had to suffer big losses over the past few years due to Pink bollworm. It caused reduction of one million bales of cotton and in financial terms, the sector suffered loss of one billion dollars. CCRI Multan endeavored to incorporate mechanized farming keeping in view the future demand. The mechanical boll picker could be operated by any tractor. It spreads cotton bolls and expose them to the sunlight that kills Pink bollworm and its larvae. It can also enhance per acre production by three maunds provided plant population is in accordance with the set standard and every plant has at least three bolls on an average.

Syed Fakhar Imam, Chairman Kashmir Committee & Progressive Cotton Farmer from Kabirwala reviewing the performance of Mechanical Boll Picker and appreciated the work done by the Institute for addressing Pink bollworm problem. He stated that this machine will not only save the crop from Pink bollworm but will also increase the cotton yield as well.

iv) Publications of "The Pakistan Cottongrower"

CCRI, Multan has initiated publication of a quarterly journal "The Pakistan Cottongrower". The journal is bilingual, published in Urdu and English languages. Articles related to cotton agronomy, nutrition management, varietal development, insect pests & diseases management, and post-harvest handling are published. Moreover, weather condition (temperature, rainfall), cotton market news and world cotton outlook of the subject quarter are also regular feature of the Journal. Articles of researchers and technical field officers of private pesticide/seed/fertilizer industry are also encouraged for publication with approval by the Editorial Board. The journal is being distributed among cotton researchers, academicians, private pesticide & seed association and most importantly the cotton farmers.

v) Publication of Monthly Newsletter

The Institute has also started publication of monthly Newsletter for highlighting major activities and events organized during the crop season 2020-21. The newsletter publication are being made on regular basis. The soft copies of the newsletters were also emailed to researchers, policymakers, farmers and other stakeholders. Moreover, the Newsletter has also been placed on the website and facebook account of the Institute as well.

vi) TeleCotton

CCRI Multan introduced TeleCotton SMS service for the guidance of the cotton farmers. Short messages were sent during the crop season 2020 related to the aspects of current cotton crop situation viz., varietal selection, seed treatment, land preparation, irrigation, pesticide and fertilizer application, and proper picking. A total of 18,725 cotton farmers from all the four provinces are included in the list to receive day to day cotton crop management messages. Moreover, farmers were also responded to their queries with regard to crop management.

vii) Website & Social Media

The Institute also initiated highlighting cotton research and development activities carried out during crop season 2020-21 utilizing social media tools (www.facebook.com/CCRIM.PK). This has attracted cotton farmers, researchers, and students very effectively. The followers and members appreciated the activities carried out by the Institute. The Institute has also upgraded the website (www.ccri.gov.pk) of the Institute highlighting major cotton research and development activities, brief program of various disciplines, cotton market rates, weather situation and other related activities.

IV. SEMINARS / TRAINING PROGRAMS

i) Seminar "Revival of Cotton Crop & Pink Bollworm Management"

CCRI Multan organized one-day program "Revival of Cotton Crop and Pink bollworm Management" in collaboration with Kashtkar Foundation Multan on February 04, 2021. Mr. Saqib Ali Ateel, Secretary Agriculture, South Punjab Secretariat chaired the program. More than 200 farmers attended the program. Lectures on soil health improvement, production technology of new varieties, agronomic practices, insect pests management with special emphasis on Pink bollworm delivered. The demonstration of Mechanical boll picker was also made to the farmers.

ii) 4th National Seminar "Pink Bollworm Management"

CCRI Multan organizes 4th National Seminar on Pink Bollworm Management. Syed Fakhar Imam, Federal Minister National Food Security & Research attended the program via zoom link. Mr. Saqib Ali Ateel, Secretary Agriculture South Punjab Secretariat Multan; Mr. Bilal Israel, Chairman Punjab Cotton R&D Board; Dr. Muhammad Ali Talpur, VP, PCCC; Dr. Khalid Abdullah, Cotton Commissioner, Prof Dr Asif Ali, VC, MNSUA Multan, Mr. Hidayat Ullah Bhutto, Director CCRI Sakrand; Dr. Shah Nawaz Khuro, Mr. Khalid Khokhar, President Pakistan Kissan Itehad and cotton researchers, representative of pesticides companies and farmers attended the seminar.

iii) Refresher Course on Cotton Production Technology

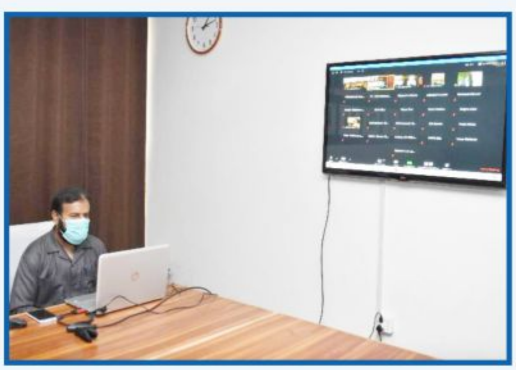
CCRI Multan organized one-day Refresher Course on "Cotton Production Technology" for the agricultural officers from public and private sector. A total of 65 field officers from pesticide & seed companies, NGOs (SANIFA, BCI, SWRDO, SMART) and progressive farmers attended the program. Lectures on cotton agronomy, soil health improvement, varietal development, Pink bollworm and Whitefly management, Insecticide Resistance Management, Biological Control of Pests, Spray Application Techniques & Safe Use of Insecticides, Cotton Diseases & Their Management, Fibre Properties & Testing, and Information Dissemination Methodologies were delivered. Pre- and post-training evaluation of participants were also conducted to assess the knowledge level of the participants. Later, prizes were also distributed among winners of the evaluation test. Certificates among all the participants were also distributed.

Dr. Zahid Mahmood, Director CCRI Multan stated that the Institute endeavors to upscale the capacity building of the stakeholders in advancements of cotton production technology. He stated that such training programs will be continued during the cotton season for effective management of the cotton crop. He also appreciated the enthusiastic participation of the field staff and hoped that everybody will make efforts for enhancing the cotton production in the country.

iv) Online Training Program for Agriculture Officers from KP and Balochistan

CCRI Multan organized an online training program for the agriculture research and extension officials from Khyber Pakhtunkhwa and Balochistan provinces on April 16, 2020. The arrangement was made due to the prevailing COVID-19 pandemic in the country. The online meeting was enthusiastically attended by 40 researchers from the two provinces. Dr. Zahid Mahmood, Director CCRI Multan briefed about the need for holding the training program. He presented the overall cotton research and development program carried out by the Institute. Later, lectures on cotton agronomy, varietal development and recommendations for suitable varieties as per climatic and agroecological zones, plant nutrition and soil health improvement, and insect pests management. The lecturers were delivered by senior cotton researchers Dr. Rabia Saeed; Dr. Muhammad Naveed Afzal; Dr. Muhammad Idrees; and Dr. Fiaz Ahmad.

While concluding the session, Dr. Zahid Mahmood, Director CCRI Multan thanked all the participants for attending this training program and hoped that the country will soon get rid of this disease, Insha Allah. He urged the participants to remain vigilant and actively participate in the cotton development programs in their respective provinces. CCRI Multan will continue providing support by the provision of quality seed and extensive training programs for the farmers as well as the agriculture researchers of the provinces.



V. HIGH LEVEL MEETINGS

i) Cotton Crop Management Group Meeting

The 3rd meeting of the Cotton Crop Management Group for the crop season 2020 was held at CCRI Multan under the chairmanship of Mr. Nauman Ahmad Langrial, Minister for Agriculture Punjab. Mr. Wasif Ali Khurshed, Secretary Agriculture Punjab and Mr. Saqib Ali Ateel, Secretary Agriculture, South Punjab also co-chaired the meeting. Agriculture officials, representative from pesticide and seed companies, farmers association attended the meeting. Cotton crop condition, insect pests and disease situation, irrigation water availability and other matters related to provision of subsidy on whitefly specific pesticides, seed, and fertilizers, farmers training programs, crop management under rains, were discussed in detail. Representatives of Pesticide companies assured the required quantity of cotton-pest specific pesticide during the remaining cotton season. Farmers organization complained about the loadshedding, extra billing, low quality pesticides and their mixing, seed quality and germination problems hampering cotton productivity. Agriculture Minister Punjab assured the farmer members for redressal of issues pertaining to cotton production and marketing, pesticide quality, prices and availability for enhancing the cotton production. An honorary shield was also awarded to Prof Dr Asif Ali, Vice Chancellor, MNSUA Multan from CCRI Multan, upon receiving award of 'Tamgha-e-Imtiaz".

VI. SURVEY OF COTTON AREAS DAMAGED DUE TO LOCUST ATTACK

Heavy rainfall in late 2019 created ideal conditions for this pest to multiply population leading to swarm spread from Yemen into East Africa. Since January 2020, it has become a serious problem in East Africa particularly in Uganda and Kenya afterwards reached Ethiopia, Somalia, South Sudan. Locusts have also been migrating from Africa to Pakistan. The Government of Pakistan declared a national emergency to counter an invasion of desert locusts on 1st February 2020. This year, the locusts attack is worse in 26 years. It has started invading different areas of the South Punjab as well and affected crops mainly cotton, mango, and rice saplings. Central Cotton Research Institute (CCRI), Multan also participated in conducting surveys in Southern Punjab i.e., Multan, Khanewal, Jhanian, Makhdum Rasheed, Muzafargarh, Kehror Pacca, Dunya Pur, DG Khan. The cotton sown in surveyed area ranges from 5 acres to 200 acres. Similarly, the damage to the cotton crop was estimated 15% to 100% especially disturbing for the small farmers whose cotton crop was completely swallowed by the locust. Farmers attempted to ward-off the locusts by beating drums in an attempt to scare them away. Farmers have either to re-sow cotton where completely damaged and apply excessive inputs where partially damaged. This resulted extra burden for the farmers. CCRI Multan also issued advisory to the farmers for combating this pest by applying Lambda-cyhalothrin @ 330 ml or Delta-methrin @ 350 ml or Cyper-methrin @ 330 ml per 120 liter water.

The responsibility for locust control lies with the Federal Department of Plant Protection. Moreover, recently, the government has also constituted “National Locust Control Center” under the National Disaster Management Authority (NDMA). Aerial and ground operations have been launched for elimination of locusts through targeted approach with the coordination of federal and provincial departments. This strategy has effectively helped eliminating the first wave of locust. Another locust swarm is also expected to arrive from Iran by third week of June and all the government functionaries are on alert accordingly.

VII) COVID-19 AWARENESS PROGRAM & PREVENTIVE MEASURES

Corona virus (COVID-19) an infectious disease being spread all over the world including its rising trend in Pakistan. Accordingly, following the guidelines from the government, the Institute took emergent measures by organizing an awareness seminar "COVID-19 & Preventive Measures" for the staff of CCRI Multan. Dr. Zahid Mahmood, Director CCRI Multan gave detailed briefing about the prevalence & spread of the disease and precautionary measures. He also highlighted importance of cleanliness and other safety measures during office hours. Dr. Athar Nadeem, Virologist, Federal Public Health Department, Canada also briefed about the COVID-19 and preventive measures to limit the spread of this disease.

Similar awareness program was also arranged for the female labourers / farm workers of the Institute. Dr. Nabiha Noor briefed about the Crona Virus, spread, damages and prevention measures among the female farm workers. Similar awareness program was also carried for the family members of the employees.

Following the government advisory and recommendations of awareness seminar “COVID-19 Disease and Prevention Measures” held at the Institute on 17.03.2020; the following precautionary measures are hereby advised to be followed strictly by all the officials during working hours till further orders

In addition, masks and sanitizers were also distributed among staff and field workers. Moreover, Crona Disinfectant Walk-Through Gate was also installed at the Institute for shower spraying of Chlorine.

Implementation of Precautionary Measures for COVID-19

Following the government instructions, the Institute strictly implemented the following precautionary measures against COVID-19 outbreak.

- Wearing of face mask in office premises.
- Temperature check through Thermometer Gun at entrance.
- Entry of all staff from Sanitizer Walk-through gate
- Keep distance of at least 1 meter from anyone.
- Follow no-touch greeting to avoid germs expansion.
- Wash hand regularly with plenty of soap/liquid soap, alcohol-based sanitizer and water.
- Gathering of more than 4 persons at the Institute is strictly prohibited.
- Avoid unnecessary or frequent visits of outer persons at the Institute.
- Employees are exempted to mark attendance through Biometric till further orders.


Safe Distance while Offering Prayers


Field Work


Thermometer Gun


Sanitizer Walk-Through Gate

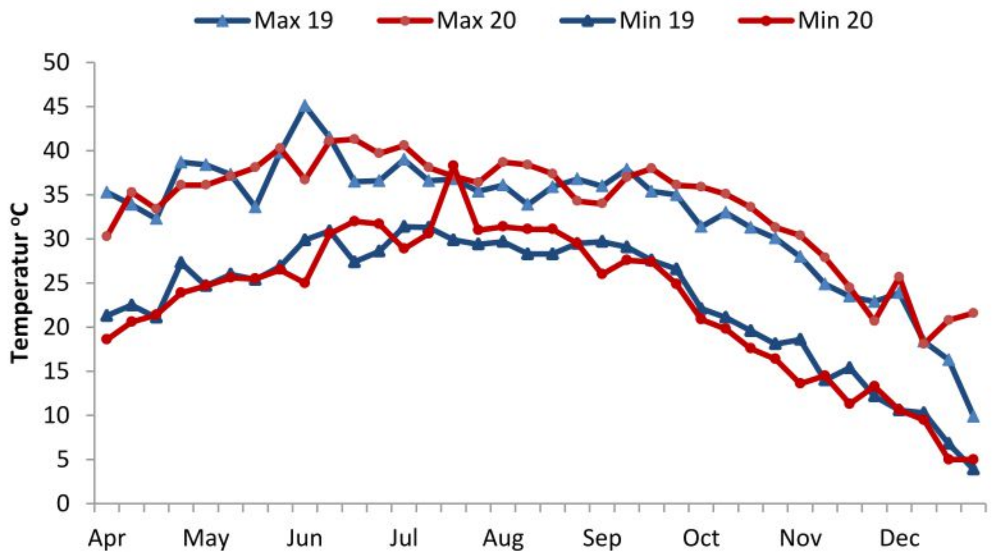

Floor Sanitization


Door Locks Sanitization

VIII) COTTON CROP CONDITION: PUNJAB

i) Weather Condition

The pattern of maximum temperatures during cotton crop season 2020-21 remained higher especially between July-August and October. The annual average maximum temperature during 2020-21 remained 38.9°C while it was 39.5°C during last year. Similarly, the annual average minimum temperature during current year remained at 29.8°C while it was 30.1°C during last year. The minimum relative humidity remained 63.1% while it remained 85.8% at maximum level, during current season. A total of 398.2 mm rainfall was recorded during the crop season as compared to 267.4 mm rainfall during the last year.



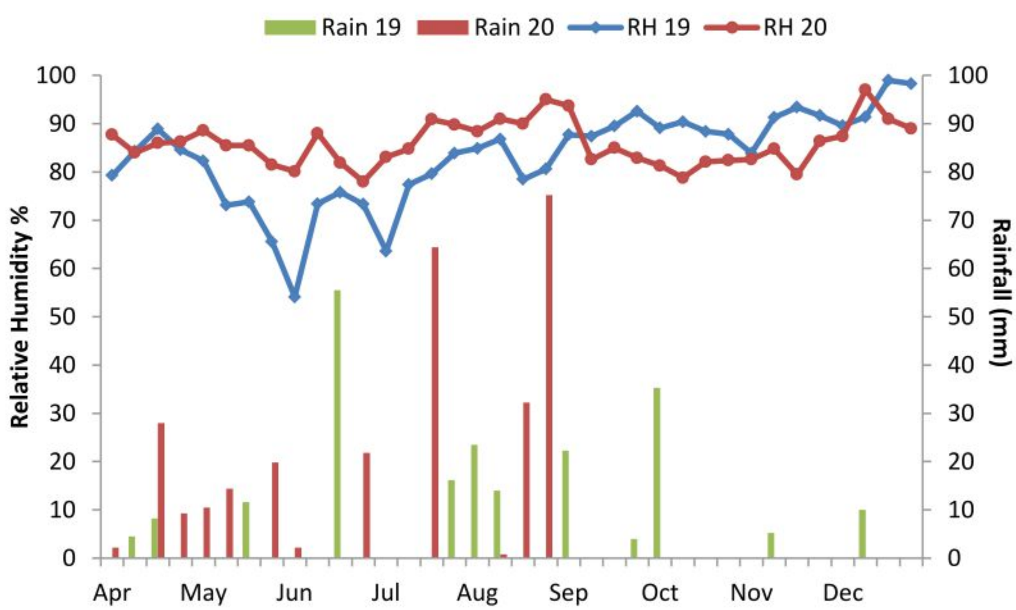


Fig. 1 Weekly Average Temperature, Relative Humidity and Total Rainfall during 2019 and 2020.

ii) Cotton Situation

Cotton crop season 2020 started with the challenges of low germination of cotton seed, onslaught of Locust, high pressure of whitefly, ineffectiveness of pesticides in controlling pests, and heavy rains damaging the standing cotton substantially in Sindh and Punjab provinces. Though despite COVID-19 pressure, government facilitated in provision of essential inputs and controlling the attack of locust. The Agriculture Department, Sindh reported that the rains and floods had completely damaged 26.7% cotton crop on 167,641 hectares and 19% or 124,587 hectares of area was partially damaged. About 80% crop was damaged in districts of Umerkot and Mirpurkhas. Rains had also put negative impact on cotton crop in the Punjab province as crop standing over 8,034 acres was badly affected. Whitefly remained the most damaging during the cotton season 2020. Some of the key highlights of cotton crop season 2020 are as under:-

1. High cost of production coupled lower prices of produce and excessive cultivation of competing. crop led to reduce cotton area from 1.889 million hectare to 1.546 million hectares in the Punjab showing a shortfall of 18% in the sown area.
2. Seed germination problem and Locust invasion during March-April.
3. Heavy rains in July-August-September, damaged around 30-40% of standing cotton in Sindh
4. High temperature in September.
5. Heavy infestation of Whitefly and & Pink bollworm in Aug-Sep, Crop was blackened due to heavy infestation of Whitefly.
6. Farmers complaint about high prices of pesticides and their ineffectiveness to control pests.

Targets 2020

Province	Area (Million Hectares)	Production (Million Bales)
Punjab	1.60	6.0
Sindh	0.64	4.6
Khyber Pakhtunkhwa	0.01	0.0065
Balochistan	0.06	0.291
Total	**2.31**	**10.89**

Sowing Position 2020

Province	Target	Area Sown		% Change Over	
	2020-21	2020-21	2019-20	Target	Last Year
Punjab	1.60	1.546	1.889	96.6%	-18.16
Sindh	0.64	0.615	0.599	96.1%	+2.7
Khyber Pakhtunkhwa	0.01	0.000216	0.000213	2.2%	+1.41
Balochistan	0.06	0.057	0.038	95.0%	+50.0
Total	**2.31**	**2.218**	**2.526**	**96.02%**	**-12.19**

Cotton Production Assessments 2020

Province	Expected Production (million bales)	
	1st CCAC (02.10.2020)	2nd CCAC (14.12.2020)
Punjab	5.30	4.900
Sindh	3.000	2.500
Khyber PakhtunKhwa	0.0065	0.0065
Balochistan	0.291	0.291
Pakistan	**8.597**	**7.70**

Source: Cotton Crop Assessment Committee meetings

IX. DISCIPLINE-WISE RESEARCH & DEVELOPMENT ACTIVITIES

1. AGRONOMY

The crop agronomic management is carried out in accordance with ecological principles. The agronomic experiments manipulate the new ideas and approaches having direct and indirect effects on crop yield formation. The soil, water, nutrients, weeds management, planting time optimization and planting techniques for candidates and benchmark varieties (GMO's & Non GMO's) evolved by CCRI, Multan keeping in view the climatic vagaries are mainly focused. The crop growth model DSSAT (Decision Support System for Agro-Technology Transfer) is being applied to address the climate change issue and to design effective adaptation strategies for sustainable cotton production. Meanwhile, experiments on incorporation of cotton sticks and wheat straw for improving soil health are also in process. The agro-economic feasibility of different intercrops in cotton is being evaluated as a promising substitute to increase profitability of cotton. The major output of the agronomic experiments appeared in form of improved cotton productivity while minimizing the adverse impacts of various biotic and abiotic stresses and to take advantage of the favourable environment. The daily record of metrological observations is also maintained with the section which is utilized in crop management strategies.

1.1 Effect of time of sowing on productivity of advanced genotypes

Four genotypes i.e. Cyto-164, Cyto-226, CIM-735 and CIM-610 were tested at seven sowing dates starting from March15 to June 15 at fifteen days interval. Experimental design was RCBD with split plot arrangements. Sowing dates were kept in main plots and genotypes in sub plots with four repeats. The net plot size was 20 ft x 30 ft. Bed-furrows were prepared after land preparation in dry condition. Sowing was done with delinted seeds by dibbling method followed by irrigation. Dual Gold 960 EC @ 2 L per hectare was sprayed after sowing on moist beds. Nitrogen at the rate of 150 kg ha^{-1} was applied in three split doses. Other cultural practices and plant protection measures were adopted as per need of the crop. Data on plant height, boll number, boll weight, seed cotton yield and CLCuD incidence percentage are given in Table 1.1.

Table 1.1 Effect of sowing dates on plant height, seed cotton yield, yield components and CLCuD incidence

Sowing dates	Genotypes	Plant height (cm)	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 90 DAS
March 15	Cyto-164	154.9	32	2.55	3162	0.0
	Cyto-226	177.6	27	2.49	2605	0.0
	CIM-735	189.9	35	2.76	3452	2.0
	CIM-610	173.6	29	2.63	2920	1.1
April 01	Cyto-164	152.5	22	2.56	2194	0.0
	Cyto-226	170.6	21	2.51	2014	0.0
	CIM-735	184.6	26	2.78	2635	5.3
	CIM-610	167.9	20	2.66	2022	0.0
April 15	Cyto-164	152.6	20	2.59	2015	0.0
	Cyto-226	163.3	22	2.53	2121	0.0
	CIM-735	184.9	23	2.81	2267	6.6
	CIM-610	165.1	20	2.68	2025	4.0
May 01	Cyto-164	139.8	19	2.61	1874	6.0
	Cyto-226	153.8	19	2.56	1867	3.2
	CIM-735	160.4	18	2.84	1762	20.1
	CIM-610	164.4	19	2.72	1939	12.1
May 15	Cyto-164	138.8	19	2.64	1893	8.9
	Cyto-226	139.0	17	2.58	1641	4.8
	CIM-735	150.9	14	2.88	1374	26.5
	CIM-610	162.7	15	2.75	1447	23.0
June 01	Cyto-164	80.8	11	2.68	983	100.0
	Cyto-226	87.8	11	2.61	963	100.0
	CIM-735	98.7	12	2.91	1136	100.0
	CIM-610	87.3	12	2.79	1100	100.0
June 15	Cyto-164	75.9	10	2.70	854	100.0
	Cyto-226	68.8	9	2.65	751	100.0
	CIM-735	79.7	10	2.95	896	100.0
	CIM-610	77.5	10	2.82	869	100.0

DAS* = Days after sowing

Sub-effects

Sowing dates	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 90 DAS
March-15	174.0	31	2.61	3035	0.8
April 01	168.9	22	2.63	2216	1.3
April 15	166.5	21	2.65	2107	2.7
May 01	154.6	19	2.68	1861	10.4
May 15	147.9	16	2.71	1589	15.8
June 01	88.7	12	2.75	1046	100.0
June 15	75.5	10	2.78	843	100.0

Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 90 DAS
Cyto-164	127.9	19	2.62	1854	30.7
Cyto-226	137.3	18	2.56	1709	29.7
CIM-735	149.9	20	2.85	1932	37.2
CIM-610	142.6	18	2.72	1760	34.3
C.D 5%					
Sowing date (SD)	11.9	0.66	ns	151.2	5.30
Genotype (G)	3.7	0.20	0.02	62.5	5.12
SD x G	ns	3.59	ns	304.4	ns

The data presented in Table 1.1 indicated that on overall average basis of sowing dates, genotype CIM-735 produced significantly higher seed cotton yield as compared to Cyto-164, CIM-610 and Cyto-226. The genotype CIM-735 produced 4.2%, 9.8% and 13.0% higher seed cotton yields than Cyto-164, CIM-610 and Cyto-226 respectively. Plant height of all genotypes decreased as the sowing was delayed (Fig. 1). March 15 sown crop produced significantly higher number of bolls than other sowing dates (Fig. 2). Seed cotton yield decreased as sowing was delayed (Fig. 4). While, boll weight increased as the sowing was delayed (Fig. 3). Among all sowing dates maximum boll weight (2.78 g) was produced from June 15 sown crop. The maximum bolls per plant (31) and seed cotton yield (3035 kg ha^{-1}) were harvested from March 15 sown crop.

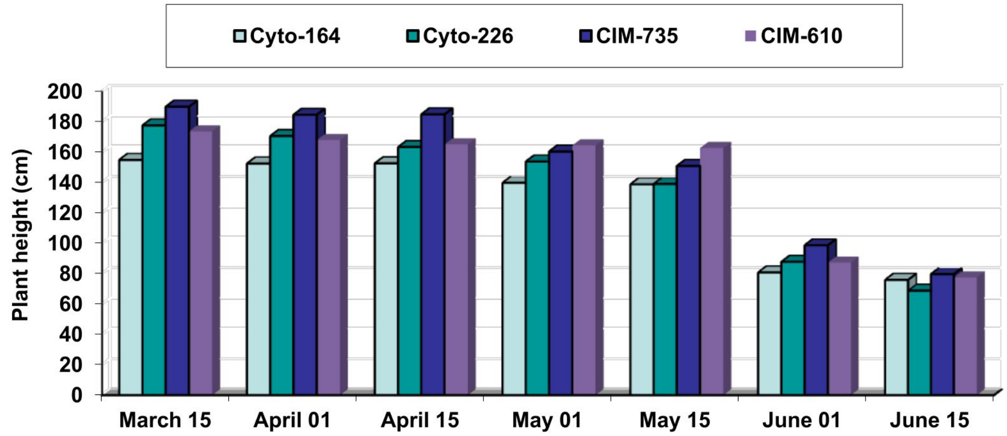


Fig 1. Sowing dates x genotypes interaction on plant height

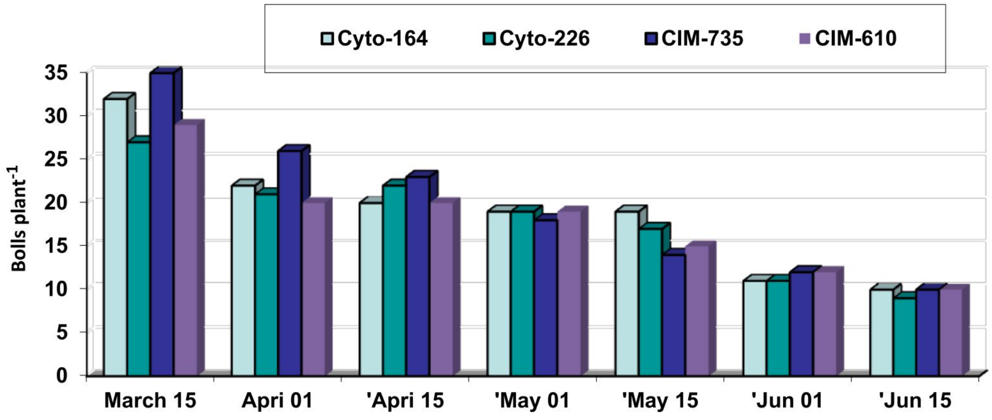


Fig 2. Sowing dates x genotypes interaction on bolls plant^{-1}

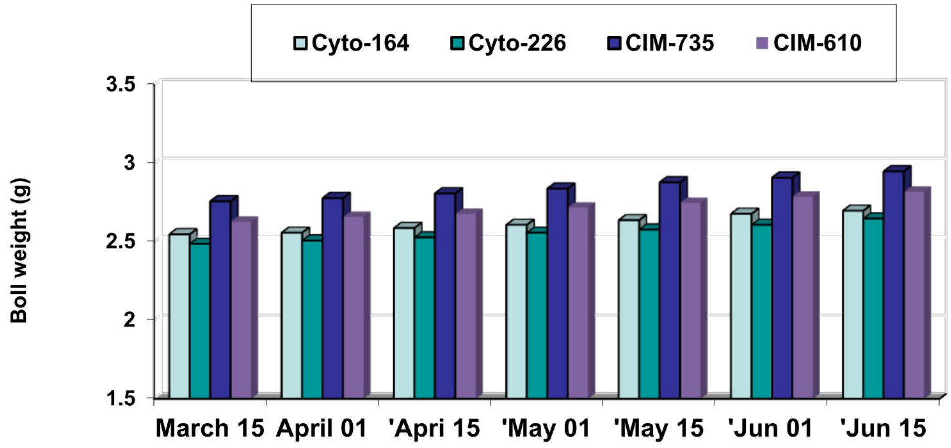


Fig 3. Sowing dates x genotypes interaction on boll weight

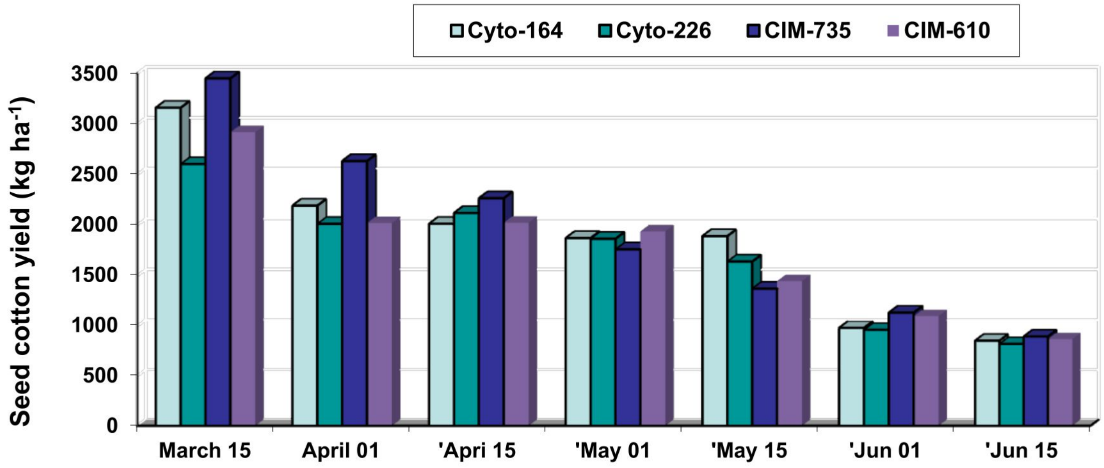


Fig 4. Sowing dates x genotypes interaction on seed cotton yield

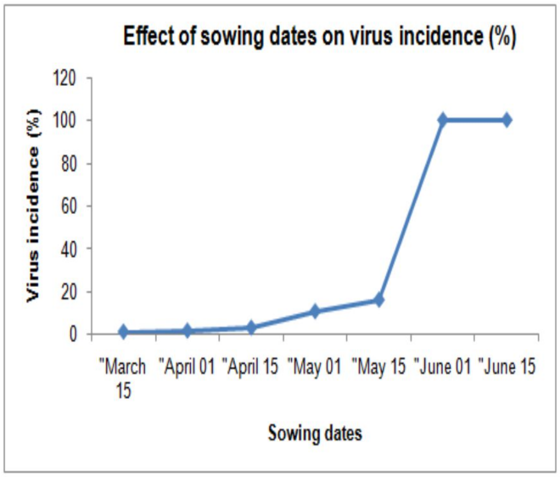


Fig 5. Sowing dates effect on virus infestation at 90 DAS

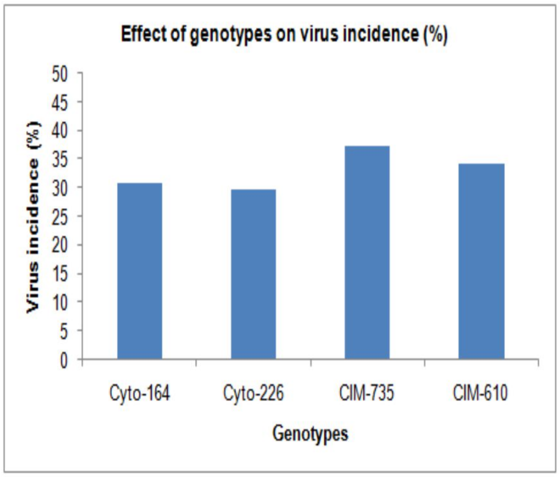


Fig 6. CLCuD incidence in different genotypes at 90 DAS

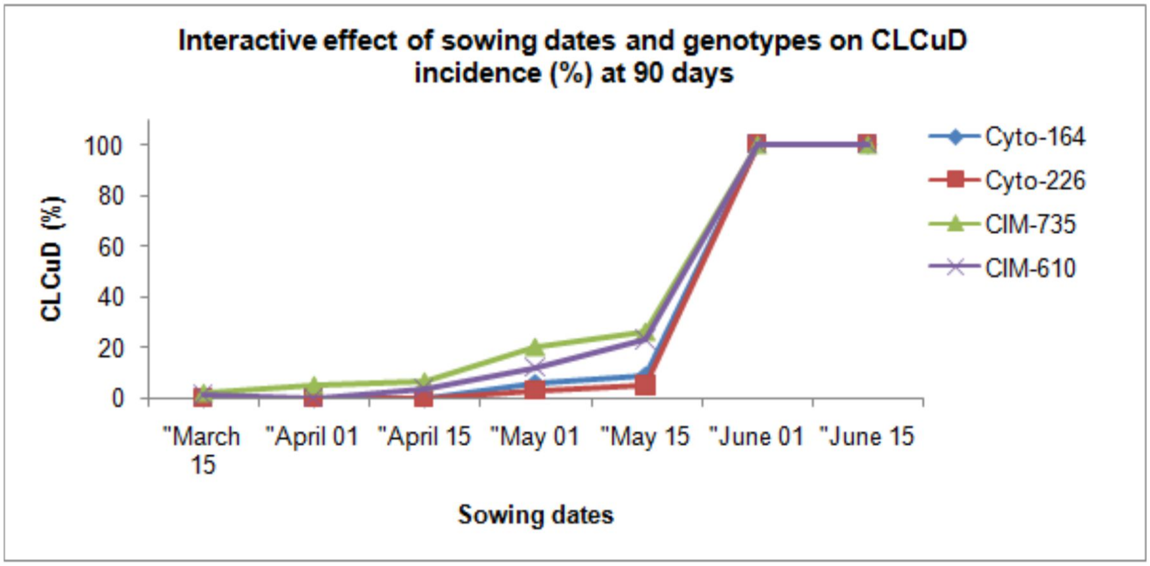


Fig 7. Sowing dates x genotypes interaction for CLCuD incidence (%) at 90 DAS

The data on CLCuD showed that the disease incidence gradually increased as the sowing was delayed from March 15 up to June 15. The incidence of CLCuD at 90 days after sowing was observed 100% in June 01 and June 15 sown crop. Whereas, March 15, April 01, April 15, May 01, and May 15 sown crop showed 0.8%, 1.3%, 2.7%, 10.4% and 15.8% virus infestation respectively (Fig. 5). On the average basis of sowing dates, genotype Cyto-226 showed 1.0%, 4.6% and 7.5% less CLCuD incidence than Cyto-164, CIM-610 and CIM-735 respectively (Fig. 6). The interaction between sowing dates and genotypes on CLCuD incidence is illustrated in (Fig. 7).

1.2 Effect of time of sowing on production of transgenic cotton

Six transgenic cotton genotypes i.e. *Bt.*CIM-775, *Bt.*CIM-785, *Bt.*CIM-875, *Bt.*Cyto-533, *Bt.*Cyto-535, *Bt.*Cyto-536 with one standard *Bt.*Cyto-179 were evaluated at seven different sowing dates starting from March 15 to June 15 at fortnightly interval. Experimental design was RCBD with split plot arrangements, sowing dates were kept in main plot and genotypes in sub plots with four repeats. The net plot size was 20 ft x 20 ft. Bed-furrows were prepared after land preparation in dry condition. Sowing was done by manual dibbling of seeds at 22.5 cm plant to plant distance followed by irrigation. Dual Gold 960 EC @ 2 L per hectare was sprayed after sowing on moist beds. Other cultural practices and plant protection measures were adopted as per need of the crop. Data on plant height, boll number, boll weight, seed cotton yield and CLCuD incidence percentage recorded are given in Table 1.2.

Table-1.2 Effect of sowing dates on plant height, seed cotton yield, yield components and CLCuD incidence

Sowing dates	Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 90 DAS
March 15	*Bt*.CIM-775	163.3	35	2.71	3523	0.0
	Bt.CIM-785	132.2	33	2.75	3250	0.0
	Bt.CIM-875	173.3	28	2.79	2797	0.0
	Bt.Cyto-533	130.5	26	2.70	2543	0.0
	Bt.Cyto-535	137.8	31	2.77	3069	0.0
	Bt.Cyto-536	136.0	22	2.69	2216	0.0
	Bt.Cyto-179	130.0	26	2.78	2615	0.0
April 01	*Bt*.CIM-775	160.2	24	2.72	2425	0.0
	Bt.CIM-785	129.8	25	2.78	2515	0.0
	Bt.CIM-875	170.7	20	2.81	2005	0.0
	Bt.Cyto-533	128.5	24	2.72	2424	0.0
	Bt.Cyto-535	135.0	25	2.80	2525	0.0
	Bt.Cyto-536	131.4	20	2.70	1980	0.0
	Bt.Cyto-179	139.0	25	2.81	2530	0.0
April 15	*Bt*.CIM-775	157.5	24	2.75	2348	0.0
	Bt.CIM-785	129.2	21	2.81	2126	0.0
	Bt.CIM-875	170.5	20	2.87	1980	1.2
	Bt.Cyto-533	121.6	15	2.74	1526	1.2
	Bt.Cyto-535	135.0	19	2.86	1898	0.0
	Bt.Cyto-536	122.5	15	2.72	1445	0.0
	Bt.Cyto-179	123.8	15	2.84	1540	7.3
May 01	*Bt*.CIM-775	157.0	23	2.80	2343	0.0
	Bt.CIM-785	128.2	12	2.86	2161	35.2
	Bt.CIM-875	170.0	19	2.91	1898	9.3
	Bt.Cyto-533	121.5	15	2.79	1520	23.3
	Bt.Cyto-535	132.2	21	2.90	1889	27.5
	Bt.Cyto-536	122.4	14	2.78	1435	33.6
	Bt.Cyto-179	123.3	15	2.86	1536	26.8
May 15	*Bt*.CIM-775	156.0	21	2.86	2071	9.0
	Bt.CIM-785	127.4	14	2.91	1345	11.5
	Bt.CIM-875	168.0	19	2.95	1890	9.9
	Bt.Cyto-533	99.8	13	2.85	1254	59.1
	Bt.Cyto-535	119.6	15	2.94	1526	64.2
	Bt.Cyto-536	114.5	13	2.84	1250	53.9
	Bt.Cyto-179	121.6	15	2.92	1520	66.4
June 01	*Bt*.CIM-775	146.2	11	2.92	1043	52.7
	Bt.CIM-785	108.4	10	2.96	945	100.0
	Bt.CIM-875	154.8	11	3.04	1060	36.0
	Bt.Cyto-533	85.3	10	2.91	932	92.1
	Bt.Cyto-535	101.8	11	3.02	1060	75.0
	Bt.Cyto-536	91.7	10	2.90	940	90.0
	Bt.Cyto-179	99.8	10	2.95	942	100.0
June 15	*Bt*.CIM-775	115.0	9	2.96	857	77.3
	Bt.CIM-785	88.2	9	2.98	882	100.0
	Bt.CIM-875	138.5	9	3.08	895	100.0
	Bt.Cyto-533	74.5	10	2.95	925	100.0
	Bt.Cyto-535	81.1	10	3.05	940	100.0
	Bt.Cyto-536	83.0	9	2.92	880	100.0
	Bt.Cyto-179	95.0	9	3.00	885	100.0

DAS* =Days after sowing

Sub-effects

Sowing dates	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 90 DAS
March 15	143.3	29	2.74	2859	0.0
April 01	142.1	23	2.76	2343	0.0
April 15	137.2	18	2.80	1838	1.4
May 01	136.4	18	2.84	1826	22.2
May 15	129.6	16	2.90	1551	39.1
June 01	112.6	10	2.96	989	78.0
June 15	96.5	9	2.99	895	96.8

Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 90 DAS
Bt.CIM-775	150.7	21	2.82	2087	19.9
Bt.CIM-785	120.5	19	2.86	1889	35.2
Bt.CIM-875	163.7	18	2.92	1789	22.3
Bt.Cyto-533	108.8	16	2.81	1589	39.4
Bt.Cyto-535	120.4	19	2.91	1844	38.1
Bt.Cyto-536	114.5	15	2.79	1449	39.6
Bt.Cyto-179	118.9	16	2.88	1653	42.9

C.D. 5%

Sowing date (SD)	4.54	1.18	ns	118.81	3.19
Genotype (G)	9.74	1.29	ns	128.97	2.33
SD x G	ns	3.17	ns	318.15	6.55

The plant height, bolls per plant and seed cotton yield decreased while boll weight was increased with the delay in sowing (Fig. 8, 9, 10 and 11). The maximum plant height (143.3 cm), bolls plant^{-1} (29) and seed cotton yield (2859 kg ha^{-1}) were harvested from March 15 sown crop. Among all sowing dates maximum boll weight (2.99 g) was produced by June 15 sown crop. On overall average basis of sowing dates, *Bt*.CIM-775 produced 10.5%, 13.2%, 16.7%, 26.3%, 31.3% and 44.0% more and significantly higher seed cotton yield than *Bt*.CIM-785, *Bt*.Cyto-535, *Bt*.CIM-875, *Bt*.Cyto-179, *Bt*.Cyto-533 and *Bt*.Cyto-536 respectively.

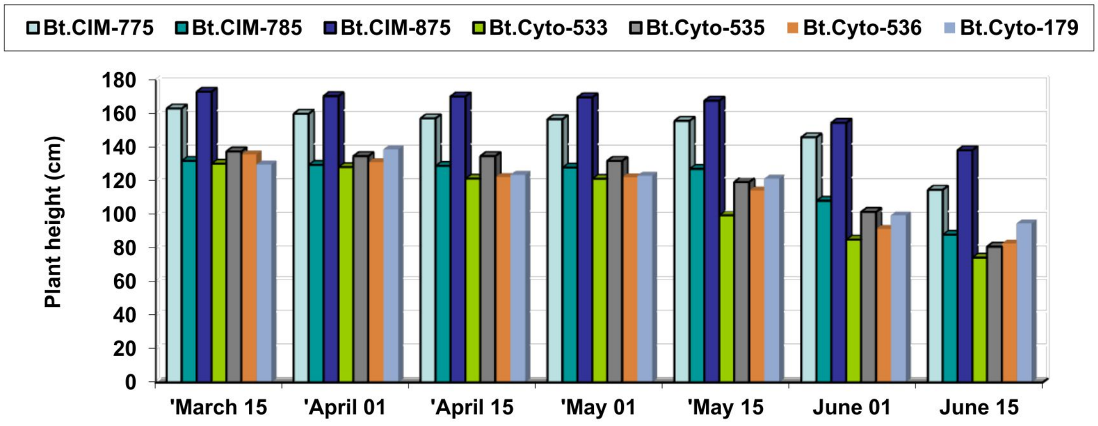


Fig 8. Sowing dates x genotypes interaction on plant height

The data on CLCuD indicated that the disease incidence increased as the sowing was delayed from March 15 to June 15. The incidence of CLCuD after 90 days was observed to be 78.0% in June 01 and 96.8% in Jun 15 sown crop. While March 15, April 01, April 15, May 01 and May 15 sown crops showed 0.0%, 0.0%, 1.4%, 22.2% and 39.1% virus infestation, respectively (Fig. 12). On the average basis of sowing dates, genotype *Bt*.CIM-775 showed 2.4%, 15.3%, 18.2%, 19.5%, 19.7% and 23.0% less incidence of CLCuD than *Bt.*CIM-875, *Bt.*CIM-785, *Bt.*Cyto-535, *Bt.*Cyto-533, *Bt.*Cyto-536 and *Bt.*Cyto-179 respectively (Fig. 13).The interaction between sowing dates and genotypes on CLCuD incidence is illustrated in Fig. 14.

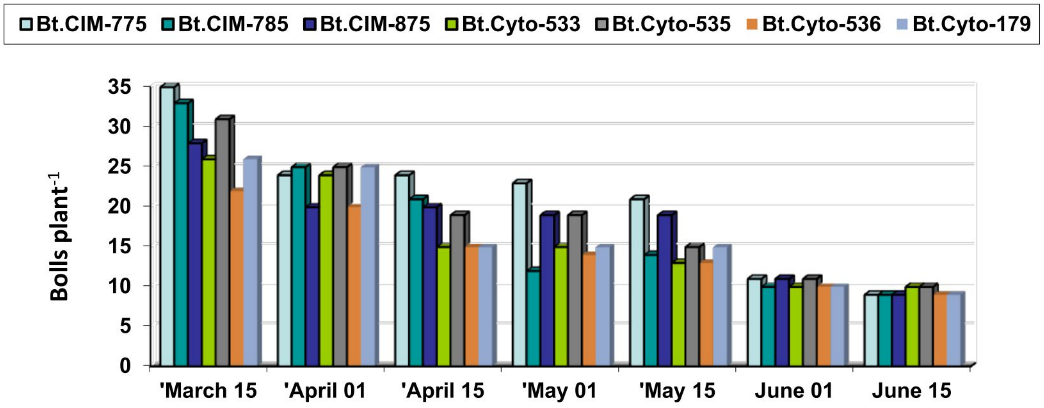


Fig 9. Sowing dates x genotypes interaction on bolls plant^{-1}

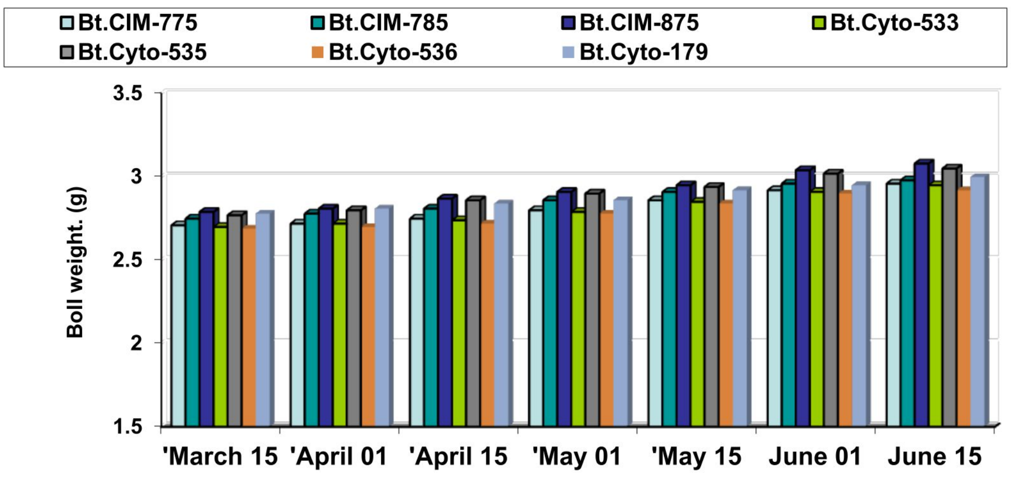


Fig 10. Sowing dates x genotypes interaction on boll weight

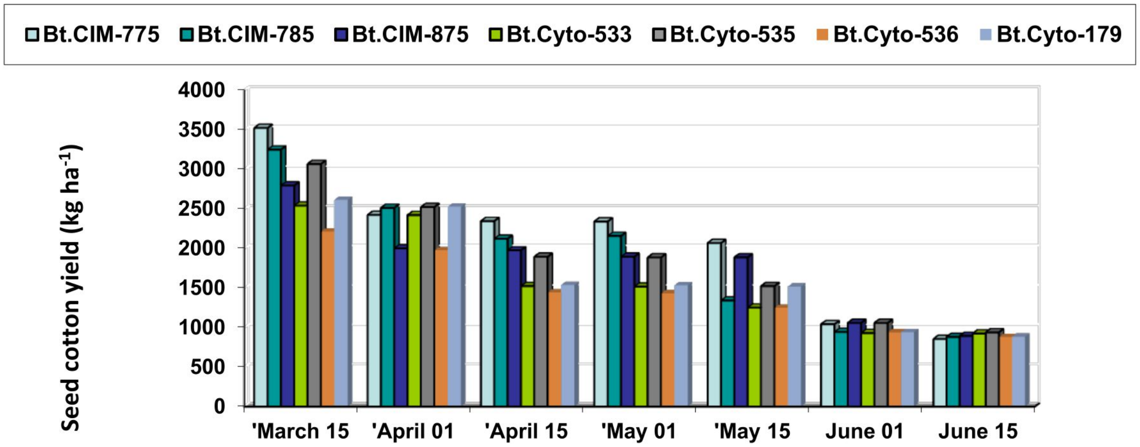


Fig 11. Sowing dates x genotypes interaction on seed cotton yield

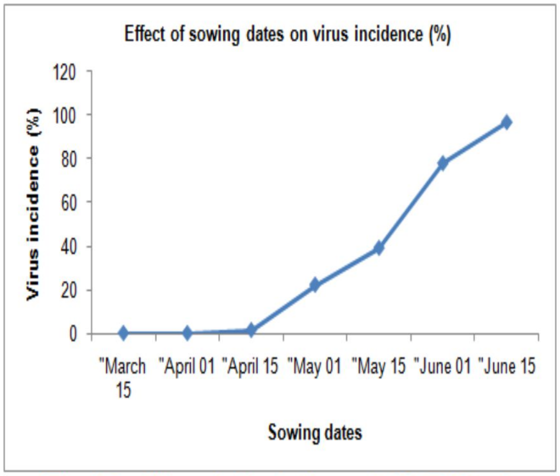


Fig 12. Virus infestation at 90 DAS at various sowing dates

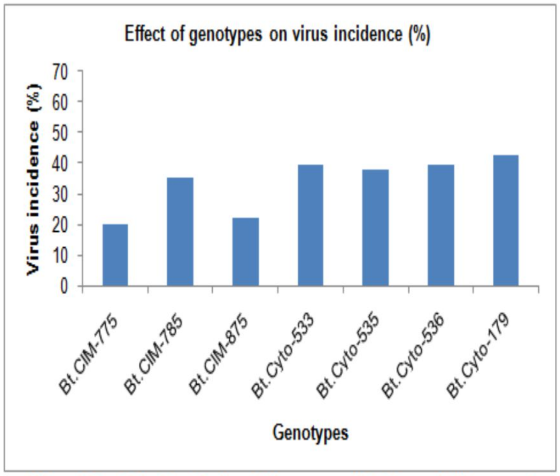


Fig 13. CLCuD incidence (%) in different genotypes at 90

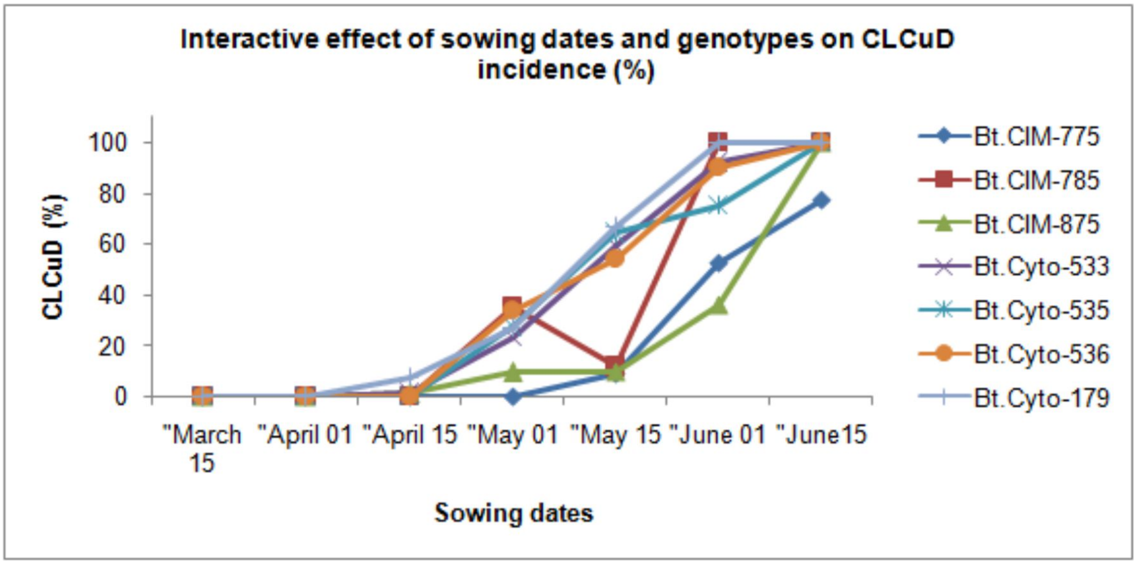


Fig 14. Sowing dates x *Bt.* genotypes interaction for CLCuD incidence (%) at 90 DAS

1.3 Splitting nitrogen application according to dry matter accumulation

The impact of splitting two nitrogen application rates (150 and 250 kg ha^{-1}) was studied on four genotypes. In this regard, the each nitrogen application rate was splitted into 10% as basal dose, 25% at squaring, 25% at flowering and 40% at peak flowering (T_1), 25% as basal dose, 25% at squaring, 25% at flowering and 25% at peak flowering (T_2), No basal dose, 25% at squaring, 25% at flowering and 50% at peak flowering (T_3) and No basal dose, 33% at squaring, 33% at flowering and 33% at peak flowering (T_4). The genotypes *Bt.* CIM-775, *Bt.* CIM-785, *Bt.* CIM-875 and *Bt.* Cyto-535 were included in the study. The treatments were arranged according to Randomized Complete Block Design (RCBD) with split-split plot arrangement with three replications. The net plot size measured was 500 sq ft. The genotypes were allocated in main plot, nitrogen rates to sub-plot and application timing was kept in sub-sub plot. The seed bed preparation was completed following standard practices using conventional tillage. It was followed by formation of bed-furrows in dry condition. The seeds were manually dibbled at 22.5 cm space on dry beds followed by irrigation. The sowing was done on 10th April 2020. The Dual Gold 960 EC @ 2L per hectare was applied as pre-emergence on moist beds within 24 hours after sowing. The gap filling was carried out with third irrigation. The week and disease affected plants were pulled during third week after sowing to maintain recommended plant population. The first split was applied on 1st June 2020 and second split was applied on 16th July 2020 and third application was made on 18th August 2020.The uniform set of cultural practices and plant protection measures were adopted as per need of the crop. The plant height was measured from five randomly selected plants with measuring rod from soil surface to top of plant. The boll weight was worked out by picking all opened bolls from three selected plants. The whole plot was manually picked and seed cotton weight was converted on hectare basis. The data on plant height, yield and yield components are given in Table 1.3.

The data in Table 1.3 highlighted that plant height, bolls per plant, boll weight, and seed cotton yield was significantly increased with increasing nitrogen rates. Increasing nitrogen from 150 to 250 kg ha^{-1} resulted in an increase in plant height by 7.6 cm, bolls by 0.8 per plant, boll weight by 0.03 g, and seed cotton by 119 kg ha^{-1}. The genotype *Bt.* Cyto-875 produced the maximum plant height out of other genotypes and it was followed by *Bt.* CIM-775. The *Bt.* CIM-785 and *Bt.* Cyto-535 did not differ significantly from each other for plant height. The maximum bolls per plant and seed cotton were produced in *Bt.* Cyto-535, while other genotypes did not produce statistically different numbers of bolls and seed cotton yield with each other. Regarding boll weight, each genotype produced statistically different values. The impact of application strategies was non-significant for plant height, while it resulted in significant variations for bolls per plant, boll weight, and seed cotton yield. The highest values of yield and yield components were recorded with three equal splits of nitrogen application at squaring, flowering, and peak flowering (T_4).

Table 1.3 Interactive effects of nitrogen rates, genotypes and nitrogen application strategies on plant height, bolls per plant, boll weight and seed cotton yield

Genotypes	Nitrogen rates (kg ha^{-1})	Nitrogen application strategy	Plant height (cm)	Bolls per plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})
***Bt.* CIM-775**	**150**	T1	130.7	17	2.31	1546
		T2	132.6	17	2.30	1454
		T3	132.1	18	2.32	1621
		T4	133.2	18	2.41	1663
	250	T1	140.4	18	2.35	1651
		T2	137.7	18	2.34	1601
		T3	139.8	19	2.35	1777
		T4	135.3	20	2.41	1831
***Bt.* CIM-875**	**150**	T1	149.5	16	2.75	1674
		T2	158.0	15	2.74	1594
		T3	155.5	18	2.79	1974
		T4	164.2	20	2.82	2191
	250	T1	157.0	16	2.77	1763
		T2	162.5	16	2.77	1697
		T3	170.5	19	2.82	2088
		T4	169.0	21	2.84	2280
***Bt.*CIM-785**	**150**	T1	117.7	17	2.56	1653
		T2	113.5	17	2.53	1563
		T3	104.5	18	2.57	1730
		T4	111.5	19	2.59	1830
	250	T1	126.0	18	2.60	1778
		T2	122.5	18	2.59	1673
		T3	113.2	19	2.61	1845
		T4	118.4	20	2.64	1945
***Bt.* Cyto-535**	**150**	T1	106.0	22	2.88	2353
		T2	118.3	20	2.86	2260
		T3	114.2	23	2.89	2592
		T4	122.2	24	2.91	2699
	250	T1	115.1	22	2.89	2450
		T2	124.5	21	2.88	2448
		T3	126.0	23	2.91	2682
		T4	127.9	25	2.92	2790

T_1 = 10% at basal, 25% at squaring, 25% at flowering and 40% at peak flowering, **T_2** = 25% at basal, 25% at squaring, 25% at flowering and 25% at peak flowering, **T_3** = No basal, 25% at squaring, 25% at flowering and 50% at peak flowering, **T_4** = No basal, 33% at squaring, 33% at flowering and 33% at peak flowering.

Sub-effects

Nitrogen rates (kg ha^{-1})	Plant height (cm)	Bolls per plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})
150	129.0	19	2.64	1900
250	136.6	20	2.67	2019

Genotypes	Plant height (cm)	Bolls per plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Bt. CIM-775	135.2	18	2.35	1643
Bt. CIM-875	160.8	18	2.79	1907
Bt. CIM-785	115.9	18	2.59	1752
Bt. Cyto-535	119.3	23	2.89	2534

Application strategy	Plant height (cm)	Bolls per plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})
T_1 = 10% at basal, 25% at squaring, 25% at flowering and 40% at peak flowering	130.3	18	2.64	1858
T_2 = 25% at basal, 25% at squaring, 25% at flowering and 25% at peak flowering	133.7	18	2.63	1786
T_3 = No basal, 25% at squaring, 25% at flowering and 50% at peak flowering	132.0	20	2.66	2039
T_4 = No basal, 33% at squaring, 33% at flowering and 33% at peak flowering	135.2	21	2.69	2154

C.D. 5%

Variables	Plant height (cm)	Bolls per plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Genotypes (G)	6.70	2.17	0.03	158.00
Nitrogen (N)	2.99	0.66	0.02	101.37
Application strategies (AS)	ns	1.13	0.03	103.64
G × N	ns	ns	ns	ns
G × AS	ns	ns	ns	ns
D × AS	ns	ns	ns	ns
G × D × AS	ns	ns	ns	ns

1.4 Modeling the cotton genotype performance at temporal variations

Climate change is a serious threat to cotton production, particularly in arid environments. Pakistan has been included in the list of the most vulnerable countries of the world. It has been proposed in the results of many studies on climate change impact assessment that the current management practices need to be redesigned to effectively address the issue. Such studies required decades of continuous experimentation, however, crop growth and simulation models including DSSAT (Decision Support System for Agro-Technology Transfer) generate reliable results after calibration and evaluation using observed data from a few years field experimentation. CSM-CROPGRO-Cotton Model embedded in DSSAT was used in this study. The current study was aimed to optimize planting time and estimate the yield performance of genotypes. Three genotypes i.e. *Bt.*CIM-789, *Bt.*Cyto-511 and *Bt.*Cyto-179 were planted in mid-March, mid-April, mid-May, and mid-June to generate a range of environmental conditions. The experimental design was Randomized Complete Block Design (RCBD) with split plot arrangement. The genotypes were designated to the main plot and planting time to sub-plot. The phenology data on days taken for 50% squaring, flowering and boll split initiation recorded from six randomly selected plants from each plot. The experimental data on phenology, yield and biomass used for calibration and evaluation of the CSM-CROPGRO-Cotton Model. The best performing treatment observed in the results was used for calibration and the remaining results were used for model evaluation. Baseline weather data (1980-2020) and future scenario weather data were made available through Pakistan Meteorological Department (PMD). The crop management data and weather files have been maintained.

Table 1.4: Effect of temporal variations on phenology, plant height, seed cotton yield, and its component of various genotypes

Genotypes	Sowing date	Days taken to 50% squaring	Days taken to 50% flowering	Days taken to first boll split	Plant height (cm)	Bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Bt. CIM-789	March 15	42.7	62.7	101.0	140.2	28	2.81	2832
	April 15	35.7	57.7	91.7	130.5	17	2.86	1696
	May 15	46.0	63.3	140.0	99.1	15	2.96	1535
	June 15	45.0	69.7	140.0	84.0	10	3.03	990
Bt. Cyto-511	March 15	40.0	62.0	99.7	132.7	31	2.74	3117
	April 15	32.7	57.0	86.7	131.0	16	2.81	1625
	May 15	44.7	62.7	139.0	121.6	15	2.90	1500
	June 15	45.0	67.7	139.0	83.5	9	2.97	870
Bt. Cyto-179	March 15	41.7	62.7	98.0	144.2	26	2.78	2615
	April 15	33.7	55.0	89.7	121.5	15	2.84	1540
	May 15	43.7	61.7	141.0	120.7	15	2.93	1520
	June 15	45.0	68.7	141.0	96.0	9	3.00	885

Sub-effects

Genotypes	Days taken to 50% squaring	Days taken to 50% flowering	Days taken to first boll split	Plant height (cm)	Bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Bt. CIM-789	42.3	63.3	118.2	113.5	18	2.92	1764
Bt. Cyto-511	40.6	62.3	116.1	117.2	18	2.86	1778
Bt. Cyto-179	41.0	62.0	117.4	120.6	16	2.89	1640

Temporal variations	Days taken to 50% squaring	Days taken to 50% flowering	Days taken to first boll split	Plant height (cm)	Bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
March 15	41.4	62.4	99.6	139.0	28	2.78	2855
April 15	34.0	56.6	89.3	127.7	16	2.84	1621
May 15	44.8	62.6	140.0	113.8	15	2.93	1519
June 15	45.0	68.7	140.0	87.8	9	3.00	915

C.D 5%

Temporal variation (T)	1.03	1.63	2.99	9.41	1.55	0.05	186.36
Genotypes (G)	1.45	ns	ns	ns	0.46	ns	ns
T X G	ns	ns	ns	ns	ns	ns	ns

The data about phenology, plant height, yield, and yield components of genotypes to temporal variations revealed a significant impact of sowing date. However, the differences across genotypes remained non-significant except for days to squaring and bolls per plant (Table 1.4). The advent of squaring and flowering time gets earlier with delay in sowing from March 15th to April 15th. It showed an increasing trend with the subsequent delay in sowing from May 15th to June 15th. On an overall basis, the crop planted in June 15th required maximum duration for attaining squaring, flowering and boll split initiation. The boll split days were initially decreased with delay in sowing from March 15th to April 15th and extended with further delay in sowing. The reduction in plant height, bolls, and seed cotton yield due to late sowing was 51.2 cm, 19.0 per plant, and 1940 kg ha^{-1}, respectively.

The *Bt*.Cyto-511 required minimum days for attaining squaring and boll split initiation. While, earlier flowering was recorded in *Bt*. Cyto-179. The genotypes did not differ significantly in days to flowering, boll split initiation, plant height, boll weight, and seed cotton yield. The interactive effect of treatments was non-significant for all recorded data. The model showed that earlier planting will compensate for the negative impact of climate change in the future (Figure 15).

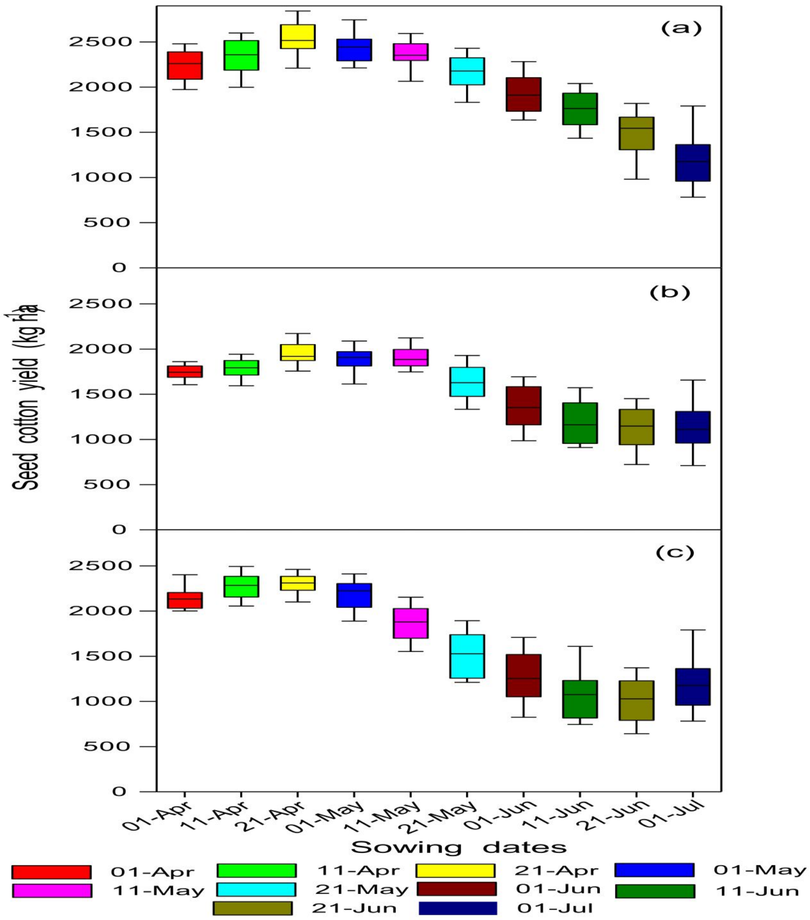


Figure 15: Simulated seed cotton yield (a) Bt.CIM-789, (b) Bt.CIM-511, (c) Bt.Cyto-179 as affected by sowing dates for future scenario

1.5 Cotton yield response to residues management and tillage systems in cotton-wheat cropping system

The huge amount of residue production is prominent feature of cotton-wheat cropping system. The wheat straw is generally burned in the field and cotton sticks are used for cooking in rural areas. The residues may be incorporated in the soil to improve the soil fertility profile and other relevant characteristics. The experiment was designed to evaluate the impact of the cotton sticks and wheat straw incorporation in combination with conventional tillage and conventional tillage + chiseling on soil health and crop yield. The treatments included were no residue incorporation (T_1), cotton sticks incorporation (T_2), cotton sticks & wheat straw incorporation (T_3) and wheat straw incorporation (T_4). The cotton cultivars C-Bulk and TS-01 were sown on 10th June 2020 under normal production practice. The experiment will remain for five years from 2018-2023. The tillage system was applied following residue incorporation. The post picking left over cotton sticks were incorporated at the rate of 3874 and 4359 for treatment of cotton sticks, wheat straw and cotton sticks along with chiseling, while in conventional tillage, the residues were incorporated at the rate of 2691 and 2799 kg ha^{-1} for treatment of cotton sticks and wheat-straw along with cotton sticks incorporation, respectively. The pre-incorporation soil samples were collected from field at 0-15 cm and 15-30 cm for initial soil profile. The wheat has been sown on 18th December, 2020 following the cotton. The plant height and bolls numbers was measured from five representative plants from each plot. The boll weight was worked out by picking opened bolls from four plants. The whole plot was manually picked, weighted and yield was converted on hectare basis. The normal agronomic practices are being carried out as per need of the crop. Data on soil analysis are given in Table 1.5a.

The results showed significant impacts of tillage and residues treatments on plant height, boll numbers, and seed cotton yield. While, all the recorded parameters were significantly different among genotypes (Table 1.5). The maximum plant height (84.2 cm), bolls (8.7 per plant), and seed cotton yield (823.0 kg ha^{-1}) were recorded in the combination of chiseling and conventional tillage. All the residue incorporation treatments produced higher values of recorded observation then no residues. The incorporation of cotton sticks and wheat straw resulted in the maximum plant height, bolls, and seed cotton yield with the values of 88.3 cm, 9.4 per plant, and 907 kg ha^{-1}. However, it did not produce statistically higher seed cotton yield over alone cotton sticks incorporation. Among the genotypes, C-Bulk although produced taller plants but it did not exceed the TS-01 regarding the number of bolls, boll weight, and seed cotton yield. It produced 116 kg ha^{-1} more seed cotton yield over C-Bulk on account of more bolls and boll weight.

The incorporation of cotton sticks, combined incorporation of cotton sticks and wheat straw and wheat straw alone improved organic matter, available phosphorus and potassium 0.17, 0.07 & 0.02%, 0.05, 0.50 & 0.75 mg kg^{-1} and 8.3, 18.9 & 7.8 mg kg^{-1}, respectively.

Table 1.5 Effect of various tillage and crop residues management on plant height, yield and yield components of various genotypes

Tillage	Crop residues incorporation	Genotypes	Plant height (cm)	Bolls per plant	Boll weight (g)	Seed cotton yield (Kg ha^{-1})
Conventional and chiseling	Cotton sticks	C-Bulk	93.5	8	2.41	760
		TS-01	78.5	9	2.50	876
	Cotton sticks and wheat straw	C-Bulk	94.6	9	2.44	869
		TS-01	80.6	10	2.54	1014
	Wheat straw	C-Bulk	93.7	8	2.42	766
		TS-01	77.5	9	2.52	924
	No residue	C-Bulk	78.5	7	2.38	625
		TS-01	76.6	8	2.47	750
Conventional	Cotton sticks	C-Bulk	82.2	8	2.40	754
		TS-01	72.3	9	2.52	861
	Cotton sticks and wheat straw	C-Bulk	88.4	9	2.42	818
		TS-01	89.5	9	2.53	928
	Wheat straw	C-Bulk	84.5	8	2.40	710
		TS-01	74.6	8	2.50	754
	No residue	C-Bulk	75.5	5	2.38	501
		TS-01	72.4	7	2.45	626

Sub-effects

Tillage	Plant height (cm)	Bolls per plant	Boll weight (g)	Seed cotton yield (Kg ha^{-1})
Conventional and Chiseling	84.2	9	2.46	823
Conventional	79.9	8	2.45	744

Genotypes	Plant height (cm)	Bolls per plant	Boll weight (g)	Seed cotton yield (Kg ha^{-1})
C-Bulk	86.4	8	2.41	725
TS-01	77.8	9	2.50	842

Crop residues incorporation	Plant height (cm)	Bolls per plant	Boll weight (g)	Seed cotton yield (Kg ha^{-1})
Cotton sticks	81.6	9	2.46	813
Cotton sticks and wheat straw	-88.3	9	2.48	907
Wheat straw	82.6	8	2.46	789
No residue	-75.8	7	2.42	625

C.D. 5%

Variable	Plant height (cm)	Bolls per plant	Boll weight (g)	Seed cotton yield (Kg ha^{-1})
Tillage (T)	2.39	0.65	ns	62.11
Residue (R)	7.20	1.03	ns	102.08
Genotypes (G)	3.59	0.58	0.03	69.88
T × R	ns	ns	ns	ns
T × G	ns	ns	ns	ns
R × G	ns	ns	ns	ns
T × R × G	ns	ns	ns	ns

Table 1.5a: Soil analysis

Crop residues incorporation	Texture	Saturation (%)	EC dsm^{-1}	pH	Organic matter (%)	Available phosphorus (mg kg^{-1})	Available potassium (mg kg^{-1})
Cotton sticks	Loam	40.4	5.67	8.30	0.75	7.85	250.5
Cotton sticks and wheat straw	Loam	40.5	6.00	8.15	0.65	8.30	261.1
Wheat straw	Loam	39.8	5.99	8.14	0.60	8.55	250.0
No residue	Loam	39.5	6.10	8.28	0.58	7.80	242.2

1.6 Cotton yield and fiber quality response to high density planting system (HDPS)

The performance of two cotton genotypes i.e. *Bt.* CIM-775 and *Bt.* CIM-875 was assed at three row spacings (45, 60 and 75 cm) and three plant spacings (15.0, 22.5 and 30.0 cm). The treatments were laid out according to Randomized Complete Block Design (RCBD) with split-split-plot arrangement in three replications. The genotypes were kept in main plots, row and plant spaces were allocated in sub and sub-sub plot, respectively. The net plot size was variable keeping in view the row spacings. The soil was thoroughly prepared with conventional tillage implements and the seeds were sown on beds on 16th April, 2020. The row and plant spaces were maintained according to respective treatments. The pre-emergence application of the Dual Gold 960 EC @ 2L per hectare was carried out on moist beds within 24 hours after planting. The crop was grown under normal crop management. The data on plant population and number of bolls (m^{-2}) was recorded using desired row length. The plant height was measured from five plants. The boll weight was worked out by collecting the known number of bolls before final picking. All the plants from each plot were manually picked, weighed and yield converted on hectare basis. The recorded data are present in Table 1.6.

Table 1.6: Effect of planting density on plant population, plant height, seed cotton yield and its components

Genotypes	Row spacing (cm)	Plant spacing (cm)	Plant population (ha^{-1})	Plant height (cm)	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Bt.CIM-775	45	15.0	113390.9	189.8	81.3	2.43	1652
		22.5	74073.2	183.5	85.4	2.49	1764
		30.0	55753.4	182.5	74.3	2.60	1607
	60	15.0	83926.2	180.8	180.1	2.44	3684
		22.5	56973.3	171.1	129.7	2.55	2763
		30.0	41973.3	170.9	121.8	2.69	2763
	75	15.0	68243.9	180.5	112.2	2.48	2344
		22.5	45563.8	164.5	134.6	2.59	2947
		30.0	33858.7	164.5	123.5	2.70	2813
Bt. CIM-875	45	15.0	111008.2	210.9	70.6	2.47	1473
		22.5	73719.7	208.2	72.7	2.51	1518
		30.0	56077.7	207.3	53.5	2.62	1183
	60	15.0	83747.8	207.8	106.4	2.62	2344
		22.5	56959.8	206.2	97.2	2.65	2177
		30.0	42124.8	203.3	82.6	2.67	1842
	75	15.0	67262.2	199.9	117.6	2.66	2612
		22.5	45165.2	194.5	104.2	2.74	2411
		30.0	33878.9	193.7	90.4	2.74	2076

Sub-effects

Genotypes	Plant population (ha^{-1})	Plant height (cm)	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Bt.CIM-775	63750.7	176.5	115.9	2.55	2482
Bt.CIM-875	63327.1	203.5	88.4	2.63	1960

Row spacing(cm)	Plant population (ha^{-1})	Plant height (cm)	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
45	80670.5	197.0	73.0	2.52	1533
60	60950.9	190.0	119.6	2.60	2595
75	48995.5	182.9	113.8	2.65	2534

Plant spacing (cm)	Plant population (ha^{-1})	Plant height (cm)	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
15.0	87929.9	195.0	111.4	2.52	2352
22.5	58742.5	188.0	104.0	2.59	2263
30.0	43944.5	187.0	91.0	2.67	2047

C.D. 5%

	Plant population (ha^{-1})	Plant height (cm)	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Genotypes (G)	ns	20.68	5.59	0.04	217.11
Row spacing (RS)	2664.6	ns	6.33	ns	82.80
Plant spacing (PS)	1795.2	ns	5.96	0.12	91.21
G x RS	ns	ns	8.96	ns	117.10
G x PS	ns	ns	ns	ns	128.99
RS x PS	3109.4	ns	10.32	ns	157.98
G x RS x PS	ns	ns	14.60	ns	223.41

The maximum plant population was recorded in 15.0 cm plant spaces and 45.0 cm row spacings and it decreased with widening of either row or plant spaces or both. None of the treatment factors except genotypes produced significant variations in plant height. The genotype *Bt.* CIM-875 produced significantly taller plants than *Bt.* CIM-775. The genotypes did not respond to

Visit of Ambassador, Portugal Embassy Islamabad

Visit of HE Paulo Neves Pocinho, Ambassador, Portugal Embassy Islamabad along with Ms Mariana Pocinho visited CCRI Multan plant spacing for number of bolls (m^{-2}). While, the effect of genotypes x row spacing, genotypes x plant spacing, row spacing x plant spacing and genotypes x row spacing x plant spacing remained significant for bolls (m^{-2}). The boll weight was significantly affected by genotypes and plant spacings. The highest boll weight was recorded in *Bt.* CIM-875 between genotypes and 30.0 cm out of plant spacings. It was also observed that boll weight improved with increasing plant to plant distance. The seed cotton yield varied significantly among main factors and their interactions including genotypes x row spacing, genotypes x pant spacing, row spacing x plant spacing and genotypes x row spacing x plant spacing. The highest seed cotton yield was recorded from *Bt.* CIM-775, 60 cm and 15 cm out of genotypes, row spacing and plant spacing, respectively.

1.7 Impact of high-density planting system on yield performance of various genotypes in national coordinated varietal trial (NCVT) 2020

The field performance of four new genotypes under NCVT system was tested under high density planting system. The coded genotypes including 2088, 2089, 2090 and 2091 were sown at 15.0 cm and 22.5 cm plant to plant distance. The treatments were laid out in three replications according RCBD split plot by allocating genotypes to main plots and plant spacings to sub plots. The crop was sown on 11th June 2020. The cultural practices were carried out as per need of the crop. The fertilizers were applied at the rate of 150 kg N + 50 kg P_2O_5 + 50 kg K_2O per hectare. The entire phosphorous was applied in one split i.e. 30 days after sowing (DAS), nitrogen was applied into three equal splits (1st split at 30 DAS, 2nd split at 45 DAS and the 3rd split at 60 DAS) and the potash was applied in two equal splits (1st split at 45 DAS and the 2nd split at 60 DAS).

The data presented in Table 1.7 showed considerable differences due to main factors, while interaction remained non-significant. The genotypes did not vary in plant height. The maximum plant population and boll weight were recorded in genotype 2091. While, genotype 2089 produced maximum bolls (m^{-2}) and seed cotton yield. The plant spaces significantly affected plant population, bolls (m^{-2}) and seed cotton yield.

Table 1.7: Effect of planting density on plant population, plant height, seed cotton yield and its components

Genotypes (code)	Plant spacing	Plant population (ha^{-1})	Plant height (cm)	Bolls (m^{-2})	Boll weight (g)	Seed Cotton Yield (Kg ha^{-1})
2088	15.0-cm	60199	81.5	45.0	2.39	622
	22.5-cm	46990	73.6	38.6	2.40	534
2089	15.0-cm	65134	78.8	63.7	2.68	924
	22.5-cm	49250	74.2	51.5	2.70	810
2090	15.0-cm	68131	71.8	53.7	2.66	826
	22.5-cm	51175	69.8	43.4	2.67	678
2091	15.0-cm	70016	78.4	57.4	2.86	882
	22.5 cm	52306	73.2	41.6	2.85	710

Genotypes (code)	Plant population (ha^{-1})	Plant height (cm)	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (Kg ha^{-1})
2088	53594.7	77.6	41.8	2.40	578
2089	57192.0	76.5	57.6	2.69	867
2090	59652.8	70.8	48.5	2.67	752
2091	61161.0	75.8	49.5	2.86	796

Plant spacing	Plant population (ha^{-1})	Plant height (cm)	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (Kg ha^{-1})
15.0-cm	65870.0	77.6	55.0	2.65	814
22.5-cm	49930.3	72.7	43.8	2.66	683
C.D. 5%					
Genotypes (G)	3341.5	ns	6.65	0.06	129.89
Plant spacing (PS)	1803.2	ns	2.68	ns	58.10
G x PS	ns	ns	ns	ns	ns

1.8 Agro-economics feasibility for cotton based intercropping systems

The cotton genotype Bt.Cyto-179 was sown on 29th April 2020 to evaluate the impact of various intercrops including mungbean (Niab-Mung 2006, fodder maize (SG-2002) and sesame (T-6).The experimental design was RCB design. The cultural practices were carried out as per need of the crop. The net plot size was 20 ft x 90 ft. Bed-furrows were prepared after land preparation in dry condition by employing 45 cm apart rows. Cotton delinted seeds and intercrops' seed were sown at 22.5 cm plant to plant distance by dibbling method followed by irrigation. Dual Gold 960 EC @ 2 L per hectare was sprayed after sowing on moist beds. Nitrogen at the rate of 150 kg ha^{-1} was applied in three split doses. Other cultural practices and plant protection measures were adopted as per need of the crop. Data on plant population, plant height, bolls m^{-2}, boll weight and seed cotton yield are given in Table 1.8.

1.8 Impact of different intercrops on plant population, plant height, bolls m^{-2}, boll weight and seed cotton yield

Intercrops	Plant population (ha^{-1})	Plant height (cm)	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (Kg ha^{-1})	Intercrop yield (Kg ha^{-1})	Income (Rs. ha^{-1})		Total income (Rs. ha^{-1})
							Cotton	Intercrop	
Cotton + Maize	39125.8	116.5	62.4	2.97	1347	25000	141435	62500	203935
Cotton + Mung bean	38595.9	140.0	81.1	3.01	1771	182	185955	36400	222355
Cotton + Sesame	38879.9	137.0	69.8	3.03	1589	242	166845	42350	209195
Cotton	73896.5	141.0	95.5	2.84	2278	-	239190	-	239190
C.D.5%	7898.5	18.02	11.24	ns	261.66	-	-	-	-

The data presented in Table 1.8 revealed that among all the treatments, the maximum plant height was observed in cotton alone while the minimum plant height and bolls m^{-2} were observed in cotton + maize intercropping system. Among the intercrops, cotton + mungbean produced 11.5% and 31.5% higher seed cotton yield as compared to cotton + sesame and cotton + maize intercrops respectively. The cotton alone produced significantly higher seed cotton yield as compared to the all other treatments. This increase in seed cotton yield of cotton alone can be associated with the double plant population as is obvious from the data. As well as the economic returns are concerned, fodder maize produced 25000 kg ha^{-1} of green fodder with an income of Rs. 62500/- as compared to 182 kg ha^{-1} of mung bean and 242 kg ha^{-1} of sesame with monetary returns of Rs.36400/- and 42350/- respectively. The cotton alone has given higher income over all other treatments. However, as for as the performance of different intercropping system is concerned, cotton + mung bean produced 6.3% and 9.0% high income as compared to cotton + sesame and cotton + maize, respectively.

1.9 Evaluation of the impact of mulching strategies on weed control and seed cotton yield

The cotton cultivar Bt.Cyto-535 was sown on 5th May 2020. The mulching material included rice straw, wheat straw and maize straw along with no mulch treatment. The treatments were laid out according to RCB design. The cultural practices were carried out as per need of the crop. The net plot size was 20 ft x 20 ft with three repeats. Bed-furrows were prepared after land preparation in dry condition. Sowing was done with delinted seeds by dibbling method followed by irrigation. Dual Gold 960 EC @ 2L per hectare was sprayed after sowing on moist beds. All mulches were manually placed to comprehensively cover the soil surface fifteen days after sowing. Nitrogen at the rate of 150 kg ha^{-1} was applied in three split doses. Other cultural practices and plant protection measures were adopted as per need of the crop. Data on plant height, boll number, boll weight and seed cotton yield are given in Table 1.9.

The data presented in Table 1.8 displayed that all the mulching material resulted greater plant height over control. Among the mulching materials, the maximum plant height was observed in wheat straw while minimum plant height was observed in control. Rice straw produced 36.0%, 26.7% and 9.9% higher seed cotton yield than wheat straw, maize straw and no mulch, respectively.

1.9 Effect of mulching material on plant height, bolls per plant, boll weight and seed cotton yield

Mulches	Plant height (cm)	Bolls plant^{-1}	Boll weight (g)	Seed cotton yield (Kg ha^{-1})
Rice straw	136.0	15	2.95	1599
Wheat straw	146.0	11	2.98	1175
Maize straw	141.5	12	3.02	1262
No mulch	131.5	14	3.00	1455
C.D.5%	ns	1.79	ns	188.45

Table 1.9a Effect of mulches on dry weight of weeds (gm^{-2}) and percent weed control at 30 days after sowing

Mulches	Dry weight of weeds gm^{-2}		Percent weed control over no mulch	
	Narrow leaves weeds	Broad leaves weeds	Narrow leaves weeds	Broad leaves weeds
Rice straw	5.0	7.3	59.0	64.4
Wheat straw	5.5	7.7	54.9	62.4
Maize straw	5.2	7.6	57.4	62.9
No mulch	12.2	20.5	-	-
C.D.5%	1.26	2.09	-	-

Table 1.9b Effect of mulches on dry weight of weeds (gm^{-2}) and percent weed control at 60 days after sowing

Mulches	Dry weight of weeds gm^{-2}		Percent weed control over no mulch	
	Narrow leaf weeds	Broad leaf weeds	Narrow leaf weeds	Broad leaf weeds
Rice straw	10.5	20.0	65.5	75.2
Wheat straw	11.2	21.5	63.2	73.3
Maize straw	11.0	20.7	63.8	74.3
No mulch	30.4	80.5	-	-
C.D.5%	3.10	8.07	-	-

The data presented in Table 1.9a and 1.9b show that rice straw mulch gave more control of broad and narrow leaf weeds as compared to all other mulch treatments. Similarly, all mulch treatments suppressed the weed population significantly in comparison with no mulch. At 30 days after sowing, rice straw mulch resulted in 59.0 and 64.4% narrow and broad leaf weeds control, wheat straw mulch resulted in 54.9 and 62.4% narrow and broad leave weeds control and maize straw mulch resulted in 57.4 and 62.9% narrow and broad leave weeds control over no mulch (Table 1.9b). At 30 days after sowing, rice straw mulch resulted in 65.5 and 75.2% narrow and broad leave weeds control, wheat straw mulch resulted in 63.2 and 73.3% narrow and broad leaf weeds control and maize straw mulch resulted in 63.8 and 74.3% narrow and broad leaf weeds control over no mulch (Table 1.9b).

1.10 Internship

Agronomy Section provided research facilities to one Ph.D. scholar from Faculty of Agricultural Science and Technology, Bahauddin Zakariya University, Multan. In addition, this facility was extended to twenty two students of B.Sc. (Hons.) Agriculture (Agronomy) from different Agricultural Colleges/Universities across the country. These students participated in ongoing research activities and availed internship training under the supervision of section experts.

1.11 Cost of production of one acre cotton for the year 2020-21 is given below

Sr. No.	Operations and Inputs	Number/ Quantity	Rate (Rs)	Amount (Rs.)
1.	Seedbed Preparation			**5440**
	a) Cultivation (Ploughing + planking)	4	600/cultivation	2400.00
	b) Leveling	1	500/leveling	500.00
	c) Bed and furrow making	1	1000/acre	1000.00
	d) Pre-emergence Weedicides	1.2	1200/liter	1440.00
	e) Bund making	1	100/acre	100.00
2.	Seed			**2125.00**
	a. Cost	8 kg.	10000/40 kg	2000.00
	b. Transportation	-	25/bag	5.00
	c. Delinting	-	600/40 kg	120.00
3.	Sowing	2 men day	1378/acre	**1378.00**
4.	Thinning	2 men day	1378/acre	**1378.00**
5.	Interculturing and earthing up	4	600/acre	**2400.00**
6.	Irrigation			**12089.00**
	a. Land preparation (3 hours)	1/3 canal		
	b. *Rouni*(4 hours)	2/3 tubewell	500/hour of tubewell	9333.00
	c. Post planting irrigation (21hours)			
	d. Cleaning of water channel and labour charges for irrigation	4 man day	689/man day	2756.00
7.	*Abiana*(Water rates)	-	125/acre	**125.00**
8.	Fertilizer			**9389.00**
	a. DAP (Di-Amonium Phosphate)	1 bag	3650/bag	3650.00
	b. Urea	3.0 bags	1650/bag	4950.00
	c. Transportation	4.0 bags	25/bag	100.00
	d. Fertilizer Application Charges	1man day	689/day	689.00
9.	Plant Protection			**15450.00**
	a. Sucking	9	1450/spray	13050.00
	b. Bollworm	2	1200/spray	2400.00
10.	Harvesting (Picking charges)	800 Kg	12.0/kg	**9600.00**
11	Stick Cutting	2 men day	689/man day	+1378.00
11a	Value of cotton sticks			-1378.00
12.	Managerial Charges for 1 acre	7 months	30000/month/100 acre	**2100.00**
13.	Land Rent	7 months	40,000/acre/annum	**23,333.00**
14.	Unforeseen Expenses	-	3000/acre	**3000.00**
15.	Production Expenditure	-	-	
	a. Including Land Rent			**87807.00**
	b. Excluding Land Rent			**64474.00**
16.	Mark-up on Investment	7 months	12.5% for one year	
	a. Including Land Rent			**6402.59**
	b. Excluding Land Rent			**4701.23**
17.	Total Expenditure	--		
	a. Including Land Rent			**94209.59**
	b. Excluding Land Rent			**69175.23**
18.	Income of Seed Cotton	800 kg	4200/40 kg	**84000. 00**
19.	Market expenses	800 kg	100/40 kg	**2000. 00**
20.	Cost of Production at Farm level	-		
	a. Including Land Rent		Per 40 kg	**4710.48**
	b. Excluding Land Rent			**3458.76**
21.	Cost of production at Market	-		
	a. Including Land Rent.		Per 40 kg	**4810.48**
	b. Excluding Land Rent.			**3558.76**

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2. PLANT BREEDING & GENETICS SECTION

Plant Breeding & Genetics Section develops new cotton varieties or lines with desirable fibre properties equipped with inbuilt resistance/tolerance against insect-pest and diseases by utilizing purposeful breeding (crossing) of closely or distantly related genotypes. Plants are cross-bred to introduce traits/genes from one variety or line into a new genetic background.

The promising hybrids, *Bt*. and non-*Bt*. strains of all the cotton breeders of the country were evaluated under National Coordinated Variety Testing (NCVT) Program of Pakistan Central Cotton Committee. The prominent commercial varieties (*Bt*. and non-*Bt*.) were also tested for their performance under local agro-climatic conditions in standard varietal trials. The breeding materials in different filial generations were screened out for selection into next generation. Major emphasis was laid on the selection of material having resistance/tolerance to Cotton Leaf Curl Virus (CLCuV), and tolerance against heat & drought along with excellent fibre characteristics. The genetic stock of World Cotton collections comprising of 6143 cultivars of four species of *Gossypium* are being preserved for short (25 years), medium (50 years) and long (100 years) duration as well as for utilization in breeding program by cotton breeders in the country and abroad. Promising lines i.e. Bt.CIM-775 and Bt.CIM-875 developed by utilizing USDA and local cotton germplasm material were tested for second and first years respectively in NCVT. Trainings were also imparted to small farmers, progressive growers and students from different universities. This year two varieties i.e. *Bt.* CIM-663 and *Bt*.CIM-343 were approved for general cultivation in Punjab by the Punjab Seed Council. A summary of the results is as below.

2.1 Testing of new strains

2.1.1 Varietal Trial-1

Objective: Testing and evaluation of promising medium long staple *Bt.* strains for the development of commercial varieties

Seven medium long staple promising *Bt.* strains viz., *Bt*.CIM-741, *Bt*.CIM-743, *Bt*.CIM-744, *Bt*.CIM-746, *Bt*.CIM-768, *Bt*.CIM-769 and *Bt*.CIM-770, were evaluated against one commercial variety *Bt*.CIM-602 at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal. Data of seed cotton yield and other parameters are given in **Tables 2.1, 2.2** and **2.3**.

Averaged across the two locations, the strain *Bt*.CIM-746 produced the highest seed cotton yield of 1844 kg ha^{-1} followed by *Bt*.CIM-770 having yield 1747 kg ha^{-1} while the standard variety *Bt*.CIM-602 yielded 1654 kg ha^{-1} .**(Table 2.1).**

Table 2.1 Performance of advanced strains in Varietal Trial-1 at two locations

Sr. #	Strains	Seed cotton yield (kg ha^{-1})			Av. Boll weight (g)	Plant Pop. (ha^{-1})
		Multan	Khanewal	Average		
1	CIM-741	1363	1426	1395	2.6	41605
2	CIM-743	1809	1538	1674	2.4	34073
3	CIM-744	1541	1752	1647	2.8	37929
4	CIM-746	1757	1931	1844	2.7	38557
5	CIM-768	1112	1542	1327	2.8	36853
6	CIM-769	1363	1555	1459	2.6	40171
7	CIM-770	1809	1685	1747	2.5	40978
8	*Bt*.CIM-602	1541	1766	1654	2.1	38557

Sowing date 17.04.2020, C.V =6.76

CD (5%) for seed cotton: Locations (L) = 87.814; Varieties (V) = 155.43: L x V = 153.35

The new strain *Bt*.CIM-768 produced the highest lint percentage of 39.4 followed by *Bt*.CIM-743 having lint percentage values of 39.2 compared with the standard *Bt*.CIM-602 i.e. 37.2 (**Table 2.2**). The new strain *Bt*.CIM-768 produced the longest staple of 29.6 mm, followed by *Bt*.CIM-769 with 29.2 mm while the standard *Bt*.CIM-602 produced 27.5 mm staple length **(Table 2.2).**

Table 2.2 Lint percentage and staple length of advanced strains in Varietal Trial-1 at two locations

Sr. #	Strains	Lint (%age)			Staple length (mm)		
		Multan	Khanewal	Average	Multan	Khanewal	Average
1	CIM-741	36.7	36.9	36.8	26.5	26.3	26.4
2	CIM-743	39.0	39.3	39.2	28.5	28.7	28.6
3	CIM-744	37.3	37.5	37.4	26.5	27.5	27.0
4	CIM-746	36.3	36.8	36.6	27.2	27.7	27.5
5	CIM-768	39.1	39.6	39.4	29.2	29.9	29.6
6	CIM-769	38.2	39.2	38.7	29.0	29.4	29.2
7	CIM-770	38.3	38.8	38.4	26.9	27.5	27.2
8	CIM-602	37.0	37.3	37.2	27.1	27.8	27.5

All the new strains possess desirable micronaire value ranging from 4.4 to 4.9 in comparison to *Bt*.CIM-602 with 4.8.The fiber strength of all the new strains and standard are in the desirable range, i.e., 26.5 to 28.3 g/tex **(Table 2.3).**

Table 2.3 Micronaire value and fibre strength of advanced strains in Varietal Trial-1 at two locations

Sr. #	Strains	Micronaire value			Fibre strength (g/tex)		
		Multan	Khanewal	Average	Multan	Khanewal	Average
1	CIM-741	4.8	4.9	4.9	26.5	26.7	26.6
2	CIM-743	4.4	4.2	4.3	27.4	27.9	27.7
3	CIM-744	5.0	4.8	4.9	26.2	26.8	26.5
4	CIM-746	4.7	4.6	4.7	26.1	27.1	26.6
5	CIM-768	4.5	4.2	4.4	28.8	27.0	27.9
6	CIM-769	4.3	4.1	4.2	28.0	28.5	28.3
7	CIM-770	4.2	4.1	4.2	27.1	27.6	27.4
8	CIM-602	4.9	4.7	4.8	26.6	26.9	26.8

2.1.2 Varietal Trial-2

Objective: Testing and evaluation of promising medium long staple strains for the Development of commercial varieties

Nine new strains with medium-long staple viz., *Bt*.CIM-763, *Bt*.CIM-766, *Bt*.CIM-767, *Bt*.CIM-771, *Bt*.CIM-772, *Bt*.CIM-773, *Bt*.CIM-774, *Bt*.CIM-776 and *Bt*.CIM-777 were tested at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal against a commercial variety *Bt*.CIM-602.

Data presented in **Table 2.4** showed that averaged across locations the new strain *Bt*.CIM-763 produced the highest seed cotton yield of 1410 kg ha^{-1}, followed by *Bt*.CIM-777 with 1348 kg ha^{-1} while the standard varieties *Bt*.CIM-602 produced 1158 kgha-^{1}.

The strain *Bt*.CIM-766 had the highest lint percentage of 38.9, followed by 38.5% of *Bt*.CIM-774 in comparison to the commercial varieties *Bt*.CIM-602 produced 37.7 lint percentages. The strain *Bt*.CIM-772 produced the longest staple of 28.8 mm followed by *Bt*.CIM-767 having 28.3mm **(Table 2.5)** while standard *Bt*.CIM-602 produced 28.1 mm staple length

All the strains possess desirable micronaire value except CIM-777 with the value of 5.1. The fibre strength of the strains ranged from 25.7 to 28.2 g/tex **(Table 2.6).**

Table 2.4 Performance of advanced strains in Varietal Trial-2 at two locations

Sr. #	Strains	Seed cotton yield (kg ha^{-1}) Multan	Khanewal	Average	Av. boll weight (g)	Plant Pop. (ha^{-1})
1	CIM-763	1420	1400	1410	2.7	37570
2	CIM-766	1068	1256	1162	2.3	38467
3	CIM-767	1070	1258	1164	2.3	37481
4	CIM-771	1175	1368	1272	2.4	39184
5	CIM-772	1025	1488	1257	2.3	39722
6	CIM-773	1165	1088	1127	3.1	40440
7	CIM-774	1135	1255	1195	3.0	40350
8	CIM-776	1225	1025	1125	2.4	35687
9	CIM-777	1238	1458	1348	3.0	38467
10	CIM-602	1022	1293	1158	2.3	37301

Sowing date 19.05.2020 C.V =6.68
CD (5%) for seed cotton: Locations (L) = 87.713; Varieties (V) = 170.60: L x V = 181.05

Table 2.5 Lint percentage and staple length of advanced strains in Varietal Trial-2 at two locations

Sr. #	Strains	Lint (%age)			Staple length (mm)		
		Multan	Khanewal	Average	Multan	Khanewal	Average
1	CIM-763	36.6	37.7	37.2	28.5	27.9	28.2
2	CIM-766	39.3	38.5	38.9	27.7	28.3	28.0
3	CIM-767	37.4	37.5	37.5	28.6	28.0	28.3
4	CIM-771	36.8	38.2	37.5	27.8	28.3	28.1
5	CIM-772	38.6	37.1	37.9	29.1	28.4	28.8
6	CIM-773	39.2	37.2	38.2	26.9	27.8	27.4
7	CIM-774	38.6	38.3	38.5	26.9	28.6	27.8
8	CIM-776	37.5	37.5	37.5	28.0	28.3	28.2
9	CIM-777	36.8	36.9	36.9	27.5	28.5	28.0
10	CIM-602	37.6	37.8	37.7	27.8	28.3	28.1

Table 2.6 Micronaire value and fibre strength of advanced strains in Varietal Trial-2 at two locations

Sr. #	Strains	Micronaire value			Fibre strength (g/tex)		
		Multan	Khanewal	Average	Multan	Khanewal	Average
1	CIM-763	4.4	4.0	4.2	27.5	26.3	26.9
2	CIM-766	4.6	4.6	4.6	25.8	26.3	26.1
3	CIM-767	3.8	4.3	4.1	27.8	27.0	27.4
4	CIM-771	3.9	3.8	3.9	28.0	28.3	28.2
5	CIM-772	4.1	3.9	4.0	26.8	26.1	26.5
6	CIM-773	4.6	4.5	4.6	25.5	25.9	25.7
7	CIM-774	4.8	4.6	4.7	26.0	26.8	26.4
8	CIM-776	5.0	4.8	4.9	27.1	28.0	27.6
9	CIM-777	5.1	5.0	5.1	28.0	26.9	27.5
10	CIM-602	4.2	4.6	4.4	27.3	29.0	28.2

2.1.3 Varietal Trial-3

Objective: Testing and evaluation of promising medium long staple *Bt.* strains for the development of commercial varieties

Nine medium staple promising *Bt.* Strains *Bt.*CIM-757, *Bt.*CIM-758, *Bt.*CIM-759, *Bt.*CIM-762, *Bt.*CIM-778, *Bt.*CIM-779, *Bt.*CIM-780, *Bt.*CIM-781 and *Bt.*CIM-664 were evaluated against commercial variety *Bt.*CIM-602 at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal. Data on seed cotton yield and other parameters are given in **Tables 2.7, 2.8** and **2.9**.

Averaged across two locations, the strain *Bt*.CIM-762 produced the highest seed cotton yield of 2091 kg ha^{-1} followed by *Bt*.CIM-757 having yield of 1711 kg ha^{-1} while the standard *Bt*.CIM-602 produced yield of 1334 kg ha^{-1} **(Table 2.7).**

Table 2.7 Performance of advanced strains in Varietal Trial-3 at two locations

Sr. #	Strains	Seed cotton yield (kg ha^{-1})			Av. Boll weight (g)	Plant Pop. (ha^{-1})
		Multan	Khanewal	Average		
1	CIM-757	1772	1650	1711	2.3	41605
2	CIM-758	1587	1520	1554	2.4	41247
3	CIM-759	1588	1670	1629	2.5	40529
4	CIM-762	2401	1780	2091	2.3	41336
5	CIM-778	1551	1760	1656	2.2	40709
6	CIM-779	1158	1420	1289	2.5	38377
7	CIM-780	1242	1632	1437	2.4	32459
8	CIM-781	1087	1289	1188	2.2	41785
9	CIM-664	1637	1690	1664	2.4	40529
10	CIM-602	1207	1460	1334	2.1	37660

Sowing date 26.04.2020, C.V =7.38
CD (5%) for seed cotton: Locations (L) = 77.713; Varieties (V) = 125.60: L x V = 175.05

The new strain *Bt*.CIM-781 produced the highest lint percentage of 39.2, followed by *Bt*.CIM-758 having lint percentage value of 38.9 **(Table 2.8).** The new strains *Bt*.CIM-757 produced the longest staple of 29.1 mm, followed by *Bt*.CIM-759 with 29.0 mm while the standards *Bt*.CIM-602 produced 27.3 mm staple length **(Table 2.8).**

Table 2.8 Lint percentage and staple length of advanced strains in Varietal Trial-3 at two locations

Sr. #	Strains	Lint (%age)			Staple length (mm)		
		Multan	Khanewal	Average	Multan	Khanewal	Average
1	CIM-757	38.2	38.0	38.1	29.0	29.2	29.1
2	CIM-758	38.5	39.2	38.9	29.2	28.5	28.9
3	CIM-759	38.2	38.1	38.2	29.3	28.7	29.0
4	CIM-762	39.2	37.5	38.4	29.2	28.1	28.7
5	CIM-778	37.4	36.8	37.1	28.2	27.9	28.1
6	CIM-779	36.5	35.9	36.2	27.2	27.1	27.2
7	CIM-780	37.5	36.7	37.1	27.4	27.0	27.2
8	CIM-781	39.6	38.8	39.2	28.1	27.5	27.8
9	CIM-664	38.4	37.9	38.2	28.2	28.0	28.1
10	CIM-602	37.1	37.6	37.4	27.2	27.4	27.3

All the new strains possess desirable micronaire values ranging from 4.1 to 4.7. The fibre strength of all the new strains and standards is in the desirable range, i.e. 26.6 to 28.1 g/tex **(Table 2.9).**

Table 2.9 Micronaire value and fibre strength of advanced strains in Varietal Trial-3 at two locations

Sr. #	Strains	Micronaire value			Fibre strength (g/tex)		
		Multan	Khanewal	Average	Multan	Khanewal	Average
1	CIM-757	4.5	4.3	4.4	27.1	26.9	27.0
2	CIM-758	4.4	4.1	4.3	28.0	27.5	27.8
3	CIM-759	4.8	4.6	4.7	27.4	27.6	27.5
4	CIM-762	4.0	4.3	4.2	28.0	27.9	28.0
5	CIM-778	4.4	4.7	4.6	27.3	28.1	27.7
6	CIM-779	4.5	4.3	4.4	27.4	27.9	27.7
7	CIM-780	4.2	4.0	4.1	27.8	28.3	28.1
8	CIM-781	4.6	4.3	4.5	27.5	27.7	27.6
9	CIM-664	4.6	4.5	4.6	26.0	27.1	26.6
10	CIM-602	4.4	4.1	4.3	27.0	26.9	27.0

2.1.4 Varietal Trial-4

Objective: Testing and evaluation of promising medium long staple *Bt.* strains for the development of commercial varieties

Nine medium staple promising *Bt.* Strains *Bt.*CIM-782, *Bt.*CIM-783, *Bt.*CIM-784, *Bt.*CIM-786, *Bt.*CIM-787, *Bt.*CIM-750, *Bt.*CIM-751, *Bt.*CIM-753 and *Bt.*CIM-788 were evaluated against commercial variety *Bt.*CIM-602 at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal. Data on seed cotton yield and other parameters are given in **Tables 2.7, 2.8** and **2.9**.

Averaged across locations, the strain *Bt.*CIM-788 produced the highest seed cotton yield of 2012 kg ha^{-1} followed by *Bt.*CIM-787 having yield of 1840 kg ha^{-1} while the standard *Bt.*CIM-602 produced 1367 kg ha^{-1} yield **(Table 2.7).**

Table 2.7 Performance of advanced strains in Varietal Trial-4 at two locations

Sr. #	Strains	Seed cotton yield (kg ha^{-1})			Av. Boll weight (g)	Plant Pop. (ha^{-1})
		Multan	Khanewal	Average		
1	CIM-782	1683	1790	1737	2.9	38019
2	CIM-783	1536	1685	1611	3.5	38377
3	CIM-784	1409	1684	1547	2.9	41067
4	CIM-786	1413	1230	1322	3.1	37301
5	CIM-787	1899	1780	1840	3.6	37301
6	CIM-750	1330	1970	1650	3.3	37391
7	CIM-751	1399	1680	1540	3.1	24120
8	CIM-753	1893	1750	1822	2.9	37660
9	CIM-788	2103	1920	2012	3.0	36763
10	CIM-602	1274	1460	1367	2.2	29680

* Sowing date =19.05.2020 CV = 6.7%
CD (5%) for seed cotton: Locations (L) =57.57; Varieties (V) =128.73; L x V = 182.05

The new strains *Bt.*CIM-783 produced the highest lint percentage of 40.6, followed by *Bt.*CIM-782 having lint percentage value of 40.1 **(Table 2.8).** The new strains *Bt.*CIM-788 produced the longest staple of 28.5 mm, followed by *Bt.*CIM-786 with 28.4 mm while the standard *Bt.*CIM-602 produced 27.9 mm staple length **(Table 2.8).**

All the new strains possess desirable micronaire values ranging from 4.1 to 4.8 including the standard *Bt.*CIM-602. The fibre strength of all the new strains and standard is in the desirable range. **(Table 2.9).**

Visit of Fields of Cotton Farmers

Dr. Zahid Mahmood, Director CCRI Multan visited various cotton fields across Punjab to monitor the insect pests & disease and cotton crop situation of the respective areas. Farmers were advised for taking effective plant protection measures for management of insect pests.

Table 2.8 Lint percentage and staple length of advanced strains in Varietal Trial-4 at two locations

Sr. #	Strains	Lint (%age)			Staple Length (mm)		
		Multan	Khanewal	Average	Multan	Khanewal	Average
1	CIM-782	40.2	40.0	40.1	28.0	28.3	28.2
2	CIM-783	40.9	40.3	40.6	28.1	28.4	28.3
3	CIM-784	35.2	37.8	36.5	28.2	28.0	28.1
4	CIM-786	37.3	38.4	37.9	28.1	28.6	28.4
5	CIM-787	38.2	37.9	38.1	28.9	27.6	28.3
6	CIM-750	38.8	38.0	38.4	27.9	28.5	28.2
7	CIM-751	40.1	39.2	39.7	28.2	28.0	28.1
8	CIM-753	37.6	38.1	37.9	27.9	27.4	27.7
9	CIM-788	39.0	38.5	38.8	28.2	28.8	28.5
10	CIM-602	37.4	37.9	37.7	27.7	28.0	27.9

Table 2.9 Micronaire value and fibre strength of advanced strains in Varietal Trial-4 at two locations

Sr. #	Strains	Micronaire value			Fibre strength (g/tex)		
		Multan	Khanewal	Average	Multan	Khanewal	Average
1	CIM-782	4.9	4.7	4.8	26.3	27.8	27.1
2	CIM-783	4.2	4.4	4.3	27.9	26.9	27.4
3	CIM-784	3.7	4.5	4.1	28.0	28.3	28.2
4	CIM-786	3.8	4.5	4.2	27.9	28.5	28.2
5	CIM-787	4.3	4.1	4.2	28.1	27.6	27.9
6	CIM-750	3.9	4.6	4.3	27.8	28.6	28.2
7	CIM-751	3.8	4.3	4.1	27.6	28.2	27.9
8	CIM-753	4.0	4.2	4.1	27.3	27.9	27.6
9	CIM-788	4.5	4.2	4.4	27.9	29.1	28.5
10	CIM-602	4.2	4.6	4.4	27.5	28.5	28.0

2.2 Micro Varietal Trials

2.2.1 Micro Varietal Trial-1

Objective: Testing of newly bulked medium staple *Bt.* strains to develop Commercial varieties

Five newly bulked strains numbering from MV-1/20 to MV-5/20 were tested against commercial variety *Bt.*CIM-602 at CCRI, Multan. The new strain MV-5/20 surpassed all the strains and standard variety in seed cotton yield by producing 1764 kg ha^{-1} followed by MV-4/20 with 1581 kg ha^{-1} compared with 1308 kg ha^{-1} of *Bt.*CIM-602 **(Table 2.10).**

The strain MV-3/20 produced the highest lint percentage of 40.3 followed by 40.1 percent lint in MV-2/20 while the commercial variety *Bt.*CIM-602 produced the lint percentage of 37.5. The strain MV-2/20 produced the longest staple of 29.2 mm, followed by 29.0 mm in MV-5/20 compared with the fibre length of 27.8 mm in commercial variety *Bt.*CIM-602. Micronaire values of all the strains are in acceptable limit. The strain MV-3/20 maintained the maximum fibre strength of 27.6 g/tex, followed by 27.1 g/tex in MV-2/20 while standard *Bt.*CIM-602 had 26.9 g/tex.

Table 2.10 Performance of advanced strains in Micro Varietal Trial-1 at CCRI, Multan

Sr. #	Strains	Seed Cotton Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micro-naire value	Fibre strength (g/tex)	Av. boll wt. (g)	Plant Pop. (ha^{-1})
1	MV-1 /20	1354	36.9	28.1	4.0	26.3	2.4	35687
2	MV-2/20	1461	40.1	29.2	4.5	27.1	2.4	39453
3	MV-3/20	1388	40.3	28.1	4.7	27.6	2.3	31563
4	MV-4/20	1581	39.7	28.1	4.9	26.7	3.1	39812
5	MV-5/20	1764	40.0	29.0	4.9	25.7	2.9	38557
6	*Bt.*CIM-602	1308	37.5	27.8	4.4	26.9	2.2	32280

Sowing date 17.04.2020, CD (5%) for seed cotton: Strains =396.74; CV % =11.15

2.2.2 Micro Varietal Trial-2

Objective: Testing of newly bulked medium-long staple *Bt.* strains to develop commercial varieties

Five newly bulked strains numbering from MV-06/20 to MV-10/20 were tested against commercial variety *Bt.*CIM-602 at CCRI, Multan. The new strain MV-09/20 surpassed all the strains and standard variety in seed cotton yield by producing 1278 kg ha^{-1}, followed by MV-07/20 with 1145 kg ha^{-1} compared with 1025 kg ha^{-1} of *Bt.*CIM-602 **(Table 2.11).**

The strain MV-08/20 produced the highest lint percentage of 39.0 followed by 38.9 percent lint in MV-09/20 while the commercial variety *Bt.*CIM-602 produced the lint percentage of 36.3. The strain 07/20 produced the longest staple of 29.1 mm, followed by 28.9 mm in MV-08/20 compared with the fibre length of 27.5 mm in commercial variety *Bt.*CIM-602. All the strains have desirable micronaire and fiber strength values.

Table 2.11 Performance of advanced strains in Micro-Varietal Trial-2 at CCRI, Multan

Sr. #	Strains	Seed Cotton Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micro-naire value	Fibre Strength (g/tex)	Av. boll wt. (g)	Plant Pop. (ha^{-1})
1	MV-06/20	1030	38.4	27.9	4.0	27.9	2.2	39274
2	MV-07/20	1145	37.9	29.1	4.2	27.1	2.2	38557
3	MV-08/20	1048	39.0	28.9	4.0	27.0	2.9	38198
4	MV-09/20	1278	38.9	28.1	4.6	28.6	2.1	36405
5	MV-10/20	1041	37.0	27.1	4.5	26.9	2.0	36225
6	Bt.CIM-602	1025	36.3	27.5	4.2	28.9	2.1	38736

Sowing date 19.05.2020, CD (5%) for seed cotton = 275.15, CV. % = 6.90

2.2.3 Micro Varietal Trial-3

Objective: Testing of newly bulked medium-long staple strains to develop commercial varieties

Nine newly bulked strains numbering from MV-11/20 to MV-19/20 were tested against commercial variety *Bt.*CIM-632 at CCRI, Multan. Data presented in **Table 2.12** indicated that the new strain MV-16/20 surpassed all the new strains yielding 1837 kg ha^{-1}, followed by strains MV-14/20 produced 1817 kg ha^{-1} while the standard *Bt.*CIM-602 yielding 1519 kg ha^{-1}. The new strain MV-17/20 produced the lint percentage of 39.0 followed by MV-14/20 with 38.8 % in comparison to *Bt.*CIM-632 having 36.1 lint percentages. The strains MV-16/20 has the longest staple of 29.2 mm followed by MV-14/20 with the staple of 28.9 mm compared with the staple length of 27.2 mm in standard variety *Bt.*CIM-632. All the genotypes have desirable micronaire value ranging from 3.9 to 4.6. All the strains were showing fibre strengths ranging from 26.9 to 27.9 g/tex.

Table 2.12 Performance of advanced strains in Micro-Varietal Trial-3 at CCRI, Multan

Sr. #	Strains	Seed cotton yield (kg ha-1)	Lint (% age)	Staple Length (mm)	Micro naire value	Fibre Strength (g/tex)	Av. boll weight (g)	Plant Pop. (ha-1)
1	MV-11/20	1577	38.2	27.1	4.3	26.9	3.1	39991
2	MV-12/20	1643	37.8	27.7	4.0	27.9	3.1	41247
3	MV-13/20	1426	37.0	27.1	3.9	27.0	3.0	38557
4	MV-14/20	1817	38.8	28.9	4.1	26.9	2.9	40529
5	MV-15/20	1234	36.4	27.9	4.1	26.9	3.1	37301
6	MV-16/20	1837	38.5	29.2	4.2	27.1	2.9	38915
7	MV-17/20	1471	39.0	28.9	4.0	27.0	3.2	40888
8	MV-18/20	1657	36.6	28.1	4.6	27.6	2.5	38915
9	MV-19/20	1626	37.0	26.1	4.1	26.9	3.0	38198
10	Bt.CIM-632	1519	36.1	27.2	4.1	26.9	2.7	35867

Sowing date = 19.05.2020, CD (5%) for seed cotton: 315.786, CV% = 11.65

2.2.4 Micro-Varietal Trial-4

Objective*:* Testing of medium long staple *Bt.* strains to develop commercial varieties

Six newly bulked elite *Bt*. strains from MV-20/20 to MV-25/20 were tested against commercial variety *Bt.*CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.13**.

The strain MV-21/20 out-yielded all the strains and standard variety by producing 2206 kg ha^{-1} seed cotton, followed by MV-23/20 having seed cotton yields of 2188 kg ha^{-1} against commercial variety *Bt.*CIM-602 which produced 1722 kg ha^{-1} seed cotton. The strain MV-21/20 produced the higher lint percentage of 39.8% followed by MV-24/20 with 39.5% compared with that of 39.4% by *Bt.*CIM-602.

The strain MV-20/20 produced the longest staple of 29.2 mm, followed by the 29.1 mm of strain MV-24/20 compared with the 29.0 mm of *Bt.*CIM-602. All the strains have desirable micronaire values ranging from 4.0 to 4.6. The fibre strength of all the new strains was observed within the range i.e. 26.8 to 29.3.

Table 2.13 Performance of advanced strains in Micro-Varietal Trial-4 at CCRI, Multan

Sr.#	Strains	Seed Cotton Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micro naire value	Fibre Strength (g/tex)	Av. boll weight (g)	Plant Pop. (ha^{-1})
1	MV-20/20	2152	38.9	29.2	4.6	26.8	2.3	36584
2	MV-21/20	2206	39.8	28.3	4.4	27.7	2.2	23313
3	MV-22/20	1901	35.3	28.4	4.4	27.7	2.0	32280
4	MV-23/20	2188	35.9	27.3	4.0	27.6	2.1	35867
5	MV-24/20	1793	39.5	29.1	4.1	27.8	2.5	37839
6	MV-25/20	1991	36.8	28.6	4.1	29.3	2.3	35508
7	*Bt.*CIM-602	1722	39.4	29.0	4.0	27.0	2.2	21520

Sowing date 20.05.2020, CD (5%) for seed cotton 210.65 CV. % = 8.18

2.2.5 Micro-Varietal Trial-5

Objective: Testing of medium long staple *Bt.* strains to develop commercial varieties

Seven newly bulked elite strains MV-26/20 to MV-32/20 were tested against commercial variety *Bt.*CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.14.**

The strain MV-30/20 out-yielded all the strains and standard variety by producing 2479 kg ha^{-1} seed cotton followed by MV-29/20 having seed cotton yields of 2250 kg ha^{-1} against commercial variety *Bt.*CIM-602 which produced 1459 kg ha^{-1} seed cotton. The strains MV-26/20 and MV-28/20 produced the higher lint percentage values of 38.6 and 38.1, respectively compared with that of 37.2% by *Bt.*CIM-602.

The strain MV-26/20 produced the longest staple of 28.8 mm, followed by 28.7 mm in MV-28/20 compared with the fibre length of 27.3 mm in commercial variety *Bt.*CIM-602. All strains have desirable micronaire values ranging from 4.0 to 4.9. The strain MV-31/20 maintained the maximum fibre strength of 28.3 g/tex followed by MV-26/20 and MV-28/20 with 28.0 g/tex while standard *Bt.*CIM-602 had 27.3 g/tex fibre strength.

Table 2.14 Performance of advanced strains in Micro-Varietal Trial-5 at CCRI, Multan

Sr. #	Strains	Seed Cotton Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micro-naire value	Fibre Strength (g/tex)	Av. boll weight (g)	Plant pop. (ha^{-1})
1	MV-26/20	1780	38.6	28.8	4.7	28.0	2.6	40529
2	MV-27/20	2044	37.6	28.2	4.0	27.7	2.7	31563
3	MV-28/20	1493	38.1	28.7	4.9	28.0	3.1	38198
4	MV-29/20	2250	37.9	27.6	4.3	27.3	2.5	39812
5	MV-30/20	2479	37.3	27.9	4.5	27.9	2.1	40529
6	MV-31/20	2094	37.2	28.3	4.6	28.3	3.7	39991
7	MV-32/20	2240	37.5	28.2	4.2	27.1	2.2	41067
8	Bt.CIM-602	1459	37.2	27.3	4.4	27.3	2.5	40350

Sowing date = 21.02.2020; CD (5%) for seed cotton = 373.01; CV. % = 10.76

2.2.6. Micro-Varietal Trial-6

Objective: Testing of *Bt.* strains to develop commercial varieties

Seven newly bulked elite strains MV-33/20 to MV-39/20 were tested against a commercial variety *Bt.*CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.15.**

The strain MV-39/20 out-yielded all the strains and standard variety by producing 2608 kg ha^{-1} seed cotton, followed by MV-37/20 having seed cotton yields of 2276 kg ha^{-1} against commercial variety *Bt.*CIM-602 which produced 1493 kg ha^{-1} seed cotton respectively. The strains MV-33/20 & MV-38/20 produced the higher lint percentage values of 41.5 and 40.7 respectively while standard *Bt.*CIM-602 produced 36.1 % lint.

The strain MV-34/20 produced the longest staple of 29.4 mm, followed by 29.2 mm in MV-35/20 compared with the staple length of 27.2 mm of commercial variety *Bt.*CIM-602. All strains have desirable micronaire values raging from 4.0 to 4.7. The strain MV-34/20 produced the maximum fibre strength 29.0 g/tex followed by 28.4 g/tex of MV-35/20 as compared to the 26.5 of standard variety *Bt.*CIM-602.

Table 2.15 Performance of advanced strains in Micro-Varietal Trial-6 at CCRI, Multan

Sr. #	Strains	Seed Cotton Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micro-naire value	Fibre Strength (g/tex)	Av. boll weight (g)	Plant pop. (ha^{-1})
1	MV-33/20	2063	41.5	28.5	4.3	28.1	3.1	40529
2	MV-34/20	1811	37.5	29.4	4.4	29.0	2.7	41247
3	MV-35/20	1910	37.6	29.2	4.5	28.4	2.6	41067
4	MV-36/20	2247	39.5	27.8	4.2	26.6	2.4	41067
5	MV-37/20	2276	36.7	28.8	4.7	28.2	2.7	41964
6	MV-38/20	1846	40.7	28.0	4.6	27.3	3.1	41605
7	MV-39/20	2608	38.0	28.8	4.0	28.0	2.7	41426
8	*Bt.*CIM-602	1493	36.1	27.2	3.8	26.5	2.7	42502

Sowing date:21.05.2020 CD (5%) for seed cotton: Strains = 541.97, CV% =15.23

2.3 Coordinated Variety Testing Program

2.3.1 National Coordinated Varietal Trial (Set-A)

Objective: - Evaluation of promising *Bt.* Strains of different cotton breeders of Pakistan

The cotton seed of eight strains under coded numbers was received from Director Research (PCCC) for evaluation. Data on seed cotton production and of other parameters are presented in **Table 2.16**.

The results indicated that the strain PC-2008 produced yield 679 kg ha^{-1} followed by PC-2005 with 602 kg ha^{-1} seed cotton yield. PC-2001 produced lowest yield that is 206 kg ha^{-1}. The strain PC-2003 produced the lint percentage of 37.0%, followed by PC-2001 & PC-2007 with 36.9%. The strain PC-2004 produced the value of staple length at 27.2 mm, followed by PC-2002 which has staple length of 26.7 mm. All the strains had he desirable micronaire value except PC-2003. Two strains have values of fibre strength not according to required standard

Table 2.16 Performance of Cotton Strains in National Coordinated Varietal Trial at CCRI Multan (Set-A)

Sr. #	Strains	Seed cotton yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micro-naire value	Fibre Strength (g/tex)	Boll Weight	Plant Pop. (ha^{-1})
1	PC-2001	206	36.9	26.1	4.3	26.9	2.1	35687
2	PC-2002	476	35.8	26.7	4.0	27.9	2.2	36046
3	PC-2003	269	37.0	26.1	3.5	27.0	1.9	38377
4	PC-2004	216	35.1	27.2	4.1	26.9	1.9	39274
5	PC-2005	602	33.6	25.9	4.1	26.9	1.8	38915
6	PC-2006	539	33.3	26.6	4.2	27.1	2.4	32997
7	PC-2007	432	36.9	25.9	4.0	25.9	2.2	40888
8	PC-2008	679	36.6	25.9	4.6	25.9	1.8	42861

Sowing date = 09.06.2020

2.3.2 National Coordinated Varietal Trials (Set-B)

Objective: Testing of promising *Bt.* strains of different cotton breeders of Pakistan

Twenty six strains from different cotton breeders of the country were received under coded numbers from Director Research PCCC for evaluation at CCRI Multan.

The data presented in **Table 2.17** showed that the PC-2027 produced the highest seed cotton yield of 2101 kg ha^{-1}, followed by PC-2012 having 1842 kg ha^{-1} seed cotton yield while PC-2015 produced lowest yield 93 kg ha^{-1}.

Data also revealed that the strain PC-2027 produced the highest lint percentage of 39.2, followed by PC-2031 with 38.5%. Strain PC-2012, PC-2019 and PC-2025 produced the longest staple with 27.2 mm length followed by PC-2010 with 26.7 mm.

Training Program for farmers of CABI-CAPAS Project

A group of 35 organic cotton farmers of Barkhan and Lasbella, Balochistan along with Mr. Babar Latif Baloch, Project Manager visited CCRI Multan for learning and experience sharing regarding organic cotton. Dr. Zahid Mahmood, Director CCRI Multan briefed the participants about cotton programs and support measures carried for the Balochistan province.

Training of Cotton Classers, PCSI

A group of 14 Classers from Pakistan Cotton Standards Institute (PCSI) Multan led by Mian Muhammad Nasir Ali, Officer Incharge, PCSI Regional Office Multan visited CCRI Multan. The trainees were briefed about various activities carried out by the Institute. Later the participants visited cotton fields, stores and labs at the Institute.

All strains have desirable micronaire values except PC-2023 and PC-2024. Maximum fibre strength was maintained by PC-2025 having 28.0 g/tex, followed by PC-2019 with 27.9 g/tex.

Table 2.17 Performance of different Bt. Strains of public Sector in National Coordinated Varietal Trial (Set-B) at CCRI, Multan

Sr. #	Strains	Seed-cotton Yield (kg ha-1)	Lint (%age)	Staple length (mm)	Micronaire value	Fibre strength (g/tex)	Boll Weight	Plant Pop. (ha-1)
1	PC-2009	872	37.9	26.1	4.5	26.8	2.4	40529
2	PC-2010	1336	36.8	26.7	4.2	27.0	2.8	42143
3	PC-2011	1236	38.0	26.1	4.5	26.9	2.4	40709
4	PC-2012	1842	36.1	27.2	4.0	27.8	3.6	41605
5	PC-2013	825	34.3	25.9	4.2	26.8	2.6	40529
6	PC-2014	457	33.5	26.6	4.5	27.8	2.4	33894
7	PC-2015	93	35.9	25.9	4.0	26.9	2.1	12195
8	PC-2016	648	35.6	25.9	4.6	26.8	2.5	43757
9	PC-2017	1255	36.4	25.5	4.4	26.6	2.2	39633
10	PC-2018	974	36.3	25.8	4.5	26.8	2.6	41605
11	PC-2019	1387	36.5	27.2	4.4	27.9	3.0	35687
12	PC-2020	1596	35.8	25.7	4.6	26.8	2.6	42143
13	PC-2021	497	37.4	25.9	4.4	26.9	2.0	41605
14	PC-2022	1319	38.4	26.5	4.1	27.2	2.7	37301
15	PC-2023	967	34.7	26.1	3.6	27.1	1.6	40888
16	PC-2024	497	33.1	24.4	5.4	25.3	1.7	41964
17	PC-2025	1191	35.8	27.2	4.1	28.0	3.1	40888
18	PC-2026	514	35.9	25.2	3.9	24.1	1.9	41605
19	PC-2027	2101	39.2	25.5	4.6	26.7	2.7	39991
20	PC-2028	874	35.9	26.0	4.4	27.1	2.6	40350
21	PC-2029	905	37.1	25.8	4.6	26.7	2.4	42143
22	PC-2030	985	35.4	26.3	4.7	26.9	2.8	42502
23	PC-2031	1128	38.5	25.7	4.8	26.3	2.4	32639
24	PC-2032	731	37.1	26.6	4.2	27.0	3.1	41964
25	PC-2033	469	34.8	26.0	4.3	27.0	2.2	36584
26	PC-2034	789	36.4	25.8	4.6	26.7	2.5	40888

Sowing date: 09-06-2020

2.4 Testing of Commercial Varieties

2.4.1. Standard Varietal Trial-1

Objective: To test the performance of commercial varieties of Pakistan under the agro-climatic conditions of Multan

Seven commercial non *Bt*. varieties of the country were tested at CCRI, Multan. Data recorded on seed cotton yield and other parameters are presented in **Table 2.20**. The results indicated that variety CIM-610 excelled among all varieties by producing seed cotton yield of 1837 kg ha^{-1} followed by the variety CIM-496 with 1626 kg. ha^{-1} and CIM-620 with 1578 kg ha^{-1} seed cotton production. Variety CIM-573 had the highest lint percentage of 38.8, followed by varieties Cyto-124 having lint percentage of 38.5. The variety CIM-610 maintained the staple length of 27.6 mm, followed by the variety the CIM-573 with 27.2 mm staple length.

Micronaire values of all the varieties were according to the standard. Fibre strength of all the genotypes was in the desirable range.

Table 2.20 Performance of commercial varieties in Standard Varietal Trial-I at CCRI, Multan

Sr. #	Varieties	Year of released	Seed Cotton Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micro-naire value	Fibre Strength (g/tex)	Av. Boll wt. (g)	Plant Pop. (ha^{-1})
1	CIM-482	2000	1471	36.9	27.1	4.1	26.9	2.7	36943
2	CIM-496	2005	1626	36.9	26.2	4.3	26.9	2.6	36943
3	CIM-573	2012	1426	38.8	27.2	4.0	27.0	2.6	34073
4	CIM-608	2013	1577	37.0	27.1	3.9	27.1	2.7	34073
5	Cyto-124	2015	1438	38.5	26.7	4.0	26.9	2.6	33356
6	CIM-620	2016	1578	37.2	26.9	4.1	27.9	2.5	36584
7	CIM-610	2018	1837	37.4	27.6	4.2	27.0	2.4	36763

Sowing date = 12.06.2020, CD (5%) for seed cotton: 300.31, CV% = 10.50

2.4.2. Standard Varietal Trial-2

Objective: To test the performance of commercial *Bt.* varieties of Pakistan under the agro-climatic conditions of Multan

Twelve *Bt*. commercial varieties of the country were tested at CCRI, Multan. Data recorded on seed cotton yield and other parameters are presented in **Table 2.21**. The results indicated that variety NIAB-1048 excelled among all varieties by producing seed cotton yield of 1418 kg ha^{-1}, followed by the variety RH-668 with 1380 kgha^{-1} while *Bt*.CIM-632 produced lowest (1025 kg ha^{-1}) seed cotton production. *Bt*.CIM-632 had the highest lint percentage of 38.9, followed by NIAB-545 i.e. 37.9%. Staple lengths of all the varieties were below the standard except Bt.CIM-602. Micronaire and fiber strength of all the varieties were up to the standard.

Table 2.21 Performance of commercial varieties in Standard Varietal Trial-2 at CCRI, Multan

Sr. #	Varieties	Year of release	Seed Cotton Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micro-naire value	Fibre Strength (g/tex)	Av. Boll wt. (g)	Plant Pop. (ha^{-1})
1	Bt.CIM-600	2016	1235	37.4	27.1	4.1	26.8	2.5	39274
2	Bt.CIM-602	2013	1269	37.8	28.3	4.2	27.0	2.3	37391
3	Bt.CIM-632	2018	1025	38.9	27.2	4.9	27.9	2.5	39005
4	FH-142	2013	1276	36.9	27.9	4.0	27.2	2.3	37391
5	RH-668	2018	1380	36.8	26.9	4.2	26.8	2.4	39543
6	NIAB-1048	2018	1418	37.4	27.6	4.5	27.3	2.9	40081
7	Crystal-12	2018	1275	35.9	27.9	4.0	26.1	2.8	37122
8	Sitara-15	2018	1155	37.2	27.9	4.6	26.8	2.3	36315
9	RH-662	2018	1070	37.8	26.5	4.4	27.6	2.5	37122
10	FH-152	2018	1136	37.3	26.8	4.5	26.8	2.6	39274
11	NIAB-545	2018	1345	37.9	27.2	4.4	26.9	2.7	38198
12	Sahara-150	2018	1378	37.2	27.7	4.6	26.3	2.9	38198

Sowing date = 19.05.2020, C.D. (5%) for seed cotton= 67.73 CV% = 3.41

2.5 Breeding Material

2.5.1 Selection from Breeding Material

Single plant selections were made from the breeding material in different segregating populations for further testing and screening against biotic and a biotic stresses. The detail of breeding material planted and number of plants selected during 2020-21 are given in **Table 2.22**.

Table 2.22 Detail of single plants selected from breeding material

Generation/Trial	No. of plants Selected	Range	
		Lint (%age)	Staple length (mm)
VT	185	37.5-43.2	28.0-30.5
MVT	290	39.0-43.6	28.1-30.8
PRT	225	37.9-42.7	29.1-31.0
F_{6-7} single lines	975	38.2-44.6	28.2-30.2
F_5 single lines	1110	38.0-42.2	28.2-30.2
F_4 generation	1235	38.7-42.5	28.7-30.5
F_3 generation	1850	37.2-42.5	27.1-30.5
F_2 generation	2330	36.9-42.9	27.6-31.5
Others	1237	37.3-45.6	27.1-32.7

2.6 Maintenance of Genetic Stock of World Cotton Collection

2.6.1 Maintenance/Preservation of Cotton Genetic Stock at CCRI Multan

Six thousand one hundred and fourty three genotypes are being maintained at the Cold Room of CCRI Multan for long (100 years), medium (50 years) and short term (25 years). One third of the seed was planted in the field for production of fresh seed as well as to utilize in the hybridization program. Detail of genetic stock is given in **Table 2.23.** The seed of genetic stock were also supplied, locally and abroad, to different scientists, cotton growers, academia and different institutes/research stations for their research/breeding programs. The detail is given in **Table 2.24.**

Table 2.23 Detail of Genetic Stock of World Cotton Collection

Local genotypes		1210
Exotic genotypes		4933
	Total	**6143**
Species-Wise Detail		
Gossypium herbaceum L.		556
Gossypium arboreum L.		1025
Gossypium hirsutum L.		4453
Gossypium barbadense L.		109

2.7. Early Generation Seed production of commercial varieties

Single lines of *Bt and non Bt* approved varieties were sown in the field. All the agronomic practices were ensured throughout the cropping season. Single plants were selected from pure and uniform families. These single plants were ginned for further fibre traits testing and multiplication of pure seed. The selected plants will be sown as pure family. The detail is given in **Table 2.25**.

Table 24 List of scientists/researchers whom received the cotton germplasm 2020-21

Name of Scientist / Research Institute	No. of stock
Dr. Asim Gulzar, Assistant Professor, Department of Entomology PMAS-Arid Agriculture University, Rawalpindi.	03
Hassan Serwar, Jewller, Pipli Road, Gerha Mor, Tehsil Mailsi, District, Vehari.	20
Dr. Mazhar Din Keerio, Principal Scientist/Director, Cotton Research Institute Tando Jam.	16
Mr. Abdul Razaque Soomro, Senior Breeder, ICI Pakistan Limited, 4th Floor, Siddique Center (Shapes), Abdali Road, Multan.	31
Dr. Muhammad Saeed, Associate Professor, Department of Botany, Government College University, Faisalabad.	01
Dr. Irfan Afzal, (Associate Professor/ Focal Person), Seed Science and Technology, University of Agriculture, Faisalabad.	13
Dr. Sheraz Ahmad Khan, Assistant Professor, Department of Agriculture, University of Swabi, Swabi.	10
Dr. Ghulam Sarwar, Cotton Botanist, Cotton Research Station, Ayub Agriculture Research Institute, Jhang Road, Faisalabad.	58
Dr. Ghulam Sarwar, Principal Scientist (Cotton), Cotton Research Station, Ayub Agriculture Research Institute, Jhang Road, Faisalabad.	16
Dr. Muhammad Kamran Qureshi, Assistant Professor, Department of Plant Breeding & Genetics, Faculty of Agricultural Science & Technology Bahauddin Zakariya University, Multan.	07
Plant Virologist (Potato), Plant Virologist Section, Plant Pathology Research Institute, Faisalabad.	01
Dr. Abdul Qayyum, Chairman, Department of Plant Breeding & Genetics, Faculty of Agricultural Science & Technology Bahauddin Zakariya University, Multan.	20
Dr. Abdul Qayyum, Professor Chairman, Department of Plant Breeding & Genetics Section, Bahauddin Zakariya University, Multan.	80
Farzana Ashraf, Head, Cytogenetics Section, Central Cotton Research Institute, Multan.	01
Dr. Sajid Aleem Khan, Assistant Professor, Department of Plant Pathology, University of Agriculture, Faisalabad.	20
Rao Sohail Ahmad (Ph.D), Assistant Professor, Centre of Agricultural Biochemistry & Biotechnology (CABB), University of Agriculture, Faisalabad.	50
Muhammad Waseem Akhtar, Moza Abbas Nagar, Tehsil and District, Bahawalpur.	02
Dr. Muhammad Tehseen Azhar, Lecturer, Plant Breeding and Genetics, University of Agriculture, Faisalabad.	05
Dr. Akash Fatima, Assistant Professor, Institute of Plant Breeding and Biotechnology, Muhammad Nawaz Shareef University of Agriculture, Multan.	04
Ch. Muhammad Hanif, Deputy General Manager Seeds, Four Brothers, P.O. Makhdoom Rasheed, 33KM, Vehari Road, Adda, 9-Kasi, Near Insaaf Oil Mils, Multan.	14
Total Accessions	**372**

Table 2.25 Detail of pre-basic seed produced during 2020-21

Sr. #	Variety	Family No.	Total Families
1	Bt.CIM-632	15	40
2	Bt.CIM-600	18	40
3	Bt.CIM-602	14	40
4	CIM-496	19	40
5	CIM-554	17	40
6	CIM-620	15	40
7	CIM-610	14	40

2.8 Study of gene flow/crossing %age in cotton crop

2.8.1 Three cotton varieties i.e. CIM-496, Bt.CIM-632 and Russian red leaf with distinguishable morphological traits (Leaf color normal green and red) were sown. Normal plant protection and agronomic practices were adopted to get normally formed bolls. Bolls were picked, ginned and the seed will be sown for next year to study the gene flow/out crossing %age.

2.9 Pak-US ICARDA Cotton Project CCRI Multan Component

2.9.1 Use of USA cotton germplasm for the evolution of CLCV resistant/tolerant varieties.

A total of 47 single plants selected from previous year plants in the field (25 accessions received year from USDA) were also screened in field condition to CLCuV. All the plants were found susceptible for CLCuV. Similarly 123 promising single plants were selected from different generations (F_2 to F_6). Screening of more than 1200 genotypes in field condition and their seed were also preserved in cold Room Chamber. Beside this, 6143 cotton germplasm were preserved at Cold Room for short, medium and long term. A total of 46 accessions out of 3277 which were imported during the Pak-US- ICARDA cotton project were found to be resistant against CLCuV. These 46 accessions were ratooned at CCRI Multan from the last 5-7 years. Out of these 46 accessions square formation and flower induction were started in only few accessions in the month of December 2020 as detailed in Table 2.26. In Set-D accessions USG-1087/13 one boll was formed. While in Set-K only one accession USG-618/14 having flowers and bolls formations were observed. In Set-N only one accession i.e. USG-2269/14 buds formation and flower induction were observed. The seed formed in all the bolls were found inviable due to the harsh climatic condition of this year.

Table 2.26 Ratoon crop of resistant accessions of 2013-14 having bud and flower formation

Sr. No.	Set No.	Year	No of total Accessions	Resistant accessions	Accessions having buds and flower formation
1	C	2013	200	3	0
2	D	2013	200	10	01
3	K	2014	200	3	01
4	N	2014	600	30	01
		Total	**1200**	**46**	**03**

Besides the above activities Plant Breeding and Genetics made successes by developing to high yielding strains i.e. *Bt*.CIM-775 (second year) and *Bt*.CIM-875 (first year) were tested in NCVT of Pakistan Central Cotton Committee trail. While four other advance lines developed using these accessions of US Germplasm are in their advance varietal trial. Moreover, the US cotton germplasm, resistant/tolerant to CLCuV are also included in regular cotton breeding program of Plant Breeding & Genetics Section of CCRI Multan.

Farmers Advisory Committee (FAC) Meetings

The Institute regularly held Farmers Advisory Committee (FAC) during the crop season 2020 and total of 12 meetings were held. The meetings focusses for devising cotton crop management strategy for the respective fortnight and issued advisory to the farmers for management of cotton crop. Ch. Muhammad Arshad, MPA/grower member from Khanpur also attended the meeting and deliberated various issues pertaining to cotton production

3. CYTOGENETICS

Cytogenetics section is working on interspecific hybridization to combat diverse upcoming biotic and abiotic intimidation. Interspecific germplasm introgression enables unique opportunities for genetic analysis and improvement of domesticated plants but is commonly impeded by barriers to transmission and recombination, insufficient genetic resolution, and the difficulty of deriving economically suitable products. However, intensive selection that accompanies contemporary breeding strategies has also introduced a very high degree of genetic uniformity in the field, making crops vulnerable to emerging challenges. Cytogenetic Section is working on creation of novel genetic variation into the gene pool of cultivated cotton that can buffer the crop against agro-environmental challenges brought about by shifts in climate. The main objective of cytogenetic section is transferring desirable genes of the wild species to the cultivated cotton for commercial exploitation and to study inter and intra-genomic relationships in the genus *Gossypium*. The genus *Gossypium* to which cotton belongs has 54 well-established species, only 4 of which are cultivated. Interspecific hybridization to broaden the genetic base of the existing cultivars and development of new cultivars with all desirable traits is an important endeavor in utilizing the abundant genetic variation from the wild cotton relatives.

3.1 Maintenance of *Gossypium* Germplasm

Thirty species of *Gossypium* (cultivated and wild) are being maintained in living herbarium at CCRI, Multan for exploitation in hybridization program. List is given below.

Table. 3.1. List of wild species maintained at CCRI, Multan during 2020-21

Sr. No.	Species Name	Genome	Habit
1.	*G. hirsutum*	2AD1	Cultivated
2.	*G. barbadense*	2AD2	Cultivated
3.	*G. tomentosum*	2AD3	Wild
4.	*G. darwinii*	2AD5	Wild
5.	*G. herbaceum*	A1	Cultivated
6.	*G. arboreum*	A2	Cultivated
7.	*G. anomalum*	B1	Wild
8.	*G. capitis-viridis*	B4	Wild
9.	*G. sturtianum*	C1	Wild
10.	*G. nandewarense*	C1-n	Wild
11.	*G. australe*	C3	Wild
12.	*G. thurberi*	D1	Wild
13.	*G. harknessii*	D2-2	Wild
14.	*G. davidsonii*	D3-d	Wild
15.	*G. klotzschianum*	D3-k	Wild
16.	*G. aridum*	D4	Wild
17.	*G. raimondii*	D5	Wild
18.	*G. gossypioides*	D6	Wild
19.	*G. lobatum*	D7	Wild
20.	*G. trilobum*	D9	Wild
21.	*G. laxum*	D8	Wild
22.	*G. stocksii*	E1	Wild
23.	*G. somalense*	E2	Wild
24.	*G. areysianum*	E3	Wild
25.	*G. incanum*	E4	Wild
26.	*G. longicalyx*	F1	Wild
27.	*G. bickii*	G1	Wild
28.	*G. australe*	G2	Wild
29.	*G. nelsonii*	G3	Wild
30.	*G. lenceolatum*	2AD?	Wild

In addition; Thirty-one interspecific hybrids (five diploid, seven triploid, five tetraploid, two pentaploids and four hexaploid interspecific hybrids) and 8 tri species combinations are also maintained (Table 3.2).

Table.3.2. List of Interspecific hybrids maintained at CCRI, Multan.

Sr. No	Interspecific Hybrids	No
1	Diploid hybrids	5
2	Triploid	7
3	Tetraploid	5
4	Pentaploid	2
5	Hexaploid	4
6	Tri-species combinations	8
	Total	**31**

A. Through Seed

For the strengthening of *Gossypium* species in living herbarium at CCRI, Multan seeds of twenty-three wild species were germinated in an incubator at 28 $\pm$ 2ºC and then shifted in earthen pots in glass house. List of species is given in (Table-3.3).

Table 3.3. List of wild species planted in glass house through seed

Sr. No.	Name of Species	No. of seeds planted	No. of seeds germinated
1.	*G. arboreum*	15	4
2.	*G. anomalum*	5	2
3.	*G. capitis-viridis*	7	2
4.	*G. thurberi*	38	8
5.	*G. harknessii*	12	2
6.	*G. davidsonii*	7	3
7.	*G. klotzschianum*	7	2
8.	*G. aridum*	12	5
9.	*G. raimondii*	29	7
10.	*G. gossypioides*	15	4
11.	*G. laxum*	9	2
12.	*G. stocksii*	33	7
13.	*G. somalense*	23	7
14.	*G. areysianum*	24	7
15.	*G. incanum*	7	2
16.	*G. longicalyx*	6	2
17.	*G. bickii*	24	5
18.	*G. herbaceum* (Red)	15	3
19.	*G. herbaceum* (Green)	15	5
20.	*G. darwinii*	13	6
21.	*G. nelsonii*	26	5
22.	*G. raimondii*	10	3
23.	*G. barbadense*	10	4
	Total	**362**	**97**

B. Through Approach Grafting

Approach grafting has been utilized to maintain the already existing wild species. The detail is given below (Table 3.4).

Table 3.4. List of wild Species maintained through approach grafting

Sr. No.	Name of species	No. of grafts
1	*G. herbaceum (red)*	8
2	*G.capitis veridis*	5
3	*G. lobatum*	6
4	*G. laxum*	6
5	*G. gossipoides*	7
6	*G. longicalyx*	4
7	*G. bickii*	5
8	*G. incanum*	5
9	*G. somalense*	6
10	*G. tomentosum*	4
11	*G. stocksii*	5
12	*G. anomalum*	6
13	*G. tomentosum*	4
14	*G. areysianum*	5
15	*G. nelsonii*	5
1	2*(G. arbo. X G. somalense)* 2n	8
2	*(G. hirs. X G. arbo.)* 3n	7
3	2*(G. hirs. X G. ano.) X G. barba.*4n	8
4	*G. barba* X 2*(G. arbo. X G. stockii)* 5n	8
5	*G. barba* X 2*(G. arbo. X G. stockii)* 6n	7
	Total	**119**

C. Through Cutting

Cuttings of wild species and interspecific hybrids were planted in the field and earthen pots in glass house to maintain the precious material. The detail is given in below.

Fig.3.1. Maintenance of wild species during 2020

Table 3.5. List of species /hybrids maintained through cuttings

Sr. No.	Name of species	No. of Cuttings
1	*G. laxum*	25
2	G. stocksii	18
3	G. laxum	30
4	G. lanceolatum	18
5	G. areysianum	18
6	G. lobatum	16
7	*G. tomentosum*	19
8	*G. anomalum*	17
9	*G. harknessii*	15
10	*G. klotzschianum*	14
11	*2(G.hirsutum* x *G.anomalum)*	25
12	*2(G.hirsutum* x *G.anomalum)* x *G.barbadense* (5n)	18
13	*2(G.arbo.* x *G.anomalum)* x *G.hirsutum* (5n)	30
14	*2(G.hir.* x *G.stocksii)* (6n)	18
15	*2(G.arbo.* x *G.anomalum)* x *G.hirsutum* (4n)	18
16	*2(G.arbo.* x *G.somalense)* (4n)	18
17	*2(G.hir.* x *G.anomalum)* (3n)	14
18	*2(G.hir.* x *G.anom.)* x *G.hir.* (5n)	18
19	*2(G.arbo.* x *G.anomalum)* (2n)	30
20	*(G. arboreum* x *G.australe)* (2n)	24
21	2(*G.hir.x G. stocksii*) x *G. hirsutum* (5n)	19
22	2(*G.hir.x G. anomalum*) (3n)	14
23	*(G.arborerum* x *G.capitis veridis)* x *G. arbo.*	24
24	*(G. arboreum* x *G.herbaceum)* (2n)	24
25	*2(G.arbo.* x *G.anomalum)* x *G. hirsutum* (4n)	15
26	2(*G. hirsutum* x *G. bickii*) x *G. barba.* (6n)	17
27	2(*G.arboreum .x G. stocksii*) (4n)	18
28	*(G.arboreum* x *G.thurberii*) (2n)	18
29	*G.hirsutum* x *G.herkensii* (3n)	36
30	*2(G.hirsutum* x *G.stockii)* (4n)	36
31	*G.hirsutum* x *G.gossypiodes* (3n)	18
32	*G.hirsutum*	18
33	*G.barbadense*	17
	Total	**677**

3.2 Development of Auto-Tetrapolid

Seeds of *G. arboreum* were treated with 0.01% colchicine to obtain autotetraploid. Seed treatment was done for 24, 48 and 72 hours. Plants treated with 0.01% concentration for 72 hours are under observation. These were checked cytologically. All the plants were diploid except one. This plant has stunted growth. Cytologically will be checked on availability of buds.

Table. 3.6 (A): Detail of treated plants

No of treatments	Colchicine concentration (%)	No of Seeds treated	No of plants germinated	Results
1	0.01 (24 hrs)	25	16	All plants were normal
2	0.01(48 hrs)	25	13	All plants were normal
3	0.01(72 hrs)	25	8	One plant has stunted growth, thick stem and thick leaves
4	control	25	3	-

Table. 3.6 (B): Chromosomal configurations of *G.arboreum*

PMC No.	I's	II's	III's	IV's	Total	Remarks
1	-	13	-	-	26	All Plant were fertile but no effect of colchicine treatment except one which is under observation
2	-	13	-	-	26	

Fig-3.2. Twenty six chromosome in *G arboreum* (Seed treatment)

3.3. Hybridization

Interspecific hybridizations for incorporation of valuable wild species genes for stress resistance into the cultivated cottons were undertaken according to availability of flowers during the season. For intraspecific hybridization, large number of pollinations (5313) were attempted in 80 combinations. Similarly, 219 pollinations in 5 combinations were attempted in interspecific crosses. The boll setting was present in 80 combinations. Boll setting could not be obtained in other combinations either due to incompatibility among different species or sterility barriers existing at pre- and post- fertilization stages in hybridization. The hormones i.e Gibberallic Acid (GA) and Nephthaline acetic acid (NAA) were exogenously applied at the rate of 50 and 100mg $L^{-1}$of water respectively, after 24 hours of pollination. The application continued till 72 hours to retain the crossed bolls.

Table-3.7. Detail of Hybridization

Hybridization	No of cross combination	No of crosses attempted
Interaspecific hybridization	80	5313
Interspecific hybridization	5	219

3.4. Selection from Breeding Material

Single plant selections were made from the Cyto breeding material in different interspecific and intraspecific segregating generations for further testing and screening against biotic and abiotic stress. The detail of breeding material planted and number of plants selected during 2020 is given in **Table 3.8**.

Table 3.8 Detail of single plants selected from breeding material

Generation/Trial	No. of plants Selected	Range	
		Lint (%age)	Staple length (mm)
VT	205	37.8-41.1	28.2-31.0
MVT	135	39.8-41.3	28.3-31.1
F_6 single lines	320	39.2-44.6	28.7-33.2
F_5 single lines	730	38.2-42.2	27.9-31.2
F_4 generation	903	38.0-43.5	27.2-30.2
F_3 generation	1150	37.8-42.3	28.1-30.2
F_2 generation	1420	33.5-44.2	23.3-31.2

3.5 Performance of New Cyto-strains in Micro Varietal Trials

3.5.1. Micro Varietal Trial-1

Objective: Testing of Long staple material for economic and fibre quality traits

Six Bt. strains having tolerance against cotton leaf curl virus (CLCuD) viz., MV1, MV2, MV3, MV4, MV5 and MV6 were tested in replicated micro-varietal trial on a plot size of 15' x 12.5' along with Cyto-179 as standard. The performance of this material is shown in Table 3.9.

Table 3.9 Performance of Cyto-strains in Micro Varietal Trial -1 during 2020-21

Strain	Yield (kg ha^{-1})	Plant Pop.(ha^{-1})	Boll weight (g)	Lint (%)	Length (mm)	Micronaire (µg inch^{-1})	Strength (g tex^{-1})
MV-1	2390	39989	2.8	37.1	29.6	4.1	29.1
MV-2	2455	28126	2.3	38.2	28.6	4.1	30.6
MV-3	1580	41902	3.4	39.1	30.2	4.4	30.8
MV-4	2340	44772	2.5	37.0	30.1	4.2	30.0
MV-5	2170	41519	3.0	38.1	28.9	4.3	30.7
MV-6	2375	44389	2.9	38.4	31.0	4.1	31.9
Cyto-179	1035	44772	3.1	38.2	27.2	4.7	25.3

Table 3.9 showed that maximum seed cotton yield was produced by MV-2 (2455 kg ha^{-1}) followed by MV-1 (2390kg ha^{-1}) and MV-6 (2375 kg ha^{-1}) compared with standard Cyto-179 (1035 kg ha^{-1}). The line MV-3 found to have highest lint%(39.1%) followed by MV-6 (38.4%) compared with standard Cyto-179 (38.2%).

The line MV-6 produced the medium long staple of 31.0 mm followed by MV-3 & MV-4 (30.2 & 30.1 mm, respectively) compared with 27.2 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.1 to 4.4 µg inch^{-1}. The maximum fibre strength (31.9 g tex^{-1})) produced in MV-6 (32.9 g tex^{-1}) followed by MV-3 (30.8.0 g tex^{-1}) compared with 25.3 g tex^{-1} of standard Cyto-179.

3.5.2. Micro Varietal Trial-2

Objective: Testing of newly bulked white fly resistant strains against commercial varieties

Six *Bt*. strains viz., MV7, MV8, MV9, MV10, MV11& MV12 were tested in replicated micro-varietal trial on a plot size of 15' ×12.5' along with Cyto-179 as standard. Data presented in Table-3.10 exhibited that maximum seed cotton yield was produced by MV-10 (2720 kg ha^{-1}) followed by MV-9 (2290 kg ha^{-1}) compared with Cyto-179 (960 kg ha^{-1}). Maximum lint % was produced by MV-9 (39.3%) followed by MV-8 (38.4%) compared with standard Cyto-179 (37.6%).

The line MV-12 produced the medium long staple of 30.1 mm followed by MV-9 & MV-10 (30.0 & 29.7 mm respectively) compared with 27.1 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.1 to 4.6 µg inch^{-1}. The maximum fibre strength (31.0 g tex^{-1})) produced in MV-10 followed by MV-12 (30.9 g tex^{-1}) compared with 26.3 g tex^{-1} of standard Cyto-179.

Table 3.10 Performance of advanced strains in Micro Varietal Trial-2 during 2020-21

Strain	Yield (kg ha^{-1})	Plant Population (ha^{-1})	Boll weight (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg inch^{-1})	Strength (g tex^{-1})
MV-7	2045	44772	2.8	37.1	28.3	4.1	30.1
MV-8	1180	44198	3.2	38.4	29.2	4.3	30.6
MV-9	2290	44198	2.9	39.3	30.0	4.1	30.8
MV-10	2720	45537	2.3	38.1	29.7	4.4	31.0
MV-11	1860	44581	2.9	38.1	29.1	4.6	30.7
MV-12	1170	44198	2.6	38.3	30.1	4.1	30.9
Cyto-179	960	45155	3.1	37.6	27.1	4.9	26.3

3.5.3. Micro Varietal Trial-3

Objective: Testing of newly bulked heat resistant strains against commercial varieties

Six new Bt strains having heat tolerance viz., MV-13, MV-14, MV-15, MV-16, MV-17 and MV-18 were tested in replicated micro-varietal trial on a plot size of 15' ×12.5' along with Cyto-179 as standard. Data presented in Table-3.11 exhibited that maximum seed cotton yield was produced by MV-16 (2830 kg ha^{-1}) followed by MV-18 (2230 kg ha^{-1}) compared with Cyto-179 (1033 kg ha^{-1}). Maximum lint % produced by MV-13 (39.3%) followed by MV-14 (39.1%) compared with standard Cyto-179 (37.7%). The line MV-17 produced the medium long staple of 29.1 mm followed by MV-15 (28.9 mm) compared with 27.1 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.1 to 4.6 µg inch^{-1}. The maximum fibre strength was produced in MV-17 & MV-18 (30.9 g tex^{-1}) followed by MV-14 (30.8 g tex^{-1}) compared with 26.9 g tex^{-1} of standard Cyto-179.

Table 3.11 Performance of Cyto-strains in Micro Varietal Trial -3 during 2020-21

Strain	Yield (kg ha^{-1})	Plant Population (ha^{-1})	Boll weight (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg inch^{-1})	Strength (g tex^{-1})
MV-13	2215	44007	2.9	39.3	28.1	4.1	29.7
MV-14	2060	44963	2.9	39.1	28.4	4.3	30.8
MV-15	1680	41711	2.8	38.4	28.9	4.5	29.5
MV-16	2830	42859	3.5	38.8	28.8	4.1	29.0
MV-17	2087	42285	3.7	38.6	29.1	4.6	30.9
MV-18	2230	40754	2.8	38.2	28.3	4.4	30.9
Cyto-179	1033	36353	3.1	37.7	27.1	4.7	26.9

Performance of New Cyto-strains in Varietal Trials

3.5.4. Varietal Trial-1

Objective: Testing of new advance Bt strains against commercial varieties

Six *Bt*. strains having tolerance against cotton leaf curl virus (CLCuD) viz., V1, V2, V3, V4, V5 and V6 were tested in replicated varietal trial on plot size 30' x 12.5' along with Cyto-179 as standard. The performance of this material is given in Table 3.12.

Data presented in Table 3.13 exhibited that maximum seed cotton yield was produced by V-6 (2480 kg ha^{-1}) followed by V-5 (2355 kg ha^{-1}) compared with standard Cyto-179 (1030 kg ha^{-1}). Maximum lint % produced V-1 (39.7%) and V-4 (39.3%) compared with Cyto-179 (37.1%).

The strain V-2 produced the medium long staple of 29.2 mm followed by 29.1 mm of V-4 compared with Cyto-179 (27.0 mm). All the strains have desirable micronaire values ranging from 4.1 to 4.5 µg inch^{-1}. The maximum fibre strength (30.6 g tex^{-1}) produced by V-2 followed by V-6 (30.2 g tex^{-1}) compared with 26.3 g tex^{-1}of standards Cyto-179.

Table 3.12 Performance of Cyto-strains in VT-1during 2020-21

Strain	Yield (kg ha^{-1})	Plant population (ha^{-1})	Boll wt. (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg inch^{-2})	Strength (g tex^{-1})
V-1	2270	41137	3.1	39.7	28.1	4.1	29.1
V-2	1830	41902	3.5	39.1	29.2	4.1	30.6
V-3	1365	30039	2.8	37.9	28.3	4.4	29.8
V-4	2320	41137	2.8	39.3	29.1	4.3	30.0
V-5	2355	41711	2.8	38.1	29.0	4.5	29.7
V-6	2480	41519	3.0	38.3	29.0	4.2	30.2
Cyto-179	1030	40563	3.3	37.1	27.0	4.9	26.3

3.5.5 Varietal Trial-2

Objective: Testing of new advance *Bt* strains against commercial varieties

Seven CLCuD tolerant *Bt* strains viz., V-7 to V-13 were screened in replicated varietal trial on plot size 30' ×10' along with Cyto-179 as standard. The performance of this material is given in Table 3.13. Data showed that maximum seed cotton yield was produced by V-7 (2577 kg ha^{-1}) followed by V-8 (2085 kg ha^{-1}) and V-10 (1995 kg ha^{-1}) compared with standard Cyto-179 (1020kg ha^{-1}). Maximum lint % was produced by V-9 (40.1%) followed by V-13 (39.1%) compared with standards Cyto-179 (38.4%).

Table 3.13 Performance of Cyto-strains in VT-2 during 2020-21

Strain	Yield (kg ha^{-1})	Plant population (ha^{-1})	Boll wt. (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg $inch^{-1}$)	Strength (g tex^{-1})
V-7	2577	39897	2.9	38.8	28.9	4.3	28.3
V-8	2085	38462	2.8	38.3	28.1	4.6	28.1
V-9	1041	40758	2.2	40.1	29.7	4.0	30.9
V-10	1995	39515	3.0	38.9	29.1	4.7	28.1
V-11	1160	38462	2.2	37.9	29.7	4.4	29.3
V-12	1240	40949	2.7	37.3	29.1	4.7	28.0
V-13	1095	40758	2.9	39.1	30.3	4.4	29.9
Cyto-179	1020	40949	2.8	38.4	26.9	4.5	27.3

V-13 produced longest staple of 30.3 mm followed by V-9 (29.7 mm) compared with Cyto-179 (26.9 mm). All the strains have desirable micronaire values ranging from 4.0 to 4.7 µg $inch^{-1}$. The maximum fibre strength (30.9 g/tex) was produced by V-9 followed by V-13 (29.9 g tex^{-1}) in contrast to standard Cyto-179 (27.3 g tex^{-1}).

3.5.6. Varietal Trial-3

Objective: Testing of newly bulked medium staple strains against commercial varieties

Four new *Bt* strains having tolerance against cotton leaf curl virus (CLCuD) viz., V-14 to V-17 with medium-long staple were tested along with Cyto-179 as standard. The performance of this material is given in Table 3.14. It showed that maximum seed cotton yield was produced by V-14 (1471 kg ha^{-1}) followed by V-15 (1281 kg ha^{-1}) compared with standard Cyto-179 (890 kg ha^{-1}). Maximum boll weight (4.0 g) was produced by V-17 followed by V-14 (3.3g) compared with 3.0g of standard Cyto-179. Maximum lint % produced by V-14 (39.2%) followed by V-17 (38.8%) compared with standard Cyto-179 (37.7%).

Table 3.14 Performance of Cyto-strains in Varietal Trial-3 during 2020-21

Strain	Yield (kg ha^{-1})	Plant Population (ha^{-1})	Boll weight (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg $inch^{-1}$)	Strength (g tex^{-1})
V-14	1471	40885	3.3	39.2	28.6	4.3	29.6
V-15	1281	39809	3.1	38.6	28.2	4.5	28.9
V-16	1190	35505	2.5	37.8	28.8	4.3	29.4
V-17	1160	36581	4.0	38.8	28.4	4.6	28.6
Cyto-179	890	37119	3.0	37.7	27.0	4.9	26.7

The strains V-16 and V-14 produced the longest staple length of 28.8 and 28.6mm, respectively compared with 27.0 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.3 to 4.6 µg $inch^{-1}$. The maximum fibre strength (29.6 g tex^{-1}) was produced by V-14 followed by V-16 (29.4 g tex^{-1}) compared with 26.7 g tex^{-1} of Cyto-179.

High Level Visits

Mr. Saqib Ali Ateel, Secretary Agriculture South Punjab Multan visiting cotton fields at CCRI Multan on Nov 04, 2020.

Mr. Bilal Israel, Chairman, Cotton Research & Development Board, Punjab visiting cotton fields at CCRI Multan on Aug 27, 2020

3.5.7 Varietal Trial-4

Objective: Testing of new advance Non-*Bt* strains against commercial varieties

Four CLCuD tolerant non-*Bt* strains viz., V18, V19, V20 & V21 were tested along-with Cyto-124 and CIM-608 as standards. The performance of this material is given in Table 3.15.

Data showed that maximum seed cotton yield was produced by V-18 (1915 kg ha^{-1}) followed by V-19 (1895 kg ha^{-1}) as compared to standards Cyto-124 (990kg ha^{-1}) and CIM-608 (875 kg ha^{-1}). Maximum lint % was produced by V-20 (38.9%) followed by V-18 (38.8%) compared with standards Cyto-124 (38.2%) and CIM-608 (37.9%).

Table 3.15. Performance of Cyto-strains in VT-3 during 2019-20

Strain	Yield (kg ha^{-1})	Plant population (ha^{-1})	Boll wt. (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg $inch^{-1}$)	Strength (g tex^{-1})
V-18	1915	38446	2.4	38.8	29.6	4.1	30.1
V-19	1895	39020	2.6	37.8	29.8	4.3	30.5
V-20	1180	39307	2.5	38.9	30.1	4.1	30.8
V-21	845	37872	2.8	37.6	30.4	4.4	29.0
Cyto-124	990	38446	2.5	38.2	29.2	4.6	29.9
CIM-608	875	39307	2.4	37.9	30.5	4.7	29.6

The strain V-21 produced longest staple of 30.4 mm followed by V-20 (30.1 mm) compared with Cyto-124 (29.2 mm) and CIM-608 (30.5mm). All the strains have desirable micronaire values ranging from 4.1 to 4.6 (µg $inch^{-1}$). The maximum fibre strength (30.8 g tex^{-1}) was produced by V-20 followed by V-19 (30.5 g tex^{-1}) compared with 29.9 and 29.6 g tex^{-1} of standards Cyto-124 and CIM-608 respectively.

Coordinated Variety Testing Programme

3.5.8 National Coordinated Varietal Trial (Set-C)

Objective: - Testing of promising *Bt.* Strains of different cotton breeders of Pakistan

The cotton seed of twenty 26 strains under coded numbers was received from Director Research (PCCC) for evaluation. Data on seed cotton production and other parameters are presented in **Table 3.16**.

The results indicated that the strain PC-2047 produced maximum yield of 1433 kg ha^{-1} followed by PC-2052 with 1421 kg ha^{-1} of seed cotton yield respectively. PC-2044 produced lowest yield that is 282 kg ha^{-1}. The strain PC-2049 produced the highest lint percentage of 38.9%, followed by PC-2048 & PC-2046 with 38.6 & & 38.5% respectively. The strain PC-2052 produced the highest value of staple length 28.2 mm, followed by PC-2047 which has staple length of 28.1 mm. Most of the strains had the desirable micronaire value. Few strains have values of fibre strength according to required standard.

Table 3.16 Performance of Cotton Strains in National Coordinated Varietal Trial at CCRI Multan (Set-C)

Strains	Seed-cotton Yield (kg ha^{-1})	Lint (%age)	Staple length (mm)	Micronaire value	Fibre strength (g/tex)	Boll Weight	Plant Pop. (ha^{-1})
PC-2035	661	37.4	26.8	4.6	25.8	2.5	32639
PC-2036	817	36.8	27.3	4.6	25.3	3.1	30307
PC-2037	870	37.2	27.1	4.4	25.1	2.3	39812
PC-2038	1404	38.2	27.1	4.4	27.0	2.3	42681
PC-2039	1374	36.2	27.0	4.5	26.4	2.8	42681
PC-2040	719	36.7	26.6	4.3	25.7	2.2	33715
PC-2041	1336	37.0	26.8	4.7	25.3	3.3	37481
PC-2042	577	38.8	26.8	4.4	25.8	2.1	37660

PC-2043	651	36.8	27.1	4.4	26.5	2.0	40709
PC-2044	282	35.9	27.3	4.3	26.1	2.1	13271
PC-2045	872	35.7	27.0	4.3	26.1	2.6	36046
PC-2046	863	38.5	26.8	4.7	25.9	2.7	39453
PC-2047	1433	35.8	28.1	4.1	27.3	2.8	41605
PC-2048	1141	38.6	26.8	5.0	24.0	3.0	41785
PC-2049	1353	38.9	27.5	5.0	25.1	2.4	39991
PC-2050	505	37.1	27.3	4.1	26.7	2.5	39633
PC-2051	582	37.2	26.7	4.9	25.3	2.4	37301
PC-2052	1421	37.1	28.2	4.5	25.9	2.6	43399
PC-2053	744	37.4	27.3	4.6	27.9	2.5	36763
PC-2054	666	37.2	27.3	4.5	26.8	2.4	42681
PC-2055	496	37.0	27.1	4.5	26.6	2.4	28335
PC-2056	1169	38.3	27.4	4.6	26.9	2.6	41247
PC-2057	1028	37.0	27.4	4.7	26.4	3.1	42502
PC-2058	601	36.7	27.0	4.1	25.7	2.4	38557
PC-2059	786	36.4	27.1	4.8	25.0	2.6	38763
PC-2060	1016	37.7	26.9	4.1	25.8	2.7	40888
PC-2061	859	36.3	27.3	4.1	26.9	2.4	38915

Sowing date = 09.06.2020

3.5.9 National Coordinated Varietal Trials (Set-D)

Objective: Testing of promising *Bt.* strains of different cotton breeders of Pakistan

Twenty six strains from different cotton breeders of the country were received under coded numbers from Director Research PCCC for evaluated against commercial variety Bt.CIM-602 at CCRI Multan.

The data presented in **Table 3.17** showed that PC-2082 produced the highest seed cotton yield of 1195 kg ha^{-1}, followed by PC-2067 with 1138 kg ha^{-1} seed cotton yield while PC-2087 produced lowest yield 367 kg ha^{-1}.

Data also revealed that the strain PC-2082 produced the highest lint percentage of 39.1%, followed by 2067 with 38.7%. While strain PC-2076 produced the longest staple with 28.4 mm length followed by PC-2083 with 28.3 mm.

The ranging of micronaire value is from 3.8 to 5.1 µg inch^{-1}. Maximum fibre strength was maintained by PC-2068 having 26.3 g tex^{-1}, followed by PC-2079 with 26.1 g tex^{-1} fibre strength.

Table 3.17 Performance of different Bt. Strains of public Sector in National Coordinated Varietal Trial (Set-D) at CCRI, Multan

Strains	Seed-cotton Yield (kg ha^{-1})	Lint (%age)	Staple length (mm)	Micronaire value	Fibre strength (g/tex)	Boll Weight	Plant Pop. (ha^{-1})
PC-2062	533	37.9	26.8	4.6	25.9	2.0	40350
PC-2063	826	37.6	26.3	4.7	25.1	2.2	42681
PC-2064	691	38.1	26.7	4.6	25.0	2.5	38915
PC-2065	806	37.3	27.0	4.6	25.9	2.3	39812
PC-2066	798	36.3	27.0	4.6	25.9	2.8	37481
PC-2067	1138	38.7	29.9	5.0	24.3	2.6	40888
PC-2068	1080	37.3	28.2	4.4	26.3	2.8	40171
PC-2069	773	36.4	26.9	5.0	24.8	2.2	40350
PC-2070	448	36.6	27.3	4.3	26.3	1.7	41785
PC-2071	624	38.3	27.3	4.3	25.7	2.6	38736
PC-2072	862	37.7	26.8	5.0	23.5	2.6	41785
PC-2073	731	36.1	28.2	4.6	25.7	2.8	29411
PC-2074	755	36.9	26.8	4.6	25.3	2.6	40350
PC-2075	405	35.3	26.9	3.8	25.6	2.5	29411

PC-2076	1105	37.8	28.4	4.6	24.1	2.3	44654
PC-2077	833	37.6	27.8	4.4	25.8	2.7	39095
PC-2078	840	37.3	26.9	4.4	25.3	2.5	39812
PC-2079	590	37.3	27.1	4.1	26.1	1.8	39991
PC-2080	544	36.7	26.7	4.6	25.4	2.1	41785
PC-2081	470	38.4	25.9	4.7	24.9	2.3	33535
PC-2082	1195	39.1	28.1	4.1	26.3	2.1	42143
PC-2083	1114	37.6	28.3	4.1	26.1	3.1	44833
PC-2084	861	37.1	27.1	4.9	24.9	2.5	42502
PC-2085	1072	37.3	26.8	4.8	25.7	3.0	43757
PC-2086	547	35.4	26.6	4.6	24.9	1.9	38915
PC-2087	367	34.3	26.3	4.5	25.1	1.3	40350

Sowing date 06.09.2020

3.6. Mapping population development for Fiber Quality

Objectives: Development of mapping population for Fiber Quality

F_2 population was sown in the field. Agronomic and plant protection measures were applied. DNA extraction was performed from young leaves using CTAB according to (Zhang & Stewart, 2000). DNA quantification was checked using 1% gel electrophoresis.

Fig-3.3. DNA isolation

3.7 Early Generation Seed (EGS) System

50 single plants from approved varieties of Cyto Section (Cyto-177, Cyto-178, Cyto-179, Cyto-124, CIM-608) were sown in the field at maturity. Single plants were selected which will be used for the production of pre-basic seed.

Table-3.18. No of families selected in EGS

Variety	No of families selected
Cyto-177	05
Cyto-178	05
Cyto-179	15
Cyto-124	11
CIM-608	07

3.8 Cotton Biotechnology

The Biotechnology lab. has been established to develop local cultivars with export quality lont yield and also resistant to drought stress and bollworms. Apart from lab work, the impact of Abiotic & Biotic stresses on cotton fibre quality studied. The lab is equipped with basic instruments that are necessary to carry out genetic transformation and GMO testing of cotton genotypes. The genes of different traits synthetically synthesized for transformation in local cotton cultivars. Genes of different traits have been synthetically synthesized for transformation in local cotton cultivars:

Sr # No	Name of Gene	Function
1	Cry2A	Pink Bollworm Resistance
2	DREB2	Abiotic stresses including drought tolerance
3	MYB (Fmaily gene)	Pink Bollworm Resistance

Milestones achieved till the date are below.

- Genetic transformation of Cry1Ac Vip3A and Gt-genes for glyphosate resistance genes, into commercial cultivar, and now under evaluation for gene stability and other molecular analysis to develop resistance against bollworms and herbicides.

Cry2A, DREB2 and MYB (family Gene) genes transformation in the local cotton cultivars Codon optimisation and chemical synthesis of insecticidal gene.

Full length nucleotide sequences of above-mentioned genes were retrieved from Gene Bank, and checked for complete open reading frames (ORFs) by using online tool available on Expert Protein Analysis System (ExPASy). The codon usage was optimised according to cotton (Gossypium hirsutum) to et high transgene expression through a web-based tool freely available on integrated DNA Technology (IDT) website. Each gene was attached with CaMV 35S promoter and NOS terminator for gene expression.

Next Strategy

Working on challenging issues of cotton crop. Genetic Manipulation of cotton crop to improve abiotic stress tolerance abilities such as water scarcity is the major factor in future that effect the cotton yield. To cope with this situation, biotechnology lab currently working on genetic transformation of synthetically developed drought resistance gene in commercial cultivar. Agrobacterium mediated genetic transformation method will be used to transform above-mentioned synthetic gene construct to develop transgenic local cotton cultivars. CaMV 35S promoter and NOS terminator was used for gene expression in the synthetic cassette. The reason behind the use of constitutive promoter is that it gives maximum gene expression in Plants. Synthetically synthesized gene cassette was cloned into pCAMBIA1301 Plasmid vector. Then this construct was transformed to Agrobacterium.

Gene Description

Dehydration responsive element binding proteins (DREB) are members of a larger family of transcription factors, many of which have been reported to contribute to plant responses to abiotic stresses in several species. A sequence of 438bp transcribe the mRNA that translate 146 amino acids. The other one (Cry2A) transcribed insecticidal proteins. The gene sequence got from NCBI, the origin of this protein is from *Bacillus thuringiensis* that constitute the active ingredient in many biological insecticides and biotech crops expressing *B. thuringiensis* genes (Bt crops). For the control of lepidopteran pests, *B. thuringiensis* Cry1 and Cry2 class proteins are being used either in sprayable products or in transgenic plants. A sequence of 1905bp transcribe the mRNA that translate 1635 amino acids.

Equipment that was purchased for Molecular analysis and experimental purpose is given below.

Sr# No	Name of Equipment	Function
1	qPCR	Quantification of gene expression level
2	Temp Controlled Centrifuge	Separation of solid liquids on density basis
3	Nan-drop Spectrophotometer	Quantification of nucleic acid

4. ENTOMOLOGY

Studies were conducted on various aspects under field and laboratory conditions including 1) surveys of cotton growing areas for pink bollworm infestation, 2) studies on inclination of pink bollworm to cotton genotypes, 3) monitoring of lepidopterous pests with sex pheromone and light traps, 4) National Coordinated Varietal Trials on *Bt.* & non-*Bt.* strains, 5) sowing date impact on the development of dusky cotton bug, 6) evaluation of foliar insecticides against sucking insect pests & bollworms and 7) monitoring of insecticide resistance in cotton pests. Efforts were continued to develop mass rearing techniques of pink bollworm along with rearing and maintaining natural enemies of cotton pests for usage in the lab and field. Internship facilities` were provided to students of various Universities.

The section actively participated in online and face to face training programmes, organized by the Institute for the farmers and staff of Agriculture Extension and Pest Warning & Quality Control (PW&QC) Department and pesticide companies. Scientists also recorded IPM programs for broadcasting on electronic media.

4.1 Studies on Pink Bollworm

4.1.1 Pink bollworm infestation in green bolls in major cotton growing area

Surveys were conducted in major cotton growing districts of Punjab (Khanewal, Vehari, Lodhran, Bahawalpur, Multan, Muzaffar Garh, DG Khan and Rajan Pur) to assess pink bollworm infestation. For this purpose, immature bolls (14-28 days old) were collected from the surveyed area during September. Cotton in all the areas was found infested with pink bollworm and maximum damage percentage was recorded in Vehari followed by Khanewal. Live larval percentages were higher in Khanewal followed by Multan and Vehari **(Table-4.1)**. All the surveyed varieties/strains were found to be susceptible against pink bollworm. Maximum pink bollworm infestation and live larvae were detected in IUB-2018 and minimum in FH-992 followed by NIAB-1078 as compared to other varieties (**Fig. 4.1**).

Generally, boll infestation was higher in most of the districts as compared to last year except in Khanewal. While, live larval percentage was higher in all the districts as compared to the corresponding period of last year **(Table-4.1)**.

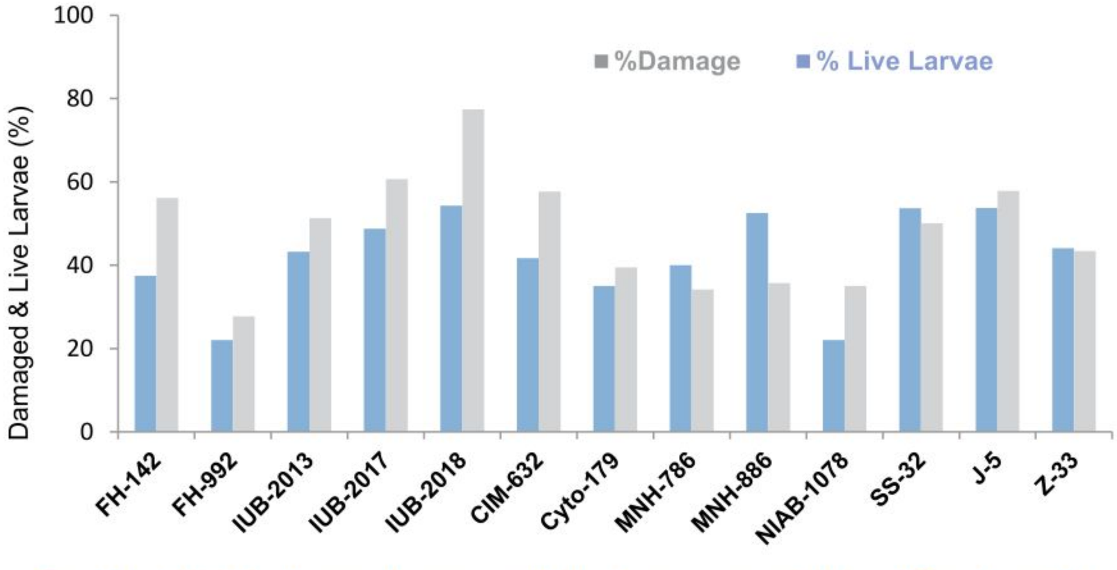

Fig. 4.1 Pink bollworm damage and live larvae recorded in different varieties collected from major cotton growing districts

Table-4.1 Pink bollworm damage and live larvae recorded from major cotton growing districts

District	2020		2019		± %age	
	% Boll damage	% Larvae	% Boll damage	% Larvae	% Boll damage	% Larvae
Vehari	66.7	71.5	61.6	42.0	8.3	70.2
Khanewal	64.6	74.7	68.8	48.8	-6.1	53.1
Bahawalpur	50.3	53.4	21.0	17.0	139.5	214.1
Lodhran	50.0	50.9	48.0	22.0	4.2	131.4
Multan	57.6	72.4	35.3	24.7	63.2	193.1
Muzaffar Garh	44.3	25.7	8.8	7.2	403.4	256.9
DG Khan	30.0	19.5	6.0	5.5	400.0	254.5
Rajan Pur	36.2	32.6	-	-	-	-

4.1.2 Studies on inclination of PBW to cotton genotypes

The trial was conducted to assess preference and non-preference of PBW towards different promising genotypes. For this, the following varieties; CIM-602, RH-668, Sitara-15, CIM-632, CIM-600, NIAB-1048, FH-152and FH-142 were planted on 8th June in RCBD with three replicates. Pink bollworm infestation increased gradually in October and reached to its maximum level during November on all tested varieties. During the month of October maximum damage (%) was observed on CIM-602 followed by CIM-600 while maximum damage (%) was observed on CIM-632 followed by Sitara-15 and FH-152 during November (**Table-4.2**). Maximum % alive larvae were observed on CIM-632 during the month of October and November (**Table-4.3**). Generally, the percent damage and alive larval population (%) was higher in November and lower in October on all tested varieties. **(Fig. 4.2)**.

Table-4.2 Pink bollworm damage in different Bt cotton varieties

Varieties	%Damage Sampling Months	
	October	November
CIM-602	11.67	23.33
RH-668	5.00	24.17
Sitara-15	3.33	31.67
CIM-632	5.00	35.83
CIM-600	8.33	29.17
NIAB-1048	6.67	26.67
FH-152	3.33	31.67
FH-142	8.33	30.00

Table-4.3 Pink bollworm alive larvae in different Bt cotton varieties

Varieties	% Alive larvae Sampling Months	
	October	November
CIM-602	1.67	7.50
RH-668	0.00	9.17
Sitara-15	0.00	7.50
CIM-632	6.67	10.00
CIM-600	1.67	7.50
NIAB-1048	1.67	8.33
FH-152	3.34	6.67
FH-142	3.33	6.67

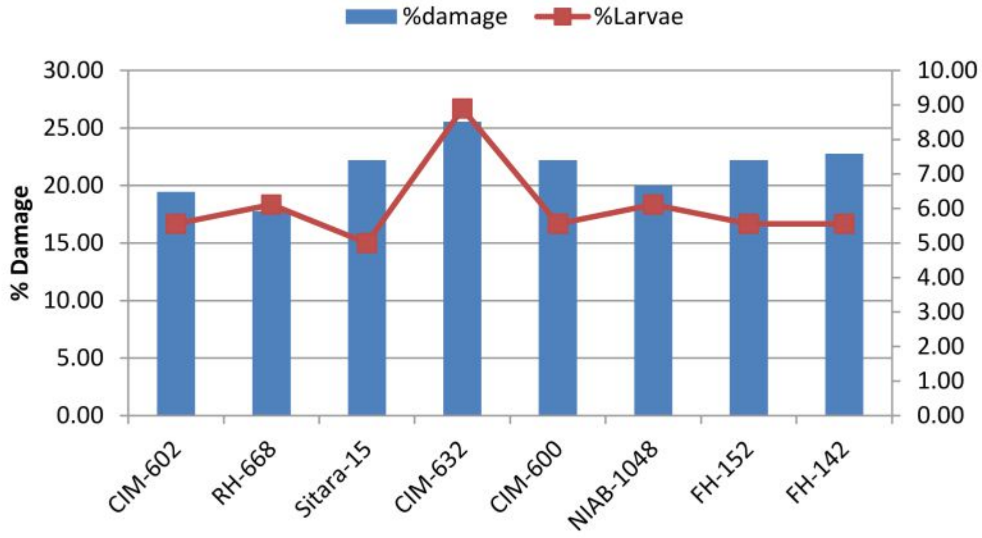

Fig. 4.2 Seasonal pink bollworm damage and alive larvae

4.1.3 Behavioral studies of Pink Bollworm

A study was undertaken to assess the behavior and population dynamics of PBW on Bt and non-Bt genotypes sown in paired plots. To evaluate behavior of PBW in the presence of non Bt refugee, the Set-1 (Bt 10 lines + non Bt 1 line), Set-II (Bt 1 line + non Bt 1 line) and Set-III (no refugee, Bt and non Bt separate blocks) were planted on 15th April. Bt (CIM-343) and non Bt (Cyto-124) varieties were sown in RCBD with three replicates.

Prevalence of PBW infestation in Set-I & Set-III was detected in October and in Set-II during September. In all sets, maximum PBW infestation was recorded on Bt in October **(Table-4.4)**. Overall, pink bollworm infestation was slightly lower on Bt in Set-1 and higher on Bt in Set-III **(Fig. 4.3).** Whereas, percentage of live larvae was also lower on Bt in Set-I as compared to other sets **(Fig. 4.4).**

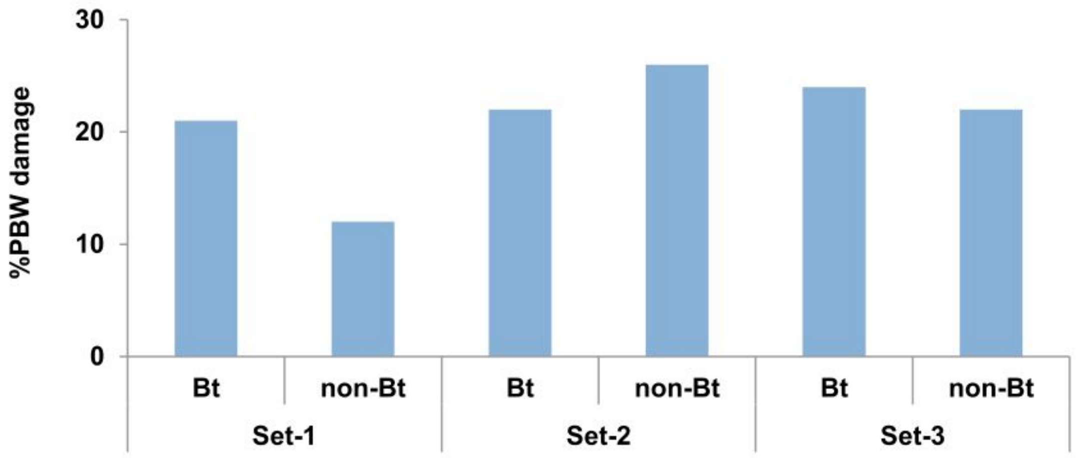

Fig. 4.3 Impact of non-Bt refugee on pink bollworm infestation percentage

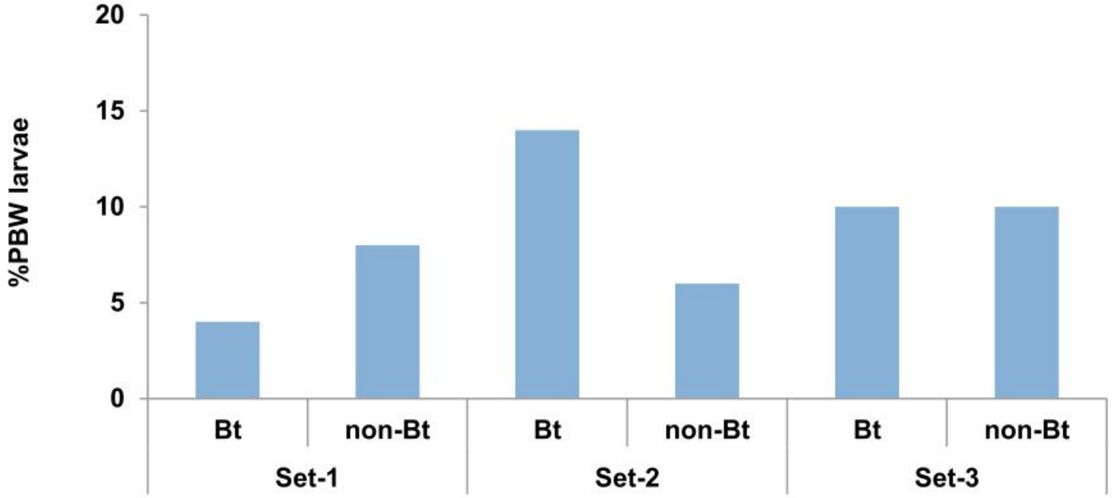

Fig. 4.4 Impact of non-Bt cotton refuge on pink bollworm live larval population (%)

Table-4.4 Impact of non-Bt refugee on PBW infestation and live larval population (%)

	Varieties	% Damage					% Larvae				
		30-Sep	15-Oct	30-Oct	15-Nov	30-Nov	30-Sep	15-Oct	30-Oct	15-Nov	30-Nov
Set-1	CIM-343	0	15	20	35	25	0	0	5	10	5
	Cyto-124	0	0	30	10	20	0	0	20	10	10
Set-2	CIM-343	10	0	20	30	50	0	0	0	20	50
	Cyto-124	10	30	20	30	40	0	10	10	0	10
Set-3	CIM-343	0	20	20	50	30	10	0	0	20	20
	Cyto-124	0	0	10	30	50	10	0	0	0	10

4.2 Monitoring of lepidopterous pests

4.2.1 Monitoring of lepidopterous pests with sex pheromone traps

Male moth activity of lepidopterous pests viz. *Pectinophora gossypiella*, *Earias insulana, Earias vittella, Helicoverpa armigera, Spodoptera litura* and *Spodoptera exigua* was monitored with sex pheromone baited traps throughout the year at CCRI, Multan and farmer's field at Khanewal. Overall, increasing population trend was detected in P. *gossypiella*, whereas declining trend was observed in *E. vittella, S. litura* and *H. armigera* at both locations as compared to last year. Comparatively, male moth catches of all the species except *Earias* spp. were higher at farmer's field than at CCRI, Multan **(Table-4.5).** Weekly male moth catch activities are given in **Fig. 4.5 (a-f).**

4.2.1.1 *Pectinophora gossypiella* (Pink bollworm)

Male moth's activity remained zero upto 4th week of March at CCRI, Multan and 3rd week of April at farmer's field. There was a fluctuating trend in moth activity and maximum catches were recorded in last week of October at CCRI, Multan and 2nd week of November at farmer's field. Moth catches at farmer's field were 235.9% higher than at Multan **(Fig. 4.5a).** Overall, male moth catches were 100.9% and 91.6% higher at Multan and farmer's field respectively as compared to last year **(Table-4.5).**

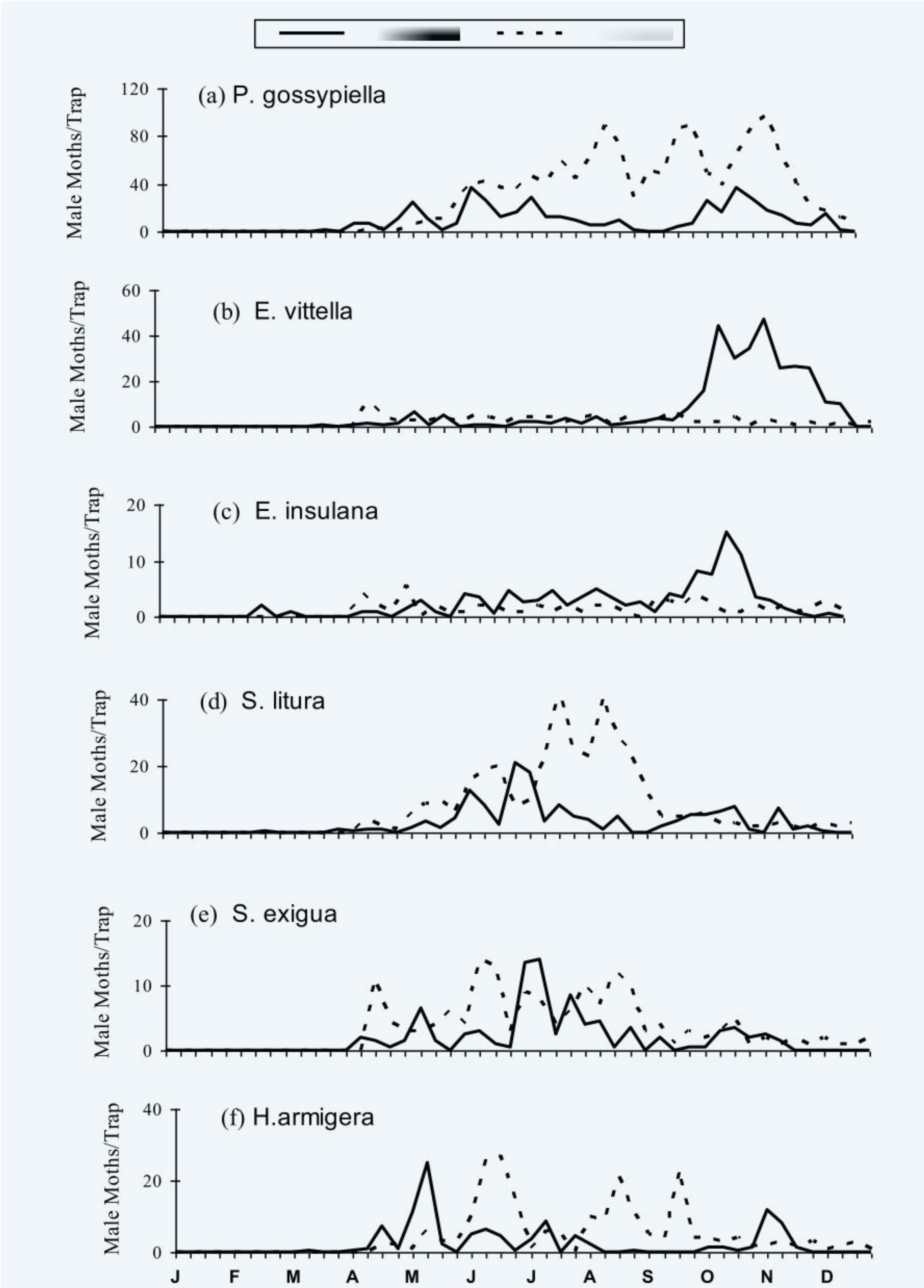

Fig.4.5 **Weekly male moth catches of Lepidopterous pests in sex pheromone traps at CCRI, Multan and farmer's field (Khanewal).**

4.2.1.2 *Earias vittella* (Spotted bollworm)

Male moth catches remained zero upto 4th week of March and 3rd week of April at CCRI, Multan and farmer's field, respectively. Moth activity reached at its peak in 2nd week of October at CCRI, Multan and 3rd week of April at farmer's field. Moth catches at farmer's field were 44.3% lower than at Multan **(Fig. 4.5b).** Overall, male moth catches were 33.4% and 75.0% lower at Multan and farmer's field, respectively as compared with last year **(Table-4.5).**

4.2.1.3 *Earias insulana* (Spiny bollworm)

Male moth catches remained zero upto 4th week of February at CCRI, Multan and 3rd week of April at farmer's field. Moth's activity was not consistent and showed fluctuating trend throughout the season. Moth catches were 67.1% lower at farmer's field than at Multan **(Fig. 4.5c).** Overall, male moth catches were 121.2% higher at Multan and 3.2% lower at farmer's field than that of last year **(Table-4.5).**

4.2.1.4 *Spodoptera litura* (Armyworm)

Male moth activity started from 1st week of April at CCRI, Multan and 4th week of April at farmer's field with fluctuating trend afterwards. Maximum catches were recorded in 1st and 4th week of July at CCRI, Multan and farmer's field, respectively. Moth catches were 100.4% higher at farmer's field than at Multan **(Fig. 4.5e)**. Overall, male moth catches were 51.3% and 89.3% lower at Multan and farmer's field compared to last year **(Table-4.5).**

4.2.1.5 *Spodoptera exigua* (Beet armyworm)

Male moth activity remained zero upto 2nd week of April at CCRI, Multan, and its peak was observed in 2nd week of July. At farmer's field moth's activity started in 3rd week of April with fluctuating trend afterwards and maximum catches were recorded in in 2nd week of June. Moth catches were comparatively 153.9% higher at farmer's field than Multan **(Fig. 4.5d)**. Overall, male moth catches were about 1.3% lower at Multan and 6.1% higher at farmer's field to that of last year **(Table-4.5).**

Table-4.5 Comparison of male moth catches of lepidopterous pests in sex pheromone traps

Insect pest	CCRI, Multan			Farmer' field		
	2019	2020	± %age	2019	2020	± %age
P. gossypiella	212.0	425.9	**100.9**	746.7	1430.5	**91.6**
E. vittella	166.0	110.5	**-33.4**	246.0	61.5	**-75.0**
E. insulana	146.5	324.0	**121.2**	110.0	106.5	**-3.2**
S. litura	230.0	112.0	**-51.3**	2090.0	224.5	**-89.3**
S. exigua	149.5	147.5	**-1.3**	353.0	374.5	**6.1**
H. armigera	130.5	87.0	**-33.3**	611.0	165.5	**-72.9**

4.2.1.6 *Helicoverpa armigera* (American bollworm)

Male moth's activity started in 2nd week of March at CCRI, Multan and in in 3rd week of April at farmer's field. Moth activity remained inconsistent and reached at peak in 1st week of November at CCRI, Multan and 4th week of June at farmer's field with fluctuated trend afterwards at both locations. Moth catches at farmer's field were 90.2% higher than at Multan **(Fig. 4.5)**. Overall, male moth catches were 33.3% and 72.9% lower to that of last year at CCRI, Multan and farmer's field, respectively **(Table-4.5).**

4.2.2 Monitoring of lepidopterous pests with light traps

Moth activity of *E. insulana*, *E. vittella*, *S. litura*, *S. exigua* and *H. armigera* was monitored throughout the year with inflorescent light traps at CCRI, Multan. Overall, declining population trend was detected in all lepidopterous pests as compared to last year **(Table-4.6).** Moth catches on weekly basis are given in **Fig. 4.6 (a-e).**

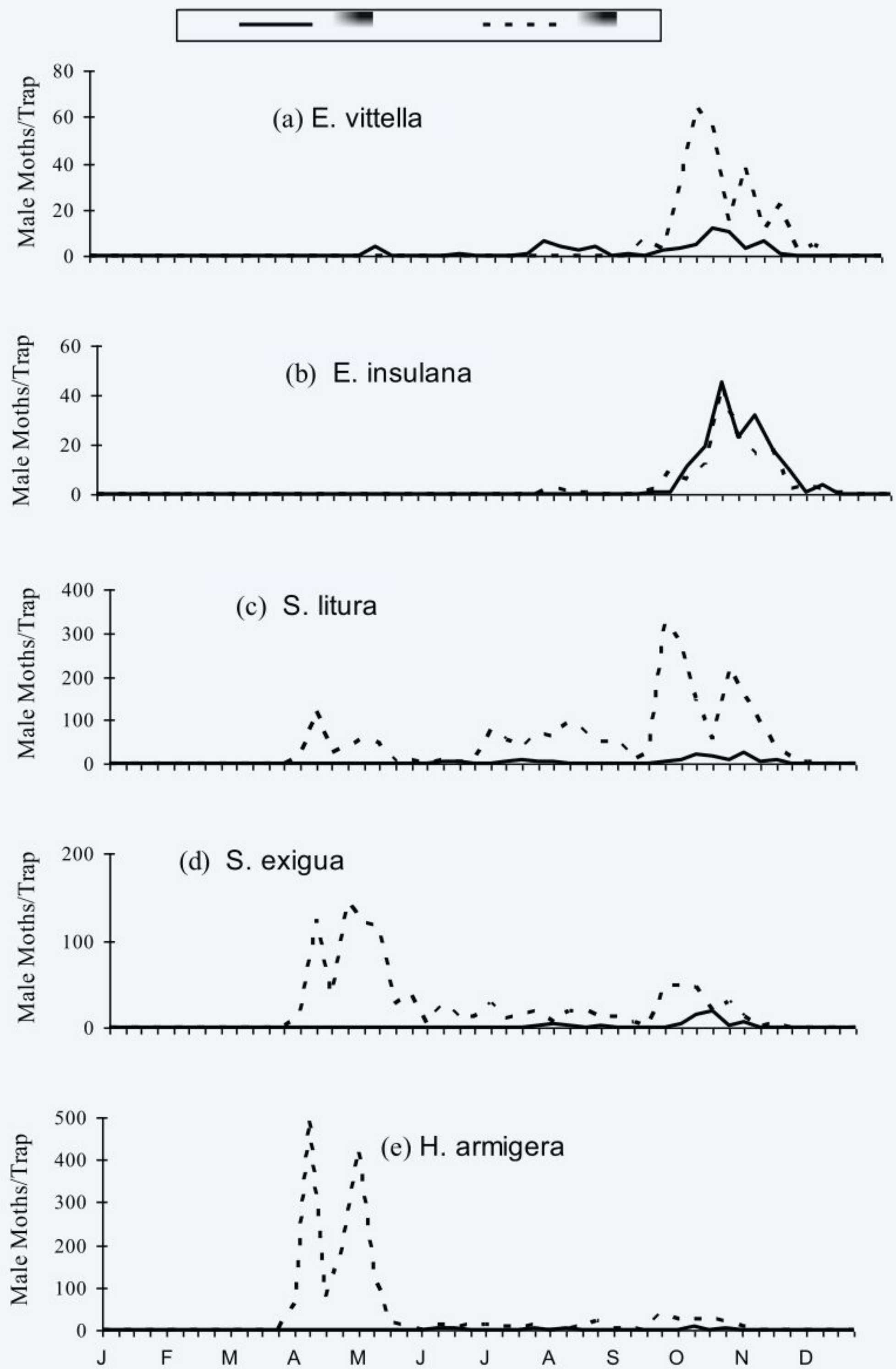

Fig. 4.6 Weekly moth catches of lepidopterous pests in light traps at CCRI, Multan

Training Program for Lok Sanjh

A training program on Cotton Production Technology was organized for the field officers of Lok Sanjh Foundation on November 13, 2020. The field officers comprises of Producer Unit Managers and Area Coordinators from Layyah, Bhakkar, TT Singh, Fort Abbas, Bahawalnagar, and Chishtian. Training was imparted on agronomical improvement, cotton varieties with their features, soil health improvement, insect pests & disease management and demonstration of mechanical boll picker.

4.2.2.1 *Earias vittella* (Spotted bollworm)

Male moth catches of *E. vittella* were zero upto 4th week of June. Afterwards population increased with fluctuating trend and reached at peak in 2nd week of October **(Fig. 4.6a).** Total number of moth catches was 43.1% lower than last year **(Table-4.6).**

4.2.2.2 *Earias insulana* (Spiny bollworm)

Moth's activity of *E. insulana* remained zero from January to 2nd week of April. Population was inconsistent throughout the season and reached to its maximum in 2nd week of October. Moth's activity remained zero in December **(Fig. 4.6b).** Overall number of moth catches was 60.5% lower as compared to last year **(Table-4.6).**

4.2.2.3 *Spodoptera litura* (Armyworm)

Moth's activity started in 4th week of February with inconsistent trend and its peak was observed during 1st week of November. **(Fig. 4.6c)**. Overall, moth catches were 97.9% lower as compared to last year **(Table-4.6).**

4.2.2.4 *Spodoptera exigua* (Beet armyworm)

Moth's activity remained zero upto 3rd week of July and reached at its peak in 3rd week of October. Moth's catches remained zero in December **(Fig. 4.6d)**. Overall, moth catches were -86.0% lower to that of last year **(Table-4.6).**

4.2.2.5 *Helicoverpa armigera* (American bollworm)

Moth's catches appeared in 1st week of April with fluctuating trend throughout the season and its peak intensity was perceived in 2nd week of October **(Fig. 4.6e)**. Total number of moth catches was 96.4% lower than the last year **(Table-4.6).**

Table-4.6 Comparison of moth catches of lepidopterous pests in light traps based on total catches during the year/trap

Insect pest	2019	2020	% change (±)
Earias vittella	255.0	145.0	**-43.1**
Earias insulana	165.0	65.1	**-60.5**
Spodoptera litura	2253.0	47.5	**-97.9**
Spodoptera exigua	1044.0	146.0	**-86.0**
Helicoverpa armigera	1700.0	61.0	**-96.4**

4.3 National Coordinated Varietal Trials (NCVT)

4.3.1 Pest situation in set-A (PC-2001-PC-2008)

In this set eight (8) strains were tested for their tolerance/ susceptibility to insect pest complex. Jassid population was below ETL while whitefly population was above ETL on all tested strains except on PC-2001 during July. Thrips population was below ETL on all tested strains. During August Jassid population remained zero on all the tested strains. Whitefly population was above ETL while thrips population remained below ETL on all tested strains. Jassid population remained zero on all the tested strains. Whitefly and thrips population was below ETL on all tested strains **(Table 4.7)**. Bollworms population remained zero on all the tested strains.

4.3.2 Pest situation in Set-B (PC-2009-PC-2034)

In this set twenty-six (26) strains were tested for their tolerance/ susceptibility to insect pest complex. During July, jassid population was below ETL on all tested strains except on PC-2020, 2033, 2017 & 2018 while whitefly population was above ETL on all tested strains except on PC-2029, 2021 & 2024. Thrips population was below ETL on all tested strains. Jassid and thrips population was below ETL on all the tested strains while whitefly population was above ETL on all the tested strains during the month of August. Jassid population remained zero on all the tested strains. Whitefly was below ETL on all the tested strains except PC-2021 & 2025 during the month of September **(Table-4.8)**. Bollworms population remained zero on all the tested strains.

Table-4.7 Seasonal population of sucking insect pests in Set A

Strains	Number of sucking insect pests per leaf								
	Jassid			Whitefly			Thrips		
	July	Aug	Sep	July	Aug	Sep	July	Aug	Sep
PC-2001	0.0	0.0	0.0	3.7	9.3	4.1	4.2	0.2	0.0
PC-2002	0.6	0.0	0.0	5.1	10.7	3.6	2.8	0.0	0.0
PC-2003	0.2	0.0	0.0	7.9	14.9	4.4	3.0	0.0	0.2
PC-2004	0.4	0.0	0.0	6.5	12.9	2.4	5.9	0.0	0.2
PC-2005	0.1	0.0	0.0	5.8	8.5	3.4	3.5	0.0	0.3
PC-2006	0.1	0.0	0.0	5.4	18.7	3.7	3.5	0.0	0.1
PC-2007	0.1	0.0	0.0	12.1	16.7	3.0	4.3	0.0	0.2
PC-2008	0.8	0.0	0.0	6.3	17.7	3.5	2.0	0.0	0.3

Table-4.8 Seasonal population of sucking insect pests in Set B

Strains	Number of sucking insect pests per leaf								
	Jassid			Whitefly			Thrips		
	July	Aug	Sep	July	Aug	Sep	July	Aug	Sep
PC-2009	0.1	0.0	0.0	7.6	12.4	4.7	5.7	1.9	0.3
PC-2010	0.1	0.2	0.0	4.6	11.7	2.9	1.8	2.3	0.3
PC-2011	0.3	0.2	0.0	5.5	20.6	3.6	2.6	2.3	0.2
PC-2012	0.3	0.3	0.0	7.2	22.7	3.9	5.0	2.1	0.2
PC-2013	0.2	0.1	0.0	8.4	25.9	4.0	3.8	2.1	0.3
PC-2014	0.7	0.1	0.0	4.8	22.3	3.7	1.7	0.0	0.1
PC-2015	0.3	0.2	0.0	5.9	22.5	3.5	2.9	0.4	0.4
PC-2016	0.4	0.2	0.0	5.3	18.9	2.9	1.2	0.4	0.1
PC-2017	1.0	0.2	0.0	5.2	33.4	4.3	3.2	1.4	0.2
PC-2018	1.0	0.1	0.0	5.1	16.7	3.0	1.7	1.8	0.1
PC-2019	0.3	0.0	0.0	6.6	20.4	4.2	6.1	0.8	0.4
PC-2020	2.2	0.0	0.0	4.2	18.2	3.4	0.0	0.0	0.3
PC-2021	0.0	0.0	0.0	3.8	11.5	5.4	1.6	1.2	0.3
PC-2022	0.5	0.0	0.0	5.5	32.3	3.6	2.3	0.0	0.1
PC-2023	0.0	0.0	0.0	4.5	24.7	4.2	4.1	0.0	0.4
PC-2024	0.3	0.1	0.0	3.8	16.1	3.9	2.0	0.0	0.2
PC-2025	0.3	0.0	0.0	6.5	13.8	5.2	1.5	0.0	0.2
PC-2026	0.2	0.2	0.0	5.0	9.3	3.2	2.7	0.0	0.4
PC-2027	0.4	0.0	0.0	3.7	9.3	4.6	4.0	0.0	0.4
PC-2028	0.7	0.0	0.0	4.5	14.8	4.2	2.9	0.0	0.3
PC-2029	0.1	0.0	0.0	3.3	22.7	4.8	2.0	0.0	0.2
PC-2030	0.2	0.0	0.0	4.7	23.7	3.5	2.5	0.0	0.2
PC-2031	0.3	0.1	0.0	5.2	11.8	3.7	1.8	0.0	0.3
PC-2032	0.2	0.0	0.0	6.2	16.2	4.1	1.9	0.0	0.2
PC-2033	1.1	0.0	0.0	6.3	17.1	3.5	1.6	0.0	0.1
PC-2034	0.3	0.1	0.0	6.6	18.1	4.1	1.3	0.0	0.1

4.3.3 Pest situation in Set-C (PC-2035-PC-2061)

In this set 27 cotton strains were tested for their tolerance/susceptibility to insect pest complex. Jassid population remained below ETL during July on all the tested strains except on PC-2039, 2041, 2049 & 2057. Its population was negligible on all the tested strains in August and stayed zero in September. Whitefly population was above ETL during July except on PC-2043, 2051, 2054, 2055, 2056 & 2060. Whitefly reached at its peak in August and remained above ETL on all the tested strains. However, its population declined in September and maximum numbers were observed on PC-2055. Thrips remained below ETL throughout the season on all the tested strains **(Table-4.9)**. Bollworms population remained zero on all the tested strains.

4.3.4 Pest situation in Set-D (PC-2062-PC-2087)

In this set 26 cotton strains were tested for their tolerance/susceptibility to insect pest complex. Population of jassid remained below ETL on all the tested strains except on PC-2075, 2083 & 2085 during July. Its population was below ETL on all the tested strains in August and detected zero in September. Population of whitefly was below ETL on PC-2062, 2063, 2064, 2067, 2071, 2072, 2075, 2077, 2082, 2083, 2084 & 2085 during July. Its population reached at its maximum in August and remained above ETL on all the tested strains with a declining trend afterwards in September. Thrips population remained below ETL on all the tested strains during study period **(Table-4.10)**. Bollworms population remained zero on all the tested strains.

4.4 Impact of sowing period on the Dusky cotton bug infestation

The trial was conducted to assess the impact of dusky cotton bug (DCB) infestation on early and normal sown cotton. To evaluate two sowing dates, the early sown cotton (Mid-April) was planted on 14th April and normal sown cotton (Mid-May) on 16th May. Three Bt varieties (Cyto-179, CIM-632 &CIM-602) and two non Bt varieties (CIM-717 & CIM-620) were planted in split-plot design with three replicates. Main plots were sowing dates whereas varieties were in subplots.

Prevalence of DCB in Mid-April sown cotton was detected in June with fluctuating trend and population reached at its peak in November. Initially its infestation was higher on squares and gradually shifted to open bolls, seemingly that dusky bug has less preference to small and mature bolls **(Fig. 4.7 & 4.8).** In Mid-May sown cotton DCB appeared in July and reached at its maxim in November **(Fig. 4.8)**. In this sowing period initially DCB was higher on flowers. Generally, DCB preferably harbored and multiplied in open bolls as compared to other fruiting parts in both sowing dates **(Fig. 4.7)**.

Table-4.9 Seasonal population of sucking insect pests in Set-C

Strains	Number of sucking insect pests per leaf								
	Jassid			Whitefly			Thrips		
	July	Aug	Sep	July	Aug	Sep	July	Aug	Sep
PC-2035	0.7	0.0	0.0	7.5	15.5	4.3	1.6	0.0	0.2
PC-2036	0.6	0.0	0.0	9.4	11.4	2.9	3.4	0.0	0.0
PC-2037	0.0	0.0	0.0	7.6	15.2	3.0	2.0	0.0	0.5
PC-2038	0.5	0.0	0.0	8.6	14.8	3.4	4.3	0.4	0.0
PC-2039	1.0	0.0	0.0	6.0	12.2	3.2	3.1	1.0	0.4
PC-2040	0.5	0.2	0.0	7.4	13.0	3.7	3.8	0.0	0.4
PC-2041	1.4	0.0	0.0	6.2	14.6	4.9	2.2	0.0	0.2
PC-2042	0.4	0.0	0.0	7.6	16.7	2.9	1.7	0.0	0.2
PC-2043	0.9	0.0	0.0	2.8	17.5	4.3	2.1	0.0	0.3
PC-2044	0.0	0.0	0.0	6.3	16.0	3.6	1.5	0.0	0.2
PC-2045	0.1	0.0	0.0	10.2	12.6	3.7	4.1	0.0	0.6
PC-2046	0.8	0.0	0.0	5.9	11.3	4.1	3.9	0.0	0.1
PC-2047	0.6	0.0	0.0	9.4	12.6	3.2	1.2	0.0	0.1
PC-2048	0.1	0.0	0.0	5.5	10.6	2.5	2.8	0.0	0.3
PC-2049	1.1	0.0	0.0	5.5	11.1	3.0	3.9	0.0	0.0
PC-2050	0.3	0.0	0.0	5.0	11.1	5.4	2.2	0.0	0.5
PC-2051	0.7	0.0	0.0	4.1	11.5	2.2	2.5	0.0	0.0
PC-2052	0.4	0.0	0.0	6.0	11.1	5.2	1.0	0.0	0.1
PC-2053	0.3	0.0	0.0	5.8	11.1	4.6	3.1	0.0	0.0
PC-2054	0.2	0.0	0.0	3.7	12.4	3.6	2.1	0.7	0.4
PC-2055	0.5	0.0	0.0	4.5	17.6	5.0	0.0	0.0	0.0
PC-2056	0.7	0.0	0.0	4.7	12.9	4.1	4.4	0.0	0.1
PC-2057	1.1	0.0	0.0	7.7	12.9	3.8	1.9	0.0	0.1
PC-5058	0.4	0.1	0.0	9.2	9.8	3.8	1.8	0.0	0.3
PC-2059	0.6	0.0	0.0	7.4	17.6	3.8	0.7	0.0	0.4
PC-2060	0.1	0.1	0.0	3.0	16.9	3.8	1.8	0.0	0.5
PC-2061	0.1	0.0	0.0	5.2	17.0	4.5	1.2	0.0	0.6

Table-4.10 Seasonal population of sucking insect pests in Set-D

Strains	Number of sucking insect pests per leaf								
	Jassid			Whitefly			Thrips		
	July	Aug	Sep	July	Aug	Sep	July	Aug	Sep
PC-2062	0.4	0.0	0	3.2	11.2	6.0	2.6	0.7	0.3
PC-2063	0.0	0.0	0.0	3.2	12.4	2.8	1.7	0.8	0.3
PC-2064	0.6	0.0	0.0	4.6	13.9	8.7	1.3	0.8	0
PC-2065	0.4	0.0	0.0	6.0	9.7	5.6	2.9	1.0	0.2
PC-2066	0.5	0.0	0.0	5.3	5.3	3.4	1.0	1.0	0
PC-2067	0.3	0.0	0.0	4.4	20.8	3.9	2.8	1.4	0.2
PC-2068	0.2	0.0	0.0	6.0	22.9	3.7	8.3	1.3	0.5
PC-2069	0.5	0.0	0.0	6.3	23.8	5.8	1.8	1.4	0.2
PC-2070	0.3	0.0	0.0	5.6	23.9	4.4	3.9	1.0	0.2
PC-2071	0.8	0.0	0.0	3.7	20.3	4.9	3.9	1.1	0.2
PC-2072	0.8	0.0	0.0	3.2	28.7	4.2	0.5	0.8	0.2
PC-2073	0.3	0.0	0.0	8.0	24.0	5.2	6.0	1.0	0.3
PC-2074	0.7	0.0	0.0	5.2	19.8	6.2	2.0	1.0	0.4
PC-2075	1.0	0.0	0.0	2.7	17.4	5.5	0.9	1.0	0.1
PC-2076	0.3	0.0	0.0	5.8	17.1	2.7	3.4	0.8	0.1
PC-2077	0.5	0.0	0.0	3.1	11.6	2.1	1.1	1.6	0.3
PC-2078	0.6	0.0	0.0	6.9	17.9	4.5	1.2	1.3	0.4
PC-2079	0.5	0.2	0.0	6.4	19.1	6.8	4.5	0.7	0.4
PC-2080	0.1	0.0	0.0	8.7	16.8	3.5	3.8	1.1	0.2
PC-2081	0.2	0.1	0.0	7.0	18.3	3.4	3.4	1.5	0.3
PC-2082	0.9	0.0	0.0	4.6	25.3	4.1	2.5	0.6	0.4
PC-2083	1.2	0.0	0.0	3.8	17.7	4.6	0.8	0.7	0.3
PC-2084	0.1	0.0	0.0	3.2	22.6	3.9	0.6	2.1	0.4
PC-2085	1.4	0.1	0.0	4.6	19.1	2.5	3.2	0.9	0.3
PC-2086	0.3	0.0	0.0	6.1	14..6	4.0	4.0	1.3	0.3
PC-2087	0.8	0.1	0.0	5.5	14.7	3.8	2.0	0.7	0.4

Maximum DCB population in Mid-April planted cotton was recorded on CIM-632 followed by CIM-620 in November. While, in Mid-May planted cotton DCB was higher on CIM-602 followed by CIM-632. On the whole, DCB was higher on CIM-632 and lower on CIM-717 & Cyto-179 as compared to other tested varieties **(Table-4.11).** Overall, population of DCB was higher on early sown crop as compared to normal sown cotton **(Fig.4.9)**.

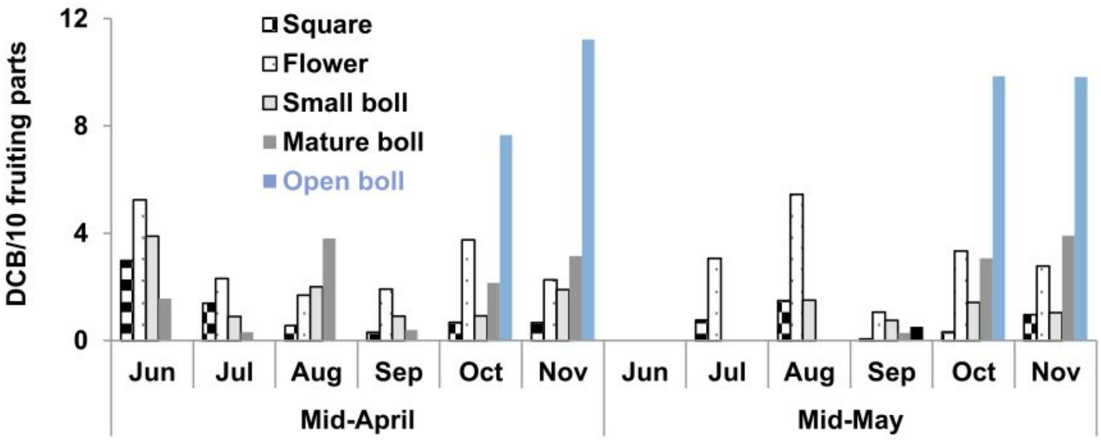

Fig. 4.7 Seasonal incidence of dusky cotton bug on different fruiting parts

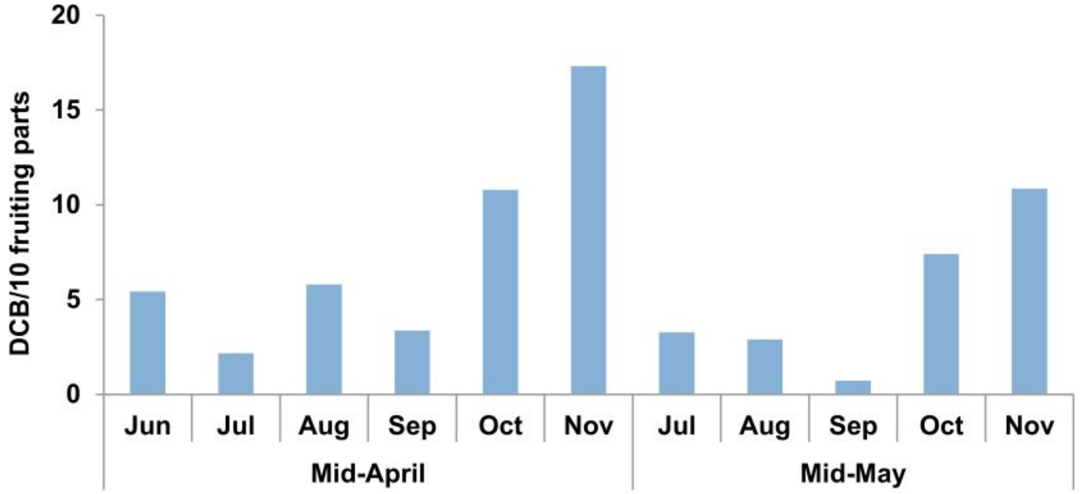

Fig. 4.8 Population dynamics of dusky cotton bug on Mid-April and Mid May sown cotton

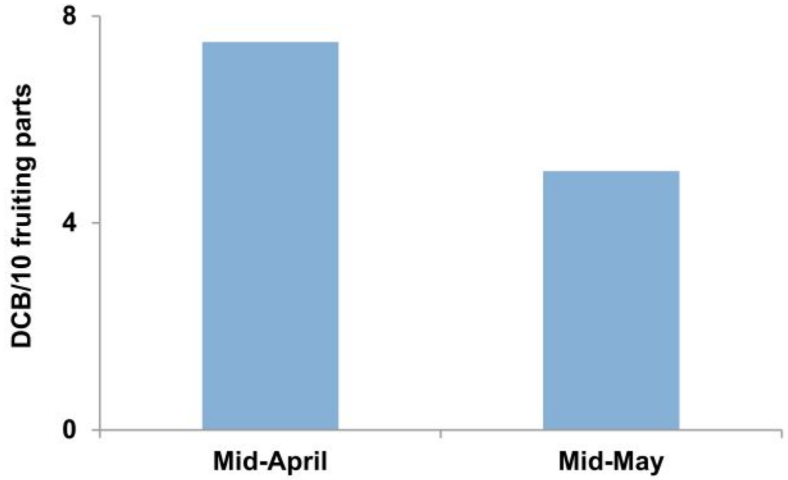

Fig. 4.9 Comparative impact of sowing dates on dusky cotton bug

Table-4.11 Integrated impact of sowing date and varieties on dusky cotton bug infestation

Sowing Date	Month	Dusky cotton bug/ 10 fruiting parts				
		CIM-602	CIM-620	CIM-632	CIM-717	Cyto-179
Mid-April	June	4.1	5.0	4.1	10.0	4.0
	July	1.6	1.9	3.7	1.1	2.5
	August	2.4	1.8	3.5	0.7	20.6
	September	0.8	1.0	0.8	7.8	6.4
	October	12.3	15.6	13.0	6.3	6.7
	November	21.9	25.0	33.4	0.7	5.6
Mid-May	July	1.1	0.6	0.8	13.2	0.7
	August	6.9	1.7	1.6	3.1	1.2
	September	0.9	0.8	0.9	0.9	0.1
	October	11.2	6.3	5.9	7.7	5.9
	November	13.0	8.5	12.2	11.2	9.4

Table-4.13 Efficacy of different insecticides against Jassid

Common Name	Dose (ml/g)	Mortality %	
		72 hour	1-Week
Chlorfenapyr + Dinotefuran 43WDG	150	62.9	70.6
Flonicamid + Nitenpyram 22.5 %WDG	200	85.7	89.4
Imidaclolprid + Fipronil 80 WDG	50	60.7	75.2
Nitenpyram 50 %WDG	40	78.1	87.5
Flunicamid + Abmectin	400	72.6	81.3
Aba+Thiamethoxam 108 SC	300	70.2	76.9
Nitenpyram 10 SL	200	76.2	80.2
Nitenpyram + Acephate 48 % SP	300	77.1	82.9
Chlorfenapyr + Nitenpyram 60 WDG	100	76.6	82.1
Abamectin + Dinotifuran 30 WP	75	76.3	80.5
Chlofen + Bepro + Ometho 42 % EC	400	72.6	77.8
Flonicamid 50 WDG	80	73.4	79.4
Dinotefuran + Spirotatramat 17 %WDG	250 g	81.8	88.9
Bifenthrin 30 % SC	50	71.4	77.3
Diafenthiuron 50 SC	200	71.2	77.0
Chlorfenapyr + Nitenpyran 50 WDG	150 g	88.6	92.9
Flonicamid + Abamectin 10.7 WG	300	69.9	74.6
Chlorfenapyr + Dinotifuran 43 WDG	150	68.8	72.5
Chlorfenapyr + Nitenpyram 50 WDG	150	65.7	71.4
Dimathoate 40 SC	400	78.4	72.5
Chlorfenapyr + Fipronil 24.4 SC	300	77.4	83.3
Chlorfenapyr + Nitenpyram 50 WDG	150	77.8	71.6
Dinotefuran 80 WDG	150	74.5	79.3
CD 5%	-	**5.49**	**5.63**

Pretreatment data 3.50 per leaf

Table-4.14 Efficacy of different insecticides against whitefly

Insecticides	Dose (ml/g)	Mortality % age	
		72 hour	1-Week
Imidacloprid 25 WP	250	23.1	31.7
Acetapmiprid 20 SL	150	46.7	37.4
Diafenthiuron 80 WDG	150	55.3	45.6
Diafenthiuron 50 SC	200	58.6	47.5
Abamectin + Thiamethoxam 108 SC	300	51.2	30.4
Acetmiprid + Thiocylam hydrogen Oxilate 28 WP	200	60.9	54.3
Flunicamid 50 WDG	80	64.2	68.4
Buprofezin 35 WP	600	45.4	42.2
Pyriproxifen 10.8 EC	400	44.1	35.5
Pyriproxfen + Diafenthiuron 50 SC	400 + 150	60.7	64.5
Pyriproxifen + Acetamiprid 41.6 EC	250	69.1	36.4
Spirotatramat 240 SC	125	60.8	46.5
Metrin 0.5 AS	500	31.3	39.5
Pyriproxifen 20% WDG	250	69.0	53.2
Pyriproxifen 10.8%	500	50.2	44.0
Abamectin + Spirotatrama 12% SC	100	54.8	57.3
Acetamiprid 20% SP	150	61.9	52.4
Metrin 0.5 SC	500	65.9	56.2
Buprofenzin 25% WP	600	60.3	31.9
CD 5%	-	**9.59**	**9.80**

Pre-treatment data 9.80 per leaf

4.6 Insecticide resistance monitoring

4.6.1 Mealybug *(Phenacoccus solenopsis)*

Phenacoccus solenopsis, mealybug collected from cotton fields of Multan were exposed to seven insecticides viz. imidacloprid, acetamiprid, nitenpyram, pyriproxyfen, chlorfenapyr, profenophos and methoxyfenozoid using leaf dip method. Second instar nymphs of *P. solenopsis* were exposed to each insecticide treatment at which concentration and observations on mortality were taken 48 h after treatment for conventional insecticides and 72 h after treatment for new chemistry insecticides.

LC_{50} values of neonicotinoids (imidacloprid, acetamiprid) and organophosphate (profenophos) were very low. While, LC_{50} value of methoxyfenozide was higher as compared to other insecticides **(Table-4.15).**

4.6.2 Dusky cotton bug *(Oxycarenus hyalinipennis)*

Oxycarenus hyalinipennis, dusky cotton bug collected from cotton fields of Multan were exposed to six insecticides viz., fipronil, nitenpyram, clothianidin, triazophos, profenofos and carbodiimide (diafenthiuran) using leaf dip method. Adults of *O. hyalinipennis* were exposed and observations on mortality were taken 48 h after treatment for conventional insecticides and 72 h after treatment for new chemistry insecticides.

Results indicated very high LC_{50} values for profenofos followed by nitenpyram as compared to other insecticides. These LC_{50} values indicated resistance development to these insecticides in this location **(Table-4.16)**. Hence, there is a dire need to develop and apply insecticide resistance management (IRM) strategies.

Table-4.15 **Response of *Phenacoccus solenopsis* to different insecticides collected from Southern Punjab**

Insecticide	Slope + SE	95% fiducial limits	LC50 (ppm)
Imidacloprid	1.17 ± 0.20	0.81 – 2.69	1.61
Acetamiprid	1.26 ± 0.21	0.80 – 2.42	1.49
Nitenpyram	1.46 ± 0.25	7.44 – 20.63	13.12
Priproxyfen	1.46 ± 0.24	18.27 – 50.59	32.71
Chlorfenapyr	17.1 ± 0.27	14.37 – 35.61	23.48
Profenfos	1.38 ± 0.21	1.41 – 4.02	2.53
Methoxyfenozide	1.14 ± 0.19	35.83 – 113.82	67.22

Table-4.16 **Response of *Oxycarenus hyalinipennis* to different insecticides collected from Southern Punjab**

Insecticide	Slope + SE	95% fiducial limits	LC50 (ppm)
Fipronil	2.41 + 0.36	0.75 – 1.34	1.01
Nitenpyram	2.09 + 0.32	64.32 – 122.94	90.30
Clothiandin	1.40 + 0.25	31.20 – 78.72	47.00
Triazophos	1.24 + 0.24	15.08 – 46.17	23.85
Profenofos	1.40 + 0.24	129.90 – 307.46	196.33
Carbodiimide (Diafenthiuron)	2.45 + 0.36	31.23 – 55.56	41.90

5. PLANT PATHOLOGY SECTION

Cotton leaf curl disease remained one of the major devastating during the study period. Research studies were carried out on sowing period impact on the prevalence of cotton leaf curl disease, management and control strategy of various cotton diseases, viz., cotton leaf curl, boll rot, and wilting of cotton. Experiments were conducted under greenhouse and field conditions. The promising strains in Pakistan Central Cotton Committee's (PCCC) i.e. National Coordinated Varietal Trials (NCVT) and Punjab Government Trial i.e. Provincial Cotton Coordinated Trial (PCCT), for Bt. and non-Bt. varieties were screened for their reaction to various diseases.

The section participated in training programs, organized by the Institute for the farmers and staff of the Agriculture Extension. The section also provided internship facilities for different universities.

5.1 Screening of Breeding Material against CLCuD

The advanced strains/genotypes of this Institute included in varietal, micro varietal trials and various national coordinated varietal trials were screened for their reaction to CLCuD under field conditions. One hundred and eighty-two families were screened during the year. Data presented in **Table-5.1** revealed that all families of breeding material showed symptoms of the CLCuD under filed conditions except three families, which exhibited resistance against CLCuD in VT-3 and MVT-1 and two families showed a high level of tolerance against CLCuD, in VT-1 and NCVT-B.

Table 5.1 CLCuD status in Breeding Material under field condition

Experiment	No. of Families Screened	No. of Families showing Res. to CLCuD	Disease index Range	Name of strain Resistance or Tolerance
VT-1	8	0	0.22 ~ 14.43	
VT-2	9	0	7.02 ~68.42	
VT-3	10	2	0.00~ 19.09	CM-21,CM-22
VT-4	10	0	13.98~63.11	
MVT-1	6	1	0.00~11.33	CM-5
MVT-2	5	0	12.76~ 63.66	
MVT-3	8	0	50.77~ 77.85	
MVT-4	6	0	12.42 ~52.52	
MVT-5	7	0	6.67 ~46.98	
MVT-6	7	0	9.63~ 63.13	
NCVT-A	8	0	76.90 ~79.10	
NCVT-B	26	0	3.03~81.39	
NCVT-C	27	0	79.49~82.12	
NCVT-D	26	0	27.22~81.30	
SVT-I	7	0	75.43~79.18	
SVT-II	12	0	56.58~78.04	
Total	182	3		

VT = Varietal Trial
MVT = Micro-Varietal Trial
NCVT = National Coordinated Varietal Trial
SVT = Standard Varietal Trail

5.2 Evaluation of National Coordinated Varietal Trial against Different Diseases

National coordinated Varietal Trial was planted in four sets. Detail is given below

Set A (Non-Bt)	Set B (Bt)	Set C (Bt)	Set D (Bt)
8 strains	26 strains	27 strains	26 strains

All entries were tested against stunting, boll rot and Cotton Leaf Curl Disease under field conditions.

NCVT-Set-A

In set- A, all the NCVT strains were found susceptible to cotton leaf curl disease. Minimum disease index (76.90) and disease severity (3.08) was recorded in 2003. All strains remained free from boll rot incidence and stunting (Table 5.2).

NCVT-Set-B

In set-B, all the NCVT strains were found highly susceptible to cotton leaf curl disease. Minimum disease incidence (6.06%), disease index (3.03) and disease severity (2.00) was recorded in 2022. All strains were free from boll rot incidence and stunting (Table 5.3).

NCVT-Set-C

In set-C, all the NCVT strains were observed to be highly susceptible to cotton leaf curl disease. Minimum disease severity (3.19%) and disease index (79.7% & 79.7%) was recorded in 2038 and 2045 (Table-5.4).

NCVT-Set-D

In set-D, all NCVT strains were found highly susceptible to cotton leaf curl disease except 2068, which was tolerant. Minimum disease incidence (45.3 %) and disease index (27.2%) and diseases severity(2.4%) was recorded in 2068. Incidence of boll rot and stunting was recorded in traces (Table-5.5).

5.3 Epidemiological Studies on CLCuD

5.3.1 Incidence of Cotton Leaf Curl Disease (CLCuD) in Sowing Date Trial

(A) *Bt*-Strains

Six Bt strains. CIM-775, CIM-785, CIM-875, Cyto-535, Cyto-533, Cyto-536 with one standard Cyto-179 were tested at six different sowing dates to observe the response to CLCuD. The planting was done from 15th March till 15th June at 15 days' interval. The experimental design was split-plot (main plots: Sowing time; sub-plot: genotype). Data on CLCuD incidence were recorded fortnightly on day 30 after each planting date during the season. The results are given in Fig-5.1.

It is seen from the Fig-5.1 that the appearance of CLCuD was only 1.4 % on the crop planted on 15th March at 135 DAP and reached 24% after 180 DAP The disease incidence was marginally increased until 0.7 % at 105 DAP and reached to its maximum level (68.3 %) on 165 DAP in 1st April planting.

In 15th April planting, disease incidence was 1.4% at 75 DAP and reached to 66.9 % at 150 DAP. Whereas in 1st May planting disease incidence was 0.4 % at 45 DAP and reached to 73.5 % at 135 DAP.

In15th May planting disease symptoms appeared upto 3.2% within 60 days and disease incidence was recorded at 64.3% on 15th September after 120 DAP. On 1st June planting CLCuD started to appear at 45 DAP and rapidly increased and attained its maximum level (91.3 %) at the end of September after 105 DAP. On 15th June planting disease increased, at its maximum level (96.8 %) within 90 DAP.

The crops, which were planted earlier, showed less disease incidence until July. All the cultivars showed a minimum level of incidence when planted on 15th March, 1st April and 15th April, in comparison to 1st May, 15th May, 1st June sowing and 15th June sowing (Fig-5.2).

Averaged across planting dates, there was a considerable varietal difference in all sowing dates. CIM-775 and CIM-875 performed better even in May Planting. (Fig-5.2).

Data on incidence and severity were recorded during the end of September from each sowing date and computed for disease index. Averaged across cultivars, the minimum disease index of 30 % was recorded on the crop planted on 15th March as compared to other planting dates. On average basis of planting dates, a great differences were found in all genotypes. The minimum disease index of 13.1 % followed by 22.7 % was recorded CIM-775 and Cyto-535 (Table-5.6).

On an average basis of sowing dates, a maximum fortnightly increase in the disease was recorded during mid-August. Among environmental parameters, the maximum temperature range was 35.8~38.5°C while the minimum temperature 29.6~31.3°C with the relative humidity of 84.6~ 89.1 %. It has been observed that if the difference between maximum temperature and minimum temperature is less incidence of cotton leaf curl disease is more and vice-versa. Rainfall also plays an important role in disease epidemiology (Table-5.7).

Table-5.2 Stunting, Cotton Leaf Curl Disease Incidence, Severity, Disease Index and Boll Rot of Cotton on NCVT Set-A

NCVT Set A Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
2001	0.00	100	3.09	77.17	0.00
2002	0.00	100	3.09	77.22	0.00
2003	0.00	100	3.08	76.90	0.00
2004	0.00	100	3.10	77.48	0.00
2005	0.00	100	3.20	79.90	0.00
2006	0.00	100	3.16	78.88	0.00
2007	0.00	100	3.16	79.10	0.00
2008	0.00	100	3.14	78.46	0.00

Disease Severity

*__0__ = Complete absence of symptoms

1 = Small scattered vein thickening

2 = = Large groups of veins involved

3 =All veins involved

4 = All veins involved and severe curling

Disease Index= Disease percentage x Disease severity/maximum severity value (4)

Table-5.3 Stunting, Cotton Leaf Curl Disease Incidence, Severity, Disease Index and Boll Rot of Cotton on NCVT Set-B

NCVT Set B Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
2009	0.00	100.00	3.13	78.19	0.00
2010	0.00	100.00	3.16	79.08	0.00
2011	0.00	100.00	3.14	78.40	0.00
2012	0.00	100.00	2.94	73.43	0.00
2013	0.00	100.00	3.20	80.00	0.00
2014	0.00	100.00	3.18	79.59	0.00
2015	0.00	100.00	3.23	80.73	0.00
2016	0.00	100.00	3.14	78.54	0.00
2017	0.00	100.00	3.14	78.43	0.00
2018	0.00	100.00	3.15	78.74	0.00
2019	0.00	100.00	3.23	80.75	0.00
2020	0.00	100.00	3.18	79.52	0.00
2021	0.00	100.00	3.18	79.50	0.00
2022	0.00	6.06	2.00	3.03	0.00
2023	0.00	100.00	3.14	78.52	0.00
2024	0.00	100.00	3.15	78.66	0.00
2025	0.00	100.00	3.19	79.87	0.00
2026	0.00	67.00	3.18	53.45	0.00
2027	0.00	100.00	2.94	73.41	0.00
2028	0.00	100.00	3.06	76.46	0.00
2029	0.00	100.00	3.11	77.80	0.00
2030	0.00	100.00	3.20	79.95	0.00
2031	0.00	100.00	3.26	81.39	0.00
2032	0.00	100.00	3.17	79.18	0.00
2033	0.00	100.00	3.14	78.40	0.00
2034	0.00	100.00	3.11	77.69	0.00

Disease Index= Disease percentage x Disease severity/maximum severity value (4)

Table-5.4 Stunting, Cotton Leaf Curl Disease Incidence, Severity, Disease Index and Boll Rot of Cotton on NCVT Set-C

NCVT Set C Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
2035	0.00	100.00	3.28	81.91	1.00
2036	0.00	100.00	3.27	81.74	0.00
2037	0.00	100.00	3.28	82.12	0.00
2038	0.00	100.00	3.19	79.68	0.00
2039	0.00	100.00	3.25	81.17	0.00
2040	0.00	100.00	3.27	81.73	0.00
2041	0.00	100.00	3.20	79.92	0.00
2042	0.00	100.00	3.24	80.93	0.00
2043	0.00	100.00	3.20	80.11	0.00
2044	0.00	100.00	3.44	86.00	0.00
2045	0.00	100.00	3.19	79.71	0.00
2046	0.00	100.00	3.23	80.85	0.00
2047	0.00	100.00	3.21	80.26	0.00
2048	0.00	100.00	3.24	81.12	0.00
2049	0.00	100.00	3.19	79.80	0.00
2050	0.00	100.00	3.29	82.21	0.00
2051	0.00	100.00	3.27	81.70	0.00
2052	0.00	100.00	3.20	80.02	0.00
2053	0.00	100.00	3.21	80.18	0.00
2054	0.00	100.00	3.26	81.42	0.00
2055	0.00	100.00	3.26	81.56	0.00
2056	0.00	100.00	3.22	80.46	0.00
2057	0.00	98.29	3.31	81.42	0.00
2058	0.00	100.00	3.22	80.49	0.00
2059	0.00	100.00	3.25	81.33	0.00
2061	0.00	100.00	3.24	81.08	0.00

Disease Index= Disease percentage x Disease severity/maximum severity value (4).

(B) Non Bt.

Three cotton genotypes i-e Cyto-226, Cyto-164 and CIM-735 along with one standard variety CIM-610 were sown on six different sowing dates to observe the response to CLCuD infestation. The trial was conducted with the collaboration of the Agronomy Section of the Institute. The planting was done from 15th March to 15th June at 15 days interval. The experiment design was split-plot (main plots: sowing time: subplots genotypes). Data on CLCuD incidence were recorded fortnightly at day 30 from each sowing date during the season. Results are given in Fig-5.3

Effect of the appearance of cotton leaf curl disease incidence and its progression differed considerably with sowing dates. Minimum CLCuD of infestation of 0.1 % was observed in 15th March planting in mid-July (120 DAP) /With the advancement of age, the infestation level reached to 15.9 % (180 DAP) during the end of September. The disease incidence was marginally increased upto 2.6 % at 105 DAP and reached to its maximum level of 27.8 % on 165 DAP in 1st April planting

In 15th April planting, disease incidence was 0.3% at 60 DAP and reached to 44.4 % at 150 DAP. Whereas in 1st May planting disease incidence was 1.3 % at 60 DAP and reached to 32.6 % at 135 DAP

A gradual increase in CLCuD incidence was observed on the 15th May planted crop. The disease started in early-June with a minimum level of incidence of 0.1 % which increased moderately and reached to 83.2 % at 120 DAP in mid-September.

In 1st June and 15th June planting, the disease started within 30-45 DAP (3.5% and 17.8 %) and at 90 DAP it reached up to 100 %(Fig-5.3).

Cyto-226 showed a minimum level of disease incidence from 15th March to 1st

May planting as compared to other genotypes. Average across sowing dates. Comparison among the varieties revealed that there are no varietal differences in June sowing all varieties showed maximum CLCuD infestation after 90 DAP (Fig-5.4)

Table-5.5 Stunting, Cotton Leaf Curl Disease Incidence, Severity, Disease Index and Boll Rot of Cotton on NCVT Set-D

NCVT Set C Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
2035	0.00	100.00	3.28	81.91	1.00
2036	0.00	100.00	3.27	81.74	0.00
2037	0.00	100.00	3.28	82.12	0.00
2038	0.00	100.00	3.19	79.68	0.00
2039	0.00	100.00	3.25	81.17	0.00
2040	0.00	100.00	3.27	81.73	0.00
2041	0.00	100.00	3.20	79.92	0.00
2042	0.00	100.00	3.24	80.93	0.00
2043	0.00	100.00	3.20	80.11	0.00
2044	0.00	100.00	3.44	86.00	0.00
2045	0.00	100.00	3.19	79.71	0.00
2046	0.00	100.00	3.23	80.85	0.00
2047	0.00	100.00	3.21	80.26	0.00
2048	0.00	100.00	3.24	81.12	0.00
2049	0.00	100.00	3.19	79.80	0.00
2050	0.00	100.00	3.29	82.21	0.00
2051	0.00	100.00	3.27	81.70	0.00
2052	0.00	100.00	3.20	80.02	0.00
2053	0.00	100.00	3.21	80.18	0.00
2054	0.00	100.00	3.26	81.42	0.00
2055	0.00	100.00	3.26	81.56	0.00
2056	0.00	100.00	3.22	80.46	0.00
2057	0.00	98.29	3.31	81.42	0.00
2058	0.00	100.00	3.22	80.49	0.00
2059	0.00	100.00	3.25	81.33	0.00
2061	0.00	100.00	3.24	81.08	0.00

Disease Index= Disease percentage x Disease severity/maximum severity value (4)

Table 5.6 Disease index of Cotton Leaf Curl on cultivars planted at different times

Varieties	Sowing Dates							
	15th March	1st April	15th April	1st May	15th May	1st June	15th June	Ave
CIM-775	3.68	3.57	2.40	1.74	4.57	37.13	38.39	13.07
CIM-785	8.14	29.26	32.14	35.00	4.49	38.89	38.86	26.68
CIM--875	2.59	60.07	66.72	74.70	81.35	79.51	77.96	63.27
Cyto-535	61.25	2.31	2.44	4.72	12.14	37.50	38.00	22.62
Cyto-533	53.44	60.39	65.46	75.33	79.32	76.29	77.70	69.70
Cyto-179	28.89	61.55	67.05	78.06	81.15	77.73	78.36	67.54
Cyto-536	52.50	56.93	59.08	63.03	77.17	77.79	76.04	44.70
AVR.	30.07	39.16	42.19	47.51	48.60	60.69	60.76	47.00

D.I = Disease Index, Disease incidence **x** Severity/ maximum severity value (4)

Table.5.7 Relationships between Fortnightly Increase in CLCuD and Temperature and humidity on Bt-Cotton

Sowing date	16-30/4	1-15/5	16-31/5	1-15/6	16-30/6	1-15/7	16-31/7	1-15/8	16-31/8	1-15/9
15th March	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.5	0.0	9.2
1st April		0.0	0.0	0.0	0.0	0.0	0.0	0.7	3.4	6.8
15th April			0.0	0.0	0.2	0.6	0.6	3.9	7.1	36.6
1st May			0.0	0.4	2.4	0.0	3.5	16.0	4.6	23.7
15th May				0.0	0.0	0.0	3.2	22.0	13.9	23.0
1st June					0.0	0.5	32.0	8.6	36.8	13.4
15th June						0.9	36.5	12.1	47.3	0.0
Average	**0**	**0**	**0**	**0.08**	**0.43**	**0.29**	**11.03**	**9.26**	**16.16**	**16.1**
Temp Max C	34.7	36.6	39.2	39.0	40.6	39.3	36.8	38.5	35.8	35.5
Temp Min C	22.6	24.5	26.0	27.8	31.9	29.7	29.6	31.3	30.3	26.8
Difference	**12.1**	**12.1**	**13.2**	**11.2**	**8.7**	**9.6**	**7.1**	**7.3**	**5.5**	**8.7**
RH %age 8a.m	69.7	59.8	68.5	73.0	82.5	80.9	84.6	86.8	89.1	86.8
RH %age 5p.m	53.4	54.0	48.1	52.1	47.3	55.5	68.0	71.6	72.9	69.7
Difference	**32.8**	**33.0**	**35.4**	**32.0**	**32.6**	**28.4**	**22.3**	**18.1**	**19.6**	**18.5**
Rainfall	4.1	1.7	1.3	0.3	0.0	0.0	0.0	0.1	6.7	0.0

Data on incidence and severity were recorded during the end of September from each treatment and computed for disease index. Average across strains, the minimum disease index 22.3 % and 30.2% was recorded on the crop planted on 15th March and 1st April as compared to other planting dates. Averaged across planting dates, a minimum disease index (14.2%) was recorded on genotype CIM-226 (Table-5.8).

Table-5.8 Disease Index of CLCuD (%) in different strains with respect to sowing dates

Strains	Planting Dates							Average
	15th March	1st April	15th April	1st May	15th May	1st June	15th June	
CIM-610	27.9	30.8	45.9	51.8	77.3	76.6	27.9	30.8
CIM-735	32.3	33.5	79.9	76.7	79.1	76.6	32.3	33.5
CIM-226	6.8	14.2	27.0	42.6	55.8	77.4	6.8	14.2
Cyto-164	9.2	35.7	29.3	61.8	73.3	53.2	9.2	35.7
Average	22.3	30.2	42.1	52.9	60.0	67.7	22.3	30.2

D.I = Disease Index, Disease incidence x Severity/ maximum severity value (4)

On the average basis of sowing dates, a maximum fortnightly increase in the disease was recorded in August. Among environmental parameters, the maximum temperature range was 35.8~38.5°C while the minimum temperature 29.6~31.3°C with the relative humidity of 84.6~ 89.1 %. It has been observed that if the difference between maximum temperature and minimum temperature is less incidence of cotton leaf curl disease is more and vice-versa. Rainfall also plays an important role in disease epidemiologyas it increase humidity.. It was also be noted that early sown crops were less affected by CLCuD than late sown crops due to plant vigour (Table-5.9)

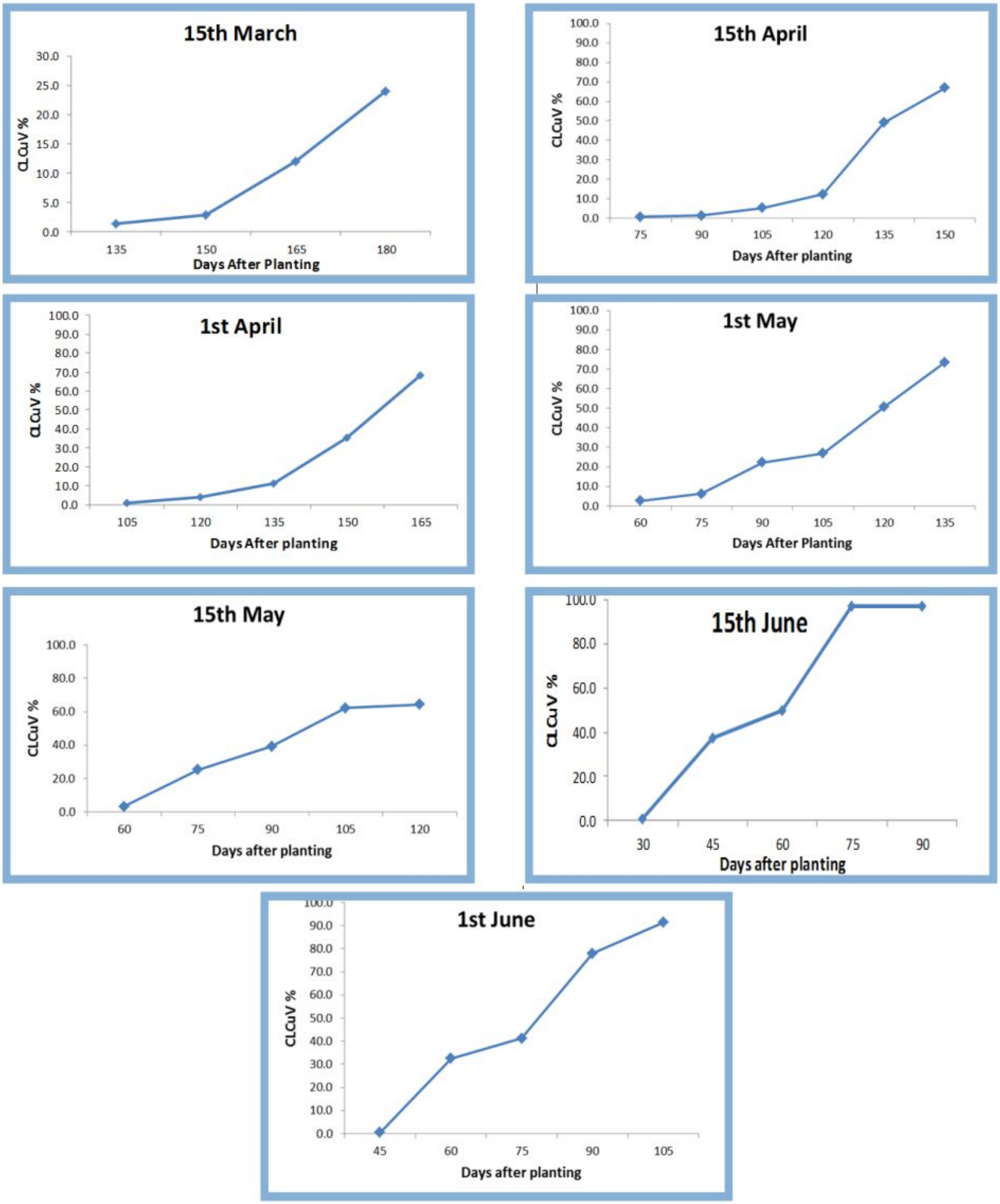

Fig-5.1 CLCuD incidence as influenced by planting dates and in different Bt-strain

Training Program for SWRDO

A training program was organized on "Better Production Technology of Cotton, Climate Change Issues, and Their Mitigation Strategies" for the field officers of Sangtani Women Rural Development Organization (SWRDO) at CCRI Multan on November 3, 2020. Training was imparted on agronomical improvement, cotton varieties with their features, soil health improvement, insect pests & disease management and demonstration of mechanical boll picker.

Training Program for SAS

A training program was organized on "Cotton Production Technology" for the registered farmers of South Asian Sources Pvt Ltd. on October 28, 2020. Training was imparted on agronomical improvement, cotton varieties with their features, soil health improvement, insect pests & disease management and demonstration of mechanical boll picker.

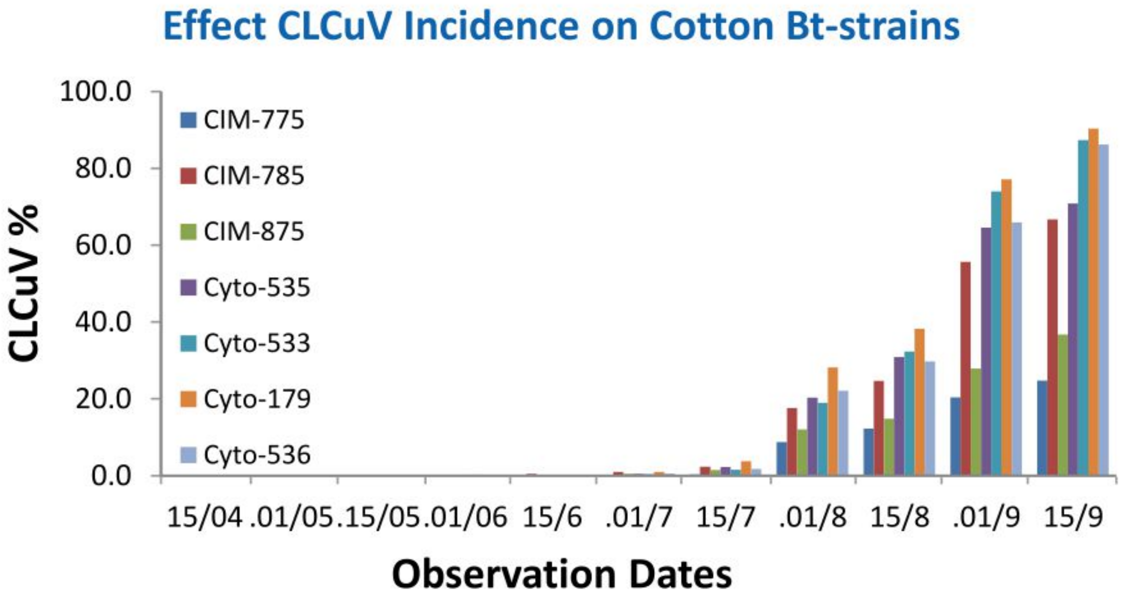

Fig-5.2 incidence of CLCuD in Bt-cotton strains

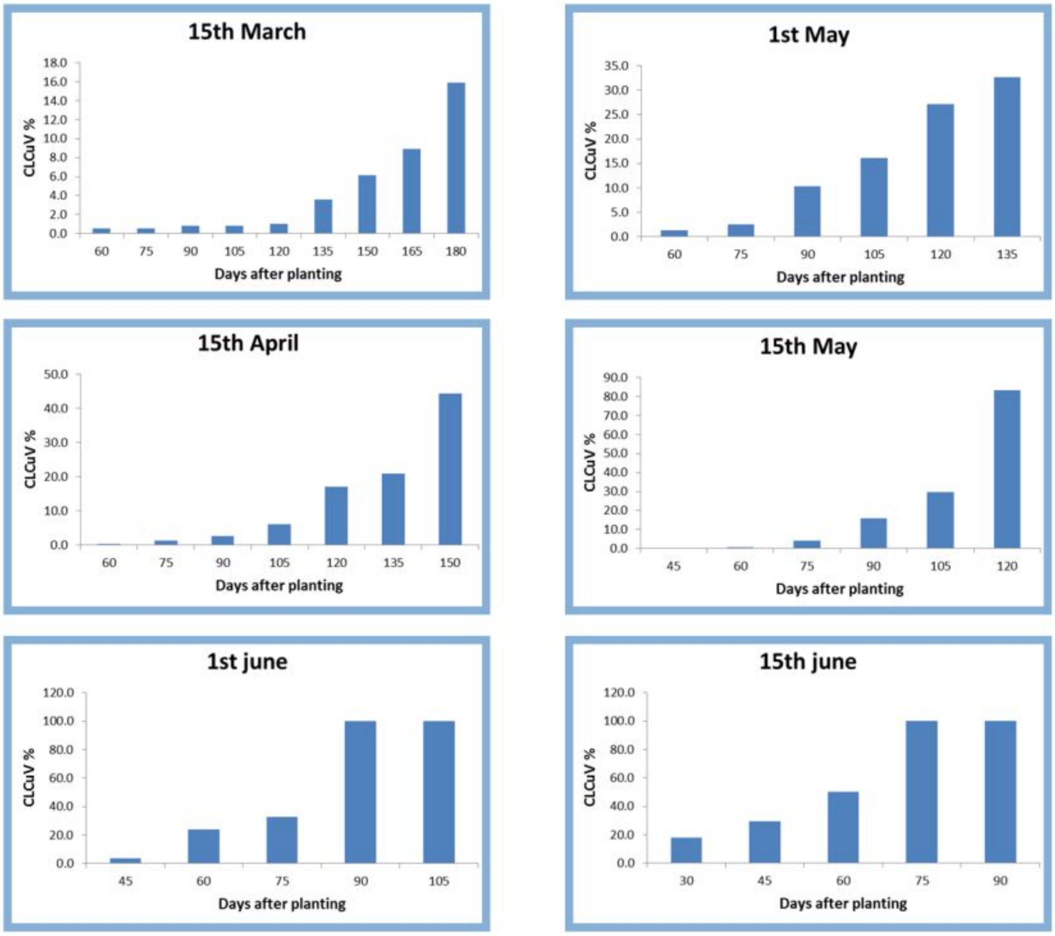

Fig-5.3 CLCuD incidence as influenced by planting dates and in different Non-Bt strains

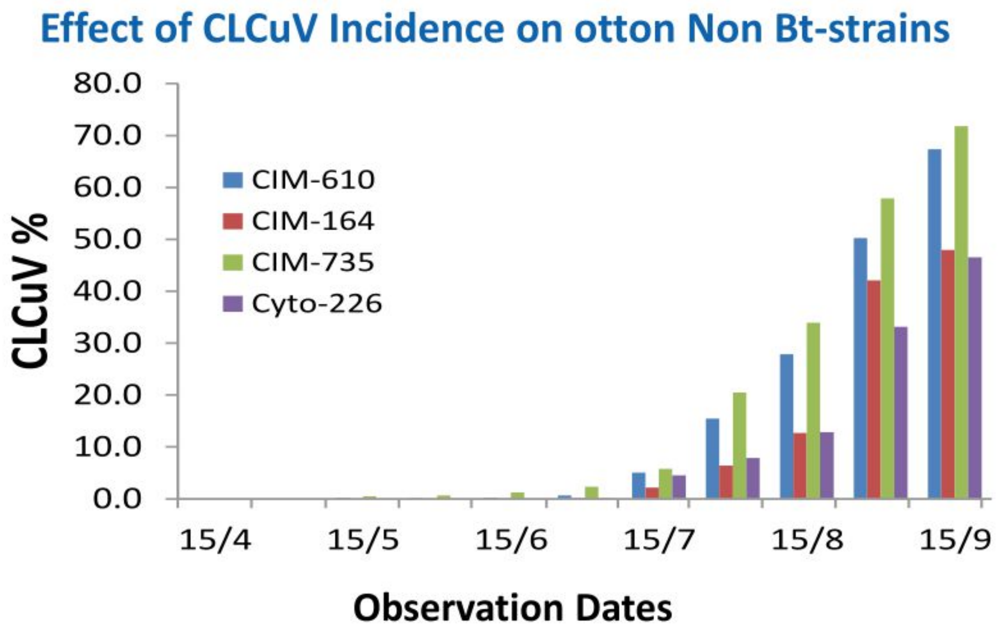

Fig-5.4 Incidence of CLCuD in Non-Bt-cotton strains

Table 5.9 Relationship between fortnightly increases in CLCuD with weather parameters during 2020

Sowing date	16-30/4	1-15/5	16-31/5	1-15/6	16-30/6	1-15/7	16-31/7	1-15/8	16-31/8	1-15/9
15th March	0.0	0.5	0.0	0.3	0.0	0.2	2.5	2.6	2.8	7.0
1st April		0.0	0.3	0.4	0.6	1.3	7.7	4.3	9.5	3.7
15th April			0.3	1.1	1.3	3.4	10.4	3.8	24.1	0.0
1st May			0.0	1.3	1.3	7.8	5.8	11.0	5.4	0.0
15th May				0.1	0.2	3.7	11.8	13.8	53.6	0.0
1st June					0.0	3.5	20.6	8.5	67.4	0.0
15th June					17.8	11.7	20.9	49.6	0.0	0.0
Average	**0**	**0.2**	**0.1**	**0.5**	**3.0**	**4.5**	**11.4**	**13.4**	**23.3**	**1.52**
Temp Max C	34.7	36.6	39.2	39.0	40.6	39.3	36.8	38.5	35.8	35.5
Temp Min C	22.6	24.5	26.0	27.8	31.9	29.7	29.6	31.3	30.3	26.8
Difference	**12.1**	**12.1**	**13.2**	**11.2**	**8.7**	**9.6**	**7.1**	**7.3**	**5.5**	**8.7**
RH %age 8a.m	69.7	59.8	68.5	73.0	82.5	80.9	84.6	86.8	89.1	86.8
RH %age 5p.m	53.4	54.0	48.1	52.1	47.3	55.5	68.0	71.6	72.9	69.7
Difference	**32.8**	**33.0**	**35.4**	**32.0**	**32.6**	**28.4**	**22.3**	**18.1**	**19.6**	**18.5**
Rainfall	4.1	1.7	1.3	0.3	0.0	0.0	0.0	0.1	6.7	0.0

5.4 Boll Rot of Cotton

5.4.1 Sowing Dates Trials

(a) Effect on *Bt*-Strains

An experiment was conducted to quantify the occurrence of boll rot disease in different Bt-strains planted at different dates from, 15th March, to 15th June with fortnightly interval. The results are given in Table 5.10

Averaged across the strains, the crop planted on 1st May was more affected by boll rot as compared to other planting times. Similarly averaged across sowing dates, all strains showed boll rot less than 2 %. However, minimum boll rot was recorded in CIM-775 as compared to other strains. The boll rot disease ranged from 0.14 to 2.06 % in sowing dates on an average basis of genotypes (Table 5.10).

(b) Effect on Non-Bt-Strains

Another experiment (non-Bt varieties) was conducted to quantify the boll rot disease in different strains planted from 15th March to 15th June with fortnightly interval.

The boll rot disease was recorded and results are given in Table 5.11.

Averaged across sowing dates, maximum boll rot was recorded in CIM-226 as compare to other Strains. Averaged across the strains, the crop planted on 15th May was more affected by boll rot as compared to other planting times. On an average basis of genotypes, boll rot disease ranged from 0.57 to 4.00 % in different sowing dates (Table-5.11).

Table-5.10 Effect of Boll Rot of Cotton Disease (%) on Bt-cotton strains planted at different times

	Sowing Dates							
Strains	15th March	1st April	15th April	1st May	15th May	1st June	15th June	Average
CIM-775	0.57	0.46	0.65	2.06	0.00	0.00	0.00	**0.54**
CIM-785	0.74	0.50	1.84	2.51	1.43	0.00	1.11	**1.16**
CIM--875	0.77	0.68	2.94	1.81	1.74	0.00	0.64	**1.23**
Cyto-535	2.76	1.18	0.91	1.22	2.99	0.00	1.92	**1.57**
Cyto-533	1.15	1.18	0.94	2.92	0.00	0.99	1.59	**1.25**
Cyto-179	2.68	1.38	2.07	3.08	3.24	0.00	0.00	**1.78**
Cyto-536	2.21	2.82	1.90	0.82	1.32	0.00	0.00	**1.29**
Average	**1.55**	**1.17**	**1.61**	**2.06**	**1.53**	**0.14**	**0.75**	

Table-5.11 Effect of Boll Rot of Cotton Disease (%) on Non-Bt Cotton Cultivars planted at different times

Strains	15th March	1st April	15th April	1st May	15th May	1st June	15th June	Average
CIM-610	1.21	0.38	1.25	1.69	0.99	1.75	1.23	**1.22**
CIM-735	1.16	0.77	0.62	0.91	0.37	1.75	0.00	**0.80**
CIM-226	1.37	0.69	1.17	2.18	14.24	1.15	3.30	**3.44**
Cyto-164	1.45	0.43	1.24	0.87	0.38	1.04	1.59	**1.00**
Average	**1.30**	**0.57**	**1.07**	**1.41**	**4.00**	**1.42**	**1.53**	

5.5 Evaluation of bio pesticides (Plants Extracts) for management of CLCuD vector (Whitefly)

An experiment was conducted to evaluate different plants extracts against whitefly (CLCuV Vector). Planting of the crop was done on 19th May. The experimental design was RCBD. Six plant extracts @ 1ml/10ml of water were used. Data of Whitefly population recorded 72 hours after spray. The spray of different treatments was repeated after 45, 60 and 90 DAP. After 90 days, the whitefly population crossed ETL and no further mortality was observed with bio pesticides. The crop monitored regularly throughout the season. Data showed that onion extracts caused a substantial decrease in the number of live adult o whiteflies, respectively, compared to other treatments. Although the whitefly population remained low in onion extract treatment only at the early stage when whiteflies not flare-up to ETL. The results are given in (Table-5.12)

	Percent Mortality		
Bio-pesticides	1st spray	2nd spray	3rd spray
Moringa	25.0	27.6	8.3
Tobacco	6.5	21.4	20.0
Sana Makki	46.6	17.3	22.0
Neem	44.2	24.5	21.3
Curry Pata	20.3	27.7	17.7
Onion	72.5	34.3	29.6

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6. PLANT PHYSIOLOGY /CHEMISTRY SECTION

The productivity of cotton crop is facing variable challengs including biotic and abiotic stresses. Rising temperature due to climate change, squeezing profitability and shift of farmers to other crops for higher income have caused significant reduction in cotton crop area and its production. Apart from urbanization, intensifcation in cropping pattern and increasing demand for food and fibre have overloaded the already squeezing land and water resources for agriculture. One of the key factor to attain sustianbility in crop production is to identify and best utilize the available resources (land, water, fertilizer, germplasm) with a precise and cost effective approach. Soil health being the backbone of crop production cannot be ignored as a deteriorated soil may limit agricultural productivity at a level much higher than the other factors. Introducing stress tolerance by the use of conventional plant based products and specific biochemicals are gaining attention to overcome yield losses due to variable stresses faced by the cotton plant during its growth period.

Physiology/Chemistry Section continued its endeavors to characterise cotton germplasm for its adaptability to high temperature stress and under conditions of water scarcity for its better utilization and making cotton production more profitable in stress prone areas. The stagnancy in yield could only be achieved by using balanced and integrated nutrition management approach so as to compensate the nutrient depletion and maintain soil fertility for sustained productivity. Different products were tested to mitigate the adverse effects of water and high temperature stresses, and to produce healthy cotton seed. Increasing input prices and current management practices have not only deteriorated soil health but also raised the cost of production to the unbearable extent, thus narrowing profit margin of the cotton farmers. Restoration and maintenance of soil health could be made possible by minimising the cultivation practices with least disturbance to the dwelling soil micro- flora and fauna. A long-term study has been undertaken by adopting minimum tillage under cotton-wheat production system. Apart from the research studies conducted, scientists of the section participated in a number of diverse activities, some of which are described hereunder.

The scientists of the section actively participated in different trainings/seminars organized by the Institute or other organizations. Trainings were imparted to technical staff of Agricultural Extension Dept. (KP & Balochistan), private seed companies. Research internship facilities were provided to students from Ghazi University, DG Khan and MNSUA, Multan. Supervision of PhD and MPhil students from different academic instituitions remained continue. Contributed in organizting the training program on revival of cotton by the Institute and imparted training to the faremers on soil health and nutrient management. Participated in TV and radio programs; contributed in Tele Cotton messages and technical advisory committee meetings. Video clips on topics of nutrient and crop management at critical growth stages were released and widely telecasted on social media for farmers guidance. Moreover, the scientists participated in different national and international seminars/meetings (virtual or otherwise) conducted by CCRI, International Cotton Advisory Committee, Better Cotton Initiative and International Cotton Researchers Association. Also particiaped and gave oral presentation in International Conference on smart potassium nutrition management in crops at MNSUA. Scientists and other staff of the section participated in orginzing Word Cotton day celebrations on October 7, 2020.

The results of the studies conducted by the section are reported below in detail.

6.1 Heat Tolerance

6.1.1 Adaptability of genotypes to temperature stress

Cotton (*Gossypium hirsutum* L.) is a cash crop of Pakistan. It is highly affected by various diseases and environmental stresses like high temperature, drought and salinity. Among these all yield limiting factors, heat stress has significant effects on the growth, productivity and the quality of cotton crop. Recent research has indicated that high temperature is an important abiotic factor adversely affecting cotton yields. High temperatures (> 35^{o}C) are common throughout the cotton growing season in many regions of the world which adversely affect growth and development of the crop and ultimately limiting the plant performance. The future cotton production is likely to occur under the increasing intensity of multiple abiotic stresses, including extreme and prolonged high temperatures. In Pakistan cotton is generally cultivated in warm areas. The genotypes recommended for general cultivation in cotton growing areas face very high temperature of more than 45°C during the months of May and June, which is almost 15 to 20°C higher than the optimum temperature required for its normal growth. Plant growth such as shoot development, flowering and fiber quality traits are influenced largely due to high temperature. The surface temperature of the planet has increased approximately by 0.6°C, since the late 19th century. This rise in global temperature is due to increasing concentrations of CO_2 and other greenhouse gases (e.g., methane, nitrous oxide, etc.) in the atmosphere which results from the excessive use of fossil fuels. Although cotton originated in warm climates, but it could sustain under certain level of high temperature stress. The existing and future increases in temperature during cotton crop urges to take initiatives for the evolution of germplasm with better tolerance to heat stress. Due to global warming, temperature fluctuations are faster than ever before and cotton yields have been decreased substantially due to increased temperatures. The optimum temperature for the photosynthetic carbon fixation in cotton is about 32^{o}C and photosynthesis decreases significantly at temperatures of 36^{o}C and above. The high temperature environments (35-40^{o}C) are frequently associated with infertility and cotton-boll retention problem and number of productive bolls.

Keeping in view the importance of high temperature stress, the present studies were conducted to screen the newly evolved cotton germplasm and to identify the potential genotypes which possess better tolerance to heat-stress and could produce appropriate yields in heat prone areas of the region.

In the reported study, screening of sixteen cotton genotypes was carried out by planting the crop in mid-April so as the fruiting phase faces the hottest period of crop season. The experiment was conducted under field conditions in the research area of CCRI, Multan.

The results revealed that the genotypes showed wide variation in various physiological parameters conferring to heat tolerance in cotton. Genotypes CIM-775, GH-Sanabal, CIM-785, CRIS-3/19 and Cyto-511 excelled in heat tolerance considering different traits compared with the other genotypes (Table 6.1).

Table 6.1 Physiological traits for determining heat tolerance in different genotypes

Genotypes	AD (%)	PV (%)	FSNN	FSNH (cm)	SNNFB	SNHFB (cm)	% BSFP	% BSSP	RCIL (%)	EC (µS cm^{-1})	Proline(µg/g)
CIM-775	88	82	16	9	10	16	17	10	32	320	8.9
GH-Sanabal	73	81	15	10	9	13	16	9	41	383	8.3
CIM-785	73	77	18	8	13	18	16	9	47	411	7.9
CRIS-3/19	73	76	15	9	12	18	16	8	56	429	7.6
CYTO-511	62	77	17	9	11	16	15	8	61	430	7.2
SLH-50	62	75	16	8	13	22	14	7	63	437	7.2
GH-Hamaliya	62	70	14	9	10	14	13	7	66	463	6.9
SLH-51	62	71	15	9	12	17	13	6	69	468	6.1
SLH-Chandi	62	70	14	9	13	19	13	6	69	504	5.9
CYTO-536	51	69	15	8	12	15	13	6	73	527	5.8
CRIS-2/19	51	68	15	9	11	15	12	4	73	530	5.1
CYTO-535	48	65	17	9	11	16	12	5	75	530	4.8
CIM-875	40	63	16	10	14	21	12	6	77	542	4.5
CYTO-533	40	63	16	8	13	16	10	5	78	564	4.2
CYTO-537	40	67	15	9	12	18	9	5	82	577	3.8
CRIS-1/19	22	58	16	8	13	22	8	4	88	649	3.6
Mean	**57**	**71**	**16**	**9**	**12**	**17**	**13**	**7**	**66**	**485**	**6.1**
LSD	53.4**	10**	1.5 ^{ns}	0.3 ^{ns}	2.1 ^{ns}	3.1*	6.9**	2.0 ^{ns}	9.1**	32.8**	1.1**

***significant at p<0.01; ns: non-significant*

AD: Anther dehiscence
PV: Pollen viability
FSSN: First sympodial node no.
FSNH: First symp. node height
SNNFB: Symp. node no bearing 1st boll
SNHFB: Symp. node height bearing 1st boll
BSFP: Boll set on 1st position
BSSP: Boll set on 2nd position
RCIL: Relative cell injury level
EC: Electrical conductivity

Physiological traits having relevance to heat tolerance were recorded in the genotypes. Results showed that there were positive correlations of pollen viability (r=0.97), percent boll set on first (r=0.98) and second (r=0.91) positions along sympodia with seed cotton yield. There were negative correlations of cell injury (r = –0.95) and electrical conductivity (r = –0.98) with the seed cotton yield. These traits can be taken into account while selecting future genotypes to overcome heat stress problems (Table 6.2).

Table 6.2 Relationship between seed cotton yield and physiological traits determining heat tolerance

Parameters	AD	PV	EC	RCI	BSFP	BSSP	NBPP	BW
PV	0.94**							
EC	-0.97**	-0.96**						
RCI	-0.93**	-0.94**	0.96**					
BSFP	0.95**	0.92**	-0.95**	-0.92**				
BSSP	0.88**	0.91**	-0.93**	-0.94**	0.91**			
NBPP	0.94**	0.97**	-0.97**	-0.95**	0.96**	0.94**		
BW	0.93**	0.94**	-0.95**	-0.99**	0.92**	0.93**	0.96**	
SCY	0.98**	0.97**	-0.98**	-0.95**	0.98**	0.91**	0.97**	0.95**

AD : Anther dehiscence; BSSP : Boll set on 2nd position; NBPP : Number of bolls per plant
PV : Pollen viability; RCIL : Relative cell injury level; BW : Boll weight
BSFP : Boll set on st position; EC : Electrical conductivity; SCY : Seed cotton yield

***significant at p<0.01; ns: non-significant*

The dehiscence of anthers decreased gradually dipping to the lowest level until first week of August. From 2nd week of August onward, anther dehiscence showed a variable increasing trend in different genotypes and reached to its maximum by 2nd week of September. Among the genotypes studied, CIM-775 showed the highest while CRIS-1/19 the lowest dehiscence of anthers during the peak flowering period. The dehiscence of anthers for three genotypes, during the flowering phase is depicted in Fig. 6.1.

Genotypes differed greatly in their overall yield performance. The genotype CIM-775 produced the highest seed cotton yield than the other genotypes tested. Seed cotton yield of different genotypes ranged from 735 to 1524 kg ha^{-1} (Table 6.3).

Fibre characteristics like staple length, uniformity index, fibre strength and fibre fineness varied marginally among different genotypes. Staple length varied from 24.1 to 28.4 mm, Uniformity Index varied from 79.7 to 85.2%, Micronaire varied from 4.0 to 5.3 and fibre strength from 23.5 to 29.2 G/Tex among different genotypes (Table 6.4).

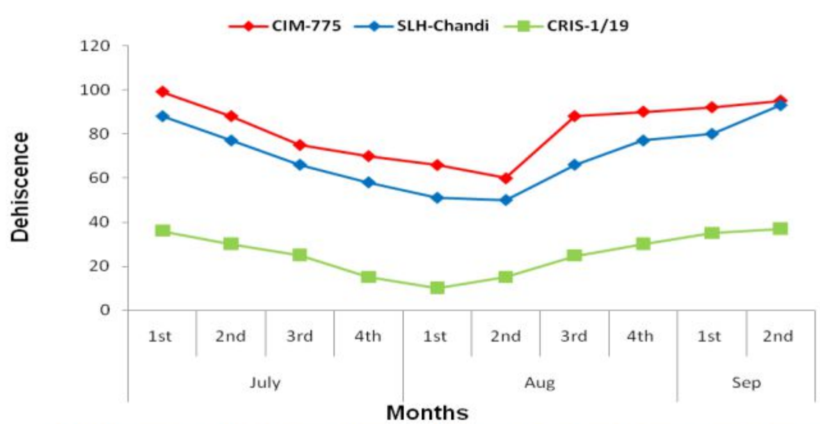

Fig. 6.1 Dehiscence of anthers during the season for three genotypes

Table 6.3 Seed cotton yield in different genotypes planted in mid-April

Genotypes	Number of bolls per plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})
CIM-775	27	3.32	1524
GH-Sanabal	26	3.28	1435
CIM-785	24	3.10	1381
CRIS-3/19	24	2.82	1345
CYTO-511	24	2.70	1291
SLH-50	20	2.62	1273
GH-Hamaliya	19	2.62	1166
SLH-51	18	2.54	1166
SLH-Chandi	17	2.52	1166
CYTO-536	17	2.46	1076
CRIS-2/19	16	2.38	1076
CYTO-535	16	2.36	1076
CIM-875	14	2.16	986
CYTO-533	14	2.16	897
CYTO-537	14	2.12	897
CRIS-1/19	10	2.06	735
LSD	8.6**	0.20**	672**

**significant at p<0.01

Table 6.4 Effect of heat stress on fiber characteristics in different genotypes

Genotypes	Staple length (mm)	Uniformity Index (%)	Micronaire (µg $inch^{-1}$)	Strength (G/Tex)
CIM-775	26.5	83.8	4.7	27.1
GH-Sanabal	27.2	84.7	5.0	26.0
CIM-785	26.9	83.7	4.7	27.0
CRIS-3/19	27.8	84.2	5.2	27.4
CYTO-511	25.2	85.2	4.7	26.5
SLH-50	24.6	81.0	4.5	25.8
GH-Hamaliya	26.2	83.3	5.2	26.9
SLH-51	26.0	82.4	5.2	26.2
SLH-Chandi	24.1	80.7	4.8	25.8
CYTO-536	27.9	84.0	4.0	28.7
CRIS-2/19	25.8	80.7	4.9	26.5
CYTO-535	28.4	84.7	4.7	29.2
CIM-875	26.7	85.2	5.1	26.0
CYTO-533	26.0	82.2	4.8	26.1
CYTO-537	26.1	84.8	4.4	27.3
CRIS-1/19	24.1	79.7	5.3	23.5

6.1.2 Evaluation of stress alleviating biochemicals in cotton under heat stress conditions

Abiotic stresses such as salinity, drought and extreme temperatures strongly influence crop production throughout the world. Among these, high temperature is one of the most common stresses, which impacts defensive system, chlorophyll contents, photosynthetic apparatus, antioxidant enzymes and productivity of field crops. For example, daily average temperature for optimum cotton growth is 32°C and cotton crop is predominantly cultivated under semiarid conditions where maximum day temperature reaches to 48–50°C. Important physiological process e.g. leaf chlorophyll and carbon assimilation process of cotton has been found very sensitive to high temperature. For example, a small increase in air temperature above optimum (32°C) can significantly reduce leaf photosynthesis. Further, a temperature above 35–40°C significantly restrict elongation of fruiting branch (sympodial branches) in cotton. Heat stress influences cellular biochemistry by accelerating reactive oxygen species

(ROS) production. While, plants may metabolize ROS through up-regulating antioxidants defense enzymes. Plant growth regulators have been found effective in improving crop performance against abiotic stresses by activating defensive system. For example, hydrogen peroxide H_2O_2, a signaling molecule has been found effective to activate plant defensive system in plants under high temperature stress. An organic extract from *Moringa* leaves containing zeatine-a group of cytokinin has also been found effective in increasing chlorophyll contents under stressed condition. Similarly, ascorbic acid can reduce oxidative cellular injury, improve chlorophyll contents and maintain redox state of photosynthetic process. Indole-3-acetic acid (IAA) is the main auxin in plants. IAA has many different effects, such as inducing cell elongation and cell division with all subsequent results for plant growth and development. On a larger scale, IAA serves as signaling molecule necessary for development of plant organs and coordination ofgrowth.

Foliar spray of lower concentrations of salicylic acid (SA) increased the H_2O_2 level and also reduced the Catalase (CAT) activity which increased the potential of plants to withstand the heat stress. SA application reduced electrolyte leakage and CAT activity with a concomitant enhancement in the activities of glutathione reductase and guaiacol peroxidase. Exogenous application of these diverse chemicals on cotton plants offers an effective strategy to mitigate various abiotic stresses. Owing to their etsablished characteristics, these bio-regulators were anticipated to be the best choice in mitigating/protection the damage of high temperature stress on cotton crop.

A field experiment was conducted to evaluate the efficacy of exogenously applied bio-regulators as thermal stress alleviators on two cotton genotypes viz. GH-Hamaliya (heat tolerant) and CIM-789 (heat susceptible). The crop was sown on 15th of April 2020 in a randomized complete block design (RCBD) with split-split plot arrangement (genotypes; main plot, seed heat treatment; sub plots and biochemicals treatments; sub-sub plot). The experiment was divided into two sets prior to sowing i.e. seed without heat treatment (NHT, Set-A) and seed with heat treatment (HT, Set-B) at 60ºC for 5 hours.

A total of five stress alleviating bio-chemicals were applied though foliar sprays for improving heat tolerance in both sets. Foliar sprays of specified solution concentrations were initiated when the crop reached fruiting phase i.e. 35-40 days old. Subsequent foliar sprays were done after a suitable interval (15-20 days); to make a total of three sprays. The crop was fertilized with recommended NPK fertilizers. Standard production and management practices were adopted. The detail of treatments applied is given below:

Treatments	Bio-chemicals	Dose
T1	Control	Water alone
T2	Indole Acetic Acid(IAA)	80 mg/L
T3	Hydrogen peroxide(H_2O_2)	30 mg/L
T4	Salicylic Acid (SA)	50 mg/L
T5	Moringa Leaf Extract(MLE)	30 ml/L
T6	Ascorbic Acid	150 mg/L

Plant reproductive development parameters like seed cotton yield, number of bolls per plant and boll weight differed significantly ($p<0.05$) among various treatments and among the two genotypes ($p<0.01$). **In CIM-789**, NHT set, the seed cotton yield ranged from 980 to 1201 kg ha^{-1} with number of bolls per plant from 14 to 25, while in HT set it varied from 1063 to 1311 kg ha^{-1} with number of bolls per plant from 18 to 28. Heat treatment of seeds prior to sowing resulted in increase in number of bolls and seed cotton yield of CIM-789 (heat susceptible) genotype. **In GH-Hamaliya,** NHT set, the seed cotton yield ranged from 1021 to 1380 kg ha^{-1} with number of bolls per plant varied from 18 to 30, while in HT set it varied from 938 to 1242 kg ha^{-1} with number of bolls per plant from 17 to 28. Owing to its heat tolerance characteristics, heat treatment of seed prior to sowing in GH-Hamaliya did not produce positive effects on its seed cotton yield and therefore, non-heat treated plots produced higher seed cotton yield than treated plots. Averaged across the genotypes, and both sets, T2 showed the maximum **s**eed cotton yield (kg ha^{-1}) where IAA was applied @ 80 mg/l. In case of both genotypes the foliar application of different biochemicals showed the significant effect as compared to seed heat treatment (Table 6.5 & 6.6).

Table 6.5 Effect of stress alleviating chemicals on seed cotton yield

Biochemical/ Dose	Seed Cotton yield(kg ha^{-1})				
	CIM-789		GH-Hamaliya		Mean
	NHT	HT	NHT	HT	
T1: Control(Water alone)	980	1063	1021	938	1001
T2: IAA @ 80 mg/L	1201	1311	1380	1242	1283
T3: H_2O_2 @ 30 mg/L	1007	1118	1132	1104	1090
T4: SA @50 mg/L	1145	1242	1311	1214	1228
T5:MLE @ 30 mg/L	1132	1242	1311	1242	1232
T6: AA @150 mg/L	1104	1173	1173	1118	1142
Mean	1095	1191	1221	1143	
Genotypes			ns		
Heat Treatment			ns		
Genotypes×Heat Treatment			ns		
Bio-chemicals			**		
Genotypes× Bio-chemicals			ns		
Heat Treatment×*Bio-chemicals			ns		
Genotypes × Heat Treatment× Bio-chemicals			ns		

IAA : Indole Acetic Acid, H_2O_2: Hydrogen per oxide, SA: Salicylic acid, MLE: Moringa Leaf extract, AA: Ascorbic acid **significant at p<0.01, *significant at p<0.05, ns: non-significant

Table 6.6 Effect of stress alleviating chemicals on Number of Bolls per plant

Biochemical/ Dose	Number of bolls per plant				
	CIM-789		GH-Hamaliya		Mean
	NHT	HT	NHT	HT	
T1: Control(Water alone)	14	15	18	17	16
T2: IAA @ 80 mg/L	25	28	30	28	28
T3: H_2O_2 @ 30 mg/L	15	22	24	22	21
T4: SA @50 mg/L	21	25	29	25	25
T5:MLE @ 30 mg/L	20	24	27	24	25
T6: AA @150 mg/L	19	23	25	23	23
Mean	19	23	26	23	
Genotypes			**		
Heat Treatment			**		
Genotypes× Heat Treatment			ns		
Bio-chemicals			**		
Genotypes× Bio-chemicals			**		
Heat Treatment×*Bio-chemicals			*		
Genotypes × Heat Treatment× Bio-chemicals			**		

IAA : Indole Acetic Acid, H_2O_2: Hydrogen per oxide, SA: Salicylic acid, MLE: Moringa Leaf extract, AA: Ascorbic acid **significant at p<0.01, *significant at p<0.05, ns: non-significant

In CIM-789, NHT set, the boll weight varied from 2.30 to 2.60g, while in HT set it varied from 2.52 to 2.80g. **In GH-Hamaliya,** NHT set, the boll weight varied from 2.74 to 3.22g, while in HT set, it varied from 2.40 to 2.84g. In CIM-789 heat treatment of seed caused a positive although non-significant effect on boll weight while in case of GH-Hamaliya heat treatment did not increase the boll weight. Averaged across the genotypes, and both sets, T2 showed the maximum boll weight (2.86g) where IAA was applied @ 80 mg/l (Table 6.7).

The assessment of physiological and biochemical parameters such as, anther dehiscence during 3rd week of june - 2nd week of September, pollen viability, cell injury and proline contents were determined from the leaves sampled from 90 days old crop. Results indicated that anther dehiscence **in** CIM**-789**, NHT set, the Anther dehiscence varied from 40 to 81%, while in HT set it varied from 41 to 82%, Pollen viability in NHT set, varied from 33 to 77%, while in HT set it varied from 37 to 81%,Relative cell injury in NHT set, varied from 50 to

88%, while in HT set it varied from 45 to 84% while proline contents in NHT set, varied from 3.20 to 4.90(µg/g), while in HT set it varied from 3.90 to 7.10 (µg/g).

Table 6.7 Effect of stress alleviating chemicals on Boll weight(g)

Biochemical/ Dose	Boll Weight(g)				Mean
	CIM-789		GH-Hamaliya		
	NHT	HT	NHT	HT	
T1: Control(Water alone)	2.30	2.52	2.74	2.40	2.49
T2: IAA @ 80 mg/L	2.56	2.80	3.22	2.84	2.86
T3: H_2O_2 @ 30 mg/L	2.38	2.60	2.74	2.60	2.58
T4: SA @50 mg/L	2.60	2.70	3.12	2.72	2.78
T5:MLE @ 30 mg/L	2.54	2.58	2.80	2.70	2.66
T6: AA @150 mg/L	2.50	2.56	2.76	2.60	2.60
Mean	2.48	2.63	2.90	2.64	
Genotypes			ns		
Heat Treatment			ns		
Genotypes× Heat Treatment			ns		
Bio-chemicals			ns		
Genotypes× Bio-chemicals			ns		
Heat Treatment×*Bio-chemicals			ns		
Genotypes × Heat Treatment× Bio-chemicals			ns		

IAA : Indole Acetic Acid, H_2O_2: Hydrogen per oxide, SA: Salicylic acid, MLE: Moringa Leaf extract, AA: Ascorbic acid **significant at p<0.01, *significant at p<0.05, ns: non-significant

In GH-Hamaliya, NHT set, the Anther dehiscence varied from 56 to 85%, while in HT set it varied from 58 to 89%,Pollen viability in NHT set, varied from 45 to 81%, while in HT set it varied from 51 to 82%, Relative cell injury in NHT set, varied from 33 to 86%, while in HT set it varied from 30 to 79% while proline contents in NHT set, varied from 3.60 to 6.20(µg/g), while in HT set it varied from 4.80 to 7.10(µg/g). On the basis of results, it was observed in both genotypes, that Anther dehiscence and pollen viability improved significantly with the seed heat treatment and biochemical application but relative cell injury of leaves decreased expressively with seed heat treatment and biochemical application while proline contents, increased remarkably with seed heat treatment to cope up with high temperature stress conditions by activating the plant defence mechanism (Table 6.8-6.11).

Table 6.8 Effect of stress alleviating chemicals on Anther Dehiscence%

Biochemical/ Dose	Anther Dehiscence%				Mean
	CIM-789		GH-Hamaliya		
	NHT	HT	NHT	HT	
T1: Control (Water alone)	40	41	56	58	49
T2: IAA @ 80 mg/L	81	82	85	89	84
T3: H_2O_2 @ 30 mg/L	51	60	61	64	59
T4: SA @50 mg/L	79	81	85	86	83
T5:MLE @ 30 mg/L	69	73	70	75	72
T6: AA @150 mg/L	54	62	61	70	62
Mean	62	67	70	74	
Genotypes			**		
Heat Treatment			**		
Genotypes× Heat Treatment			ns		
Bio-chemicals			**		
Genotypes× Bio-chemicals			**		
Heat Treatment×*Bio-chemicals			**		
Genotypes × Heat Treatment× Bio-chemicals			ns		

IAA : Indole Acetic Acid, H_2O_2: Hydrogen per oxide, SA: Salicylic acid, MLE: Moringa Leaf extract, AA: Ascorbic acid **significant at p<0.01, *significant at p<0.05, ns: non-significant

Table 6.9 Effect of stress alleviating chemicals on Pollen Viability

Biochemical/ Dose	Pollen Viability				
	CIM-789		GH-Hamaliya		Mean
	NHT	HT	NHT	HT	
T1: Control(Water alone)	33	37	45	51	42
T2: IAA @ 80 mg/L	77	81	81	82	80
T3: H_2O_2 @ 30 mg/L	45	55	55	61	54
T4: SA @50 mg/L	76	75	77	82	78
T5:MLE @ 30 mg/L	62	68	65	73	67
T6: AA @150 mg/L	45	58	58	65	57
Mean	56	62	64	69	
Genotypes			**		
Heat Treatment			**		
Genotypes× Heat Treatment			ns		
Bio-chemicals			**		
Genotypes× Bio-chemicals			**		
Heat Treatment×*Bio-chemicals			**		
Genotypes × Heat Treatment× Bio-chemicals			**		

IAA : Indole Acetic Acid, H_2O_2: Hydrogen per oxide, SA: Salicylic acid, MLE: Moringa Leaf extract, AA: Ascorbic acid **significant at p<0.01, *significant at p<0.05, ns: non-significant

Table 6.10 Effect of stress alleviating chemicals on Relative Cell injury %

Biochemical/ Dose	Relative Cell injury %				
	CIM-789		GH-Hamaliya		Mean
	NHT	HT	NHT	HT	
T1: Control(Water alone)	88	84	86	79	84
T2: IAA @ 80 mg/L	66	50	50	44	53
T3: H_2O_2 @ 30 mg/L	71	62	61	52	62
T4: SA @50 mg/L	50	51	33	30	41
T5:MLE @ 30 mg/L	62	45	41	39	47
T6: AA @150 mg/L	69	59	53	49	58
Mean	68	59	54	49	
Genotypes			**		
Heat Treatment			**		
Genotypes× Heat Treatment			ns		
Bio-chemicals			**		
Genotypes× Bio-chemicals			**		
Heat Treatment×*Bio-chemicals			*		
Genotypes × Heat Treatment× Bio-chemicals			**		

IAA : Indole Acetic Acid, H_2O_2: Hydrogen per oxide, SA: Salicylic acid, MLE: Moringa Leaf extract, AA: Ascorbic acid **significant at p<0.01, *significant at p<0.05, ns: non-significant

Table 6.11 Effect of stress alleviating chemicals on Proline content (µg/g)

Biochemical/ Dose	Proline content (µg/g)				Mean
	CIM-789		GH-Hamaliya		
	NHT	HT	NHT	HT	
T1: Control(Water alone)	4.80	5.00	3.90	4.80	4.63
T2: IAA @ 80 mg/L	3.20	3.90	3.60	4.60	3.83
T3: H_2O_2 @ 30 mg/L	3.60	6.70	5.40	5.80	5.38
T4: SA @50 mg/L	4.90	7.10	6.20	7.10	6.33
T5:MLE @ 30 mg/L	4.30	4.50	6.00	6.50	5.33
T6: AA @150 mg/L	4.80	5.60	5.10	6.30	5.45
Mean	4.27	5.47	5.03	5.85	
Genotypes			**		
Heat Treatment			**		
Genotypes× Heat Treatment			ns		
Bio-chemicals			**		
Genotypes× Bio-chemicals			**		
Heat Treatment×*Bio-chemicals			**		
Genotypes × Heat Treatment× Bio-chemicals			**		

IAA : Indole Acetic Acid, H_2O_2: Hydrogen per oxide, SA: Salicylic acid, MLE: Moringa Leaf extract, AA: Ascorbic acid **significant at p<0.01, *significant at p<0.05, ns: non-significant

6.1.3 Characterization of cotton germplasm for heat tolerance

Cotton (*Gossypium hirsutum* L.) is a cash crop of Pakistan. It is highly affected by environmental stresses like high temperature, drought and salinity. Among these yield-limiting factors, heat stress has significant effects on the growth, productivity and the quality of cotton crop. Higher temperatures (>35°C) are common throughout the cotton growing season in many regions of the world which adversely affect growth and development of the crop and ultimately limiting the plant performance. In Pakistan, cotton is generally cultivated in warm areas. The genotypes recommended for general cultivation in cotton growing areas usually face day time temperature exceeding 45°C or even up to 50°C, in some areas, during the months of May through July, which is approximately 15 to 20°C higher than the optimum temperature required for normal cotton plant growth. Plant growth such as shoot development, flowering and fiber quality traits are influenced largely due to high temperature. Identification of specific traits contributing to heat tolerance in cotton germplasm is a practical approach which may help in developing heat tolerant varieties for the region. Therefore, the present study was carried out with the objectives to screen cotton germplasm for its heat tolerance characteristics, under field conditions, in collaboration with Plant Breeding and Genetics Section of the Institute.

Leaf samples of 147 accessions of the cotton genepool entries were collected from the field to determine relative cell injury (RCI%), an indicator of heat tolerance. RCI ranged from 20.3 to 91.1% in different accessions of genepool (Table 6.12).

Table 6.12 Relative cell injury in different accession of gene pool material

Acc. No	RCI%	Acc. No	RCI%	Acc. No	RCI%	Acc. No	RCI%	Acc. No	RCI%
1801	59.0	1837	52.5	1870	42.4	1907	78.9	1937	31.7
1802	40.4	1838	76.1	1871	75.5	1908	52.9	1938	33.3
1803	64.4	1839	48.2	1872	74.4	1909	53.6	1939	41.1
1805	76.7	1840	29.0	1874	53.9	1910	43.4	1940	45.5
1806	53.6	1842	90.5	1875	47.5	1911	31.8	1941	39.7
1808	77.8	1843	79.2	1876	79.7	1912	26.3	1942	21.9
1811	76.5	1844	38.7	1877	44.3	1913	45.2	1943	25.8
1812	41.4	1845	76.7	1878	38.0	1914	37.1	1944	47.0
1813	29.7	1846	56.6	1879	46.7	1915	53.2	1945	51.6
1814	55.7	1847	44.2	1881	78.7	1916	39.8	1946	39.6
1815	35.5	1849	54.2	1882	59.4	1917	34.2	1947	28.4
1816	56.0	1850	40.5	1883	33.6	1918	77.4	1948	47.9
1817	61.5	1851	42.0	1885	76.6	1919	64.4	1949	52.6
1818	63.9	1852	45.9	1886	44.5	1920	55.8	1950	27.7
1819	50.6	1853	67.7	1888	44.0	1921	23.9	1951	24.4
1820	56.1	1854	75.3	1891	55.4	1922	30.9	1952	74.4
1821	75.3	1855	32.0	1892	28.5	1923	42.7	1953	21.3
1823	61.0	1856	69.9	1893	72.3	1924	71.9	1954	43.2
1824	47.4	1857	70.8	1894	47.6	1925	26.2	1955	64.8
1825	71.6	1858	43.8	1895	70.4	1926	43.4	1956	24.5
1826	45.2	1859	65.2	1896	47.4	1927	75.4	1957	72.3
1828	36.5	1860	38.0	1897	79.2	1928	37.2	1958	84.0
1829	34.2	1861	44.6	1898	91.1	1929	48.5	1959	62.9
1830	37.5	1862	20.3	1899	32.0	1930	78.2	1960	22.7
1831	37.4	1863	49.5	1900	68.6	1931	32.3	1961	53.2
1832	62.0	1864	45.8	1901	21.8	1932	38.2	1962	39.7
1833	59.4	1865	43.0	1903	73.0	1933	47.3	1963	83.6
1834	22.8	1866	59.0	1904	26.5	1934	30.3		
1835	42.5	1867	45.3	1905	57.9	1935	29.0		
1836	79.1	1869	59.6	1906	59.3	1936	33.5		

Based on RCI the accessions were grouped into 3 categories. A total of 45 accessions had RCI in the range of 20.3-40.5 %, (categorized as heat tolerant), 60 accessions had RCI in the range of 4.6-60.5% (categorized as medium tolerant) and 42 accessions with RCI of more than 60.5 % were categorized as heat susceptible (Figure 6.2).

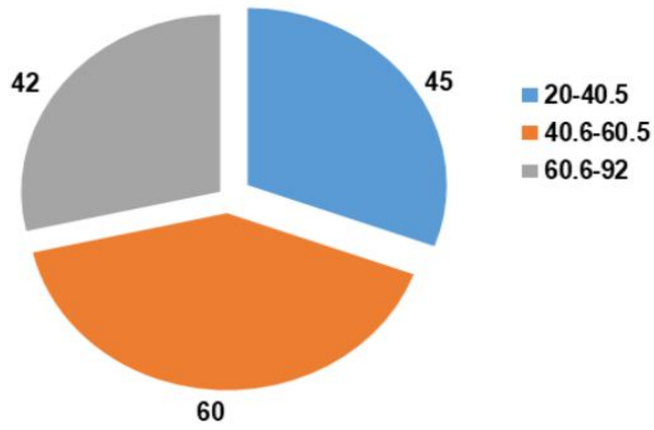

Figure 6.2 Categorization of genepool accessions based on relative cell injury levels

6.2 Soil Health and Plant Nutrition

6.2.1 Long term effects of reduced tillage on soil health and cotton-wheat / berseem productivity

The greatest challenge to the world in the years to come is to provide food to burgeoning population, which is likely to rise to 8,909 million in 2050. The scenario would be more terrible, when we visualize per capita availability of arable land. The growth rate in agriculture has been the major detriment in world food production. The cultivation of agricultural soils has, until recently, predominantly been achieved by inverting the soil using tools such as the plough, thus burying the fertile portion of soil to lower depth. Soil tillage is one of the basic and important components of agricultural production technology. Various forms of tillage tools are practiced throughout the world, such as the use of simple stick or jab to the sophisticated para-plough. The practices developed, with whatever equipment used, can be broadly classified into no tillage, minimum tillage, conservation tillage and conventional tillage.

Soil tillage refers to physical, chemical or biological soil manipulation to optimize conditions for germination, seedling establishment and crop growth. Tillage is a labour-intensive activity in low-resource agriculture practiced by small landholders, and a capital and energy-intensive activity in large-scale mechanized farming. Continual soil inversion can in some situations lead to a degradation of soil structure leading to a compacted soil composed of fine particles with low levels of soil organic matter (SOM). Such soils are more prone to soil loss through water and wind erosion eventually resulting in desertification. This process can directly and indirectly cause a wide range of environmental problems. The conventional soil management practices result in losses of soil, water and nutrients in the field, and degrade the soil with low organic matter content and a fragile physical structure, which in turn lead to low crop yields and low water and fertilizer use efficiencies apart from the fuel and labor costs. Therefore, scientists and policy makers are emphasizing on reduced tillage. Compared to conventional tillage, there are several benefits from reduced tillage such as economic benefits of labor cost and time saving, erosion protection, soil and water conservation, and increases of soil fertility.

The experiment was designed to evaluate the effect of reduced tillage on soil health and crop productivity as well as to reduce the cost of production. Pre-plant soil samples were collected from the field to determine soil properties. Sowing was done on April 29, 2020. Germination of the cotton-seed was badly affected by rain that came twice just after planting of seed.

Pre-plant soil samples were collected to determine the soil variability across the experimental field. Physio-chemical analyses of the samples revealed that the soil is silt loam in

Technical Advisory Committee Meeting

Mr. Ali Arshad, Additional Secretary (Task Force), Agriculture Department Punjab chaired the Technical Advisory Committee meeting held at CCRI Multan on 27.08.2020. Mr. Bilal Israel, Chairman, Cotton R&D Board, Punjab; Dr. Saghir Ahmad, Director Cotton Punjab; Dr. Zahid Mahmood, Director CCRI Multan along with other representatives and officials attended the meeting. The Committee devised management strategy of cotton crop during the next fortnight.

Exposure Visit of Chief Executives of NGOs

A delegation of NGOs working on cotton including Dr. Shafiq Ahmad, Regional Director BCI; Mr. Zafar Wahga, CEO Smart Agriculture; Dr. Shahid Zia, CEO Lok Sanjh; Mr. Muhammad Mansoor, Project Manager Smart Agriculture and Mr. Muhammad Tayyab, AC, Lok Sanjh Foundation visited CCRI Multan.

texture and alkaline in reaction. Soil pH was 8.37, electrical conductivity was 3.13 mS cm^{-1}, organic matter content was 0.68%, extractable phosphorus remained 18.3 mg kg^{-1} soil and extractable potassium remained 179.4 mg kg^{-1}. Post-harvest sample analyses revealed that there was no change in soil texture while pH in normal tillage plot was 8.41 while in reduced tillage plot pH was 8.31. Electrical conductivity remained at 3.24 mS cm^{-1} in normal tillage and 3.31 mS cm^{-1} in reduced tillage plot, organic matter content remained at 0.65% in normal tillage plot and 0.88% in reduced tillage plot, extractable phosphorus at 17.7 mg kg^{-1} soil in normal tillage while 25.4 mg kg^{-1} in reduced tillage plots, extractable potassium at 175.6 mg kg^{-1} and 189.7 mg kg^{-1} in reduced tillage plots (Table 6.13). Plant growth and development parameters were recorded from normal tillage and reduced tillage plots at maturity. The plant height was 174 cm and 165 cm, number of nodes 48 and 47, inter nodal length 3.62 and 3.43 cm, number of bolls per plant 10 and 10, boll weight 3.14 and 3.09 g, seed cotton yield 295 kg ha^{-1} and 250 kg ha^{-1} in normal tillage and reduced tillage plots, respectively (Table 6.13). Data on fiber traits revealed that, staple length was 27.1 and 27.8 mm, uniformity index was 81.6 and 83.9%, micronaire was 5.0 and 5.1, fiber strength was 26.8 and 26.2 g/tex in normal tillage and reduce tillage plots, respectively.

Table 6.13 Summary of parameters taken in normal tillage and reduce tillage plot

Parameters	Height (cm)		Node		Inter node (cm)		Boll per plant		Boll weight (g)		Yield (kg ha^{-1})	
	NT	RT	NT	RT	NT	RT	NT	RT	NT	RT	NT	RT
Pant character	174	165	48	47	3.62	3.43	10	10	3.14	3.09	295	250
Soil parameters			**pH**		**EC (mS cm^{-1})**		**OM (%)**		**Extractable-P (mg kg^{-1})**		**Extractable-K (mg kg^{-1})**	
Pre-planting soil properties			8.37		3.13		0.68		18.3		179.4	
			NT	RT	NT	RT	NT	RT	NT	RT	NT	RT
Post-harvest soil properties			8.41	8.32	3.24	3.31	0.65	0.88	17.7	25.4	175.6	189.7

6.2.2 Does phosphorus application time affect root development and cotton productivity

Plants are sessile organisms; therefore, soil conditions of their standing ground are very important for growth, development, and completion of life cycle. Plants take up the available nutrients and water from the soil to support their life. Physicochemical properties of soils along with fertility status determine the fate of growing crops. Crop utilization of applied fertilizer phosphorus is generally low due to sorption and precipitation reactions in soils. Consequently, a large accumulation of phosphorus takes place over the years, particularly in the soils that receive regular and liberal rates of P applied to each crop in a cropping system. This is mainly because the applied P is usually fixed very quickly and is retained in the top layers of the soil leading to P-fixation in soil. The residual P accumulated from previous additions can influence not only speciation and availability of P but also the availability of other nutrients. Under these circumstances, it is necessary to ascertain the optimum time of P application that not only increase the P use efficiency but also reduce the cost of chemical P fertilizer. There exit a contradiction on the appropriate time of P application to cotton crop. However, according to many researches, application of P as basal dose is the recommended practice for crops. Moreover, farmers do not pay much attention to the time of phosphorus fertilizers application and thus end up with the lower efficiency of applied phosphorus. However, due to various reasons, it is not always feasible to apply the entire P as basal dose because less P is required at the time of planting. Under such circumstances, it is appropriate to know whether split applications of P or delayed application is practicable without any loss in yield and P use efficiency. Keeping in view, the significance of optimum time of P application for improving the soil phosphorus availability and productivity of cotton, present experiment was conducted to find out the appropriate phosphorous application time in cotton crop.

A field experiment was conducted at the experimental area of Central Cotton Research Institute, Multan during the cotton crop season 2020-21. Two cotton genotypes viz. CYTO-511 and Cyto-535 were selected for the study. The treatments were laid out in RCBD with split-plot arrangement (P application time main plots; genotypes: sub-plots). Crop was sown on May 18, 2020. The detail of treatments applied is given below:

Treatments	P application time		
	Pre-sowing	25 DAP	50 DAP
T1	0	0	0
T2	50	0	0
T3	0	50	0
T4	0	25	25

Field was divided into four blocks to check indigenous soil nutrient status and variability. For this purpose pre-plant composite soil samples were collected from the plough layer of experimental field before imposition of treatments. Physical and chemical characteristics of the soil samples were determined. Results indicated that the soil is silt loam in texture and alkaline in reaction. Soil pH varied from 8.19 to 8.35, electrical conductivity from 2.00 to 3.30 mS cm^{-1}, organic matter content from 0.64% to 0.88%, extractable phosphorus from 17.7 to 24.3 mg kg^{-1} soil and extractable potassium from 188 to 202 mg kg^{-1} soil across the field (Table 6.14).

Table 6.14 Physical and chemical characteristics of soil at pre-planting

Block No.	pH	EC (mS cm^{-1})	O.M (%)	Extractable-P (mg kg^{-1} soil)	Extractable-K (mg kg^{-1} soil)
1	8.19	3.30	0.80	18.5	201
2	8.31	3.27	0.87	24.3	188
3	8.35	2.00	0.64	21.6	192
4	8.33	2.07	0.64	17.8	202

After cotton picking, composite soil samples were collected from each plot subjected to different P treatments and analyses performed in the laboratory for different soil parameters. Results revealed that pH varied from 8.34 to 840, EC ranged from 1.06 to 1.44, OM varied from 1.12 to 1.47%, extractable P from 23.7 to 48.2 mg kg^{-1} soil and extractable K 185.0 to 208.1 mg kg^{-1} soil in different P treatments. Generally, the values of all parameters increased in post-harvest samples as compared to pre-planting samples, except EC that showed a decrease over initial level (Table 6.15).

Table 6.15 Physical and chemical characteristics of soil at post-harvest

P application time	pH	EC (mS cm^{-1})	OM (%)	Extractable-P (mg kg^{-1} soil)	Extractable-K (mg kg^{-1} soil)
Control	8.34	1.15	1.12	23.7	185.0
Full at Sowing	8.36	1.06	1.34	42.8	208.1
Full at 25 DAP	8.42	1.46	1.41	43.1	198.1
½ at 25+½ at 50 (DAP)	8.44	1.44	1.47	48.2	195.8

Data on plant structure development were recorded at maturity. In plots where P was applied pre-planting, the main stem height, number of nodes on main stem and inter-nodal length remained higher over control as well as over other P application treatments (Table 6.16). Averaged across genotypes, main stem height varied from 91 to 119 cm, number of nodes on main stem varied from 35 to 43 and intermodal distance from 2.66 to 2.58 cm among different treatments. Similarly, the root growth was also higher in those plots where P was applied at pre-planting and at 25 DAP as compared to those where P was applied in two splits i.e. ½ at 25 +½ at 50 DAP and also in control (Figure 6.3).

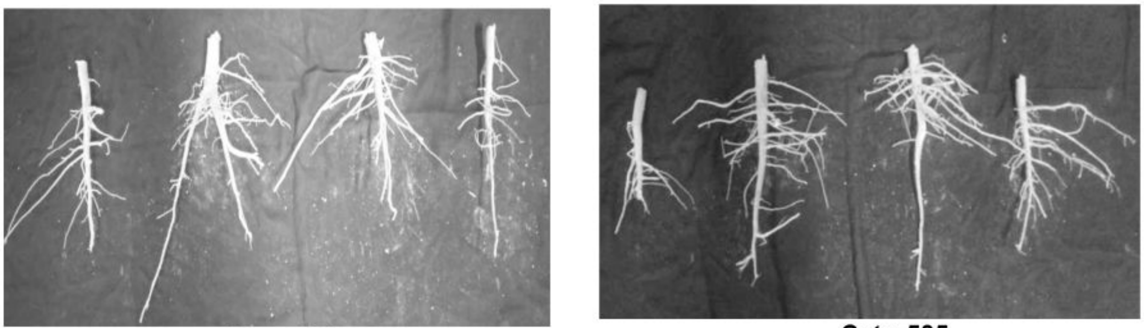

Figure 6.3 Root growth at maturity in two genotypes under different P treatments

Table 6.16 Plant structure at maturity in two genotypes under different P treatments

P application time	Height (cm)			Node			Inter-nodal length (cm)		
	Cyto-511	Cyto-535	Av.	Cyto-511	Cyto-535	Av.	Cyto-511	Cyto-535	Av.
Control	91	91	91	37	33	35	2.43	2.73	2.58
Full at Sowing	110	127	119	39	46	43	2.81	2.74	2.78
Full at 25 DAP	102	115	109	38	41	40	2.71	2.80	2.76
½ at 25 +½ at 50 DAP	101	111	106	40	40	40	2.54	2.77	2.66
Genotype		*			*			ns	
P application time		*			ns			ns	
Interaction		ns			ns			ns	

The fresh weight of different plant parts was determined from harvested plant samples. Data revealed that fresh weight of leaf, stalk and root was higher in plots where P was applied at pre-planting and at 25 DAP as compared to those where P was applied in two splits ½ at 25 DAP+½ at 50 DAP and with no P (Table 6.17). In treatment where P was applied at sowing fresh weight of leaf, stalk and root increased by 48%, 45%, 86% in Cyto-511 and 26%, 20%, 57% in Cyto-535 as compared to those where P applied in two splits ½ at 25 DAP+½ at 50 DAP.

Table 6.17 Fresh weight of different plant parts at maturity in two genotypes under different P treatments

P application time	Leaves weight (g)		Stalk weight (g)		Root weight (g)	
	Cyto-511	Cyto-535	Cyto-511	Cyto-535	Cyto-511	Cyto-535
Control	52.5	76.0	65.8	133.0	11.3	12.0
Full at Sowing	88.3	105.7	128.1	212.0	28.0	30.7
Full at 25 DAP	90.2	99.7	125.3	207.8	22.7	25.7
½ at 25 +½ at 50 DAP	59.8	83.3	88.2	177.0	15.0	19.3
Genotype		*		*		*
P application time		*		*		*
Interaction		ns		*		ns

Seed cotton yield, bolls per plant, and boll weight varied among different P treatments and between cotton genotypes. Delayed application of P caused increase in seed cotton yield and its components. The maximum seed cotton yield was observed in the treatment where P was applied at 25 DAP as compared to pre-planting P application and split application of P at ½ 25 DAP+½ 50 DAP in both cotton genotypes (Table 6.18).

Fiber traits such as staple length, uniformity index, micronaire and fiber strength varied considerably among treatments and between genotypes. In plots where P was applied at sowing staple length, uniformity index, micronaire and strength were improved as compared to P applied at 25 DAP or in two splits as ½ at 25 DAP+½ at 50 DAP, and control (Table 6.19).

Table 6.18 Seed cotton yield and it components in two genotypes under different P treatments

P application time	Boll per plant		Boll weight (g)		Yield (kg ha^{-1})	
	Cyto-511	Cyto-535	Cyto-511	Cyto-535	Cyto-511	Cyto-535
Control	5	4	2.23	2.30	109	218
Full at Sowing	7	7	2.73	3.51	243	458
Full at 25 DAP	8	9	2.89	3.19	328	541
½ at 25 +½ at 50 DAP	7	8	2.78	3.07	221	439
Genotype	*		*		*	
P application time	*		ns		*	
Interaction	*		ns		*	

Table 6.19 Fiber traits in two genotypes under different P treatments

P application time	Staple length (mm)		Uni. index (%)		Micronaire		Strength (G/Tex)	
	Cyto-511	Cyto-535	Cyto-511	Cyto-535	Cyto-511	Cyto-535	Cyto-511	Cyto-535
Control	27.3	26.8	80.4	82.1	4.4	4.9	27.4	26.1
Full at Sowing	28.5	27.7	83.4	82.9	4.5	4.9	28.7	28.5
Full at 25 DAP	26.3	26.2	81.7	80.8	4.6	5.0	27.5	25.0
½ at 25 +½ at 50 DAP	27.5	26.5	82.0	80.7	4.3	4.3	27.8	26.7
Genotype	*		ns		*		*	
P application time	*		*		*		*	
Interaction	ns		ns		*		ns	

6.2.3 Improving resource use efficiency and soil health by integrating seasonal crops in cotton

Cotton is an industrial crop as well as cash crop for the farmers in Pakistan. The area and production of cotton in the country are lower to fulfill annual industrial demand of 15 million bales. Cotton cultivated area has shifted to other season crops like rice, maize and sugarcane due to economic factors. One option to meet the country's demand is the vertical expansion of cotton plant to gain better yields per unit area. The other viable options adopted by different neighboring countries are to intercrop other crops along with cotton. Intercropping is the proven option of vertical expansion of cotton that can help to ensure both subsistence and disposable income to the farmers. Long duration with initially slow growing cotton and short duration fast maturing crop appeared to be the most compatible companion crops in the intercropping system that may prove to enhance productivity and economics of the farmers. The overall productivity in terms of land equivalent ratio (LER) and cotton yield equivalent ratio are generally higher in intercropping system than that in sole stand. The productivity and efficiency of intercropping system depends, to the large extent, on the nature and extent of plant competition and the spatial arrangement and densities of the component crops. Farmers are developing different crop production systems to increase productivity and sustainability since ancient times. This includes crop rotation, relay cropping and intercropping of major crops with other crops. However, several factors like cultivar selection, seeding ratios, planting pattern and competition between mixture components affect the growth of species in intercropping system. A new experiment was designed with the objectives to increase the farm income per unit land area and for making efficient utilization of available resources with concurrent improvement in soil health. One cotton genotype was grown along with different crops as intercrops. Detail is given below:

T1	Cotton-sole
T2	Cotton-straw mulch
T3	Cotton-Rice
T4	Cotton-Soybean
T5	Cotton-Cluster bean

Pre-plant composite soil samples were collected from the plough layer of experimental field before imposition of treatments. Physical and chemical characteristics of the soil samples were determined. Results indicated that the soil is silt loam in texture and alkaline in reaction. Soil pH varied from 8.35 to 8.46, electrical conductivity from 2.26 to 2.66 mS cm^{-1}, organic matter content from 0.59 to 0.98%, extractable potassium (K) from 114 to 144 mg kg^{-1} soil and extractable sodium from 376 to 511 mg kg^{-1} soil across the field (Table 6.20).

Table 6.20 Physical and chemical characteristics of soil at pre-planting

Sample No.	pH	EC (mS cm^{-1})	OM (%)	Ext. K (mg kg^{-1} soil)	Ext. Na (mg kg^{-1} soil)
1	8.40	2.63	0.66	155	452
2	8.47	2.30	0.66	114	376
3	8.42	2.23	0.59	144	388
4	8.46	2.66	0.98	144	509
5	8.35	2.45	0.93	134	511
6	8.34	2.26	0.97	134	410

Plant structure development in different treatments was recorded at maturity. Main stem height, nodes on main stem and inter-nodal length varied among different treatments. Plant height varied from 143.7 to 165.7 cm, numbers of nodes on main stem from 41 to 50 and inter nodal distance from 3.27 to 3.48 cm in different treatments. Maximum height was observed in cotton-straw mulch treatment (165.7 cm, while minimum height of 143.7 cm was observed in cotton-cluster bean treatment (Table 6.21).

Table 6.21 Effect of intercropping on plant structure development

Treatment	Height (cm)	Nodes	Inter
Cotton-sole	151.3	46	3.27
Cotton- Straw Mulch	165.7	50	3.29
Cotton-Rice	163.7	49	3.27
Cotton-Soybean	157.7	46	3.41
Cotton-Cluster Bean	143.7	41	3.48
Statistical effect	*	*	ns

Data revealed that seed cotton yield, number of bolls per plant and boll weight varied significantly among various treatments. Number of bolls per plant varied from 5 to 17, boll weight ranged from 3.03 to 4.00 g and seed cotton yield from 277 to 507 kg ha^{-1}, in different treatments. Maximum seed cotton yield (507 kg ha^{-1}) and number of bolls per plants (17) were observed in cotton-rice intercropping system. Soybean crop failed due to high temperature and severe insect pest attack. Rice crop yielded 512 kg ha^{-1} paddy rice while cluster bean produced 130 kg ha^{-1} (Table 6.22)

Table 6.22 Effect of intercropping on yield and yield attributing factors

Treatment	Boll per plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})	Intercrop yield (kg ha^{-1})
Cotton-sole	13	3.03	338	--
Cotton-Straw Mulch	10	4.00	307	--
Cotton-Rice	17	3.30	507	512
Cotton-Soybean	16	3.70	307	--
Cotton-Cluster Bean	5	3.41	277	130
Statistical effect	*	*	*	

Soil temperature was recorded during the reproductive growth stage of crop. Moreover, post-harvest soil samples were collected after final picking of cotton. Data regarding moisture content and bulk density of soil were measured. Results revealed that soil temperature varied from 37.2 to 39.6^{0}C, the moisture content ranged from 12.3 to 17.5% and from 14.6 to 20.8 %

in bed and furrows, respectively, while bulk density ranged from 1.41 to 1.58 (g/cc) and from 1.49 to 1.62 (g/cc) in bed and furrows, respectively, in different treatments (Table 6.23).

Table 6.23 Effect of intercropping on soil moisture content and bulk density

Treatment	Moisture %		Bulk Density (g/cc)		Soil Temp (^{0}C)
	Bed	Furrow	Bed	Furrow	
Cotton-sole	12.3	15.1	1.47	1.60	39.6
Cotton- Straw Mulch	17.5	20.1	1.53	1.62	37.2
Cotton-Rice	13.5	20.8	1.41	1.49	37.6
Cotton-Soybean	14.9	20.0	1.56	1.57	38.0
Cotton-Cluster Bean	14.1	14.6	1.58	1.56	39.6
Statistical Effect	*	*	ns	*	*

Fiber traits such as staple length, uniformity index, micronaire and fiber strength varied among different treatments. Staple length ranged from 26.7 to 27.8 mm, uniformity index from 81.6 to 83.5%, micronaire from 4.4 to 4.9 and strength 25.0 to 27.5 g/tex in different treatments (Table 6.24)

Table 6.24 Effect of intercropping on fiber traits

Treatment	Staple length (mm)	Uni. index (%)	Micronaire	Strength (G/Tex)
Cotton-sole	26.7	81.6	4.9	25.0
Cotton- Straw Mulch	27.3	83.6	4.9	26.2
Cotton-Rice	27.4	82.9	4.8	26.0
Cotton-Soybean	27.8	83.5	4.8	27.5
Cotton-Cluster Bean	27.2	83.4	4.4	26.5

Land equivalent ratio (LER), area time equivalent ratio (ATER) and cotton yield equivalent ration (CYER) were measured in different treatments. LER indicate the efficient utilization of land and higher value of LER showed better utilization of land, ATER indicate efficient utilization of land within given time, less value of ATER than LER showed the best utilization within given time and CYER indicate the addition befits from inter crop in term of seed cotton. Cotton-rice intercropping treatment LER, ATER and CYER were higher which indicated cotton-rice intercropping is more suitable and economical for farmer (Tale 6.25).

Table 6.25 Effect of intercropping on economic analysis

Treatment	LER	ATER= (LERxDc/Dt)	CYER=SCY+(IYxIYP/PSC)
Cotton- Straw Mulch	0.91	N/A	N/A
Cotton-Rice	1.60	1.6x120/180=1.06	763
Cotton-Soybean	0.91	N/A	N/a
Cotton-Cluster Bean	0.81	0.81X120/180=0.54	375

LER: Land Equivalent Ratio, ATER: Area Time Equivalent Ratio, CYER=Cotton Yield Equivalent Ratio Dc=Time taken by intercrop, Dt= Total time taken by system, IY= Intercrop yield, IYP= Intercrop yield Price, PSC=Price of one kg seed cotton

6.3 Plant-Water Relationships

6.3.1 Adaptability of genotypes to water stress conditions

By the twenty-first century, a considerable progress has been made in industry, economy and finance as well as great innovations in medicine; human health sector and in extending the lifespan. In spite of all this progress, today, more than 1 billion people, nearly a sixth of the world's population, suffer from chronic hunger and malnutrition due to a lack of food. In addition, nearly 800 million people are under-nourished. A serious concern is that the world's hunger has been increasing at a rapid pace in recent years. The vast majority of the world's hungry people live in developing countries. Southern Asia also faces the greatest hunger burden with about 280 million undernourished people.

One of the important reasons for undernourishment, malnutrition and hunger is global and regional drought, which reduces agricultural production. In addition to annual drought-related agricultural losses, long-term technology-increased global grain production, the principal indicator of food security, is currently growing slower than the population increase rate. Future prospects are not encouraging since it will require an increase in food production of nearly 70% to feed 2 billion more people by the mid of the century. This situation is further complicated by climate warming, which is assumed to intensify droughts, increasing their area, strength, duration and leading to a further reduction of agricultural production. In years, when moderate-to-intensive drought covers more than 20% of the world's main agricultural areas, there is less food production than what the world needs for consumption. The situation has already deteriorated in the twenty-first century, when in the first 17 years, world grain production was below the consumption and in almost half of the years grain production was 3–6% below consumption. Moreover, in all of these years, drought was the major cause affecting food security and world's sustainability. Although, drought cannot be prevented, instead, it can be detected early and damages to agriculture could be predicted well in advance of harvest in order to provide on time food assistance to avoid hunger. Therefore, one of the most important tasks for prediction of food insecurity is to detect drought early and estimate agricultural production losses several months ahead of harvest. Drought effect not only decreases plant height, shoot growth rate, and yield but also diminishes root growth. It has been found from the earlier studies that varieties/cultivars in each species vary from one another in their reaction to drought conditions, signifying that drought tolerance in these groups can be improved through breeding. Physiological traits linked with drought tolerance in cotton have strong relationship with yield parameters. For example, photosynthetic rate, which significantly decreases with the imposition of water stress, can be used, effectively, for germplasm screening under drought conditions. Since, the germplasm with genetic variability may exhibit differential response under normal and water deficit conditions, regular screening of emerging germplasm need to be carried out for better adaptability and sustainable production. The following studies were, therefore, conducted to evaluate advanced cotton genotypes for drought tolerance characteristics under field conditions. Outcome of this study will help to understand the relationship of different physiological and growth traits of cotton and their direct and indirect effects related to cotton productivity.

A field experiment was conducted at the experimental area of Central Cotton Research Institute, Multan during the cotton crop season 2020-21. A total of twelve cotton genotypes viz. CIM-775, CIM-785, CIM-875, Cyto-533, CYTO-535, CYTO-536, CYTO-537, GH-Hamalyia, GH-Sanabal CRIS-1/19, CRIS-2/19 and CRIS-3/19 were evaluated for their performance under two water regimes applied on the basis of leaf water potential (LWP) i.e. -1.6 $\pm$ 0.2 MPa Ψ_w (normal irrigation; NS) and -2.4 $\pm$ 0.2 MPa Ψ_w (water stressed; WS). The treatments were laid out in RCBD with split-plot arrangement (water stress main plots; genotypes: sub-plots). Crop was sown on April 18, 2020. Water stress was imposed at squaring phase i.e. at 40 days after planting that continued till crop maturity. Leaf water potential was continuously monitored by employing Pressure Chamber Technique. The quantity of irrigation water applied was measured through "Cut Throat Flume" during the season. Total quantity of water applied was 2854 m^3 in NS plots and 1984 m^3 in water stressed plots. The precipitation received was 269.6 mm during the crop growth period.

Data on plant structure and development were recorded at maturity. Main stem height, nodes on main stem and inter-nodal length varied significantly with water regime and among the genotypes. Main stem height ranged from 129 to 203 cm, nodes on main stem from 41 to 49 and inter-nodal length from 3.17 to 4.17 cm in different genotypes under normal irrigation. In water stress conditions, the main stem height ranged from 100 to 165 cm, nodes on main stem from 33 to 44 and inter-nodal length from 2.83 to 3.85 cm in different genotypes. Averaged across water regimes, main stem height varied from 117 to 184 cm, nodes on main stem from 37 to 46 and inter-nodal length from 3.00 to 4.01 cm. Imposition of water stress caused a decrease of 12.1% in main stem height, 7.3% in nodes on main stem and 4.30% in inter-nodal length, irrespective of genotypes (Table 6.26).

Table 6.26 Plant structure at maturity in cotton genotypes under two water regimes

Genotype	Height (cm)			Node			Inter-Node (cm)		
	NS	WS	Avg	NS	WS	Avg	NS	WS	Avg
CIM-775	149	147	148	44	40	42	3.38	3.82	3.60
CIM-785	145	119	132	41	37	39	3.55	3.23	3.39
CIM-875	203	165	184	49	43	46	4.17	3.85	4.01
Cyto-533	130	104	117	41	37	39	3.17	2.83	3.00
Cyto-535	154	135	145	43	44	44	3.57	3.09	3.33
Cyto-536	148	128	138	44	40	42	3.37	3.23	3.30
Cyto-537	136	100	118	40	34	37	3.45	2.90	3.18
GH-Hamaliya	129	116	123	40	38	39	3.28	3.07	3.18
GH-Sanabal	156	134	145	45	33	39	3.45	4.02	3.74
Cris-1/19	147	135	141	41	41	41	3.62	3.33	3.48
Cris-2/19	145	143	144	43	43	43	3.39	3.30	3.35
Cris-3/19	150	149	150	43	43	43	3.53	3.46	3.50
Mean	149	131		42	39		3.49	3.34	
Treatment (Tr)		*			ns			*	
Genotype (G)		*			*			*	
TrxG		*			*			*	

Leaf area (LA) and leaf fresh weight per leaf varied significantly among genotypes and between water regimes. Leaf area ranged from 24.7 to 115.0 cm^2 and leaf fresh weight from 1.39 to 4.77 g in different genotypes, irrespective of water regimes. The imposition of water stress decreased LA and leaf fresh weight by 28.7% and 28.3 %, respectively (Table 6.27).

Table 6.27 Leaf area and fresh weight in different genotypes under two water regimes

Genotype	Leaf area (cm^2)			Leaf fresh weight (g)		
	NS	WS	Avg	NS	WS	Avg
CIM-775	77.3	53.7	65.5	3.14	1.91	2.53
CIM-785	70.3	56.7	63.5	2.84	2.29	2.57
CIM-875	115.0	89.0	102.0	4.77	3.67	4.22
Cyto-533	71.0	40.3	55.7	2.79	1.90	2.35
Cyto-535	66.7	42.3	54.5	2.49	2.10	2.30
Cyto-536	30.3	24.7	27.5	2.01	1.39	1.70
Cyto-537	71.0	29.7	50.4	2.95	1.62	2.29
GH-Hamaliya	67.7	32.7	50.2	2.44	1.81	2.13
GH-Sanabal	77.0	66.7	71.9	3.16	1.96	2.56
Cris-1/19	71.3	45.0	58.2	2.96	1.76	2.36
Cris-2/19	50.3	42.3	46.3	1.86	1.76	1.81
Cris-3/19	46.3	57.7	52.0	2.85	2.43	2.64
Mean	67.9	48.4		2.86	2.05	
Treatment (Tr)	*			*		
Genotype (G)	**			**		
TrxG	*			ns		

Proline content, relative water content (RWC) and chlorophyll SPAD values varied significantly among genotypes and between water regimes. The proline ranged from 7.5 - 13.5 (µg g^{-1} FW), RWC from 71.1 - 91.4%, and chlorophyll content (SPAD) from 48.2 to 55.3 in different genotypes, irrespective of water regimes. The imposition of water stress increased proline content from 9.2 to 11.7 (µg g^{-1} FW), decreased RWC from 84.7 to 76.4%, and also lowered chlorophyll content from 54.5 to 51.1, on overall basis (Table 6.28).

Data revealed that seed cotton yield, number of bolls per plant and boll weight varied significantly among the genotypes and under water regimes. Number of bolls per plant varied from 9 to 26, boll weight from 1.53 to 3.78 g, and seed cotton yield from 360 to 1315 kg ha^{-1}, in different genotypes, irrespective of water regimes. With the imposition of water stress, seed cotton yield decreased from 867 to 653 kg ha^{-1}, bolls per plant from 20 to 15 and boll weight from 3.01 to 2.61 g irrespective of the genotypes. Water stress decreased the seed cotton yield, number of boll per plant and boll weight by 24.7%, 25.0% and 13.3% respectively. The genotype CIM-775 produced the maximum seed cotton yield of 1315 kg ha^{-1} with 22 bolls per plant and boll weight of 2.75 g in normally irrigated plots, similarly under water stress condition CIM-775 maintained highest yield (Table 6.29). The positive interactions among water regimes and genotypes for yield parameters reveal that the genetic variability and their differential response to varied conditions can help in varietal selection for better yield performance and use of identified desirable traits in breeding programs.

Table 6.28 Proline content, relative water content and chlorophyll SPAD values in different genotypes under two water regimes

Genotype	Proline content (µ g g^{-1} FW)			RWC (%)			Chlorophyll (SPAD)		
	NS	WS	Avg	NS	WS	Avg	NS	WS	Avg
CIM-775	8.9	12.9	10.9	85.7	76.6	81.2	57.2	50.4	53.8
CIM-785	8.5	11.5	10.0	86.6	75.7	81.2	51.2	52.0	51.6
CIM-875	9.8	11.2	10.5	89.3	71.1	80.2	56.6	48.2	52.4
Cyto-533	11.1	14.4	12.8	91.4	76.1	83.8	56.0	54.5	55.3
Cyto-535	5.8	9.5	7.7	84.6	79.4	82.0	56.1	52.0	54.1
Cyto-536	7.4	12.0	9.7	76.7	72.9	74.8	52.0	50.9	51.5
Cyto-537	10.2	12.6	11.4	86.3	83.2	84.8	55.1	52.3	53.7
GH-Hamaliya	12.2	13.5	12.9	81.0	74.8	77.9	57.6	52.1	54.9
GH-Sanabal	7.5	8.9	8.2	83.8	72.3	76.1	54.6	48.6	51.6
Cris-1/19	7.4	10.4	8.9	82.4	72.9	77.7	49.3	46.4	47.9
Cris-2/19	11.7	12.9	12.3	85.7	84.3	85.0	50.2	54.1	52.2
Cris-3/19	9.4	10.5	10.0	83.3	81.7	82.5	58.0	51.7	54.9
Mean	9.2	11.7		84.7	76.4		54.5	51.1	
Treatment (Tr)	*			*			*		
Genotype (G)	**			*			**		
TrxG	**			ns			**		

Table 6.29 Seed cotton yield and yield components in different genotypes under two water regimes

Genotype	Boll per plant			Boll weight (g)			Yield (kg ha^{-1})		
	NS	WS	Avg	NS	WS	Avg	NS	WS	Avg
CIM-775	22	21	22	2.75	2.67	2.71	1315	956	1136
CIM-785	16	12	14	3.35	2.82	3.09	1076	717	897
CIM-875	12	10	11	3.33	3.11	3.22	1017	717	867
Cyto-533	20	16	18	3.60	2.70	3.15	777	598	688
Cyto-535	21	13	17	3.52	3.02	3.27	897	777	837
Cyto-536	18	18	18	2.95	2.50	2.73	777	478	628
Cyto-537	15	12	14	3.14	2.55	2.85	957	717	837
GH-Hamaliya	23	19	21	2.54	2.69	2.62	955	777	866
GH-Sanabal	26	9	18	3.78	3.12	3.45	837	778	808
Cris-1/19	21	12	17	1.70	1.53	1.62	598	360	479
Cris-2/19	20	19	20	2.87	2.48	2.68	598	478	538
Cris-3/19	21	21	21	2.61	2.12	2.37	598	478	538
Mean	20	15		3.01	2.61		867	653	
Treatment (Tr)	*			*			*		
Genotype (G)	*			*			**		
TrxG	*			*			**		

Staple length, uniformity index, micronaire and fiber strength varied among genotypes and between water regimes. The staple length ranged from 24.1 to 29.0 mm, uniformity index from 80.6% to 86.0%, micronaire from 4.1 to 5.5 and fiber strength from 23.0 to 30.7 G/Tex in different genotypes, irrespective of water regimes. The imposition of water stress caused a decrease in staple length, uniformity index and strength (Table 6.30).

Table 6.30 Fiber traits in different cotton genotypes under two water regimes

Genotype	Staple length (mm)			Uni-Index			Micronaire			Strength		
	NS	WS	Mean	NS	WS	Mean	NS	WS	Mean	NS	WS	Mean
CIM-775	26.6	25.5	26.1	84.1	83.4	83.8	5.0	5.1	5.1	26.8	25.0	25.9
CIM-785	27.1	26.6	26.9	82.7	82.0	82.4	4.9	4.5	4.7	27.5	26.7	27.1
CIM-875	27.9	27.2	27.6	86.0	83.9	85.0	4.9	5.3	5.1	27.2	26.2	26.7
Cyto-533	27.1	26.4	26.8	84.4	84.4	84.4	5.0	5.3	5.2	26.0	25.8	25.9
Cyto-535	27.4	27.2	27.3	82.2	82.1	82.2	4.3	4.7	4.5	28.6	28.5	28.6
Cyto-536	29.0	27.3	28.2	85.1	81.9	83.5	4.4	4.1	4.3	30.7	27.3	29.0
Cyto-537	26.0	25.9	26.0	83.7	83.1	83.4	5.5	5.2	5.4	24.3	24.9	24.6
GH-Hamaliya	25.5	25.1	25.3	81.1	81.7	81.4	4.8	5.3	5.1	25.2	25.0	25.1
GH-Sanabal	27.4	26.3	26.9	83.8	82.4	83.1	4.4	4.9	4.7	28.9	27.0	28.0
Cris-1/19	24.6	24.1	24.4	80.6	81.4	81.0	4.7	5.1	4.9	23.6	23.0	23.3
Cris-2/19	24.3	25.5	24.9	83.2	82.8	83.0	5.1	5.3	5.2	27.6	23.3	25.5
Cris-3/19	28.3	27.7	28.0	83.1	83.4	83.3	5.2	4.7	5.0	27.4	28.7	28.1
Mean	26.7	26.3		83.3	82.7		5.0	5.0		27.0	26.0	
Treatment (Tr)	ns			ns			ns			*		
Genotype (G)	**			*			*			*		
TrxG	ns			ns			ns			ns		

6.3.2 Exogenous application of bio-chemicals to improve drought tolerance in cotton

Increasing scarcity of irrigation water is a principal threat to sustainable production of cotton. Water-deficit stress is a major environmental factor restricting more than a third of the arable land for cultivation around the world. Drought is a common abiotic stress during the cotton-growing season, which causes a series of negative effects on cotton growth, yield and fiber quality. Cotton is dreadfully drought sensitive crop and is prone to yield reduction by drought, because drought stress is a complex phenomenon that affects the physiology of cotton plant. In addition, cotton is a very susceptible plant to the quantity of irrigation water and therefore, irrigation management is very complicated. The flowering and boll-forming stage is the key yield determinant period of cotton plants. Water stress occurring during this stage will undoubtedly seriously affect cotton development and final productivity. During the last decade, the foliar application of plant growth regulators and biomolecules, such as brassinosteroids and polyamine has become an established procedure in crop production to increase yield and quality of the crop under abiotic stresses as drought.

Foliar application of plant growth regulator, at low concentrations, plays an important role in plant's defense systems against biotic and abiotic stresses. These bio-chemicals are involved in the regulation of plant physiological processes including stomatal closure, chlorophyll and protein synthesis, nutrient uptake, transpiration, and photosynthesis. Studies have indicated that exogenous application of bio-chemicals may lead to improvements in morpho-physiological traits that are involved in determination of plant yield. Furthermore, application of bio-chemicals induces the degradation of reactive oxygen species and increase the activity of antioxidant enzymes especially under water stress. The objective of the present work was to study the possible role of bio-chemicals in mitigating water deficit stress and quantification of parameters that improve cotton productivity. Biochemical applied along with their concentration are given in Table 6.31.

Table 6.31 Bio-chemicals and their concentration applied through foliar spray in two cotton genotypes

Bio-chemicals	Water treatments	
	No stress (NS)	Water stress (WS)
IAA @150 µM	NS	WS
Calotrope Leaf Ext. @ 50 ml/L	NS	WS
Salicylic acid @ 20 mM	NS	WS
$AgNO_3$ @ 40 µM	NS	WS
Acetic acid @ 50 mM	NS	WS
Control (Water alone)	NS	WS

Survey of Cotton Crop 2020

14.07.2020
District Lodhran & Bahawalpur

14.07.2020
PSC farm Perowal, Vehari, Malsi, Duniapur.

10.07.2020
Muzafargarh, DG Khan and Rajanpur areas.

09.07.2020
Khanewal, kabirwala, Abdul hakeem, Shorkoat, T. T Singh, Rajana, kamaliya, chichawatni, Kasowal and Mian Channu.

The crop was sown on April 18, 2020 in a randomized complete block design with split-split plot arrangement. Bio-chemicals were applied through foliar sprays; first application starting from squaring stage and subsequent applications after 20 days intervals. Two cotton genotypes CIM-678 and CIM-303 were used as test crop. The NPK fertilizers were applied to soil according to recommended fertilizer doses. Standard production and management practices were adopted.

Plant structure development in different treatments was recorded at maturity. Main stem height, nodes on main stem and inter-nodal length varied among different treatments. In normal irrigated plots (NS), main stem height varied from 165.7 to 185.7 cm, number of nodes on main stem from 43 to 51 and inter-nodal length from 3.59 to 4.12 cm in CIM-678, while in CIM-303 main stem height varied from 120.3 to 153.3 cm, number of nodes on main stem from 41 to 43 and inter-nodal length from 3.20 to 3.65 cm in different treatments. However, in water stressed plots (WS), the main stem height varied from 139.7 to 171.3 cm, number of nodes on main stem from 39 to 44 and inter-nodal length from 3.47 to 3.86 cm in CIM-678, while in CIM-303 the main stem height varied from 115.3 to 127.3 cm, number of nodes on main stem from 38 to 41 and inter-nodal length from 2.84 to 3.11 cm in different treatments (Table 6.32).

Table 6.32 Plant structure at maturity in different treatments under no stress and water stress condition in two genotypes

Treatments	Water level	Height (cm)		Node		Inter-nodal	
		CIM-678	CIM-303	CIM-678	CIM-303	CIM-678	CIM-303
Control	NS	166.3	134.7	46	41	3.62	3.29
	WS	140.3	115.3	39	39	3.57	2.93
$AgNO_3$	NS	183.3	153.3	50	41	3.75	3.20
	WS	164.0	127.3	40	40	3.86	2.92
Salicylic Acid	NS	165.7	123.3	43	43	3.59	3.03
	WS	139.7	119.0	40	39	3.47	2.90
Acetic acid	NS	182.0	120.3	45	42	4.12	3.65
	WS	164.7	117.0	43	41	3.86	3.11
Calotrope Leaf Ext.	NS	179.3	132.0	51	43	3.90	3.29
	WS	149.7	117.7	44	38	3.65	2.98
IAA	NS	185.7	141.7	47	42	3.91	2.93
	WS	171.3	114.0	43	41	3.62	2.84
Treatment (Tr)		*		*		*	
Genotype (G)		*		*		ns	
Biochemical (Bio)		**		ns		*	
TrXG		*		ns		*	
TrxBio		*		*		ns	
BioxG		*		ns		ns	
TrXGXBio		*		ns		ns	

Proline content, relative water contents (RWC) and chlorophyll (SPAD) varied significantly among different treatments and between genotypes under normal irrigation and water stress condition. The proline content varied from 8.22 to 11.22 µg g^{-1} FW, RWC from 72.6 to 91.4% and chlorophyll (SPAD) values from 46.4 to 57.6 in CIM-678, while in CIM-303 the proline content varied from 8.86 to 11.57 µg g^{-1} FW, RWC from 73.2 to 89.3% and chlorophyll (SPAD) values from 48.6 to 58.0 in different treatments, irrespective of water regimes. Maximum proline contents were observed where calotrope leaf extract was applied and maximum chlorophyll contents were observed where acetic acid and IAA applied (Table 6.33).

Seed cotton yield and yield contributing factors differed variably among various treatments and between genotypes under normal irrigation and water stress condition. Data on seed cotton yield, boll per plant and boll weight were recorded at maturity. In normal irrigated plots (NS), bolls per plant varied from 16 to 33, boll weight from 2.47 to 2.71 g and seed cotton yield from 646 to 1004 kg ha^{-1} in CIM-678, while in CIM-303 boll per plant varied from 14 to 29, boll weight from 2.64 to 3.04 g and seed cotton yield from 466 to 753 kg ha^{-1} in different treatments. However, in water stressed plots (WS), bolls per plant varied from 15 to 25, boll weight from 2.09 to 2.60 g and seed cotton yield from 646 to 753 kg ha^{-1} in CIM-678, while in CIM-303 bolls per plant varied from 12 to 19, boll weight from 2.35 to 2.95 g and seed cotton yield from 359 to 538 kg ha^{-1} in different treatments. Foliar application of bio-chemicals enhanced the yield and yield attributing factors in normal irrigation and water stress condition as compared to control, however in normal irrigation and water stress condition maximum yield was obtained in the treatment where salicylic acid @ 20 mM was applied in both genotypes (Table 6.34). Heavy rain in the month of September damaged opened bolls on the crop and the overall severe white fly infestation not only limited fruit production directly but also through secondary effect of sooty mould that damaged the fruit, thereby causing ultimate reduction in yield.

Table 6.33 Proline content, relative water content and chlorophyll content (SPAD) in different treatments under no stress and water stress condition in two genotypes

Treatments	Water level	Proline (µg g^{-1} FW)		RWC (%)		Chlorophyll (SPAD)	
		CIM-678	CIM-303	CIM-678	CIM-303	CIM-678	CIM-303
Control	NS	8.60	8.92	84.4	85.3	50.2	55.1
	WS	9.09	9.65	72.6	73.2	52.3	54.1
AgNO3	NS	8.22	8.86	87.1	89.3	54.6	56.6
	WS	9.67	9.89	74.9	74.4	48.2	48.6
Salicylic Acid	NS	8.80	9.79	84.4	89.2	52.0	51.2
	WS	10.04	11.19	77.9	80.3	52.0	50.9
Acetic acid	NS	9.29	9.09	87.7	86.7	57.6	49.3
	WS	9.57	9.62	78.5	74.3	46.4	52.1
Calotrope Leaf Ext.	NS	9.15	9.39	91.4	85.7	56.0	57.2
	WS	11.22	11.57	76.1	76.6	50.4	54.5
IAA	NS	8.74	9.69	88.3	85.0	56.1	58.0
	WS	9.02	9.69	76.0	78.7	51.7	52.0
Treatment (Tr)		**		*		**	
Genotype		*		ns		**	
Biochemical		**		**		**	
TrXG		*		ns		**	
TrxBio		ns		ns		**	
BioxG		**		**		**	
TrXGXBio		**		ns		**	

Table 6.34 Seed cotton yield and yield attributing factors in different treatments under no stress and water stress condition in two genotypes

Treatments	Water level	Boll per plant		Boll weight (g)		Yield (kg ha^{-1})	
		CIM-678	CIM-303	CIM-678	CIM-303	CIM-678	CIM-303
Control	NS	17	14	2.47	2.70	732	466
	WS	15	12	2.41	2.39	646	359
$AgNO_3$	NS	16	19	2.47	2.78	932	574
	WS	23	19	2.09	2.38	753	395
Salicylic Acid	NS	25	22	2.63	2.78	1004	753
	WS	21	19	2.60	2.53	753	538
Acetic acid	NS	26	14	2.56	2.69	789	502
	WS	25	15	2.50	2.35	646	359
Calotrope Leaf Ext.	NS	17	18	2.71	2.64	825	574
	WS	21	15	2.32	2.49	681	430
IAA	NS	33	29	2.56	3.04	646	717
	WS	20	13	2.39	2.95	646	430
Treatment (Tr)		*		*		*	
Genotype		**		*		**	
Biochemical		ns		ns		*	
TrXG		**		ns		ns	
TrxBio		ns		ns		ns	
BioxG		ns		**		ns	
TrXGXBio		ns		ns		ns	

Staple length, uniformity index, micronaire and fiber strength varied between genotypes. The staple length ranged from 24.5 to 26.2 mm, uniformity index from 79.0 to 81.4%, micronaire from 4.3 to 5.2 and fiber strength from 24.6 to 26.1 G/Tex in CIM-678, while in CIM-303 staple length ranged from 24.5 to 26.4 mm, uniformity index from 79.8 to 82.8%, micronaire from 4.9 to 5.3 and fiber strength from 23.3 to 26.8 G/Tex in different treatments, irrespective of water regimes. The imposition of water stress caused a decrease in staple length, uniformity index and strength (Table 6.35).

Table 6.35 Fiber traits in different treatments under no stress and water stress condition in two genotypes

Treatments	Water level	Staple length (mm)		Uni-Index (%)		Micronaire		Strength (G/tex)	
		CIM-678	CIM-303	CIM-678	CIM-303	CIM-678	CIM-303	CIM-678	CIM-303
Control	NS	26.0	26.2	80.6	82.4	4.4	5.2	25.4	24.8
	WS	24.7	25.3	80.3	81.1	4.5	5.0	26.1	24.2
$AgNO_3$	NS	26.2	25.8	80.9	82.2	4.6	5.3	24.9	24.0
	WS	24.7	25.6	79.0	82.2	5.0	5.3	25.3	24.8
Salicylic Acid	NS	25.3	26.4	79.4	81.9	4.6	4.9	25.0	24.9
	WS	24.5	24.9	79.4	82.8	4.6	5.0	25.3	26.3
Acetic acid	NS	25.6	26.4	79.9	81.2	4.3	5.1	25.7	26.5
	WS	24.8	24.5	80.0	81.0	4.4	4.9	25.7	24.1
Calotrope	NS	25.3	26.1	81.4	82.0	4.5	5.2	24.6	24.4
Leaf Ext.	WS	24.9	25.3	79.6	79.8	5.2	4.9	25.6	26.8
IAA	NS	25.6	25.8	81.1	82.1	4.5	5.3	25.8	23.3
	WS	25.2	25.0	81.0	81.6	4.7	5.1	25.7	24.4
Treatment (Tr)		ns		ns		ns		ns	
Genotype		*		*		*		*	
Biochemical		ns		ns		ns		ns	
TrXG		ns		ns		ns		ns	
TrxBio		ns		ns		ns		ns	
BioxG		ns		ns		ns		ns	
TrXGXBio		ns		ns		ns		ns	

6.4 Seed Physiology

6.4.1 Evaluation of stress alleviating biochemical in cotton under heat stress conditions on cottonseed health and productivity

Cotton crop is mainly grown for fiber but has many other valuable uses. Cotton seed has 30% starch, 25% semidrying oil and 16-20% protein. Cotton is also an important source of vegetable oil and cottonseed cake.It is also required in edible oil industries. Cottonseed quality is also determined by its content of mineral and non-mineral nutrients such as N, C, S, K, Ca, Zn, and Fe because of their direct or indirect contribution to: protein synthesis (such as N, K, S); oil (such as C and N); carbohydrates (such as C, K, B); metabolite synthesis (Cu, Zn, Fe, Mg); integrity of cell membrane and cell wall structure (Ca and B); cell membrane, lipid synthesis, energy transfer and phosphorylation reactions, carbohydrate metabolism, and nutrient active uptake processes (P); and osmoregulation, stomatal closure, carbohydrate movement, and nutrient mobility (K). Cotton plant has a natural mechanism to prevent from different stresses such as inadequate and inconsistent rainfall, salinity, water shortage, extreme temperature, and some other factors are not only limiting crop yields by square drying, premature floral abscission and failure to set the bolls also associated with poor productivity and maily effect the cottonseed health. Considering present situation, it is imperative to switch to some more sophisticated techniques that shall combat abiotic environmental challenges and improve crop yield efficiently . In many cases stress alleviating chemicals are needed to maintain proper plant size and to promote boll set and early maturity to combat with high temperature conditions. Stress alleviating chemicals are substances when applied in small amounts modify the growth of plant and ultimately enhancing seed vigor and seed health.The use of these compounds to maintain plant height, shoot fresh weight, shoot dry weight, root fresh weight , root dry weight, square retention, net assimilation rate, net photosynthetic rate.

They play a key role in internal control mechanism of plant growth by interacting with key metabolic processes such as nucleic acid and protein synthesis. Foliar spays of biochemicals could also be used to manipulate leaf duration, dry matter accumulation and net photosynthetic rate in plants. The spray application technique is a key process influencing the effectiveness of a foliar biochemical. Foliar application provides a means of quickly correcting plant defense mechanism, when stress identified on the plant.

The aim of this investigation was to evaluate the response of cotton in terms of growth, cottonseed health and productivity to stress alleviating biochemical under heat stress conditions . A field experiment was conducted to evaluate the efficacy of exogenously applied bio-regulators as thermal stress alleviators on two cotton genotypes viz. GH-Hamaliya(heat tolerant) and CIM-789(heat susceptible). The crop was sown on 15th of April 2020 in a randomized complete block design (RCBD) with split-Split plot arrangement (genotypes; main plot,seed heat treatment ;subplots and biochemicals treatments; sub split plot). The experiment was divided into two sets prior to sowing i.e. Seed without any heat treatment (NHT, Set-A) and seed with heat treatment (HT, Set-B) at 60ºC for 5 hours.

A total of five stress alleviating bio-chemicals were applied though foliar sprays for improving heat tolerance in both sets.Foliar sprays of specified solution concentrations were initiated when the crop reached fruiting phase i.e. 35-40 days old. subsequent foliar sprays were done after a suitable interval (15-20 days); to make a total of three sprays. The crop was fertilized with recommended NPK fertilizers. Standard production and management practices were adopted. The detail of treatments applied is given below:

Treatments	Bio-chemicals	Dose
T1	Control	Water alone
T2	Indole Acetic Acid(IAA)	80 mg/L
T3	Hydrogen peroxide(H_2O_2)	30 mg/L
T4	Salicylic Acid (SA)	50 mg/L
T5	Moringa Leaf Extract(MLE)	30 ml/L
T6	Ascorbic Acid	150 mg/L

Composite soil samples from the plough layer were collected before imposition of treatments. Physical and chemical characteristics of the soil were determined. The results indicated that the experimental soil has silt loam texture, alkaline pH, medium levels of organic matter, available-P, extractable-K, extractable-Zn and B (Table 6.36).

Table 6.36 Physical and chemical characteristics of soil at pre- planting

Characteristics	Values
pH	7.89
ECe (dSm^{-1})	2.59
Organic matter (%)	1.22
$NaHCO_3$-P (mg Kg^{-1})	10.2
NH_4OAc-K(mg Kg^{-1})	131
AB-DPTA-Zn (mg Kg^{-1})	0.88
Hot water extractable-B (mg Kg^{-1})	0.61
Textural class	silt loam

The assessment of seed quality parameters was done from the mature cotton seeds. Results indicated that the exogenously applied bio-regulators on two cotton genotypes viz. GH-Hamaliya(heat tolerant) and CIM-789(heat susceptible) improved seed health parameters such as seed germination, seed index, oil and crude protein content. Average across the genotypes, in both sets(NHTand HT), pH, electrical conductivity, Na and K concentrations from the seed exudates decreased by seed heat treatment and foliar application of biochemicals in T2 showed the maximum change where AA was applied @80 mg/L. Biochemical analysis of the oil revealed that the free fatty acids of both genotypes (both sets) were within safe limits i.e. less than1.0%.**In CIM-789**, NHT set, seed germination varied from 35-68%, seed index from 6.6-

7.7g, oil content from 13.2 to19.1 % and crude protein from 17.0 to 27.2 % in different treatments.while in HT, set seed germination varied from 37-68%, seed index from 6.6-7.8g, oil content from 13.0 to20.2 % and crude protein from 18.5 to 27.5 % in different treatments.

In GH-Hamaliya, NHT set, seed germination varied from 52-72%, seed index from7.3-8.1g, oil content from 14.7 to 20.1 % and crude protein from 20.4 to 28.7 % in different treatments.while in HT, set seed germination varied from 64-79%, seed index from 7.5-8.7g, oil content from 15.0 to22.5 % and crude protein from 20.9 to 29.0 % in different treatments.(Table 6.37). Seed germination pattern of both genotypes in NHT and HT are depicted in Figure 6.4.

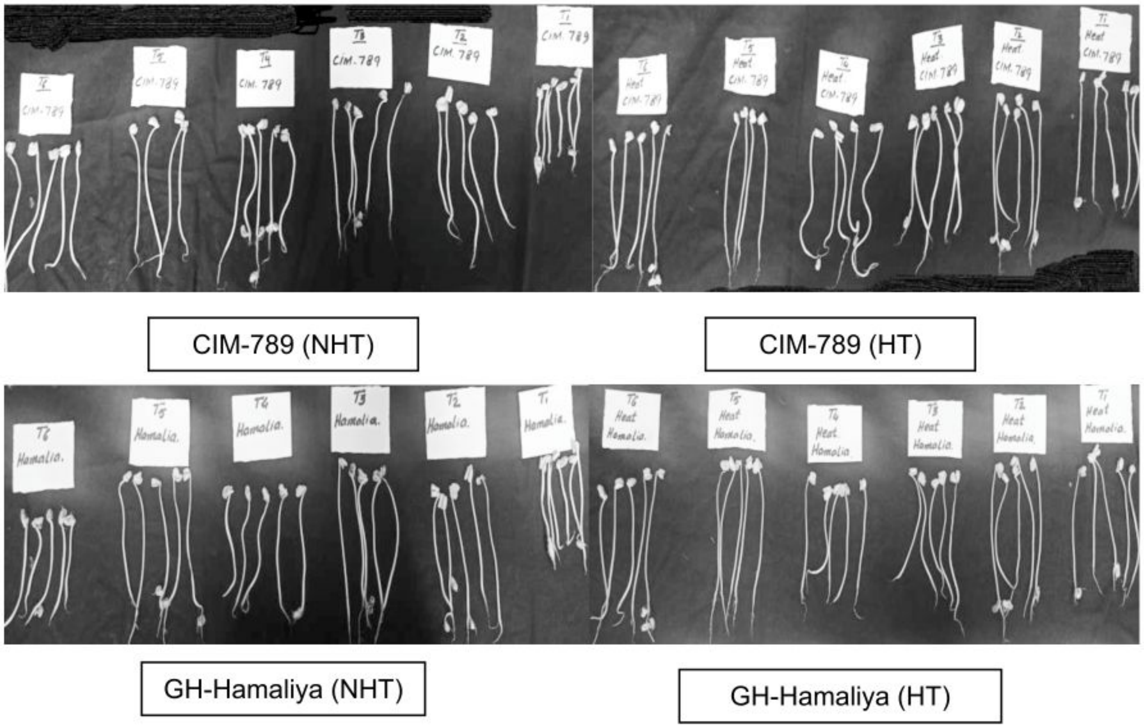

Fig 6.4 Germination pattern of CIM-789 and GH-Hamaliya in NHT & HT treatments

Table 6.37 Effect of seed primed or foliar applied stress alleviating biochemical on seed quality parameters

Treatments/ Dose	pH				Mean
	CIM-789		GH-Hamaliya		
	NHT	HT	NHT	HT	
T1: Control(Water alone)	7.37	7.23	7.29	6.97	**7.22**
T2: IAA @ 80 mg/L	7.27	7.21	7.21	7.12	**7.20**
T3: H_2O_2 @ 30 mg/L	7.24	7.19	7.21	7.20	**7.21**
T4: SA @50 mg/L	7.26	7.21	7.23	7.12	**7.21**
T5:MLE @ 30 mg/L	7.26	7.12	7.25	7.09	**7.18**
T6: AA @150 mg/L	7.11	7.10	7.23	7.05	**7.12**
Mean	**7.25**	**7.18**	**7.24**	**7.09**	
EC ($\mu S\ cm^{-1}$)					
T1: Control(Water alone)	237	199	255	194	**221**
T2: IAA @ 80 mg/L	192	155	170	157	**169**
T3: H_2O_2 @ 30 mg/L	248	204	253	125	**208**
T4: SA @50 mg/L	219	146	204	147	**179**
T5:MLE @ 30 mg/L	222	176	222	160	**195**
T6: AA @150 mg/L	225	185	219	172	**200**
Mean	**224**	**178**	**221**	**159**	
Na (%)					
T1: Control(Water alone)	1.01	0.95	0.98	0.84	**0.95**
T2: IAA @ 80 mg/L	0.98	0.78	0.93	0.89	**0.90**

T3: H_2O_2 @ 30 mg/L	0.92	0.88	1.01	0.96	**0.94**
T4: SA @50 mg/L	0.99	0.92	0.89	0.84	**0.91**
T5:MLE @ 30 mg/L	1.00	0.76	1.04	0.90	**0.93**
T6: AA @150 mg/L	0.94	0.90	0.92	0.90	**0.92**
Mean	**0.97**	**0.87**	**0.96**	**0.89**	
		K (%)			
T1: Control(Water alone)	1.36	1.26	1.35	1.03	**1.25**
T2: IAA @ 80 mg/L	1.22	0.96	1.11	0.97	**1.07**
T3: H_2O_2 @ 30 mg/L	1.41	1.26	1.29	1.28	**1.31**
T4: SA @50 mg/L	1.26	1.01	1.23	0.95	**1.11**
T5:MLE @ 30 mg/L	1.37	1.18	1.15	1.02	**1.18**
T6: AA @150 mg/L	1.39	1.25	1.22	1.11	**1.24**
Mean	**1.34**	**1.15**	**1.23**	**1.06**	
		Seed index (g)			
T1: Control(Water alone)	6.6	6.6	7.3	7.5	**7.0**
T2: IAA @ 80 mg/L	7.7	7.8	8.1	8.7	**8.1**
T3: H_2O_2 @ 30 mg/L	7.0	7.1	7.4	7.5	**7.3**
T4: SA @50 mg/L	7.4	7.7	7.8	8.0	**7.7**
T5:MLE @ 30 mg/L	7.2	7.3	7.8	7.9	**7.6**
T6: AA @150 mg/L	7.2	7.2	7.5	7.7	**7.4**
Mean	**7.2**	**7.3**	**7.7**	**7.9**	
		Germination (%)			
T1: Control(Water alone)	52	54	64	66	**59**
T2: IAA @ 80 mg/L	66	68	72	79	**71**
T3: H_2O_2 @ 30 mg/L	35	37	52	64	**47**
T4: SA @50 mg/L	58	60	70	74	**66**
T5:MLE @ 30 mg/L	40	47	62	66	**54**
T6: AA @150 mg/L	68	72	67	70	**69**
Mean	**53**	**56**	**65**	**70**	
		Oil (%)			
T1: Control(Water alone)	13.2	13.0	14.7	15.0	**14.0**
T2: IAA @ 80 mg/L	19.1	20.2	20.1	22.5	**20.5**
T3: H_2O_2 @ 30 mg/L	13.8	16.0	15.7	15.1	**15.2**
T4: SA @50 mg/L	17.6	18.7	17.9	18.7	**18.2**
T5:MLE @ 30 mg/L	17.2	17.4	18.5	19.3	**18.1**
T6: AA @150 mg/L	16.2	17.0	17.3	18.7	**17.3**
Mean	**16.2**	**17.1**	**17.4**	**18.2**	
		Free fatty acid (%)			
T1: Control(Water alone)	0.98	0.80	0.89	0.81	**0.87**
T2: IAA @ 80 mg/L	0.68	0.58	0.59	0.51	**0.59**
T3: H_2O_2 @ 30 mg/L	0.70	0.63	0.81	0.79	**0.73**
T4: SA @50 mg/L	0.67	0.61	0.59	0.54	**0.60**
T5:MLE @ 30 mg/L	0.64	0.62	0.60	0.52	**0.60**
T6: AA @150 mg/L	0.68	0.64	0.64	0.57	**0.63**
Mean	**0.73**	**0.65**	**0.69**	**0.62**	
		Crude protein (%)			
T1: Control(Water alone)	17.0	18.5	20.4	20.9	**19.2**
T2: IAA @ 80 mg/L	26.1	27.5	28.7	29.0	**27.8**
T3: H_2O_2 @ 30 mg/L	21.7	21.7	23.5	24.7	**22.9**
T4: SA @50 mg/L	27.2	27.6	27.7	28.2	**27.7**
T5:MLE @ 30 mg/L	26.3	26.7	27.1	27.8	**27.0**
T6: AA @150 mg/L	25.0	26.3	26.3	26.5	**26.0**
Mean	**23.9**	**24.7**	**25.6**	**26.2**	

7. Transfer of Technology Section

Transfer of Technology Section is playing a significant role to disseminate the research findings/ practices of cotton scientists for the development of new cotton production & seed technology to cotton growers & the stakeholders through information & communication technologies (ICT) / mass media.

7.1 Human Resource Development

7.1.1 Training Programs

The following training programs were arranged during the season:

i) Cotton Production Technology
ii) Advance agronomic practices for better cotton yield
iii) Importance of micronutrients & macro nutrients
iv) Organic Cotton Cultivation
v) Cotton insect pest management
vi) Weed Management
vii) Cotton varieties & their characteristics
viii) Cotton seed technologies
ix) integrated pest management
x) Management of cotton diseases especially for CLCuV
xi) Cotton crop management
xii) Causes of fibre traits deterioration in Pakistan
xiii) Management of PBW & sucking insect pests
xiv) Off-season management of PBW management

Training programs for Field Staff Agri. (Extension) Department/ farmers & with other departments

Date	Organized/ Coordinated by	Venue	Resource Person	Participants
12.03.2020	CCRI,Multan	CCRI, Multan	Dr. Zahid Mahmood & all heads of sections	**Total = 73** Master Trainees from Private sector
27.02.2020	CCRI, Multan& SMART Agriculture, Lodhran	CCRI, Multan	Dr. Zahid Mahmood	**Total = 15** Master Trainees NGO
16.04.2020	CCRI,Multan & Ext.deptt.of KPK & Baluchistan	CCRI, Multan	Dr. Zahid Mahmood	**Total = 40** Agriculture research and extension officials from KPK and Balochistan
15.09.2020	PCSI, Multan	CCRI, Multan	Dr. Zahid Mahmood	**Total = 16** Cotton Selectors
12.10.2020	CABI & CCRI, Multan	CCRI, Multan	Dr. Zahid Mahmood	**Total = 35** Growers from Baluchistan
28.10.2020	South Asian Sourcing Pvt. Ltd	CCRI, Multan	Dr. Zahid Mahmood	**Total = 13** Master Trainee
03.11.2020	Sangtani Women Rural Development Organization	CCRI, Multan	Dr. Zahid Mahmood	**Total = 37** Master Trainee
12.11.2020	Lok Sanjh	CCRI, Multan	Dr. Zahid Mahmood	**Total = 37** Master Trainees (Layyah, Bhakkar, TT Singh, Fort Abbas, Bahawalnagar, Chishtian)

a. Training Program

CCRI Multan organized one-day training program on "Revival of Cotton Crop and Pink bollworm Management" in collaboration with Kashtkar Foundation Pakistan on February 04, 2021. Mr. Saqib Ali Ateel, Secretary Agriculture, South Punjab Secretariat chaired the program. More than 200 farmers attended the program. Lectures on soil health improvement, production technology of new varieties, agronomic practices, insect pests management with special emphasis on Pink bollworm delivered.

b. Training on "Project Monitoring & Evaluation System (PMES)"

Mr. Ihsan Ullah and Ms Aqsa Noreen from Planning Wing, Ministry of National Food Security & Research imparted practical training on "Project Monitoring & Evaluation System (PMES)" at the institute on September 2,2020 for incorporating projects activities and financial reports on monthly and quarterly basis into the online web-based system. The scientific staff of the institute attended the program.

7.1.2 TV Programs/ Tellops

The following TV sots /programs were conducted during the season:

Date	TV Channel	Topic	Resource Person	Remarks
12.03.2020	Rohi	Objectives of Master Trainee Refresher Course	Dr.Zahid Mahmood	03-minutes
-do-	Neo TV	-do-	-do-	03-minutes
05.03.2020	Hum TV	Effects of rainfall on crops	do-	02-minutes
06.04.2020	Rohi	Cotton Sowing Recommendations	Dr.Zahid Mahmood	03-mintutes
08.04.2020	-do-	"Recommendations about early stage of cotton cultivation"	-do-	-do-
13.04.2020	-do-	Seed delinting	-do-	-do-
15.04.2020	-do-	Live morning show کپاس کے کاشتکار بھائیوں کو مفید مشورے *	Dr.Fiaz Ahmad	1hr & 30-minutes
16.04.2020	NeoTV	Objectives of online training program	Dr.Zahid Mahmood	03-mintutes
-do-	-do-	TeleCotton Service & Seed providing at farmer's door step	Mr.Sajid Mahmood	03-mintutes
18.04.2020	-do-	ہماری کپاس	Dr.Zahid Mahmood	1 hour
20.04.2020	GTv	کپاس کے لئے زمین کا انتخاب،کپاس کے بیج کا انتخاب اور زمین کی تیاری بارے سفارشات	Dr.Muhammad Naveed Afzal	03-mintutes
11.08.2020	Rohi	Management of Cotton Crop in August	i.Dr.Fiaz Ahmad ii.Dr.M. Naveed Afzal	02-minutes
12.08.2020	Rohi	Current cotton situation and its issues	Dr.Zahid Mahmood	40-minutes
20.08.2020	Rohi	Cotton gene pool	Dr.M.Idrees Khan	03-minutes
03.09.2020	ARY	Management of Cotton Crop in September	Sajid Mahmood	02-minutes
27.08.2020	Rohi	Current Cotton Crop Situation	i.Dr.Fiaz Ahmad ii.Sajid Mahmood	03-minutes
22.10.2020	Rohi	Recommendations on Clean Cotton Picking	Dr.Zahid Mahmood	03-minutes
07.10.2020	ARY	WC-Day	Dr.Zahid Mahmood	02-minutes
-do-	AAP	-do-	-do-	03-minutes
-do-	PTV	-do-	Dr.Khalid Abdullah	-do-
-do-	Sama	-do-	Dr.Zahid Mahmood	-do-
-do-	Rohi	-do-	-do-	-do-
-do-	PTV	Reasons of low cotton production	Dr.Khalid Abdullah	40-minutes
16.10.2020	Sama	Objectives of PBW seminar	Dr.Zahid Mahmood	03-minutes
-do-	News 1	-do-	-do-	03-minutes
23.10.2020	HUm	Reasons of cotton decline	Mr.Sajid Mahmood	03-minutes
09.11.2020	Neo TV	Performance of CCRI Varieties	Dr.Zahid Mahmood	03-minutes
-do-	PTV	Best practices for better cotton yield	Dr.Zahid Mahmood	03-minutes
16.12.2020	Rohi	Off-season management of PBW	Dr.Zahid Mahmood	03-minutes
28.12.2020	Neo TV	Use of cotton sticks and PBW management	Dr.Zahid Mahmood	03-minutes
28.12.2020	Sama TV	Off-season management of PBW	Dr.Zahid Mahmood	03-minutes

7.1.3 Radio Programs

The following radio programs were recorded during the season:

Date	Radio	Topic	Resource Person	Remarks
02.04.2020	Radio Pakistan	"Free seed germination lab test in CCRI"	Dr. Zahid Mahmood	Recorded 5-minutes
-do-	-do-	"Cotton varieties & their characteristics"	-do-	Recorded 3-minutes
23.04.2020	-do-	"Soil Analysis & Health"	Dr.Fiaz Ahmad	Recorded 3-minutes
-do-	-do-	"Advance agronomic practices for better cotton yield"	Dr.M.Naveed Afzal	Recorded 3-minutes

7.1.4 Media/Press Coverage

The section arranged media coverage for following event during the season:

Date	Media Coverage
16.04.2020	Online Training Program
29.04.2020	ٹیکنیکل ایڈوائزری کمیٹی سی سی آر آئی ملتان کا پہلا اجلاس
07.10.2020	ورلڈ کاٹن ڈے
13.10.2020	سیکریٹری زراعت جنوبی پنجاب کا سی سی آر آئی ملتان کا دورہ
16.11.2020	4th National Seminar on Pink Bollworm Management
09.11.2020	Visit of media workers delegation

7.1.5 Preparation of Video Clips

Following video clips were prepared and uploaded on social media for farmer's advice/information during the season:

Date	Topic
23.03.2019	Seed delinting through sulfuric acid
04.05.2020	Selection and preparation of soil and seeds before cotton cultivation
11.05.2020	Cotton thinning must be done within 25 to 30 days after planting
21.05.2020	100 % seed germination at CCRI Multan experimental farm
28.05.2020	Farmer's Advisory Message by Dr.Zahid Mahmood
24.06.2020	Fertilizer management for cotton in current scenario: Dr. Fiaz Ahmad
02.07.2020	How to prevent cotton fruit-shedding in hot weather: Dr. Zahid Mahmood
11.07.2020	Cotton Field Survey in three districts i.e Muzaffargarh, D.G. Khan and Rajanpur areas
14.07.2020	Spray method to control cotton pests کپاس کے کیڑوں پر قابو پانے کے لئے سپرے کا طریقہ کار
30.07.2020	Rank growth in cotton & less fruit retention: Dr. Fiaz Ahmed
31.07.2020	Yellowing of cotton crop and its treatment: Dr. Fiaz Ahmed
10.08.2020	Preparation of nutrient solutions for foliar spray on cotton crop: Dr. Fiaz Ahmad
14.07.2020	Testing cotton fibre cotton quality at CCRI, Multan: M.Ilyas Sarwar
21.08.2020	Yellow sticky traps for whiteflies management: Dr.Zahid Mahmood
19.09.2020	CCRI Multan pipeline cotton varieties i.e CIM-678 & Glyphosate in grower field
15.09.2020	Use of Boom Sprayer Machine for
14.09.2020	Fertilizer management of cotton crop in September: Dr. Fiaz Ahmed
08.09.2020	With better cotton management in September-October, we can achieve 80% yield:
05.09.2020	Role of rouging in making pure and quality cotton seeds: Dr.Idrees Khan
01.09.2020	Pink Boll worm Control and Cotton Crop Management in September: Dr.Zahid Mahmood
26.08.2020	Cotton crop management in monsoon: Dr.Fiaz Ahmad
21.08.2020	Yellow sticky traps for whiteflies management: Dr.Zahid Mahmood
01.10.2020	Cotton crop management approaching maturity by Dr.Fiaz Ahmad
04.10.2020	Messages recorded of various dignitaries on the occasion of World Cotton Day
28.12.2020	New cotton varieties of CCRI Multan-2021: Dr.Zahid Mahmood
28.12.2020	new cotton varieties of CCRI Multan 2021
13.01.2021	Control of Pink bollworm with a machine

7.1.6 Press Releases

Sixty Two (62) press releases throughout the season were sent to the press time to time for publication.

7.1.7 Articles

Thirty Five (35) Urdu/English articles with up to date recommendations were composed and sent to the press for the guidance of cotton growers during the season.

7.1.8 Tele-Cotton SMS Service

Following activities regarding Tele-Cotton SMS Service were conducted during the season:

A. Fifteen (15) Tele-Cotton SMS were sent to 22000(approx) cotton growers, extension workers and other stakeholders regarding better crop management during the season.

B. Almost Two Thousand (800) clients of Tele-Cotton were registered in data – base during the season.

7.1.9 Distribution of Printed Material

The following leaflets were distributed among growers, extension workers, agri. students of different colleges/universities etc. & field officers of Agri. Extension (Punjab) for their information and guidance during the season:

- Recommendations of Cotton Variety CIM-496
- Recommendations of Cotton Variety CIM-534
- Recommendations of Cotton Variety CIM-573
- Recommendations of Cotton Variety CIM-608
- Recommendations of Cotton Variety CIM-620
- Recommendations of Cotton Variety Cyto-124
- Recommendations of Cotton Variety Cyto-179
- Recommendations of Cotton Variety Bt.CIM-598
- Recommendations of Cotton Variety Bt.CIM-599
- Recommendations of Cotton Variety CIM-496
- Recommendations of Cotton Variety Bt.CIM-602
- Management of Pink Bollworm
- Recommendations for better seed germination
- *Kapsa Ki Kasht Aur Nighehdasht*
- *Kapas K Beej Ka Ugaaou Aur Behtar Sifarshat*
- *Kapaas mein Potash ki Ahmiyat*
- *Kaps Ki Mealy Bug Aur Oos Ka Insdaad*
- *Kapaas Ki Patta Maror Bemari Sy Bachaou Ki Hikmat-E-Amli*
- *Kapaas ki Meleybug*
- *Kapaas ki gulabi sundi or os ka insdaad*
- *Kapaas ki gulabi sundi ka tadaruk bazarya pb-ropes*
- *CCRI Multan: An introduction*

7.1.10 Agriculture Exhibitions

The institute displayed a stall in agricultural exhibition during the season:

Date	Organized by	Venue	Resource Persons
February 13,2020	Agri.Ext.Deptt. Punjab	Muzafargarh	i. Dr.Noor Muhammad ii. Dr.Khadim Hussain

7.2 Meetings

7.2.1 Cotton Crop Management Group (CCMG)

Following three (03) Cotton Crop Management Group (CCMG) meetings were held at the Institute during the season:

Meeting was attended by all the stakeholders of cotton economy including Vice Chancellor, MNSUA, Multan, Director Generals (DGs) Extension, PW&QC, Research, information and agri scientists, district officers' agriculture extension from Multan, Sahiwal, Bahawalpur and DG Khan Divisions, and senior officials of water management and energy, chief engineers of irrigation department, Punjab, representative of MEPCO, Multan and progressive growers, pesticides & fertilizers' companies' representatives were attended the meetings.

Date/Venue	Chaired by/Special guests
CCRI, Multan	Malik Nauman Ahmad Langrial, Minister for Agriculture, Punjab Mr. Ali Arshad, Additional Secretary (Task Force), Punjab Dr. Khalid Abdullah,Cotton Commissioner, Mintex
11.08.2020	Mr. Ali Arshad, Additional Secretary (Task Force), Punjab
05.09.2020	i.Malik Nauman Ahmad Langrial, Minister for Agriculture, Punjab ii. Mr. Wasif Ali Khurshed, Secretary Agriculture Punjab and Mr. Saqib Ali Ateel, Secretary Agriculture, South Punjab

7.2.2 Cotton Seed Germination Meeting

Makhdoom Khusro Bukhtiar, Minister for National Food Security & Research chaired the meeting on "Cotton Seed Germination" at Islamabad on March 8, 2020. Dr. Muhammad Hashim Popalzai, Secretary MNFS&R; Dr. Khalid Abdullah, Cotton Commissioner, Dr. Zahid Mahmood, Director CCRI Multan along with other officials attended the meeting.

7.2.3 Standing Committee Meeting

15th meeting of the Standing Committee on National Food Security and Research held at National Agricultural Research Center (NARC). Islamabad on January 11,2021 under chairmanship of Sardar Riaz Mehmood Khan Mazari. Dr.Zahid Mahmood .Director of the Institute participated along with all members of this committee.

7.2.4 Punjab Seed Council

54th meeting of Punjab Seed Council was held on 28th January 2021 at Lahore chaired by Minister of Agriculture Punjab for approval of crop varieties. Cotton varieties developed by CCRI Multan viz Bt.CIM-343 and Bt.CIM-663 were approved for general cultivation in Punjab. Both of these varieties are high yielding, heat tolerance, big boll, with high lint %age will boost Punjab cotton production.

7.2.5 Kharif 2020 meeting

Annual Research Program for Kharif 2020 meeting of Adaptive Research Punjab was held at Agriculture House Lahore on March 16, 2020. Dr. Muhammad Anjum Ali, DG, (Ext. & AR) Punjab Lahore chaired the meeting. All SSMS/ DD Adaptive Research Punjab presented farmers problems oriented Research Trials studies. Professors of different Universities and scientists of Basic Research Institutes attended the meeting and they gave suggestion to improve the presented studies.

7.2.6 Cotton Research and Development Board meeting

Cotton Research and Development Board meeting was held on 4th April ,2020 under the Chairmanship of Sohail Mahmood Harral at MNSUA, Multan. Dr Saghir Ahmad Director Cotton/Member Secretary Board presented the research program. Dr Asif Ali VC MNSUA Multan, Khalid Khokhar President Kissan Itehad, Dr Muhammad Zaffar Iqbal Director ABRI FSD, Shehzad Sabir Director Agri Ext Multan Division, Dr Zahid Mahmood Director CCRI representative of PCPA, Progressive growers attended the meeting. The participants emphasized on develop high yield varieties; mechanical picking, improving oil content and reducing cost of production were discussed in the meeting. The members also strongly recommend for announcement of cotton support price, subsidy on Pink Bollworm ropes, pesticides, fertilizers and electricity and increasing funding for research.

7.2.7 Meeting on Issues of Low germination of cotton seed

Meeting regarding factors of low germination of cotton seed and devising strategy for availability of quality seed was chaired by Dr. Abid Mahmood, Director General Agriculture (Research) AARI Punjab on July 16, 2020 at CRS Multan.Dr. Zahid Mahmood, Director and Mr. Sajid Mahmood, Head, Technology Transfer, CCRI Multan attended the meeting.

7.2.8 Meeting for Procurement of Kharif Crops

Meeting of the Punjab Seed Corporation for Procurement of Kharif Crops was held at Lahore on September 10, 2020 under the chairmanship of Dr. Ghazanfar Ali Khan, Managing Director, Punjab Seed Corporation. Dr. Zahid Mahmood, Director, CCRI Multan attended the meeting with other participants.

7.2.9 Cotton Research & Development Board Meeting

A meeting on "Cotton Research & Development Board Meeting" was held at Cotton Research Station, Multan on August 24, 2020 under the chairmanship of Dr.Rao Asif Ali, Vice Chancellor, MNSUA-M. Mr.Sohail Harral co-chaired the meeting. A new chairman of Cotton Research & Development Board Mr. Muhammad Bilal Israel was selected unanimously for next three years. Dr. Muhammad Naveed Afzal & Mr.Sajid Mahmood attended the meeting with other participants.

7.2.10 Preparation of Cotton Calendar

Meeting for finalization of Cotton Calendar was held on December 28, 2020 under the chairmanship of Mr. Saqib Ali Ateel, Secretary Agriculture, South Punjab Secretariat Multan. Dr.Zahid Mahmood .Director of the Institute participated along with all members of this committee

7.2.11 Farmers Advisory Committee Meeting

Twelve (12) farmers' advisory committee meetings were held at the Institute under Dr. Zahid Mahmood, Director of the. Fortnightly recommendations were presented in the meeting for the guidance of cotton growers.

7.2.12 PCCC's Revival Committee meeting

PCCC's Revival committee meeting held at CCRI Multan on December 24, 2020 under the chairmanship of Ex-Vice President, PCCC Mr. Muhammad Arshad, Dr.Zahid Mahmood .Director of the Institute participated along with all members of this committee

7.3 MoU b/w CCRI Multan & PMD, Lahore

CCRI Multan and Pakistan Meteorological Department inked an MoU on February 27, 2020 for generation and dissemination of meteorological data among various stakeholders of the region. Mr. Ajmal Shad, Regional Director, Pak Met, Lahore briefed about the department and the weather data generation facilities. Dr. Zahid Mahmood, Director CCRI Multan informed that the Institute will liaison with the PMD for effective and timely dissemination of weather data to the cotton farmers in the area.

7.4 World Cotton Day

CCRI Multan celebrated the World Cotton Day on 7th October 2020. Mr. Saqib Ali Ateel, Secretary Agriculture, South Punjab Secretariat; Dr. Khalid Abdullah, Cotton Commissioner MNFS&R; Dr. Zahid Mahmood, Director CCRI Multan; Dr. Jasomal, Chairman PCGA, Dr. Shafiq Ahmad, BCI; Mr. Asif Majeed, CEO Kanzo, Mr. Khalid Khokhar, President Kisan Itehad and Mr. Suhail Mahmood Harral, PCGA chaired the program. The speakers highlighted the importance of cotton crop in the economy of Pakistan. Cotton production problems were discussed and measures were suggested for its enhancement and revival in the country. More than 500 participants from various stakeholders, NGOs and farmers attended the program.

7.5 Cotton Walk

On the eve of World Cotton Day at the institute, a walk was arranged in commemorating the importance of cotton for the economy of Pakistan. Mr. Saqib Ali Ateel, Secretary Agriculture, South Punjab Secretariat, Dr. Khalid Abdullah, Cotton Commissioner MNFS&R; Prof. Dr. Asif Ali, Vice Chancellor MNSUAM, Dr. Zahid Mahmood, Director CCRI Multan; Mr. Khalid Khokhar, President Kissan Itehad along with other number of participated in the walk.

7.6 National Seminar on Pink Bollworm Management

CCRI Multan organizes 4th National Seminar on Pink Bollworm Management on November 16, 2020. Syed Fakhar Imam, Federal Minister National Food Security & Research attended the program via zoom link. Mr. Saqib Ali Ateel, Secretary Agriculture South Punjab Secretariat Multan; Mr. Bilal Israel, Chairman Punjab Cotton R&D Board; Dr. Muhammad Ali Talpur, VP, PCCC; Dr. Khalid Abdullah, Cotton Commissioner, Prof Dr Asif Ali, VC, MNSUA Multan, Mr. Hidayat Ullah Bhutto, Director CCRI Sakrand; Dr. Shah Nawaz Khuro, Mr. Khalid Khokhar, President Pakistan Kissan Itehad and cotton researchers, representative of pesticides companies and farmers attended the seminar.

7.7 Participation in Workshop/Conference

Date	Workshop/Conference	Venue	Organized by	Participants
October 23, 2020	"Pesticides Visual Tools Guidelines"	Multan	FAO	i.Dr.Zahid Mahmood ii.Mr.Sajid Mahmood

7.8 Visits

a. Dignitaries

Dignitaries/Delegation	Dated
Syed Fakhar Imam ,MNA, Chairman Kashmir Committee	08.03.2020
Engr. Prof. Dr. Akhtar Ali Malik, Vice Chancellor, NFC Inst of Eng & Technology, Multan	28.02.2020
Mr. Abdul Rasheed Ahmad, Executive Director/CEO, CropLife Pakistan	24.09.2020
Mr.Saqib Ateel ,Secretary South Punjab	13.10.2020
PCGA delegation comprising Dr. Jasomal, Chairman; Mr. Dilip Kumar, Ex Vice Chairman; Mr. Sohail Mehmood, Ex Chairman PCGA	20.10.2020
Dr. Shafiq Ahmad, Regional Director BCI; Mr. Zafar Wahga, CEO Smart Agriculture; Dr. Shahid Zia, CEO Lok Sanjh; Mr. Muhammad Mansoor, Project Manager Smart Agriculture and Mr. Muhammad Tayyab, AC, Lok Sanjh	15.10.2020
Mr.Saqib Ateel ,Secretary South Punjab	04.11.2020
HE Paulo Neves Pocinho, Ambassador, Portugal Embassy Islamabad along with Ms Mariana Pocinho	28.10.2020
Mr. Muhammad Arshad, Consultant, ICARDA	24.12.2020
Mr. Muhammad Arshad, Consultant, ICARDA	24.12.2020
Honorable Syed Fakhar Imam, Minister for National Food Security & Research	30.01.2021

b. Student Study Tour

Name of University/Institution	Participants
University of Agriculture, Faisalabad	70
University College of Agriculture, BZU, Multan	45

7.9 Face book Page CCRI, Multan

A page on Face book www.facebook.com/CCRIM.PK is being regularly updated by the Section to disseminate the research activities of the Institute on social media.

Independence Day Celebration

Tree Plantation (Aug 14, 2020)

8 FIBRE TECHNOLOGY SECTION

Fibre Technology section was established in 1976. The prime objective of Fibre Technology section is to provide technical support to Plant Breeding & Cytogenetics sections in testing of fibre characteristics and spinning potential of newly developed cotton cultivars & strains and facilitates the other sections of the institute as well, to investigate the effect of different agricultural practices on fibre characteristics. The section also extended these facilities to the cotton breeders working in Central Cotton Research Institute Sakrand, Cotton Research Station Ghotki, Cotton Research Station D.I. Khan, Cotton Research Station Mirpur Khas, Cotton Research Station Lasbella, Cotton Research Station Sibbi and to other relevant public and private parties as well. Research activities were focused to study the effect of bio-chemicals' application on cotton fibre properties to improve drought tolerance and the role of stress alleviating chemicals on cotton fibre characteristics under heat stress conditions.

The department was unable to conduct "Quality Survey" for the reported crop year in the core cotton producing districts due to financial constraints. It is unfortunate that Quality survey could not be conducted. Lint samples of commercial cotton varieties are collected from ginning factories and evaluated for quality of lint available in market for spinning industry.

Moreover, the spinning industry of Punjab province was also visited to accumulate information regarding the utilization of cotton fibre with special reference of the cotton fibre traits and others fibres as well in industry along with imported cotton. In-addition the joint proposal by CCRI, Multan & University of Agriculture Faisalabad, entitled, "Development of Artificial Neural Network-based system for intelligent prediction of the potential of high yielding as well as high quality indigenous cotton varieties/genotypes" was submitted for approval.

The achievements are given as under:

8.1 Testing of Lint Samples

The lint samples received from various sections of the institute, research stations of PCCC, government research stations, research scholars of different universities were tested for different fibre characteristics. The section also provided technical support to Pakistan Institute of Cotton Research & Technology, Karachi for the lint samples collected by PICR&T during the Quality Survey of ginning factories from Sindh region, these samples were analyzed at Fibre Technology Section to publish a comprehensive report entitled "Quality Survey of Pakistan Cottons" which reflects a true picture of commercially grown cotton at different locations and this report is fruitful for cotton Breeders, Ginners, Spinners, exporters and all stakeholders of cotton.

The detail of the samples tested is given in Table 8.1.

Table 8.1 Number of Samples Tested for Various Fibre Characteristics

Source	Fibre Length (mm)	Fibre Strength (g tex^{-1})	Micro-naire (µg inch^{-1})	Color grade	Total
Breeding & Genetics Section, CCRI, Multan	8006	8006	8006	4	**24022**
Cyto-genetics Section, CCRI, Multan	2225	2225	2225	0	**6675**
Agronomy Section, CCRI, Multan	8	8	8	8	**32**
Fibre Technology Section, CCRI, Multan	750	750	750	750	**3000**
Plant Physiology/Chemistry, CCRI, Multan	70	70	70	0	**210**
Research Material Director CCRI, Multan	11921	11921	11921	0	**35763**
Cotton Research Station, Mirpur Khas	100	100	100	0	**300**
Cotton Research Station, Sahiwal	156	156	156	0	**468**
Cotton Research Station, Ghotki	745	745	745	0	**2235**
Cotton Research Station, Lasbella	189	189	189	0	**567**
Cotton Research Station, Sibbi	87	87	87	0	**261**
AARI, Faisalabad (Chief Scientist)	58	58	58	0	**174**
FSC & RD, Khanewal	91	91	91	0	**273**
Quality Survey (Sindh)	156	156	156	156	**624**
Research Sholars (MNSUA)	48	48	48	0	**144**
Outside Research Station	3	3	3	0	**9**
Total	**24613**	**24613**	**24613**	**918**	**74757**

8.2 Testing of Commercial Samples

The section has extended the testing services to facilitate private sector. The number of samples tested is given in Table 8.2

Table 8.2 Number of Samples Tested for Various Fibre Characteristics

Source	Fibre Length (mm)	Micronaire (µg inch^{-1})	Fibre Strength (g tex^{-1})	Color grade	Trash (%)	Total
Private Sector	160	160	160	74	30	**584**

8.3 The effect of bio-chemicals application on cotton fibre properties to improve drought tolerance.

The objective of this study was to evaluate the role of bio-chemicals application on cotton fibre properties in improving drought tolerance. This experiment was conducted with the collaboration of Plant Physiology/Chemistry section. Two genotypes were selected for this experiment. The layout of experiment was randomized complete block design with three replications. The sowing and application of chemicals was done by Plant Physiology/Chemistry section. Five plants of both genotypes were tagged from each treatment and from each replication. Picking was done on maturity and ginned at miniature ginning machine. The samples were tested for fibre characteristics on High Volume Instrument (HVI-900A). The results obtained are presented in Table 8.3.

Table 8.3 Fibre characteristics of genotypes CIM-678 and CIM-303 as affected by water stress and bio-chemicals.

Genotype	Water Stress	Bio-Chemicals	Fibre length (mm)	Uni. Index	MIC	Strength (g/tex)	Lint (%)
CIM-678	No Stress	Indole Acetic Acid	25.2	81.1	4.7	25.8	40.3
		Calotrop Leaf Extract	24.9	81.4	4.5	24.6	38.5
		Acetic Acid	24.8	79.9	4.3	25.7	42.0
		Salicylic Acid	24.5	79.4	4.6	25.0	43.1
		$AgNO_3$	24.7	79.0	4.6	24.9	49.1
		Control	24.7	80.3	4.4	25.4	37.6
	Stress	Indole Acetic Acid	25.6	81.0	4.5	25.7	37.8
		Calotrop Leaf Extract	25.3	79.6	4.6	25.6	39.6
		Acetic Acid	25.6	80.0	4.4	25.7	38.9
		Salicylic Acid	25.3	79.4	4.6	25.3	40.3
		$AgNO_3$	26.2	80.9	5.0	25.3	41.6
		Control	26.0	80.5	4.5	26.1	37.6
CIM-303	No Stress	Indole Acetic Acid	25.8	82.1	5.3	23.3	38.5
		Calotrop Leaf Extract	25.3	82.0	5.2	24.4	37.6
		Acetic Acid	26.4	81.2	5.1	26.5	37.7
		Salicylic Acid	24.9	81.9	4.9	24.9	38.9
		$AgNO_3$	25.8	82.2	5.3	24.0	33.1
		Control	26.2	81.2	5.2	24.8	39.6
	Stress	Indole Acetic Acid	25.0	81.6	5.1	24.4	40.6
		Calotrop Leaf Extract	26.1	79.8	4.5	26.8	37.8
		Acetic Acid	24.5	81.0	4.9	24.1	42.6
		Salicylic Acid	26.4	82.8	5.0	26.3	38.2
		$AgNO_3$	25.6	82.2	5.3	24.8	37.6
		Control	25.3	82.4	5.0	24.2	39.6

8.3.1 Genotypic Variation in Fiber Characteristics

Genotype	Fibre length (mm)	Uni. Index	MIC	Strength (g/tex)	Lint (%)
CIM-678	25.2	80.2	4.6	25.4	40.5
CIM-303	25.6	81.7	5.1	24.9	38.5
Water Stress effect on Fiber Characteristics					
Stress	25.6	80.9	4.8	25.4	39.4
No Stress	25.3	81.0	4.8	24.9	39.7
Bio-chemicals effect on Fiber Characteristics					
Indole Acetic Acid	25.4	81.5	4.9	24.8	39.3
Calotrop Leaf Extract	25.4	80.7	4.7	25.4	38.4
Acetic Acid	25.3	80.5	4.7	25.5	40.3
Salicylic Acid	25.3	80.9	4.8	25.4	40.1
AgNo3	25.6	81.1	5.1	24.8	40.3
Control	25.6	81.1	4.8	25.1	38.6

Data on variation in fibre traits in genotypes water stress and biochemical treatments is given table 8.3.1. Results showed that genotype CIM-303 has better fibre length but genotype CIM-678 has better other fibre characteristics. Table 8.3.1 represented the water stress effect on fibre characteristics. Imposed water stress has produced better fiber characteristics. Among the bio-chemicals $AgNO_3$ and control has better fibre length and uniformity index than others, calotrop leaf extract and acetic acid showed better mic value and strength. Acetic acid, salicylic acid and $AgNO_3$ showed better lint percentage than other bio-chemicals.

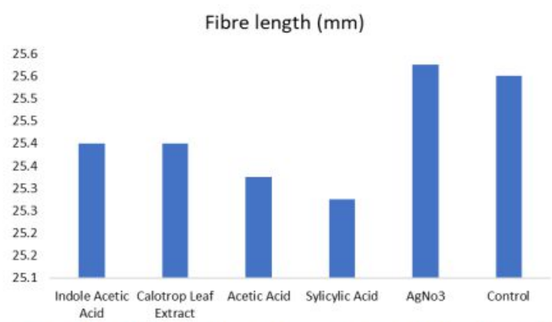

Fig. 8.1 Effect of bio-chemicals on fibre length

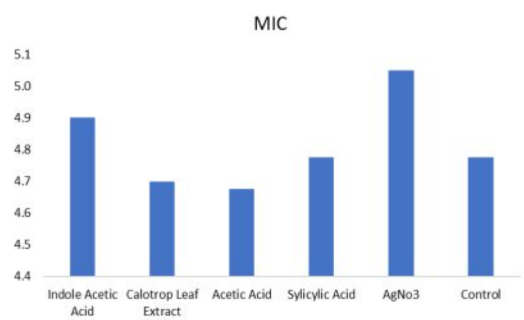

Fig. 8.2 Effect of bio-chemicals on MIC

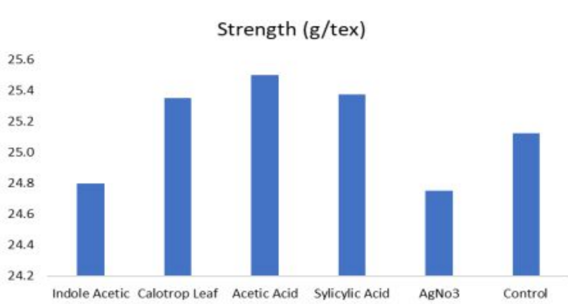

Fig. 8.3 Effect of bio-chemicals on fibre strength

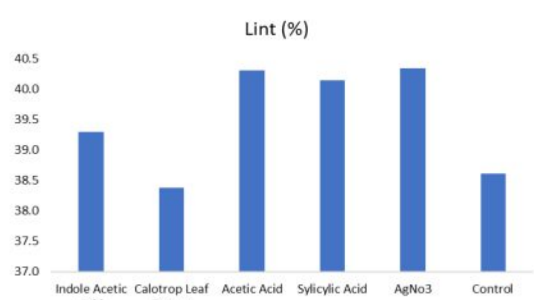

Fig. 8.4 Effect of bio-chemicals on lint percentage

8.4 The role of stress alleviating chemicals on cotton fibre characteristics under heat stress conditions.

The objective of this study was to evaluate the role of stress alleviating chemicals on cotton fibre characteristics under heat stress conditions. This experiment was conducted with the collaboration of Plant Physiology/Chemistry section. Two genotypes were and selected for this experiment. The layout of experiment was randomized complete block design with three replications. The sowing and application of chemicals was done by Plant Physiology/Chemistry section. Five plants of both genotypes were tagged from each treatment and from each replication. Picking was done at maturity and ginned at miniature ginning machine. The samples were tested for fibre characteristics on High Volume Instrument (HVI-900A). The results obtained are presented in Tables 8.4.1 and 8.4.2.

Table 8.4.1 Fibre characteristics of Hamalia and CIM-789 as affected by different stress alleviating chemicals

Genotype	Treatments	Stress alleviating Chemicals	Fibre length (mm)	Uni. Index	MIC	Strength (g/tex)	Lint (%)
Hamalia	Non Heat Stress	Control	26.1	84.0	5.1	25.3	36.2
		Indole Acetic Acid	25.0	83.9	5.4	25.9	35.6
		Hydrogen Peroxide	25.6	81.9	5.1	25.4	37.6
		Salicylic Acid	26.0	85.1	5.3	24.4	36.8
		Moringa Leaf Extract	26.3	84.1	5.1	26.6	36.5
		Ascorbic Acid	25.7	80.5	5.1	24.8	36.8
	Heat Stress	Control	25.3	83.8	4.9	25.1	35.7
		Indole Acetic Acid	25.2	83.4	5.4	25.5	36.9
		Hydrogen Peroxide	26.1	82.4	5.3	25.2	38.4
		Salicylic Acid	25.6	82.4	5.1	26.5	40.6
		Moringa Leaf Extract	26.8	85.0	5.0	26.0	37.4
		Ascorbic Acid	26.5	83.6	5.0	27.4	33.4
CIM-789	Non Heat Stress	Control	25.2	82.4	5.0	25.3	38.4
		Indole Acetic Acid	25.2	81.2	4.6	26.1	37.0
		Hydrogen Peroxide	24.8	81.9	5.0	24.8	35.7
		Salicylic Acid	26.6	84.5	5.4	24.7	35.5
		Moringa Leaf Extract	25.2	84.2	5.3	24.5	39.2
		Ascorbic Acid	25.7	83.7	5.1	25.4	38.4
	Heat Stress	Control	25.5	82.4	5.0	24.5	35.7
		Indole Acetic Acid	26.4	84.2	5.4	23.7	37.2
		Hydrogen Peroxide	24.8	83.0	5.3	22.9	36.1
		Salicylic Acid	26.2	84.0	5.1	26.6	36.3
		Moringa Leaf Extract	26.4	83.6	5.0	27.5	35.0
		Ascorbic Acid	26.4	82.8	5.6	25.4	34.7

Sub Effects

8.4.2 Fiber Characteristics of two genotypes

Genotype	Fibre length (mm)	Uni. Index	MIC	Strength (g/tex)	Lint (%)
Hamalia	25.9	83.3	5.2	25.7	36.8
CIM-789	25.7	83.2	5.2	25.1	36.6
8.4.3 Heat Treatment effect on Fiber Characteristics					
Non Heat Treated	25.6	83.1	5.1	25.3	37.0
Heat Treated	25.9	83.4	5.2	25.5	36.5
8.4.4 Effect of Stress alleviating Chemicals					
Control	25.5	83.2	5.0	25.1	36.5
Indole Acetic Acid	25.5	83.2	5.2	25.3	36.7
Hydrogen Peroxide	25.3	82.3	5.2	24.6	37.0
Salicylic Acid	26.1	84.0	5.2	25.6	37.3
Moringa Leaf Extract	26.2	84.2	5.1	26.2	37.0
Ascorbic Acid	26.1	82.7	5.2	25.8	35.8

The whole data of the experiment presented in Table 8.4 Table 8.4.1 represented the genotype effect on fibre characteristics which showed that genotype Hamalia has better fibre characteristics. Table 8.4.2 represented the treatments effect on fibre characteristics. Heat treated cotton has better fiber characteristics. Table 8.4.3 represented the stress alleviating chemicals effect on fibre characteristics showed that Salicylic Acid and Moringa Leaf Extract have better fibre characteristics than others stress alleviating chemicals.

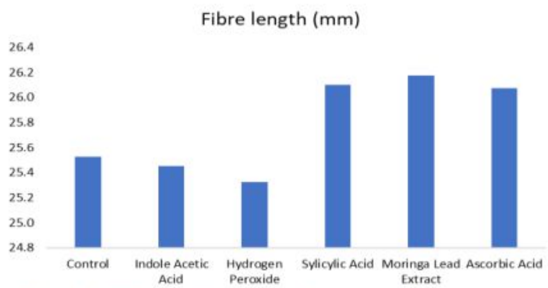

Fig. 8.5 Effect of stress alleviating chemical on fibr length

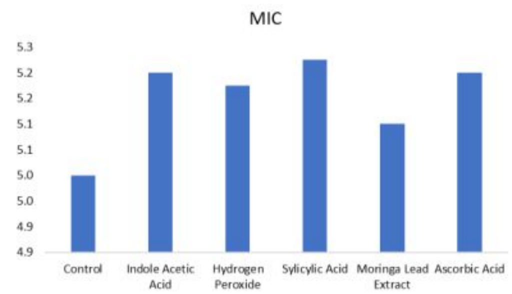

Fig. 8.6 Effect of stress alleviating chemical on MIC

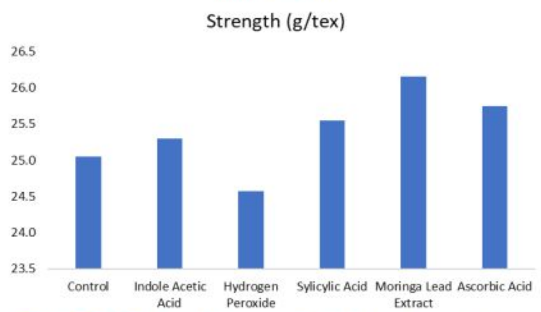

Fig. 8.7 Effect of stress alleviating chemical on fibre strength

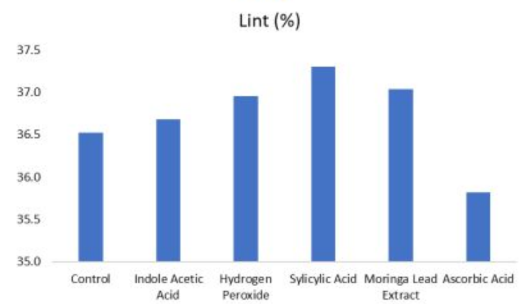

Fig. 8.8 Effect of stress alleviating chemical on lint percentage

8.5 Survey of Spinning Industry of Pakistan

Survey of spinning industry was conducted to collect data regarding the utilization of cotton fibre with special reference of the cotton fibre traits and others fibers as well in industry and to focus the economics comparatives. Seven spinning units were visited in the Punjab to ascertain the cotton fibre and yarn quality being consumed by the spinning industry. The data collected are presented in Table 8.5.

Table 8.5.1 Survey of Spinning Industry

Mill #	No. of Spindles	Production Capacity (100 lb bags /day)	Types of Fibre	Average count	Counts Spun from Pak Cotton	Spun from Imported Cotton
1	46200	850	Polyester, Viscose	25s	10s to 40 s	-
2	10000	1350	Polyester	20s	7s to 30s	-
3	42000	750	Cotton	30s	12s to 52s	52s
4	18700	520	Cotton	30s	10s to 52s	30s, 40s
5	84000	270,000 lbs per day	Cotton, Polyester	13s	20s	24s
6	27840	500	Cotton, Polyester, Viscose Rayon, Linen, Bamboo	26s	20s to 30s	60s to 80s
7	25200	495	Cotton	25s	16s to24s	40s

Table 8.5.2 Comparison of Fibre Traits of Pakistani vs Imported Cotton

Country	Fibre Length (mm)	Strength (g/tex)	Micronaire	Trash %	Rd	+b
Pakistan	27.4	28.0	4.8	8	70	8.5
Imported	28.7	33	4.2	3.5	76	10
Brazil	28.0	31	4.2	3.5	75	10
Afghanistan	28.0	31	4.6	5.2	77	9.7

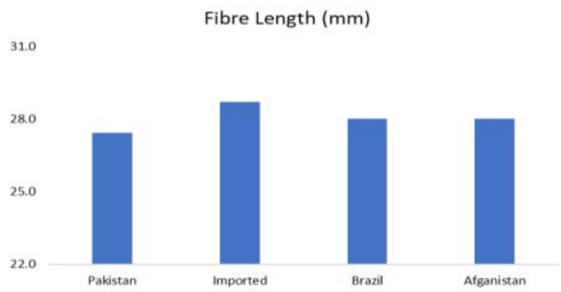

Fig. 8.9 Comparison of fibre length

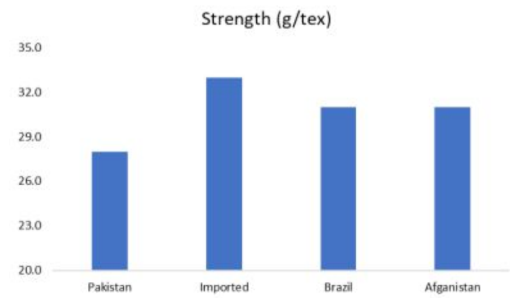

Fig. 8.10 Comparison of fibre strength

Fig. 8.11 Comparison of Micronaire

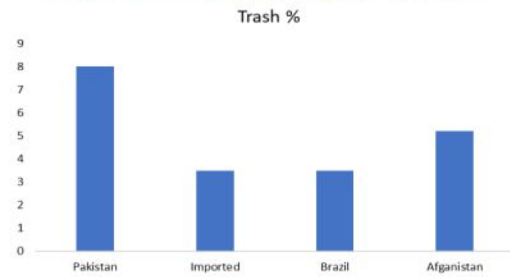

Fig. 8.12 Comparison of trash percentage

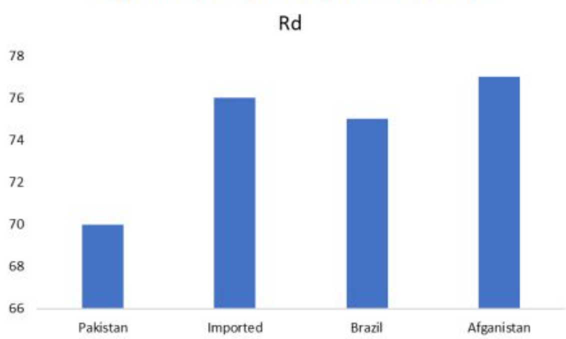

Fig. 8.13 Comparison of degree of whiteness

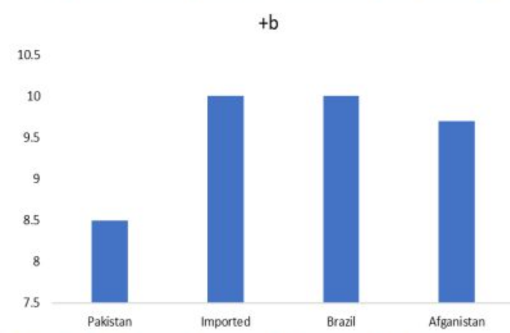

Fig. 8.14 Comparison of degree of yellowness

8.6 ICA-Bremen Cotton Round Test Program

The Fibre Technology Section participated in the ICA-Bremen Cotton Round Test Program under Faser Institute, Germany to keep the fibre testing equipment in calibrated form. Three lint samples were received during the year 2018. The lint samples were tested for different fibre characteristics. The results were submitted to the Faser Institute, Germany and fibre analysis met with other testing laboratories in the world.

The results of the Institute's Laboratory and the average results of the other participating laboratories are presented in Table 8.6.1.

Table 8.6.1 ICA-Bremen Cotton Round Test Program with Faser Institute, Germany

Date of Test	Sample No.	Name of Test	Results of CCRI, Multan (1)	Avg. results Of all Labs (2)	Difference (1-2)
01.07.20	**2020/1**	**Conventional Instruments**			
		Micronaire	4.6	4.61	-0.01
		Pressley Index (0")	10.11	9.42	0.69
		G / tex (1/8")	27.2	--	--
		Elongation (%)	6.2	--	--
		HVI-900A			
		U.H.M.L. (mm)	33.1	32.74	0.36
		Uniformity Index (%)	87.1	86.19	0.91
		Micronaire	4.5	4.62	-0.12
		G/tex (1/8")	42.6	44.05	-1.45
		Elongation (%)	5.60	6.02	-0.42
		Rd (Reflectance)	76.4	76.87	-0.4
		+b (Yellowness)	9.5	9.36	0.14
04.09.20	**2020/2**	**Conventional Instruments**			
		Micronaire	4.62	4.5	0.12
		Pressley Index (0")	7.4	6.75	0.65
		G / tex (1/8")	22.0	---	--
		Elongation (%)	5.9	--	--
		HVI-900A			
		U.H.M.L. (mm)	28.8	28..75	0.23
		Uniformity Index (%)	83.0	82.85	0.15
		Micronaire	4.57	4.55	0.02
		G/tex (1/8")	29.7	29.96	-0.26
		Elongation (%)	6.3	6.97	0.67
		Rd (Reflectance)	73.0	74.06	-1.06
		+b (Yellowness)	9.1	9.09	0.01
11.11.20	**2020/3**	**Conventional Instruments**			
		Micronaire	3.4	3.47	-0.07
		Pressley Index (0")	8.4	8.04	0.36
		G / tex (1/8")	23.7	----	---
		Elongation (%)	4.9	----	--
		HVI-900A			
		U.H.M.L. (mm)	28.8	29.11	-0.31
		Uniformity Index (%)	82.2	82.43	-0.23
		Micronaire	3.35	3.46	-0.11
		G/tex (1/8")	30.0	32.16	-2.16
		Elongation (%)	5.2	5.95	-0.75
		Rd (Reflectance)	69.6	71.87	-2.27
		+b (Yellowness)	13.7	13.32	0.38

9. STATISTICS

This Section is imparting extensively (considerably) in the Statistical domain and stretching to extending assistance to scientists of the institute in planning experimental design and therein analysis of data. The record of cotton statistics and daily market rates of cotton commodities were maintained.

9.1 Experimental Design Layout:

This section designed layout of field experiments conducted by different sections of Central Cotton Research Institute Multan. Randomized complete block design was used in 32 experiments while split plot and split-split plot was used in 19 and 24 experiments respectively. Furthermore F-pool design was used in 7 experiments sown at CCRI, Multan and PSC Farms, Khanewal.

9.2 Statistical Analysis

110 sets of experimental data were analyzed by the Statistics Section during 2020-21 in which included 20 data sets of Breeding & Genetics, seventeen Cytogenetics, eleven Pathology, forty Entomology, twenty two Fibre Technology sections of the institute. Detail presented in Table 9.1.

Table 9.1 Detail of Statistical Analyses.

Sections	RCBD	Split	Split-Split	F-Pool	Regression	Total
Agronomy	---	---	---	---	---	**---**
Physiology	---	---	---	---	---	**---**
Breeding	13	---	---	7	---	**20**
Cytogenetics	11	2	4	---	---	**17**
Pathology	---	---	11	---	---	**11**
Entomology	30	7	3	---	---	**40**
Fiber	6	10	6	---	---	**22**
Total	**60**	**19**	**24**	**7**	**---**	**110**

9.3 Prices of Seed Cotton and its Components

Daily Spot Rates of Cotton (lint) were documented. The average weekly price for Base Grade cotton per 40 kg for the three cotton seasons i.e. 2018-19, 2019-20 and 2020-21 exclusive of upcountry charges are shown in Fig 9.1.

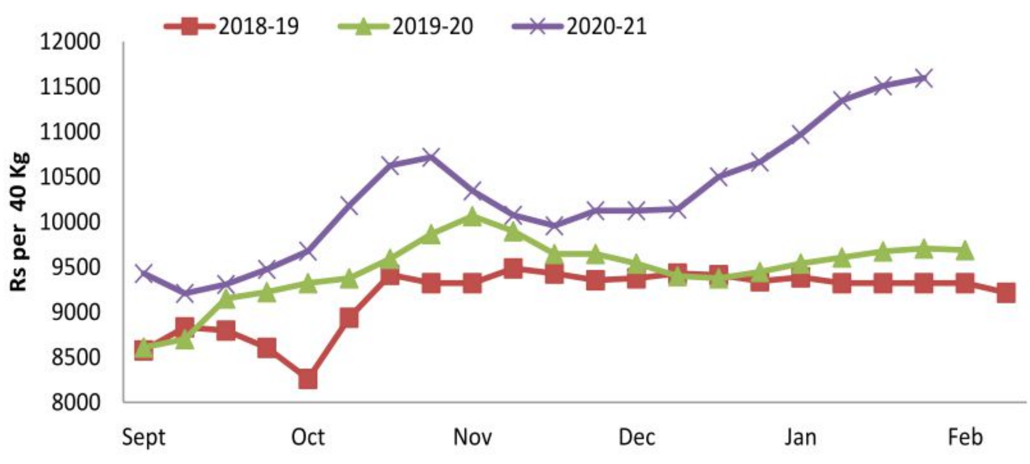

Figure 9.1: Weekly Average Spot Rates of Lint announced by Karachi Cotton Association during Cotton Seasons 2018-19, 2019-20 and 2020-21

The data presented in Figure 9.1 showed the fluctuation of rate during the seasons of last three years. In year 2020-21 rates were comparatively higher than previous years. In year 2019-20 the average price was at Rs. 9480 per 40 kg with the minimum value of Rs. 8610 per 40 kg in the month of September 2019 and maximum of 10065 per 40 kg in November 2019 while in 2020-21 the average price was at Rs. 10299 per 40 kg with the minimum value of Rs. 9208 per 40 kg in September 2020 and maximum value of Rs. 11597 per 40 kg in January 2021.

Rates of seed-cotton, Cottonseed and Cottonseed Cake were collected from Market Committee Khanewal. The prices are provided for Rs per 40kg, temporal trend of rates for three years on weekly basis is illustrated in Fig. 9.2. to 9.4.

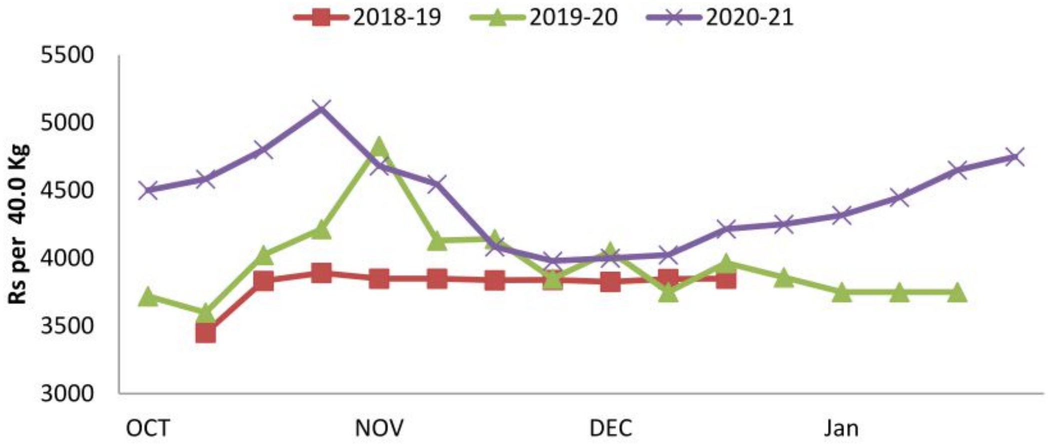

Figure 9.2: Weekly Average Rates (Rs /40Kg.) of Seed-cotton of Khanewal Market during 2018-19, 2019-20 and 2020-2021.

The seed-cotton rates are presented in figure 9.2 showed that the rates of 2020-21 are much higher than that of previous years. In 2019-20 the average seed-cotton rates of Khanewal market were at 3959 per 40 kg with minimum of 3599 per 40 kg and maximum Rs. 4830 per 40 kg while in 2020-21 the average rate was Rs. 4433 per 40 kg with maximum rate was 5100 per 40 kg and minimum rate was Rs.4433 per 40 kg. The percent increase of prices in 2020-21 average price over 2018-19 is 16.44%, and from 2019-20 is 11.97%.

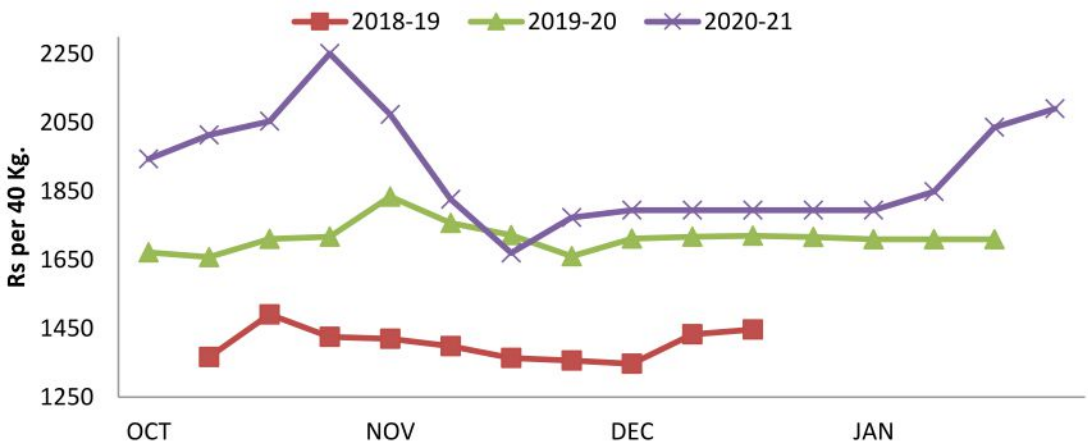

Figure 9.3: Weekly Average Rates (Rs /40Kg.) of Cottonseed of Khanewal Market during 2018-19, 2019-20 and 2020-21.

The cottonseed rates remained higher than the previous years. The maximum value of Rs.2251 was in October 2020 while minimum price of Rs. 1773 was in November 2020. The average price for 2020-21 was 1910 per 40 kg. Price comparison from last year revealed that average price Rs. 1405 per 40 kg was attained in 2018-19 with minimum price of Rs. 1347 per 40 kg and maximum price of Rs. 1491 per 40 kg in October 2018 while the average price Rs. 1715 per 40 kg was obtained in 2019-20 with maximum price was Rs. 1834 per 40 kg and minimum price was 1658 per 40 kg.

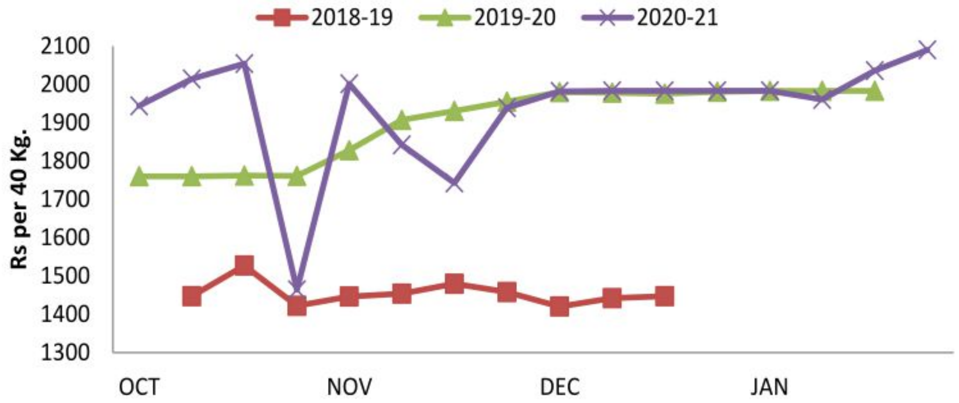

Figure 9.4: **Weekly Average Rates (Rs /40Kg.) of Cottonseed Cake of Khanewal Market during 2018-19, 2019-20 and 2020-21.**

Cottonseed cake rates of year 2020-21 were higher than year 2018-19 and 2019-20. Average rate of 2019-20 was Rs.1902 per 40 kg with maximum at Rs.1983 per 40 kg and minimum Rs.1760 per 40 kg while in 2020-21 the average rate was Rs.1938 per 40 kg with maximum Rs.2090 per 40 kg and minimum at Rs.1464 per 40 kg.

9.4 Rates of seed-cotton in four different cities of Punjab:

Figure 9.5 depicts the comparative rates of seed-cotton in Khanewal, Vehari, Rahim-Yar Khan and Vehari districts..

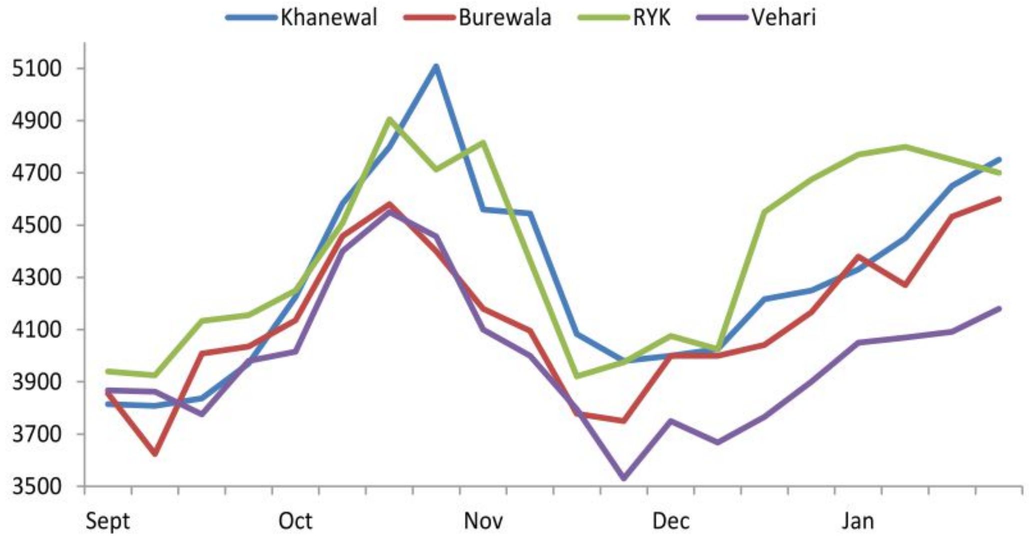

Fig 9.5: Rates of seed-cotton in 2020-21

The highest average rate was Rs.4397 per 40 Kg in Rahim-yar Khan, and the lowest average rate was Rs.3990 in Vehari. The maximum rate of Rs.5108 per 40 Kg was in Khanewal in the last week of October and the lowest rate was Rs.3624 in Burewala in second week of September.

9.5 Study of factors affecting the Lint rates in Pakistan.

The year 2020 was an unprecedented and factors which predominately effected the market were completely different from factors normally shaping the market. In February, the onset of pandemic (COVID-19) kept the market stagnant for first quarter of the year. As the world went into complete standstill the marketing activities also halted. The KCA remained closed for four weeks. Even after opening in April the market was so sluggish that barely any bales were traded in April.

As the markets were closed in European countries along with America the export orders were also cancelled. This sent a panic wave in the local industry and in response the 40% of export-oriented industry closed. This uncertainty kept the market unstable till August. From September onward the low incidence of disease in Pakistan made us the favorite shopping destination for western buyers. Due to high incidence of COVID in India and Bangladesh; the textile industry was completely closed there, and western buyers rushed to Pakistan for placing their orders. Simultaneously the government announced a special package for textile sector. These two factors coupled together revived the textile industry in Pakistan.

The cotton production in the country decreased significantly due to which the rates of cotton reached the all-time highest of more than 11000 rupees per 40 kg. This scenario has rung alarm bells for planners. For the consistent growth of textile sector in the country it is necessary that Pakistan produces 1.5 million bales of cotton annually. Otherwise, the foreign exchange earned by exporting textile products will be consumed for importing cotton in the country. It is the need of the time that govt announce a support price for cotton, because by ensuring the profitability of farmer the revival of cotton will become possible in Pakistan. Secondly a crop zoning should also be implemented in the country. The weekly KCA rates (40 Kg) are given in the following table.

Date	Base Grade Fibre Length 25.9-26.4 mm Micronaire 3.8-4.9	Date	Base Grade Fibre Length 25.9-26.4 mm Micronaire 3.8-4.9
07.02.20	9688	07.08.20	8760
15.02.20	9776	15.08.20	8859
23.02.20	9732	23.08.20	8994
28.02.20	9645	31.08.20	9189
07.03.20	9645	07.09.20	9430
15.03.20	9645	15.09.20	9208
23.03.20	9466	23.09.20	9308
31.03.20	N.A	31.09.20	9474
07.04.20	N.A	07.10.20	9678
15.04.20	N.A	15.10.20	10181
23.04.20	N.A	23.10.20	10625
30.04.20	9431	30.10.20	10717
07.05.20	9378	07.11.20	10347
15.05.20	9217	15.11.20	10074
23.05.20	9217	23.11.20	9958
31.05.20	9100	31.11.20	10127
07.06.20	9034	07.12.20	10127
15.06.20	8895	15.12.20	10142
23.06.20	8605	23.12.20	10503
30.06.20	8698	30.12.20	10664
07.07.20	9002	07.01.21	10970
15.07.20	9032	15.01.21	11348
23.07.20	8972	23.01.21	11510
31.07.20	8751	31.01.21	11597

The average rate from February 2020 till January 2021 was Rs.8890 per 40 kg while the lowest rate was Rs.8605 in third week of June 2020 and the highest rate was Rs.11597 in last week of January 2021.

9.6 Cost of cultivation for Cotton and major substitutive crops.

For the last few years, the area under cotton crop is reducing in Pakistan. The farmers are shifting to other crops mainly due to the reason that growing cotton is no longer a profitable preposition. Hence an effort has been made to calculate the cost of production of cotton and other crops which are grown in place of cotton. Mainly sugarcane, maize, and rice are preferred by farmers. This comparative analysis of the profitability of these crops will help us to understand the major reason behind the reduction of cotton crop in Pakistan.

In the following table a comparative summary of production cost (per acre) of these crops are given and the profitability of each crop is calculated.

Comparative Profitability

Operations	Maize	Sugarcane	Rice	Cotton
Land Preparation	8825	8825	4000	8475
Sowing	7000	8000	6050	2400
Fertilizer	29975	30975	5390	11875
Irrigation	10975	20575	20300	10975
Plant Protection	2550	2800	3000	21500
Harvesting	4400	5500	2200	4400
Land Rent	15000	30000	15000	15000
Miscellaneous	2200	2200	550	1100
Total Expenditure	**80925**	**108875**	**56490**	**75725**
Yield (Maunds)	90	750	60	18
Rate per Maund	1300	220	1500	4500
Total Value of yield	**117000**	**165000**	**90000**	**81000**
Profit	**36075**	**56125**	**33510**	**5275**

It is evident from this table that in comparison to its substitutes cotton is least profitable. It is imperative to decrease the cost by subsidies and increase the yield by introducing new varieties. Furthermore, a support price should also be announced by the government to motivate farmers to grow more cotton. The detail cost of production (per acre) for each crop is given in separate tables.

PCGA delegation comprising Dr. Jasomal, Chairman; Mr. Dilip Kumar, Ex Vice Chairman; Mr. Sohail Mehmood, Ex Chairman visited CCRI Multan on Oct 20, 2020

	Maize per acre cost of production			
	Operations/ Inputs	**No of operations/units per acre**	**Cost per unit/operation**	**Cost per Acre**
1	**Prepatory Tillage**			
1.1	Ploughing/ Cultivation	3	1000	3000
1.2	Planking	2	1000	2000
	Subtotal			**5000**
2	**Seed Bed Preparation**			
2.1	Ploughing/ Cultivation	2	1000	2000
2.2	Planking	1	1000	1000
2.3	Sowing (M.Day)	1	550	550
2.4	Bund Making (M.Day)	0.5	550	275
	Subtotal			**3825**
3	**Seed**			
3.1	Seed (kg) Hybrid	10	700	**7000**
4	**Farm Yard Manure**			
4.1	Trolly	1	1000	1000
4.2	Labor	1	500	500
	Subtotal			**1500**
5	**Fertilizer**			
5.1	Urea	3.5	2200	7700
5.2	DAP	2	4500	9000
5.3	SOP (MOP)	2	5500	11000
5.4	Transportation	7.5	30	225
5.5	Labor	1	550	550
	Subtotal			**28475**
6	**Irrigation**			
6.1	Cleaning water course	0.5	550	275
6.2	Tubewell Irrigation	4	2400	9600
6.3	Labor	2	550	1100
	Subtotal			**10975**
7	**Interculture**			
7.1	Hoeing / weeding	4	550	2200
	Subtotal			**2200**
8	**Plant Protection**			
8.1	Weedicide	1	1200	1200
8.2	Granule	1	1350	1350
	Subtotal			**2550**
9	**Harvesting (M.Day)**	8	550	4400
10	**Land Rent**	Six months		15000
	Grand Total			**80925**

Sugarcane per acre cost of production				
	Operations/ Inputs	**No of operations/units per acre**	**Cost per unit/operation**	**Cost per Acre**
1	**Prepatory Tillage**			
1.1	Rotavator	1	1500	1500
1.2	Chiesel Plough	1	1500	1500
1.3	Planking	2	1000	2000
	Subtotal			**5000**
2	**Seed Bed Preparation**			
2.1	Ploughing/ Cultivation	2	1000	2000
2.2	Planking	1	1000	1000
2.3	Sowing (M.Day)	1	550	550
2.4	Bund Making (M.Day)	0.5	550	275
	Subtotal			**3825**
3	**Seed**			
3.1	Seed (kg) Hybrid	10	800	**8000**
4	**Farm Yard Manure**			
4.1	Trolly	2	1000	2000
4.2	Labor	1	500	500
	Subtotal			**2500**
5	**Fertilizer**			
5.1	Urea	3.5	2200	7700
5.2	DAP	2	4500	9000
5.3	SOP (MOP)	2	5500	11000
5.4	Transportation	7.5	30	225
5.5	Labor	1	550	550
	Subtotal			**28475**
6	**Irrigation**			
6.1	Cleaning water course	0.5	550	275
6.2	Tubewell Irrigation	8	2400	19200
6.3	Labor	2	550	1100
	Subtotal			**20575**
7	**Interculture**			
7.1	Hoeing / weeding	4	550	2200
	Subtotal			**2200**
8	**Plant Protection**			
8.1	Weedicide	1	1000	1000
8.2	Granule	1	1800	1800
	Subtotal			**2800**
9	**Harvesting (M.Day)**	10	550	**5500**
10	**Land Rent**	12 Months		**30000**
	Grand Total			**108875**

Rice per acre cost of production				
	Operations/ Inputs	**No of operations/units per acre**	**Cost per unit/operation**	**Cost per Acre**
1	**Land Preparation**			
1.1	Dry Ploughing	1	1000	1000
1.2	Wet Ploughing	1	1000	1000
1.3	Planking	2	1000	2000
	Subtotal			**4000**
2	**Nursery**			**2200**
3	**Palntation (M.Day)**	7	550	**3850**
4	**Fertilizer**			
4.1	Urea	1	2200	2200
4.2	Zinc Sulphate	1	1100	1100
4.3	Micro Nutrients	1	900	900
4.4	Transportation	3	30	90
4.5	Labor	2	550	1100
	Subtotal			**5390**
5	**Irrigation**			
5.1	Tubewell Irrigation	8	2400	19200
5.2	Labor	2	550	1100
	Subtotal			**20300**
6	**Manual weeding**	1	550	**550**
7	**Plant Protection**			
7.1	Weedicide	1	1300	1300
7.2	Pesticides	1	1700	1700
	Subtotal			**3000**
8	**Harvesting (M.Day)**	4	550	**2200**
9	**Land Rent**	Six Months		**15000**
	Grand Total			**56490**

Cotton per acre cost of production				
	Operations/ Inputs	**No of operations/units per acre**	**Cost per unit/operation**	**Cost per Acre**
1	**Prepatory Tillage**			
1.1	Ploughing/ Cultivation	2	1000	2000
1.2	Planking	2	1000	2000
	Subtotal			**4000**
2	**Seed Bed Preparation**			
2.1	Land levelling	1	1000	1000
2.2	Seed Bed Preparation	1	1000	1000
2.3	Sowing & thinning(M.Day)	4	550	2200
2.4	Bund Making (M.Day)	0.5	550	275
	Subtotal			**4475**
3	**Seed**			
3.1	Seed (kg) Hybrid	8	300	**2400**
5	**Fertilizer**			
5.1	Urea	3	2200	6600
5.2	DAP	1	4500	4500
5.4	Transportation	7.5	30	225
5.5	Labor	1	550	550
	Subtotal			**11875**
6	**Irrigation**			
6.1	Cleaning water course	0.5	550	275
6.2	Tubewell Irrigation	4	2400	9600
6.3	Labor	2	550	1100
	Subtotal			**10975**
7	**Interculture**			
7.1	Hoeing / weeding	2	550	1100
	Subtotal			**1100**
8	**Plant Protection**			
8.1	Weedicide	1	1500	1500
8.2	Pesticide	10	2000	20000
	Subtotal			**21500**
9	**Harvesting (M.Day)**	8	550	4400
10	**Land Rent**	Six months		15000
	Grand Total			**75725**

VIII. RECOMMENDATIONS

Unlike other countries, cotton crop in Pakistan faces a number of challenges such as weather adversaries including higher (day & night) temperatures, irregular rainfall pattern, shortage canal irrigation water supplies, availability of water at sowing time and peak demand period, non-judicial use of crop inputs (irrigation, fertilizer, pesticide etc.), deteriorating soil health (salts, fertility problems) rising cost of inputs resulting in un-economical crop yields, insect-pest complex (whitefly, jassid, thrips, Bollworms, dusky & red cotton bugs etc), diseases (CLCuV, stem & twig blight) and fluctuating produce prices. In addition, the *Bt* cotton has now become vulnerable to Pink Bollworm infestation which not only increases the cost of production through additional use of pesticides but also limits crop yield. To ensure sustainable crop productivity along with economic returns for the farmers, concerted efforts need to be carried out at all levels involving the cotton sector stakeholders through public and private partnership approach. Based on the research work conducted by the scientists of the Institute, all the way through, following recommendations are made to dilute cotton production problems and getting maximum yield from the available resources.

SOIL SELECTION AND ITS PREPARATION

- Select best piece of land available for cotton cultivation.
- Farm machinery be optimized and be in ready condition for efficient and timely operations.
- Where plant growth is restricted and downward penetration of water in the soil is slow, crosswise chiseling/ripping or deep ploughing should be done.

IMPROVEMENT OF SOIL HEALTH

- Improvement and maintenance of soil physical condition ensures better soil productivity. Therefore, green manuring/farm yard manures should be incorporated one month before sowing to improve the physical condition of the soil. Among green manure crops, berseem is the best choice.
- After the use of combine harvester, tradition of burning wheat straw is not beneficial. It must be incorporated into the soil to improve the physical properties and organic matter content of soil.
- Disc harrow rather than rotavator should be used for wheat straw incorporation and it must be followed by irrigation along with ½ bag of Urea to accelerate the decomposition process and to avoid white ant problem.
- Cure and preserve the farmyard manure properly in pits. Donot keep in heaps in the open sky.
- Reclamation of saline-sodic soils is accomplished by incorporating recommended quantity of gypsum into the soil followed by 2-3 heavy irrigations. This should be followed by green manuring to restore soil fertility.
- Chiseling should be done after every 3 years to break the hard/plough pan and to improve root growth and soil physical health.

PLANTING

- In problem soils (saline, clayey and lands with salt patches of varying sizes) planting on bed-furrow is better than drill planting.
- Bed-furrow planting ensures better plant population. It saves 30% irrigation water over conventional planting (flat cultivation). It protects the crop from the damages of heavy rains. Apply second irrigation 3-4 days after sowing on bed-furrow to ensure better seedling emergence and growth. Afterwards, apply irrigation 8-10 days interval.
- To sustain the good physical soil conditions, always cultivate the fields in '*wattar*' condition (workable condition) and never cultivate in dry condition.

- Laser level the fields properly for uniform and economized application of fertilizer and irrigation water.
- Apply single '*rouni'* on well-leveled fields for flat (conventional) planting due to scarcity of canal water.
- Planting the cotton at proper time, late planting should be avoided to minimize the yield losses and virus infestation.

RECOMMENDATION OF COTTON VARIETIES FOR GENERAL CULTIVATION

- Recommendation of Bt. & Non Bt cotton varieties for general cultivation in core and non-core cotton areas of the Punjab

Bt Varieties	Non-Bt Varieties
Bt. CIM-663, Bt.CIM-343, MNH-1035, FH Supper Cotton-17, NIAB-1011, Hatf-3, CEMB Klean Cotton 03, BS-20, ICI-2424, Bt. CIM-632, Bt.CIM-602, Bt. Cyto-177, Bt. Cyto-178, Bt.CIM-600, Bt.cyto-179, NIAB-824, FH-118, VH-259, BH-178, IUB-2013 Sitara-008, Sitara-11	GS Ali-7, CIM-610, CIM-620, Cyto-124, CIM-496, CIM-506, CIM-554, CIM-573, NIAB-777, NIAB-Kiran, NIAB-112, SLH-317, BH-187, NIBGE-115, NIAB-852, NIAB-846

- Always purchase 10% more cotton seed than required for re-planting in case of any damage or lower germination.
- Always sow 10% area with Non-Bt along with Bt varieties, as refuge crop, to avoid development of resistance in insects.
- Generally use delinted seed. One liter of commercial sulphuric acid is sufficient for delinting 10 kg fuzzy cotton seed. Wash thoroughly and dry the seed under shady and well ventilated area. Always store cotton seed in gunny bags or cotton cloth bags in such a way that air could pass across the bags from bottom to top. Avoid the storage cotton seed in plastic bags.
- Check seed germination before planting. Use delinted seed @ 6-8 kg/acre with 75 percent germination for flat planting. Adjust seed rate according to germination percentage.
- Ensure that seed drill is in perfect condition and drop the seed uniformly at appropriate depth for perfect emergence of cotton seedlings.
- Optimum sowing time for core areas in Punjab is from 1st April to 31st May and non-core areas is 1st April to 15th May. The yield decreases drastically in June planting. Planting up to May 15th should be preferred. It gives better yield than late planting.
- Ensure 23,000-25,000 plants per acre for obtaining profitable yield.

THINNING

- Thinning should be completed after dry hoeing and before first irrigation in flat planting (conventional) by allowing 9-12" plant to plant distance within the lines to obtain 17000-23000 plants per acre. On bed-furrow planting, thinning should be completed when plants are 10cm (4") in height 25 days after sowing. Remove weak or virus affected plants.
- A uniform early good crop stand ensures profitable cotton production.

WEED CONTROL

- Weed management should be done through integrated weed management approach (a combination of chemical, mechanical and manual weeding methods).
- The first 40-70 days after sowing are crucial and growth of weeds is faster than cotton plant, therefore, all possible measures should be adopted to control weeds.

- Use of pre-emergence herbicides save the crop from early weed infestation when the crop does not permit mechanical hoeing operations.
- S-Metalacholar 960 EC and Acetachlor 50EC should not be incorporated in the soil at sowing time. They cause mortality of cotton seedlings during emergence. These herbicides are used on bed-furrow planting as surface application within 24 hours of sowing/irrigation on moist soil.
- Pendimathelin 330 EC can be used as pre-emergence herbicide in flat planting at seed bed preparation by incorporating into soil at 5 cm depth.
- Pendimathelin 330 EC can be used in bed-furrow planting in dry condition before sowing.
- Glyphosate 490 G/L @ 4.7 lit ha^{-1} can be used as post-emergence weedicide provided that the application is carried out with protective shield.
- Grasses especially "*Swanki*" and "*Madhana*" at 3 to 4 leaf stage can be controlled by spraying Haloxifop @ 400 ml/ac and quizalpop @ 20 g/acre as post-emergence without protecting the cotton plants. Haloxifop can be used more than one time at any growth stage of cotton plant. No phyto-toxicity was observed on crop by the spray of said herbicide.
- In flat planting, interculturing is very effective for weed eradication at early stage. After every shower of rain, and irrigation when the fields attain '*wattar*' conditions (workable condition) hoeing should be done and this practice should be continued as long as the crop permits. After every interculturing, weeds which could not be eradicated by interculturing must be removed manually and the crop should be earthed up during the last interculturing operation

IRRIGATION

- For flat (conventional) planting, apply first irrigation 30-40 days after sowing keeping in view the variety, soil type, crop and weather conditions. Subsequent irrigations should be applied at 12-15 days interval. There should not be any water stress to the crop from 1st August to end of September. Apply that quantity of irrigation water which should be absorbed by the soil within 24 hours. Water standing in field after 24 hours results fruit shedding. Be sure that white flower should not appear at the top of plant which is an indication of water stress to the crop especially before the month of September.
- In bed-furrow planting, after germination, subsequent irrigations should be given at 8-10 days interval.
- Last irrigation must be applied in mid of October to avoid delay in crop maturity and late season pest attack.
- Irrigation should not be applied after 60 percent bolls have been opened.
- In case of excessive vegetative growth, mepiquat chloride @ 400 ml/acre in 3-4 split doses (if needed) during the months of July and August may be used to regulate the plant growth and enhance fruit bearing.

FERTILIZER

- Fertilizers should be used on the basis of soil test reports. Soils showing available phosphorus less than 10 ppm, use upto 100 kg P_2O_5 per hectare at the time of planting or after thinning. Mixing of phosphate fertilizer with farmyard manure in 1:2 ratio improves its efficiency. Use 50 kg K_2O per hectare at planting, to soils showing available potassium less than 125 mg kg^{-1} soil. Cotton-wheat is the major cropping pattern in the cotton area. Farmers should also use recommended levels of phosphorus and potassium fertilizers for wheat crop.
- In normal season planting, 150-200 kg N per hectare should be applied in split doses and fertilizer application should be completed by end of August. Excessive use of

nitrogen does not improve the yield but attracts the pests, delays the crop maturity and adds up cost of production.

- To improve the efficiency of nitrogen, phosphorus and potassium fertilizers, these may be applied in split doses. Band placement or fertigation of phosphorus in splits is more efficient than the broadcast at time of sowing.
- The crop showing deficiency of nitrogen late in the season can be sprayed in morning/evening with 3% urea solution (3 kg urea per 100 litre water) but it should not be mixed with the insecticides.
- Fertigation (fertilizer solution dripping into irrigation water) of nitrogenous fertilizer is also a useful method to apply nitrogen during the cropping season but its efficacy is more in leveled fields.
- The adverse effects of water shortage in cotton crop may be minimized by the combined application of phosphorus and potassium fertilizers.
- Gypsum as a source of sulphur may be added @ 50-100 kg per hectare in light textured and saline-sodic soils to correct sulphur deficiency syndrome. Alternatively use elemental sulfur @ 10 kg ha^{-1}.
- Three-four foliar sprays of boron and zinc @ 0.05% solution [(250g zinc sulphate with 21% Zn, 300g boric acid)/ per 100 litre water] should be done to improve fruiting.
- Mixing of 2% urea in the spray tank along with B and Zn nutrients enhances the efficacy of foliar spray.
- Potassium application through foliar sprays of 2% KNO_3 or K_2SO_4 (soluble potash) solution improves yield over non-sprayed crop and minimizes the adverse effects of biotic and abiotic stresses.
- Half of the recommended dose of NPK fertilizers i.e. $75N+25P_2O_5+25K_2O$ kg ha^{-1} is as effective as recommended dose ($150N+50P_2O_5+50K_2O$ kg ha^{-1}) when applied in conjunction with poultry broiler litter.
- For early germination and seedling vigor, cotton seed may be primed with gibberellic acid (GA @ 10 mg per litre) prior to sowing.
- Application of magnesium sulphate both by fertigation and foliar sprays proved benefial in improving seedcotton production. However, foliar application of magnesium @ 6 kg per hectare in three splits was more productive and cost-effective.
- Seed priming and subsequent foliar sprays of amino acid proline @ 0.1% increases cotton health and production. The efficiency of proline is further increased by addition of B & Zn in foliar sprays.

FRUIT SHEDDING

- Fruit shedding results either due to natural adversaries like high temperature coupled with high relative humidity, cloudiness, and intermittent rains or due to insufficient nutrition, excessive or shortage of water and pest attack.
- Take care of nutritional deficiency, irrigation, pests and don't worry about natural shedding.

PLANT PROTECTION

- Keeping in view the losing efficacy of *Bt* cotton against pink bollworm, farmers are advised to plant cotton not before the 1st April.
- Always use seed delinted with sulphuric acid to avoid carryover of pink bollworm residing in double seed
- Seed treatment with insecticide ensures better crop growth and saves it from sucking pests at early stage.
- The first spray should be delayed as long as crop tolerates pests so that predators and parasites could play their role to suppress the pest population.
- Pyrethroids or their combinations should be avoided at early stage of the crop.

- Pesticides application should be on the pest scouting basis at the following economic threshold levels (ETL).
- Insect growth regulators (IGRs) are most effective against whitefly at immature stages (whitefly nymphs).
- Leftover bolls are the main source of pink bollworm for the next cotton crop. Therefore, the cotton field should be grazed after picking to reduce the number of left over bolls. It is better if the cotton sticks are shredded and incorporated into the soil which will improve the physical condition of the soil. In case the cotton sticks are to be kept for fuel purpose, these should be kept in bundles and top portion should be directed towards sun and should be used by mid-February.
- Removal of leftover bolls after picking with mechanical boll picker (MBP) machine is an effective strategy that will not only manage or reduce Pink bollworm but also save sticks to be used by the farmers for fuel purpose.
- Spray machines must be perfectly in order and properly calibrated. Use hollow cone nozzles with uniform flow rate, fine mist and keep the nozzle at 1.5 to 2 feet height from the plant canopy to ensure better coverage of the crop.
- Use right dose of right insecticide at appropriate time with clean water for better results. Spray in the morning or late in the afternoon. Do not spray when rain is expected. If the rain has affected spray application, it should be repeated. Pest scouting should also be done after 3-4 days of spray to assess efficacy of the pesticide.

Economic Threshold Levels of Different Pests

Name of insects	Economic threshold levels
Jassid	1-2 adults/nymphs per leaf
Whitefly	5 adults/nymphs or both per leaf
Thrips	8-10 adults/nymphs per leaf
Spotted bollworm	3 larvae/25 plants
Pink bollworm	5 % bolls damage
American bollworm	5 brown eggs or 3 larvae or collectively 5/25 plants
Armyworm	On appearance

CONTROL OF DISEASES

- The seed should be treated with fungicides for seed rot and seedling diseases during early planting.
- Previous year's cotton stubs should be removed from the fields. The reason being that new sprout from diseased stubs is the source of Cotton Leaf Curl Virus (CLCuD) transmission to the newly planted crop.
- Always plant more than one virus resistant/tolerant variety to create genetic barrier.
- Use healthy and delinted seed.
- Avoid the late planting of cotton to minimize the CLCuD incidence.
- The seed should also be treated with systemic insecticide to protect the crop against whitefly which is the vector of CLCuV.
- Whitefly is the vector of CLCuD. It should be managed and controlled at economic threshold level.
- Reduce the whitefly population during mid-June to end-August and other pests to manage CLCuD.
- The diseased and weak seedlings should be removed at thinning stage and buried.
- Weeds in and around cotton fields, water channels and field bunds should be eradicated. Reduce the whitefly population during mid-June to end of August and other pests to manage CLCuD.
- Judicious use of fertilizer and irrigation helps in the management of CLCuD.

- Application of fertilizer and irrigation should be given in accordance with recommendations. Excessive use of these inputs increases the incidence of boll rot of cotton.
- Good drainage / proper irrigation helps to grow healthy plants and show more resistance against wilt and boll rot diseases.

PICKING & STORAGE

1. Seed cotton on the plant is a precious silver fiber. Maintaining its quality during picking, storing and transportation from field or store to the ginning factories is helpful to get quality price.
2. Start picking when 60-70% bolls are opened. Avoid picking under adverse weather conditions when the sky is cloudy or rain is expected. After rain, pick seed cotton when it is dry.
3. Do not start picking early in the morning when there is dew on the crop. Let the dew dry and then start picking.
4. Start picking from the bottom to the top. Pick fully opened and fluffy bolls. Seed cotton should be free from weeds and crop trash.
5. Use cotton cloth bags for transportation. Do not use plastic or gunny bags.
6. Do not place cotton on moist soils in the field.
7. Store the seed cotton in ventilated stores in heaps of pyramid shape for proper aeration. The floor of the store should be of concrete and dry.
8. Moisture content in the seed cotton should be less than 12% otherwise the seed cotton will heat up subsequently deterioration the quality of lint cotton seeds.

IX. PUBLICATIONS

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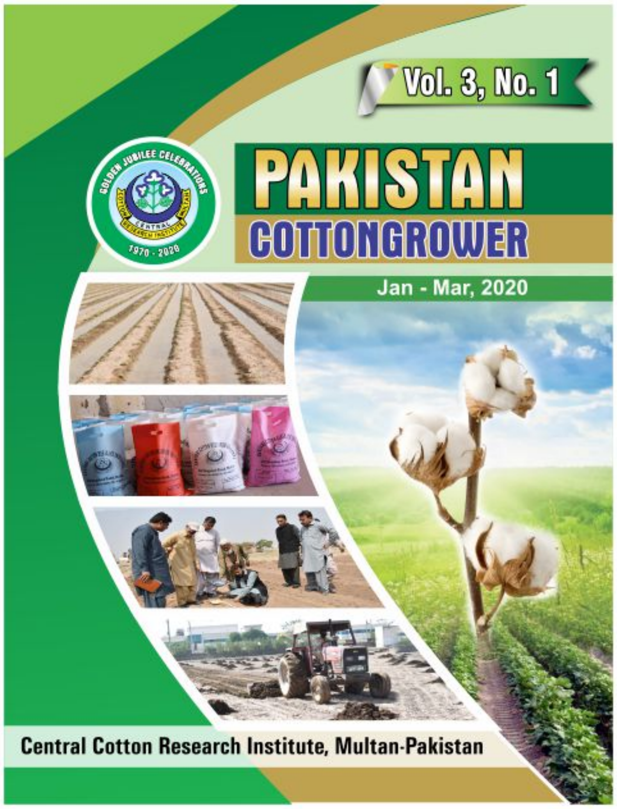
Mr. Saqib Ali Ateel, Secretary Agriculture South Punjab Multan visiting Entomology Laboratory at CCRI Multan on Oct 13, 2020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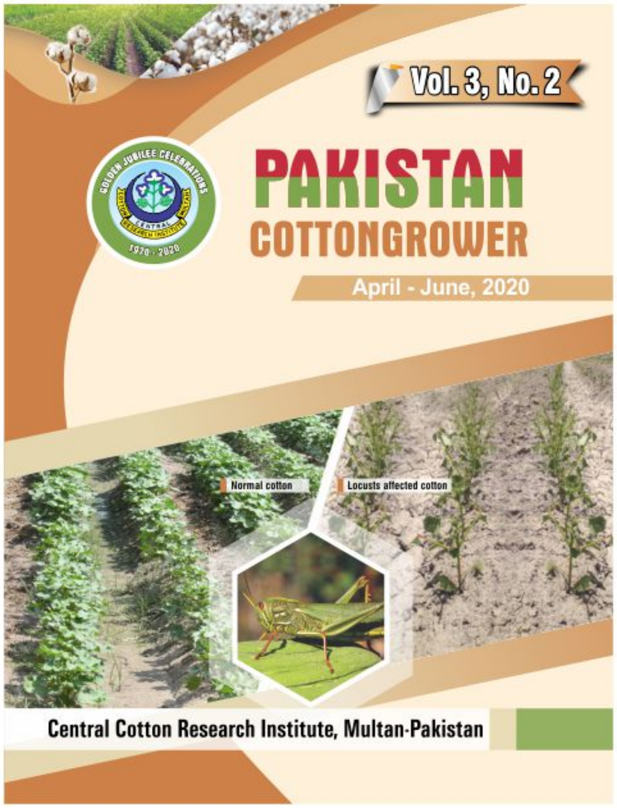
Central Cotton Research Institute, Multan-Pakistan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COTTONGROWER
April - June, 2020
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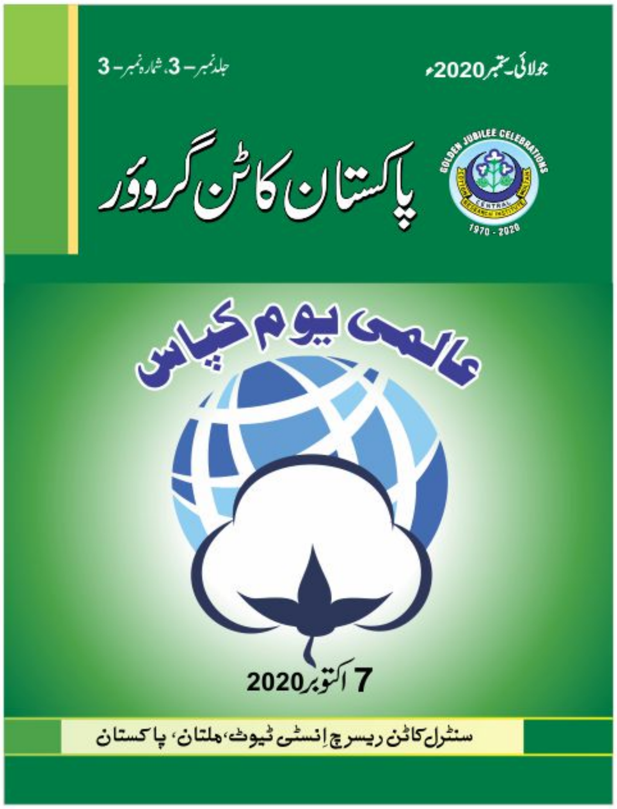
Locusts affected cotton
Central Cotton Research Institute, Multan-Pakistan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عالمی یوم کپاس
7 اکتوبر 2020
سنٹرل کاٹن ریسرچ انسٹی ٹیوٹ، ملتان، پاکستان


جلد نمبر – 3، شمارہ نمبر – 4
پاکستان کاٹن گروور
اکتوبر۔دسمبر 2020ء
جنوبی پنجاب میں کپاس کی بہتر پیداوار کیلئے کاٹن کیلنڈر کی تشکیل
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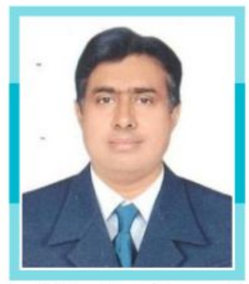

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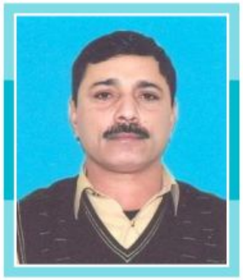

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Annexure-I

Comparative Monthly Meteorological Data Recorded at CCRI, Multan during 2019 and 2020

Month	Air Temperature (ºC)				Relative Humidity				Average Wind Speed (Km h^{-1})		Rainfall (mm)		Evapo-transpiration (cm day)		Soil Temperature (ºC) 0 cm	
	Minimum		Maximum		Minimum		Maximum									
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
January	8.0	7.1	17.6	15.5	76	73	97	97	4.0	3.8	11.0	25.1	0.18	0.10	9.4	9.5
February	9.9	11.3	19.0	23.3	66	56	95	89	5.0	4.5	25.1	4.6	0.24	0.38	11.1	12.4
March	15.0	14.7	24.1	23.8	64	60	88	89	5.3	6.4	21.0	88.4	0.42	0.45	17.4	14.5
April	23.0	21.1	34.9	33.8	62	56	84	86	6.4	6.4	12.7	39.5	0.73	0.53	26.4	24.8
May	25.8	25.3	37.2	38.0	47	51	73	85	6.1	6.1	11.6	44.7	1.18	0.74	30.3	29.8
June	29.2	29.0	39.9	39.9	49	50	69	82	6.9	5.8	55.5	24.0	1.11	0.91	34.1	31.3
July	30.5	29.7	36.9	38.0	58	62	77	87	7.4	6.2	16.2	64.4	0.96	0.97	35.2	32.8
August	28.9	30.8	35.6	37.1	62	72	83	91	5.7	6.1	37.5	108.2	0.92	0.91	33.2	34.1
September	28.3	26.5	36.1	36.4	66	64	89	86	4.4	3.6	26.3	0.0	0.99	0.57	32.4	29.5
October	20.2	18.6	31.5	33.9	71	58	89	81	2.9	2.3	35.3	0.0	0.42	0.58	23.6	23.5
November	15.1	13.1	24.8	25.9	67	59	90	83	2.9	2.7	5.2	0.0	0.29	0.26	17.2	16.6
December	7.9	7.4	16.9	21.4	71	67	95	91.2	2.9	2.5	10.0	0.0	0.17	0.15	10.4	10.6

S. R.

MINISTÉRIO DOS NEGÓCIOS ESTRANGEIROS
Embaixada de Portugal em Islamabad

Islamabad, 09 November 2020

To,
Dr. Zahid Mehmood,
Director Central Cotton Research Institute (CCRI),
Multan.

Dear Dr. Zahid,

I wish to express our deep appreciation and gratitude for your efforts to arrange our visit to the Central Cotton Research Institute, Multan. The hospitality, dedication and cordial reception by your wonderful staff assured the success of the visit.

I look forward to seeing you in future.

Best Regards,

Paulo Neves Pocinho

Ambassador of Portugal

VISITOR'S BOOK

CENTRAL COTTON RESEARCH INSTITUTE, MULTAN.

Date	Name	Address	Remarks if any
29/10/20	Paulo Neves Pocinho	Ambassador of Portugal to Pakistan	I would like to congratulate the Institute for the fantastic job it is being done here and thanking for welcoming myself and my family. I'm sure the cotton industry and the people of Pakistan benefit a lot from the research work to improve the industry. Thank you [signature]

Years of Excellence in
Cotton Research & Development

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