PBW Manager
Controls Pink Bollworm from Leftover Bolls and enhances cotton yields

GOLDEN JUBILEE CELEBRATIONS
COTTON CENTRAL RESEARCH INSTITUTE MULTAN
1970 - 2020

Annual Report
2019-2020

CENTRAL COTTON RESEARCH INSTITUTE, MULTAN

Annual Report 2019-20

CENTRAL COTTON RESEARCH INSTITUE, MULTAN

Pakistan Central Cotton Committee

Ministry of National Food Security & Research

Government of Pakistan

CONTENTS

ANNUAL REPORT
CENTRAL COTTON RESEARCH INSTITUTE, MULTAN
2019-20

I. 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, it is now celebrating its 50th year 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:

- Study the cotton plant from botanical, genetical, production, physiological, chemical, entomological, pathological and other relevant facets in a coordinated manner.
- Undertake research work of national importance, handle problems of inter-regional nature.
- To develop cost-effective cotton production technology.
- Advance knowledge on the cotton plant responses to environment with a view to better cope with the adverse impacts in the changing climate scenario.
- Provide education and training on cotton production technology to the agriculture research, extension, teaching staff and other stakeholders.
- Identify problems of cotton growers and advocate remedial measures.
- Promote mechanization in cotton production system.
- Transfer production technology to the cotton growers.
- Educate and motivate cotton growers and monitor research outcomes.
- Provide technical support to the Pakistan Central Cotton Committee in coordinating and developing a national programme for cotton research and development.
- Training manpower across the country and other cotton growing countries on “cotton research and development”.
- 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
- Development of Mapping population for fibre quality
- Preliminary lab work in progress for transformation
- Ideotype development for mechanical 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.

In addition, the Institute has also collaborated with Cotton Breeding, Seed Production and Agrotechnologies Research Institute (CBSPARI) under the research and production center of agriculture and food supply of the Republic of Uzbekistan for cotton research and development programs.

The Institute has been entrusted a three-years project on “Better Cotton Initiative (BCI) for Sustainable Cotton Production in Pakistan” by the Ministry of National Food Security & Research, Government of Pakistan.

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 126 staff members including 31 officers and 95 other staff members remained at the Institute during the period under report. The position of technical staff during the year 2019-20 is given in **Annexure-I**.

iii) Budget

The sanctioned budget from the year 2017-18 to 2019-20 is given below:

(Rs. Million)

Sr. #	Detail	2017-18	2018-19	2019-20
1.	Pay & Allowances	61.860	74.859	71.588
2.	Medical	2.930	0.500	0.500
3.	Traveling Allowance	1.800	2.200	2.200
4.	Group Insurance	0.617	0.653	0.599
5.	Utility Bills*	7.160	9.835	11.680
6.	Contingencies	48.200	40.806	48.022
	Total	**122.567**	**128.853**	**134.589**

* 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 2019-20 is given below:

(Rs. Million)

Sr. #	Head	2017-18	2018-19	2019-20
1.	Farm Produce	4.000	3.331	2.726
2.	Non-Farm Produce	1.200	0.950	1.340
	Total	**5.200**	**4.231**	**4.066**

* Period from 1st July to 28th February

II RESEARCH ACTIVITIES

i) Research Experiments

The research experiments conducted during 2019-20 along with estimated cost for each experiment, carried out by various sections are as follows:

Name of Scientist	Experiment	Approx. Cost of (Rs.)
	AGRONOMY SECTION	
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 the 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 for	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 Junaid 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	Testing of Lint Samples	235,000

Danish Iqbal		
--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

(July 2018 to June 2019)

ii) CCRI Multan Nominated as Center of Excellence for Cotton Research

The Ministry of National Food Security & Research has proposed to establish a Center of Excellence on Cotton Research & Development at Central Cotton Research Centre (CCRI), Multan in collaboration with the Chinese agro scientists and researchers as it has a stronghold on agriculture research. In this connection, a 9-member high level officials including agriculturalists led by Mr. Wen Wanhe, Group Leader, CMEC International, China visited CCRI Multan on November 2, 2019. Dr. Khalid Abdullah, Vice President, PCCC also accompanied the delegation. The delegation visited in connection with exploring cooperation among Pakistan and China for the development of the agriculture sector especially cooperation in cotton research and development. Dr. Zahid Mahmood, Director CCRI Multan briefed the delegation about cotton research and development activities carried out by the Institute. Later the participants also visited labs and fields.

iii) Recommendations of Cotton Varieties

The 79th meeting of Expert Sub-committee Punjab at AARI, Faisalabad was held at Ayub Agricultural Research Institute Faisalabad on 18.07.2019 for variety recommendations. Cases of five candidate Bt cotton varieties i.e. Bt.CIM-343, *Bt.*CIM-663, *Bt.*Cyto-515, Bt.Cyto-225 and one non-Bt variety CIM-717 were presented by Dr. Muhammad Idrees Khan, Head Plant Breeding & Genetics under supervision of Dr. Zahid Mahmood, Director CCRI Multan. The varieties are good yielder with excellent fibre characteristics. *Bt.*CIM-343 and *Bt.*CIM-663 were recommended to the Punjab Seed Council for approval and general cultivation in the Punjab.

Bt.CIM-663

Bt.CIM-343

iv) Performance of Bt.CIM-775 in NCVT 2019-20

Cotton variety Bt.CIM-775 developed by the Plant Breeding & Genetics Section of the Institute gave excellent results in the National Coordinated Varietal Trials (NCVT) 2019-20. Amongst the 102 cotton varieties tested during 2019, Bt.CIM-775 secured second position at Pakistan level, while stood first in the Punjab and Khyber Pakhtukhawa. This variety has been developed through crossing of germplasm received under Pak-US-ICARDA Cotton Project. Bt.CIM-775 has the yield potential of 50-60 maunds. Due to its light greenish color, the variety has inbuilt character of greater tolerance against drought and performed well under water stress conditions. The variety has 28.6mm staple length, lint percentage of 39.5 with 4.3 micronaire value.

v) Cotton Biotechnology Group

The Cotton Biotechnology Group constituted for conducting research studies comprising of developing resistance against cotton whitefly, pink bollworm, drought resistance and fibre quality improvement programs. Two Research Associates have been inducted to strengthen the laboratory work. Gene functional study is a powerful approach to verify the functions of novel genes. Genes from different databases have been selected and optimized the codon according to *Gossypium hirsutum* genome. Different gene casettes are being designed which confer resistance against biotic e.g. insect pests and abiotic stresses e.g. drought and nodulation for nitrogen compensation. The aim is to develop tissue culture laboratory and intiate new technology called Cotton Fiber Culture. Through this approach, cotton fiber can be developed invitro under aseptic conditions. These technologies will help to develop insect resistant varieties with better fibre production.

vi) Pink bollworm & Red Cotton Bug Management

Rearing of susceptible strains of Pink bollworm (5th generation) without exposure of pesticides is being carried out in the laboratory to get susceptible strains as a baseline to compare with the field-collected population of Pink bollworm. Bioassays will be conducted on both laboratory-reared and field-collected populations to test the resistance level of various insecticides. The entomological staff continued inspecting the damage and larvae of Pink bollworm from the field-collected cotton bolls. Rearing of susceptible strains of Red Cotton Bug without exposure of pesticides (37th generation) remained in focus. The reared strains will be

used as a baseline to compare with field-collected strains. Later, bioassays will be conducted on both laboratory-reared and field-collected strains for testing the resistance level to various insecticides.

Installation of PB Rope in the cotton experimental fields of CCRI Multan for the control of Pink bollworm. All the scientific and field staff participated in this activity and prayed for the betterment of cotton crop in the country.

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 about 30 cm above the crop canopies and were adjusted vertically as the crop attained additional growth.

viii) Insecticide Resistance Management Program

Bioassay studies based on leaf-dip method using aquous solutions of various concentrations of different insecticiees were carried out in the laboratory.

i) Number of insecticides bio-assayed against Cotton Jassid were 14 each at Multan, Khanewal and Bahawalpur. Of these, Chlorfenapyr, Spintoram, Nitenpyram and Flupyradifuron were highly effective.
ii) Out of 12 insecticides, Carbodamide and Metrin best performed against Whitely.
iii) Seven products were tested against Dusky Cotton Bug and Mealybug. Of these, Thiamethoxam and Triazophos performed most effective against Dusky Cotton Bug whereas, Profenofos, Imidacloprid and Nitrenpyram were highly effective against Mealybug at Multan.

ix) Better Cotton Initiative Program

The Ministry of National Food Security & Research launched a project "Better Cotton Initiative (BCI) for Sustainable Cotton Production in Pakistan". The project has been initiated with an allocation of Rs. 300 million and will be executed in 5 districts; 3 in Sindh (Shaheed Benazir Abad, Noshero Feroz, Dadu) and 2 in Punjab (Multan, DG Khan). Under the project, 30,000 farmers will be targeted during 1st year, the number increasing to 60,000 and 80,000 in 2nd and 3rd years. The project activities will be carried out by the CCRI Multan and CCRI Sakrand in collaboration with BCI Organization and Agriculture Extension Departments of the respective province. Dr. Zahid Mahmood, will act as Project Manager; Dr. Fiaz Ahmad, Provincial Coordinator (Punjab) and Mr. Abdul Wahab Soomro, Provincial Coordinator (Sindh). This project aims to move forward in producing BCI Certified Cotton in bulk and a million hectares of land would be brought under BCI production technology in 2020 to meet demand of famous international brands. The internationally famous brands that manufacture products using cotton as raw material will shift to BCI cotton by 2025. BCI is an international body that certifies cotton worldwide after a three-tier checking system i.e., cotton produced through environment-friendly technology, socially compliant that no child labour was involved and that women workers were paid in full and carry economic benefits for farmers. Pakistan was the first country to produce BCI certified cotton five years ago and was maintaining momentum to move forward. Moreover, many NGOs and Punjab government are also working on BCI plan and have targeted to bring one million hectares area under BCI certified cotton in 2020. This project would cover a part of the one-million-hectare target in five districts.

x) Pakistan and Uzbekistan Cooperation In Cotton Research & Development Proposals

The Cotton Breeding, Seed Production and Agrotechnologies Research Institute (CBSPARI) under the research and production center of agriculture and food supply of the Republic of Uzbekistan offered to collaborate with CCRI Multan for cotton research and development programs. The collaboratiove program will focus on developing early maturing and climate resilient cotton varieties; drought and salt tolerant varieties for various soil-climatic regions of Uzbekistan; provide cotton germplasm with required features from Cold Storage / Gene Bank

established at the Institute; nutrient use efficiencies and soil health improvement; jointly conduct varietal development and seed technology research programs; establish Pak-Uzbek Biological Lab at the Institute for rearing of beneficial insects and control of insect pests through biological means; assistance for developing input-use-efficient cotton varieties; facilitate exchange of cotton scientists for trainings and participation in seminars and jointly publishing of Newsletter highlighting activities carried out by both partner institutes.

xi) Collaborative Program for Utilization of Short Staple High Yielding Cotton Varieties for Spinning at Different Counts

The University of Agriculture, Faisalabad (UAF) and Central Cotton Research Institute, Multan (CCRI) in collaboration with M/s Masood Textile Mills Limited (MTM) has planned to carry out project "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". Since there exist a great variability in the textile products starting from socks, Denim, knitwear, lawn, suiting and a large variety of home textiles. The manufacturing of all kinds of products for different end users, with the cotton of same characteristics results in quality deterioration or make the products cost intensive. This decrease in production or quality directly influences the textile industry, which is forced to import the expensive raw materials to fulfil its production requirements. Owing to increased raw material costs, the manufactured product is more expensive and non-competitive in the international markets. This ultimately reduces the exports and the foreign exchange earnings of the country. This project will focus to develop Artificial Neural Network based prediction system which will help to use of high yielding short staple cotton varieties for the production of coarser yarns/fabrics and low yielding superior quality cottons for finer high value products and the system will provide the indigenous quality-based grading system of cotton.

xii) Weather Data Generation Program between Pakistan Meterological Department and CCRI Multan

CCRI Multan and Pakistan Meteorological Department entered an understanding for generation of weather data. Under this collaborative program, CCRI Multan agreed to provide an office along with required utility and computer facilities, internet connection and also hostel accommodation for the operational staff performing duty round the clock. After establishment of the system, meterological data will be generated round the clock at his premesis and will be available for dissemination to the Agriculture, Irrigation, Local Inhabitants, Aviation Purpose, PDMA & Policy-makers / Planners and Cotton Growers. The data will be utilized for the research and development purpose at CCRI Multan as well as a number of educational institutions situated in the South Punjab. Pakistan Meteorological Department (PMD) would provide all its technical support and the requisite Meteorological Equipment as well as staff concerned. The data generated would be according to World Meteorological Organization (WMO) standards.

xiii) Activities under Research Projects

Pink bollworm Project : A comprehensive integrated scientific approach for the development of sustainable management strategies of Pink Bollworm (*Pectinophora gossypiella*)

In order to manage Pink bollworm through integrated pest management, molecular approaches and development of resistant cotton germplasms; the Punjab Agricultural Research Board (PARB), Government of the Punjab has initiated a three-years project "A comprehensive integrated scientific approach for the development of sustainable management strategies of Pink Bollworm (*Pectinophora gossypiella*)" starting from 201#-2020. Under the projects, Pink bollworm rearing laboratory was established in Entomology Section at the Institute for the first time in the country. For rearing of Pink bollworm, cotton seed based artificial diet has been developed. Pink bollworm collected from ginning waste and left over bolls is being successfully reared on locally developed artificial and natural diets. Now, efforts are being made for its mass rearing. Moreover, to determine the impact of sowing time on the PBW infestation or population dynamics,

sowing date trial was also conducted during 1st week of March, April and May, respectively. Male moth activity of Pink bollworm, *Pectinophora gossypiella* was monitored through sex pheromone baited traps at CCRI, Multan and farmer's field at Chak 116/10R Jahanian, District Khanewal throughout the year. Behavior of pink bollworm against different varieties under field conditions was evaluated. The effectiveness of pesticide against pink bollworm was also determined by spraying of pesticide in different timings and stage of cotton crop. Impact of topping fifty days before last picking and its impact on pink bollworm infestation was assessed. The data regarding infestation of pink bollworm was collected for correlation with Bt toxin in transgenic genotypes.

Whitefly Project: Management of whitefly by integrated strategies and development of resistant cotton germplasm through genetic engineering

In order to manage cotton whitefly through an integrated approach, the Punjab Agricultural Research Board (PARB), Government of the Punjab has initiated a three-years project "Management of whitefly by integrated strategies and development of resistant cotton germplasm through genetic engineering" starting from 201#-2020. The main objective of the project is the characterization of whitefly through conventional and molecular approaches, development of whitefly management strategies based on natural enemies and integrated pest management strategies and development of resistant cotton germplasms against whitefly by RNA interference. Under this project, CCRI Multan carried out monitoring of resistance to different insecticides against whitefly. Moreover, to determine the impact of planting time on the whitefly infestation or population dynamics, trial was conducted on 1st April, 1st May and 1st June, respectively. Furthermore, to isolate cotton cultivars for their response to whitefly on the basis of mechanism of plant resistance, trial was conducted containing different cotton cultivars (FH-142, FH-152, CIM-600, CIM-602, CIM-632, RH-668, NIAB-1048, Crystal-12, Sitara-15). Field experiments were also conducted to check the efficacy of conventional and new chemistry insecticides against whitefly population. Whitefly rearing laboratory was also established in Entomology Section of CCRI Multan and Whitefly is being reared on live cotton plants in this newly established lab. to develop susceptible strain.

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"

The United States Department of Agriculture (USDA) in coordination with the International Center for Agriculture Research in Dry Areas (ICARDA) initiated a cotton project involving all the cotton research institutions in Pakistan for the evolution of CLCuV resistant/tolerant cotton varieties. Cotton germplasm has been provided by the USDA for screening against Cotton Leaf Curl Virus resistance/tolerance. A total of 180 accessions of US cotton germplasm comprising of Set-V and W (*Gossypium hirsutum* L.) was distributed among CCRI, Multan (Set-W = 45), CRI Multan (Set-W = 45), CRS Vehari (Set-V = 32) and NIBGE, Faisalabad (Set-V = 58). Out of the 45 accessions which were provided to CCRI Multan, 20 were sown on 2nd July 2018 at experimental fields of CCRI Multan and the remaining 25 accessions were sown on June 1st 2019. The data for various parameters i.e., germination %age, plant population, disease infestation & severity, boll formation, along with physiological, morphological and fibre quality traits were also recorded. Two candidate varieties i.e. CIM-303 and CIM-775 which were evolved from crosses between local and US CLCuV resistant germplasm were tested in 1st and 2nd years in NCVT trials 2018-19 and 2019-20, respectively. Variety CIM-303 has completed its two years while CIM-775 will be tested for 2nd year during 2020-21 in National Coordinated Varietal Trial. CIM-775 has performed extra ordinarily and stood 2nd among 102 candidate varieties of NCVT 2019-20. Three other candidate lines, (using blood of US CLCuV resistant cotton germplasm) are in advanced varietal trials. At CCRI Multan the ratoon of 52 photoperiod sensitive and CLCuV resistant accessions were maintained in field condition and flower buds appeared in 14 accessions. 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.

xiv) PSDP Projects 2020

The following projects have been submitted to the Ministry of National Food Security & Research (MNFS&R), for consideration under PSDP program 2020.

Sr. No.	Name	Period	Amount (Rs. Million)
1.	Cotton Productivity Enhancement Through Eco Friendly Pink Bollworm Management and Capacity Building Program under PM Emergency Program	2 Years	672.1128
2.	Upgradation of Central Cotton Research Institute Sakrand and Cotton Productivity Enhancement through Capacity Building and Management of PBW in Sindh under PM Emergency Program	2 Years	1091.1240
3.	Horizontal Development of Cotton in KPK and Balochistan through Capacity Building under PM Emergency Program	2 Years	893.09476
4.	Cotton Yield and Fibre Quality Response to High Density Planting System	3 Years	35.288
5.	Development of Transgenic Climate Smart Cotton Varieties By Functional Analysis of WRKY Tfs Genes In Wild *Gossypium* Species	3 Years	59.444
6.	An Integrated Approach for Development of Resistance/Tolerance against Cotton Leaf Curl Virus (CLCuV) in Cotton Exploiting Field and Molecular Assays	3 Years	34.51
7.	Screening of Cotton (*Gossypium hirsutum* L.) Germplasm for Evolution of Heat/ Drought Tolerant Varieties	3 Years	37.350

III COTTON PROMOTION & DEVELOPMENT ACTIVITIES

i) Seed Germination Test Facility

CCRI Mutlan introduced free of cost seed germination test facility to the cotton farmers during the crop season 2019-20. The Institute has also negotiated with the courier company for fetching seed from farmers for this purpose. The germination test report is conveyed to the farmers through Whatsapp, message or email in a weeks time. A total of 167 samples were tested between 15.03.2019 to 23.04.2019 with an average germination of 55 percent. This facility was initiated to facilitate the farmers in adjusting of seed requirement as per germination test report for planting purpose.

ii) Walk for "Kapas Ugao, Maeshat Bachao"

CCRI Multan arranged a walk-in front of Multan Press Club with the slogan of "Kapas Ugao, Maeshat Bachao" in collaboration with WWF Shuja Abad. The objective of the walk was to persuade farmers for planting the cotton crop on more area for benefiting farmers as well as the economy of the country. Dr. Zahid Mahmood, Director CCRI Multan led the walk. The staff of CCRI Multan along with cotton farmers participated in the walk.

iii) Cotton Crop Revival Committee Meeting

The meeting of the Cotton Crop Revival Committee" was held at CCRI Multan under the chairmanship of Ali Arshad, Additional Secretary (Task Force). The Committee was constituted during the CCMG meeting held on 10.06.2019, while observing the continuous decline in cotton production in the Punjab province.

The objective of the Committee is to chalk out short term plan/strategies for the effective management of cotton crop 2019-20 and devise long term strategy for revival of cotton crop in the Punjab province. The participants deliberated upon short and long term strategies for the improvement in cotton productivity.

The strategies included timely provision of quality pesticides, fertilizers and weedicides at affordable prices, management of Pink bollworm and Whitefly; provision of pheromone traps / PB Ropes and extensive training programs for the cotton farmers. Moreover, desilting of canals and irrigation water availability, crop zoning, proper spraying techniques, and clean picking also included in the strategies. Improvement in cotton research programs for development of cotton varieties with high yielding, insect pests & disease resistance, and input-efficient were also recommended.

iv) Cotton Crop Management Group Meeting

Four meetings of the Cotton Crop Management Group (CCMG) were held during the crop season 2019-20 at CCRI Multan. The meetings were held under the chairmanship of Malik Nauman Ahmad Langrial, Minister for Agriculture, Punjab. Mr. Jahangir Khan Tareen, progressive farmer also attended the meetings. Cotton researchers, agriculture research, extension and plant protection officials, academicians, representatives of private pesticide associations, Irrigation, Pakistan Meteorological Department and progressive cotton growers attended the meeting. The meeting deliberated upon the management of cotton crop during the current year.

v) Workshop on "Cotton & Climate Change"

CCRI Multan in collaboration with Pakistan Meteorological Department organization one-day awareness program about "Cotton Production under Changing Climatic Conditions" on November 18, 2019. Mr. Muhammad Ajmal Shad, Director, Regional Meteorological Center Lahore talked about "Pakistan Meteorological Scenario and Crop Cultivation" while Dr. Shakeel Ahmad, Chairman Agronomy Department, Bahauddin Zakariya University delivered talk on

"Adaption to Climate Change". Dr. Rabia Saeed, Head Entomology CCRI Multan delivered talk about "Impact of Climate on Insect Pest of Cotton". Prof. Dr. Jalal Arif, Dean, Faculty of Agricultural Sciences, University of Agriculture Faisalabad; Mian Ahsan ul Haq Laleka, Mr. Khurshid Ahmad Kanjo, Seed Association of Pakistan, agriculture extension officials and farmers attended the program.

Dr. Zahid Mahmood, Director CCRI Multan briefed about challenges in cotton production. He described that during the current decade, cotton production has severely been affected due to rising temperatures and onslaught of heavy and prolonged rains. Collaborative efforts required for proper dissemination of weather advisories and rain forecast at district level so that decisions for pest control and crop irrigation could well be taken. The participants of the program also visited the cotton fields of CCRI Multan and appreciated the performance of varietal development.

vi) Training Program "Cotton Mealybug Management"

Cotton Mealybug has emerged an important pest of the cotton crop and its increased infestation has also been observed during the current season as well. The Institute has thus planned to conduct one-day training program "Management of Cotton Mealybug" held on September 5, 2019, specifically for the field staff of Agri Ext Deptt, Punjab. Twenty Agriculture Officers from the Agriculture Extension Department Punjab attended the program. The objective of the training program was to refresh and upgrade the knowledge of extension agents who will, in turn, guide the farmers for management of Mealybug. The training included lectures on biology, host plants and control measures of the Mealybug. Lectures on Insecticide Resistance Management and Effective Spray Application Techniques were also delivered. Later, a practical demonstration of control in the field was also shown to the participants.

vii) Farmers' Advisory Committee meetings

CCRI Multan constituted 'Farmers Advisory Committee' for the guidance of cotton farmers on fortnightly basis. A total of 14 meetings were held during the cotton crop season. One meeting each in Sindh and Khyber Pakhtunkhwa was also held in coordination with Director CCRI Sakrand and Incharge CRS DI Khan to devise crop management strategy in the respective province. The advisory being issued related to cotton crop management in the respective fortnight which included arrangements for seed, soil analysis and cotton nutrition management, land preparation, irrigvation water management, insect pests and disease management, farm machinery and sprayer arrangements, proper and clean picking.

viii) World Cotton Day Celebrations

The 7th October has been designated by the WTO, FAO & ICAC for global celebrations as *World Cotton Day* to highlight the importance of cotton crop in the economies of the developing countries. Accordingly, CCRI, Multan also celebrated this day. The celebration was organized in coordination with WWF Pakistan, CottonConnect and other private sector organizations. A seminar was also organized highlighting the importance of cotton crop and measures for its enhancement. A large number of cotton researchers, planners and farmers attended the program and deliberated the importance of cotton crop and measures for its revival in areas where production is on the decline. Cotton Walk was also arranged to highlight the importance. School children also participated in these programs.

ix) Launching of "Pakistan Cottongrower"

CCRI, Multan has initiated publication of a quarterly journal "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.

x) Publication of Monthly Newsletter

The Institute has also started publication of monthly Newsletter for highlighting major activities and events organized during the crop season 2019-20. 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.

xi) TeleCotton

CCRI Multan introduced TeleCotton SMS service for the guidance of the cotton farmers. Short messages were sent during the crop season 2019-20 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 22,145 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.

xii) Website & Social Media

The Institute also initiated highlighting cotton research and development activities carried out during crop season 2019-20 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.ccrim.org.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.

Inauguration of Cotton Sowing

Sahibzada Muhammad Mehbub Sultan, Minister for National Food Security & Research inaugurated cotton sowing at CCRI Multan on April 26, 2019. Dr. Muhammad Hashim Popalzai, Secretary, MNFS&R, Dr. Khalid Abdullah, Cotton Commissioner/Vice President PCCC, Dr. Khalid Khokhar, President, Pakistan Kissan Itehad and Mr. Shah Nawaz Warriach, Member Governing Body of PCCC and Dr. Zahid Mahmood, Director CCRI Multan.

IV. APPLICATION OF ADVANCED TECHNOLOGY

i) Insect Growth Chamber

Inauguration of an Insect Growth Chamber was done in the Entomology Section at CCRI, Multan provided under the Agriculture Linkage Program (ALP) project sponsored by Pakistan Agricultural Research Council (PARC). The Insect Growth Chamber will contribute to the research activities of Entomology Section, CCRI, Multan. It will help in insect rearing for the study of Insect Toxicology and other Biological Studies.

ii) Mechanical Cotton Picker

The Institute has introduced Mechanical Cotton Picker and demonstrations were held at the cotton fields of the Institute since 2018. This machine was introduced due to the rising picking charges and non availability of cotton pickers at critical time of crop harvest. This machine helps to manage large land areas, reduce labour requirements, and results in 25-40 % yield increase under high density planting system.

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.

V. International Coordination

i) Interational Cotton Researchers Association (ICRA) Secretariat

International Cotton Researchers Association (ICRA) is a forum of cotton researchers formulated in 2012 under the auspices of International Cotton Advisory Committee (ICAC). ICRA Secretariat was established at Multan after a formal MoU signing ceremony in October, 2017. Dr. Michel FOK, Chairman ICRA Executive Committee visited Pakistan and signed the agreement on behalf of ICRA and Dr. Khalid Abdullah Cotton Commissioner /Vice President on behalf of PCCC. Dr. Fiaz Ahmad was nominated as Secretary ICRA. The objectives of the ICRA are to promote research collaboration across the world, assist in organizing World Cotton Research Conferences, host a database of cotton research activities, and enhance the competitiveness of cotton through dissemination of cotton research findings and outputs.

The Secretariat office coordinated with ICRA in a number of activities such as making announcements of announcements of events through group mails and preparation of relevant promotional material; awards for young scientists from Asia, Africa, Middle East and Mediterranean regions; increasing membership of ICRA, inputs for regional network meetings, participation in online meetings, publication of ICRA newsletters in English, French and Spanish languages, printing and distribution of ICRA brochure and stickers in regional network meetings, preparation of theme based potential reviewer's list and keeping a record of all research paper submissions for the forthcoming World Cotton Research Conference, 2020.

VI. HUMAN RESOURCE DEVELOPMENT

i) Post-doc Fellowships

- Dr. Khezir Hayat Bhatti, Scientific Officer, Cytogenetics being awarded the Islamic Development Bank Postdoctoral Fellowship 2019-20. His Research Topic is "Association analysis and Genomewide Association Mapping for Oil contents in a World Cotton Germplasm using DArTseq genotyping tool". The research will be carried out at the University: Faculty of Agricultural and Natural Sciences Bolu Abant Izzet Baysal University Golkoy Campus, Turkey.
- Dr. Rabia Saeed, Head, Entomology, being awarded the Islamic Development Bank Postdoctoral Fellowship 2019-20. His Research Topic is "Study of lethal and sub lethal effects of RNAi transgenic lines on Coccinellids using advanced molecular techniques". The research will be carried out at the University: Faculty of Agricultural Sciences and technologies, Department of Agricultural Genetic Engineering, Nigde Omer Halisdemir University , Turkey.

ii) Pursuing PhD Studies

Following scientists of the Institute have been enrolled for the PhD studies during the year 2019-20 in respective disciplines of agriculture in various national and international universities.

Name of Scientist	Major Subject	University
Danish Iqbal, Scientific Officer (Fibre Technology)	Textile Sciences & Engineering (Cellulose Nanofiber Assemblies, Preparations, Porous Structures and Applications)	Qingdao University, Qingdao, China.

iii) Training Programs

The scientists of CCRI Multan attended the following training programs during the year 2019-20.

Name of Scientist	Topic of Training	Period of Training	Institute
Dr. Muhammad Idrees Khan, Head, Plant Breeding & Genetics	Plant Genetics Resources Use in Pre- Breeding and Varietal Development Practices.	Nov 12, 2019	Organized by FAO at University of Agriculture Sargodha.
Muhammad Tariq, Scientific Officer, Agronomy	Farmers integrated learning model	Dec 16-17, 2019	MNS-University of Agriculture, Multan
Sajid Mahmood, Head, Transfer of Technology	Media Management in Government	Jan 20-24, 2020	Secretariat Training Institute, Establishment Division, Islamabad

iv) Participation in National/International Seminars/Conferences/Workshops

The following scientists attended cotton seminars/workshops organized by various organizations during the year 2019-20.

Name of Scientist	Topic of Seminar/Workshop	Date	Institute
Muhammad Ilyas Sarwar	Research & policy recommendation on reduction of cotton-textile water footprint".	12.02.2020	WWF, Lahore
Dr. Fiaz Ahmad Noor Muhammad	Paradoxical agriculture strategy for high yield	28-01-2020	MNSUA, Multan
Dr. Fiaz Ahmad Asia Perveen Noor Muhammad	Cotton production under changing climatic condition	18-11-2019	CCRI, Multan
Dr. Fiaz Ahmad Asia Perveen Noor Muhammad	Persistent Organic Pollutants	06-09-2019	CCRI, Multan
Dr. Fiaz Ahmad Asia Perveen Noor Muhammad	Sustainable Agricultural Production	16-07-2019	CCRI, Multan

v) Publication of Book Chapters

- Khezir Hayat, Adem Bardak, Donay Parlak, Farzana Ashraf, Hafiz Muhammad Imran, Abdul Haq, Muhammad Azam Mian, Junaid Ali Khan, Zahid Mahmood and Naeem Akhtar. *Biotechnology for Cotton Improvement*. Book: Cotton Production and Uses - Agronomy, Crop Protection, and Postharvest Technologies. Springer. Accepted for Publication.
- Afzal, M.N., M. Tariq, M. Ahmed, G. Abbas and Z. Mehmood. 2020. *Managing Planting Time for Cotton Production*. In: Shakeel, A., Hasanuzzaman M. (eds) Cotton Production and Uses Agronomy, Crop Protection, and Postharvest Technologies. Springer, Singapore, (Accepted).
- Sarwar, M.I. and D.Iqbal. 2020. *Quality Aspects of Cotton Lint*. In: Shakeel, A., Hasanuzzaman M. (eds) Cotton Production and Uses Agronomy, Crop Protection, and Postharvest Technologies. Springer, Singapore, (Accepted).
- Niaz Ahmed, Muhammad Arif Ali, Subhan Danish, Usman Khalid Chaudhry, Sajjad Hussain, Waseem Hassan, Fiaz Ahmad and Nawab Ali. 2020. Role of Macro Nutrients in Cotton Production. *In* S. Ahmad, M. Hasanuzzaman (eds.), *Cotton Production and Uses,* Springer Nature Singapore Pte Ltd., pp% #1 104.

- Niaz Ahmed, Muhammad Arif Ali, Sajjad Hussain, Waseem Hassan, Fiaz Ahmad and Subhan Danish.2020. Essential Micronutrients for Cotton Production. *In* S. Ahmad, M. Hasanuzzaman (eds.), *Cotton Production and Uses,* Springer Nature Singapore Pte Ltd., pp% 10 117.

- Niaz Ahmed, Usman Khalid Chaudhry, Muhammad Arif Ali, Fiaz Ahmad, Muhammad Sarfraz, and Sajjad Hussain. 2020. Salinity tolerance in cotton, *In* S. Ahmad, M. Hasanuzzaman (eds.), "*Cotton Production and Uses",* Springer Nature Singapore Pte Ltd., pp% !" 391.

- Fiaz Ahmad, Asia Perveen, Noor Muhammad, Muhammad Arif Ali, Mohammad Naeem Akhtar, Khurram Shahzad, Subhan Danish and Niaz Ahmed. 2020. Heat Stress in Cotton: Responses and adaptive mechanisms *In S. Ahmad, M. Hasanuzzaman (eds.), "Cotton Production and Uses", Springer Nature Singapore Pte Ltd.*, pp% $ 428.

- Muhammad Ibrahim, Fiaz Ahmad, Bushra Yaqub, Ayesha Ramzan, Ayesha Imran, Muhammad Afzaal, Safdar Ali Mirza, Iqra Mazhar, Muhammad Younus, Qaisar Akram, Muhammad Sulman Ali Taseer, Ali Ahmad, and Sarfraz Ahmed. 2020. Current trends of antimicrobials used in food animals and aquaculture. *In M. Z. Hashmi (ed.), "Antibiotics and Antimicrobial Resistance Genes in the Environment",* ol. I, Elsevier Inc. pp% $ 69.

- Sarfraz Ahmed, Muhammad Ibrahim, Fiaz Ahmad, Hafsa Anwar Rana, Tazeen Rao, Wajiha Anwar, Muhammad Younus, Waqas Ahmad, Shahid Hussain Farooqi, Asma Aftab, Munawar Hussain, Muhammad Khalid, and Ghulam Mustafa Kamal. 2020. Microbial risk assessment and antimicrobial resistance. In *M. Z. Hashmi (ed.), "Antibiotics and Antimicrobial Resistance Genes in the Environment",* ol. I, Elsevier Inc. pp% 1330.

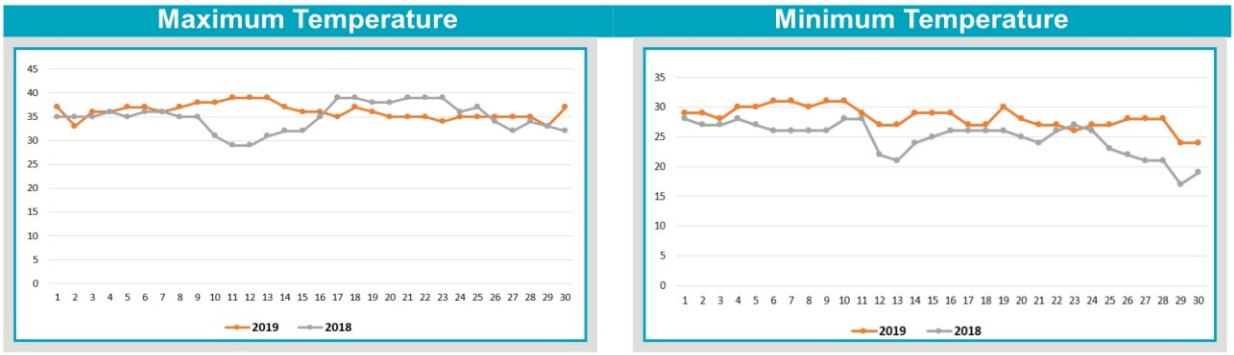
VI. COTTON CROP CONDITION: PUNJAB

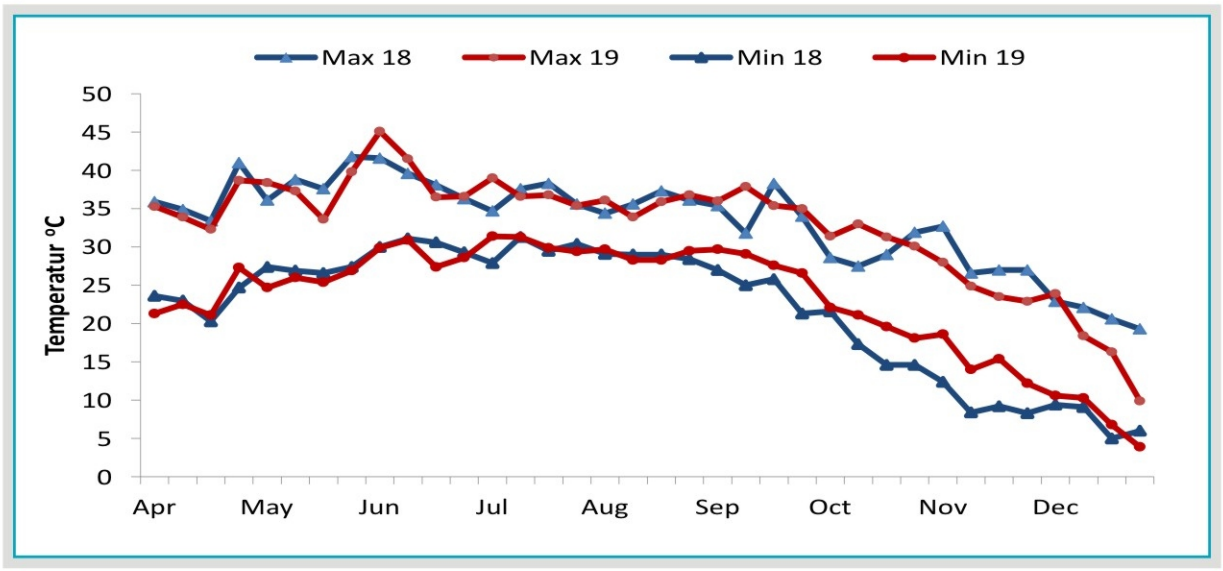
i) Weather Condition

The pattern of maximum temperatures during cotton crop season 2019-20 remained higher especially between July to November.The annual average maximum temperature during 2019-20 remained 39.9qC while it was 38.7qC during last year. Similarly the annual average minimum temperature during current year remained at 30.5qC while it was 29.8qC during last year.The minimum relative humidity remained 63.1% while it remained 85.8% at maximum level, during current season. A total of 267.4 mm rainfall was recorded during the crop season (Jan-Dec) of 2019 as compared to 26.8 mm rainfall during the last year.

The temperatures varied greatly during month of September 2019 and remained very crucial for the cotton crop. There was observed 3-10qC higher maximum temperature than last year during second week of September, while minimum temperature also rose from 3-6qC than that of last year between 5-15 September. This also resulted in heatwave in parts of South Punjab which also damaged the cotton crop substantially. The temperature, relative humidity and rainfall during the year 2019 is given in Annexure-II.

Temperatures during month of September 2019 at MULTAN





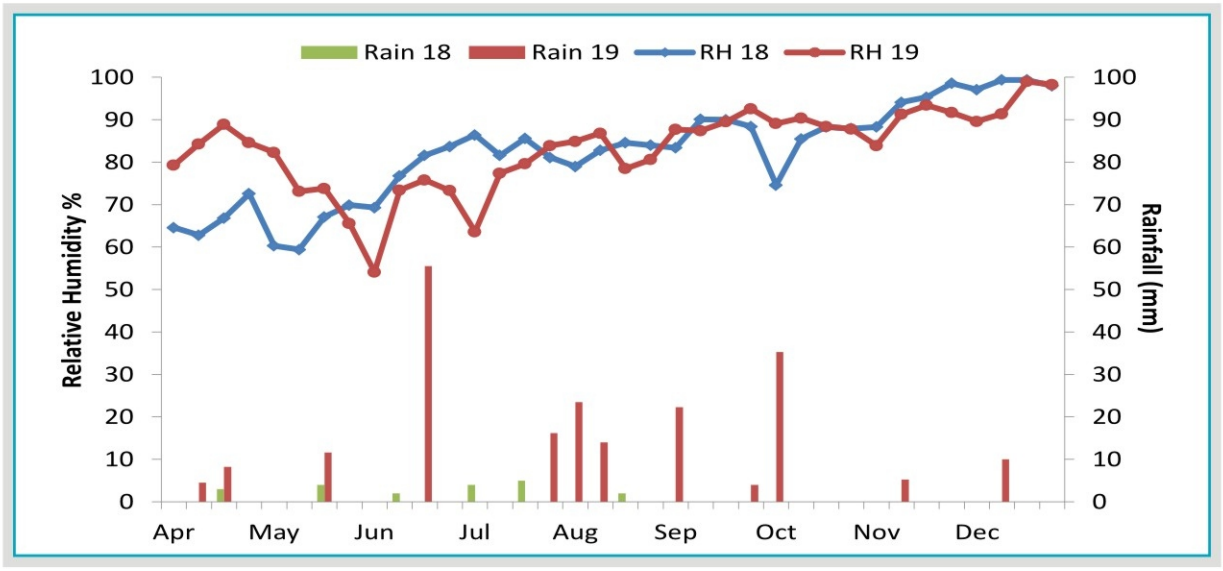


Fig. 1 Weekly Average Temperature, Relative Humidity and Total Rainfall during 2018 and 2019.

ii) Cotton Crop Situation 2019

Cotton crop season 2019-20 started with positive indicators of weather and irrigation water. Similarly, the input-provider agencies also ensured availability during the season. In addition, both the federal and provincial governments took measures for cotton crop improvement, availability of PB Ropes for control of Pink bollworm during the season. Government also constituted a high-level committee to ascertain the causes of declining cotton production trends and to devise short term and long-term strategies. Extensive farmers training programs were also launched by the Agriculture Extension Department Punjab for the management of cotton crop. Cotton advisory services have been effectively advocated through print, electronic and social media.

Targets for Area and Production of Cotton Crop 2019-20

Province	Area (Million hectares)	Production (Million bales)
Punjab	2.145	7.90
Sindh	0.640	4.60
Khyber Pakhtunkhwa	0.010	0.02
Baluchistan	0.100	0.20
Pakistan	**2.895**	**12.72**

Province-wise Sowing Position of Cotton Crop 2019-20 (Million hectares)

Province	Target (2019-20)	Area Sown 2019-20	Area Sown 2018-19	% Change Over Target	% Change Over Last Year
Punjab	2.145	1.860	1.888	86.7%	-1.5
Sindh	0.640	0.615	0.448	96.0%	+37.3
Khyber Pakhtunkhwa	0.010	0.0001	0.00016	1.0%	-37.5
Baluchistan	0.100	0.038	0.037	38.0%	+2.7
Pakistan	**2.895**	**2.513**	**2.373**	**86.8%**	**+5.9**

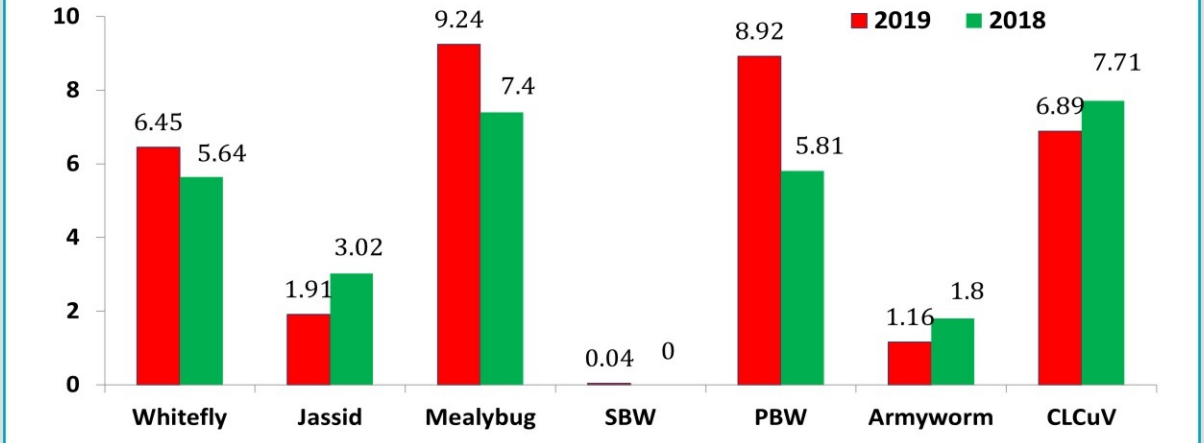
Estimate of Cotton Crop 2019-20 (Bale = 170 Kgs)

Province	Expected Production (Million bales)
Punjab	6.671
Sindh	2.680
Baluchistan & Khyber Pakhtunkhwa	0.0098
Pakistan	**9.451**

Source: 2nd CCAC Meeting held on 19.12.2019

iii) Insect Pests & Disease Position 2019

Cotton Whitefly, Mealybug, and Pink bollworm remained higher as compared to previous year. Similarly, the incidence of CLCuV was observed at 6.89% compared with 7.71% by 4th week of October in the Punjab province. The Agriculture Extension Department Punjab remained proactive in managing insect pests through fortnightly farmers advisories, extensive farmers training programs and provision of PB Ropes for the control of Pink bollworm. The overall insect pests & CLCuV position is as below:

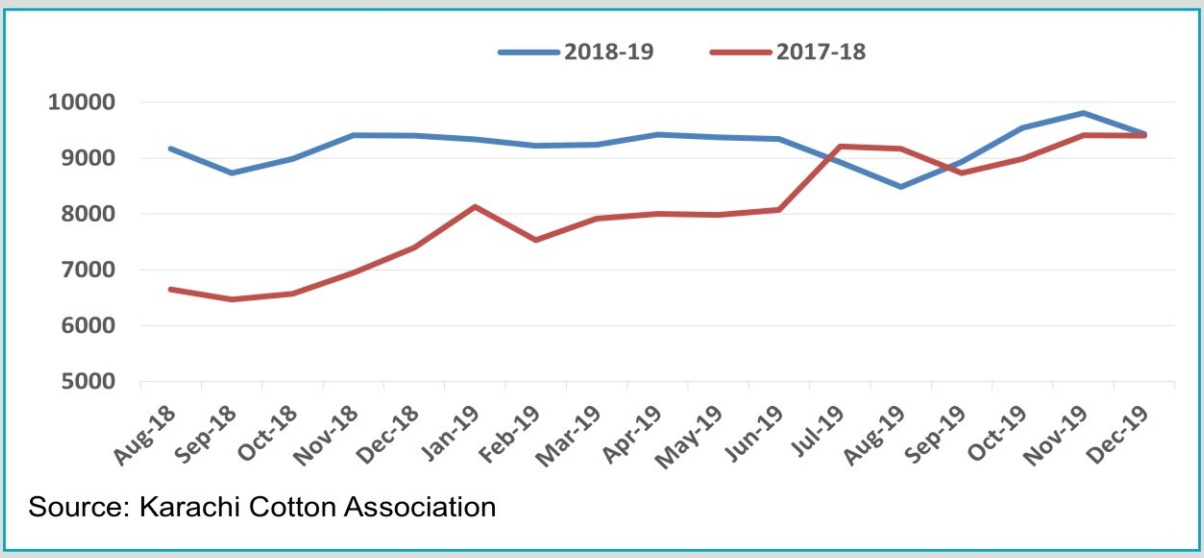


Source: PWQC Report (4th week of October, 2019)

iv) Cotton Market Situation

The seasonal cotton prices remained much better with '*Phutti*' price at Rs.3500-3950 and lint price at Rs. 8500-9500 per 40 kgs during the current season. Moreover, the overall quality of cotton was also excellent and surveyed resulted revealed staple length of 27.8mm, micronaire of 4.5 with around 4% trash which was acceptable for the ginning and textile industry in the country.

Monthly Average Prices of Raw Cotton (Rs per 40 Kgs)



Source: Karachi Cotton Association

The cotton arrival into ginning factories reached to 8.548 million bales arrived during current year compared with 10.701 upto 15th February, 2020 depicting shortfall of 20%.

Province	2019	2018	% Change over last year
Punjab	5,073,998	6,552,515	- 22.66
Sindh	3,473,979	4,148,481	- 16.26
PAKISTAN	**8,547,977**	**10,700,996**	**- 20.12**

Source: PCGA Arrival 15th Feb, 2020

Agricultural Research Sub Committee Meeting

The 2019-Agricultural Research Sub Committee (ARSC) meeting of the PCCC held at CCRI Multan from April 8-10, 2019. Dr. Khalid Abdullah, Vice President PCCC chaired the meeting. CCRI Multan facilitated all the events. The results of cotton experiments conducted during previous years were discussed and the experiments to be conducted during next year were approved. Moreover, list of cotton varieties developed by the public and private seed sector research institutions were also finalized for testing and evaluation in the National Coordinated Varietal Trials.

1. AGRONOMY

The cotton is very responsive to environmental conditions. The main focus of agronomic research is to match the crop key growth stages to optimum environmental conditions. Therefore, transgenic genotypes are planted from March-15 to June-01 and advanced genotypes are planted from April-15 to June-15 to explore the extreme potential of these new cultivars. These experiments are regular feature of the section to screen out the advance cultivars for a range of planting windows. Furthermore, trials are also conducted to evaluate the nitrogen requirement of ever evolving new conventional and transgenic genotypes. The feasibility of high density planting system (HDPS) is being studied for natural yield improvement by manipulating the plant populations. The experiment on assessment of climate change impact and future adaptation are in process by using crop model "DSSAT". The crop residues are continuously being incorporated to sustain the productivity of cotton wheat cropping system. The efficacy of pre-plant and pre-emergence weedicides has been evaluated for effective weed management in cotton. The recording of meteorological data is another permanent activity for decision making in crop management.

1.1 Effect of time of sowing on productivity of advanced genotypes

Three genotypes i.e. Cyto-226, Cyto-164 and CIM-610 were tested at five sowing dates starting from April 15 to June 15 at fifteen days interval. Experimental design was split plot. 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 seed by dibbling method followed by irrigation. Dual Gold 960 EC @ 2L 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, number of nodes per plant, number of bolls per plant, boll weight, seed cotton yield and CLCuD incidence percentage are given in Table 1.1.

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

Sowing dates	Genotypes	Plant height (cm)	Number of nodes $plant^{-1}$	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 75 DAS
April 15	Cyto-226	142.1	36.4	24	2.44	2254	1.3
	Cyto-164	140.7	36.2	25	2.55	2482	1.4
	CIM-610	143.6	38.0	26	2.75	2585	12.8
May 01	Cyto-226	140.8	36.3	23	2.45	2188	2.4
	Cyto-164	132.0	34.3	21	2.59	2037	3.5
	CIM-610	136.4	36.5	24	2.78	2420	29.5
May 15	Cyto-226	122.4	32.4	19	2.47	1740	29.9
	Cyto-164	107.1	30.6	19	2.61	1810	31.1
	CIM-610	122.9	32.6	20	2.82	1905	29.8
June 01	Cyto-226	95.4	29.5	15	2.48	1320	67.3
	Cyto-164	103.1	30.5	15	2.65	1398	60.0
	CIM-610	120.8	32.3	16	2.85	1485	68.9
June 15	Cyto-226	88.0	28.0	13	2.50	1173	74.2
	Cyto-164	99.9	30.0	14	2.68	1262	79.9
	CIM-610	104.0	30.4	12	2.87	1112	84.7

DAS* = Days after sowing

Sub-effects

Sowing dates	Plant height (cm)	Number of nodes $plant^{-1}$	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 75 DAS
April 15	142.1	36.9	25.0	2.58	2440	5.2
May 01	136.4	35.7	22.7	2.61	2215	11.8
May 15	117.5	31.9	19.3	2.63	1818	30.3
June 01	106.4	30.8	15.3	2.65	1401	65.4
June 15	97.3	29.5	13.0	2.68	1182	79.6

Genotypes	Plant height (cm)	Number of nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 75 DAS
Cyto-226	117.7	32.5	18.8	2.47	1735	35.0
Cyto-164	116.6	32.3	18.8	2.62	1798	35.2
CIM-610	125.5	34.0	19.6	2.81	1901	45.1
			C.D 5%			
Sowing date (SD)	12.7	5.3	2.89	ns	307.4	6.08
Genotype (G)	ns	ns	0.70	0.04	88.6	0.61
SD x G	ns	ns	1.57	ns	198.2	1.36

The data presented in Table 1.1 indicated that on overall average basis of sowing dates, genotype CIM-610 produced significantly higher seed cotton yield as compared to Cyto-164 and Cyto-226. The genotype CIM-610 produced 5.7% and 9.6% higher seed cotton yields than Cyto-164 and Cyto-226, respectively. Average across the genotypes, plant height and number of bolls plant^{-1} were decreased as the sowing was delayed (Fig. 1 & 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 (2.68 g) was produced from June 15 sown crop. The maximum bolls per plant (25.0) and seed cotton yield (2440 kg ha^{-1}) were harvested from April 15 sown crop.

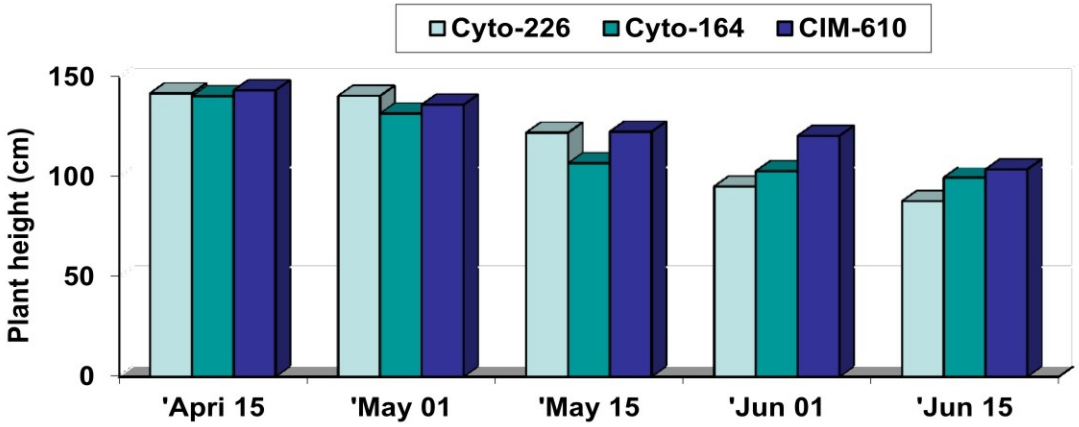


Fig 1 Sowing dates x genotypes interaction on plant height

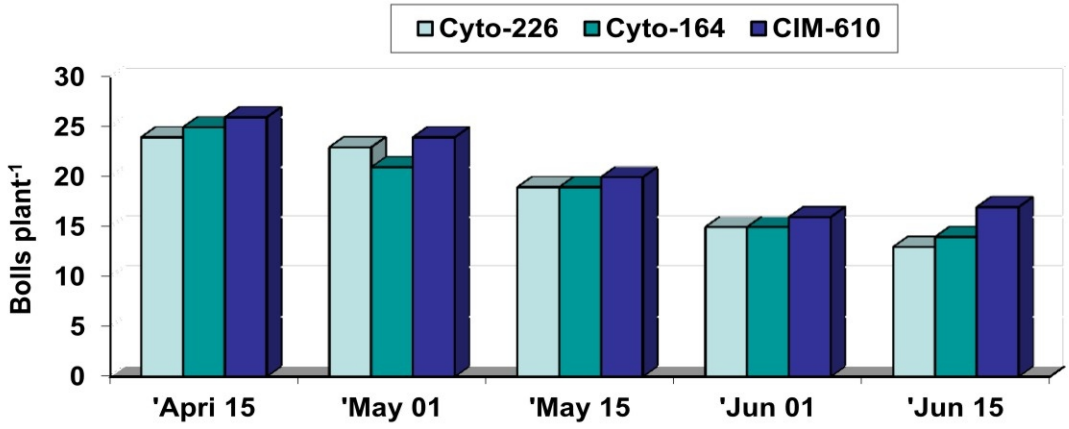


Fig 2 Sowing dates x genotypes interaction on bolls plant^{-1}

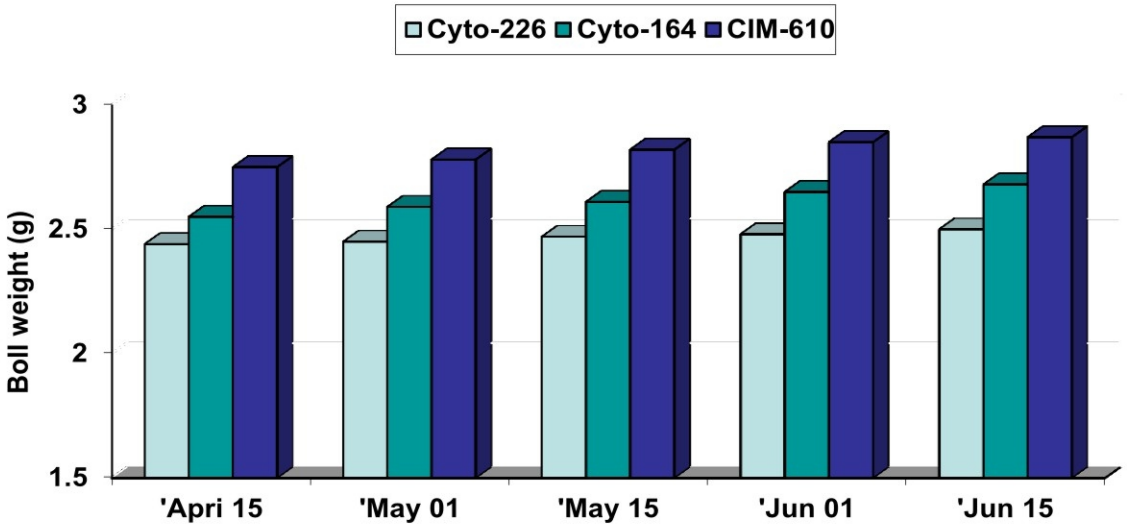


Fig 3 Sowing dates x genotypes interaction on boll weight

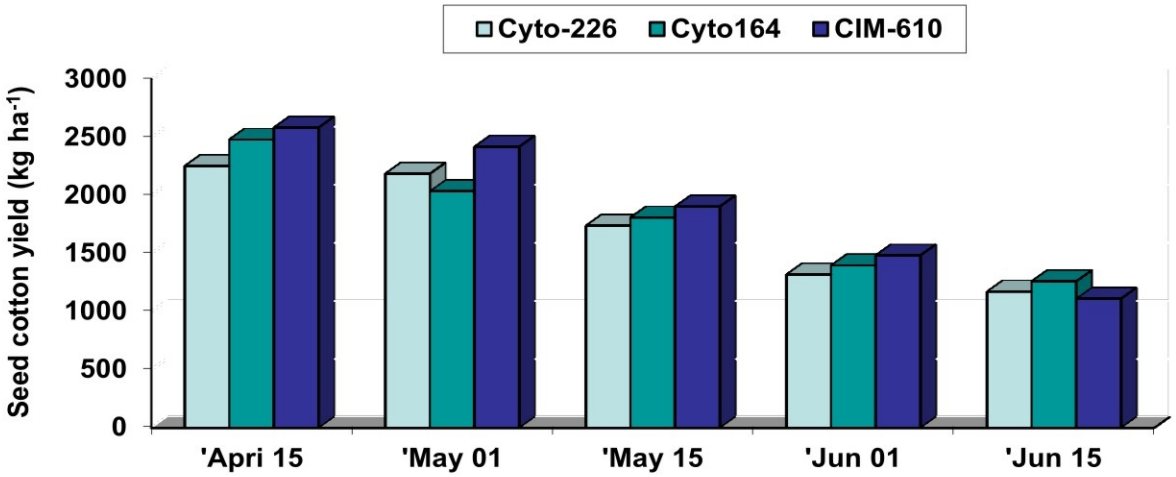


Fig 4 Sowing dates x genotypes interaction on seed cotton yield

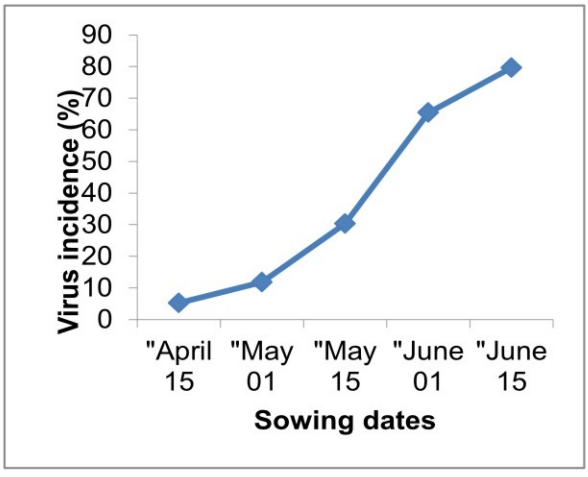


Fig 5. Sowing dates effect on virus infestation at 75 DAS

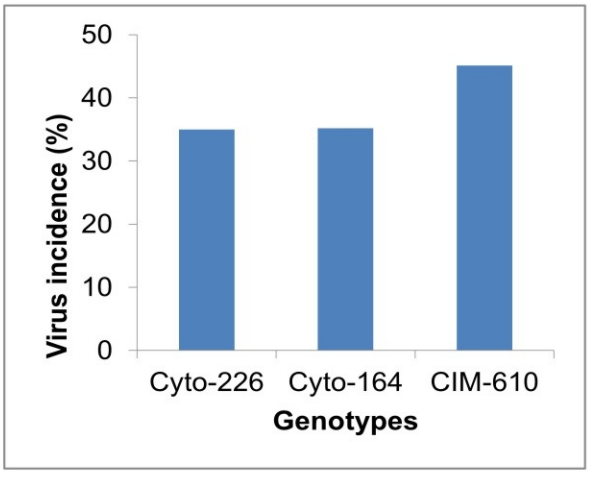


Fig 6. CLCuD incidence in different genotypes

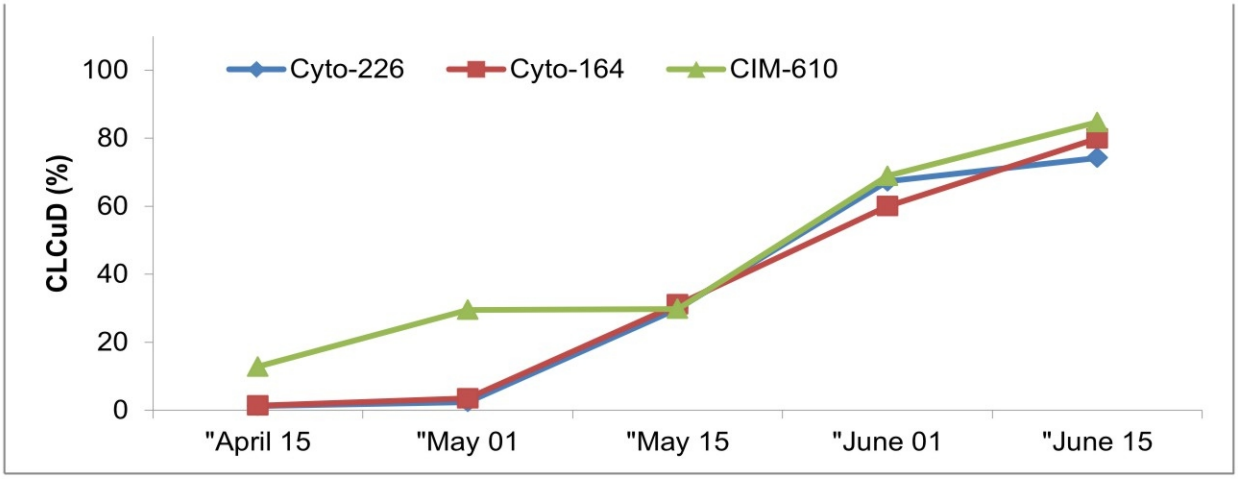


Fig 7. Interactive effect of sowing dates and genotypes on CLCuD incidence at 75 DAS

The data on CLCuD showed that the disease incidence gradually increased as the sowing was delayed from April 15 up to June 15. The incidence of CLCuD at 75 days after sowing was observed 79.6% in June 15 sown crop. Whereas, April 15, May 01, May 15 and June 01 sown crops showed 5.2%, 11.8%, 30.3% and 65.4% virus infestation, respectively (Fig. 5). On the average basis of sowing dates, genotype CIM-226 showed 10.1% less CLCuD incidence than CIM-610 (Fig. 6). The interaction between sowing dates and genotypes is illustrated in Fig. 7.

1.2 Effect of time of sowing on productivity of transgenic cotton

Five transgenic cotton genotypes i.e. *Bt.*CIM-789, *Bt.*Cyto-511, *Bt.*CIM-678, *Bt.*CIM-303 and *Bt.*CIM-785 with one standard *Bt.*Cyto-179 were evaluated at six different sowing dates starting from March 15 to June 01 at fortnightly interval. Experimental design was split plot; sowing dates were kept in main plot and genotypes in sub plots with four repeats. The net plot size was 20 ft x 28 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 @ 2L 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, nodes number, boll number, boll weight, seed cotton yield and CLCuD incidence percentage recorded are given in Table 1.2.

The plant heights, nodes per plant, bolls per plant and seed cotton yield were decreased while boll weight was increased with delay in sowing (Fig 8, 9, 10 and 11). The maximum plant height (142.1 cm), nodes plant^{-1} (37.0), bolls plant^{-1} (40.3) and seed cotton yield (4035 kg ha^{-1}) were harvested from March 15 sown crop. Among all sowing dates maximum boll weight (3.00 g) was produced from June 01 sown crop. On overall average basis of sowing dates, *Bt.*CIM-678 produced 5.5%, 5.5%, 7.1%, 7.5% and 9.2% significantly more seed cotton yield than *Bt.*CIM-303, *Bt.*CIM-785, *Bt.*Cyto-511, *Bt.*Cyto-179, and *Bt.*CIM-789, respectively.

Cotton Crop Management Group Meeting

Cotton Crop Management Group (CCMG) was held at CCRI Multan on August 23, 2019 under the chairmanship of Malik Nauman Ahmad Langrial, Minister for Agriculture, Punjab. Mr. Jahangir Khan Tareen, senior member PTI also attended the meeting.

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

Sowing dates	Genotypes	Plant height (cm)	Number of nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 90 DAS
March 15	*Bt*.CIM-789	136.2	36.2	40	2.82	3960	0.0
	Bt.Cyto-511	143.7	37.3	42	2.78	4245	1.4
	Bt.CIM-678	162.4	39.4	41	2.76	4093	1.3
	Bt.CIM-303	132.7	35.6	40	2.80	3948	0.0
	Bt.CIM-785	137.9	36.4	42	2.74	4220	0.0
	Bt.Cyto-179	139.8	37.1	37	2.82	3743	0.7
April 01	*Bt*.CIM-789	133.1	36.0	34	2.85	3350	0.7
	Bt.Cyto-511	140.1	37.2	30	2.84	3020	5.0
	Bt.CIM-678	152.5	37.8	33	2.80	3265	2.1
	Bt.CIM-303	128.6	34.5	29	2.84	2937	5.0
	Bt.CIM-785	136.2	36.2	33	2.76	3240	0.0
	Bt.Cyto-179	131.1	35.4	32	2.85	3195	4.3
April 15	*Bt*.CIM-789	131.6	35.6	23	2.90	2278	18.6
	Bt.Cyto-511	138.1	36.8	27	2.88	2710	12.5
	Bt.CIM-678	151.0	37.5	27	2.82	2673	55.0
	Bt.CIM-303	127.6	34.3	26	2.92	2636	57.0
	Bt.CIM-785	134.3	36.4	26	2.82	2577	17.4
	Bt.Cyto-179	129.0	34.8	26	2.90	2625	17.4
May 01	*Bt*.CIM-789	128.5	34.8	23	2.96	2314	100
	Bt.Cyto-511	128.3	34.3	24	2.92	2462	100
	Bt.CIM-678	139.0	37.0	26	2.85	2598	100
	Bt.CIM-303	123.8	33.3	25	2.94	2544	100
	Bt.CIM-785	127.0	34.5	25	2.87	2565	100
	Bt.Cyto-179	127.9	34.6	25	2.95	2556	100
May 15	*Bt*.CIM-789	117.2	31.9	19	3.02	1935	100
	Bt.Cyto-511	115.9	31.1	19	2.97	1901	100
	Bt.CIM-678	133.0	36.0	25	2.88	2510	100
	Bt.CIM-303	113.8	30.7	23	3.00	2336	100
	Bt.CIM-785	120.0	31.8	18	2.91	1780	100
	Bt.Cyto-179	120.4	32.5	19	3.00	1921	100
June 01	*Bt*.CIM-789	96.7	29.1	16	3.06	1648	100
	Bt.Cyto-511	98.5	29.8	15	3.01	1447	100
	Bt.CIM-678	122.1	33.2	18	2.90	1772	100
	Bt.CIM-303	97.0	28.8	16	3.04	1636	100
	Bt.CIM-785	103.7	30.0	17	2.94	1650	100
	Bt.Cyto-179	93.9	26.7	17	3.02	1696	100

DAS* =Days after sowing

Sub-effects

Sowing dates	Plant height (cm)	Number of nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 90 DAS
March 15	142.1	37.0	40.3	2.79	4035	0.6
April 01	137.0	36.2	31.8	2.82	3168	2.9
April 15	135.3	35.9	25.8	2.87	2583	29.7
May 01	129.1	34.8	24.7	2.92	2507	100
May 15	120.1	32.3	20.5	2.96	2064	100
June 01	102.0	29.6	16.5	3.00	1642	100

Genotypes	Plant height (cm)	Number of nodes plant^{-1}	Number of bolls plant^{-1}	Bollweight (g)	Seed cotton Yield (kg ha^{-1})	CLCuD incidence (%) at 90 DAS
Bt.CIM-789	123.9	33.9	25.8	2.94	2581	53.2
Bt.Cyto-511	127.4	34.4	26.2	2.90	2631	53.2
Bt.CIM-678	143.3	36.8	28.3	2.84	2819	59.7
Bt.CIM-303	120.6	32.9	26.5	2.92	2673	60.3
Bt.CIM-785	126.5	34.2	26.8	2.84	2672	52.9
Bt.Cyto-179	123.7	33.5	26.0	2.92	2623	53.7

C.D 5%

Sowing date (SD)	16.614	4.05	4.1041	ns	287.05	2.1076
Genotype (G)	5.931	1.26	1.2965	ns	105.29	0.5436
SD x G	ns	ns	3.1759	ns	257.91	1.3316

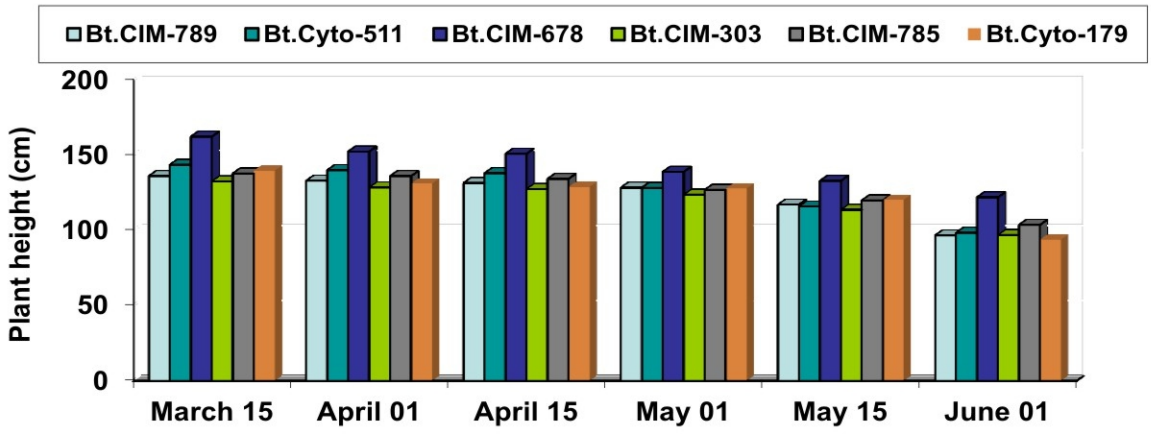


Fig 8 Sowing dates x genotypes interaction on plant height

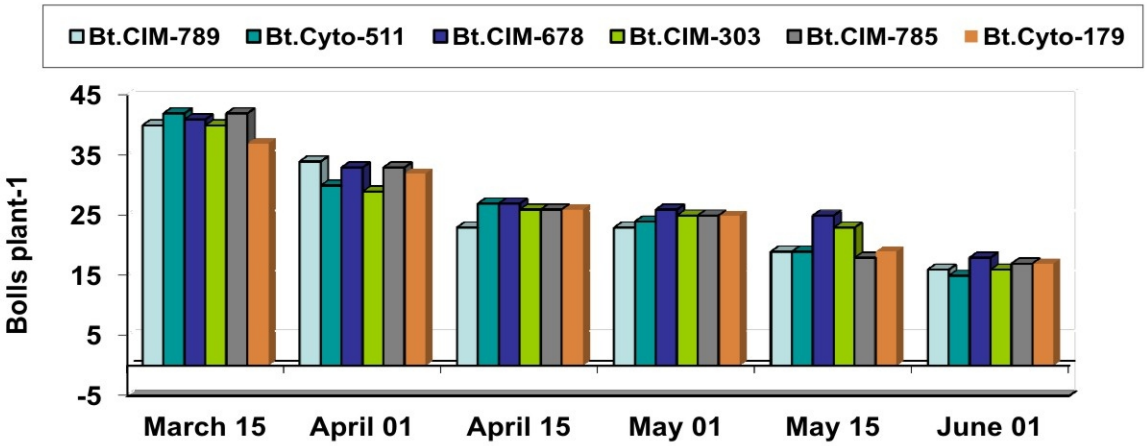


Fig 9 Sowing dates x genotypes interaction on bolls plant^{-1}

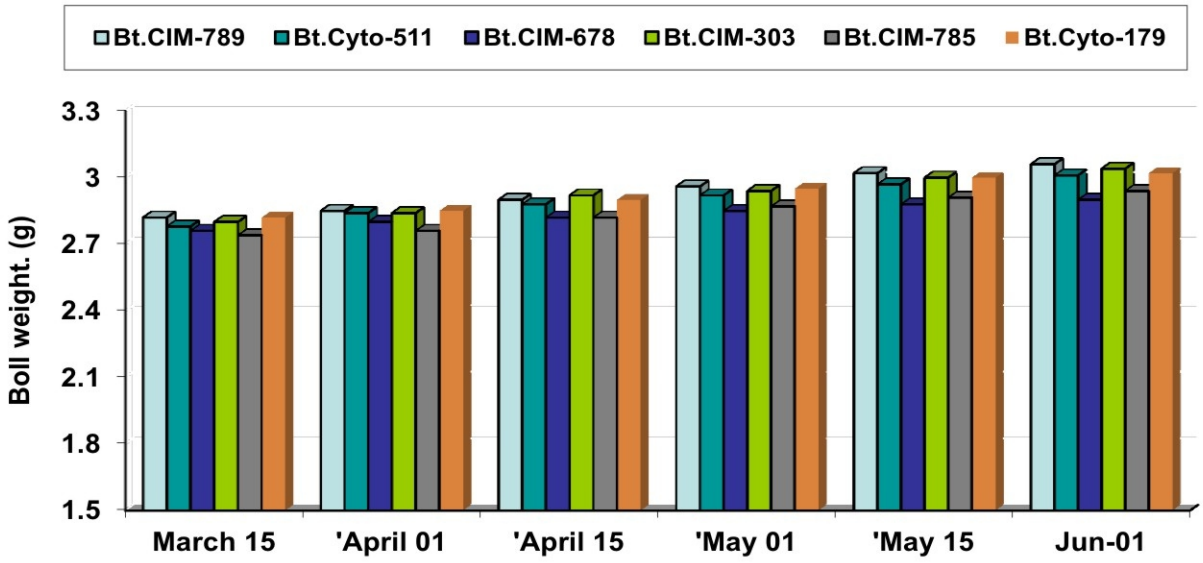


Fig 10 Sowing dates x genotypes interaction on boll weight

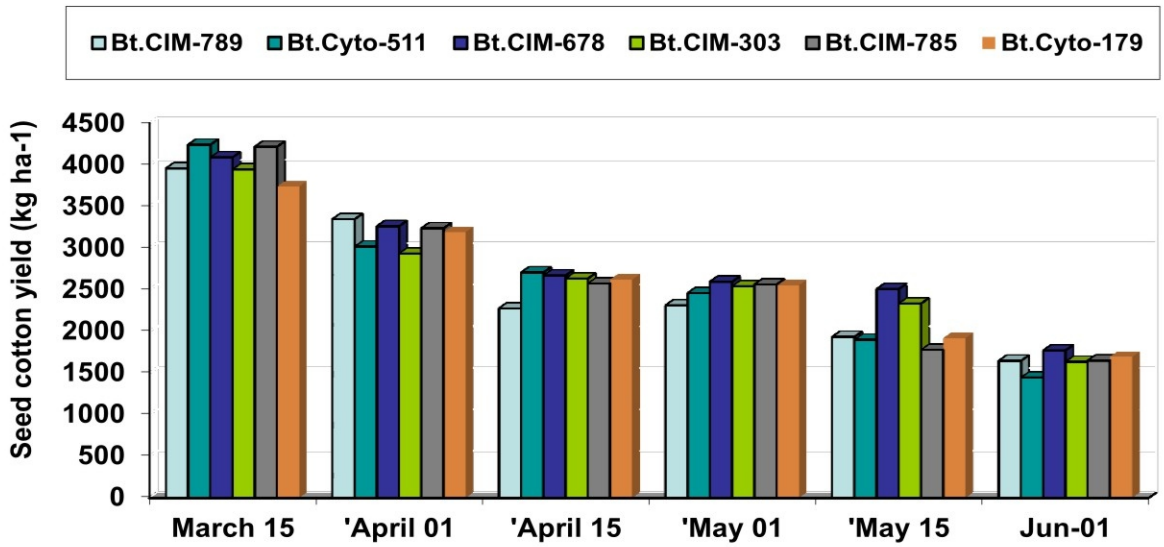


Fig 11 Sowing dates x genotypes interaction on seed cotton yield

The data on CLCuD indicated that the disease incidence increased as the sowing was delayed from March 15 to June 01. The incidence of CLCuD after 90 days of sowing was observed to be 100.0% in May 01, May 15 and June 01 sown crops. While, March 15, April 01 and April 15 sown crops showed 0.6%, 2.9% and 29.7% virus infestation, respectively (Fig. 12) at 90 DAS. On the average basis of sowing dates, genotype *Bt*.CIM-785 showed 0.3%, 0.3%, 0.9%, 6.8% and 7.4% less incidence of CLCuD than *Bt*.CIM-789, *Bt*.Cyto-511, *Bt*.Cyto-179, *Bt*.CIM-678 and *Bt*.CIM-303, respectively (Fig. 13).The interaction between sowing dates and genotypes is illustrated in Fig. 14.

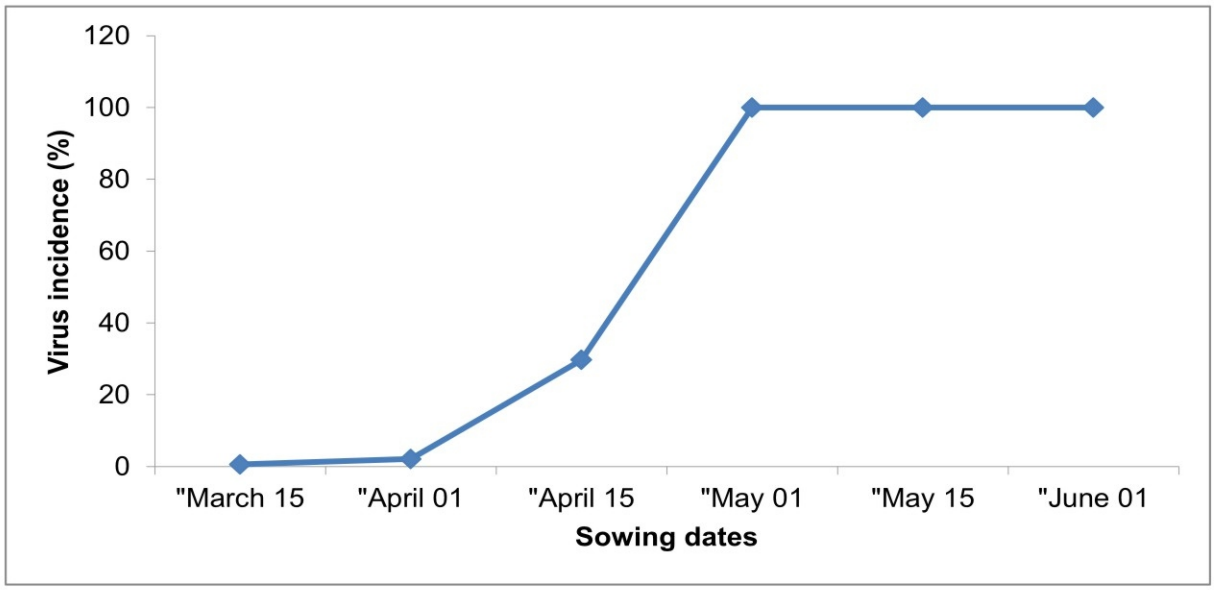


Fig 12. Virus Infestation at 90 DAS in various sowing dates

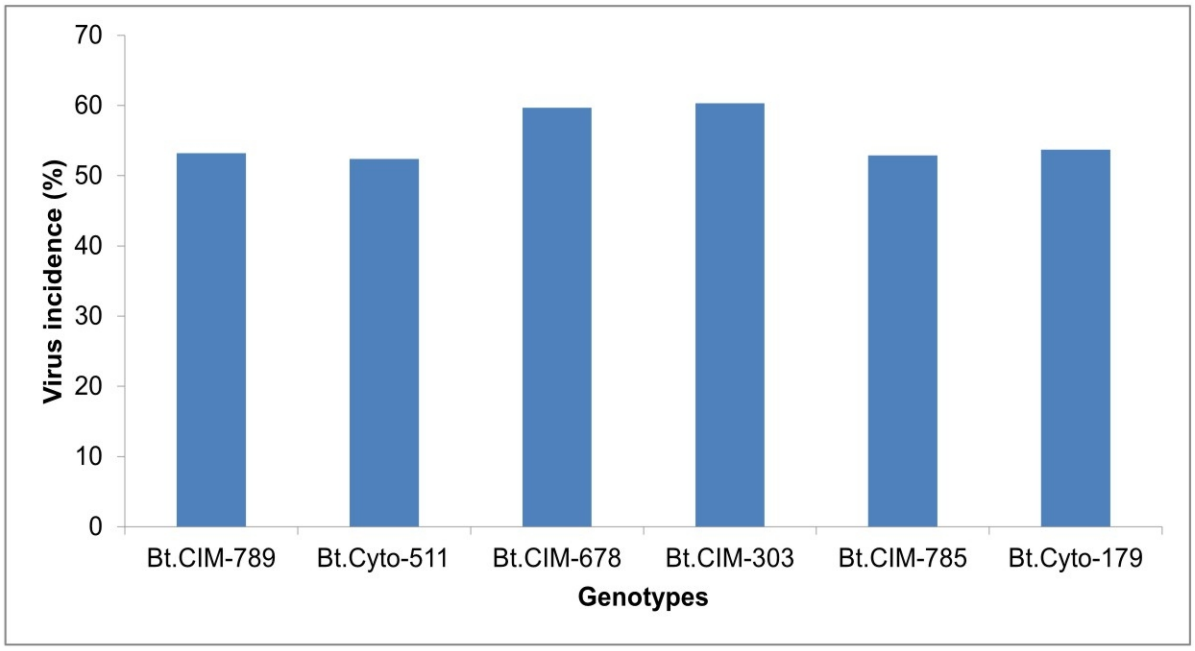


Fig 13. CLCuD incidence in different genotypes

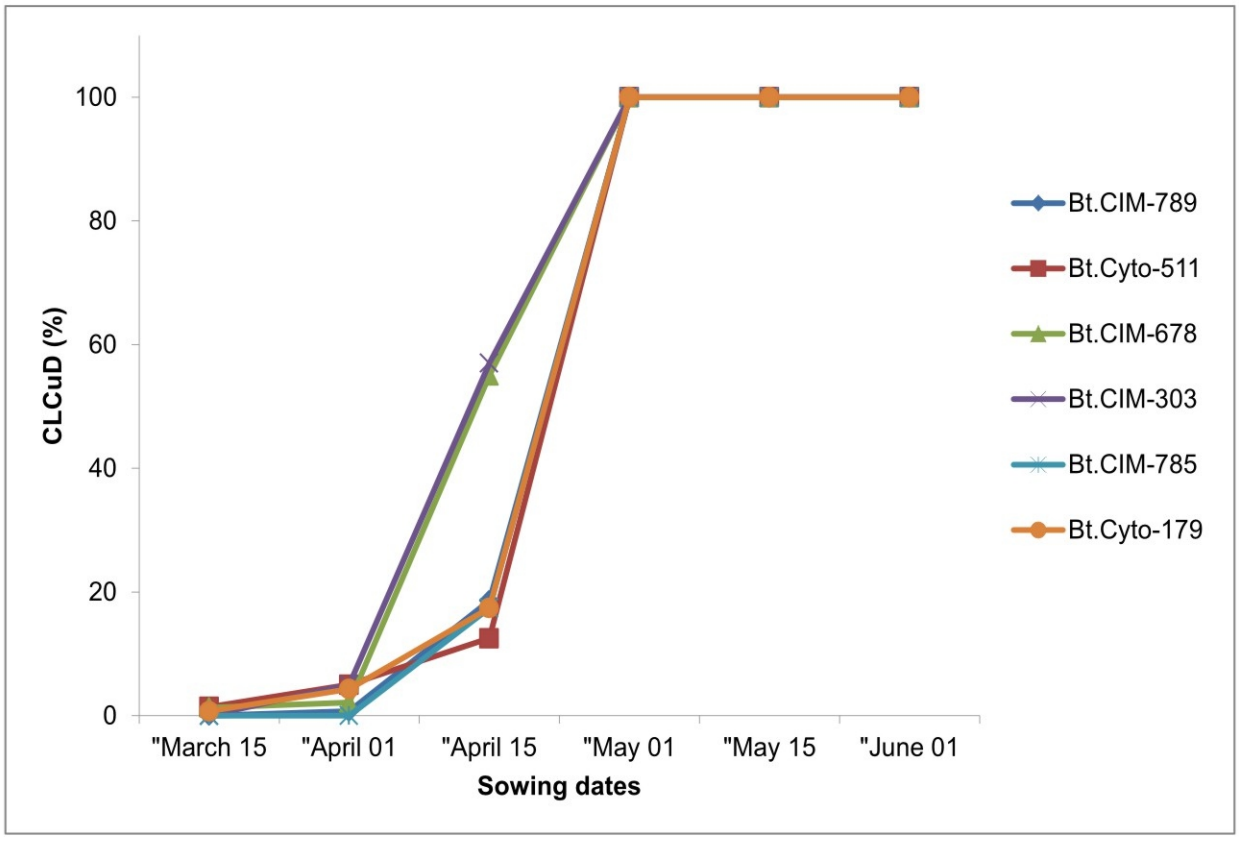


Fig 14. Interactive effects of sowing dates and genotypes on CLCuD incidence at 90 DAS

1.3 Yield response and nitrogen use efficiency of transgenic cotton genotypes to nitrogen applications

The nitrogen requirement of five genotypes including *Bt*.CIM-789, *Bt*.Cyto-511, *Bt*.CIM-678, *Bt*.Cyto-533 and *Bt.* Gh. Himalaya was determined. The nitrogen levels were comprised of 0, 75, 150, 225 and 300 kg N ha^{-1}. The treatments were arranged according to Randomized Complete Block Design (RCBD) with split plot arrangement and three replications were used. Each plot comprised of eight rows with 23 feet length. The nitrogen rates were allocated to main plots and genotypes were placed in sub-plots. The land 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 on 13.06.2019 at 22.5 cm space on dry beds followed by irrigation. 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 nitrogen fertilizer was applied on 23rd July 2019, 17th August 2019 and 12th September 2019 in three equal splits. The uniform set of cultural practices and plant protection measures were adopted as per need of the crop. Five randomly selected plants were used for recording plant height, number of nodes and bolls per plant. The boll weight was worked out by picking 50 bolls from each plot at maturity. The whole plot was manually picked and seed cotton weight was converted on hectare basis. The agronomic nitrogen use efficiency was calculated by measuring the yield increase with unit increase in nitrogen supply. The data on plant height, nodes, yield & yield components and agronomic nitrogen use efficiency are given in Table 1.3.

Table 1.3 Interactive effects of nitrogen fertilizer and genotypes on plant height, nodes, seed cotton yield, yield parameters and agronomic nitrogen use efficiency

Nitrogen dose (kg ha^{-1})	Genotypes	Plant height (cm)	Number of nodes $plant^{-1}$	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})	Agronomic nitrogen use efficiency (kg kg^{-1})
0	*Bt.* CIM-789	72.4	23.1	15	2.85	1543	-
	Bt. Cyto-511	78.4	24.2	13	2.67	1295	-
	Bt. CIM-678	101.5	31.9	17	2.56	1696	-
	Bt. Cyto-533	71.3	22.6	11	2.73	1108	-
	Bt. Gh. Himalaya	79.0	24.1	14	2.46	1423	-
75	*Bt.* CIM-789	85.1	25.7	19	2.89	1936	5.2
	Bt. Cyto-511	83.4	25.7	16	2.70	1620	4.3
	Bt. CIM-678	107.8	33.6	21	2.62	2056	4.8
	Bt. Cyto-533	78.2	24.4	14	2.80	1447	4.5
	*Bt.*Gh. Himalaya	86.6	26.2	18	2.50	1771	4.6
150	*Bt.* CIM-789	95.5	28.6	22	2.94	2249	4.7
	Bt. Cyto-511	89.3	27.2	20	2.75	1967	4.5
	Bt. CIM-678	115.8	35.1	24	2.66	2378	4.5
	Bt. Cyto-533	86.5	26.8	17	2.83	1720	4.1
	*Bt.*Gh. Himalaya	89.6	26.9	21	2.52	2031	4.1
225	*Bt.* CIM-789	100.6	30.0	24	2.96	2396	3.8
	Bt. Cyto-511	95.0	28.8	22	2.77	2217	4.1
	Bt. CIM-678	123.3	37.2	26	2.69	2609	4.1
	Bt. Cyto-533	90.8	27.7	20	2.85	1998	4.0
	*Bt.*Gh. Himalaya	98.0	29.2	22	2.53	2177	3.4
300	*Bt.* CIM-789	105.3	31.3	25	3.01	2507	3.2
	Bt. Cyto-511	99.4	30.0	23	2.79	2340	3.5
	Bt. CIM-678	129.0	38.6	27	2.69	2689	3.3
	Bt. Cyto-533	95.0	28.9	21	2.87	2090	3.3
	*Bt.*Gh. Himalaya	103.1	30.5	24	2.55	2359	3.1

Sub-effects

Nitrogen dose (kg ha^{-1})	Plant height (cm)	Number of nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	Agronomic nitrogen use efficiency (kg kg^{-1})
0	80.5	25.2	14.0	2.65	1413	-
75	88.2	27.1	17.6	2.70	1766	4.7
150	95.3	28.9	20.8	2.74	2069	4.4
225	101.5	30.6	22.8	2.76	2279	3.9
300	106.4	31.9	24.0	2.78	2397	3.3

Genotypes	Plant height (cm)	Number of nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	Agronomic nitrogen use efficiency (kg kg^{-1})
Bt. CIM-789	93.1	27.9	21.0	2.93	2126	4.2
Bt. Cyto-511	89.1	27.2	18.8	2.74	1888	4.1
Bt. CIM-678	115.5	35.3	23.0	2.64	2286	4.2
Bt. Cyto-533	84.4	26.1	16.6	2.82	1673	4.0
*Bt.*Gh. Himalaya	89.9	27.2	19.8	2.51	1952	3.8
			C.D 5%			
Nitrogen (N)	9.42	1.91	2.03	0.06	167.28	-
Genotypes (G)	6.10	1.86	1.80	0.08	146.08	-
N x G	ns	ns	ns	ns	ns	-

The results presented in Table 1.3 highlighted that impact of nitrogen had been significant for plant height, nodes per plant, bolls per plant, boll weight and seed cotton yield and these parameters were increased with each incremental nitrogen level. Increasing nitrogen rates from 0 to 300 kg ha^{-1} improved plant height, nodes, bolls, boll weight and seed cotton yield from 80.5 to 106.4 cm, 25.2 to 31.9 per plant, 14.0 to 24.0 per plant, 2.65 to 2.78 g and 1413 to 2397 kg ha^{-1}, respectively. The additional seed cotton yield of 53, 656, 866 and 984 kg ha^{-1} over unfertilized plots was obtained from 75, 150, 225 and 300 kg ha^{-1}, respectively. Each increase in nitrogen from 0 to 225 kg ha^{-1} produced statistically higher seed cotton yield, however, the differences between 225 and 300 kg ha^{-1} remained non-significant with each other. The higher seed cotton yield was linked with improved yield formation traits. The agronomic nitrogen use efficiency (ANUE) describes the relative yield gains per kg nitrogen applied. Table 1.3 showed that ANUE was initially high and gradually decreased from 4.7 to 3.3 kg kg^{-1} with increasing nitrogen rate from 75 to 300 kg N.

The significant differences among genotypes were observed for recorded parameters. The genotype *Bt.* CIM-678 and *Bt.* Cyto-533 produced the tallest and shortest plants with the height of 115.5 cm and 84.4 cm, respectively. The highest seed cotton yield along with maximum number of bolls per plant was recorded from *Bt.* CIM-678 followed by *Bt.* CIM-789. It produced 17.1%, 21.1%, 36.6% and 7.5% more seed cotton yield than *Bt.* Gh. Himalaya, *Bt.* Cyto-511, *Bt.* Cyto-533 and *Bt.* CIM-789, respectively. It produced higher seed cotton yield on account of a greater number of bolls per plant. Relatively bigger bolls with average boll weight of 2.93 g were produced from *Bt.*CIM-789 and small bolls with boll weight of 2.51 g were obtained from *Bt.* Gh. Himalaya. The cultivars differences for ANUE were marginal, however, the maximum ANUE (4.2) was recorded from *Bt.* CIM-678 and *Bt.* CIM-789 and lowest (3.8) was from *Bt.* Gh. Himalaya. None of the parameters showed significant interactions between genotypes and nitrogen rates, indicating that nitrogen requirement did not vary among genotypes (Fig. 15-19).

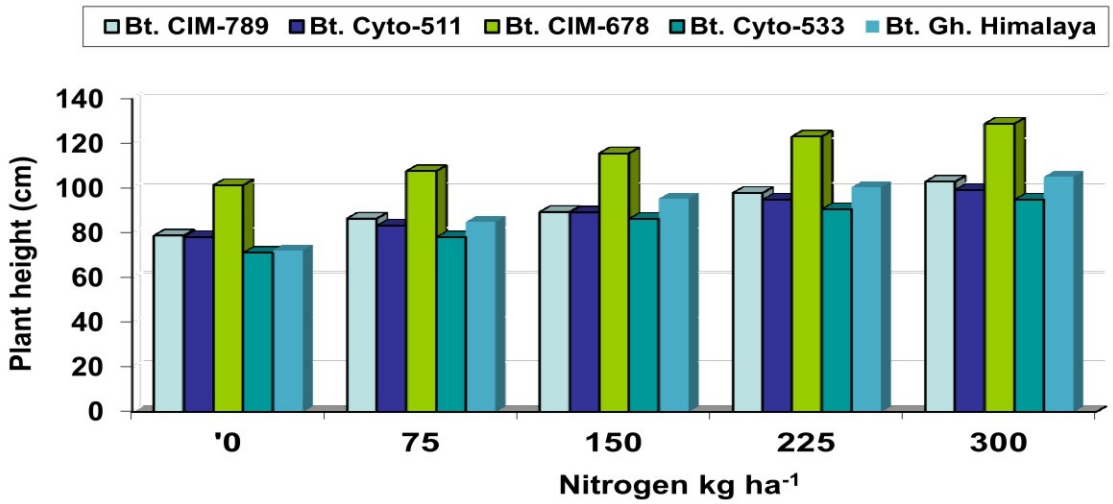


Fig 15 Nitrogen levels X genotypes interaction on plant height

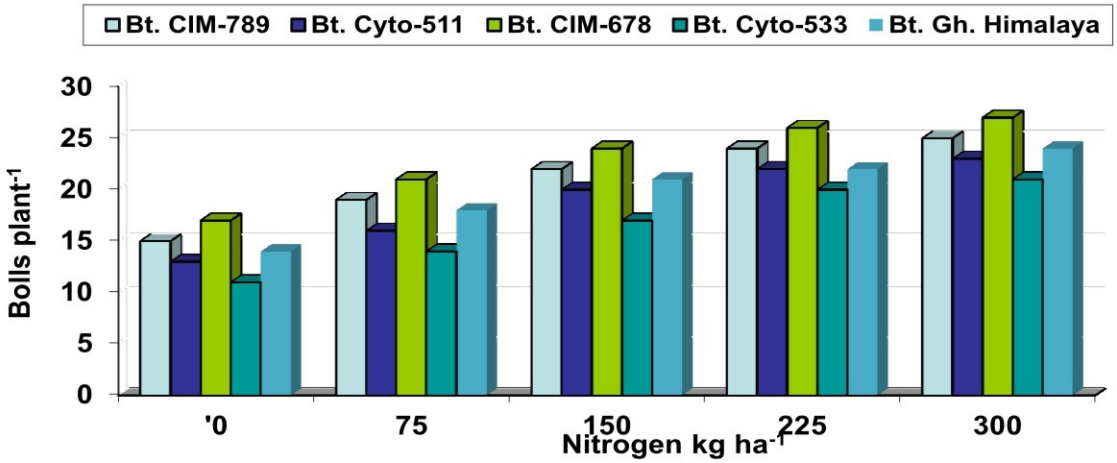


Fig 16 Nitrogen levels X genotypes interaction on bolls plant^{-1}

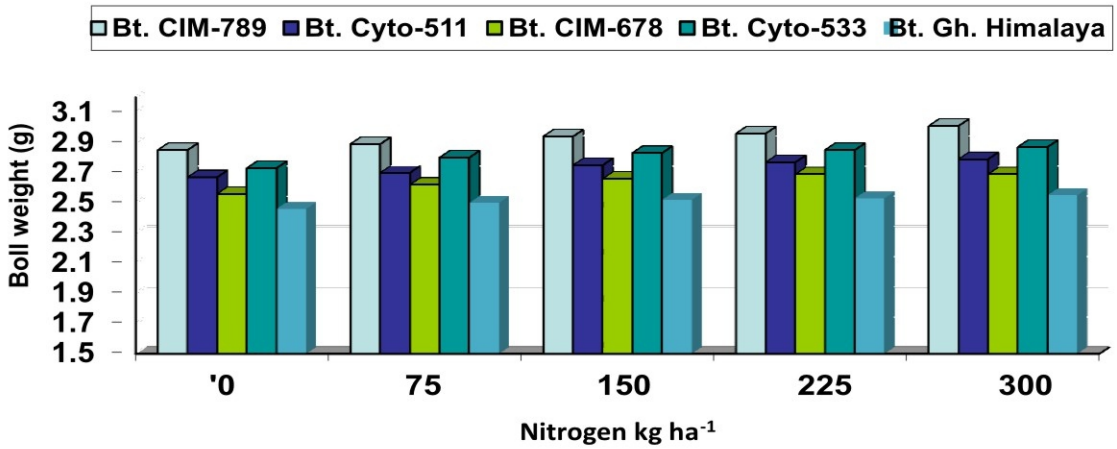


Fig 17 Nitrogen levels X genotypes interaction on boll weight

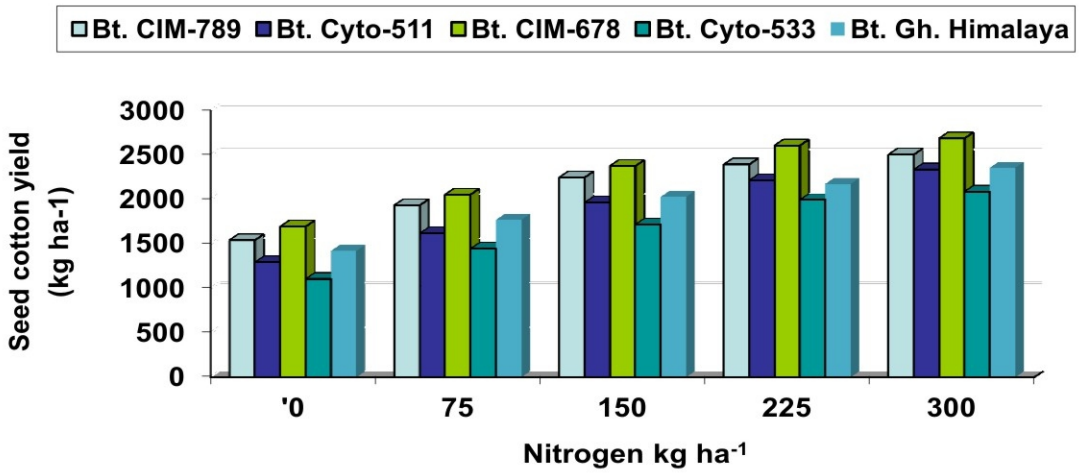


Fig 18 Nitrogen levels X genotypes interaction on seed cotton yield

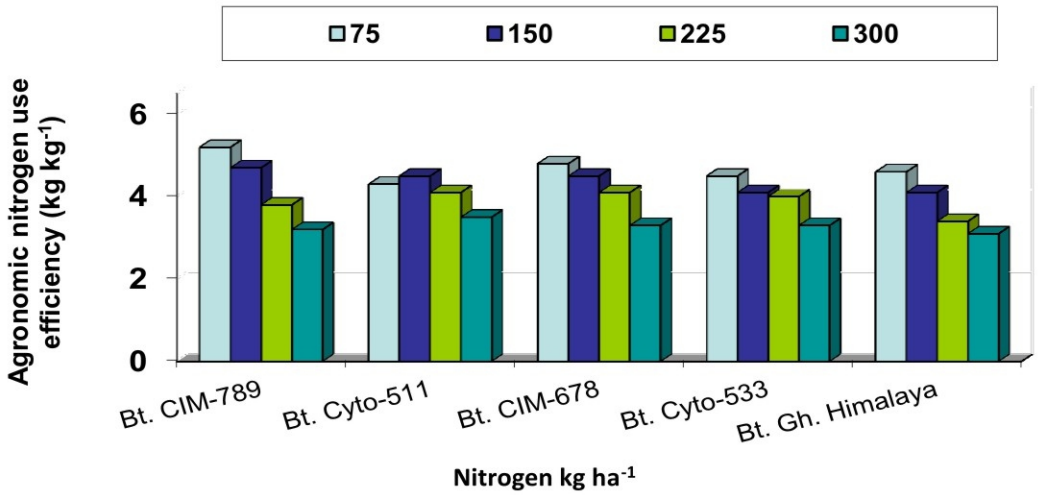


Fig 19. Nitrogen levels X genotypes interaction on agronomic nitrogen use efficiency

1.4 Modeling the cotton genotypes performance at temporal variations

The climate change is a continuous process and threatening cotton production. Pakistan has been ranked among the most vulnerable countries in the world. The current agronomic practices need a redesigning to effectively address the warming trend issue. Decades are required for such type of experimentation, however, crop growth and simulation models like DSSAT (Decision Support System for Agro-Technology Transfer) generates reliable results after calibration and evaluation using short term field observed data. CSM-CROPGRO-Cotton Model embedded in DSSAT will be used for the assessment of climate change and adaptation strategies. The current study was aimed to optimize planting time and estimate yield performance of genotypes. Three genotypes i.e *Bt*. CIM-789, *Bt*. Cyto-511 and *Bt*. Cyto-179 were planted on 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 planting time was designated to main plot and genotypes to sub-plot. The net plot size measurement was 20 ft x 28 ft. The phenology data on days taken for 50% squaring, flowering and boll split initiation were recorded from six randomly selected plants from each plot. The experimental data on phenology, plant height, yield and yield components will be used for calibration and evaluation of the CSM-CROPGRO-Cotton Model. Best performing treatment

Training Program for Cotton Farmers

CCRI Multan organized one-day training program for the contracted cotton farmers of WWF-BCI Shuja Abad on March 18, 2019. More than 100 small cotton farmers participated. The group was led by Mr. Abdul Rasheed Bhutto, Project Coordinator, along with Mr. Hammad Nazir and Mr. Muhammad Adeel, Producer Managers. Dr. Zahid Mahmood, Director CCRI Multan briefed the visiting cotton farmers about the performance of cotton varieties and production technology developed by the Institute and introduction of the mechanical cotton picker. Dr. Muhammad Naveed Afzal, Head Agronomy gave a presentation about agronomic practices (seed treatment, land preparation, sowing, irrigation) for enhancing cotton productivity.

observed in the results will be used for calibration and remaining results will be used for model evaluation. The evaluation of the model will also be carried out by using third year field data. Baseline weather data (1980-2018) and future scenario weather data will be made available through Pakistan Meteorological Department (PMD). Various GCM (General Circulation Model) at RCP 8.5 will be used for assessment of climate change for future scenario and then adaptation strategies will be made for reducing the negative impact of warming trend in future scenario. The crop management data and weather file have been maintained.

Table 1.4: Effect of temporal variations on plant structure, phenology, seed cotton yield and its components for various genotypes

Sowing Date	Genotypes	Plant height (cm)	Number of Nodes plant^{-1}	Days taken to 50% squaring	Days taken to 50% flowering	Days taken to first boll split	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
March 15	*Bt.* CIM-789	136.2	36.2	44.0	62.7	97.7	40	2.82	3960
	Bt. Cyto-511	143.7	37.2	43.7	61.7	97.7	42	2.78	4245
	Bt. Cyto-179	139.8	37.1	43.7	61.0	97.0	37	2.82	3743
April 15	*Bt.* CIM-789	131.6	35.6	38.7	59.0	93.7	23	2.90	2278
	Bt. Cyto-511	138.1	36.8	39.7	59.0	95.0	27	2.88	2710
	Bt. Cyto-179	129.0	34.8	38.0	55.0	92.0	26	2.90	2625
May 15	*Bt.* CIM-789	117.2	31.9	46.0	65.7	98.0	19	3.02	1935
	Bt. Cyto-511	115.9	31.1	47.0	68.0	96.7	19	2.97	1901
	Bt. Cyto-179	120.4	32.5	45.0	65.0	98.7	19	3.00	1921
June 15	*Bt.* CIM-789	101.0	29.9	51.7	69.7	96.0	16	3.04	1592
	Bt. Cyto-511	91.4	27.7	52.0	67.7	95.3	15	3.00	1460
	Bt. Cyto-179	91.1	27.6	51.7	69.7	93.0	15	3.02	1475

Sub-effects

Temporal variations	Plant height (cm)	Number of Nodes plant^{-1}	Days taken to 50% squaring	Days taken to 50% flowering	Days taken to first boll split	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
March 15	139.9	36.9	43.8	61.8	97.5	39.7	2.81	3983
April 15	132.9	35.7	38.8	57.7	93.6	25.3	2.89	2538
May 15	117.8	31.8	46.0	66.2	97.8	19.0	3.00	1919
June 15	94.5	28.4	51.8	69.0	94.8	15.3	3.02	1509

Genotypes	Plant height (cm)	Number of Nodes plant^{-1}	Days taken to 50% squaring	Days taken to 50% flowering	Days taken to first boll split	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Bt. CIM-789	121.5	33.4	45.1	64.3	96.3	24.5	2.95	2441
Bt. Cyto-511	122.2	33.3	45.6	64.1	96.2	25.8	2.91	2579
Bt. Cyto-179	120.1	33.0	44.6	62.7	95.2	24.3	2.94	2441

C.D 5%

Temporal variation (T)	12.05	3.07	2.18	2.90	2.57	1.89	0.07	292.69
Genotypes (G)	ns	ns	ns	ns	ns	1.19	ns	116.57
T X G	ns	ns	ns	ns	ns	2.37	ns	109.98

The data pertaining to phenological response, plant structure and yield components of genotypes to temporal variations revealed significant impact of sowing date, while genotype differences for these parameters remained non-significant (Table 1.4). The advent of squaring, flowering and boll split took less time from March 15 to April 15, while subsequent delays further extended the days required for advent of squaring, flowering and boll split. Therefore, the squaring and flowering took maximum days in June 15 sown crop. The maximum days for attaining boll split stage were from May 15 followed by decrease in June 15. The reduction in plant height, nodes, bolls and seed cotton yield due to late sowing was 45.4 cm, 8.5 per plant, 24.4 per plant and 2474 kg ha^{-1}, respectively.

Among the genotypes, *Bt*.Cyto-179 required minimum number of days for completion of various phenological parameters. The maximum boll weight was obtained from *Bt.* Cyto-789. The highest number of bolls and seed cotton yield was recorded from *Bt*.Cyto-511. The interactive effect of treatments was non-significant for phenology, plant height, nodes and boll weight, while significant interactions were observed for number of bolls and seed cotton yield. The comparison of genotypes at different sowing dates revealed that the genotype *Bt.* CIM-789 produced higher number of bolls than *Bt.* Cyto-179 at March 15. Whereas, the genotype *Bt.* Cyto-179 produced higher number of bolls than *Bt.* CIM-789 at April-15. The genotype *Bt.* Cyto-511 produced the highest seed cotton yield at March 15 and April 15, while *Bt.* Cyto-789 produced the highest seed cotton yield on May 15 and June 15. The genotypic differences for seed cotton yield were more prominent in March 15 and April 15 which stood non-significant in subsequent sowing dates.

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

The bulk residue production is prominent feature of cotton-wheat cropping system. The declining fertility trend of the soil is quite alarming. Burning of wheat crop residues in the field and burning of cotton sticks in rural areas for cooking is a regular activity. The residues may be incorporated for the improvement of 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 experiment will continue for five years from 2018-2023. In the present year, cotton cultivar *Bt*.Cyto-179 was sown on 24th May 2019 under normal production practice. The treatments included were no residue incorporation (T1), cotton sticks incorporation (T2), cotton sticks & wheat straw incorporation (T3) and wheat straw incorporation (T4). The tillage system was applied following residue incorporation. The post picking left over cotton sticks were incorporated at the rate of 5274, 3875, 2906 and 3121 kg ha^{-1} for treatment of cotton sticks along with chiseling-conventional tillage, in wheat-cotton straw incorporation treatment along with chiseling-conventional tillage, in cotton sticks treatments along with conventional tillage and wheat-cotton straw incorporation with conventional tillage, respectively, while tillage system was applied according to treatments plan. Before residue incorporation soil samples were collected from field at 0-15 cm, 15-30 cm and 30-60 cm for initial soil profile. The normal agronomic practices were carried out as per need of the crop. Data on soil analysis are given in Table 1.5

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

Tillage	Crop residues	Plant height (cm)	Number of Nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Conventional tillage and chiseling	Cotton sticks incorporation	122.6	34.9	21	2.66	2123
	Wheat straw and cotton sticks incorporation	121.7	34.6	20	2.60	1938
	Wheat straw incorporation	120.0	33.8	20	2.65	2005
	No residues	108.2	32.4	19	2.58	1910
	Cotton sticks	102.4	31.0	20	2.63	1975

Conventional tillage	incorporation Wheat straw and cotton sticks incorporation	99.2	30.5	18	2.58	1818
	Wheat straw incorporation	90.6	28.5	19	2.62	1935
	No residues	86.2	27.8	18	2.56	1794

Sub-effects

Tillage system	Plant height (cm)	Number of Nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Conventional tillage and chiseling	118.1	33.9	20.0	2.62	1994
Conventional tillage	94.6	29.5	18.8	2.60	1881

Crop Residues	Plant height (cm)	Number of Nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Cotton sticks incorporation	112.5	33.0	20.5	2.65	2049
Wheat straw and cotton sticks incorporation	110.5	32.6	19.0	2.59	1878
Wheat straw incorporation	105.3	31.2	19.5	2.64	1970
No residues	97.2	30.1	18.5	2.57	1852

C.D 5%

Tillage (T)	13.81	0.19	0.97	ns	62.39
Residue (R)	7.83	1.65	ns	ns	ns
T x R	ns	ns	ns	ns	ns

The data presented in Table 1.5a revealed that taller plants with greater number of nodes and bolls per plant, heavier boll weight and higher seed cotton yield were achieved from combination of chiseling and conventional tillage in tillage treatments. The maximum plant height, nodes and bolls per plant, boll weight and seed cotton yield were produced from plots in which cotton sticks were incorporated. The combination of chiseling and conventional tillage produced 6.1% greater seed cotton yield than conventional tillage alone. Incorporation of cotton sticks, wheat straw in combination with cotton sticks and wheat straw produced 10.6%, 1.4% and 6.4% higher seed cotton yield than no residue incorporation treatment.

Table 1.5b: Soil analysis

Tillage system	Saturation (%)	Texture	pH	EC (ds/m)	Organic matter (%)	Available phosphorus (mg kg^{-1})	Available potassium (mg kg^{-1})
Conventional tillage & chiseling	40.0	Loam	8.18	5.92	0.65	7.33	247.5
Conventional tillage	39.5	Loam	8.33	6.20	0.69	7.48	245.0

Residues	Saturation (%)	Texture	pH	EC (ds/m)	Organic matter (%)	Available phosphorus (mg kg^{-1})	Available potassium (mg kg^{-1})
Cotton sticks incorporation	40.0	Loam	8.33	5.77	0.74	7.60	245.0
Wheat straw & cotton sticks incorporation	40.0	Loam	8.20	6.10	0.64	6.80	255.0
Wheat straw incorporation	39.0	Loam	8.18	6.09	0.59	7.80	245.0
No residues	40.0	Loam	8.30	4.99	0.56	7.40	240.0

TRAINING PROGRAM "COTTON MEALYBUG MANAGEMENT"

CCRI Multan organized one-day training program "Management of Cotton Mealybug" on September 5, 2019, for the field staff of Agri Ext Deptt, Punjab. 20 Agriculture Officers from the Agriculture Extension Department Punjab attended the program.

The data in Table 1.5b indicated that incorporation of cotton sticks, cotton sticks and wheat straw and wheat straw only improved organic matter by the 0.18%, 0.08% and 0.03%, respectively. While, the respective increase in available potassium was 2.08%, 6.25% and 2.08%.

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

The yield and fibre quality performance of *Bt*. Cyto-313 and *Bt*. CIM-343 was evaluated across different rows and plant spaces. Row spacings comprised of 45, 60 and 75 cm, while plant spaces were 15, 22.5 and 30 cm. The treatments were compared in Randomized Complete Block Design (RCBD) with factorial arrangement in three replications. Soil was thoroughly prepared with conventional tillage implements and the seeds were sown on beds on 31stMay, 2019. The row and plant spaces were maintained according to respective treatments. Pre-emergence application of the Dual Gold 960 EC @ 2L per hectare was carried out on moist beds within 24 hours after planting. Other cultural practices and plant protection measures were adopted as per need of the crop. Plant height was measured with measuring rod from ground level to highest leaf tip. Data on plant population and number of bolls (m^{-2}) were calculated using desired row length and width. While, boll weight was worked out from 50 selected bolls. Seed cotton from each plot was manually picked, weighted and converted on hectare basis. Data on plant population, plant height, boll number, boll weight and seed cotton yield are given 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)	Number of nodes $plant^{-1}$	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Bt.CIM-343	45	15.0	130512	84.9	25.9	145.8	2.65	3095
		22.5	89458	82.8	24.8	117.0	2.76	2699
		30.0	72824	79.7	23.6	102.0	2.81	2306
	60	15.0	104161	110.6	33.5	133.2	2.72	2889
		22.5	71937	109.0	30.8	96.0	2.79	1956
		30.0	52597	94.9	26.5	89.0	2.87	1875
	75	15.0	85707	98.2	32.0	120.4	2.76	2807
		22.5	55223	97.3	29.9	102.5	2.85	2347
		30.0	43911	93.3	27.3	93.2	2.94	1933
Bt.Cyto-313	45	15.0	127117	104.9	29.5	141.6	2.63	3018
		22.5	94600	97.6	27.2	128.2	2.68	2791
		30.0	73727	94.3	26.1	104.0	2.74	2348
	60	15.0	104012	116.0	30.8	131.4	2.70	2847
		22.5	72332	114.4	30.4	106.2	2.72	2376
		30.0	53236	113.2	29.3	100.5	2.78	2183
	75	15.0	81086	108.0	32.4	115.5	2.71	2523
		22.5	53997	106.9	32.0	97.0	2.79	1960
		30.0	42231	99.5	28.1	88.2	2.84	1820

Sub-effects

Genotypes	Plant population (ha^{-1})	Plant height (cm)	Number of nodes $plant^{-1}$	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Bt.CIM-343	78481	94.5	28.3	111.0	2.79	2434
Bt.Cyto-313	78038	106.1	29.5	112.5	2.73	2430

Row spaces (cm)	Plant population (ha^{-1})	Plant height (cm)	Number of nodes $plant^{-1}$	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
45	98040	90.7	26.2	123.1	2.71	2710
60	76379	109.7	30.2	109.4	2.76	2354
75	60359	100.5	30.3	102.8	2.82	2232

Plant spacing (cm)	Plant population (ha^{-1})	Plant height (cm)	Number of nodes plant^{-1}	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
15.0	105432	103.8	30.7	131.3	2.70	2863
22.5	72925	101.3	29.2	107.8	2.77	2355
30.0	56421	95.8	26.8	96.2	2.83	2078
C.D 5%						
Genotypes (G)	ns	5.07	ns	ns	ns	ns
Row spacing (RS)	4665.1	6.20	1.88	5.20	ns	122.1
Plant spacing (PS)	4665.1	6.20	1.88	5.20	0.09	122.1
G x RS	ns	ns	ns	ns	ns	172.6
G x PS	ns	ns	ns	ns	ns	ns
RS x PS	ns	ns	ns	ns	ns	ns
G x RS x PS	ns	ns	ns	ns	ns	ns

Significant differences among genotypes were observed for plant height. Genotype *Bt.* Cyto-313 produced 11.6 cm taller plants than *Bt.* CIM-343. Row spacings significantly affected the plant population, plant height, nodes, bolls and seed cotton yield. Row spacing of 45 cm produced maximum plant population, bolls and seed cotton yield. Significant influence of the plant spacings was observed for all recorded observations. The plant population, plant height, nodes, bolls and seed cotton yield were improved with decreasing plant spacing, while boll weight was improved with increasing plant spacing. Genotypes and row spacing interaction revealed that the genotype *Bt.* Cyto-313 planted at 60 cm row spacing exceeded the *Bt.* CIM-343 planted at 45 cm row spacing. Therefore, it is concluded the narrowing down the row and planting spacings may be an effective tool for yield improvement.

1.7 Effect of pre-plant and pre-emergence weedicides application for weed control in cotton.

Efficacy of pre-plant and post-plant weedicide was tested for initial weed control in cotton. The treatments were comprising of no pre-plant weedicides (conventional), Glyphosate (pre-plant) and Gramoxone (pre-plant) in combination with untreated check, manual weed control, Panida grandi 43.5 EC @ 1.853 liter ha^{-1} and Dual gold 960 EC @ 2.0 liter ha^{-1} for effective weed control in cotton. The pre-plant treatment of Glyphosate 48% SL@ 4.7 liter ha^{-1} and Gramoxone 200 SL@ 2.5 liter ha^{-1} was carried out on 24-05-2019 in their respective plots. The cultivar *Bt.*Cyto-179 was sown on 3rd June. The Panida grandi 43.5 EC @ 1.853 liter ha^{-1} and Dual gold 960 EC @ 2.0 liter ha^{-1} were sprayed in respective plots on moist beds during 24 hours after sowing. Other cultural practices and plant protection measures were adopted as per need of the crop. The data on dry weight (g m^{-2}) and percent weed control 30 and 60 days after sowing, plant height, nodes per plant, number of bolls per plant, boll weight and seed cotton yield are given in Table in 1.7a, 1.7b and 1.7c

Table 1.7a: Dry weight of weeds (gm^{-2}) and percent weed control at 30 days after planting

Pre-plant Treatments	Pre-emergence Treatments	Dry weight (g m^{-2})		Percent weed control	
		Broad Leaves	Narrow Leaves	Broad Leaves	Narrow Leaves
No weedicides	Panida Grandi 43.5 EC @1.853 L ha^{-1}	15.6	12.7	81.1	62.7
	Dual Gold 960 EC @ 2.0 L ha^{-1}	13.5	10.1	83.6	70.4
	Manual weeding (25,41,55 DAS)	6.0	5.3	92.7	84.5
	Untreated check	82.5	34.1	-	-
Glyphosate 48% SL @ 4.7 L ha^{-1}	Panida Grandi 43.5 EC @1.853 L ha^{-1}	12.7	11.1	81.8	66.3
	Dual Gold 960 EC @ 2.0 L ha^{-1}	10.3	9.2	85.2	71.1

Gramoxone 200 SL @ 2.5 L ha^{-1}	Manual weeding (25,41,55 DAS)	6.1	5.0	91.3	84.8
	Untreated check	69.9	32.8	-	-
	Panida Grandi 43.5 EC @1.853 L ha^{-1}	12.9	12.9	78.6	58.6
	Dual Gold 960 EC @ 2.0 L ha^{-1}	10.8	9.3	82.2	70.2
	Manual weeding (25,41,55 DAS)	6.0	5.1	90.1	83.7
	Untreated check	60.3	31.1	-	-

Sub-effects

Pre-plant treatment	Dry weight (g m^{-2})		Percent weed control	
	Broad Leaves	Narrow Leaves	Broad Leaves	Narrow Leaves
No weedicides	29.4	15.6	85.8	72.5
Glyphosate 48% SL @ 4.7 L ha^{-1}	24.8	14.5	86.1	74.0
Gramoxone 200 SL @ 2.5 L ha^{-1}	22.5	14.6	83.6	70.8

Pre-emergence Treatment	Dry weight (g m^{-2})		Percent weed control	
	Broad Leaves	Narrow Leaves	Broad Leaves	Narrow Leaves
Panida Grandi 43.5 EC @1.853 L ha^{-1}	13.7	12.2	80.5	62.5
Dual Gold 960 EC @ 2.0 L ha^{-1}	11.5	9.5	83.7	70.5
Manual weeding (25,41,55 DAS)	6.0	5.1	91.4	84.3
Untreated check	70.9	32.7	-	-

C.D 5%

Pre-plant (PP)	2.77	ns
Pre-emergence (PE)	3.40	1.71
PP x PE	5.90	ns

The data presented in Table 1.7a depicts the weed scenario at 30 days after sowing. Among pre-plant weedicide treatment i.e. Glyphosale 48% SL exhibited strong control of broad and narrow leave weeds as compared to Gramoxone 200 SL and no weedicide treatments. All the pre-emergence applications namely Panida Grandi 43.5 EC, Dual Gold 960 EC and manual weed control treatments significantly suppressed the weeds' population as compared to untreated check. Panida Grandi 43.5 EC weedicide resulted in 80.5% and 62.5% more broad and narrow leave weed control over untreated plots. Dual Gold 960 EC (Pre-emergence weedicide) resulted in 83.7% and 70.5% more broad and narrow leave weeds control over untreated respectively. While the manual weeding resulted in 91.4 and 84.3% broad and narrow leave weeds control over untreated respectively.

Table 1.7b: Dry weight of weeds (gm^{-2}) and percent weed control at 60 days after planting

Pre-plant treatment	Pre-emergence Treatment	Dry weight ($g\ m^{-2}$)		Percent weed control	
		Broad Leaves	Narrow Leaves	Broad Leaves	Narrow Leaves
No weedicides	Panida Grandi 43.5 EC @1.853 L ha^{-1}	82.5	34.7	48.7	56.3
	Dual Gold 960 EC @ 2.0 L ha^{-1}	76.5	25.5	52.5	67.9
	Manual weeding (25,41,55 DAS)	4.1	2.4	97.5	97.0
	Untreated check	160.9	79.5	-	-
Glyphosate 48% SL @ 4.7 L ha^{-1}	Panida Grandi 43.5 EC @1.853 L ha^{-1}	74.2	30.8	51.4	56.5
	Dual Gold 960 EC @ 2.0 L ha^{-1}	70.3	22.0	53.9	68.9
	Manual weeding (25,41,55 DAS)	4.0	2.0	97.4	97.2
	Untreated check	152.7	70.8	-	-
Gramoxone 200 SL @ 2.5 L ha^{-1}	Panida Grandi 43.5 EC @1.853 L ha^{-1}	78.9	31.6	47.5	55.1
	Dual Gold 960 EC @ 2.0 L ha^{-1}	74.4	21.9	50.5	68.8
	Manual weeding (25,41,55 DAS)	4.0	2.1	97.3	97.0
	Untreated check	150.4	70.2	-	-

Sub-effects

Pre-plant treatment	Dry weight ($g\ m^{-2}$)		Percent weed control	
	Broad Leaves	Narrow Leaves	Broad Leaves	Narrow Leaves
No weedicides	81.0	35.5	66.2	73.8
Glyphosate 48% SL @ 4.7 L ha^{-1}	75.3	31.4	67.6	74.2
Gramoxone 200 SL @ 2.5 L ha^{-1}	76.9	31.5	65.1	73.6

Pre-emergence treatment	Dry weight ($g\ m^{-2}$)		Percent weed control	
	Broad Leaves	Narrow Leaves	Broad Leaves	Narrow Leaves
Panida Grandi 43.5 EC @1.853 L ha^{-1}	78.5	32.4	49.2	56.0
Dual Gold 960 EC @ 2.0 L ha^{-1}	73.8	23.2	52.3	68.5
Manual weeding (25,41,55 DAS)	4.0	2.2	97.4	97.1
Untreated check	154.7	73.5	-	-

CD 5%

Pre-plant (PP)	Ns	ns
Pre-emergence (PE)	8.00	4.00
PP x PE	14.11	ns

The data presented in Table 1.7b reveals the weed situation at 60 days after sowing. Among pre-plant weedicides treatment i.e. Glyphosale 48% SL exhibited strong control of broad and narrow leave weeds as compared to Gramoxone 200 SL and no weedicide treatments. All

the pre-emergence applications; Panida Grandi 43.5 EC, Dual Gold 960 EC and manual weed control treatments significantly suppressed the weeds' population as compared to untreated. Panida Grandi 43.5 EC weedicide resulted in 49.2% and 56.0% more broad and narrow leave weed control over untreated check. Dual Gold 960 EC (Pre-emergence weedicide) resulted in 52.3% and 68.5% more broad and narrow leave weeds control over untreated check respectively. While the manual weeding resulted in 97.4% and 97.1% broad and narrow leave weeds control over untreated check, respectively.

Table 1.7c: Effect of pre-plant and pre-emergence weedicides application on plant height, nodes per plant, number of bolls per plant, boll weight and seed cotton yield

Pre-plant treatment	Pre-emergence treatment	Plant height (cm)	Number of nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
No weedicides	Panida Grandi 43.5 EC @1.853 L ha^{-1}	87.1	27.0	12	2.50	1178
	Dual Gold 960 EC @ 2.0 L ha^{-1}	99.6	29.2	12	2.50	1227
	Manual weeding (25,41,55 DAS)	89.6	28.4	13	2.51	1277
	Untreated check	76.5	25.2	8	2.47	820
Glyphosate 48% SL @ 4.7 L ha^{-1}	Panida Grandi 43.5 EC @1.853 L ha^{-1}	92.3	28.6	13	2.53	1253
	Dual Gold 960 EC @ 2.0 L ha^{-1}	92.8	28.9	13	2.54	1323
	Manual weeding (25,41,55 DAS)	86.9	26.5	13	2.54	1339
	Untreated check	77.7	25.6	9	2.52	844
Gramoxone 200 SL @ 2.5 L ha^{-1}	Panida Grandi 43.5 EC @1.853 L ha^{-1}	88.3	28.0	12	2.53	1196
	Dual Gold 960 EC @ 2.0 L ha^{-1}	89.0	28.2	13	2.55	1253
	Manual weeding (25,41,55 DAS)	91.4	28.4	13	2.58	1333
	Untreated check	76.2	25.0	9	2.50	848

Sub-effects:

Pre-plant treatment	Plant height (cm)	Number of nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
No weedicides	88.2	27.5	11.3	2.50	1125
Glyphosate 48% SL @ 4.7 L ha^{-1}	87.4	27.4	12.0	2.50	1190
Gramoxone 200 SL @ 2.5 L ha^{-1}	86.2	27.4	11.8	2.50	1157

Pre-emergence treatment	Plant height (cm)	Number of nodes plant^{-1}	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Panida Grandi 43.5 EC @1.853 L ha^{-1}	89.2	27.9	12.3	2.52	1209
Dual Gold 960 EC @ 2.0 L ha^{-1}	93.8	28.8	12.7	2.53	1268
Manual weeding (25,41,55 DAS)	89.3	27.8	13.0	2.54	1316
Untreated check	76.8	25.3	8.7	2.50	837

CD5%					
Pre-plant (PP)	ns	ns	ns	ns	ns
Pre-emergence (PE)	5.35	1.56	0.43	2.28	92.20
PP x PE	ns	ns	ns	2.95	ns

The data presented in Table 1.7c indicated that Glyphosate 48% SL increased the seed cotton yield as compared to Gramoxone 200 SL and no weedicides. Glyphosate 48% SL produced 2.85% and 5.78% higher seed cotton yield over Gramoxone 200 SL and no weedicides, respectively. Manual weeding, Dual Gold 960 EC and Panida Grandi 43.5 EC produced significantly higher seed cotton

yield as compared to control. Manual weeding, Dual Gold 960 EC and Panida Grandi 43.5 EC produced 57.3%, 51.5% and 44.4% significantly higher seedcotton yield over untreated check.

1.8 Internship

Agronomy Section provided research facilities to one Ph.D. scholars two M. Phill students from faculty of Agricultural Science and Technology, Bahauddin Zakariya University in addition to twenty students of B.Sc (Hons.) Agriculture (Agronomy) from different Agricultural Colleges/Universities throughout the country. They were facilitated in research activities and internship training under the supervision of experts.

1.9 Cost of production of one acre cotton for the year 2019-20 is given below

Sr. No.	Operations and Inputs	Number/ Quantity	Rate (Rs)	Amount (Rs.)
1.	Seedbed Preparation			
	a) Cultivation (Ploughing + planking)	4	600/cultivation	**5000**
	b) Leveling	1	500/leveling	2400.00
	c) Bed and furrow making	1	600/acre	500.00
	d) Pre-emergence Weedicides	1.2	1200/liter	600.00
	e) Bund making	1	60/acre	1440.00
				60.00
2.	Seed			**1685.00**
	a. Cost	8 kg.	8000/40 kg	1600.00
	b. Transportation	-	25/bag	5.00
	c. Delinting	-	400/40 kg	80.00
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			**9989.00**
	a. DAP (Di-Amonium Phosphate)	1 bag	3650/bag	3650.00
	b. Urea	3.0 bags	1850/bag	5550.00
	c. Transportation	4.0 bags	25/bag	100.00
	d. Fertilizer Application Charges	1man day	689/day	689.00
9.	Plant Protection			**11400.00**
	a. Sucking	7	1200/spray	8400.00
	b. Bollworm	3	1000/spray	3000.00
10.	Harvesting (Picking charges)	800 Kg	12.0/kg	**9600.00**
11	Stick Cutting	2 men day	689/man day	+1378.00
11 a	Value of cotton sticks			-1378.00
12.	Managerial Charges for 1 acre	7 months	25000/month/100 acre	**1750.00**
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			**83127.00**
	b. Excluding Land Rent			**59794.00**
16.	Mark-up on Investment	7 months	12.5% for one year	
	a. Including Land Rent			**6061.34**
	b. Excluding Land Rent			**4359.98**
17.	Total Expenditure	--		
	a. Including Land Rent			**89188.34**
	b. Excluding Land Rent			**64153.98**
18.	Income of Seed Cotton	800 kg	3500/40 kg	**70000. 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	**4459.42**
	b. Excluding Land Rent			**3207.70**
21.	Cost of production at Market	-		
	a. Including Land Rent.		Per 40 kg	**4559.42**
	b. Excluding Land Rent.			**3307.70**

ICARDA COTTON PROJECT REVIEW

Dr. Abdul Majeed, Country Manager; Mr. Muhammad Arshad, Cotton Consultant and Ms Sameera Younas, Consultant, ICARDA visited CCRI Multan in connection with reviewing of activities under cotton project. Dr. Zahid Mahmood, Director CCRI Multan briefed about the cotton research and development activities at the Institute. The ICARDA team appreciated the research work conducted at the Institute for evolution of cotton varieties.

2. PLANT BREEDING & GENETICS SECTION

Plant Breeding & Genetics Section continued its efforts to evolve new cotton varieties or lines with desirable fibre properties by utilizing purposeful breeding (crossing) of closely or distantly related genotypes. Plants were 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 performanceunder 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) along with excellent fibre characteristics. Pre-basic seed of commercial varieties viz., CIM-496, CIM-620, CIM-554, CIM-573, *Bt*.CIM-598, *Bt*.CIM-600, *Bt*.CIM-599, *Bt*.CIM-602 and *Bt*.CIM-632 was produced for distribution to public and private seed corporations for further multiplication. The genetic stock of World Cotton collections comprising of 6123 cultivars of four *Gossypium* species is being preserved for short, medium and long duration as well as for utilization in breeding program by cotton breeders in the country and abroad. Twenty five (25) accessions imported during 2018 were sown in field condition for CLCuV screening and morphological characterization. A promising line *Bt*.CIM-775 has recently been evolved by utilizing USDA and local cotton germplasm material. The line showed high tolerance to CLCuV and got second position at the country level in NCVT trials. Trainings were also imparted to small farmers, progressive growers and students from different universities. The summary of 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-739, *Bt*.CIM-740, *Bt*.CIM-741, *Bt*.CIM-742, *Bt*.CIM-743, *Bt*.CIM-744 and*Bt*.CIM-745, were evaluated against one *Bt*. commercial variety *Bt*.CIM-602 at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal. Data of seedcotton yield and other parameters are given in **Tables 2.1, 2.2** and **2.3**. Averaged across the two locations, the strain *Bt*.CIM-740 produced the highest seedcotton yield of 2179 kg ha^{-1} followed by *Bt*.CIM-744 having yield 1947 kg ha^{-1} while the standard variety *Bt*.CIM-602 yielded 1491 kg ha^{-1}.**(Table 2.1).**

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

Strains	Seed cotton yield (kg ha^{-1})			Lint Yield (kg ha^{-1})	Av. Boll weight (g)	Plant Pop. (ha^{-1})
	Multan (14/5)*	Khanewal (9/5)	Average			
Bt. CIM-739	2072	1691	1882	704	2.7	38646
Bt. CIM-740	2840	1517	2179	828	2.5	41785
Bt. CIM-741	1842	1445	1644	635	2.6	41157
Bt. CIM-742	2141	1332	1737	664	2.5	40888
Bt. CIM-743	2227	1281	1754	677	2.7	39633
Bt. CIM-744	2459	1435	1947	711	2.7	39991
Bt. CIM-745	2155	1588	1872	726	2.9	40798
Bt.CIM-632	1495	1486	1491	567	2.0	41157

* = Sowing date 14.05.2019, C.V = 13.06%
CD (5%) for seedcotton: Locations (L) =139.59; Varieties (V) = 279.17, L x V = 394.81

The new strain *Bt*.CIM-745 produced the highest lint percentage of 38.8 followed by *Bt*.CIM-741 and *Bt*.CIM-743 having lint percentage values of 38.6 as compared with the standard *Bt*.CIM-632 38.0 (**Table 2.2**). The new strain *Bt*.CIM-742 and *Bt*.CIM-743 produced the longest staple of 28.7 mm, followed by *Bt*.CIM-745 with 28.5 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

Strains	Lint (%age)			Staple length (mm)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
Bt. CIM-739	36.2	38.6	37.4	27.0	26.4	26.7
Bt. CIM-740	38.2	37.7	38.0	28.4	28.2	28.3
Bt. CIM-741	39.0	38.1	38.6	28.4	27.0	27.7
Bt. CIM-742	38.5	37.8	38.2	28.8	28.6	28.7
Bt. CIM-743	39.1	38.0	38.6	28.6	28.8	28.7
Bt. CIM-744	37.1	35.9	36.5	27.1	28.1	27.6
Bt. CIM-745	39.0	38.5	38.8	28.8	28.1	28.5
*Bt.*CIM-602	39.5	36.5	38.0	27.2	27.7	27.5

All the new strains possess desirable micronaire value ranging from 4.4 to 4.7 in comparison to *Bt.*CIM-632 with 4.5.The fiber strength of all the new strains and standard are in the desirable range, i.e., 26.1 to 27.7 g/tex **(Table 2.3).**

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

Strains	Micronaire value			Fibre strength (g/tex)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
Bt. CIM-739	4.9	3.9	4.4	27.1	26.6	26.9
Bt. CIM-740	4.8	4.0	4.4	26.4	28.5	27.5
Bt. CIM-741	4.9	3.9	4.4	25.5	26.7	26.1
Bt. CIM-742	4.8	4.2	4.5	25.6	28.3	27.0
Bt. CIM-743	4.5	4.4	4.5	26.8	27.9	27.4
Bt. CIM-744	4.8	4.0	4.4	26.3	28.4	27.4
Bt. CIM-745	4.8	4.5	4.7	26.4	28.9	27.7
*Bt.*CIM-602	5.0	3.9	4.5	27.3	28.0	27.7

2.1.2 Varietal Trial-2

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

Seven new strains with medium-long staple viz., *Bt.*CIM-746, *Bt.*CIM-747,*Bt.*CIM-748, *Bt.*CIM-749,*Bt.*CIM-750 and *Bt.*CIM-751 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-750 produced the highest seed cotton yield of 2662 kg ha^{-1}, followed by *Bt.*CIM-752 with 2556 kg ha^{-1} while the standard variety *Bt.*CIM-602 produced 2107 kgha-^{1}.The strain *Bt.*CIM-746 had the highest lint percentage of 41.0, followed by 40.0% of *Bt.*CIM-750 in comparison to the commercial varieties *Bt.*CIM-602 produced 39.6 lint percentages. The strain *Bt.*CIM-746 produced the longest staple of 29.2 mm followed by *Bt.*CIM-747 having 29.0mm (Table 2.5) while standard *Bt.*CIM-602 produced 27.7 mm staple length. All the strains possess desirable micronaire values ranging from 4.0 to 4.9. The fibre strength of the strains ranged from 27.6 to 29.4 g/tex (Table 2.6).

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

Strains	Seed cotton yield (kg ha^{-1})			Lint yield (kg ha^{-1}	Av. boll weight (g)	Plant Pop. (ha^{-1})
	Multan (22/5)*	Khanewal (9/5)*	Average			
Bt. CIM-746	2535	2306	2421	979	2.6	38729
Bt. CIM-747	2458	2439	2449	951	2.6	35382
Bt. CIM-748	2537	2275	2406	1000	2.5	37414
Bt. CIM-749	2738	2326	2532	1027	3.2	29525
Bt. CIM-750	3017	2306	2662	1198	3.7	34545
Bt. CIM-751	2638	2254	2446	1050	2.6	39087
Bt. CIM-752	2908	2203	2556	1178	2.8	39326
*Bt.*CIM-602	2133	2080	2107	853	2.5	40044

* = Sowing date 22.05.2019

CD (5%) for seed cotton: Locations (L) = 111.61 ; Varieties (V) = 223.22; L x V = 315.68

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

Strains	Lint (%age)			Staple length (mm)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
Bt. CIM-746	38.6	39.4	39.0	29.5	28.8	29.2
Bt. CIM-747	38.7	40.8	39.8	29.5	28.4	29.0
Bt. CIM-748	39.4	40.2	39.8	29.3	28.4	28.9
Bt. CIM-749	37.5	40.4	39.0	27.9	28.0	28.0
Bt. CIM-750	39.7	40.3	40.0	28.4	28.3	28.4
Bt. CIM-751	39.8	39.8	39.8	28.1	28.4	28.3
Bt. CIM-752	40.5	41.4	41.0	27.3	28.2	27.8
*Bt.*CIM-602	40.0	39.1	39.6	27.9	27.4	27.7

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

Strains	Micronaire value			Fibre strength (g/tex)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
Bt. CIM-746	4.7	4.7	4.7	29.8	28.8	29.3
Bt. CIM-747	4.8	4.9	4.9	30.0	28.5	29.3
Bt. CIM-748	4.4	4.6	4.5	30.2	28.6	29.4
Bt. CIM-749	4.8	4.1	4.5	28.1	27.4	27.8
Bt. CIM-750	4.1	4.5	4.3	28.6	27.7	28.2
Bt. CIM-751	4.5	4.4	4.5	27.5	28.3	27.9
Bt. CIM-752	4.5	3.7	4.1	27.7	27.4	27.6
*Bt.*CIM-602	4.2	3.8	4.0	27.8	28.2	28.0

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 viz. *Bt.*CIM-752, *Bt.*CIM-753, *Bt.*CIM-754, *Bt.*CIM-755, *Bt.*CIM-756, *Bt.*CIM-757, *Bt.*CIM-758, *Bt.*CIM-759 and *Bt.*CIM-760 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-760 produced the highest seed cotton yield of 2977 kg ha^{-1} followed by *Bt.*CIM-756 having yield of 2785 kg ha^{-1} while the standards *Bt.*CIM-602 produced yield of 1799 kg ha^{-1} **(Table 2.7).**

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

Strains	Seed cotton yield (kg ha^{-1})			Lint Yield (kg ha^{-1})	Av. Boll weight (g)	Plant Pop. (ha^{-1})
	Multan (14/5)*	Khanewal (9/5)	Average			
Bt. CIM-752	1920	1260	1590	642	2.1	40260
Bt. CIM-753	2065	1537	1801	684	2.1	41516
Bt. CIM-754	2254	1404	1829	697	2.0	41605
Bt. CIM-755	3204	2121	2663	1020	2.3	39633
Bt. CIM-756	3111	2459	2785	1083	2.5	40888
Bt. CIM-757	2914	2490	2702	1059	2.5	38377
Bt. CIM-758	2669	1373	2021	831	2.2	41964
Bt. CIM-759	3311	1240	2276	881	2.6	41336
Bt. CIM-760	3473	2480	2977	1203	2.3	39633
*Bt.*CIM-602	2029	1568	1799	687	1.9	41157

* = Sowing date 14.05.2019, C.V = 7.29%

CD (5%) for seed cotton: Locations (L) = 85.48; Varieties (V) = 191.14; L x V = 270.31

The new strains *Bt.*CIM-758 produced the highest lint percentage of 41.1, followed by *Bt.*CIM-752 and CIM-760 having lint percentage value of 40.4 **(Table 2.8).** The new strains *Bt.*CIM-757 produced the longest staple of 29.1 mm, followed by *Bt.*CIM-756 with 29.0 mm while the standards *Bt.*CIM-602 produced 27.6 mm staple length **(Table 2.8).**

All the new strains possess desirable micronaire values ranging from 4.1 to 4.8 except *Bt.*CIM-752 with 5.1 micronaire value compared with the standards *Bt.*CIM-602 had 4.2 micronaire values. The fibre strength of all the new strains and standards is

in the desirable ranged from 27.4 to 28.6 g/tex except *Bt*.CIM-752 having fibre strength of 23.8 g/tex **(Table 2.9).**

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

Strains	Lint (%age)			Staple length (mm)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
Bt. CIM-752	37.3	43.4	40.4	26.9	26.2	26.6
Bt. CIM-753	37.0	38.9	38.0	28.3	27.8	28.1
Bt. CIM-754	36.6	39.5	38.1	28.6	28.7	28.7
Bt. CIM-755	38.1	38.5	38.3	28.7	28.9	28.8
Bt. CIM-756	38.5	39.3	38.9	29.0	28.9	29.0
Bt. CIM-757	39.0	39.4	39.2	29.4	28.7	29.1
Bt. CIM-758	40.2	42.0	41.1	28.1	27.0	27.6
Bt. CIM-759	36.9	40.4	38.7	28.0	27.1	27.6
Bt. CIM-760	38.1	42.6	40.4	28.5	28.0	28.3
*Bt.*CIM-602	37.3	39.1	38.2	27.6	27.6	27.6

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

Strains	Micronaire value			Fibre strength (g/tex)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
Bt. CIM-752	5.5	4.7	5.1	24.5	23.1	23.8
Bt. CIM-753	4.9	4.1	4.5	27.2	28.2	27.7
Bt. CIM-754	4.9	4.0	4.5	28.2	28.8	28.5
Bt. CIM-755	4.8	4.0	4.4	28.5	27.7	28.1
Bt. CIM-756	4.8	4.0	4.4	29.5	27.6	28.6
Bt. CIM-757	4.7	3.9	4.3	28.8	27.3	28.1
Bt. CIM-758	4.9	4.6	4.8	28.2	26.5	27.4
Bt. CIM-759	4.4	3.7	4.1	27.9	26.9	27.4
Bt. CIM-760	4.6	3.9	4.3	27.9	26.9	27.4
*Bt.*CIM-602	4.5	3.8	4.2	27.9	26.9	27.4

2.1.4 Varietal Trial -4

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

Five medium staple promising non *Bt*. Strains viz. *Bt*.CIM-761, *Bt*.CIM-762, *Bt*.CIM-763, *Bt*.CIM-764 and *Bt*.CIM-765 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-761 produced the highest seed cotton yield of 2315 kg ha^{-1} followed by *Bt*.CIM-764 having yield of 1826 kg ha^{-1} while the standard *Bt*.CIM-602 produced 1475 kg ha^{-1} yield **(Table 2.7).**

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

Strains	Seed cotton yield (kg ha^{-1})			Lint Yield (kg ha^{-1})	Av. Boll weight (g)	Plant Pop. (ha^{-1})
	Multan (30/5)*	Khanewal (9/5)	Average			
Bt. CIM-761	2430	2200	2315	912	3.6	40798
Bt. CIM-762	1068	790	929	349	2.5	40350
Bt. CIM-763	1300	1022	1161	406	2.5	39005
Bt. CIM-764	1982	1670	1826	736	2.1	41695
Bt. CIM-765	1847	1610	1729	685	2.1	41695
*Bt.*CIM-602	1569	1380	1475	535	2.3	43040

* Sowing date =30.05.2019 CV= 3.65%

CD (5%) for seed cotton: Locations (L) = 40.20; Varieties (V) = 69.62; L x V = 98.46

The new strains *Bt*.CIM-764 produced the highest lint percentage of 40.3, followed by *Bt*.CIM-765 having lint percentage value of 39.6 **(Table 2.8).** The new strains *Bt*.CIM-764 produced the longest staple of 29.6 mm, followed by *Bt*.CIM-761 with 28.5 mm while the standard *Bt*.CIM-602 produced 27.4 mm staple length **(Table 2.8).** All the new strains possess desirable micronaire values ranging from 4.5 to 4.7including the

standard *Bt*.CIM-602. The fibre strength of all the new strains and standard is in the desirable range, i.e. 27.8 to 30.4 g/tex **(Table 2.9).**

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

Strains	Lint (%age)			Staple Length (mm)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
Bt. CIM-761	39.0	39.7	39.4	28.2	28.8	28.5
Bt. CIM-762	37.3	37.9	37.6	27.6	28.1	27.9
Bt. CIM-763	35.4	34.6	35.0	28.0	27.8	27.9
Bt. CIM-764	39.9	40.6	40.3	29.7	29.4	29.6
Bt. CIM-765	39.8	39.4	39.6	28.3	28.1	28.2
*Bt.*CIM-602	35.6	36.9	36.3	27.4	27.3	27.4

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

Strains	Micronaire value			Fibre strength (g/tex)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
Bt. CIM-761	4.9	4.0	4.5	30.2	27.9	29.1
Bt. CIM-762	4.9	4.5	4.7	28.7	26.9	27.8
Bt. CIM-763	4.7	4.5	4.6	29.0	28.8	28.9
Bt. CIM-764	4.7	4.7	4.7	31.6	29.1	30.4
Bt. CIM-765	4.7	4.4	4.6	30.1	29.5	29.8
*Bt.*CM-602	4.6	4.5	4.6	28.5	27.4	28.0

2.2 Mirco-Varietal Trials

2.2.1 Micro Varietal Trial-1

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

Ten newly bulked strains numbering from MV-1/19 to MV-10/19 were tested against commercial variety *Bt*.CIM-602 at CCRI, Multan. The new strain MV-10/19 surpassed all the strains and standard variety in seedcotton yield by producing 2852 kg ha^{-1}, followed by MV-7/19 with 2689 kg ha^{-1} and MV-1/19 having 2681 kg. ha^{-1} compared with 1825 kg ha^{-1} of *Bt*.CIM-602 **(Table 2.10).**The strain MV-1/19 produced the highest lint percentage of 41.4 followed by 40.0 percent lint in MV-2/19 while the commercial variety *Bt*.CIM-602 produced the lint percentage of 37.4. The strain MV-5/19 produced the longest staple of 29.1 mm, followed by 28.6mm in MV-6/19 compared with the fibre length of 27.9 mm in commercial variety *Bt*.CIM-602. Micronaire values of all the strains except MV-5/19 and MV-7/19 is according desirable limit. The strain MV-5/19 maintained the maximum fibre strength of 29.0 g/tex, followed by 28.7 g/tex in MV-6/19 and MV-8/19 while standard *Bt.*CIM-602 has 28.1 g/tex.

2.2.2 Micro Varietal Trial-2

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

Nine newly bulked strains numbering from MV-12/19 to MV-20/19 were tested against commercial variety *Bt*.CIM-602 at CCRI, Multan. The new strain MV-18/19 surpassed all the strains and standard variety in seed cotton yield by producing 2821 kg ha^{-1}, followed by MV-19/19 with 2575 kg ha^{-1} compared with 1017 yield of *Bt*.CIM-602 **(Table 2.11).** The strain MV-19/19 produced the highest lint percentage of 40.1, followed by 38.3 percent lint in MV-15/19 while the commercial variety *Bt*.CIM-602 produced the lint percentage of 37.3. The strain 19/19 produced the longest staple of 29.2 mm, followed by 28.3 mm in MV-18/19 compared with the fibre length of 27.3 mm in commercial variety *Bt*.CIM-602. All the strains have desirable micronaire values except MV-15/19 and MV-16/19. The strain MV-14/19 maintained the maximum fibre strength of 28.4 g/tex, followed by 27.7 g/tex in MV-13/19 and MV-17/19 while standard *Bt*.CIM-602 had 26.9 g/tex.

2.2.3 Micro Varietal Trial-3

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

Seven newly bulked strains numbering from MV-22/19 to MV-28/19 were tested against commercial variety CIM-602 at CCRI, Multan. Data presented in **Table 2.12** indicated that the new strain MV-24/19 surpassed all the new strains yielding 2777 kg ha^{-1}, followed by strains MV-22/19 and MV-26/19 which produced 2374 and 2175 kg ha^{-1} seed cotton respectively while the standard CIM-602 yielding 1438 kg ha^{-1}. The new strain MV-23/19/ produced the highest lint percentage of 39.8 followed by MV-28/19 with 38.9 % in comparison to CIM-602 having 37.6 lint percentage. The strains MV-27/19 has the longest staple of 29.3 mm followed by MV-28/19 with the staple of 29.0 mm compared with the staple length of 28.0 mm in standard variety *Bt.*CIM-602. All the genotypes have desirable micronaire value ranging from 4.2 to 4.9. All the strains were showing fibre strengths ranging from 27.7 to 30.6 g/tex.

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

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micro-naire value	Fibre strength (g/tex)	Av. boll wt. (g)	Plant Pop. (ha^{-1})
MV-1	2681	1110	41.4	27.1	5.4	27.0	3.0	43937
MV-2	2428	971	40.0	27.9	5.5	27.4	2.9	43757
MV-3	2428	964	39.7	27.7	5.3	28.2	2.8	43040
MV-4	2070	778	37.6	27.9	5.3	27.8	2.9	41067
MV-5	2251	844	37.5	29.1	4.9	29.0	3.0	39633
MV-6	2528	963	38.1	28.6	5.1	28.7	2.4	41067
MV-7	2689	1030	38.3	28.0	4.8	27.9	2.4	42861
MV-8	2514	938	37.3	28.4	5.3	28.7	2.2	40350
MV-9	2528	963	38.1	28.0	5.4	28.2	2.9	41605
MV-10	2852	1095	38.4	28.4	5.2	28.4	2.6	42502
*Bt.*CIM-602	1825	683	37.4	27.9	4.3	28.1	2.7	42681

Sowing date = 14.05.2019; CD (5%) for seedcotton: Strains = 431.19;CV % =10.39

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

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micro-naire value	Fibre Strength (g/tex)	Av. boll wt. (g)	Plant Pop. (ha^{-1})
MV-12	1337	499	37.3	27.5	4.7	25.9	2.1	42143
MV-13	1625	609	37.5	27.1	4.3	27.7	2.2	41605
MV-14	2185	787	36.0	28.2	4.3	28.4	3.8	41247
MV-15	1691	648	38.3	27.7	5.3	27.2	3.0	43578
MV-16	2550	956	37.5	28.1	5.2	27.4	3.6	44295
MV-17	2468	923	37.4	28.0	4.9	27.7	3.4	44654
MV-18	2821	1072	38.0	28.3	4.6	28.3	3.8	45013
MV-19	2575	1033	40.1	29.2	4.6	27.2	3.1	42143
MV-20	2270	856	37.7	27.0	4.4	26.4	3.2	41785
*Bt.*CIM-602	1017	379	37.3	27.3	5.0	26.9	2.0	41964

Sowing date = 14.05.2019; CD (5%) for seed cotton = 596.04; CV. % = 16.92

2.2.4 Micro-Varietal Trial-4

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

Seven newly bulked elite *Bt.* strains from MV-29/19 to MV-35/19 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-32/19 out-yielded all the strains and standard variety by producing 2606 kg ha^{-1} seed cotton, followed by MV-31/19 having seed cotton yields of 2439 against commercial variety *Bt.*CIM-602 which produced 1722 kg ha^{-1} seed cotton. The strain MV-35/19 produced the higher lint percentage of 43.8% followed by MV-30/19 with 42.5% compared with that of 37.8% by *Bt.*CIM-602.The strain MV-31/19 produced the longest staple of 28.9 mm, followed by the 28.7 mm of

WORLD COTTON DAY CELEBRATIONS

The 7th October has been designated by the WTO, FAO & ICAC for global celebrations as WORLD COTTON DAY to highlight the importance of cotton crop in the economies of the developing countries. Accordingly, CCRI, Multan also celebrated this day. The celebrations were organization jointly in coordination with WWF Pakistan, CottonConnect and other private sector organizations. A seminar was also organized highlighting the importance of cotton crop and measures for its enhancement. A large number of cotton researchers, planners and farmers attended the program and deliberated the importance of cotton crop and measures for its revival in areas where production is on the decline. Cotton Walk was also arranged to highlight the importance. School children also participated in these programs.

School Children Participation

Reception Desk

Certification Distribution

Exhibition Stalls

COTTON WALK

Visit of NIM Delegation

A group of 26 member trainees from 28th Mid-Career Management Course (In-land Study Tour) from National Institute of Management, Karachi visited CCRI Multan on October 17, 2018. Dr. Muhammad Naveed Afzal, Senior Scientific Officer, CCRI Multan briefed about the cotton research & development activities carried out at the Institute. Participants also visited Entomology Laboratories of the Institute and appreciated the research work conducted by the scientists.

strain MV-32/19 compared with the 26.5 mm of *Bt.*CIM-602. All the strains have desirable micronaire values ranging from 4.2 to 4.9. The fibre strength of all the new strains was observed within the range of 26.9 to 30.8 g/tex.

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

Strains	Seed Cotton yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micro naire value	Fibre Strength (g/tex)	Av. boll weight (g)	Plant Pop. (ha^{-1})
MV-22	2374	897	37.8	28.3	4.7	28.1	2.9	37481
MV-23	1844	734	39.8	28.5	4.6	28.4	3.4	35687
MV-24	2777	1052	37.9	28.6	4.7	28.7	3.1	38736
MV-25	2118	796	37.6	28.1	4.8	27.8	3.1	39095
MV-26	2175	831	38.2	28.5	4.7	28.9	3.5	39812
MV-27	1487	561	37.7	29.3	4.5	30.6	2.6	41426
MV-28	2090	813	38.9	29.0	4.9	28.8	4.2	33894
*Bt.*CIM-602	1438	541	37.6	28.0	4.2	27.7	2.5	35687

Sowing date =14.05.2019; CD (5%) for seedcotton =305.21; CV. % = 8.45

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

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micro naire value	Fibre Strength (g/tex)	Av. boll weight (g)	Plant Pop. (ha^{-1})
MV-29	1740	706	40.6	27.6	4.4	29.2	2.4	37300
MV-30	1985	844	42.5	26.2	4.5	27.3	2.4	39691
MV-31	2439	956	39.2	28.9	4.4	30.8	2.2	39212
MV-32	2606	1035	39.7	28.7	4.4	30.7	2.1	36343
MV-33	2343	930	39.7	28.0	4.9	28.7	3.0	32996
MV-34	1243	472	38.0	26.6	4.9	27.8	3.0	35626
MV-35	1674	733	43.8	26.5	4.5	26.9	2.4	38017
*Bt.*CIM-602	1722	651	37.8	26.5	4.2	27.7	2.0	41364

Sowing date = 30.05.2019; CD (5%) for seed cotton = 200.54; CV. % = 6.18

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-37/19 to MV-43/19 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-38/19 out-yielded all the strains and standard variety by producing 2319 kg ha^{-1} seed cotton, followed by MV-39/19 having seed cotton yields of 2200 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 1554 kg ha^{-1} seed cotton. The strains MV-43/19 and MV-41/19 produced the higher lint percentage values of 41.6 and 41.4 respectively compared with that of 37.3% by *Bt.*CIM-602.The strain MV-39/19 produced the longest staple of 28.9 mm, followed by 28.8 mm in MV-42/11 compared with the fibre length of 26.6 mm in commercial variety *Bt.*CIM-602. All strains have desirable micronaire values ranging from 4.0 to 4.9 except MV-40/19 which has 5.2.The strain MV-38/19 maintained the maximum fibre strength of 29.6 g/tex followed by MV-42/19 with 29.3 g/tex while standard *Bt.*CIM-602 had 27.4 g/tex fibre strength.

2.2.6. Micro-Varietal Trial-6

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

Eight newly bulked elite strains MV-45/19 to MV-52/19 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-46/19 out-yielded all the strains and standard variety by producing 2331 kg ha^{-1} seed cotton, followed by MV-47/19 and MV-49/19 having seed cotton yields of 2116 kg ha^{-1}, respectively against commercial variety

*Bt.*CIM-602 which produced 1632 kg ha^{-1} seed cotton. The strains MV-47/19 & MV-50/19 produced the higher lint percentage values of 39.1 while standard *Bt.*CIM-602 produced 39.9 % lint. The strain MV-46/19 produced the longest staple of 29.5 mm, followed by 29.1 mm in MV-47/19 compared with the staple length of 26.6 mm of commercial variety *Bt.*CIM-602. All strains have desirable micronaire values raging from 4.2 to 4.9. The strain MV-52/19 produced the maximum fibre strength of 29.3 g/tex followed by 28.7 g/tex of MV-46/19 & MV-51/19 as compared to the 27.5 g/tex of standard variety *Bt.*CIM-602.

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

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micro-naire value	Fibre Strength (g/tex)	Av. boll weight (g)	Plant pop. (ha^{-1})
MV-37	1937	715	36.9	27.3	4.6	28.8	2.0	40886
MV-38	2319	923	39.8	28.0	4.7	29.6	2.8	38734
MV-39	2200	847	38.5	28.9	4.4	29.2	2.3	40886
MV-40	2104	802	38.1	27.3	5.2	29.1	3.1	36821
MV-41	1578	653	41.4	27.1	4.1	28.3	3.2	40169
MV-42	1865	733	39.3	28.8	4.9	29.3	3.2	40408
MV-43	1650	686	41.6	28.4	4.0	28.7	2.2	36104
*Bt.*CIM-602	1554	580	37.3	26.6	4.3	27.4	2.2	38495

Sowing date = 30.05.2019; CD (5%) for seed cotton = 300.92; CV. % = 9.04

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

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micro-naire value	Fibre Strength (g/tex)	Av. boll weight (g)	Plant pop. (ha^{-1})
MV-45	1471	565	38.4	26.9	4.8	27.3	2.8	36405
MV-46	2331	893	38.3	29.5	4.9	28.7	2.9	36046
MV-47	2116	827	39.1	29.1	4.8	28.5	3.0	36046
MV-48	2062	794	38.5	28.9	4.8	28.0	2.9	37301
MV-49	2116	808	38.2	28.4	4.8	28.2	2.9	36225
MV-50	2080	813	39.1	28.5	4.9	27.2	2.9	35329
MV-51	1650	634	38.4	28.3	4.4	28.7	2.9	31563
MV-52	1596	562	35.2	27.9	4.2	29.3	2.9	37301
*Bt.*CIM-602	1632	651	39.9	26.6	5.0	27.5	2.5	35508

Sowing date: 22.05.2019, CD (5%) for seed cotton: Strains = 358.961, CV% = 11.26

2.3 Coordinated Variety Testing Programme

2.3.1 National Coordinated Varietal Trial (Set-A)

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

The cotton seed of twenty four strains under coded numbers was received from Director Research (PCCC) for evaluation. Data on seed cotton production and other parameters are presented in **Table 2.16**.The results indicated that the strain PC-1906 produced maximum yield 2447 kg ha^{-1} followed by NS-211 with 2306 kg ha^{-1} of seed cotton yield respectively. Tassco-115 produced lowest yield that is 1261 kg ha^{-1}. The strainSuncrop-3 produced the highest lint percentage of 41.1%, followed by PC-1901 & NS-211 with 39.8%. The strain Rohi-1 produced the highest value of staple length 29.1 mm, followed by PC-1907 which has staple length of 28.9 mm.Most of the strains had he desirable micronaire value. Few strains have values of fibre strength according to required standard.

2.3.2 National Coordinated Varietal Trials (Set-B)

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

Twenty five 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 2.17** showed that the 1942 produced the highest seed cotton yield of 2518 kg ha^{-1}, followed by NIAB-SANAB-

M having 2349 kg ha^{-1} seed cotton yield while 1939 produced lowest yield 1351 kg ha^{-1}. Data also revealed that the strain Rustam-Beej-11 (C-II) produced the highest lint percentage of 41.8, followed by 1939 with 41.0%. While strain NIAB-SANAB-M remained the longest staple length with 28.7 mm followed by Eye-22 with 28.3 mm.The ranging of micronaire value is from 3.8 to 5.5. Maximum fibre strength was maintained by NIAB-SANAB-M having 29.3 g/tex, followed by YBG- 2222(C-II) with 29.1 g/tex fibre strength.

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

Strains	Seed cotton yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micro -naire value	Fibre Strength (g/tex)	Plant Pop. (ha^{-1})
1901	1723	686	39.8	28.3	5.9	25.2	37481
1902	1541	599	38.9	26.3	5.0	24.6	39633
1903	1924	731	38.0	28.8	5.4	27.2	39812
1904	1945	737	37.9	26.7	5.4	24.3	42143
1905	1787	634	35.5	27.4	5.2	25.0	39095
1906	2447	871	35.6	27.8	4.3	25.9	43219
1907	1760	690	39.2	28.9	5.0	26.8	40709
1908	1389	501	36.1	27.0	4.9	24.6	42143
1909	1554	572	36.8	26.5	5.3	24.5	41247
Tassco-115	1261	424	33.6	26.4	4.9	25.3	41785
Tassco-112	1692	616	36.4	26.9	4.7	25.1	41605
Tahafuz-15	1953	734	37.6	26.9	5.4	25.5	39095
Diamond-2	1806	654	36.2	26.9	5.1	24.8	38557
Suncrop-3	1336	549	41.1	27.3	4.8	25.3	39453
CIM-602 (Bt-St.)	1499	553	36.9	28.6	4.1	26.5	39991
Tahafuz-12(C-II)	2061	756	36.7	27.2	4.8	25.4	40709
Suncrop(C-II)	2014	773	38.4	26.8	4.9	25.4	40171
Sayban-209	1708	617	36.1	26.9	4.8	25.2	41067
Saim-102	2042	794	38.9	27.1	4.9	24.9	39274
Rohi-2	1269	456	35.9	28.8	4.8	27.5	35329
Rohi-1	1514	522	34.5	29.1	4.6	27.4	40709
TJ-King(C-II)	1292	512	39.6	26.8	5.0	25.0	38915
1923	1965	666	33.9	27.2	5.3	25.3	38557
NS-211	2306	918	39.8	27.6	4.8	25.8	41605

Sowing date = 04.05.2019

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

Strains	Seed-cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (%age)	Staple length (mm)	Micro naire value	Fibre strength (g/tex)	Plant Pop. (ha^{-1})
Eye-22	1939	729	37.6	28.3	4.9	25.6	43578
Eye-111	2123	788	37.1	26.6	5.1	27.7	43937
Eye-20	2022	772	38.2	27.7	4.8	25.9	43757
Rustam-Beej-111(CKC)	1673	651	38.9	26.0	5.5	26.0	41247
Rustam-Beej-11(C-II)	1879	785	41.8	25.9	4.8	27.2	41964
Rustam-11	2288	824	36.0	26.6	5.5	25.5	43578
ICI-2424	1722	699	40.6	25.9	5.4	28.1	43219
YBG-2323(CKC)	1837	740	40.3	26.4	5.0	26.2	39453
YBG-2222(C-II)	1905	690	36.2	26.9	4.5	29.1	41605
1934	2139	798	37.3	26.9	5.0	27.1	44116
CIM-602 (Bt-Standard)	1986	719	36.2	28.3	3.8	26.2	43040
1936	2207	823	37.3	26.9	5.2	26.6	43757
1937	1842	717	38.9	26.7	5.0	26.7	43578

1938	1562	533	34.1	27.2	5.3	27.4	43399
1939	1351	554	41.0	26.5	5.0	26.7	28155
1940	1498	568	37.9	26.0	5.5	26.3	34611
BF-1	1986	739	37.2	27.9	4.6	26.6	38557
1942	2518	1030	40.9	27.2	5.5	26.7	39991
1943	1601	623	38.9	27.1	5.0	27.6	40888
Bahar-136	2096	805	38.4	26.6	5.1	26.6	42502
ASPL-710	1955	760	38.9	26.2	5.5	27.1	43219
ASPL-709	2050	808	39.4	26.4	5.2	26.4	42143
IR-NIBGE-15	1861	672	36.1	26.6	4.5	26.3	39812
IR-NIBGE-14	2126	761	35.8	28.3	4.7	26.8	43040
IR-NIBGE-13	2200	818	37.2	27.2	4.4	27.7	44295
NIAB-SANAB-M	2349	954	40.6	28.7	5.1	29.3	43399

Sowing date 04.05.2019

2.3.3. National Coordinated Varietal Trials (Set-C)

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

The cotton seed of twenty four candidate varieties along with one standard (*Bt.*CIM-602) were provided by the Director Research PCCC for evaluation at CCRI Multan. The data presented in **Table 2.18**showed that the strain GH-Uhad produced the highest seed cotton yield of 2481 kg ha^{-1}, followed by NIAB-135 with 2454 kg ha-1 seed cotton yield while RH-Kashish was at bottom position in respect of seed cotton yield (1010kg ha-1).Data presented in **Table 2.18** revealed that NIAB-819 and FH-Super-Cotton-2017 produced the highest lint percentage 39.1 followed by RH-677 with 38.8%.While strain VH-402, RH-Kashish and RH-670 produced the longest staple with 28.4 mm followed by *Bt.*CIM-602 (Bt Std-1) and GH-Sultan with 28.3 mm. The range of micronaire value was 4.1 to 5.3.Whereas strain RH-Kashish produced the maximum fibre strength with 27.7 g/tex followed by RH-670 with 27.5 g/tex.

Table 2.18 Performance of different *Bt.* Strains of private sector in National coordinated Varietal Trial (Set-C) at CCRI Multan

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (%age)	Staple length (mm)	Micro-naire value	Fibre strength (g/tex)	Plant Pop. (ha^{-1})
NIAB-512	2193	849	38.7	27.0	5.1	25.9	41964
NIAB-973	1697	591	34.8	27.5	5.2	26.5	38019
NIAB-819	1665	651	39.1	26.9	5.2	26.2	37301
NIAB-135	2454	937	38.2	26.9	4.8	26.0	42502
NIAB-1011	2408	915	38.0	27.8	4.6	26.5	43040
NIA-89	1403	535	38.1	25.5	4.6	24.8	42143
IUB-73	1708	654	38.3	27.3	5.3	26.0	42323
VH-383	2158	835	38.7	26.8	5.2	25.7	40888
VH-189	1674	614	36.7	27.5	5.3	25.8	38198
CIM-602(*Bt*-St.)	1889	680	36.0	28.3	4.3	27.1	41964
VH-402	1448	536	37.0	28.4	5.3	26.7	41426
SLH-33	1424	538	37.8	26.5	5.3	25.4	31383
RH-Kashish	1010	370	36.6	28.4	4.1	27.7	39274
RH-Afnan-2	1801	665	36.9	26.7	4.8	25.2	42681
RH-670	1637	635	38.8	28.4	5.2	27.5	39812
GH-Hamaliya	2441	930	38.1	28.2	4.7	26.3	39453
GH-Sultan	2322	896	38.6	28.3	4.9	26.1	42502
GH-Uhad	2481	953	38.4	28.2	4.4	25.7	41785
FH-Anmol	2090	788	37.7	27.7	5.2	23.6	38736
FH-492	2243	837	37.3	27.2	5.2	24.6	36046
FH-155	1750	644	36.8	28.2	5.0	25.9	40171
FH-Super-Cotton-2017	1935	757	39.1	26.7	5.3	24.7	40709
FH-AM-Cotton-2017	1796	668	37.2	27.2	5.2	24.6	38915
BH-224	2006	714	35.6	27.2	5.1	26.0	40709
BH-223	2030	725	35.7	26.7	5.3	25.2	40171

Sowing date = 04.05.2019

2.3.4. National Coordinated Varietal Trials (Set-D)

Objective: Testing of promising *Bt*.strains of different cotton breeders (Public seed sector) of Pakistan

The cotton seed of twenty five candidate varieties including two commercial varieties CIM-602 and Cyto-124 were provided by the Director Research PCCC for evaluation of their yield potential and fiber characters at CCRI Multan The data presented in **Table 2.19** showed that the strain *Bt*.CIM-775 produced the highest seed cotton yield of 3060 kg ha^{-1}, followed by *Bt*.CIM-678 with 3024 kg ha^{-1} seed cotton yield and *Bt*.Cyto-511 with 2187 kg ha^{-1} while CEMB-Klean-Cotton-6 was at bottom position in respect of seed cotton yield i.e. 1443 kg ha^{-1}.Data presented in **Table 2.19** revealed that CEMB-Klean-Cotton-4 produced the highest lint percentage 40.7 followed by 2000 with 39.9% while strain Bt-CIM-785, Bt-Cyto-535 produced the longest staple of 29.5 mm length followed by Bt-Cyto-533 and Cyto-226 with 29.0 and 28.8 mm respectively. The range of Micronaire value was 4.3 to 5.7, whereas strain Cyto-226 produced the maximum fibre strength with 30.3 g/tex followed by Cyto-124 (Non-*Bt*. Std) with 29.8 g/tex.

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

Eight 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-496 excelled among all varieties by producing seed cotton yield 2152 kg ha^{-1} followed by the variety CIM-573 with 2009 kg. ha^{-1} and CIM-620 with 1937 kg. ha^{-1} seed cotton production. Variety CIM-610 had the highest lint percentage of 39.8, followed by varieties CIM-620 having lint percentage of 38.8. The variety Cyto-124 maintained the longest staple length of 29.7 mm, followed by the variety the CIM-620 with 28.2 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 2.19 Performance of different strains of private sector in National coordinated Varietal Trial (Set-D) at CCRI Multan

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (%age)	Staple length (mm)	Micro-naire value	Fibre strength (g/tex)	Plant Pop. (ha^{-1})
MNH-1050	1527	521	34.1	27.6	5.7	26.6	40888
MNH-1035	1898	700	36.9	26.4	5.5	26.6	43040
CEMB-Klean-Cotton-6	1443	514	35.6	27.2	5.1	26.2	42143
CEMB-Klean-Cotton-5	1811	645	35.6	26.7	5.2	26.0	41785
CEMB-Klean-Cotton-4	1623	661	40.7	26.4	5.2	26.3	39453
CEMB-Klean-Cotton-3	1756	697	39.7	26.8	5.0	26.4	40709
CRIS-638	1757	54	39.1	26.4	5.7	26.1	41426
CRIS-673	2112	773	36.6	26.5	5.5	26.2	41426
CRIS-671	1914	718	37.5	27.7	5.3	27.1	41067
Bt-Cyto-535	1593	597	37.5	29.5	4.8	28.0	41247
Bt-Cyto-533	1598	572	35.8	29.0	4.9	27.6	42323
Bt-CIM-785	1575	595	37.8	29.5	4.8	28.3	36763
Bt-CIM-775	3060	1209	39.5	28.6	4.3	27.5	42861
Bt-Cyto-511	2187	855	39.1	28.3	4.9	27.1	33894
Bt-CIM-789	1992	751	37.7	27.4	4.8	26.3	27976
Bt-CIM-678	3024	1167	38.6	28.2	4.6	27.1	23851

Bt-CIM-303	2041	774	37.9	27.8	4.9	26.3	32280
CIM-602(Bt Std)	1683	624	37.1	28.5	4.3	27.6	41247
Cyto-124(Non-Bt Std)	1541	572	37.1	28.6	4.8	29.8	42502
NIAB-929	2122	751	35.4	27.1	5.5	27.4	40709
NIA-88	2013	694	34.5	26.1	5.7	26.3	43219
1997	1775	628	35.4	27.5	5.5	27.7	36584
CRIS-644	1651	581	35.2	26.8	5.0	26.7	41247
Cyto-226	2081	782	37.6	28.8	4.9	30.3	35867
2000	2087	833	39.9	26.0	5.2	25.9	38736
2001	1668	637	38.2	27.1	5.5	27.2	34432
MZM-7	1585	607	38.3	26.4	4.9	26.3	35508

Sowing date = 04.05.2019

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

Varieties	Year of released	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micro-naire value	Fibre Strength (g/tex)	Av. Boll wt.(g)	Plant Pop. (ha^{-1})
CIM-482	2000	1847	693	37.5	27.9	4.5	27.9	2.5	37839
CIM-707	2004	1704	629	36.9	28.0	3.8	28.0	2.5	39633
CIM-573	2012	2009	745	37.1	27.9	4.9	27.9	2.6	37481
Cyto-124	2015	1793	690	38.5	29.7	4.9	29.7	2.5	40888
CIM-620	2016	1937	752	38.8	28.2	4.9	28.2	2.5	36763
CIM-610	2018	1614	642	39.8	27.8	4.9	27.8	2.7	38736
CIM-496	2005	2152	833	38.7	27.5	4.8	27.5	2.9	37660
CIM-506	2004	1740	649	37.3	27.6	4.4	27.6	2.7	38736

Sowing date: 08.05.2019; C.D. (5%) for seed cotton 276.38 CV% = 8.53

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 1933 kg ha^{-1}, followed by the variety Sahara-150 with 1858 kgha^{-1} while *Bt*. *Bt*.CIM-632 produced lowest (1395 kg ha^{-1})seed cotton production. *Bt*.CIM-632 had the highest lint percentage of 40.2, followed by Sahara-150 (40.0%) while RH-668 had the lowest (36.3%) lint percentage. Staple length of all the varieties were above the standard. Micronaire of NIAB-1048, NIAB-545, RH-662 and Sahara-150 were above the standard. The fibre strength of all the varieties was above the standard except *Bt*.CIM-632.

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

Varieties	Year of release	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micro-naire value	Fibre Strength (g/tex)	Av. Boll wt.(g)	Plant Pop. (ha^{-1})
Bt.CIM-600	2016	1495	564	37.7	28.2	4.0	26.9	2.6	43038
Bt.CIM-602	2013	1559	606	38.9	28.3	4.3	26.6	2.5	41843
Bt.CIM-632	2018	1395	561	40.2	28.1	4.9	25.9	2.6	40886
FH-142	2013	1586	600	37.8	28.5	4.8	26.7	2.4	41603
RH-668	2018	1684	611	36.3	28.7	4.8	26.6	2.5	41843
NIAB-1048	2018	1933	729	37.7	28.4	5.1	26.2	3.1	40169
Crystal-12	2018	1790	671	37.5	28.9	4.9	27.3	3.2	42799
Sitara-15	2018	1677	624	37.2	28.9	4.3	27.3	2.4	39930
RH-662	2018	1607	599	37.3	28.1	5.8	26.0	2.6	42321
FH-152	2018	1616	621	38.4	28.9	4.8	27.8	2.7	40408
NIAB-545	2018	1738	669	38.5	28.1	5.2	27.1	2.8	40647
Sahara-150	2018	1858	743	40.0	28.7	5.2	27.8	2.9	39212

Sowing date: 30.05.2019 C.D. (5%) for seed cotton=63.84 CV% = 2.28

2.5 Breeding Material

2.5.1 Selection from Breeding Material

Single plant selections were made from the breeding material in different segregating generations for further testing and screening against biotic and abiotic stresses. The detail of breeding material planted and number of plants selected during 2019-20 is 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)	Range Staple length (mm)
VT	235	37.8-44.1	28.2-31.0
MVT	405	39.8-44.3	28.3-31.1
PRT	335	38.2-44.4	28.2-31.5
F_{6-7} single lines	1120	39.2-46.6	28.7-31.2
F_5 single lines	1230	38.2-44.2	27.9-31.2
F_4 generation	1503	38.0-43.5	28.2-30.2
F_3 generation	2150	37.8-42.3	28.1-30.2
F_2 generation	2820	36.5-42.2	27.3-31.2
Others	1620	37.5-45.1	28.1-32.0

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 twenty three (6123) 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 programme. Detail of genetic stock is given in **Table 2.23.**The seed of genetic stock were also supplied, locally and abroad, tow 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		1190
Exotic genotypes		4933
	Total	**6123**
Species-Wise Detail		
*Gossypium herbaceum*L.		556
*Gossypium arboreum*L.		1025
Gossypium hirsutum L.		4433
*Gossypium barbadence*L.		109

Table 24 List of scientists/researchers whom received the cotton germplasm 2019-20

Name of Institute / Research Scientists	No. of stock
Dr. Shahid Farooq, Assistant Professor, Harran University, Sanliurfa, Turkey.	15
Dr. Masooma Naseer Cheema, Assistant Professor, Plant Breeding & Genetics, University of Agriculture, Faisalabad.	01
Mr. Allah Ditta, Manager R&D, Bahar Seed Corporation (Regd.), Head Office, Manthar Road, Sadiqabad, District Rahim Yar Khan	12
Dr. Hafiz Muhammad Nasrullah, Agronomist, Agronomic Research Station, Chak No.83/10 -R, Khanewal.	01
Dr. Zahoor Ahmad, General Manager, Four Brothers Group Pakistan, Hea d Office 77-D/1, 1st Floor Lahore Centre, Main Boulevard Gulberg, Lahore.	12
Dr. Abdul Qayyum, Professor/Supervisor, Department of Plant Breeding & Genetics Section, Faculty of Agricultural Sciences & Technology, Bahauddin Zakariya University, Multan.	30
Dr. Muhammad Asif Saleem, Assistant Professor/Field Incharge, Department of Plant Breeding & Genetics Section, Faculty of Agricultural Sciences & Technology, Bahauddin Zakariya University, Multan.	30
Dr. Jodi Scheffler, USDA, ARS 141 Experiment Station Road, Stoneville, MS 38776 United State	56

of America	
Dr. Muqarrab Ali, Supervisor, Department of Agronomy, Muhammad Nawaz Shareef University of Agriculture (MNSUA), Multan	07
Prof. Dr. Muhammad Iqbal, Chairman, Department of Plant Breeding & Genetics, University College of Agriculture & Environmental Sciences(UCA&ES), Islamia University of Bahawalpur, Bahawalpur.	02
Mr. Muhammad Arshad, Chaudhry Abdul Mannan & Company, Ghallah Mandi Fort Abbas, Bahawalnagar,	03
Dr. Muhammad Atiq, Assistant Professor, Department of Plant Pathology, University of Agriculture, Faisalabad.	15
Principal Scientist/Director, Cotton Research Institute, Tandojam	19
Ch. Muhammad Hanif, Deputy General Manager Seeds, Four Brothers Seed Corporation, Multan.	13
The Principal, UAF Sub-Campus Burewala, Vehari	53
The Chairman, Department of Plant Breeding & Genetics Section, Faculty of Agricultural Sciences & Technology, Bahauddin Zakariya University, Multan.	32
Mr. Waqas Ahmad, Assistant Plant Breeder, ICI Pakistan Limited, Li fe Sciences Business, 4th Floor Siddique, Centre 61, Abdali Road, Multan	18
Dr. Muhammad Kamran Qureshi, Assistant Professor, Department of Plant Breeding & Genetics Section, Faculty of Agricultural Sciences & Technology, Bahauddin Zakariya University, Multan.	52
Dr. M. Mahmood Ahmad, Assistant Professor (Biotechnology), PB^2, Muhammad Nawaz Shareef University of Agriculture, Multan.	20
Dr. Ummara Waheed, Assistant Professor Institute of Plant Breeding & Biotechnology, Muhammad Nawaz Shareef University of Agriculture, Multan.	99
Dr. Ummad-ud-Din, Assistant Professor, Department of Pathology, Bahauddin Zakariya University, Multan.	17
Professor Dr. Habib-ur-Rehman Athar, Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan.	05
Dr. Muhammad Shaban, Assistant Professor, Department of Plant Breeding & Genetics Section, Faculty of Agricultural Sciences & Technology, Bahauddin Zakariya University, Multan.	03
The Chairman, Department of Entomology, Faculty of Agricultural Sciences & T echnology, Bahauddin Zakariya University, Multan	05
Dean, Faculty of Plant Protection, Muhammad Nawaz Shareef University of Agriculture, Multan	01
Dr. Muhammad Saeed, Assistant Professor, Department of Botany, Government College University, New Campus, Jhang Road, Faisalabad.	01
Dr. Asim Gulzar, Assistant Professor, Department of Entomology, PMAS -Arid Agriculture University, Rawalpindi.	03

2.7. Early Generation Seed production of commercial varieties

Single lines of *Bt and non Bt* approved varieties were sown in the fields. All the agronomic practices were made sure 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 2.25 Detail of pre-basic seed produced during 2019-20

Variety	Cotton Seed (kgs)
CIM-496	50
CIM-554	40
CIM-620	90
CIM-573	40
CIM-610	45
Bt.CIM-600	57
Bt.CIM-602	174
Bt.CIM-632	75
Total	**571**

2.8 Pak-US ICARDA Cotton Project CCRI Multan Component

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

A total of 25 accessions received this year from USDA were also screened in field condition for CLCuV infestation and other morphological characters. Similarly 146 promising single plants were selected from different generations (F_2 to F_6). Screening of more than 1200 genotypes in field condition was done and their seed were also preserved in Cold Chamber. Beside this, maintaining seed of more than 6000 cotton germplasm at Cold Room for short, medium and long term preservation. A total of 52 accessions out of 3277 which were imported during the Pak-US- ICARDA cotton project were found to be resistant against CLCuV. These 52 accessions were ratooned at CCRI Multan from the last 5 years. Out of these 52accessions flower induction started in only few accessions in the month of October - December 2019 as detailed in Table 2.30. In Set K only one accession USG-618/14 having flowers and bolls formations while in Set N there are four accessions having bud formation but one accession i.e. USG-2131/14 having only one plant which has flower formations. Accession USG-2269/14 having buds as well as flower formation, while USG-2471/14 and USG-2476/14 are having flower formation. All the flowers were analyzed for their pollens fertility and it was found that the pollens of these flowers were unfertile (Table 2.26).

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

Set No.	Year	No of total Accessions	Resistant accessions	Accessions having buds and flower formation
C	2013	200	5	0
D	2013	200	14	0
K	2014	200	3	1
N	2014	600	30	4
	Total	**1200**	**52**	**5**

All these accessions are properly maintained condition for proper buds and flower formation. Efforts were made to get fertile flowers which will be used in our breeding programs. Besides all these, milestone achieved by our section is that two varieties *Bt*.CIM-303 and *Bt*.CIM-775 developed by using the blood of this US Germplasm were tested in National Coordinated Varietal Trial for the 1st and 2nd Year. Variety *Bt*.CIM-775 got 2nd position at country level in 1st Year of National Coordinated Varietal Trial. Similarly three other advance lines also developed using these accessions of US Germplasm are in their advance varietal trial.

3. CYTOGENETICS

The human population is expected to rise from 6 billion to 10 billion by 2100, resulting in huge increased demands on agriculture and land use. This problem is compounded by climate change, which has resulted in the growing of biofuel crops. Therefore, informed plant breeding to increase yield and quality and to improve farming practice is urgently needed. Cytogenetics section is working 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.

The extensive use of only a few closely related genotypes of cotton, coupled with the widespread adoption of transgenic cultivars, has greatly reduced the genetic base of the crop. This genetic uniformity makes cotton highly vulnerable to emerging biotic and abiotic 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 auspicious 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-two 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 2019-20

Sr. No	Species Name	Genome	Habit
1.	*G. hirsutum*	2AD1	Cultivated
2.	*G. barbadense*	2AD2	Cultivated
3.	*G. tomentosum*	2AD3	Wild
4.	*G. mustelinum*	2AD4	Wild
5.	*G. darwinii*	2AD5	Wild
6.	*G. herbaceum*	A1	Cultivated
7.	*G. arboreum*	A2	Cultivated
8.	*G. anomalum*	B1	Wild
9.	*G. capitis -viridis*	B4	Wild
10.	*G. sturtianum*	C1	Wild
11.	*G. nandewarense*	C1-n	Wild
12.	*G. australe*	C3	Wild
13.	*G. thurberi*	D1	Wild
14.	*G. harknessii*	D2-2	Wild
15.	*G. davidsonii*	D3-d	Wild
16.	*G. klotzschianum*	D3-k	Wild
17.	*G. aridum*	D4	Wild
18.	*G. raimondii*	D5	Wild
19.	*G. gossypioides*	D6	Wild
20.	*G. lobatum*	D7	Wild
21.	*G. trilobum*	D9	Wild
22.	*G. laxum*	D8	Wild
23.	*G. stocksii*	E1	Wild
24.	*G. somalense*	E2	Wild

25.	*G. areysianum*	E3	Wild
26.	*G. incanum*	E4	Wild
27.	*G. longicalyx*	F1	Wild
28.	*G. bickii*	G1	Wild
29.	*G. australe*	G2	Wild
30.	*G. nelsonii*	G3	Wild
31.	*G. lenceolatum*	2AD?	Wild
32.	*G. mustellinium*	AD	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**

3.1. A. Maintenance of *Gossypium* Germplasm

Through Seed

For the strengthening of *Gossypium* species in living herbarium at CCRI, Multan seeds of twenty-eight wild species were germinated in an incubator at 28 ± 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. sturtianum*	7	2
5	*G. nandewarense*	15	6
6	*G. thurberi*	38	8
7	*G. harknessii*	12	2
8	*G. davidsonii*	7	3
9	*G. klotzschianum*	7	2
10	*G. aridum*	12	5
11	*G. raimondii*	29	7
12	*G. gossypioides*	15	4
13	*G. lobatum*	22	7
14	*G. trilobum*	5	4
15	*G. laxum*	9	2
16	*G. stocksii*	33	7
17	*G. somalense*	23	7
18	*G. areysianum*	24	7
19	*G. incanum*	7	2
20	*G. longicalyx*	6	2
21	*G. bickii*	24	5
22	*G. australe*	4	2
23	*G. herbaceum* (Red)	15	3
24	*G. herbaceum* (Green)	15	5
25	*G. darwinii*	13	6
26	*G. nelsonii*	26	5
27	*G. raimondii*	10	3
28	*G. barbadense*	10	4
	Total	**415**	**118**

Fig. 3.1. Germplasm maintanence through seed

3.1. B. Maintenance of *Gossypium* Germplasm 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)*	4
2	*G.capitis veridis*	5
3	*G. lobatum*	4
4	*G. laxum*	4
5	*G. gossipoides*	4
6	*G. longicalyx*	4
7	*G. bickii*	5
8	*G. incanum*	5
9	*G. somalense*	4
10	*G. tomentosum*	4
11	*G. stocksii*	5
12	*G. anomalum*	6
13	*G. tomentosum*	4
14	*G. areysianum*	3
15	*G. nelsonii*	2
1	*2(G. arbo. X G. somalense)* 2n	5
2	*(G. hirs. X G. arbo.)* 3n	5
3	*2(G. hirs. X G. ano.) X G. barba.4*n	4
4	*G. barba X 2(G. arbo. X G. stockii) 5*n	4
5	*G. barba X 2(G. arbo. X G. stockii) 6*n	3
	Total	**84**

Fig. 3.2 Germplasm maintanence through approach grafting

3.1. C. Maintenance of *Gossypium* Germplasm 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.

Table 3.5. List of species /hybrids maintained through cuttings

Sr. No.	Name of species	No. of Cuttings
1	*G. laxum*	16
2	G. lobatum	16
3	*G. tomentosum*	9
4	*G. anomalum*	7
5	*G. harknessii*	11
6	*G. klotzschianum*	4
7	*2(G.hirsutum* x *G.anomalum)*	25
8	*2(G.hirsutum* x *G.anomalum)* x *G.barbadense* (5n)	8
9	*2(G.arbo.* x *G.anomalum)* x *G.hirsutum* (5n)	30
10	*2(G.hir.* x *G.stocksii)* (6n)	18
11	*2(G.arbo.* x *G.anomalum)* x *G.hirsutum* (4n)	18
12	*2(G.arbo.* x *G.somalense)* (4n)	18
13	*2(G.hir.* x *G.anomalum)* (3n)	12
14	*2(G.hir.* x *G.anom.)* x *G.hir.* (5n)	8
15	*2(G.arbo.* x *G.anomalum)* (2n)	30
16	*(G. arboreum* x *G.australe)* (2n)	24
17	2(*G.hir.x G. stocksii*) x *G. hirsutum* (5n)	9
18	2(*G.hir.x G. anomalum*) (3n)	14
19	*(G.arborerum* x *G.capitis veridis)* x *G. arbo.*	24
20	*(G. arboreum* x *G.herbaceum)* (2n)	24
21	*2(G.arbo.* x *G.anomalum)* x *G. hirsutum* (4n)	12
22	2(*G. hirsutum* x *G. bickii*) x *G. barba.* (6n)	12
23	2(*G.arboreum .x G. stocksii*) (4n)	18
24	*(G.arboreum* x *G.thurberii*) (2n)	18
25	*G.hirsutum* x *G.herkensii* (3n)	36
26	*2(G.hirsutum* x *G.stockii)* (4n)	36
27	*G.hirsutum* x *G.gossypiodes* (3n)	18
28	*G.hirsutum*	18
29	*G.barbadense*	12
	Total	**505**

Fig.3.3 Germpalsm maintenance through cutting

3.2 Interspecific Hybridization

A hybridization program was conducted to develop new breeding material with superior characteristic to combat biotic and abiotic stresses. Meanwhile a parallel breeding program was conducted focusing only on extra-long staple, different cross combinations were attempted with the parent lines having extra staple length. Special importance was also given to non *Bt* material and maximum parentage were utilized for the development of non *Bt* hybrids. A comprehensive *Bt* program was utilized to develop high yielding, early maturing, drought tolerant and good fiber quality for better adoption in changing climatic scenario. Total 6917 pollinations were attempted in 80 combinations. The detail of hybridization is given in (Table 3.6).

Table 3.6. Detail of Hybridization Program conducted during 2019-2020

Sr. No	C. No.	Parentage	No. of pollinations
1.	C-1	D1 x Cyto-535	75
2.	C-2	Zm1 x Cyto-535	46
3.	C-3	Zm2 X Cyto-535	68
4.	C-4	GH-Sultan x PS-2	20
5.	C-5	Ohd x Ps-2	44
6.	C-6	Hadii x 555	55
7.	C-7	CIM-785 x I2	85
8.	C-8	Cyto-535 x I1	60
9.	C-9	Cyto-535 X d2	26
10.	C-10	555 x Ps-2	28
11.	C-11	Cyto-533 X PS-2	45
12.	C-12	Cyto-530 X ps-2	64
13.	C-13	Cyto-535 X Hadii	37
14.	C-14	H-24 x W2	12
15.	C-15	Hamalia x Ps-2	38
16.	C-16	Cyto-535 x CIM-775	73
17.	C-17	Cyto-313 X CIM-775	34
18.	C-18	Cyto-179 x CIM-775	68
19.	C-19	Cyto-535 x 28-6/19	32
20.	C-20	Cyto-313 x GH-Haddi	41
21.	C-21	Cyto-179 X I1	50
22.	C-22	CIM-789 x Cyto-535	90
23.	C-23	CIM-789 x V16	95
24.	C-26	I-1 X V-12	105
25.	C-27	I-1 X MVT-3	85
26.	C-28	I-1 X VT-1	121
27.	C-29	I-2 X I-1	71
28.	C-30	I-2 X BS-21	125
29.	C-31	I-2 X V-3	65
30.	C-32	I-2 X V-12	140
31.	C-33	MVT-1-V3 X 369	134
32.	C-34	MVT-1-V3 X BS-21	143
33.	C-35	MVT-1-V3 X VT-V3	158
34.	C-42	Cyto-511 X CIM-775	123
35.	C-45	Cyto-535 X CIM-343	63
36.	C-47	Cyto-535 X CIM-789	46
37.	C-48	Cyto-179 X CIM-678	85
38.	C-49	Cyto-179 X CIM-789	53
39.	C-50	Cyto-179 X CIM-343	64
40.	C-51	Cyto-515 X CIM-789	73
41.	C-54	Cyto-177 X I-2	107
42.	C-56	CIM-789 X Cyto-535	124
43.	C-57	CIM-789 X Cyto-530	91
44.	C-58	Cyto-177 X CIM-775	63
45.	C-59	AC-134 X Long staple	175
46.	C-60	Cyto-177 X FH-490	29
47.	C-61	Cyto-161 x SL-65	187
48.	C-62	Cyto-161 x SL-35	76
49.	C-63	Cyto-161 x CIM-707	178
50.	C-64	Cyto-124 x SL-65	134
51.	C-65	Cyto-124 x SL-35	154
52.	C-66	Cyto-161 x Cyto-225	237
53.	C-67	Cyto-161 x CIM-608	173
54.	C-68	Cyto-161 x Cyto-124	136
55.	C-69	Cyto-510 x CIM-303	150
56.	C-70	Cyto-177 x CIM-663	187
57.	C-71	Cyto-177 x CIM-789	135
58.	C-72	Cyto-178 x C-17(515)	123
59.	C-73	Cyto-511 x Cyto-177	112
60.	C-75	Cyto- 511 x Cyto-515	117
61.	C-76	Cyto-313 x CIM-303	153
62.	C-77	Cyto-516 x Cyto-179	75
63.	C-78	Cyto-178 x Cyto-516	239
64.	C-79	Cyto-516 x IUB-18	178
65.	C-80	Cyto-124 x Cyto-225	178
66.	C-81	*G. arbo. x G. gossypoides*	53
67.	C-82	*G. arbo. x G. bickii*	47

68.	C-83	*G. arbo. x G. thurberi)*	41
69.	C-84	*G. arbo.* x *G.anom.*	67
70.	C-85	*G. arbo.* x *G.nelsoni*	43
71.	C-86	*G. arbo.* x *.stocksii*	38
72.	C-87	*G.arbo.* x *G.somalense*	51
73.	C-88	*G.arbo.* x *G.incanum*	33
74.	C-89	G. arbo. x G. stocksi	29
75.	C-90	G. hir. x G. gossypoides	71
76.	C-91	G. hir. x G. incanum	23
77.	C-92	*G. hirs.* x *G. robinsonii*	51
78.	C-93	*G. hirs.* x *G. sturtianum*	39
79.	C-94	*G. hirs.* x *G. nelsonii*	47
80.	C-95	*G. hirs.* x *G. robinsonii*	49
		Total	**6917**

Total 6917 pollinations were attempted in 80 combinations. The boll setting was achieved in majority of combinations whereas in few interspecific combinations; crossed bolls were retained but seeds were not formed in them and it could be either due to incompatibility among different species or sterility barriers existing at pre and post fertilization stages of hybridization. The hormones viz., Gibberellic acid (GA) and Nephthalene acetic acid (NAA) were exogenously applied at the rates of 50 and 100 mg L^{-1} water, respectively after 24 hours of pollination. The application continued till 72 hours to retain the crossed bolls.

Fig.3.4 Hybridization

3.3 Development of Auto-Tetrapolid

1. Seeds of *G. arboreum* x *G. somalense* hybrid was treated with 0.1% colchicine to obtain autotetraploid. Seed treatment was done for 24, 48 and 72 hours. Plants treated with 0.1% concentration for 72 hours are under observation. These will be checked cytologically. These plants have stunted growth. Other plants with 0.01 % for 24 and 48 hours are normal with 26 chromosomes.
2. Shoot treatment of G. arboreum x G. hirsutum triplod was done with 0.01% colchicine. Cutting of triploid treated with colchicine were normal in ploidy level exhibiting 39 chromosomes.

Fig. 3.5: Cholchicine treatment

Buds of *G. arboreum* x *G. somalense* plant treated with colchicine for 24 and 48 hours were checked but the plant were diploid (Fig-3.6). Buds were fixed in Carnoy's solution, preserved in 70% ethanol and studied at metaphase-1.

Table. 3.7: Chromosomal configurations of *G.arboreum* x *G.somalense*

PMC No.	I's	II's	III's	IV's	Total	Remarks
1	-	13	-	-	26	Plant was fertile but no effect of
2	-	13	-	-	26	cholchicine treatment

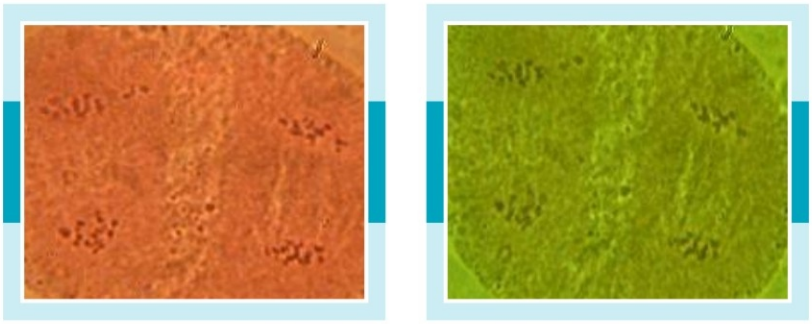


Fig-3.6. Twenty six chromosome in *G arboreum* x *G somalense* (Seed treatment)

Buds of *G.arboreum* x *G. hirsutum* plants treated with 0.01% colchicine for 24 and 48 hours were checked but the plant were still triplod (Fig-3.7). Buds were fixed in Carnoy's solution, preserved in 70% ethanol and studied at metaphase-1.

Fig-3.7. Twenty six chromosome in *G arboreum* x *G hirsutum* (Shoot treatment)

G. hirsutum x *G. arboreum.* 12 I's, 10 II's, 1 III's &1 IV's =39

3.4. Performance of Filial Generations 2019-20

Single plants with CLCuV tolerance, good yield and fibre quality traits were selected from the breeding material during 2019-20. The detail of each filial generation is as follows

Table 3.8 Detail of single plants selected from breeding material

Filial Generation	No of Plants/ Selected	Yield Plant $^{-1}$ (g)	GOT (%)	Staple Length (mm) Range	Uni. Index	Mic (µg ich^{-1})	Fibre Strength (g tex^{-1})
F_2	589	65.8-211.1	37.4-43.6	28.0-33.5	80.1-82.7	3.9-4.9	28.0-33.7
F_3	735	57.0-178.4	37.9-41.7	28.0-31.9	79.1-83.8	3.6-4.7	28.6-32.2
F_4	470	40.6-189.8	38.2-41.3	27.9-32.8	80.2-82.9	4.0-4.8	26.4-33.3
F_5	366	50.9-224.2	38.6-42.4	28.1-33.5	80.1-83.8	3.9-4.8	26.8-31.6
F_6	170	75.4-197.3	39.7-41.8	29.0-34.7	81.7-88.2	4.0-4.7	27.0-33.9

3.5 Search for Aneuploids/ Haploids

In the nature, there is spontaneous occurrence of aneuploids and haploids in *G. hirsutum and G. barbadense.* Therefore, the efforts continued to search for the monosomes in order to identify individual chromosomes and haploids for making homozygous lines of cotton. Four suspected rogue plants were observed in the Cyto

material. The cytological studies revealed that these plants were disome. These plants had 26 bivalents thus making a total number of 52 chromosomes at Metaphase-1.

3.6 Performance of New Cyto-strains in Micro Varietal Trials

3.6.1. 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 plot size 15' x 12.5' along with Cyto-179 as standard. The performance of this material is given in Table 3.9.

Table 3.9 Performance of Cyto-strains in Micro Varietal Trial -1 during 2019-20

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	1805	42975	2.8	36.8	30.6	4.2	31.1
MV-2	1925	39537	2.3	38.8	29.6	4.2	31.6
MV-3	1994	41256	3.4	39.9	30.4	4.3	31.8
MV-4	1954	41829	2.5	37.3	30.6	4.5	32.0
MV-5	1960	42975	3.0	38.6	29.6	4.5	31.7
MV-6	2149	42694	2.9	38.9	31.5	4.2	32.9
Cyto-179	1433	42975	3.1	38.7	27.5	4.8	25.7

Table 3.9 showed that maximum seed cotton yield was produced by MV-6 (2149 kg ha^{-1}) followed by MV-3 (1994 kg ha^{-1}) and MV-4 (1954 kg ha^{-1}) compared with standard Cyto-179 (1433 kg ha^{-1}). The line MV-3 (39.9%) found to have highest lint% followed by MV-6 (38.9%) compared with standard Cyto-179 (38.7%).

The line MV-6 produced the medium long staple of 31.5 mm followed by MV-1 & MV-4 (30.6 mm) compared with 27.5 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.2 to 4.8 µg inch^{-1}. The maximum fibre strength (32.9 g tex^{-1})) produced in MV-6 (32.9 g tex^{-1}) followed by MV-4 (32.0 g tex^{-1}) compared with 25.7 g tex^{-1} of standard Cyto-179, respectively.

3.6.2. 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 plot size 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-7 (2712 kg ha^{-1}) followed by MV-9 (2216 kg ha^{-1}) compared with Cyto-179 (1719 kg ha^{-1}). Maximum lint % produced by MV-9 (39.9%) followed by MV-12 (38.9%) compared with standard Cyto-179 (38.7%)

Table 3.10 Performance of advanced strains in Micro Varietal Trial-2 during 2019-20

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	2712	42291	2.8	36.8	28.6	4.2	31.1
MV-8	2082	41309	3.2	38.8	29.6	4.2	31.6
MV-9	2216	41254	2.9	39.9	30.4	4.3	31.8
MV-10	2063	42803	2.3	37.3	30.6	4.5	32.0
MV-11	1967	40670	2.9	38.6	29.6	4.5	31.7
MV-12	2101	42232	2.6	38.9	31.5	4.2	32.9
Cyto-179	1719	41146	3.0	38.7	27.8	4.8	25.7

3.6.3. Micro Varietal Trial-3

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

Six new Bt strains having tolerance against cotton leaf curl virus CLCuD viz., MV-13, MV-14, MV-15, MV-16, MV-17 and MV-18 were tested in replicated micro-varietal trial on plot size 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-18 (2594 kg ha^{-1}) followed by MV-15 (2286 kg ha^{-1}) compared with Cyto-179 (1782 kg ha^{-1}). Maximum lint % produced by MV-18 (41.2%) followed by MV-16 (40.8%) compared with standard Cyto-179 (38.7%). The line MV-17 produced the medium long staple of 29.6 mm followed by

MV-15 (29.1 mm) compared with 27.0 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.2 to 4.5 µg inch^{-1}. The maximum fibre strength (32.0 g tex^{-1}) produced in MV-16 (32.9 g tex^{-1}) followed by MV-18 (32.9 g tex^{-1}) compared with 25.9 g tex^{-1} of standard Cyto-179, respectively.

Table 3.11 Performance of Cyto-strains in Micro Varietal Trial -3 during 2019-20

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	2186	42292	2.9	39.0	28.6	4.2	31.7
MV-14	2078	42402	2.9	39.8	28.6	4.2	31.8
MV-15	2286	42694	2.8	40.4	29.1	4.3	31.5
MV-16	1977	42803	3.5	40.8	28.6	4.5	32.0
MV-17	2192	42975	3.7	39.6	29.6	4.5	31.9
MV-18	2594	42230	2.8	41.2	28.5	4.2	32.9
Cyto-179	1782	42146	3.1	38.7	27.0	4.0	25.9.8

3.6.4. Micro Varietal Trial -4

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

Six new *Bt* strains having tolerance against cotton leaf curl virus (CLCuD) viz., MV-19 to MV-24 with medium-long staple were tested along with Cyto-179 as standard. The performance of this material is given in Table 3.12. It showed that maximum seed cotton yield was produced by MV-23 (2054 kg ha^{-1}) followed by MV-19 (1986 kg ha^{-1}) compared with standard Cyto-179 (1907 kg ha^{-1}). Maximum boll weight (2.9 g) was produced by MV-23 followed by MV-22 (2.8 g) compared with 2.8 g of standard Cyto-179. Maximum lint % produced by MV-23 (40.4%) followed by MV-22 (39.8%) compared with standard Cyto-179 (38.7%).

Table 3.12 Performance of Cyto-strains in Micro Varietal Trial 4 during 2019-20

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-19	1986	40180	2.4	37.7	28.9	4.1	28.6
MV-20	1506	39944	2.4	38.4	28.7	4.6	27.9
MV-21	1707	39466	2.3	38.8	29.0	4.8	29.4
MV-22	1944	41140	2.8	39.8	29.4	4.7	29.6
MV-23	2054	39893	2.9	40.4	29.6	4.3	30.9
MV-24	1200	37183	2.2	37.6	28.6	4.5	28.6
Cyto-179	1907	40184	2.8	38.7	27.5	4.8	25.7

The strains MV-23 and MV-22 produced the longest staple length of 29.6 and 29.4mm, followed by 29.0 mm of MV-21 compared with 27.5 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.1 to 4.8 µg inch^{-1}. The maximum fibre strength (30.9 g tex^{-1}) produced by MV-23 followed by MV-22 (29.6 g tex^{-1}) compared with 25.7 g tex^{-1} of Cyto-179 respectively.

3.7 Performance of New Cyto-strains in Varietal Trials

3.7.1. 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 20' x 12.5' along with Cyto-179 as standard. The performance of this material is given in Table 3.13.

Data presented in Table 3.13 exhibited that maximum seed cotton yield was produced by V-2 (2414 kg ha^{-1}) followed by V-1 (2383 kg ha^{-1}) compared with standard Cyto-179 (1678 kg ha^{-1}). Maximum lint % produced V-1 (40.7%) and V-2 (39.8%) compared with Cyto-179 (38.7%).

The strain V-2 produced the medium long staple of 29.5 mm followed by 29.3 mm of V-4 compared with Cyto-179 (27.1 mm). All the strains have desirable micronaire values ranging from 4.1 to 4.8 µg inch^{-1}. The maximum fibre strength (32.2 g tex^{-1}) produced by V-6 followed by V-4 (32.2 g tex^{-1}) compared with 25.7 g tex^{-1}of standards Cyto-179.

Table 3.13 Performance of Cyto-strains in VT-1during 2019-20

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	2383	41151	3.1	40.7	28.6	4.2	31.1
V-2	2414	40850	3.5	39.8	29.5	4.2	31.6
V-3	1986	41280	2.8	38.9	28.4	4.3	31.8
V-4	2194	41581	2.8	40.3	29.3	4.1	32.0
V-5	2162	41710	2.8	38.6	29.2	4.1	31.7
V-6	1886	41699	3.0	39.3	29.0	4.4	32.2
Cyto-179	1678	41151	3.3	38.7	27.1	4.8	25.7

3.7.2 Varietal Trial-2

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

Six CLCuD tolerant *Bt* strains viz., V-7 to V-12 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 3.14. Data showed that maximum seed cotton yield was produced by V-9 (2079 kg ha^{-1}) followed by V-7 (1935 kg ha^{-1}) and V-10 (1813 kg ha^{-1}) compared with standard Cyto-179 (1705 kg ha^{-1}). Maximum lint % was produced by V-9 (40.1%) followed by V-11 (39.0%) compared with standards Cyto-179 (38.4%).

Table 3.14 Performance of Cyto-strains in VT-2 during 2019-20

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-7	1935	39150	2.4	37.8	28.6	4.3	28.3
V-8	1734	40064	2.6	38.3	28.1	4.6	28.1
V-9	2079	40379	2.8	40.1	29.3	4.0	30.2
V-10	1813	39199	2.2	38.9	28.4	4.7	28.1
V-11	1673	39944	2.5	39.0	28.7	4.4	29.3
V-12	1579	38259	2.2	37.2	28.0	4.7	28.0
Cyto-179	1705	39153	2.8	38.4	26.9	4.5	26.5

V-9 produced longest staple of 29.3 mm followed by V-11 (28.7 mm) compared with Cyto-179 (26.9 mm). All the strains have desirable micronaire values ranging from 4.0 to 4.7 Pg inch^{-1}. The maximum fibre strength (30.2 g/tex) produced by V-9 followed by V-11 29.3 g/tex) in contrast to standards Cyto-179 (26.5 g tex-1)

3.7.3 Varietal Trial-3

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

Four CLCuD tolerant non-*Bt* strains viz., V13, V14, V15 & V16 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-14 (2343 kg ha^{-1}) followed by V-16 (2296 kg ha^{-1}) as compared to standards Cyto-124 (1817 kg ha^{-1}) and CIM-608 (1913 kg ha^{-1}). Maximum lint % was produced by V-15 (39.9%) followed by V-14 (38.8%) compared with standards Cyto-124 (38.6%) and CIM-608 (38.9%).

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-13	2056	39884	2.4	36.8	30.6	4.2	31.1
V-14	2343	39736	2.5	38.8	29.6	4.2	31.6
V-15	2009	39399	2.5	39.9	30.4	4.3	31.8
V-16	2296	40014	2.4	37.3	30.6	4.5	32.0
Cyto-124	1817	40397	2.4	38.6	29.6	4.5	31.7
CIM-608	1913	39162	2.5	38.9	31.5	4.2	32.9

The strain V-16 produced longest staple of 30.6 mm followed by V-15 (30.4 mm) compared with Cyto-124 (29.6 mm) and CIM-608 (31.5mm). All the strains have

desirable micronaire values ranging from 4.2 to 4.5 (Pg inch^{-1}). The maximum fibre strength (32.0 g tex^{-1}) produced by V-16 followed by V-15 (31.8 g tex^{-1}) compared with 32.9 and 31.7 g tex^{-1} of standards Cyto-124 and CIM-608 respectively.

3.8. Mapping population development for Fiber Quality

Objectives: Development of mapping population for Fiber Quality

SL 19 with extra fibre length (34.7mm) and SL 169 with low fibre length (24mm) were sown for the development of mapping population. Agronomic and plant protection measures were applied. Hybridization was conducted, and mature bolls were picked.

Fig-3.8. Crossing for mapping population

DNA isolation and quantification:

DNA extraction was performed from young leaves of wild species using CTAB according to (Zhang & Stewart, 2000). DNA quantification was checked using 1% gel electrophoresis.

3.9 Early Generation Seed (EGS) System

100 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.

Variety	# of families selected
Cyto-177	18
Cyto-178	05
Cyto-179	20
Cyto-124	11
CIM-608	07

==========

4. ENTOMOLOGY

Studies were conducted on various aspects under field and laboratory conditions including 1) sowing date impact on the development of pink bollworm, 2) surveys of cotton growing areas for pink bollworm infestation, 3) monitoring of lepidopterous pests with sex pheromone and light traps, 4) host plant tolerance of CCRI, Multan strains against sucking insect pests 5) National Coordinated Varietal Trials on *Bt.* & non-*Bt.* strains 6) evaluation of foliar insecticides against sucking insect pests & bollworms and 7) monitoring of insecticide resistance in cotton pests. Mass rearing of pink bollworm on semi-synthetic diet and maintaining the stocks of natural enemies of insect pests of cotton for usage in lab and field releases were continued. Internship facilities` were provided to students of various Universities.

The section actively participated in 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 Impact of sowing time on PBW infestation

The trial was conducted to assess the level of pink bollworm infestation at different sowing dates. To evaluate three sowing dates, the Set-1 (Early-March) was planted on 9th March, Set-II (Early-April) on 1st April and Set-III (Early-May) on 1st May. Three Bt varieties (Cyto-179, CIM-632 & CIM-602) and two non-Bt varieties (CIM-717 & CIM-620) were sown in RCBD with three replicates.

Prevalence of PBW infestation and live larvae in Set-I was detected in August and in Set-II & Set-III during September. Generally, infestation and live larval percentage was higher in October and lower in August. Moreover, Set-I was severely infested with PBW during the study period as compared to other sets **(Fig. 4.1).**

Table-4.1 Seasonal average of pink bollworm damage and live larvae in Bt and non-Bt cotton varieties at different sowing dates

Varieties	% Boll damage				% Live Larvae			
	Set-I	Set-II	Set- III	Avr	Set-I	Set-II	Set-III	Avr
Cyto-179	30.4	16.7	6.7	17.9	20.0	5.0	3.3	9.4
CIM-632	18.8	20.0	20.0	19.6	16.7	13.3	10.0	13.3
CIM-602	35.0	26.7	13.3	25.0	33.3	16.7	10.0	20.0
CIM-717 (Non Bt)	30.4	23.3	16.7	23.5	17.8	15.0	8.3	13.7
CIM-620 (Non Bt)	28.8	18.3	15.0	20.7	21.1	13.3	10.0	14.8
Average	28.7	21.0	14.3		21.8	12.7	8.3	

Maximum pink bollworm damage percentage in Set-I & Set-II was recorded in CIM-602 followed by CIM-717 while in Set-III it was higher in CIM-632. However, percentage of live larvae in Set-I, Set-II & Set-III was higher in CIM-602. On the whole, infestation and live larval percentage was higher in CIM-602 and lower in Cyto-179 as compared to other tested varieties **(Table-4.1).**

Overall, pink bollworm infestation and percentage of live larvae were higher in early-March planting (Set-1) and lower in early-May planting (Set-III). So the farmers are advised to avoid planting cotton before 1st April.

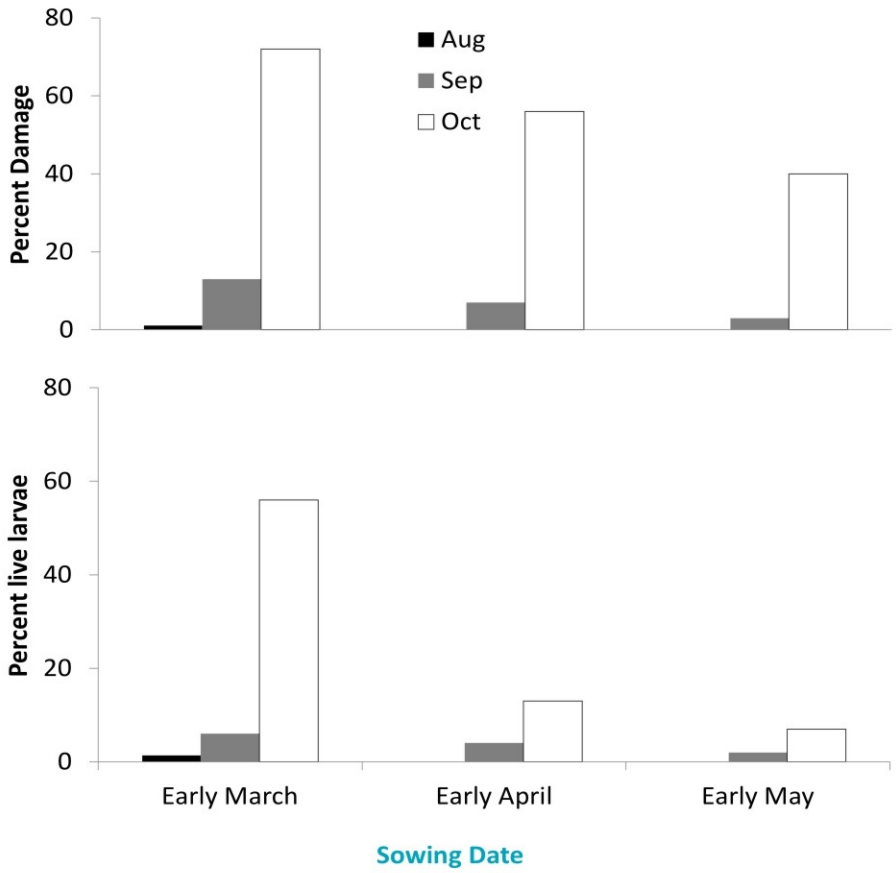


Fig. 4.1 Impact of sowing dates on pink bollworm damage and live larvae

4.1.2 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) for crop monitoring and population dynamics of insect pests of cotton. Pink bollworm infestation was detected in bolls collected from the surveyed area during October and November. The detailed results are given below.

All the cotton growing areas were infested with pink bollworm in October, afterwards pink bollworm infestation increased gradually and reached to maximum level during November. Maximum pink bollworm damage was recorded in Vehari and Muzaffar Garh in October and November, respectively. Live larvae were higher in Khanewal and Rajan Pur in October and November, respectively **(Table-4.2)**. All the surveyed varieties/strains were found to be susceptible against pink bollworm. Maximum pink bollworm infestation and live larvae were detected in BS-20 and minimum in CIM-632 as compared to other tested varieties (**Fig. 4.2**).

Overall, maximum boll infestation was observed in district Vehari followed by Multan as compared to other districts. Comparatively, variety BS-20 seems more vulnerable to pink bollworm infestation.

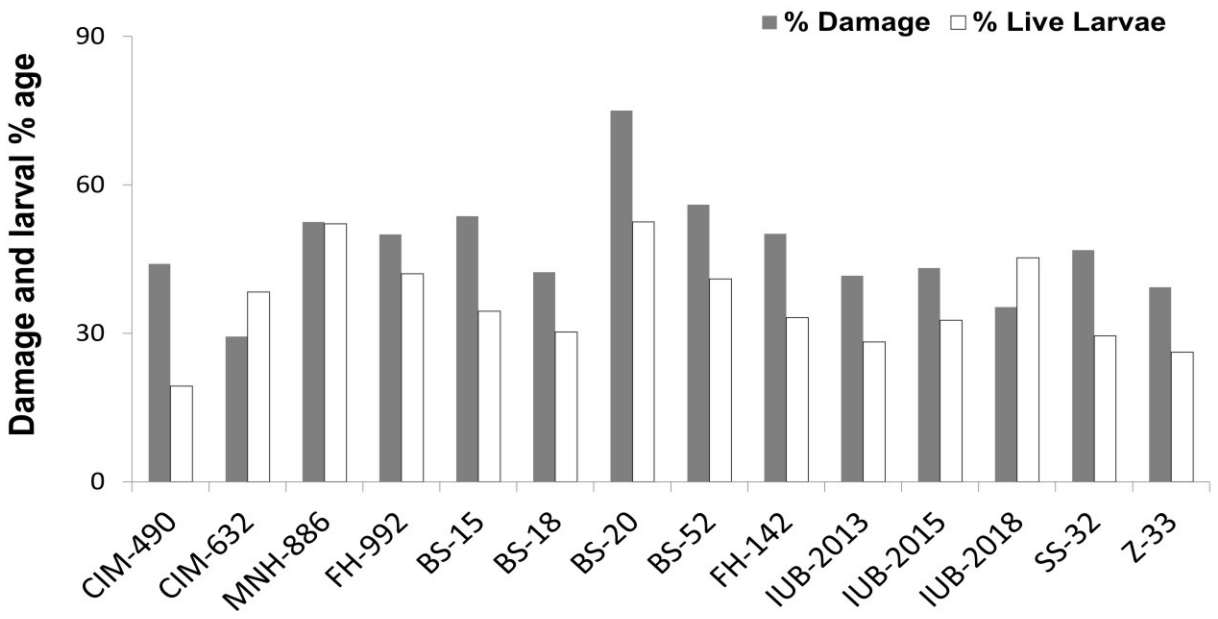


Fig. 4.2 Pink bollworm damage and live larvae recorded from major cotton growing districts

Table-4.2 Pink bollworm damage and live larvae recorded from major cotton growing districts

District	October		November		Average	
	% Boll damage	% Larvae	% Boll damage	% Larvae	% Boll damage	% Larvae
Khanewal	58.7	44.8	63.9	44.6	61.3	44.7
Vehari	65.0	44.3	71.3	47.5	68.2	45.9
Bahawalpur	27.1	15.1	41.3	45.6	34.2	30.4
Lodhran	27.4	17.8	43.6	31.8	35.5	24.8
Multan	56.6	37.3	73.0	44.0	64.8	40.7
Muzaffar Garh	13.8	6.9	79.0	53.3	46.4	30.1
DG Khan	19.6	12.2	56.8	36.8	38.2	24.5
Rajan Pur	37.5	25.5	73.4	56.4	55.5	41.0

4.2 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 Chak 116/10R (Khanewal). Overall, increasing population trend was detected in all lepidopterous pests at both locations as compared to last year. Comparatively, male moth catches of all the species except *E. insulana* were higher at farmer's field than at CCRI, Multan **(Table-4.3).** Weekly male moth catch activities are given in **Fig. 4.3 (a-f).**

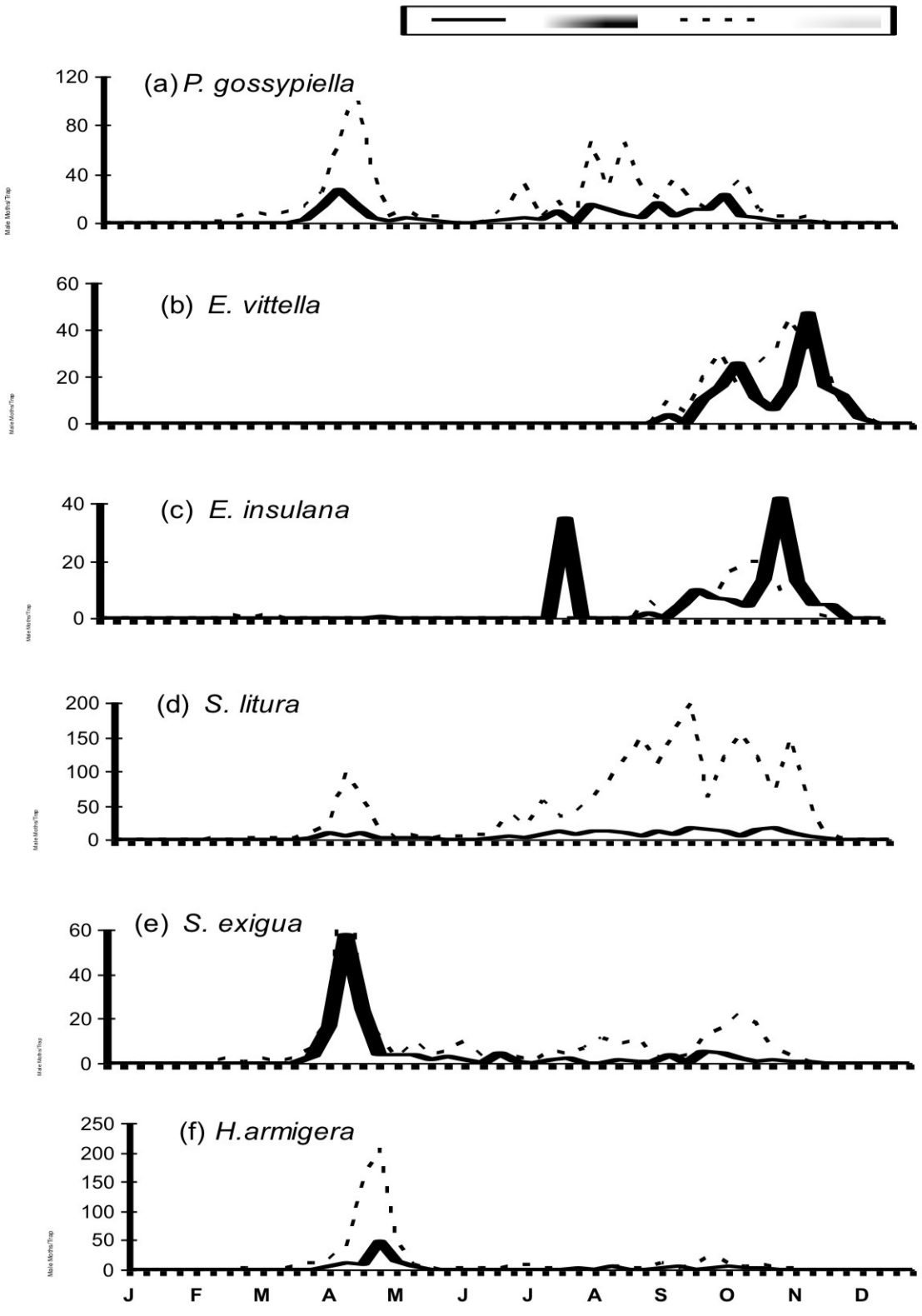


Fig.4.3 Weekly male moth catches of Lepidopterous pests in sex pheromone traps at CCRI, Multan and farmer's field (Khanewal).

4.2.1 *Pectinophora gossypiella* (Pink bollworm)

Male moth catches remained zero upto 1st week of April at CCRI, Multan and 4th week of February at farmer's field. There was a fluctuating trend in moth activity and maximum catches were recorded in 3rd week of April at CCRI, Multan and 4th week of April at farmer's field. Moth catches at farmer's field were 252.2% higher than at Multan **(Fig. 4.3a).** Overall, male moth catches were 79.6% and 42.2% higher at Multan and farmer's field respectively as compared to last year **(Table-4.3).**

4.2.2 *Earias vittella* (Spotted bollworm)

Male moth's activity remained zero upto 2nd week of September at CCRI, Multan and farmer's field. Moth activity reached at its peak in 2nd and 1st week of November at CCRI, Multan and farmer's field, respectively. Moth catches at farmer's field were 48.2% higher than at Multan **(Fig. 4.3b).** Overall, male moth catches were 320.3% and 58.7% higher at Multan and farmer's field, respectively than that of last year **(Table-4.3).**

4.2.3 *Earias insulana* (Spiny bollworm)

Male moth catches were almost zero upto 1st week of August at CCRI, Multan and 2nd week of September at farmer's field. Moth's activity was not consistent and showed fluctuating trend throughout the season. Moth catches were -24.9% lower at farmer's field than at Multan **(Fig. 4.3c).** Overall, male moth catches were 486.0% and 61.8% higher at Multan and farmer's field, respectively as compared with last year **(Table-4.3).**

4.2.4 *Spodoptera litura* (Armyworm)

Male moth activity remained zero upto 1st week of April at CCRI, Multan, afterwards population increased and its first peak was observed in 4th week of September and second peak in 1st week of November. At farmer's field moth's activity started in 1st week of April with fluctuating trend afterwards and maximum catches were recorded in in 4th week of September. Moth catches were comparatively 808.7% higher at farmer's field than Multan **(Fig. 4.3d)**. Overall, male moth catches were about 53.9% and 402.4% higher at Multan and farmer's field, respectively to that of last year **(Table-4.3).**

4.2.5 *Spodoptera exigua* (Beet armyworm)

Male moth activity started from 1st week of April and 4th week of February at CCRI, Multan and farmer's field, respectively with fluctuating trend afterwards. Maximum catches were recorded in 3rd week of April at both locations. Moth catches were 136.1% higher at farmer's field than at Multan **(Fig. 4.3e)**. Overall, male moth catches were 84.8% and 26.5% higher at CCRI, Multan and farmer's field as compared to last year **(Table-4.3).**

4.2.6 *Helicoverpa armigera* (American bollworm)

Male moth's activity started in 1st week of April at CCRI, Multan and in in 3rd week of February at farmer's field. Moth activity remained inconsistent and reached at peak in 4th week of April with fluctuated trend afterwards at both locations. Moth catches at farmer's field were 368.2% higher than at Multan **(Fig. 4.3f)**. Overall, male moth catches were 24.3% and 307.3% higher to that of last year at CCRI, Multan and farmer's field, respectively **(Table-4.3).**

Table-4.3 Comparison of male moth catches of lepidopterous pests in sex pheromone traps

Insect pest	CCRI, Multan			Farmer' field		
	2018	2019	± %age	2018	2019	± %age
P. gossypiella	118.0	212.0	**79.6**	525.0	746.7	**42.2**
E. vittella	39.5	166.0	**320.3**	155.0	246.0	**58.7**
E. insulana	25.0	146.5	**486.0**	68.0	110.0	**61.8**
S. litura	149.5	230.0	**53.9**	416.0	2090.0	**402.4**
S. exigua	81.0	149.5	**84.8**	279.0	353.0	**26.5**
H. armigera	105.0	130.5	**24.3**	150.0	611.0	**307.3**

4.3 Monitoring of lepidopterous pests with light traps

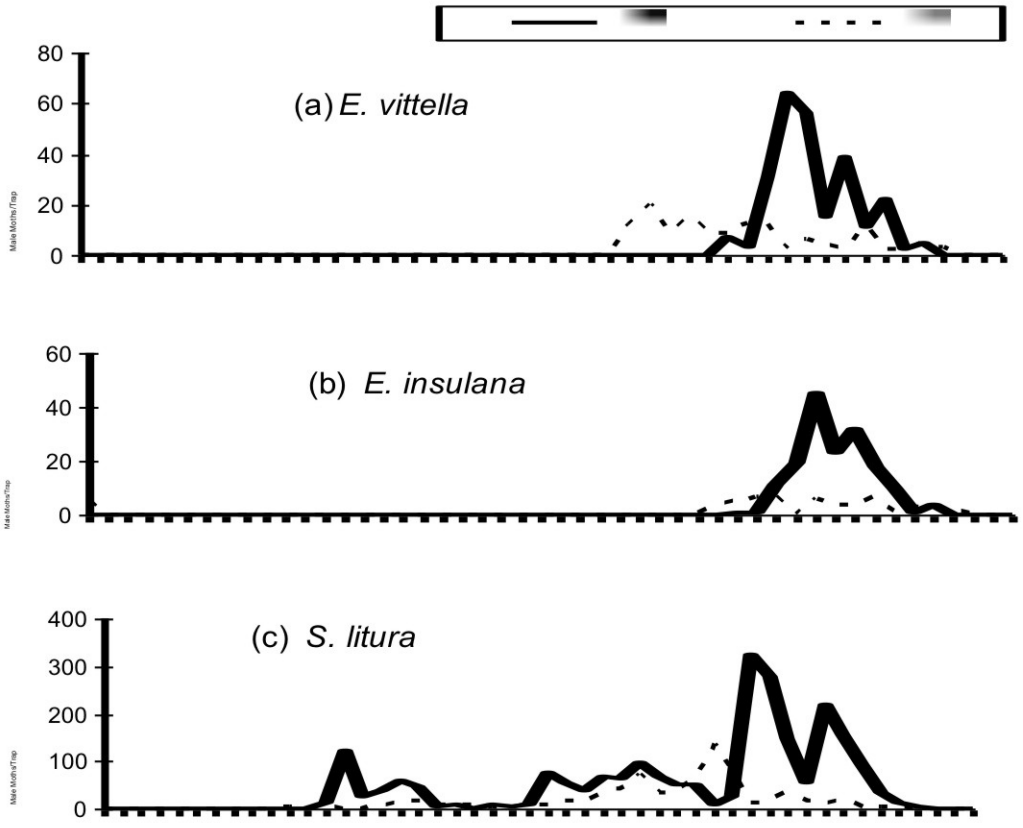
Moth activity of *E. insulana*, *E. vittella*, *S. litura*, *S. exigua* and *H. armigera* was monitored throughout the year with inflorescent light traps at CCRI, Multan. Population tendency of all the pests was almost the same as observed in sex pheromone baited traps at CCRI, Multan. Increasing population trend was perceived in all lepidopterous pests **(Table-4.4).** Moth catches on weekly basis are given in **Fig. 4.4 (a-e).**

4.3.1 *Earias vittella* (Spotted bollworm)

Male moth catches of *E. vittella* were zero upto 2nd week of September. Afterwards population increased and reached at peak in 1st week of October. Moth's activity remained zero in December **(Fig. 4.4a).** Total number of moth catches was 87.5% higher than last year **(Table-4.4).**

4.3.2 *Earias insulana* (Spiny bollworm)

Moth's activity of *E. insulana* remained zero from January to 2nd week of September. Afterwards population increased and reached at peak in 2nd week of October. No moth catches were found in December **(Fig. 4.4b).** Overall number of moth catches was 179.7% higher as compared to last year **(Table-4.4).**



Annual Review of Cotton Experiments

Agronomy Section

Plant Breeding & Genetics Section

Cytogenetics Section

Entomology

Plant Pathology Section

Plant Physiology/Chemistry Section

The performance of research trials conducted by each Section during the cotton season 2019 was being reviewed. Dr. Zahid Mahmood, Director CCRI Multan along with all the scientific and technical staff visited experimental blocks, greenhouse, laboratory work. The respective Sectional Head briefed about the results of studies conducted. The research and development activities focused on climate resilient varieties, CLCuV disease management, efficient fertilizer use, seed health improvement, insect pest management (Pink bollworm, Whitefly, Mealybug etc), insecticide resistance management, high density trials, and technology dissemination programs.

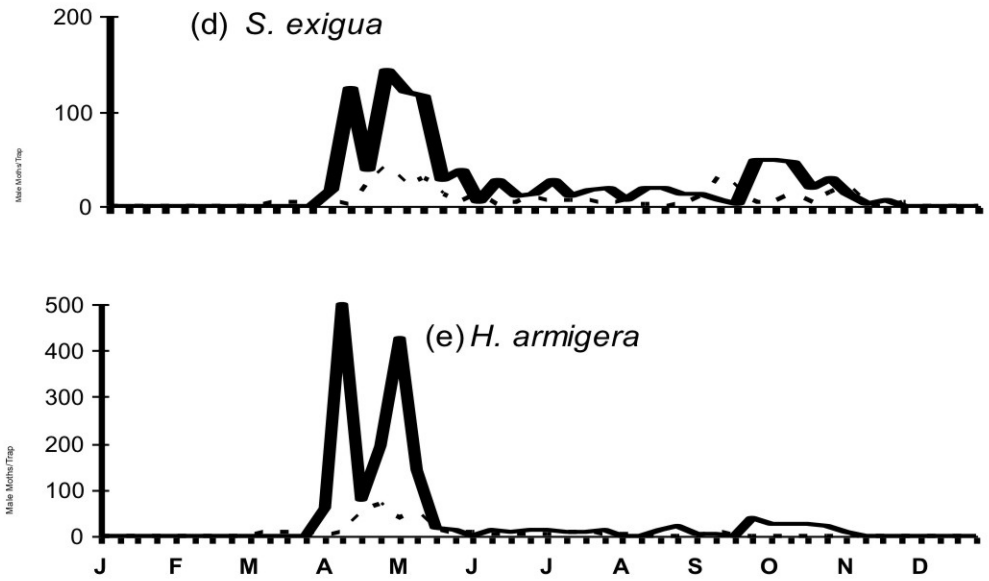


Fig. 4.4 Weekly moth catches of lepidopterous pests in light traps at CCRI, Multan

4.3.3 *Spodoptera litura* (Armyworm)

Moth's activity started in 1st week of April with inconsistent trend and reached to its maximum during 4th week of September. Moth catches remained zero in December **(Fig. 4.4c)**. Overall, moth catches were 200.4% higher as compared to last year **(Table-4.4).**

4.3.4 *Spodoptera exigua* (Beet armyworm)

Moth's activity remained zero upto 1st week of April and reached at its peak in 4th week of April. Population was inconsistent throughout the season that declined afterwards **(Fig. 4.4d)**. Overall, moth catches were 221.2% higher to that of last year **(Table-4.4).**

4.3.5 *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 April **(Fig. 4.4e)**. Total number of moth catches was 392.8% higher than the last year **(Table-4.4).**

Table-4.4 Comparison of moth catches of lepidopterous pests in light traps based on total catches during the year/trap

Insect pest	2018	2019	% change (±)
Earias vittella	136.0	255.0	**87.5**
Earias insulana	59.0	165.0	**179.7**
Spodoptera litura	750.0	2253.0	**200.4**
Spodoptera exigua	325.0	1044.0	**221.2**
Helicoverpa armigera	345.0	1700.0	**392.8**

4.4 National Coordinated Varietal Trials (NCVT)

4.4.1 Pest situation in set-A (PC-1901-PC-1924)

In this set 24 cotton strains were tested for their tolerance/susceptibility to insect pest complex. Jassid population remained below ETL during growing season on all the tested strains while its intensity was highest on PC-1908. Whitefly population was above ETL during July except on PC-1915, 24, 17, 19, 22, 16 and 10, respectively. During the month of August Whitefly population was below ETL during August on all the testing

strains except on PC-1917, 24, 23, 13 and 2, respectively. However, in September whitefly was above ETL level on all the strains except on PC-1906. Overall, its intensity was highest on PC-1901 while lowest on PC-1906. Thrips remained below ETL throughout the season on all the strains while its population was highest on PC-1904 and lowest on PC-1922. **(Table-4.5)**. Bollworms population remained zero on all the tested strains.

Table-4.5 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-1901	0.2	0.1	0	6.0	4.2	23.4	7.6	3.0	0
PC-1902	0.2	0.1	0	8.6	5.0	15.8	6.3	2.2	0
PC-1903	0.2	0.1	0	10.9	4.7	10.5	7.5	3.2	0
PC-1904	0.6	0.1	0	3.0	3.8	10.2	9.6	3.9	0
PC-1905	0.7	0.4	0	6.5	2.9	7.4	5.7	4.2	0
PC-1906	0.1	0.1	0	8.5	1.4	3.6	2.2	0.4	0
PC-1907	0.3	0.1	0	5.1	2.4	9.8	5.2	2.1	0
PC-1908	1.7	0.3	0	4.0	3.1	8.1	8.4	3.3	0
PC-1909	0.2	0.0	0	6.7	4.0	7.4	3.7	2.3	0
PC-1910	0.1	0.1	0	3.7	3.2	7.7	2.8	2.9	0
PC-1911	0.4	0.2	0	6.7	4.1	18.1	2.1	4.9	0
PC-1912	0.2	0.4	0	7.0	4.4	12.1	1.9	3.2	0
PC-1913	0.5	0.0	0	7.8	4.4	16.0	6.5	0.7	0
PC-1914	0.8	1.0	0	7.5	6.3	6.9	3.3	2.7	0
PC-1915	0.5	0.2	0	4.4	3.9	13.8	2.7	5.2	0
PC-1916	0.2	0.2	0	3.5	2.2	9.7	4.0	7.1	0
PC-1917	0.1	0.0	0	4.3	7.1	10.8	4.8	6.8	0
PC-1918	0.0	0.1	0	5.2	3.7	17.5	3.5	11.8	0
PC-1919	0.1	0.5	0	4.1	3.0	10.2	2.9	2.7	0
PC-1920	0.0	0.0	0	6.0	3.8	12.5	3.0	4.2	0
PC-1921	0.1	0.2	0	6.0	2.6	14.5	7.9	4.8	0
PC-1922	0.2	0.2	0	4.1	3.2	11.4	1.4	1.1	0
PC-1923	0.1	0.0	0	6.6	6.3	10.5	2.7	4.9	0
PC-1924	0.1	0.0	0	4.4	6.5	11.0	5.2	2.9	0

4.4.2 Pest situation in Set-B (PC-1925-PC-1950)

In this set 26 cotton strains were tested for their tolerance/susceptibility to insect pest complex. Jassid population was below ETL on all the tested strains during study period however, its maximum number was recorded on PC-1926, 29, 30 and 42, respectively. Whitefly population was above ETL during July except on PC-1934, 35, 42, 46, 48 and 10, respectively. During the month of August Whitefly population was below ETL during August on all the testing strains except on PC-1934 and. However, in September whitefly was above ETL level on all the strains. Overall, its intensity was highest on PC-1940 while lowest on PC-1950. Thrip population remained below ETL throughout the season on all the strains except on PC-1941 and 44 **(Table-4.6)**. Bollworms population remained zero on all the tested strains.

4.4.3 Pest situation in Set-C (PC-1951-PC-1975)

In this set 25 cotton strains were tested for their tolerance/susceptibility to insect pest complex. During the month of July and August jassid population was below ETL on all the tested strains except on PC-1956, 61, 69 and 64, respectively while it remained below ETL in September on all the tested strains. Overall, its intensity was highest on PC-1956 and 61. During the month of July whitefly population was above ETL on all the tested strains except on 1956, 53 and 57 respectively. Population of whitefly remained below ETL during the month of August except on PC-1964, 68, 61 and 69, respectively. While in September it remained above ETL except on PC-1953.Overall its highest population was recorded on PC-1957 and lowest on PC-1953. Thrips population remained below ETL during study period on all the tested strains and its maximum

intensity was found on PC-1973 and 63, respectively and minimum on PC-1951 **(Table-4.7)**. Bollworms population remained zero on all the tested strains.

Table-4.6 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-1925	0.0	0.7	0	9.8	4.0	18.1	5.7	2.7	0
PC-1926	0.4	1.1	0	5.1	4.2	11.9	7.6	3.0	0
PC-1927	0.1	0.5	0	8.7	3.5	9.7	2.7	2.9	0
PC-1928	0.6	0.0	0	7.7	3.8	10.4	4.4	2.5	0
PC-1929	0.6	1.3	0	6.4	4.9	17.6	1.9	2.1	0
PC-1930	0.5	1.2	0	5.8	2.4	12.0	3.4	2.2	0
PC-1931	0.3	0.1	0	9.7	2.9	12.9	6.8	3.2	0
PC-1932	0.6	0.3	0	7.1	3.3	9.7	4.3	1.3	0
PC-1933	0.7	0.1	0	4.8	3.5	10.1	5.3	2.1	0
PC-1934	0.1	0.5	0	4.2	5.1	8.3	5.0	1.9	0
PC-1935	0.3	0.3	0	4.3	4.2	7.7	6.8	0.2	0
PC-1936	0.2	0.2	0	5.6	3.6	10.1	6.7	2.0	0
PC-1937	0.5	0.8	0	7.9	2.8	14.2	2.1	1.6	0
PC-1938	0.5	0.7	0	5.3	4.0	11.1	6.1	2.6	0
PC-1939	0.3	1.0	0	7.7	3.4	8.5	3.6	1.2	0
PC-1940	0.0	0.0	0	8.5	4.3	18.9	6.4	0.4	0
PC-1941	0.6	0.7	0	5.6	4.9	9.7	9.1	2.8	0
PC-1942	1.0	0.3	0	3.5	3.3	8.6	3.1	1.3	0
PC-1943	0.7	0.6	0	5.8	3.4	16.0	4.2	2.7	0
PC-1944	0.3	0.6	0	5.3	4.2	14.7	9.9	2.5	0
PC-1945	0.4	0.0	0	3.9	5.3	11.0	5.5	2.3	0
PC-1946	0.5	0.2	0	3.5	3.3	9.5	4.0	1.9	0
PC-1947	0.3	0.1	0	7.3	4.1	10.5	7.2	2.3	0
PC-1948	0.3	0.3	0	3.3	2.7	9.5	5.8	1.8	0
PC-1949	0.6	0.3	0	3.0	3.3	10.7	7.3	2.2	0
PC-1950	0.1	0.2	0	5.3	2.6	9.6	8.0	2.8	0

Table-4.7 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-1951	0.1	0.3	0	5.2	4.9	14.5	3.1	0.9	0
PC-1952	0.2	0.1	0	5.3	3.8	8.8	3.9	2.5	0
PC-1953	0.2	0.3	0	3.7	3.6	4.2	6.2	1.5	0
PC-1954	0.4	0.1	0	3.9	2.3	12.4	7.1	2.6	0
PC-1955	0.1	0.2	0	7.3	3.8	9.0	7.8	3.4	0
PC-1956	1.9	0.0	0	3.8	2.4	8.7	2.6	3.0	0
PC-1957	0.5	0.1	0	3.7	3.4	16.1	6.3	8.0	0
PC-1958	0.5	0.1	0	8.6	3.8	12.8	4.3	2.4	0
PC-1959	0.5	0.0	0	7.6	3.0	9.9	3.5	2.4	0
PC-1960	0.3	0.1	0	5.4	4.1	12.0	3.5	2.7	0
PC-1961	0.0	1.9	0	11.5	5.4	10.9	5.0	0.0	0
PC-1962	0.1	0.0	0	4.6	4.3	7.6	6.1	1.3	0
PC-1963	0.0	0.0	0	8.7	3.6	10.2	8.1	1.6	0
PC-1964	1.2	0.1	0	9.0	5.8	13.5	3.0	4.1	0
PC-1965	0.6	0.2	0	8.0	3.9	12.3	4.2	2.6	0
PC-1966	0.2	0.2	0	6.3	2.7	10.9	3.9	4.7	0
PC-1967	0.2	0.2	0	6.1	3.6	7.7	3.8	3.1	0
PC-1968	0.3	0.1	0	8.7	5.5	7.3	2.7	1.3	0
PC-1969	1.3	0.5	0	6.5	5.3	10.6	5.0	3.0	0
PC-1970	0.2	0.3	0	9.0	2.5	11.7	2.5	4.6	0
PC-1971	0.1	0.2	0	10.8	3.4	13.0	4.3	4.6	0
PC-1972	0.2	0.2	0	8.7	2.7	13.6	6.8	1.1	0
PC-1973	0.5	0.0	0	7.3	3.8	11.9	8.5	3.1	0
PC-1974	0.2	0.0	0	5.1	4.4	12.3	4.8	2.4	0
PC-1975	0.1	0.0	0	5.8	4.3	13.6	3.9	5.7	0

4.4.4 Pest situation in Set-D (PC-1976-PC-2002)

In this set 27 cotton strains were tested for their tolerance/susceptibility to insect pest complex. During the month of July population of jassid remained below ETL on all the tested strains except on 1985 and 1994, respectively. Jassid population was above ETL mostly on all the tested strains in August while its population was zero in September. Overall, its intensity was highest on PC-2002. . Population of whitefly was above ETL during July and September mostly on all the tested strains while population of whitefly was fluctuating on all the tested strains in August. Overall, its intensity was highest on PC-1964 and 1990, respectively. Thrips population observed below ETL during July and August and September on all the tested strains except on 20 02. Overall, its intensity was higher on PC-2002 **(Table-4.8)**. Bollworms population remained zero on all the tested strains.

Table-4.8 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-1976	0.3	0.5	0	8.5	4.2	15.1	3.9	3.9	0
PC-1977	0.3	0.1	0	6.1	3.2	17.4	2.4	2.1	0
PC-1978	0.7	0.0	0	9.3	4.1	13.4	2.3	2.0	0
PC-1979	0.3	1.0	0	8.5	3.2	14.4	6.4	2.1	0
PC-1980	0.6	0.0	0	7.7	3.4	21.9	5.2	1.9	0
PC-1981	0.7	1.0	0	6.1	2.9	13.4	3.8	0.6	0
PC-1982	0.6	0.9	0	7.8	4.1	16.3	4.3	2.3	0
PC-1983	0.7	0.5	0	11.8	2.8	8.6	3.2	2.5	0
PC-1984	0.5	0.8	0	7.7	3.1	7.1	6.0	2.8	0
PC-1985	1.0	0.8	0	10.8	4.5	8.3	2.7	2.3	0
PC-1986	0.7	0.9	0	7.3	4.3	11.5	5.7	2.5	0
PC-1987	0.5	1.2	0	8.6	5.0	15.6	5.9	3.5	0
PC-1988	0.5	0.7	0	8.2	5.2	9.9	2.9	2.8	0
PC-1989	0.5	1.1	0	9.1	4.0	17.2	4.9	3.4	0
PC-1990	0.4	2.3	0	7.4	4.2	23.1	6.2	1.9	0
PC-1991	0.5	0.7	0	7.3	5.8	18.6	5.1	2.5	0
PC-1992	0.0	1.0	0	7.3	6.7	12.9	7.2	1.0	0
PC-1993	0.0	0.0	0	5.5	6.3	16.1	4.1	2.9	0
PC-1994	0.1	1.3	0	6.6	7.7	23.5	5.6	3.3	0
PC-1995	0.0	1.3	0	7.3	8.3	22.1	5.2	3.4	0
PC-1996	0.4	1.4	0	4.3	8.3	20.2	3.7	4.3	0
PC-1997	0.6	1.4	0	5.3	9.5	14.6	6.3	4.0	0
PC-1998	0.0	0.6	0	4.6	12.5	16.0	2.0	3.5	0
PC-1999	0.1	1.6	0	5.8	12.6	12.4	6.9	6.3	0
PC-2000	0.2	2.1	0	4.9	10.6	13.4	7.2	7.8	0
PC-2001	0.5	2.2	0	5.8	8.7	10.9	6.5	4.6	0
PC-2002	0.4	3.1	0	6.2	9.5	8.7	8.4	3.4	0

4.5 Studies on tolerance level of cotton genotypes to sucking insect pest complex

Different cotton cultivars (CIM-600, CIM-602, CIM-632, FH-142, FH-152, RH-668, NIAB-1048, Crystal-12, Sitara-15) were sown in last week of May 2019 to observe varietal response against insect pest complex of cotton. During the month of July Jassid populations were above ETL but during the month of August and September Jassid populations were below ETL on all tested varieties **(Table-4.9).** Maximum seasonal population of jassid was noted on Sitara-15 **(Fig. 4.5)**.

Whitefly populations in untreated plots were above during July, August and September on all tested varieties **(Table-4.10).** Maximum population was observed on Crystal-12 **(Fig. 4.6)**.

Table-4.9 Seasonal fluctuation of jassid/ leaf in untreated plots

Varieties	Insects Population		
	July	Aug	Sep
CIM-600	2.57	0.87	0.30
CIM-602	1.20	0.82	0.47
CIM-632	1.90	0.29	0.27
FH-142	2.53	0.35	0.30
FH-152	1.70	0.37	0.40
RH-668	2.13	0.51	0.10
NIAB-1048	1.40	0.04	0.17
Crystal-12	2.10	0.22	0.40
Sitara-15	1.90	0.55	1.70

Fig.4.5 Jassid population trend on cotton genotypes

Table-4.10 Seasonal fluctuation of whitefly/leaf in untreated plots

Varieties	Insects Population		
	July	Aug	Sep
CIM-600	8.10	5.47	31.60
CIM-602	10.60	4.85	27.80
CIM-632	8.63	5.79	42.30
FH-142	7.90	5.64	46.70
FH-152	6.03	5.15	45.40
RH-668	5.90	5.12	37.10
NIAB-1048	5.60	6.85	29.50
Crystal-12	8.50	6.72	66.50
Sitara-15	9.40	4.17	41.60

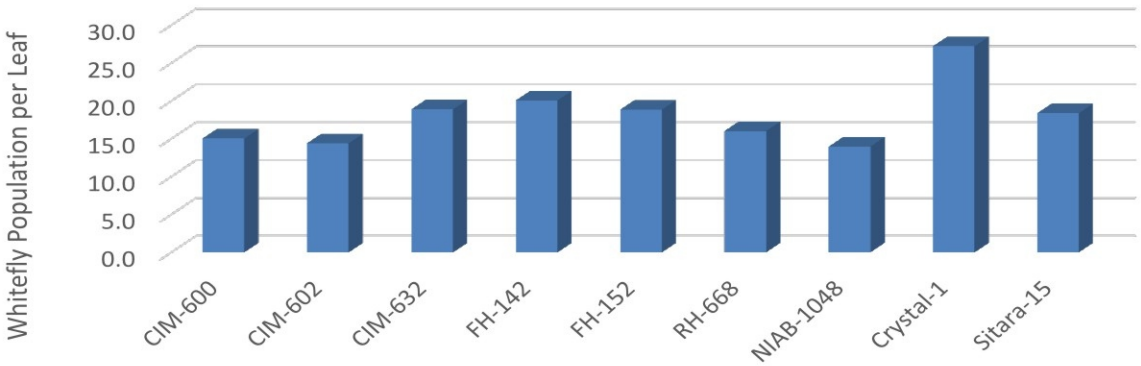


Fig.4.6 whitefly population trend on cotton genotypes

Thrips population was below ETL on all tested varieties during cropping season **(Table-4.11).** Maximum population was observed on RH-668 **(Fig. 4.7)**.

Table-4.11 Seasonal fluctuation of thrips/leaf in untreated plots

Varieties	Insects Population per leaf		
	July	Aug	Sep
CIM-600	0.17	1.67	0.60
CIM-602	0.75	1.65	0.70
CIM-632	0.13	1.65	1.37
FH-142	0.60	1.82	0.63
FH-152	0.80	1.14	0.97
RH-668	0.13	2.14	1.10
NIAB-1048	0.37	1.79	0.50
Crystal-12	0.27	1.29	0.47
Sitara-15	0.50	1.65	0.90

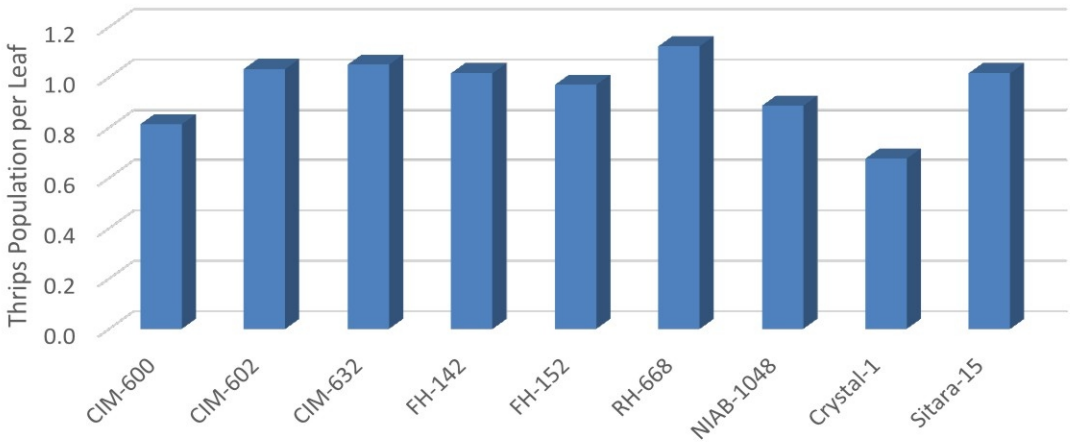


Fig.4.7 Thrips population trend on cotton genotypes

4.6 Evaluation of Foliar Insecticides

4.6.1 Thrips *(Thrips tabaci)*

Seventeen insecticides of different groups were evaluated against thrips at farmer's field. Hand operated knapksack sprayer was used for insecticide application while untreated check was kept for comparison. Fipronil 80 WG, Spintoram 120 SC, Abamectin + Thiamethoxam 108 SC, Spintoram 20 WDG, Acephate 75 SP, Acephate + Fenpyroximate + Pyriproxfen 35 EC, Imidacloprid + Fipronil 80 WG, Fipronil 50 SC Imidacloprid 70 WS Followed by Metrin 0.5 AS proved most effective after 72 hours of spray and gave more than 75% knock down pest mortality. Most of the tested insecticides loose their efficacy upto one week after application even then Abamectin + Thiamethoxam 108 SC, Imidacloprod + Fipronil 80 WG, Imidacloprid + Fipronil 80 WDG, and Cypermethrin + Profenofos 44 EC proved most effective and gave above 80 % pest mortality **(Table-4.12).**

4.6.2 Jassid *(Amrasca devastans)*

Efficacy of fifteen insecticides from different groups was evaluated against jassid at farmer's field keeping untreated check for comparison. Dinotefuran 30 SC, Chlorfenapyr + Nitenpyram 50 WDG, Dinotefuran + Chlorfenapyr 26 WP, Abamectin + Thiamethoxam 108 SC, Acephat 75 SP and Nitenpyram + Abamectin 30 WP gave more than 75% knock down pest mortality. Flonicamid 50 WG followed by Dimathoate 40 SC, gave maximum mortality one week after application as compared to other tested insecticides **(Table-4.13).**

Table-4.12 Efficacy of different insecticides against thrips

Common name	Dose acre^{-1} (ml/g)	% mortality after spray 72 hrs	1 week
Chlorfenpyr 23 SC	200 ml	60.0	75.0
Chlorfenpyr + Nitenpyram 50 WDG	150	44.4	35.6
Acephate + Fenpyroximate + Pyiproxfen 35 EC	750	80.6	73.8
Cyprermethirn + Profenofos 44 EC	500	66.9	80.6
Imidacloprid + Fipronil 80 WDG	60	78.4	84.6
Chlorfenpyr70 WDG	350	66.9	83.7
Chlorfenpyr + Emmanectin 10.5 SC	250	58.4	69.4
Imidacloprid 70 WS	100	76.3	74.2
Acephate 75 SP	350	81.9	72.5
Fipronil 50 SC	480	76.9	57.5
Abamectin + Thiamethoxam 108 SC	500	83.1	88.8
Spiromesifen + Abamectin 24 SC	100	69.4	63.1
Spentoram 120 SC	50	83.8	71.9
Imidacloprid + Fipronil 80 WG	60	85.6	87.5
Spentoram 20 WDG	30	83.1	75.6
Metrin 0.5 AS	500	76.3	67.5
Chlofenpyr 36 SC	120	61.3	66.3
CD at 5%	-	**5.97**	**7.61**

Pretreatment data = 16.0/ leaf

Table-4.13 Efficacy of different insecticides against jassid

Common name	Dose/ac (ml/g)	% mortality after spray 24 hrs.	72 hrs.	1-week
Chlorfenapyr + Dinotefuran Super 43 WDG	150	76.9	85.8	83.3
Chlorfenapyr + Nitenpyram 50 WDG	150	80.8	87.3	85.8
Dimathoate 40 SC	100	79.6	97.3	88.5
Imidaclolprid + Fipronil 80 WDG	75	73.1	88.5	80.8
Chlorfenapyr + Nitenpyram 50 WDG	200	87.3	79.6	84.6
Nitenpyram 24 SP	400	61.5	69.2	79.6
Dinotefuran 30 SC	50	89.4	74.2	73.1
Nitenpyram + Buprofezin 70 WG	150	75.8	57.6	50.0
Dinotefuran + Chlorfenapyr 26 WP	100	84.6	78.1	76.9
Nitenpyram + Abamectin 30 WP	75	79.6	81.9	73.1
Dinotefuran 80 WDG	200	69.2	84.6	80.8
Diafenthroun 50 SC	150	61.5	80.8	76.9
Abamectin + Thiamethoxam 108 SC	75	80.8	69.2	76.9
Acephate 75 SP	150	84.6	76.9	79.6
Flonicamid 50 WG	200	76.9	88.5	92.3
CD at 5%		**9.13**	**5.54**	**5.59**

Pre-treatment population = 2.6/leaf

4.6.3 Whitefly *(Bemisia tabaci)*

Efficacy of twenty of 13 insecticides from different groups and their mixtures were screened against whitefly with an untreated check was kept for comparison. None of the tested insecticides gave more than 70 % mortality. However, Pyriproxyfen 10.8 EC + Diafenthiuron 50 SC and flunicamid 50 WG gave maximum mortality 1-week after application as compared to other tested insecticides **(Table-4.14).**

4.7 Insecticide resistance monitoring

4.7.1 Jassid (*Amrasca devastans*)

Adults of *Amrasca devastans,* jassid collected from cotton fields at Khanewal, Bahwalpur and Multan were exposed to nine insecticides viz. chlorfenapyr, dimathoate, acephate, diafenthiuron, flonicamid, dinotefuran, nitenpyram, clothianidin and flupyradifurone using leaf dip method. Adults of *A. devastans* were temporarily immobilized with carbon dioxide and 50-60 adults were exposed to each insecticide treatment concentration. Five to six concentrations for each insecticide were tested and

each concentration was replicated eight times. Afterwards, observations on mortality were taken 48 h after treatment for conventional insecticides and 72 h after treatment for new chemistry insecticides.

Results indicated very low to very high LC_{50} values to tested insecticides in field populations of all locations. Among the insecticides, low LC50 values (< 1) were detected for chlorfenapyr in Bahawalpur and Multan, for diafenthiuron and dinotefuran in Multan population. LC_{50} values were very high for acephate as compared to other tested insecticides in populations of all the locations demonstrating resistance to this insecticide in all locations for *A. devastans* **(Table-4.15)**.

Table-4.14 Efficacy of different insecticides against whitefly

Common Name	Dose/acre (ml/g)	% mortality after spray		
		24 hrs.	72 hrs.	1-week
Imidacloprid 25 WP	250	48.5	53.2	37.3
Acetamiprid 20 SL	150	34.6	32.4	46.8
Diafenthiaron 80 WDG	150	36.4	44.2	49.4
Diafenthiaron 50 SC	200	45.5	35.1	53.2
Abamectin + Thiamethaxam 108 SC	300	29.9	26.0	23.4
Acetamiprid + Thiocyclam Hydrogen Oxilate 28 WP	200	45.5	30.4	26.5
Flonicamid 50 WG	80	33.7	45.8	62.3
Buprofezin 35 WP	600	31.2	33.8	20.8
Pyriproxifen 10.8 EC	400	39.0	41.6	44.2
Pyriproxifen 10.8 EC + Diafenthiuron 50SC	400+150	48.2	63.9	69.5
Pyriproxifen + Acetamiprid 41.6 EC	250	46.8	55.8	59.7
Spirotatramat 240 SC	125	41.6	50.6	57.1
Metrin 0.5 AS	500	24.7	44.2	52.8
CD at 5%	-	**6.18**	**9.16**	**6.94**

Pre-treatment population = 7.7/leaf

4.7.2 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. 2nd instars of *P. solenopsis* were exposed 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 nitenpyramin) and organophosphate (profenophos) were very low. While, LC_{50} value of pyriproxyfen was higher as compared to other insecticides **(Table-4.16)**.

4.7.3 Dusky cotton bug *(Oxycarenus hyalinipennis)*

Oxycarenus hyalinipennis, dusky cotton bug collected from cotton fields of Multan were exposed to seven insecticides viz. nitenpyram, acetamiprid, cypermethrin, indoxacarb, thiamethoxam, triazophos and profenophos 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.

LC_{50} values for actamiprid followed by profenophos found to be very high as compared to other insecticides indicating resistance to these insecticides in this location **(Table-4.17)**.

4.7.4 Whitefly (*Bemisia tabaci*)

Bemisia tabaci, whitefly collected from cotton fields of Multan, Bahawalpur and Khanewal were exposed to nine insecticides viz. imidacloprid, acetamiprid, flonicamid, pyriproxyfen, spirotetramat + biopower, flupyradifuron, thiamethoxam, cypermethrin and triazophos using leaf dip method. Adults of *B. tabaci* were temporarily immobilized with carbon dioxide and then 20-30 adults were exposed to each treated leaf discs laid on layer of agar gel (5mm thick) in plastic petri dishes. Five to six concentrations for each insecticide were tested and each concentration was replicated eight times. Observations

Workshop on “Cotton & Climate Change”

CCRI Multan in collaboration with Pakistan Meteorological Department organization one-day awareness program about “Cotton Production under Changing Climatic Conditions” on November 18, 2019.

on mortality were taken 48 h after treatment for conventional insecticides and 72 hrs after treatment for new chemistry insecticides.

Results showed moderate to very high LC_{50} values for all the tested insecticides. These LC_{50} values indicate resistance development to the tested insecticides in various locations **(Table-4.18)**. Hence, there is a dire need to develop and imply insecticide resistance management (IRM) strategies.

Table-4.15 Response of *Amrasca devastans* to different insecticides collected from various locations of Southern Punjab

Insecticide	Location	Slope ± SE	95% fiducial limits	LC50 (ppm)
Chlorfenapyr	Khanewal	2.04 ± 0.15	4.10–5.87	4.96
	Bahwalpur	1.83 ± 0.15	0.22–0.34	0.28
	Multan	2.29 ± 0.22	0.55–0.84	0.69
Dimathoate	Khanewal	1.58 ± 0.12	22.88–34.22	28.21
	Bahwalpur	1.62 ± 0.12	11.05–16.63	13.69
	Multan	1.35 ± 0.1	8.95–15.14	11.85
Acephate	Khanewal	1.61 ± 0.13	81.50–122.27	100.83
	Bahwalpur	1.60 ± 0.15	164.92–254.97	206.79
	Multan	1.71 ± 0.14	71.12–110.85	90.1
Difenthiuron	Khanewal	1.53 ± 0.10	4.27–6.44	5.29
	Bahwalpur	1.65 ± 0.14	6.54–9.95	8.16
	Multan	1.23 ± 0.12	0.56–1.06	0.79
Flonicamid	Khanewal	1.23 ± 0.09	10.95–17.55	14.01
	Bahwalpur	1.41 ± 0.23	11.26–53.51	28.6
	Multan	1.40 ± 0.12	13.88–24.02	18.64
Dinotefuran	Khanewal	0.97 ± 0.12	7.65–19.38	13.21
	Bahwalpur	1.50 ± 0.11	4.30–6.67	5.42
	Multan	1.47 ± 0.11	0.64–1.04	0.83
Nitenpyram	Khanewal	1.29 ± 0.09	8.42–13.79	10.92
	Bahwalpur	1.54 ± 0.13	1.84–2.95	2.36
	Multan	1.26 ± 0.11	1.10–1.83	1.42
Clothianidin	Khanewal	1.45 ± 0.14	64.77–104.29	82.86
	Bahwalpur	1.16 ± 0.12	8.63–15.37	11.62
	Multan	1.15 ± 0.11	3.07–5.81	4.33
Flupyradifurone	Khanewal	0.53 ± 0.07	0.43–9.44	2.39
	Bahwalpur	1.59 ± 0.13	4.54–7.20	5.80
	Multan	1.23 ± 0.09	1.61–2.74	2.14

4.2.5 American bollworm *(Helicoverpa armigera)*

Helicoverap armigera, American bollworm collected from cotton fields of Multan were exposed to five insecticides viz. profenophos, cypermethrin, indoxacarb, spinosad, and emmamectin benzoate using leaf dip method. 2nd instar larvae of *H. armigera* were exposed to different concentration of tested insecticides. 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 cypermethrin followed by indoxacarb as compared to other insecticides **(Table-4.19)**.

Table-4.16 Response of *Phenacoccus solenopsis* to different insecticides collected from Southern Punjab

Insecticide	Slope ± SE	95% fiducial limits	LC50 (ppm)
Imidacloprid	1.48 ± 0.27	0.23 – 0.81	0.49
Acetamiprid	2.13 ± 0.43	0.56 – 1.57	1.04
Nitenpyram	1.18 ± 0.24	0.32 – 1.41	0.77
Pyriproxyfen	1.20 ± 0.30	11.72 – 57.12	29.31
Chlorfenapyr	2.20 ± 0.43	0.82 – 2.00	1.38
Profenofos	1.88 ± 0.32	0.27 – 0.69	0.46
Methoxyfenozide	1.36 ± 0.29	5.07 – 17.13	10.06

Table-4.17 Response of *Oxycarenus hyalinipennis* to different insecticides collected from Southern Punjab

Insecticide	Slope ± SE	95% fiducial limits	LC50 (ppm)
Nitenpyram	1.04 ± 0.24	5.86 –22.87	11.80
Acetamiprid	1.50 ± 0.28	252.22 – 658.30	420.06
Cypermethrin	1.38 ± 0.21	24.65 – 66.21	42.12
Indoxacarb	2.20 ± 0.38	19.96 – 43.19	30.74
Thiamethoxam	1.37 ± 0.23	8.71 – 23.50	14.89
Triazophos	1.94 ± 0.36	17.70 – 40.89	28.07
Profenofos	2.38 ± 0.43	91.63 – 193.61	139.43

Table-4.18 Response of *Bemisia tabaci* to different insecticides collected from various locations of Southern Punjab

Insecticide	Location	Slope ± SE	95% fiducial limits	LC_{50} (ppm)
Imidacloprid	Multan	1.56 ± 0.15	301.12 - 495.96	393.22
	Bahawalpur	1.20 ± 0.11	73.25 – 133.82	101.05
	Khanawal	1.17 ± 0.11	172.37 – 304.5	232.78
Acetamiprid	Multan	1.58 ± 0.14	202.25– 330.97	236.26
	Bahawalpur	1.23 ± 0.13	25.48 – 45.77	34.83
	Khanawal	1.59 ± 0.12	61.88 – 98.91	79.47
Flonicamid	Multan	1.20 ± 0.19	50.22 – 261.11	134.94
	Bahawalpur	1.26 ± 0.11	145.43 –274.57	210.00
	Khanawal	1.36 ± 0.13	252.41 – 420.37	330.75
Pyrifroxyfen	Multan	1.46 ± 0.20	313.65 – 557.40	419.86
	Bahawalpur	1.22 ± 0.12	75.80 – 140.82	105.70
	Khanawal	1.73 ± 0.31	29.51 – 192.28	97.83
Spirotetramat	Multan	1.28 ± 0.09	21.08 – 35.21	27.63
	Bahawalpur	1.61 ± 0.17	310.51 – 522.06	411.68
	Khanawal	1.26 ± 0.15	235.45 – 419.60	315.15
Flupyradifurone	Multan	1.74 ± 0.18	162.48 – 257.21	207.49
	Bahawalpur	1.38 ± 0.16	175.17 – 316.62	239.78
	Khanawal	1.23 ± 0.11	46.68 – 81.70	62.95
Thiamethoxam	Multan	1.41 ± 0.13	50.28 – 88.25	68.16
	Bahawalpur	1.41 ± 0.13	72.08 – 125.04	97.01
	Khanawal	1.47 ± 0.11	19.20 – 31.13	24.82
Cypermethrin	Multan	1.43 ± 0.16	344.82 – 602.42	464.56
	Bahawalpur	1.41 ± 0.15	739.68 – 1325.27	1015.12
	Khanawal	1.23 ± 0.13	314.68 – 555.72	242.03
Triazophos	Multan	1.10 ± 0.11	218.31 – 424.03	306.16
	Bahawalpur	1.35 ± 0.15	345.80 – 634.79	479.42
	Khanawal	1.71 ± 0.27	100.98 – 464.94	258.15

Table-4.19 Response of *Helicoverpa armigera* to different insecticides collected from Southern Punjab

Insecticide	Slope ± SE	95% fiducial limits	LC50 (ppm)
Profenofos	2.56 ± 0.31	6.07 – 9.55	7.73
Cypermethrin	1.53 ± 0.19	89.22 – 165.48	123.76
Indoxacarb	1.45 ± 0.18	56.80 – 111.81	80.87
Spinosad	1.76 ± 0.22	55.82 – 98.76	75.53
Emamectin	1.67 ± 0.19	6.10 – 10.89	8.32

5. PLANT PATHOLOGY SECTION

Research studies were carried out on the prevalence, 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 Trial (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 results obtained there in are reported as under.

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. Two hundred thirteen families were screened during the year. Data present in **Table-5.1** revealed that all families of breeding material, showed symptoms of the CLCuD under filed conditions except one family which exhibitedresistance against CLCuD in NCVT-A and two families showed high tolerance against CLCuD, in MVT-2 and NCVT-D.

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	47.67 ~ 76.67	
VT-2	8	0	21.19 ~ 79.90	
VT-3	10	0	20.43 ~ 76.25	
VT-4	6	0	19.89 ~ 82.15	
MVT-1	11	0	12.19 ~ 77.36	
MVT-2	10	0	2.86 ~ 78.36	
MVT-3	8	0	24.00 ~ 73.44	
MVT-4	8	0	54.56 ~ 85.18	
MVT-5	8	0	19.13 ~ 64.11	
MVT-6	10	0	76.49 ~ 83.99	
NCVT-A	24	1	0.00 ~ 28.35	NH-211
NCVT-B	26	0	47.70 ~ 80.09	
NCVT-C	30	0	60.60 ~ 81.88	
NCVT-D	27	0	6.13 ~ 81.34	
SVT-I	7	0	52.74 ~ 95.55	
SVT-II	12	0	80.59 ~ 84.63	
Total	**213**	**0**		

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

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)
24 strains	26 strains	27 strains	27 strains

All entries were to be 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 except NH-211. Minimum disease severity was recorded in 1906 and minimum disease index was recorded in Sayban-209. Most strains are free from boll rot incidence and stunting was observed in some strains in traces (Table 5.3).

NCVT-Set-B

In set-B, all the NCVT strains were found highly susceptible to cotton leaf curl disease. Minimum disease incidence and index was recorded in 1942 and disease severity was recorded in 1941. Maximum Incidence of boll rot was recorded in 1940.Stunting was observed only in IR-NIBGE-14 (0.33) (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 and disease index was recorded in RH-Afnan-2 Maximum, boll rot incidence (1.8 %) was observed in RH-Kashish. Stunting was recorded in traces in some strains (Table-5.4).

NCVT-Set-D

In set-D, all NCVT strains found highly susceptible to cotton leaf curl disease except Bt-Cyto-511, which was highly tolerant. Minimum disease incidence and disease index was recorded in Bt-Cyto-511. Maximum CLCuD severity and disease index was observed in 2001. 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

Five *Bt* strains.CIM-789, CIM-678, CIM-303, CIM-785, Cyto-511 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 1st June at 15 days' interval. Experimental design was split plot (main plots: Sowing time; sub-plot: genotype). Data on CLCuD incidence were recorded fortnightly at 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 0.2% on crop planted from 15th March to 1st April with in 60 DAP The disease incidence was marginally increased uptil end of May (0.6 %) and reached to its maximum level (62.8 %) on 15th September in 15th March planting.

In 1st April planting, disease incidence was 2.9% in early July and reached to 87 % at the mid of September. Whereas in 15th April planting disease incidence was 29.7% at the end of July, 85 % during mid of August and reached to 91.6 % at mid-September,

In 1st May, planting incidence was 12 % upto 60 DAP (end of June) then increased sharply i.e. 49.1 to 100% at 1stAugust whereas in 15th May planting disease symptoms appeared 0.6% within 45 days and disease incidence was recorded 100% at 1stAugust after 75 DAP. In 1st June planting CLCuD started to appear at the end-July and rapidly increased and attained its maximum level (100 %) during mid-August after 75 DAP.

The crops, which were planted earlier, showed less disease incidence uptil July. All the cultivars showed minimum level of incidence when planted during 15th March. 1st April and 15th April as compare to 1st May, 15th May and 1st June sowing. Where all the varieties showed maximum level CLCuD incidence (100%) (Fig-5.2).

Averaged across planting dates, there is no varietal difference in all sowing dates. All genotypes showed same behavior i.e. performed better in early planting as compared to late planting (Fig-5.3).

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 36.6% was recorded on crop planted on 15th March as compare to other planting dates. Average planting dates, no significant differences were recorded in all genotypes Table-5.6.

On an average basis of sowing dates, maximum fortnightly increase in disease was recorded at end-July. Among environmental parameters the maximum temperature range was 33.6~36.1°C while the minimum temperature 23.4~28.7.0°C with the relative humidity 84.6~ 89.1 % during end July. It is indicated that late sown crop was more affected than earlier sown crops (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	
1901	**0.67**	100.00	2.91	72.77	0.00
1902	0.00	100.00	2.89	72.22	0.00
1903	0.00	100.00	2.90	72.38	0.31
1904	0.00	100.00	3.00	75.00	0.00
1905	0.00	100.00	2.96	74.05	0.00
1906	0.00	100.00	2.11	52.86	0.00
1907	0.00	100.00	3.01	75.21	0.00
1908	0.33	100.00	3.05	76.22	0.00
1909	0.33	100.00	2.98	74.40	0.00
Tassco-115	0.00	100.00	2.90	72.52	0.00
Tassco-112	0.33	100.00	3.00	75.01	0.50
Tahafuz-15	0.00	100.00	2.99	74.81	0.00
Diamond-2	0.33	100.00	3.03	75.69	0.33
Suncrop-3	0.00	100.00	3.03	75.83	0.00
CIM-602 (Bt-Std)	0.00	100.00	2.98	74.62	0.00
Tahafuz-12(C-II)	0.33	100.00	2.94	74.61	0.00
Suncrop(C-II)	0.00	100.00	2.98	74.39	0.00
Sayban-209	0.33	67.00	2.98	49.22	0.00
Saim-102	0.00	100.00	3.19	79.71	0.00
Rohi-2	0.00	100.00	2.96	73.94	0.00
Rohi-1	0.00	100.00	3.01	75.18	0.00
TJ-King(C-II)	0.00	100.00	3.02	75.61	00.00
1923	0.00	100.00	2.98	74.58	0.23
NS-211	0.00	0.00	0.00	0.00	0.29

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	
Eye-22	0.00	100.00	3.12	77.91	0.27
Eye-111	0.00	100.00	3.11	77.76	0.91
Eye-20	0.00	100.00	3.13	78.36	0.00
Rustam-Beej-111(CKC)	0.00	100.00	3.02	75.53	0.00
Rustam-Beej-11(C-II)	0.00	100.00	3.04	75.88	0.00
Rustam-11	0.00	100.00	3.20	80.09	0.00
ICI-2424	0.00	100.00	3.12	78.11	0.00
YBG-2323(CKC)	0.00	100.00	3.08	77.10	0.00
YBG-2222(C-II)	0.00	100.00	3.05	76.19	0.32
1934	0.00	100.00	3.13	78.18	0.00
1936	0.00	100.00	3.00	75.01	0.00
1937	0.00	100.00	3.14	78.61	0.00
1938	0.00	100.00	3.06	76.42	0.30
1939	0.00	100.00	3.05	76.22	0.34
1940	0.00	100.00	3.14	78.52	0.56
BF-1	0.00	100.00	3.17	79.26	1.09
1942	0.00	99.19	2.76	68.67	0.00
1943	0.00	65.29	2.99	47.70	0.00
Bahar-136	0.00	100.00	3.14	78.44	0.33
ASPL-710	0.00	100.00	3.11	77.83	0.00
ASPL-709	0.00	100.00	3.05	76.22	0.00
IR-NIBGE-15	0.00	100.00	3.03	75.77	0.00
IR-NIBGE-14	0.33	100.00	3.02	75.61	0.00
IR-NIBGE-13	0.00	100.00	2.97	74.35	0.00
NIAB-SANAB-M	0.00	100.00	3.06	76.44	0.00
NIAB-512	0.00	100.00	3.02	75.42	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	
NIAB-973	0.67	99.21	3.11	77.14	0.00
NIAB-819	0.33	100.00	3.21	80.20	0.00
NIAB-135	0.00	100.00	3.28	81.88	0.00
NIAB-1011	0.00	100.00	3.09	77.27	0.00
NIA-89	0.00	100.00	3.16	78.92	0.00
IUB-73	0.00	100.00	3.15	78.70	0.00
VH-383	0.33	100.00	3.23	80.72	0.82
VH-189	0.33	100.00	3.22	80.50	0.33
VH-402	0.33	100.00	3.14	78.52	0.00
SLH-33	0.33	100.00	3.11	77.67	0.00
RH-Kashish	0.33	98.37	3.21	78.90	1.80
RH-Afnan-2	0.00	76.19	3.29	60.60	0.30
RH-670	0.33	100.00	3.17	79.16	0.76
GH-Hamaliya	0.00	100.00	3.13	78.23	0.00
GH-Sultan	0.33	95.56	3.20	76.53	0.00
GH-Uhad	0.33	99.17	3.10	76.96	0.00
FH-Anmol	0.00	100.00	3.23	80.76	0.33
FH-492	0.00	100.00	3.07	76.65	0.30
FH-155	0.33	100.00	3.23	80.79	0.00
FH-Super-Cotton-2017	0.00	100.00	3.13	78.33	0.00
FH-AM-Cotton-2017	0.00	100.00	3.18	79.42	0.00
BH-224	0.00	100.00	3.16	78.92	0.00
BH-223	0.00	100.00	3.17	79.25	0.00
MNH-1050	0.00	100.00	3.12	77.90	0.00
MNH-1035	0.00	100.00	3.13	78.36	0.00

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

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

NCVT Set D Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
CEMB-Klean-Cotton-6	0.00	100.00	3.14	78.58	0.00
CEMB-Klean-Cotton-5	0.00	100.00	3.11	77.86	0.00
CEMB-Klean-Cotton-4	0.00	100.00	3.10	77.49	0.73
CEMB-Klean-Cotton-3	0.33	99.19	3.10	76.89	0.00
CRIS-638	0.00	100.00	3.10	77.39	0.00
CRIS-673	0.00	100.00	3.09	77.14	0.00
CRIS-671	0.00	100.00	3.20	79.91	0.00
Bt-Cyto-535	0.00	100.00	3.14	78.40	0.58
Bt-Cyto-533	0.00	100.00	3.13	78.20	0.00
Bt-CIM-785	0.00	100.00	3.20	79.88	0.00
Bt-CIM-775	0.00	100.00	3.19	79.63	0.00
Bt-Cyto-511	**0.33**	**10.60**	**2.30**	**6.13**	**0.00**
Bt-CIM-789	0.00	99.10	3.19	78.98	0.00
Bt-CIM-678	0.00	100.00	3.06	76.50	0.00
Bt-CIM-303	0.00	100.00	3.12	78.05	0.00
Cyto-124 (Non-Bt Std)	0.00	100.00	3.11	77.79	0.00
NIAB-929	0.00	100.00	3.02	75.50	0.00
NIA-88	0.00	100.00	3.11	77.79	0.00
1997	0.00	100.00	3.06	76.41	0.00
CRIS-644	0.33	100.00	3.04	76.07	0.00
Cyto-226	0.00	100.00	3.06	76.41	0.00
2000	0.00	100.00	3.15	78.73	0.00
2001	0.00	100.00	3.14	78.62	0.35
MZM-7	0.00	57.57	3.05	40.71	0.00
2000	0.00	100.00	3.09	77.30	0.00
2001	0.00	100.00	3.25	81.34	0.24
2002	0.00	100.00	3.19	79.79	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	15th March	1st April	15th April	1st May	15th May	1st June	Ave
CIM-303	31.7	60.7	76.2	78.8	79.8	77.91	**67.5**
CIM-678	37.9	77.3	77.6	75.8	81.3	79.7	**71.6**
CIM-789	24.0	50.2	74.0	78.0	78.1	76.9	**63.5**
Cyto-511	37.1	48.1	75.0	78.9	80.9	78.3	**66.4**
Cyto-179	65.0	72.1	78.38	78.7	80.6	79.0	**75.6**
CIM 785	23.86	33.35	76.22	77.9	82.03	80.53	**62.3**
Ave	**36.6**	**57.0**	**76.2**	**78.0**	**80.5**	**78.7**	

D.I = Disease Index, Disease incidence **x** Severity/ maximum severity value (4)
CD 5% Sowing Dates = 12.6 Varieties = 4.38

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	0.2	0.2	0.1	3.2	4.5	9.1	19.7	5.0	20.8
1st April		0.0	0.0	0.0	0.6	2.3	1.9	8.8	17.8	7.2
15th April			0.0	0.0	0.2	12.5	17.0	14.0	41.3	2.4
1st May			0.0	0.1	11.9	37.1	50.9	0.0	0.0	0.0
15th May				0.0	1.6	16.5	81.9	0.0	0.0	0.0
1st June					0.0	0.0	2.3	0.0	0.0	0.0
Average	**0.00**	**0.10**	**0.05**	**0.04**	**2.92**	**12.15**	**27.18**	**7.08**	**10.68**	**5.07**
Temp Max C	37.2	37.4	39.7	40.6	37.2	35.0	36.7	33.6	36.1	33.6
Temp Min C	22.5	27.2	27.0	30.6	30.0	29.1	28.7	26.0	23.4	26.0
RH %age	69.7	59.8	68.5	73.0	82.5	80.9	84.6	86.8	89.1	86.8

(B) Non Bt.

.

Seeds of two elite cotton genotypes i-e Cyto-226 and Cyto-164 along with one standard variety CIM-610 were sown on five different sowing dates to observe the response to CLCuD with collaboration of Agronomy section of the Institute. The planting was done from 15th April to 15th June at 15 days interval. Experiment design was split plot (main plots: sowing time: sub plots 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

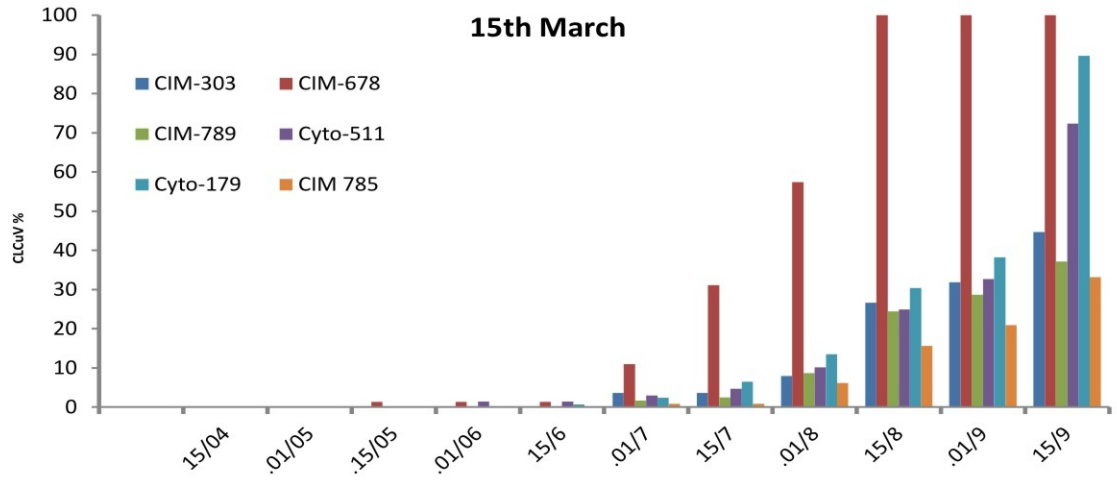
Effect of appearance of cotton leaf curl disease and its progression differed considerably with sowing dates. Minimum CLCuD infestation was observed in 15thApril Planting in mid-July data i.e. 5.2%. With the advancement of age the infestation level reached 50.7 % during the mid of September.

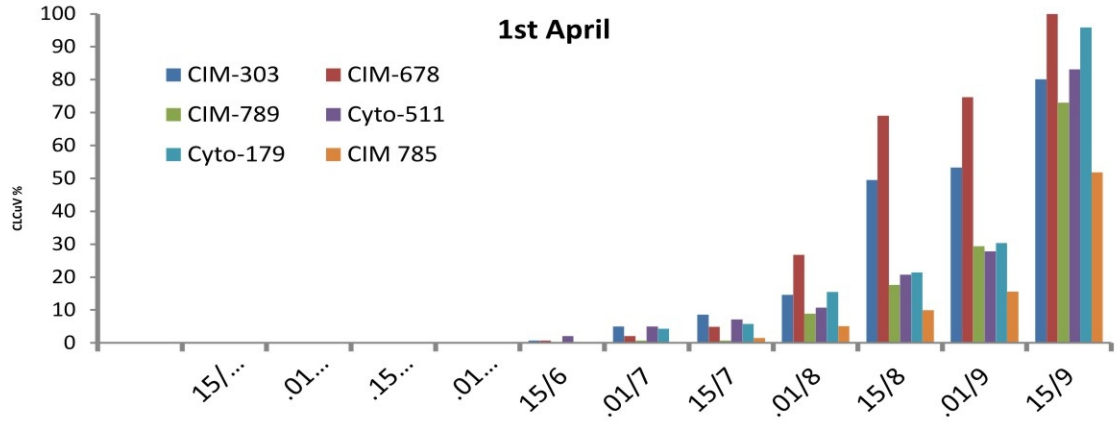
A gradual increase in CLCuD incidence was observed in 1st May planting date. The disease started in early-July with minimum level of incidence of 5.1% which increased moderately and reached to 68.1 % at the mid of September.

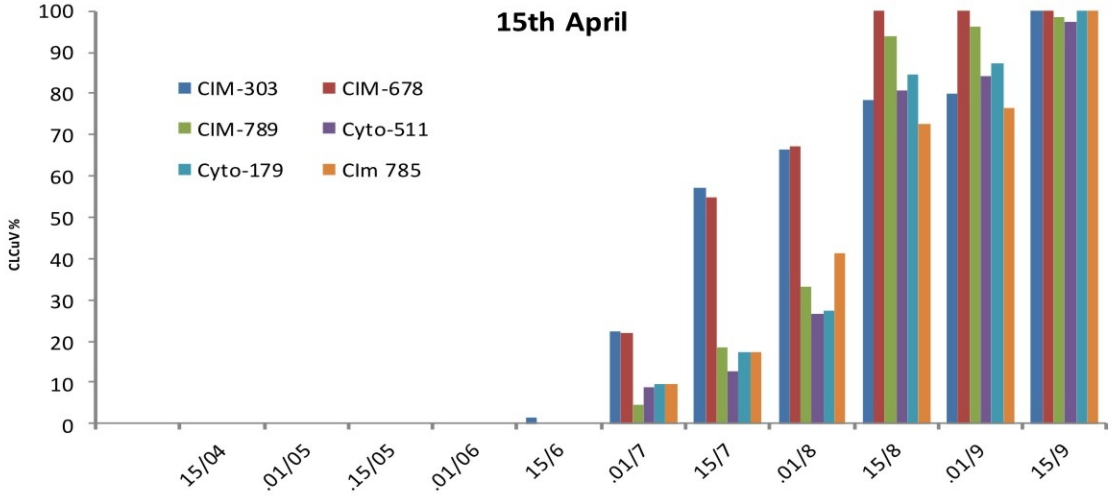
Similarly, in case of 15th May planting CLCuD incidence was only 0.1% in the mid of June and got its maximum level 96.2 % in the mid of September (135DAP).

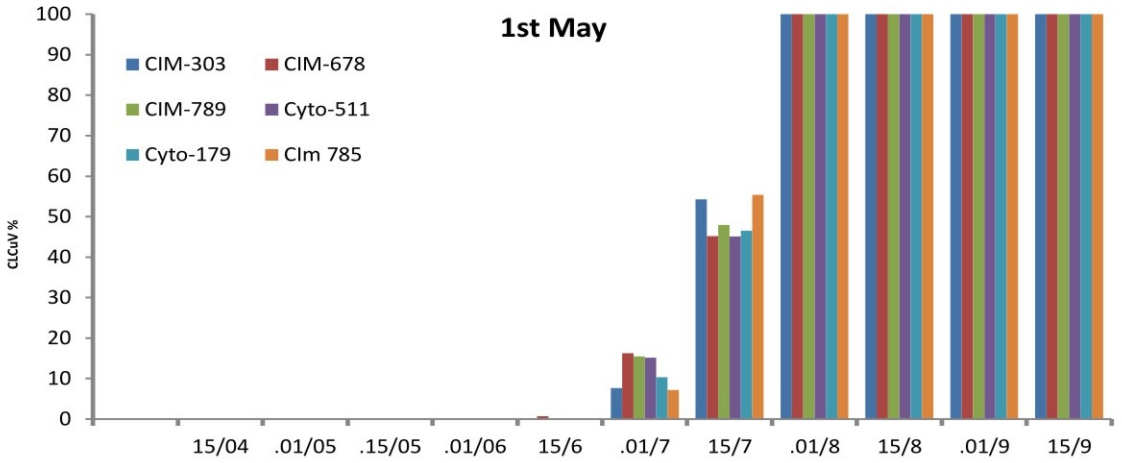
In 1stJune and 15thJune planting the disease started from mid-July (6.2% and 0.9 %) and reached up to 97.7 and 99.2 % respectively at the mid of September.

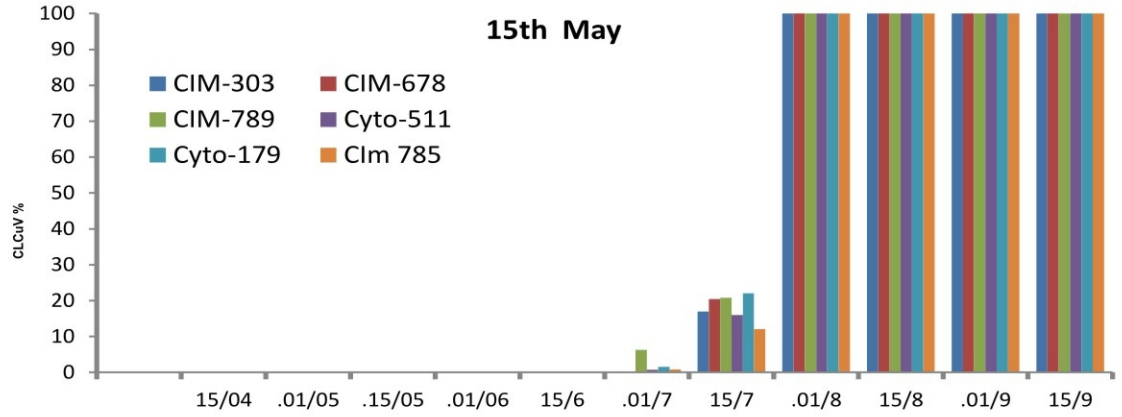
The level of disease incidence in Cyto-164 showed less in 15th April and 1st May planting as compare to CIM-610 and Cyto-226 Average across planting period. comparison among the varieties revealed There is a no varietal difference All varieties showed Maximum CLCuD infestation in earl planting and late planting during the mid of September (Fig-5.3).


15th March
CIM-303
CIM-678
CIM-789
Cyto-511
Cyto-179
CIM 785
CLCuV %
100
90
80
70
60
50
40
30
20
10
0
15/04
.01/05
.15/05
.01/06
15/6
.01/7
15/7
.01/8
15/8
.01/9
15/9


1st April
CIM-303
CIM-678
CIM-789
Cyto-511
Cyto-179
CIM 785
CLCuV %
100
90
80
70
60
50
40
30
20
10
0
15/...
.01...
.15...
.01...
15/6
.01/7
15/7
.01/8
15/8
.01/9
15/9


15th April
CIM-303
CIM-678
CIM-789
Cyto-511
Cyto-179
CIm 785
CLCuV %
100
90
80
70
60
50
40
30
20
10
0
15/04
.01/05
.15/05
.01/06
15/6
.01/7
15/7
.01/8
15/8
.01/9
15/9





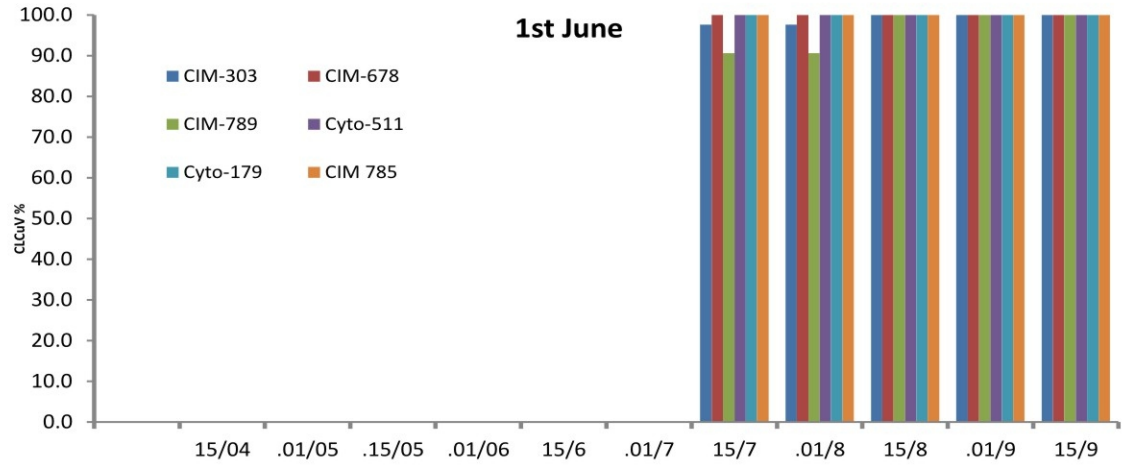


Fig-5.1 CLCuD incidence as influenced by planting dates and in different Bt-strain

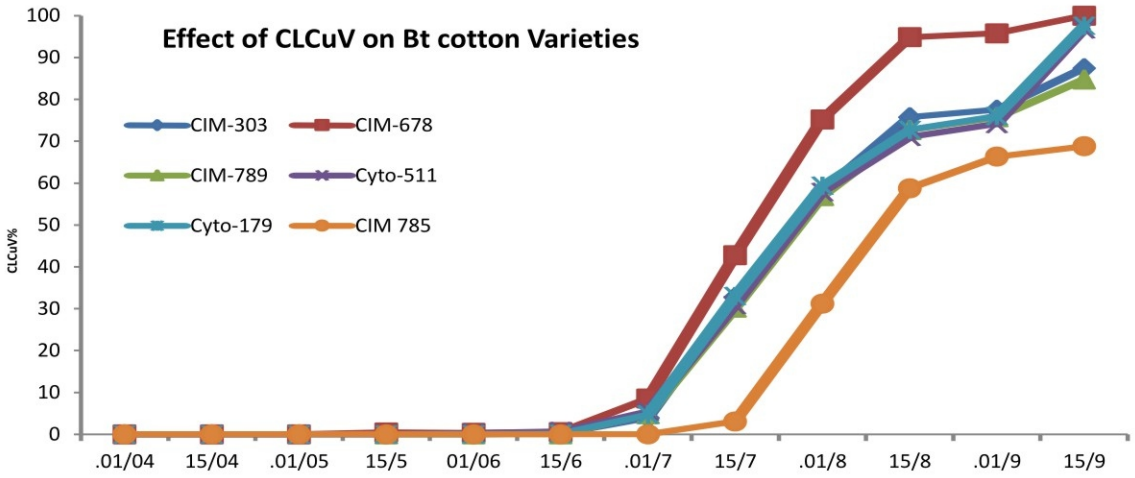
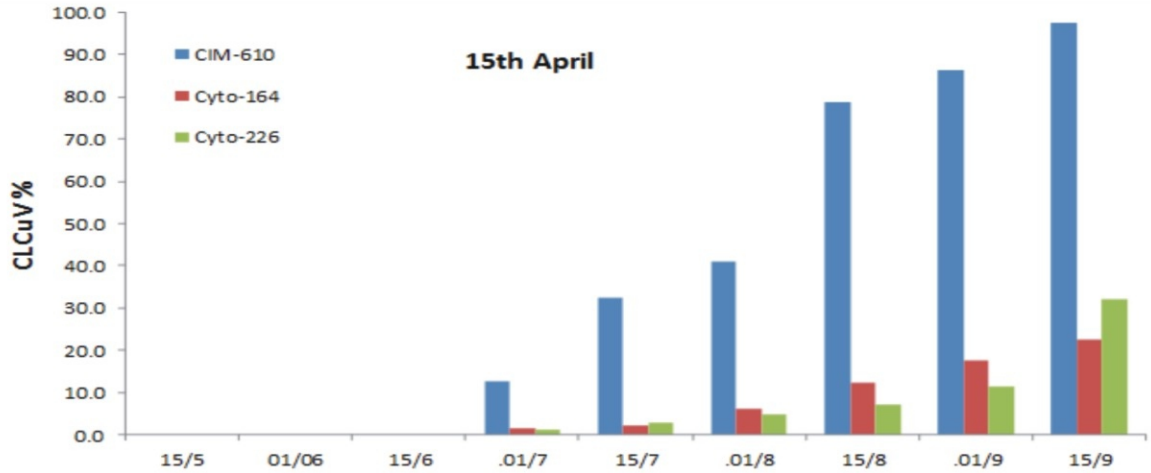
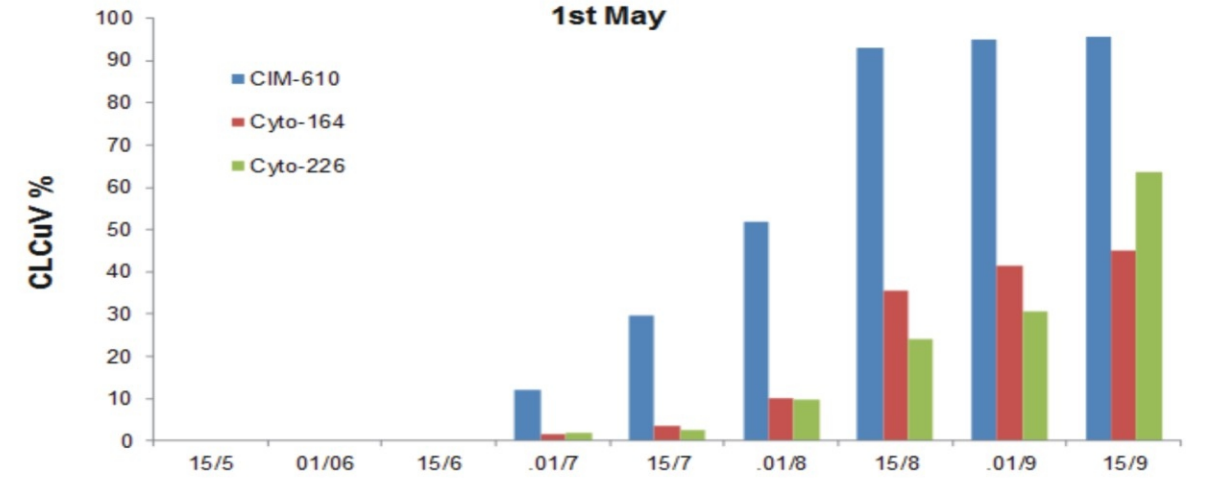
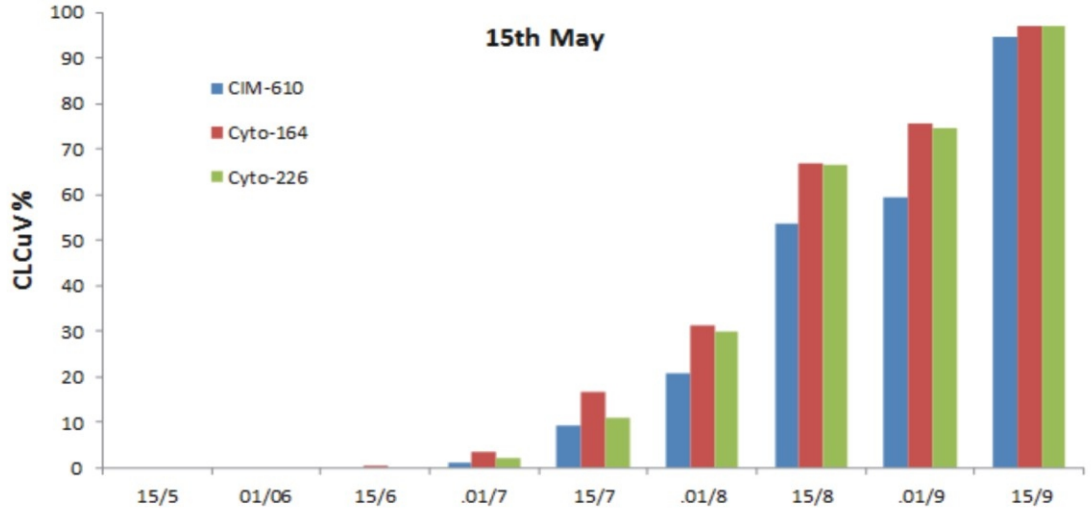
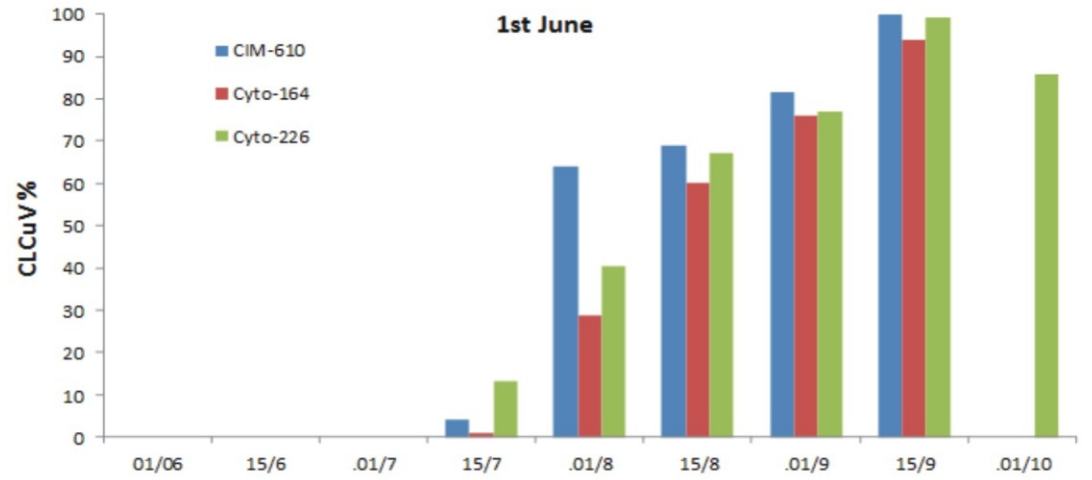


Fig-5.2 incidence of CLCuD in Bt-cotton strains









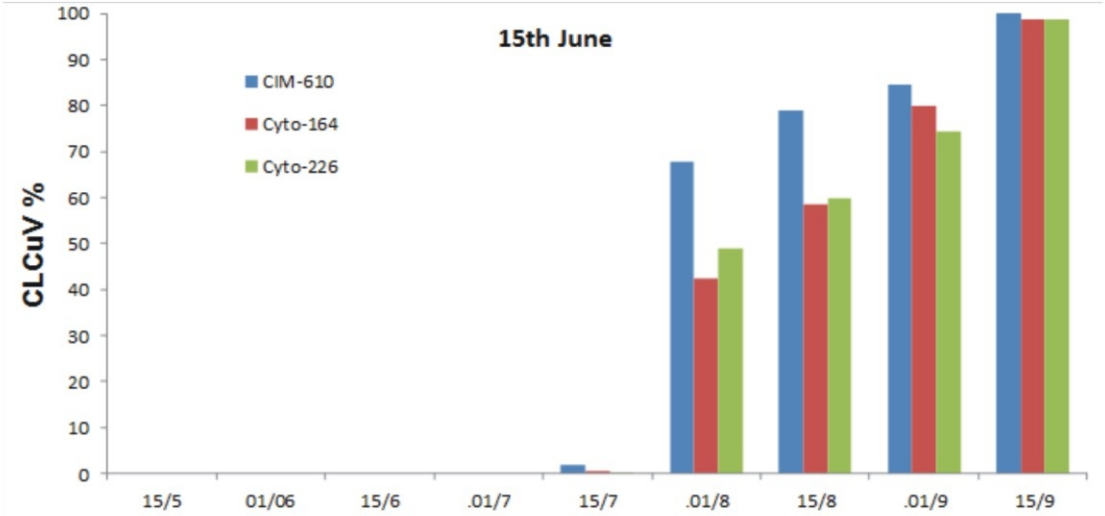


Fig-5.3 CLCuD incidence as influenced by planting dates and in different Non-Bt strain

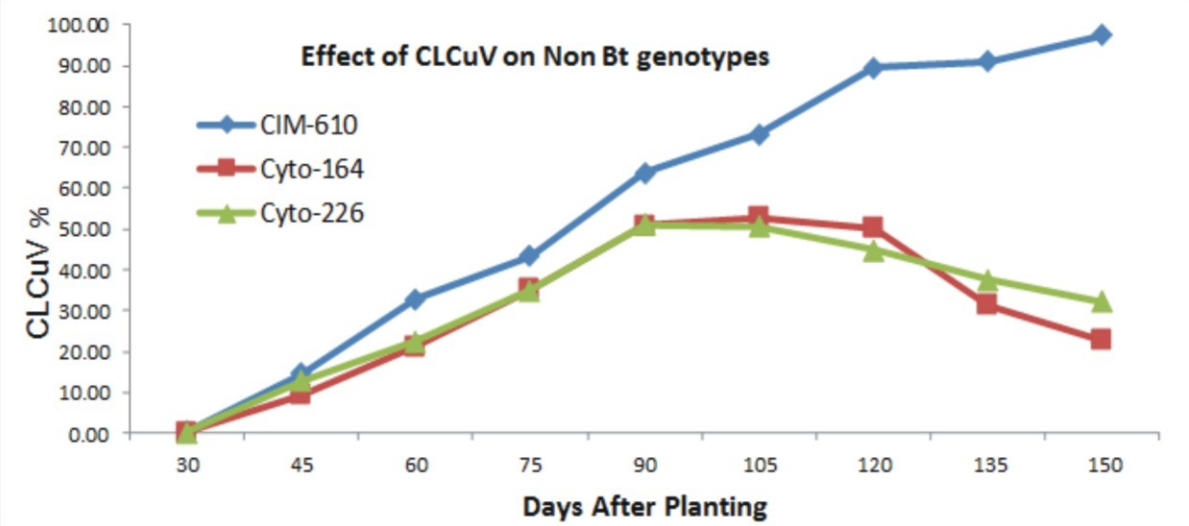


Fig-5.4 incidence of CLCuD in Non-Bt-cotton strains

Data on incidence and severity were recorded during the end of September from each treatment and computed for disease index. Average across cultivars, the minimum disease index 27.8 % was recorded on crop planted on 15th April as compared to other planting dates. Averaged across planting dates, minimum disease index (43.5%) was recorded on genotype CIM-610 Table-5.8.

Table-5.8 Disease Index of CLCuD (%) on sowing date trial

	Planting Dates					
Cultivars	15th April	1st May	15th May	1st June	15th June	Average
CIM-610	42.8	40.7	43.6	45.0	45.1	43.5
CIM-226	16.3	35.3	76.8	74.2	77.5	56.0
CIM-164	24.2	46.5	76.1	78.9	76.3	60.4
	27.8	**40.8**	**65.5**	**66.0**	**66.3**	

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

On an average basis of sowing dates, maximum level of fortnightly increase of CLCuD was recorded from mid-July to mid of September. Among environmental parameters the maximum temperature range was 33.6~36.1°C minimum temperature 23.4 ~ 28.7.0°C with the relative humidity 86.8 %~89.1 % during the above mentioned period. Humidity was maximum during the month of August, which boost up the disease level. It was also be noted that early sown crops were less affected by CLCuD than late sown crops due to plant vigor (Table-5.9).

Table 5.9 Relationship between fortnightly increases in CLCuD with weather parameters during 2019

Sowing Date	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 April	0.0	0.0	0.0	5.2	7.2	4.9	15.4	5.8
1st May		0.0	0.0	5.1	6.7	12.0	26.9	4.9
15th May			0.2	2.0	10.0	15.2	35.1	7.6
1st June				0.0	6.2	38.2	20.9	12.9
15th June				24.1	52.1	12.8	13.8	19.5
Average	**0.00**	**0.00**	**0.07**	**7.28**	**16.44**	**16.62**	**22.42**	**10.14**
Temp Max C	39.7	40.6	37.2	35.0	36.7	33.6	36.1	33.6
Temp Min C	27.0	30.6	30.0	29.1	28.7	26.0	23.4	26.0
RH %age	68.5	73.0	82.5	80.9	84.6	86.8	89.1	86.8

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 strains planted at different dates during, 15th March, 1st April, 15th April, 1st May and 15th May. The results are given in Table 5.10

Averaged across the varieties, no significant differences were noted in any crop planted during different timing, However March planting showed more disease was recorded as compared to others. Similarly averaged across sowing dates, all varieties showed boll rot less than 1 %. The boll rot disease ranged from 0.32 to 0.99 % in all sowing dates on an average basis (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 during 15th April to 15th June with fortnightly interval. The boll rot disease was recorded and results are given in Table 5.11 .

Averaged across sowing dates, Boll rot was recorded in traces in all cultivars. On an average basis, the crop planted at 15th June was more affected by boll as compared to other planting times. On an average basis, boll rot disease ranged from 0.48 to 1.70 % in different sowing dates (Table-5.11).

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

Cultivars	15th March	1st April	15th April	1st May	15th May	1 june	Average
CIM-303	0.81	0.93	0.22	1.23	1.01	1.19	0.90
CIM-678	0.68	1.49	0.20	0.00	0.00	0.70	0.51
CIM-789	1.50	0.00	0.25	0.00	0.88	0.00	0.44
Cyto--511	1.48	0.78	0.72	0.00	0.00	0.00	0.50
Cyto-179	0.86	0.92	0.75	1.03	0.00	0.00	0.59
CIM-785	0.62	0.00	1.47	0.00	0.84	0.00	0.49
	0.99	0.69	0.60	0.38	0.46	0.32	

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

Cultivars	15th April*	1st May	15th May	1st June	15th June	Average
CIM-610	0.57	1.32	0.57	0.74	1.50	0.94
CIM-226	0.26	0.59	0.54	1.20	2.18	0.95
CIM-164	0.62	0.66	0.53	0.40	1.41	0.72
	0.48	0.86	0.55	0.78	1.70	

Visit of Agriculture Extension Officers, Sindh

A twenty-member delegation of Agriculture Officers from Agriculture Extension Department Sindh visited CCRI Multan. Dr. Zahid Mahmood, Director CCRI Multan briefed the delegation about cotton research and development activities carried out by the Institute.

6. PLANT PHYSIOLOGY /CHEMISTRY SECTION

Cotton production and its sustainability is challenged by a number of biotic and abiotic stresses faced by the crop. Intensifcation in cropping pattern and increasing demand of food and fibre have further pressurized the 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 deteriorated soil may limit agricultural productivity at a level much higher than the other factors.

Physiology/Chemistry Section continued its endeavors to characterise cotton germplasm for its adaptability to high temperature stress and 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 approach so as to compensate the nutrient depletion and maintain soil fertility for sustained productivity. Use of potassium, secondary macronutrients like magnesium and stress alleviating biochemicals were evaluated for their role in mitigation of abiotic stresses and healthy cotton seed development apart from taking into account the quantitative and qualitative parameters. 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. The results of the studies conducted by the section are reported below in detail.

The scientists of the section actively participated in different trainings/seminar organized by the Institute or other organizations. Trainings were imparted to technical staff of Agricultural Extension Dept. (KP & Balochistan), WWF, private seed companies. Research internship facilities were provided to a total of five students; 2 from MNSUA, Multan and 3 from Ghazi University, DG Khan. Supervision of 4 PhD students remained continue while 2 jointly supervised MPhil students from MNSUA completed their degrees. Conducted thesis and oral evaluation of 4 MPhil students of MNSUA. Participated in radio programs; contributed in Tele Cotton messages and technical advisory committee meetings. The scientists of the section made a valuable contribution by publishing a chapter on “Heat stress in cotton: Responses and adaptive mechanism” in a books entitled :Cotton production and uses”.

6.1 Heat Tolerance

6.1.1 Adaptability of genotypes to temperature stress

Ever-increasing variability in world climate is threatening the cotton production globally due to temperature extremes, drought stress and irregular rainfall patterns. More than 50% yield reductions in arable crops has been accounted due to these stresses worldwide. Cotton is grown in most of the warmer regions of Pakistan where biotic and abiotic factors impose major threats to agricultural productivity. The most important abiotic stress, which influences cotton productivity, is the high temperature stress. The cotton plant responds actively to management and changes in the environment. Among various factors affecting seed cotton yield, high temperature acts as a key control on the rate of cotton plant growth. The ideal temperature for cotton growth is from 20ºC to 30ºC with the optimum temperature for photosynthesis is 28ºC. Temperature stress affects seedling growth, root growth, vegetative growth, flowering, fruit setting pattern leading to ultimate yield losses and deteriorated fiber quality. Heat stress, has damaging effect on production as it is estimated that crops achieve only about 25% of their potential yield. In Pakistan, temperature during summer approaches 50ºC and this beyond limit temperature severely affects seed cotton yield and fiber quality. The temperatures higher than optimum (>32°C) adversely affect the reproductive efficacy of the crop in different ways like inhibition of photosynthesis, decreased metabolism, crop growth rate, pollination, and fertilization. Therefore, identification and

cultivation of cotton cultivars with higher stress tolerance ability would produce yield benefits under both current and future weather conditions. The detailed information of advanced strains, about thermal stress tolerance, can help minimize the damaging effects of the extreme temperature events on long-term basis. Moreover, screening of the available material provides a database of desirable traits to the breeders for future variety development; and help in decision making for the varietal zoning.

In the reported study, screening of twenty-four 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 at CCRI, Multan.

The results revealed that the genotypes showed wide variation in various physiological parameters conferring to heat tolerance in cotton. Genotypes GH-Hamaliya, CRIS-682, CIM-775, NIAB-1011 and Cyto-535 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})
GH-Hamaliya	72	80	14	9	10	14	35	22	59	266
CRIS-682	69	75	15	10	9	13	34	21	58	243
CIM-775	70	77	16	9	10	16	37	25	70	272
NIAB-1011	77	81	15	9	12	18	36	25	62	295
CYTO-535	74	76	17	9	11	16	29	26	68	301
CYTO-533	75	77	16	8	13	16	28	18	60	331
NIAB-191	68	71	17	9	12	19	27	22	81	363
NIAB-135	62	70	13	7	10	15	29	21	58	308
CIM-785	61	71	18	8	13	18	33	26	68	308
CIM-303	69	70	15	8	12	15	29	23	67	327
GH-Sultan	62	69	15	9	11	15	29	24	53	301
M1-18	67	70	16	9	11	14	30	24	69	334
NIAB-818	57	68	16	10	14	21	25	20	92	342
CIM-789	63	68	12	9	13	18	24	19	75	359
NIAB-973	65	70	15	9	12	18	26	19	71	327
SLH-49	65	67	16	8	13	22	25	18	65	334
NIAB-1114	66	68	16	10	13	21	21	19	52	367
SLH-43	67	68	11	7	10	14	23	19	68	359
NIAB-898	54	65	14	9	10	16	22	19	75	380
SLH-55	61	63	14	9	13	19	20	18	60	365
NIAB-929	62	63	18	10	14	20	19	17	78	389
NIAB-819	67	70	13	9	13	19	24	18	62	386
SLH-54	68	71	15	9	12	17	24	18	65	397
CRIS-614	55	58	14	8	12	16	19	17	83	407
LSD	8.6**	11.6**	3.5^{ns}	6.3 ^{ns}	3.36 ^{ns}	6.0*	6.6**	8.6**	8.5**	46.9**

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

AD: Anther dehiscence
PV: Pollen viability
FSSN: First sympodial node no.
FSNH: First sympodial node height
SNNFB: Sympodial node no bearing 1st boll
SNHFB: Sympodial 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=0.83), percent boll set on first (r=0.83) and second (r=0.69) positions along sympodia with seed cotton yield. There were negative correlations of cell injury (r= – 0.32) and electrical conductivity (r= –0.88) with the seed cotton yield. These traits can be taken into account while selecting future genotypes to overcome heat stress problems (Table 6.2).

The dehiscence of anthers remained same until 2nd week of July and then exhibited a gradual or a sharp increase up to 3rd or 4th week of August reaching up to maximum (100%) later in the 2nd week of September except the 3rd week of August when the dehiscence showed a variable decline in the genotypes. Among the genotypes studied, NIAB-1011 showed the highest while NIAB-898 the lowest dehiscence of anthers during the peak

TRAINING PROGRAM "CLEAN COTTON PICKING"

CCRI Multan in coordination with WWF Pakistan, BCI Pakistan and Department of Agriculture Extension Punjab organized a seminar "Clean Picking and Better Cotton Production" at Chak 4 Faiz, Dera Muhammad Ishaq -Numberdar, Shujbad Laar Road, Multan on 23.09.2019. Cotton farmers of the areas participated in the seminar. Lectures on clean picking, storing and transportation were imparted.

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 GH-Hamaliya produced the highest seed cotton yield than the other genotypes tested. Seed cotton yield of different genotypes ranged from 1309 to 2796 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 24.3 to 27.8 mm, Uniformity Index varied from 80.2 to 85.8%, Micronaire varied from 4.0 to 5.8 and fibre strength varied from 24.0 to 28.6 G/Tex among different genotypes (Table 6.4).

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

Parameters	AD	PV	EC	RCI	BSFP	BSSP	NBPP	BW
PV	0.84*							
EC	-0.49*	-0.74**						
RCI	-0.45*	-0.39^{ns}	0.40^{ns}					
BSFP	0.60*	0.86**	-0.89**	-0.30^{ns}				
BSSP	0.40^{ns}	0.60**	-0.69**	-0.15^{ns}	0.80**			
NBPP	0.35^{ns}	0.48*	-0.29^{ns}	-0.15^{ns}	0.47*	0.31^{ns}		
BW	0.19^{ns}	0.24^{ns}	-0.35^{ns}	-0.24^{ns}	0.26^{ns}	0.36^{ns}	-0.51*	
SCY	0.63**	0.83**	-0.88**	-0.32^{ns}	0.83**	0.69**	0.37^{ns}	0.84*

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*

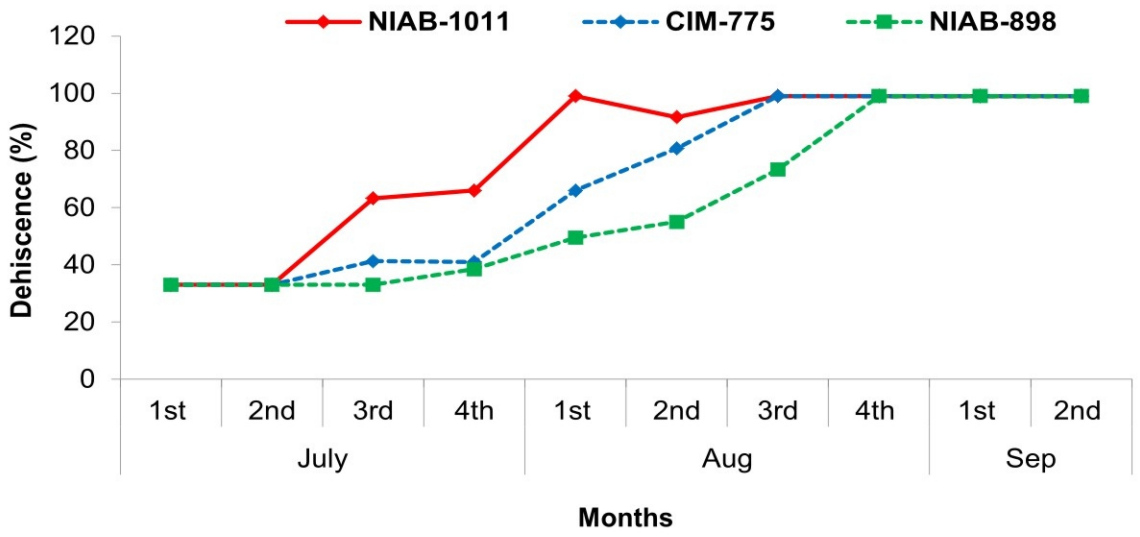


Fig. 6.1 Dehiscence of anthers during the season for three genotypes

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

Among abiotic stresses, high temperature is one of the most common stress, which not only influence crop production throughout the world but also has impacts on plant defensive system, chlorophyll contents, photosynthetic apparatus, antioxidant enzymes and crop productivity. Daily average temperature for optimum cotton growth ranges from 27–29°C. Cotton crop is predominantly cultivated under semiarid conditions where maximum day temperature reaches to 48–50°C. A small increase in air temperature above optimum (30°C) can significantly reduce leaf photosynthesis. Further, a temperature above 35–40°C significantly restricts elongation of fruiting branch (sympodial branches) in cotton. Heat stress influences cellular biochemistry by accelerating production of reactive oxygen species (ROS).

ROS are harmful to all cellular compounds and negatively influence cellular metabolic processes. Nature has provided all the organisms with self-repair mechanisms, varying in extent, to alleviate the damage by high temperature stress. The detoxification of ROS is very important and plants have evolved complex strategies to deal with them. The plant cells typically respond to increases in ROS levels by increasing the expression and activity of ROS-scavenging enzymes and increasing the production of antioxidants in order to maintain redox homeostasis. Plant's stress tolerance can be improved with the exogenous use of stress alleviating chemicals. Some of the important plant bio-regulators tested act in low concentrations to inhibit, promote or modify the morphological, physiological and biochemical processes of the plants. These substances can be applied directly to plant leaves, fruit and seed provoking alterations of vital and structural processes.

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})
GH-Hamaliya	25	2.76	2796
CRIS-682	25	2.56	2717
CIM-775	26	2.75	2710
NIAB-1011	29	2.26	2700
CYTO-535	21	3.33	2678
CYTO-533	20	3.20	2614
NIAB-191	24	2.42	2439
NIAB-135	29	2.18	2439
CIM-785	24	3.19	2345
CIM-303	27	2.52	2325
GH-Sultan	18	3.38	2316
M1-18	23	2.59	2219
NIAB-818	24	2.25	2193
CIM-789	23	2.93	2134
NIAB-973	19	2.72	2081
SLH-49	22	2.83	2080
NIAB-1114	24	2.18	2080
SLH-43	21	2.74	2026
NIAB-898	22	2.53	1973
SLH-55	20	2.85	1937
NIAB-929	24	2.19	1886
NIAB-819	25	2.18	1873
SLH-54	26	2.59	1488
CRIS-614	17	2.36	1309
LSD	**8.8****	**0.22****	**371****

**significant at p<0.01

Selenium (Se) is a signaling molecule that is concerned in activation of plant defense systems. **Se** is not an essential element but has the ability to enhance the antioxidant defense system and regulate water status of plants under stress conditions. **Hydrogen peroxide** (H_2O_2) plays a key role in cellular signaling also termed as a second messenger and has been found effective to activate defense system in plants under high temperature stress. 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.

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. 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.

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

Genotypes	Staple length (mm)	U.I. %	Micronaire (µg inch^{-1})	Strength (G/Tex)
GH-Hamaliya	26.1	83.3	5.7	26.2
CRIS-682	24.3	82.6	5.7	25.5
CIM-775	26.8	82.3	4.1	26.4
NIAB-1011	26.7	80.2	4.4	26.5
CYTO-535	27.6	84.3	4.9	28.0
CYTO-533	26.6	83.0	5.8	27.9
NIAB-191	26.8	84.0	5.2	25.6
NIAB-135	26.0	81.9	4.6	26.1
CIM-785	27.8	82.0	5.1	27.9
CIM-303	26.2	82.0	5.5	26.3
GH-Sultan	26.7	85.8	5.8	26.6
M1-18	26.1	84.7	5.7	26.6
NIAB-818	26.2	81.3	5.0	26.2
CIM-789	25.2	83.7	5.4	26.7
NIAB-973	26.3	81.4	4.6	25.8
SLH-49	26.0	83.4	5.5	26.5
NIAB-1114	26.9	80.4	4.6	26.5
SLH-43	25.5	83.1	4.9	26.8
NIAB-898	26.6	82.4	4.9	26.3
SLH-55	26.0	83.8	5.2	26.3
NIAB-929	27.0	85.7	5.4	28.6
NIAB-819	27.8	83.5	4.0	28.5
SLH-54	25.7	82.6	5.5	24.8
CRIS-614	24.8	80.5	4.1	24.0

A field experiment was conducted to evaluate the efficacy of exogenously applied bio-regulators as thermal stress alleviators on two cotton genotypes viz. Z-18 and CIM-678. The crop was sown on 10th of May 2019 in a randomized complete block design (RCBD) with split plot arrangement (genotypes; main plot and treatments; split plot). 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	Selenium(Se)	150 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 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 Z-18, main stem height varied from 96 to 110 cm, number of nodes on main stem from 44 to 47 and inter-nodal length from 2.17 to 2.42 cm in different treatments while in CIM-678, main stem height varied from 131 to 153 cm, number of nodes on main stem from 49 to 54 and inter-

nodal length from 2.60 to 3.00 cm in different treatments. In both genotypes, maximum vegetative growth was observed in treatment where salicylic acid @ 50 mg/L was applied exogenously (Table 6.5).

Table 6.5 Effect of stress alleviating chemicals on vegetative development at maturity

Genotypes	Biochemicals	Main stem height (cm)	Nodes on main stem	Inter-nodal length (cm)
Z-18	Water alone	102	47	2.17
	Se150mg/L	102	46	2.22
	$H_2O_2$30 mg/L	105	46	2.28
	SA 50 mg/L	110	46	2.39
	MLE 30 ml/L	102	44	2.32
	AA 150 mg/L	96	46	2.09
CIM-678	Water alone	143	49	2.92
	Se150mg/L	146	52	2.81
	$H_2O_2$30 mg/L	131	49	2.67
	SA 50 mg/L	144	54	2.67
	MLE 30 ml/L	153	51	3.00
	AA 150 mg/L	144	51	2.82
LSD	Genotypes	36.5**	7.46**	0.21**
	Biochemicals	9.23*	2.68^{ns}	0.07**
	Interaction	13.0*	3.21*	0.10**

Se:Selenium, H_2O_2:Hydrogen per oxide, SA: Salicylic acid, MLE: Moringa Leaf extract, AA:Ascorbc acid

Plant reproductive development parameters like seed cotton yield, number of bolls per plant, boll weight and ginning out turn (GOT%) differed notably at $p<0.05$ among various treatments but very significantly at $p<0.01$ among two genotypes. In Z-18, seed cotton yield varied from 1291 to 1372 kg ha^{-1}, number of bolls per plant varied from 16 to 21 and boll weight varied from 2.47 to 3.40 g and while in CIM-678 seed cotton yield ranged from 1372 to 1650 kg ha^{-1}, number of bolls per plant varied from 30 to 41 and boll weight varied from 2.87 to 3.84 g in different treatments. The maximum seed cotton yield, number of bolls per plant and boll weight was observed where salicylic acid was applied @ 50 mg/L by foliar application as compared to other treatments. The ginning outturn did not vary significantly among different treatments. GOT in different treatments varied from 35.3 to 38.2% in Z-18 and from 33.9 to 38.1% in CIM-678 (Table 6.6).

Table 6.6 Effect of stress alleviating chemicals on seed cotton yield, number of bolls per plant, boll weight and GOT

Genotypes	Biochemicals	Seed cotton yield (kg ha^{-1})	GOT%	Number of bolls per plant	Boll weight (g)
Z-18	Water alone	1291	35.3	16	2.47
	Se150mg/L	1354	36.0	19	3.15
	$H_2O_2$30 mg/L	1346	36.5	19	3.26
	SA 50 mg/L	1372	38.2	21	3.40
	MLE 30 ml/L	1354	37.8	19	3.31
	AA 150 mg/L	1355	36.9	18	3.27
CIM-678	Water alone	1372	33.9	30	2.87
	Se150mg/L	1480	34.7	34	2.91
	$H_2O_2$30 mg/L	1435	36.8	39	3.07
	SA 50 mg/L	1650	38.1	41	3.84
	MLE 30 ml/L	1560	35.9	41	3.30
	AA 150 mg/L	1632	35.4	37	3.09
LSD	Genotypes	84.5**	20.4^{ns}	21.3**	0.06**
	Biochemicals	138.8*	8.04^{ns}	4.96**	0.18**
	Interaction	196.3^{ns}	11.4^{ns}	7.02**	0.26**

The assessment of seed quality and biochemical parameters such as seed germination, seed index, cell injury, electrical conductivity and proline contents was done

from the leaves (90 DAP) and mature cotton seeds. Results indicated that in Z-18 seed germination varied from 64-82%, seed index from 8.60–9.71g, relative cell injury from 42–82 %, electrical conductivity from 231–375 and proline contents from 7.6–12.2 µg g^{-1} FW in different treatments and CIM-678 seed germination varied from 50-78 %, seed index from 6.36–7.90g, relative cell injury from 54–88 %, electrical conductivity from 272–412 µS cm^{-1} and proline contents from 11.6–15.4 µg g^{-1} FW in different treatments. On the basis of results, it was observed that Z-18 expressed improved biochemical parameters as compared to CIM-678 (Table 6.7). Seed germination differences in different treatments are depicted in Figure 6.2.

Table 6.7 Effect of stress alleviating chemicals on seed quality parameters

Genotypes	Biochemicals	Germination (%)	Seed index (g)	RCI (%)	EC (µS cm^{-1})	Proline contents (µg g^{-1} FW)
Z-18	Water alone	64	8.60	82	375	12.2
	Se150mg/L	66	9.01	70	363	10.3
	$H_2O_2$30 mg/L	70	9.18	61	331	9.4
	SA 50 mg/L	82	9.71	42	231	7.6
	MLE 30 ml/L	78	9.36	59	279	8.5
	AA 150 mg/L	74	9.67	52	266	8.6
	Mean	**73**	**9.26**	**61**	**307**	**9.4**
CIM-678	Water alone	50	6.36	88	412	15.4
	Se150mg/L	54	6.95	72	387	14.5
	$H_2O_2$30 mg/L	66	7.14	65	365	13.5
	SA 50 mg/L	78	7.90	54	272	12.5
	MLE 30 ml/L	76	7.18	68	295	11.4
	AA 150 mg/L	70	7.27	62	283	11.5
	Mean	**66**	**7.13**	**68**	**336**	**13.1**
LSD	Genotypes	2.40**	0.03**	2.91**	94.2**	0.57**
	Biochemical	8.24**	0.10**	6.27**	33.1**	0.45**
	Interaction	11.6 ns	0.14**	8.87 ns	46.9ns	0.64**

Figure 6.2 Effect of stress alleviating biochemicals on seed germination

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. High 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, face very high temperature of about 50°C during the month of May and June, which is approximately 20°C higher than the optimum temperature required for its normal growth, thus retarding performance to higher extent. Plant growth such as shoot development, flowering and fiber quality traits are influenced largely due to high temperature. Therefore, study was carried out 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 199 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 16% to 66% in different accessions of genepool (Table 6.8). Based on RCI the accessions were grouped into 3 categories. A total of 30 accessions had RCI in the range of 1-20%, (categorized as heat tolerant), 86 accessions had RCI in the range of 21-40% (categorized as medium tolerant) and 83 accessions with RCI of more than 40% were categorized as heat susceptible (Figure 6.3).

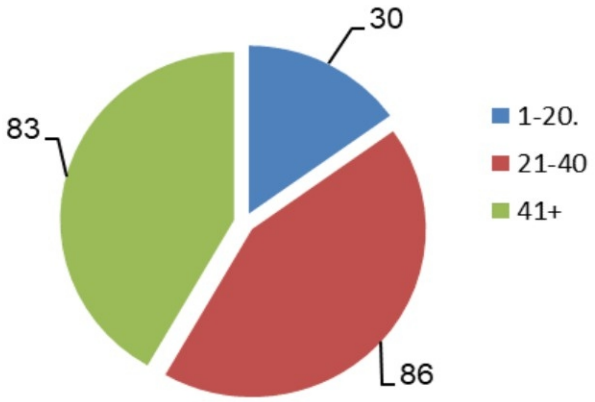


Figure 6.3 Categorization of genepool accessions based on relative cell injury levels

6.2 Soil health and plant nutrition

6.2.1 Long-term effects of minimum tillage on soil health and cotton-wheat productivity

The greatest challenge to the world in the years to come is to provide food to burgeoning population, which would likely to rise 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 are practiced throughout the world, ranging from 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

Demonstration of Mechanical Boll Picker

Makhdum Ahmad Alam Anwar

Dr. Khalid Abdullah, Vice President PCCC

Mr. Muhammad Shafiq Arain, MNA from Lodhran

Syed Fakhr e Imam

Mr. Bilal Israel & Dr. Muhammad Shakeel

Prof. Dr. Asif Ali, Vice Chancellor, MNSUA Multan

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, as experienced in USA in the 1930s. This process can directly and indirectly cause a wide range of environmental problems. The conventional soil management practices resulted in losses of soil, water and nutrients in the field, and degraded the soil with low organic matter content and a fragile physical structure, which in turn led to low crop yields and low water and fertilizer use efficiency. Therefore, scientists and policy makers put emphasis on conservation tillage systems. Compared to conventional tillage, there are several benefits from conservation tillage such as economic benefits to labor, cost and time saved, erosion protection, soil and water conservation, and increases of soil fertility.

Table 6.8 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 %
1	49.9	64	59.8	289	16.9	471	29.2	607	50.3
2	43.4	65	27.8	353	26.1	473	33.3	609	43.5
3	42.9	66	41.3	356	34.4	476	47.4	611	57.5
4	42.6	67	54.9	358	19.4	477	24.2	613	29.7
5	42.7	68	52.3	360	42.8	482	26.1	618	23.4
6	39.4	69	38.9	365	52.1	483	34.4	625	42.4
7	39.4	70	45.6	368	38.3	485	25.5	630	36.7
8	36.3	71	18.2	369	28.8	488	59.3	639	54.3
9	53.8	73	17.6	373	21.4	493	48.4	642	34.5
10	39.8	76	53.6	377	16.2	497	42.4	648	27.8
11	39.5	79	49.8	381	19.3	500	42.9	650	41.3
12	22.1	81	16.2	382	17.6	505	37.6	655	54.9
13	27.9	83	16.4	383	35.8	508	42.7	659	52.3
14	65.2	84	17.9	384	46.8	510	39.4	663	38.9
15	37.7	85	22.2	385	26.9	513	56.4	668	45.6
16	47.2	86	62.8	387	19.6	514	36.3	673	42.8
17	54.7	88	19.6	388	17.9	515	58.2	688	53.2
32	45.6	95	17.7	389	22.2	518	39.8	693	38.3
34	47.6	96	44.5	390	37.4	521	39.5	697	54.4
40	39.0	100	22.7	393	19.6	523	22.1	703	24.8
41	26.0	104	16.0	394	33.1	530	27.9	709	48.9
42	49.1	107	54.8	397	36.6	535	37.9	714	52.0
43	61.0	109	17.1	402	19.3	536	37.7	715	48.6
44	53.8	130	21.8	405	25.9	538	48.2	718	46.7
45	36.0	131	26.0	406	39.8	541	54.7	720	58.4
46	46.0	137	24.0	408	25.0	542	45.6	723	31.7
47	45.3	145	21.7	410	20.8	547	47.6	725	31.5
49	57.2	147	18.8	415	26.0	549	39.0	729	24.8
50	32.7	148	49.8	417	51.8	554	26.0	737	52.7
51	40.4	153	17.5	419	18.3	555	49.1	741	39.2
52	40.9	173	17.3	423	18.8	557	61.0	748	37.4
53	42.8	174	16.4	428	29.6	561	52.8	750	40.4
54	50.3	177	44.9	432	21.9	562	36.0	755	35.1
55	43.5	186	20.4	437	35.6	574	46.0	760	41.5
58	57.5	199	16.2	441	36.3	577	45.3	763	39.2
59	29.7	206	43.6	446	44.9	589	57.2	766	26.4
60	22.4	226	17.1	454	27.7	595	32.7	770	39.2
61	42.4	227	33.3	457	26.5	598	40.4	773	48.7
62	36.7	260	63.2	461	18.4	599	40.9	775	32.9
63	54.3	283	55	466	43.6	603	42.8		

The experiment was designed to evaluate the effect of minimum 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 delayed due to frequent rains at the time of wheat crop harvest as well as at the time of sowing. Germination of the cotton-seed was badly affected by rain that came twice just after planting of seed. Sowing could only be possible in the month of July and the crop faced high infestation of CLCuV and whitefly.

Pre-plant soil samples, by dividing the field into five portions, 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 texture and alkaline in reaction. Soil pH ranged from 8.19 to 8.35, electrical conductivity from 2.00 t0 3.30 mS cm^{-1}, organic matter content from 0.63% to 0.78%, extractable phosphorus from 15.3 to 20.6 mg kg^{-1} soil, extractable potassium from 149 to 177 mg kg^{-1} soil and total soil nitrogen from 0.18 to 0.21% in different samples. Soil samples were again collected from the field after crop harvest. Physiochemical analyses did not exhibit much difference (Table 6.9). Plant parameters were recorded from bed-furrow plots and flat-bed plots at maturity. The plant height was 74 cm and 70 cm, number of nodes 35 and 34, and number of bolls per plant 10 and 12, seed cotton yield 735 kg ha^{-1} and 798 kg ha^{-1} in flat-bed plots and bed-furrow plots, respectively.

Table 6.9 Pre-plant and post-harvest soil analysis

Sample No.	pH	EC (mS cm^{-1})	Extractable-P (mg kg^{-1})	O.M (%)	Total N (%)	Extractable-K (mg kg^{-1})
			Pre-plant			
1	8.19	3.30	16.5	0.78	0.19	161
2	8.31	3.27	15.3	0.77	0.20	150
3	8.35	2.00	20.6	0.64	0.21	152
4	8.33	2.07	17.8	0.64	0.18	177
5	8.27	2.70	15.7	0.63	0.18	149
Mean	**8.29**	**2.67**	**17.2**	**0.69**	**0.19**	**158**
			Post-harvest			
Flat-bed	8.30	2.68	17.8	0.70	0.20	161
Bed-furrow	8.32	2.70	18.0	0.69	0.21	163

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 resultant low use efficiency of applied phosphorus. But more often, 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

planned to study the appropriate phosphorous application time to increase cotton productivity.

A field experiment was conducted at the experimental area of Central Cotton Research Institute, Multan during the cotton crop season 2019-20. A total of two cotton genotypes viz. CYTO-511 and Cyto-535 were evaluated for appropriate P application time. The treatments were laid out in RCBD with split-plot arrangement (P application time main plots; genotypes: sub-plots). Crop was sown on May 30, 2019. The detail of treatments was as 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 five 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 6.10).

Table 6.10 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	0.88	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
5	8.27	2.70	0.71	17.7	199

Data on plant structure development were recorded at maturity. In plots where P was in two splits i.e. ½ at 25 DAP + ½ at 50 DAP, the main stem height, number of nodes on main stem and inter-nodal length remained higher over control as well as over plots that received full dose of P at pre-planting (Table 6.11). Averaged across genotypes, main stem height varied from 78 to 103 cm, number of node varied from 38 to 42 and intermodal distance 2.03 to 2.50 cm among different treatments. Similarly the root growth was also higher in those plots where P was applied in two splits i.e. ½ at 25 DAP+½ at 50 DAP as compared to pre-planting P application (Fig. 6.4).

Table 6.11 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	81	74	78	40	35	38	2.03	2.11	2.07
Full at Sowing	93	88	91	43	37	40	2.16	2.38	2.27
Full at 25 DAP	104	100	102	44	40	42	2.36	2.50	2.43
½ at 25 +½ at 50 DAP	106	98	102	44	39	42	2.41	2.51	2.46
Genotype		ns			*			ns	
P application time		*			ns			ns	
Interaction		ns			ns			ns	

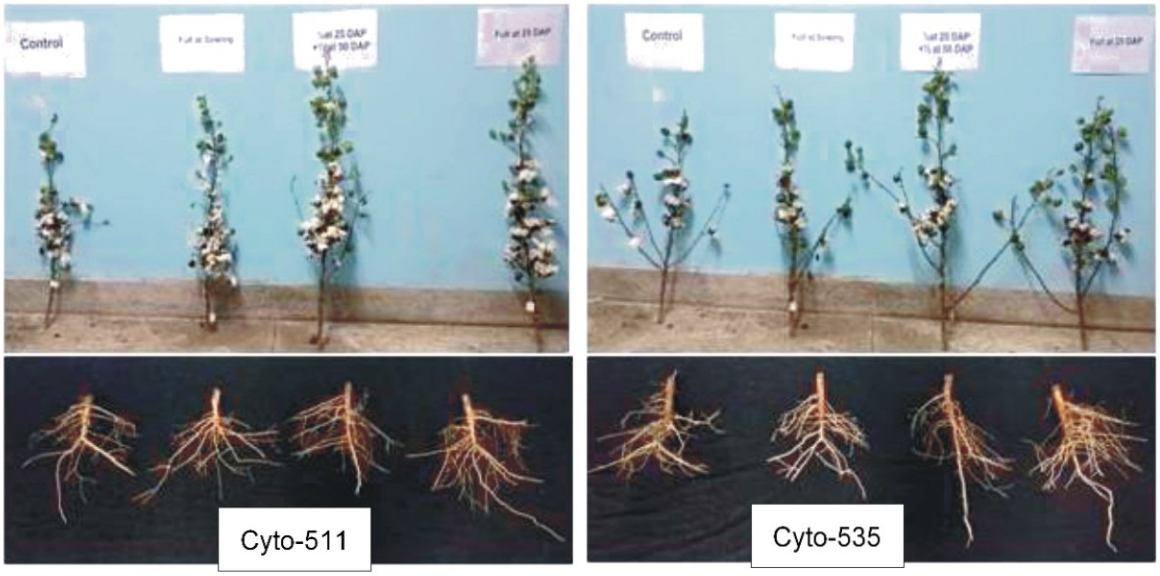


Fig 6.4 Shoot and root growth at maturity in two genotypes under different P treatments

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 25 DAP and ½ at 25 DAP+½ at 50 DAP as compared to pre planting P application and control (Table 2.3). In treatment where P was applied as ½ at 25 DAP+½ at 50 DAP, the fresh weight of leaf, stalk and root increased by 59%, 53%, 44% in Cyto-511 and 17%, 12%, 8% and 37% in Cyto-535 as compared to pre-planting P application (Table 6.12).

Table 6.12 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	105	156	156	258	29	32
Full at Sowing	111	166	209	386	27	30
Full at 25 DAP	174	195	298	414	34	36
½ at 25 +½ at 50 DAP	177	194	320	417	39	41
Genotype	*		*		*	
P application time	*		*		*	
Interaction	ns		*		ns	

Seed cotton yield, open bolls and mature green bolls per plant, and boll weight varied among different P treatments and between cotton genotypes. Seed cotton yield and its components increased with the delay and split application of P. The maximum seed cotton yield was observed in the treatment where P was applied as ½ at 25 DAP+½ at 50 DAP in both cotton genotypes. A comparison of P application time revealed that seed cotton yield was higher in plots that received full dose of P at 25 DAP as well as in plots receiving P ½ at 25 DAP+½ at 50 DAP as compared to pre-planting P application. The plots with ½ at 25 DAP+½ at 50 DAP produced yield of 1997 and 1682 kg ha^{-1} seed cotton, 23 and 15 bolls per plant, 2.29 and 3.22 g boll weight in Cyto-511 and Cyto-535, respectively (Table 6.13).

Fiber traits such as staple length, uniformity index, micronaire and fiber strength varied significantly among treatments and between genotypes. In plots where P was applied either at 25 DAP or in two splits i.e ½ at 25 DAP+½ at 50 DAP, staple length, uniformity index, micronaire and strength were improved as compared to pre-planting P application and control (Table 6.14).

Better Cotton Initiative Program by the PCCC

A consultative meeting of the project “Better Cotton Initiative for Sustainable Cotton Production in Pakistan” was held on 15.11.2019 at PCCC Headquarters Multan. The meeting was chaired by Dr. Khalid Abdullah, VP, PCCC/ Cotton Commissioner, Ministry of National Food Security & Research. Dr. Shafiq Ahmad, Coordinator BCI Pakistan; Dr. Zahid Mahmood, Project Manager; Dr. Fiaz Ahmad, Provincial Coordinator (Punjab) and Mr. Abdul Wahab Soomro, Provincial Coordinator (Sindh), Mr. Hidayatullah Bhutto, Director CCRI Sakrand and Dr. Muhammad Naveed Afzal, Head Agronomy, Mr. Sajid Mahmood, Head Technology Transfer CCRI Multan also attended.

Training Program on “Media Management”

Mr. Sajid Mahmood, Head Technology Transfer Section of CCRI Multan attended training course "Media Management in Government" at Secretariat Training Institute (STI), Govt of Pakistan (Establishment Division), Islamabad from Jan 20-24, 2020. Group photo with Dr. Zubair Iqbal Ghauri, Ex-Member, Planning Commission as Guest Speaker. Dr. Mukhtar Paris, DG STI awarded certificate.

Table 6.13 Seed cotton yield and it components in two genotypes under different P treatments

P application time	Open boll/ plant		Mature boll/ plant		Boll weight (g)		Seed cotton yield (kg ha^{-1})	
	Cyto-511	Cyto-535	Cyto-511	Cyto-535	Cyto-511	Cyto-535	Cyto-511	Cyto-535
Control	16	12	7	9	2.08	2.61	1425	1227
Full at Sowing	19	12	4	15	2.14	3.11	1699	1493
Full at 25 DAP	22	14	10	17	2.18	3.20	1880	1554
½ at 25 +½ at 50 DAP	23	15	11	17	2.29	3.22	1997	1682
Genotype	*		*		*		*	
P application time	*		ns		*		*	
Interaction	*		ns		*		ns	

Table 6.14 Fiber traits in two genotypes under different P treatments

P pplication 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	25.9	27.5	84.1	84.8	5.2	5.1	28.5	27.4
Full at Sowing	26.7	28.5	83.9	85.1	4.8	4.8	26.2	28.4
Full at 25 DAP	26.7	28.7	82.3	83.7	4.8	4.6	26.5	28.3
½ at 25 +½ at 50 DAP	27.1	28.8	82.2	85.3	4.8	4.7	26.7	28.5
Genotype	*		ns		*		*	
P application time	*		*		*		*	
Interaction	ns		ns		*		ns	

6.3 Plant-Water Relationships

6.3.1 Adaptability of genotypes to water stress conditions

Drastic climate changes and increased water scarcity challenge global food security, which is further exacerbated due to the need to feed a growing global population. A reviewed estimate states that global agricultural production might need to increase by 60–110% to meet the increasing demands as well as to provide food security to the predicted 870 million people who will be chronically undernourished by 2050. However, the rates of global crop production are far below the amounts required to meet projected demands by 2050.

Crop yield is affected by agronomic factors and various environmental variables such as water availability and temperature. There is extensive crop yield variability in many semi-arid regions, which are owed to water limitation and year-to-year fluctuations in meteorological conditions. Although an increasing temperature is a limiting factor for crop productivity in some areas of the world, drought still significantly reduces production by 9–10% on a global scale via negative effects on plant growth, physiology, and development. Caused by reduced precipitation and increased temperature, drought has been the most important limiting factor for crop productivity and, ultimately, for food security worldwide. Both surface and ground water resources in world are inadequate to meet the growing requirements for irrigation of agricultural crops. Drought has a very critical effect on growth, yield and quality characters. Limited water supply and high-energy costs can also decrease the yield of irrigated cotton. Root characteristics can be significant in predicting the response of plants to drought. Drought effect not only decreases plant height, shoot growth rate, and yield but also diminishes root growth. It has been found from earlier studies that varieties/cultivars in each species vary from one another in their actions under 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 effectively used for germplasm screening under drought conditions. Since, the response of 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 2019-20. A total of twelve cotton genotypes viz. CIM-789, CIM-785, Cyto-533, CYTO-511, CRIS-614, CRIS-682, NIAB-898, NIAB-1011, NIAB-973, NIAB-819, GH-Deebal and GH-Hamalyia 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; NI) 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 May 30, 2019. 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 2890 m^3 in NI plots a`nd 2054 m^3 in water stressed plots. The precipitation received was 175.5mm 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 varied from 57.3 cm to 96.7 cm, nodes on main stem from 29 to 42 and inter-nodal length from 1.79 to 2.57 cm in different genotypes, irrespective of water regimes. Averaged across water regimes, main stem height varied from 74.0 to 93.7 cm, nodes on main stem from 29.0 to 41.7 and inter-nodal length from 1.73 to 2.45 cm. Imposition of water stress caused a decrease of 13.4% in main stem height, 10.4% in nodes on main stem and 10.1% in inter-nodal length, irrespective of genotypes (Table 6.14).

Table 6.14 Plant structure at maturity in cotton genotypes under two water regimes

Genotypes	Height (cm)			Node			Inter-nodal distance (cm)		
	NI	WS	Av.	NI	WS	Av.	NI	WS	Av.
CIM-789	84.0	71.7	77.9	36.3	32.7	34.5	2.31	2.20	2.26
CYTO-533	68.3	64.7	66.5	38.0	33.0	35.5	1.98	1.80	1.89
CIM-785	81.0	74.7	77.9	37.7	31.7	34.7	2.34	2.17	2.26
CYTO-511	96.7	84.0	90.4	39.0	39.7	39.4	2.43	2.17	2.30
NIAB-898	91.3	89.7	90.5	41.7	37.3	39.5	2.45	2.16	2.31
CRIS-682	82.7	73.0	77.9	37.7	38.0	37.9	2.18	1.95	2.07
CRIS-614	72.3	61.3	66.8	37.7	35.3	36.5	1.92	1.73	1.83
NIAB-1011	85.7	77.3	81.5	37.3	36.3	36.8	2.36	2.08	2.22
NIAB-973	79.3	67.7	73.5	37.3	29.0	33.2	2.35	2.14	2.25
NIAB-819	71.7	57.3	64.5	39.3	29.0	34.2	2.02	1.81	1.92
DEEBAL	92.3	74.7	83.5	37.0	35.3	36.2	2.63	2.01	2.32
HAMALIYA	96.3	79.0	87.7	40.0	33.7	36.9	2.41	2.36	2.39
Mean	**83.5**	**72.9**		**38.3**	**34.3**		**2.28**	**2.05**	
Genotypes		*			*			*	
Water regime		*			ns			ns	
Interaction		**			**			*	

Relative water content (RWC), proline content and chlorophyll content varied significantly among genotypes and between water regimes. The RWC ranged from 80.1 - 95.6%, proline from 7.6 - 14.5 µg g^{-1} FW and chlorophyll content (SPAD) from 47.6 to 58.0 in different genotypes, irrespective of water regimes. The imposition of water stress decreased RWC from 92.3 to 84.2%, increased proline content from 9.1 to 13.0 µg g^{-1} FW and also lowered chlorophyll content from 53.7 to 52.0 on overall basis (Table 6.15).

Table 6.15 Proline content, relative water content and chlorophyll content in different genotypes under two water regimes

Genotypes	RWC (%)		Proline content (µg g^{-1} FW)		Chlorophyll content (SPAD values)	
	NI	WS	NI	WS	NI	WS
CIM-789	93.3	82.7	10.2	12.2	56.7	51.1
CYTO-533	94.2	86.0	9.5	12.3	55.0	55.0
CIM-785	95.1	85.1	8.5	11.0	56.7	47.6
CYTO-511	90.1	84.2	8.1	13.4	56.2	52.1
NIAB-898	95.6	89.3	9.6	14.5	52.0	49.6
CRIS-682	89.7	80.1	7.6	11.2	49.7	54.4
CRIS-614	92.9	81.3	9.6	12.5	48.8	46.1
NIAB-1011	92.9	87.9	8.3	13.7	50.5	54.1
NIAB-973	91.1	82.1	9.5	14.4	58.0	53.1
NIAB-819	90.6	81.4	8.6	11.7	54.4	53.8
DEEBAL	89.7	85.9	8.9	14.5	48.7	54.8
HAMALIYA	91.9	84.3	10.5	14.5	57.5	52.1
Mean	**92.3**	**84.2**	**9.1**	**13.0**	**53.7**	**52.0**
Genotypes	**		**		*	
Water regime	*		*		ns	
Interaction	*		*		*	

Data revealed that seed cotton yield, number of bolls per plant and boll weight varied significantly among the genotypes and under water regimes. Boll weight ranged from 1.63 to 2.88 g, number of bolls per plant varied from 9.0 to 22, and seed cotton yield from 1007 to 2417 kg ha^{-1}, in different genotypes, irrespective of water regimes. With the imposition of water stress, seed cotton yield decreased from 1874 to 1409 kg ha^{-1}, bolls per plant from 17.2 to 13.9 and boll weight from 2.40 to 2.18 g irrespective of the genotypes. The decrease, due to imposed water stress was 23.3% in seed cotton yield, 9.2 % in boll weight and 18.4% in bolls per plant. The genotype CIM-785 produced the maximum seed cotton yield of 2417 kg ha^{-1} with 17.3 bolls per plant and boll weight of 2.88 g in normally irrigated plots. The genotype GH-Deebal surpassed in yield over all other genotypes in water stressed regime. 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 6.16).

Table 6.16 Seed cotton yield and yield attributing factors in different genotypes under two water regimes

Genotypes	Boll weight (g)			Number of bolls per plant			Yield (kg ha^{-1})		
	NI	WS	Av.	NI	WS	Av.	NI	WS	Av.
CIM-789	2.69	2.47	2.58	15.1	12.3	13.7	1875	1395	1635
CYTO-533	2.75	2.72	2.74	14.7	11.0	12.9	1719	1488	1604
CIM-785	2.88	2.67	2.93	17.3	14.3	15.8	2417	1924	2170
CYTO-511	2.10	1.86	1.98	17.7	12.4	15.1	1689	1274	1482
NIAB-898	2.40	1.98	2.19	22.0	19.7	20.9	2159	1712	1935
CRIS-682	2.23	2.02	2.12	16.0	13.0	14.5	1572	1183	1378
CRIS-614	1.81	1.63	1.72	17.7	14.3	16.0	1460	1007	1234
NIAB-1011	2.14	2.08	2.11	19.3	15.0	17.2	1982	1307	1645
NIAB-973	2.14	1.70	1.92	18.0	14.0	16.0	1590	1087	1339
NIAB-819	2.34	1.94	2.14	16.0	13.7	14.9	1651	1242	1447
DEEBAL	2.66	2.62	2.64	16.7	15.0	15.9	2289	1945	2117
HAMALIYA	2.48	2.25	2.37	18.7	15.3	17.0	2290	1852	2071
Mean	**2.40**	**2.18**		**17.4**	**14.2**		**1891**	**1451**	
Genotypes	*			**			**		
Water regimes	*			*			*		
Interaction	*			*			**		

Staple length, uniformity index, micronaire and fiber strength varied among genotypes and between water regimes. The staple length ranged from 24.1 to 28.5 mm, uniformity index from 77.8% to 88.1%, micronaire from 3.7 to 5.7 and fiber strength from 24.1 to 28.8 G/Tex in different genotypes, irrespective of water regimes. The imposition of water stress caused a decrease in staple length, uniformity index, micronaire and strength (Table 6.17).

Table 6.17 Fiber traits in different cotton genotypes under two water regimes

Genotypes	Staple length (mm)			Uniformity Index (%)			Micronaire			Strength (G/Tex)		
	NI	WS	Avg	NI	WS	Avg	NI	WS	Avg	NI	WS	Avg
CIM-789	28.5	26.7	27.6	82.9	84.8	83.9	4.9	5.2	5.1	28.5	26.8	27.7
CYTO-533	27.8	26.8	27.3	85.2	85.9	85.6	5.7	5.8	5.8	28.8	26.0	27.4
CIM-785	28.4	28.2	28.3	88.1	85.6	86.9	5.4	5.1	5.3	28.3	28.5	28.4
CYTO-511	27.3	24.6	26.0	85.5	80.8	83.2	5.1	4.6	4.9	28.1	26.8	27.5
NIAB-898	28.1	25.3	26.7	85.0	80.8	82.9	5.4	5.0	5.2	27.9	26.3	27.1
CRIS-682	26.1	25.1	25.6	84.4	82.4	83.4	5.1	5.0	5.1	26.4	27.4	26.9
CRIS-614	25.2	24.1	24.7	79.4	77.8	78.6	3.5	3.7	3.6	26.9	24.2	25.6
NIAB-1011	27.9	27.1	27.5	82.5	83.1	82.8	4.6	4.7	4.7	28.0	28.6	28.3
NIAB-973	27.9	25.7	26.8	83.1	83.6	83.4	5.0	5.0	5.0	28.0	26.2	27.1
NIAB-819	24.7	24.7	24.7	84.1	84.3	84.2	5.6	5.1	5.4	24.1	25.8	25.0
DEEBAL	26.1	23.5	24.8	82.3	81.1	81.7	5.5	5.7	5.6	27.8	24.8	26.3
HAMALIYA	26.0	25.2	25.6	81.9	80.5	81.2	5.5	4.8	5.2	26.3	25.8	26.1
Mean	**27.0**	**25.6**		**83.7**	**82.6**		**5.1**	**5.0**		**27.4**	**26.4**	
Genotypes		*			*			*			ns	
Water regime		*			*			*			ns	
Interaction		*			ns			ns			ns	

6.3.2 Cotton response to potassium application under water stress

Drought is a major restrictive factor for agricultural production worldwide. It is predictable that episodic summer drought events will increase in frequency and severity due to global climate change. Drought may inhibit crop productivity especially under hot conditions. Under drought, crop photosynthesis rate reduces due to stomatal and/or non-stomatal limitations that may occur concurrently under severe stress. Non-stomatal factors are more important in reducing photosynthesis under severe stress while in mild drought stomatal limitation is the major factor affecting net photosynthesis. Drought stress can also reduce leaf area, transpiration rate and total dry matter accumulation due to shedding of leaves and fruiting structures that leads to diminished final yield. Limited carbon fixation caused by stomatal closure and reduced photosynthesis under drought stress disrupts carbohydrate metabolism and dry matter partitioning processes. Nontheless, inspite of this reduction, plants accumulate a lot of carbohydrates; which act as osmolytes to mitigate drought stress, an acclimating response in plants under drought.

Mineral nutrients play a critical role to withstand the adverse environmental conditions. Potassium (K) is an essential nutrient and is the most abundant cation in plants, plays a pertinent role in plant growth and almost in all related functions. Sufficient K in plants enhances photosynthesis, plant growth, yield, and drought resistance in plants under water stress conditions. Potassium promotes solute accumulation during drought, normal funtioning of stomata, biomass production, biomass partitioning and morphological indices in cotton crop. Yield limiting effect of water deficit stress could be overcome by increasing K supply. The objective of the present work was to study the possible role of K applied in mitigating water deficit stress and in improving growth and yield in cotton.

The crop was sown on May, 29th 2019 in a Randomized Complete Block Design with Split-Split Plot arrangement. Sulphate of potash was applied as source of K @ 0 and 50 kg ha^{-1} by fertigation. Cotton genotypes CYTO-124, CIM-554, BH-212, BS-13 and FH-142 were used as test crop. The NPK fertilizers were applied according to recommended fertilizer doses. Standard production and management practices were adopted.

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 were determined. The results indicated that the soil is silt loam in texture and alkaline in reaction. The soil is medium in organic matter (0.81%), extractable phosphorus (12.5 mg/kg), extractable potassium (98 mg/kg) and available magnesium (50 mg/kg).

Data on plant structure were recorded at maturity. In different genotypes, main stem height ranged from 61-101 cm in non-K (control) while it varied from 86-127 cm in plots with applied K (@ 50 kg K_2O/ha), irrespective of water stress. A positive relationship between genotypes and applied potassium was observed in all genotypes showing concurrent increase in main stem height and number of nodes on main stem. Among the genotypes, CIM-554 produced greater height and larger inter-nodal length, while Cyto-124 produced more number of nodes on main stem over other genotypes (Table 6.18).

Table 6.18 Effect of water stress and applied K on plant structure development at maturity

K-Level	Genotype	Main stem height (cm)			Nodes on main stem			Inter-nodal length (cm)		
		NS	WS	Mean	NS	WS	Mean	NS	WS	Mean
Control	Cyto 124	92	87	**90**	39	36	**38**	2.36	2.42	2.39
	CIM-554	101	85	**93**	38	32	**35**	2.66	2.66	2.66
	BH-212	73	61	**67**	32	31	**32**	2.28	1.97	2.13
	BS-13	82	71	**77**	37	29	**33**	2.22	2.45	2.34
	FH-142	93	78	**86**	38	35	**37**	2.66	2.05	2.36
	Mean	**88**	**76**		**37**	**33**		**2.43**	**2.31**	
50 kg (K_2O/ ha)	Cyto 124	122	96	**109**	41	38	**40**	2.98	2.53	2.75
	CIM-554	127	103	**115**	42	37	**39**	3.02	2.78	2.90
	BH-212	98	96	**97**	34	28	**31**	2.88	3.43	3.16
	BS-13	113	86	**100**	36	35	**35**	3.14	2.46	2.80
	FH-142	116	97	**107**	41	35	**38**	2.83	2.77	2.80
	Mean	**115**	**96**		**39**	**35**		**2.79**	**2.97**	
K-application (K)			*			*			*	
Genotype (G)			**			*			**	
Water regime (WR)			**			*			**	
K x Genotype			**			*			*	
K x WR			*			ns			*	
G x WR			*			*			*	
K x G x WR			ns			ns			ns	

*Significant at p≤0.05; **Significant at p≤0.01; ns: non-significant
NS (no stress @ -1.6±0.2 MPa); WS (water stress @ -2.4±0.2 MPa)

Plants from one-meter square area were harvested at maturity and partitioned into leaf, stalk and fruit portions. The dry matter yield of leaf, stalk and fruit organs increased with applied K in all genotypes, irrespective of water stress. Applied K improved the drought tolerance in all genotypes thereby increasing dry matter of leaves from 110 to 132 gm^{-2}, stalk from 160 to 254 gm^{-2} and fruits from 322 to 421 gm^{-2} by addition of K as compared to without K addition under water stress condition (Table 6.19). The concentration of K in different parts of cotton plant was determined from the oven dried plant material. Data revealed that K concentration in different plant organs did not vary greatly among the genotypes, water stress and applied-K. However, K concentration increased with applied K as well as with the imposition of water stress in leaf, stalk and seed portions. However, seed portion exhibited the highest K concentration than the other plant parts (Table 6.20). Data revealed that seed cotton yield, number of bolls per plant and boll weight varied significantly with K addition, water stress and among genotypes. The number of bolls per plant varied from 13 to 23, boll weight from 1.88 to 2.38 g and seed cotton yield from 1287 to 2278 kg ha^{-1} in different genotypes, irrespective of applied K and water regimes. Seed cotton yield, number of bolls per plant and boll weight decreased with the imposition of water stress. Consequently, average seed cotton yield decreased from 1840 to 1531 kg ha^{-1}, bolls per plant from 19 to 15 and boll weight from 2.22 to 2.07 g irrespective of the genotypes. Added K caused a variable

increase in seed cotton yield and its components in different genotypes both in no stress and water stressed conditions. The average increase in yield across the genotypes was 10.2% and 16.4%, respectively in no stress and water stressed conditions. Among the genotypes, CYTO-124 produced the maximum seed cotton yield (2278 kg ha^{-1}) and boll weight (2.38 g) in all treatments (Table 6.21).

Table 6.19 Effect of water stress and applied K on dry matter production (g m^{-2}) at maturity

K-level	Genotypes	Leaves			Stalk			Fruit		
		NS	WS	Mean	NS	WS	Mean	NS	WS	Mean
Control	Cyto 124	143	123	**133**	211	177	**194**	460	359	**410**
	CIM-554	141	117	**129**	208	178	**193**	462	326	**394**
	BH-212	106	78	**92**	158	118	**138**	293	255	**274**
	BS-13	132	111	**122**	202	154	**178**	425	330	**378**
	FH-142	133	120	**127**	201	171	**186**	450	340	**395**
	Mean	**131**	**110**		**196**	**160**		**418**	**322**	
50 kg (K_2O/ha)	Cyto 124	194	146	**170**	289	272	**281**	562	447	**504**
	CIM-554	183	141	**162**	271	265	**268**	553	436	**490**
	BH-212	126	108	**117**	212	203	**207**	355	325	**340**
	BS-13	174	130	**152**	273	252	**262**	536	426	**481**
	FH-142	181	136	**158**	270	278	**274**	559	473	**516**
	Mean	**172**	**132**		**263**	**254**		**513**	**421**	
K-application (K)		*				*		*		
Genotype (G)		**				*		**		
Water regime (WR)		**				*		**		
K x Genotype		*				*		*		
K x WR		*				*		*		
G x WR		*				ns		*		
K x G x WR		ns				ns		ns		

*Significant at p≤0.05; **Significant at p≤0.01; ns: non-significant
NS (no stress @ -1.6±0.2 MPa); WS (water stress @ -2.4±0.2 MPa)

Table 6.20 Effect of water stress and applied K on K concentration (%) in different plant organs at maturity

K-Level	Genotypes	Leaves			Stalk			Seed		
		NS	WS	Mean	NS	WS	Mean	NS	WS	Mean
Control	Cyto-124	1.09	1.10	**1.09**	1.12	1.16	**1.14**	2.11	2.16	**2.13**
	CIM-554	1.03	1.03	**1.03**	1.03	1.03	**1.03**	2.04	2.05	**2.04**
	BH-212	0.96	0.98	**0.97**	1.01	1.01	**1.01**	1.91	1.99	**1.95**
	BS-13	1.02	1.03	**1.02**	1.03	1.02	**1.02**	2.03	2.01	**2.02**
	FH-142	1.03	1.04	**1.03**	1.10	1.11	**1.10**	2.06	2.11	**2.08**
	Mean	**1.02**	**1.03**		**1.05**	**1.06**		**2.03**	**2.06**	
50 Kg (K_2O/ ha)	Cyto 124	1.13	1.21	**1.17**	1.25	1.26	**1.26**	2.31	2.44	**2.38**
	CIM-554	1.09	1.16	**1.12**	1.17	1.24	**1.21**	2.10	2.38	**2.24**
	BH-212	1.01	1.03	**1.02**	1.06	1.16	**1.11**	2.04	2.07	**2.06**
	BS-13	1.08	1.12	**1.10**	1.15	1.24	**1.20**	2.07	2.32	**2.20**
	FH-142	1.11	1.22	**1.16**	1.21	1.24	**1.23**	2.24	2.36	**2.30**
	Mean	**1.08**	**1.14**		**1.16**	**1.03**		**2.15**	**2.31**	

NS (no stress @ -1.6±0.2 MPa); WS (water stress @ -2.4±0.2 MPa)

6.4 Seed physiology

6.4.1 Exploring the role of antioxidants and growth hormone in cotton plant growth, cottonseed health and productivity

Cotton plant encounters a complex set of abiotic and biotic stresses frequently during the growing season. Abiotic stresses, being unavoidable, have major negative impact on crop production worldwide. These stresses such as inadequate and inconsistent rainfall, salinity, water shortage, extreme temperature, and some other factors are not only limiting crop yields but also seem to be inevitably worsening. Considering present situation, it is imperative to

VISIT OF DR. NEIL FORRESTER, COTTON EXPERT FROM AUSTRALIA

Dr. Neil Forrester, Cotton Expert from Australia along with Dr. Ahsan Rana, LUMS, Capt (Rtd) Arif Nadeem, former Secretary Agriculture Punjab; Syed Zafaryab Haider, DG PWQC Punjab; Khawaja Anees from APTMA and Dr. Shafqat Saeed, Dean Faculty of Agriculture, MNSUA Multan visited CCRI Multan. Dr. Zahid Mahmood, Director CCRI Multan briefed about the cotton research and development activities. The delegation also reviewed performance of Mechanical Boll Picker and visited cotton fields and laboratories.

switch to some more sophisticated techniques that shall combat abiotic environmental challenges and improve crop yield efficiently. Among these, seed priming is a commonly utilized technology in enhancing seed vigor and stress tolerance. Seed priming involves the attainment of a specific physiological state by synthetic or natural compounds. Cotton plant raised from primed seeds exhibit instant cellular response against abiotic stresses. Primed seed acquires resistance through various cellular and metabolic pathways which involve cascades of signaling networks. Studies, till date, have confirmed that primed seeds have several advantages over traditionally used methods which include uniform germination, reduction in germination and emergence time, and broad range of tolerance against disease and environmental stresses. Seed priming methods are widely used as an emerging technology to produce tolerant crop varieties against abiotic stresses. Seed priming involves soaking of seed in water, nutrients or other salts like antioxidants i.e. ascorbic acid, citric acid and growth hormones e.g. Gibberellic acid for a certain period that leads to changes in metabolic profile of the seed.

Table 6.21 Effect of water stress and applied K on seed cotton yield and its components

K-Level	Genotype	Seed cotton yield (kg ha^{-1})			Number of bolls per plant			Boll wt (g)		
		NS	WS	Mean	NS	WS	Mean	NS	WS	Mean
Control	Cyto-124	1955	1711	**1833**	20	17	**19**	2.31	2.15	**2.26**
	CIM-554	1921	1671	**1796**	20	16	**18**	2.29	2.20	**2.22**
	BH-212	1621	1287	**1454**	18	13	**16**	2.12	1.88	**2.00**
	BS-13	1801	1464	**1633**	17	14	**16**	2.18	2.01	**2.10**
	FH-142	1901	1521	**1711**	19	15	**17**	2.20	2.12	**2.16**
	Mean	**1840**	**1531**		**19**	**15**		**2.22**	**2.07**	
50 Kg (K_2O/ ha)	Cyto-124	2278	2045	**2162**	23	19	**21**	2.38	2.27	**2.33**
	CIM-554	2150	1985	**2068**	22	18	**20**	2.35	2.19	**2.27**
	BH-212	1812	1574	**1693**	19	16	**18**	2.18	2.04	**2.11**
	BS-13	1875	1572	**1724**	20	17	**19**	2.20	2.06	**2.13**
	FH-142	2020	1734	**1877**	21	17	**19**	2.26	2.20	**2.23**
	Mean	**2027**	**1782**		**21**	**17**		**2.27**	**2.15**	
K-application (K)			*			*			*	
Genotype (G)			**			*			*	
Water regime (WR)			**			*			*	
K x Genotype			ns			ns			ns	
K x WR			*			*			*	
G x WR			**			*			*	
K x G x WR			ns			ns			ns	

*Significant at p≤0.05; **Significant at p≤0.01; ns: non-significant
NS (no stress @ -1.6±0.2 MPa); WS (water stress @ -2.4±0.2 MPa)

Ascorbic Acid (AA), a small water-soluble antioxidant molecule, acts as a primary substrate in the cyclic pathway for detoxification and neutralization of superoxide radicals and singlet oxygen. Ascorbic acid (vitamin C) is one of the key products of D-glucose metabolism which play multiple roles in plant growth and development such as cell division, cell wall expansion, electron transport system and other developmental processes. The foliar spraying with ascorbic acid contributed in protecting the photosynthetic machinery from the damaging effects of stress. The application of ascorbic acid mitigated the adverse effect of salt stress on plant growth which may be due, in part, to increased leaf area, improved chlorophyll and carotenoid contents and enhanced proline accumulation. Exogenous application of ascorbic acid enhanced vegetative growth which may contribute to increased plant biomass and yield.

Citric Acid (CA) is an organic compound belonging to the family of carboxylic acids. Citric acid is present in all plants. It is one of a series of compounds involved in the physiological oxidation of fats, proteins and carbohydrates to CO_2 and water. Effects of citric acid on growth and yield of crops include plant height, yield and its components as well as protein content. The ascorbic and citric acids appeared to act in a concert which indicates a complete set of antioxidant defense system, rather than protection by a single antioxidant

under stressful conditions. The foliar spray of citric acid significantly increased shoot fresh weight, shoot dry weight, root fresh weight and root dry weight.

Gibberellic acid (GA), one of the growth hormones, is produced by the scutellum (cotyledon) of the embryo and stimulates the production of amylase by the aleuronic layer. Amylase hydrolyzes starch to simple sugars absorbed by scutellum and translocated to embryo for growth. It is often used to overcome seed dormancy, mainly through the activation of embryo growth, mobilization of reserves, and weakening of the endosperm layer. GAs play important roles in many essential plant growth and developmental processes like shoot length, root length, and seedling weight, stem elongation, leaf expansion, flower and fruit development, and floral transition.

The aim of this investigation was to evaluate the response of cotton in terms of growth, cottonseed health and productivity to seed priming or seed priming plus foliar spray with antioxidants and growth hormone. In both sets seed priming with antioxidants and growth hormone was done prior to sowing while in the other set foliar sprays were initiated when the crop reached at fruiting phase i.e. 35-40 days old. Subsequent foliar sprays were done after 15 days' intervals.The detail of treatments applied is given below:

	Application Methods	
	Seed Priming	Seed Priming +Foliar Application
Biochemicals (mg/L)	Water alone (Control)	Water alone (Control)
	AA (50)	AA(200)
	CA (100)	CA (400)
	GA (10)	GA(50)
	AA (50) + CA (100)	AA (100) + CA(200)
	AA (50) + GA (10)	AA (100) + GA (25)

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 6.22).

Table 6.22 Physical and chemical characteristics of soil at pre- planting

Characteristics	Values
pH	8.01
ECe (dSm^{-1})	2.19
Organic matter (%)	0.89
$NaHCO_3$-P (mg Kg^{-1})	10.4
NH_4OAc-K(mg Kg^{-1})	121
AB-DPTA-Zn (mg Kg^{-1})	0.98
Hot water extractable-B (mg Kg^{-1})	0.51
Textural class	silt loam

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 seed primed plots, main stem height varied from 92 to 118 cm, number of nodes on main stem from 38 to 42 and inter-nodal length from 2.42 to 2.84 cm in different treatments while in seed primed plus foliar sprayed plots, main stem height varied from 93 to 108 cm, number of nodes on main stem from 36 to 41 and inter-nodal length from 2.51 to 3.03 cm in different treatments (Table 6.23).

Seed cotton yield differed significantly ($p<0.05$) among various treatments. In seed primed plots, seed cotton yield varied from 1870 to 2170 kg ha^{-1} while in seed primed plus foliar sprayed plots, seed cotton yield ranged from 1891 to 2334 kg ha^{-1} in different treatments. The maximum seed cotton yield was produced in Gibberellic acid (GA) treated plots whether applied by seed priming (@10 mg/l GA) alone or both by seed priming plus foliar application (@ 50 mg/l GA). The ginning outturn did not vary significantly among

different treatments. The GOT in different treatments varied from 36.6 to 41.8% in seed primed and from 38.3 to 43.0 % in seed primed plus foliar applied method (Table 6.24).

Table 6.23 Effect of seed primed or foliar applied antioxidants and growth hormone on vegetative development at maturity

Biochemicals (mg/L)	Main stem height (cm)	Nodes on main stem	Inter-nodal length (cm)
		Seed primed	
T1: Water alone (Control)	92	38	2.42
T2: AA (50)	110	42	2.62
T3: CA (100)	99	39	2.54
T4: GA (10)	118	42	2.81
T5: AA (50) + CA (100)	107	40	2.68
T6: AA (50)+GA (10)	108	38	2.84
Mean	105.7	39.8	2.65
		Seed primed + Foliar Applied	
T1: Water alone (Control)	93	37	2.51
T2: AA (200)	96	38	2.53
T3: CA (400)	105	38	2.76
T4: GA (50)	108	41	2.63
T5: AA (100) + CA (200)	98	38	2.58
T6: AA (100)+GA (25)	108	36	3.00
Mean	101.3	38	2.67
LSD Application methods	8.4**	3.6**	0.36**
LSD Biochemicals	10.3*	4.6 ns	0.16**
LSD Interaction	14.6*	6.6 ns	0.23**

Table 6.24 Effect of applied biochemicals on seed cotton yield and GOT

Biochemicals (mg/L)	Seed cotton yield (kg ha ^{1})	GOT%
	Seed primed	
T1: Water alone	1870	36.6
T2: AA (50)	1990	36.8
T3: CA (100)	2080	38.0
T4: GA (10)	2170	41.8
T5: AA (50) + CA (100)	2060	38.5
T6: AA (50)+GA (10)	2155	39.2
Mean	2054	38.5
	Seed primed +Foliar Applied	
T1: Water alone	1891	38.3
T2: AA (200)	2100	38.8
T3: CA (400)	2215	40.2
T4: GA (50)	2334	43.0
T5: AA (100) + CA (200)	2171	39.8
T6: AA (100)+GA (25)	2232	41.3
Mean	2157	41.2
LSD Application methods	186.6**	10.3*
LSD Biochemical doses	75.2**	2.10**
LSD Interaction	106.4ns	2.97ns

The assessment of seed quality parameters was done from the mature cotton seeds. Results indicated that seed priming as well as seed priming plus foliar applied antioxidants (ascorbic acid and citric acid) and growth hormone (Gibberellic acid) improved parameters such as seed germination, seed index, oil and crude protein content. Biochemical analysis of the oil revealed that the free fatty acids were within safe limits i.e. less than1.0%. In seed primed treatments, seed germination varied from 70-89%, seed index from 6.97-8.34g, oil content from 13.2 to17.6 % and crude protein from 21.0 to 27.2 % in different treatments. While in seed primed plus foliar sprayed treatments, seed germination varied from 69-88%,

seed index from 6.75-8.15g, oil content from 13 to 19% and crude protein from 21.5 to 28.6 % in different treatments (Table 6.25).

Table 6.25 Effect of seed primed or foliar applied antioxidants and growth hormone on seed quality parameters

Biochemicals (mg/L)	pH	EC (µS cm^{-1})	Na (%)	K (%)	Seed index (g)	Germination (%)	Oil (%)	Free fatty acid (%)	Crude protein (%)
Seed primed									
T1: Water alone	6.3	171	0.81	0.74	6.97	70	13.2	0.98	21.0
T2: AA (50)	6.5	126	0.71	0.64	7.12	75	14.0	0.68	23.5
T3: CA (100)	6.2	134	0.69	0.69	7.22	80	13.8	0.70	21.7
T4: GA (10)	7.0	201	0.58	0.85	8.34	89	17.6	0.60	27.2
T5: AA (50)+CA (100)	5.8	187	0.69	0.67	7.68	87	15.7	0.64	26.1
T6: AA (50)+GA (10)	5.9	167	0.60	0.65	7.91	81	15.9	0.68	25.0
Mean	6.3	164	0.68	0.71	7.54	80	14.5	0.71	23.7
Seed primed + Foliar Applied									
T1: Water alone	5.2	169	0.75	0.69	6.75	69	13.0	0.80	21.5
T2: AA (200)	6.2	110	0.68	0.61	6.73	71	15.0	0.60	24.7
T3: CA (400)	6.5	104	0.59	0.58	7.11	73	16.0	0.63	21.7
T4: GA (50)	4.5	156	0.55	0.50	8.15	88	19.0	0.51	27.6
T5: AA (100)+CA (200)	5.1	165	0.57	0.62	7.36	85	17.4	0.59	27.5
T6: AA (100)+GA (25)	5.7	172	0.61	0.57	7.24	79	18.4	0.64	26.3
Mean	5.5	146	0.63	0.60	7.16	76.8	16.5	0.63	24.8

Data on fibre characteristics indicated that seed primed with antioxidants (ascorbic acid and citric acid) and growth hormone (Gibberellic acid) has non-significant effects on staple length, fibre strength, fibre fineness and uniformity index among different treatments and seed priming plus foliar applied treatments. In seed primed treatments, staple length ranged from 27.0 to 28.7 mm, fibre strength from 28.3 to 30.2 G/Tex, uniformity index from 81.4 to 84.7 and fibre fineness from 4.1 to 4.7. In seed primed plus foliar sprayed treatments, staple length ranged from 26.4 to 28.5 mm, fibre strength from 27.7 to 30.8 G/Tex, uniformity index from 81.2 to 84.7 % and fibre fineness from 4.0 to 4.8 (Table 6.26).

Table 6.26 Effect of seed primed or foliar applied antioxidants and growth hormone on fiber characteristics in different treatments

Biochemicals (mg/L)	Staple length (mm)	Uniformity index (%)	Micronaire	Strength G/Tex (1/8")
Seed primed				
T1: Water alone (Control)	27.0	81.4	4.1	28.3
T2: AA (50)	28.4	84.7	4.4	29.8
T3: CA (100)	28.5	83.2	4.5	30.1
T4: GA (10)	28.7	84.7	4.7	30.2
T5: AA (50) + CA (100)	28.6	83.2	4.5	29.8
T6: AA (50)+GA (10)	28.0	84.1	4.7	29.4
Mean	28.2	83.6	4.5	29.6
Seed primed +Foliar Applied				
T1: Water alone (Control)	26.4	81.2	4.0	27.7
T2: AA (200)	28.3	84.2	4.7	28.4
T3: CA (400)	28.1	84.0	4.6	28.7
T4: GA (50)	28.5	84.7	4.8	30.8
T5: AA (100) + CA (200)	27.7	83.7	4.3	28.0
T6: AA (100)+GA (25)	27.8	83.6	4.4	28.7
Mean	27.8	83.6	4.5	28.7

Visit of Agricultural Experts from SANIFA

Agriculture Experts from SANIFA Agri Services Ltd., Lahore visited CCRI Multan. The group was led by Mr. Moazzam Ahmed Sheikh, CEO SANIFA; Dr. Albert Galeos Santos, Breeding Consultant; Dr. Judith Kay Brown, Expert on CLCuV Monitoring Process in Pakistan and Mr. Muhammad Arshad, Consultant ICARDA.

Annual Review Meeting ICARDA Project

Cotton Project Review & Planning Meeting 2019 was held at ICARDA Office, NARC Islamabad on June 13, 2019. Ms. Jessica Mudjitaba-Fernandez Dr. Brian Scheffler, Dr. Jodi Scheffler (USDA-ARS) and Dr. Abdul Majid reviewed the progress. Representatives from various cotton research institutions from CCRI Multan, NIBGE, Faisalabad; CRS, Multan, Vehari & Faisalabad presented the progress of work done. The meeting deliberated upon review of previous year activities i.e., screening of exotic materials, breeding for CLCuV resistance/tolerance, and testing of materials (developed through US cotton germplasm) in the National Coordinated Varietal Trail (NCVT). Moreover, the modalities for preserving the cotton germplasm were also discussed. The meeting also discussed activities during carried out during the next year i.e., different sowing of filial generation, testing of CIM-303 & CIM-775 in NCVT, maintaining of photoperiod sensitive and CLCuV resistant US Germplasm for flower induction.

7. TRANSFER OF TECHNOLOGY SECTION

Transfer of Technology Section is playing a pivotal role to disseminate the research findings of cotton scientists in 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) Best agronomic practices for cotton production
iii) Soil Fertility & Health
iv) Organic Cotton Cultivation
v) Cotton Mealybug and its Management
vi) "Best Management Practices for Persistent Organic Pollutants"
vii) Weed Management
viii) Advanced breeding techniques for variety evolution
ix) Production Technology of new approved commercial cotton varieties
x) Seed Technologies
xi) Soil Health and nutrient management
xii) integrated pest management
xiii) Management of cotton diseases
xiv) Cotton crop management
xv) Causes of fibre traits deterioration in Pakistan
xvi) Management of PBW & sucking insect pests

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

Date	Organized/ Coordinated by	Venue	Resource Person	Participants
25.02.2019	WWF & CCRI,Multan	CCRI, Multan	i.Dr. Zahid Mahmood ii.Dr.Fiaz Ahmed iii.Dr.M.Naveed Afzal	Farmers=100 WWF Staff=05
05.03.2019	CCRI,Multan	-do-	i.Dr.Khalid Abdullah ii.Dr.Zahid Mahood iii.All heads of sections	Private Sectors=73 NGO's=14
March 11-12,2019	CABI & CCRI,Multan	-do-	i.Dr.Zahid Mahmood ii.Dr.M.Naveed Afzal iii.Mr.Sajid Mahmood	Master Trainees
18.03.2019	WWF & CCRI,Multan	-do-	.Dr.Zahid Mahmood ii.Dr.M.Naveed Afzal iii.Mr.Sajid Mahmood	Farmers =102 WWF Staff= 04
29.03.2019	WWF & CCRI,Multan	CCRI, Multan	i.Dr.M.Naveed Afzal ii.Mr.Sajid Mahmood	Field Facilitators(FF)=49 WWF Staff =05
01.04.2019	WWF & CCRI,Multan	CCRI, Multan	i.Dr.Zahid Mahmood ii.Dr.M.Naveed Afza	Farmers=62 FF = 13 WWF Staff =05
02.04.2019	WWF & CCRI,Multan	-do-	i.Dr.Zahid Mahmood ii.Dr.M.Naveed Afzal	Farmers =73 WWF Staff= 04
23.04.2019	WWF-Pakistan, Shuja Abad & CCRI ,Multan	CCRI, Multan	i.Dr.Zahid Mahmood ii.Dr.M.Naveed AfzaL iii.Dr.Fiaz Ahmed iv.Dr.Rabia Saeed	Producer Unit Manager 50
30.04.2019	Sangtani (NGO) & CCRI,Multan	CCRI, Multan	i. Dr.Zahid Mahmood ii.Dr.M.Naveed AfzaL	Producer Unit Manager
13.07.2019	WWF Pakistan, CCRI & Agri Ext Deptt, Balochistan	Baluchistan	i.Dr.Zahid Mahmood	Producer Unit Manager & farmers = 50

05.09.2019	CCRI,Multan	CCRI,Multan	i.Dr.Zahid Mahmood ii.Dr.Rabia Saeed iii.Ms.Shabana Wazir iv.Dr.Iqbal Arif	Master Trainees, Agri.Ext. Deptt.Punjab = 20
06.09.2019	Ministry of Climate Change, UNDP and CCRI Multan	CCRI,Multan	i.Dr.Zahid Mahmood ii. Mr. Aman Qureshi iii. Mr. Azhar Qureshi	Officers from different departments and Disciplines =34
12.09.2019	PCSI,Multan	CCRI,Multan	i.Dr.Zahid Mahmood ii. Dr.M.Naveed Afzal	Cotton Selectors = 13
03.10.2019	CCRI,Multan & Agr.Ext.Deptt.Punjab	CCRI,Multan	i.Dr.Zahid Mahmood ii.Dr.M. Naveed Afzal	Master Trainees, Agri.Officers, Department Punjab from RAEDC Vehari = 12
02.10.2019	CCRI,Multan	-do-	i.Dr.M. Naveed Afzal ii.Mr.Ilyas Sarwar	Cotton Growers from WWF-Bahawalpur= **60**
25.10.2019	CCRI,Multan	CCRI, Multan	-do-	WWF-Cotton growers , RYK = 30
29.10.2019	-do-	-do-	i.Dr.Zahid Mahmood ii.Dr.M. Naveed Afzal	WWF-Facilitators, Multan-Pakistan = 75
19.11.2019	CCRI, Multan & Agr.Ext.Deptt. Sindh	-do-	Dr. Zahid Mahmood	Agriculture Officers from Agriculture Extension Department Sindh = 20
11.02.2020	CCRI & Sangtani,NGO	CCRI, Multan	Dr.Muhammad Naveed	Field Officers = 32
12.02.2020	PCSI & CCRI	CCRI, Multan	Dr.Zahid Mahmood	Cotton Selectors = 30

7.1.2 TV Programs/Tellops

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

Date	TV Channel	Topic	Resource Person	Remarks/ Timing
25.02.2019	GNN, Multan	Economics of Cotton	Dr.Zahid Mahmood	03-mintutes
-do-	-do-	Soil Fertility & Health	Dr.Fiaz Ahmed	04-mintutes
-do-	-do-	WWF training program	Mr.Sajid Mahmood	03-mintutes
05.03.2019	Rohi/24-channel	Cotton situation 2018 and next planning for cotton crop 2019	Dr.Khalid Abdullah	03-minutes
-do-	-do-	Free Seed Germination Test	Dr.Zahid Mahmood	05-minutes
-do-	-do-	Objectives of training program	Mr.Sajid Mahmood	03-minutes
07.03.2019	-do-	Planning & strategy to get 15M cotton bales target in 2019	Dr.Zahid Mahmood	05-minutes
09.03.2019	-do-	Strategy for enhancement of Cotton Production Technology	Dr.Zahid Mahmood	07-minutes
18.03.2019	Rohi/24-channel	Objectives of Training Program & next planning for coming cotton crop	Mr.Sajid Mahmood	03-Minutes
08.04.2019	Geo News	Importance of Cotton and role of Government	Dr.Khalid Abdullah	03-mintutes
09.04.2019	Rohi	Objectives of ARSC meeting	Dr.Tasawr Malik	05-mintutes
-do-	-do-	Role of CCRI in cotton production technology	Dr.Zahid Mahmood	03-mintutes
10.04.2019	PTV ,Wisaakh	کپاس کی ا□میت ،ضرورت اور حکومتی کردار	Dr.Khalid Abdullah	30-mintutes
23.04.2019	Rohi	Free Seed Germination Test	Dr.Zahid Mahmood	23.04.2019
21.05.2019	Rohi/Channel-24	Recommendations for cotton growers	-do	21.05.2019
10.06.2019	PTV	Role of Government for enhancement of cotton production	Dr.Khalid Abdullah	03-mintutes
-do-	Rohi	Unhealthy Seed of cotton supply In Punjab	-do-	12-mintutes
27.06.2019	Public TV	Role of MNFSR for enhancement of cotton production	Dr.Khalid Abdullah	03-mintutes
-do-	Sach TV	Suggestions for better cotton	Dr.Zahid Mahmood	04-mintutes

		yield		
11.07.2019	Rohi	Fruit Shedding and its management	Dr.Fiaz Ahmed	03-minutes
02.10.2019	Public TV	Irrigation and fertilizer management for the current cotton crop.	Dr.Zahid Mahmood	03-mintutes
18.08.2019	Rohi TV	Current Cotton Crop Situation	-do-	04-minutes
05.09.2019	Rohi TV	Objectives of Cotton Mealybug and its Management Training Program	Dr.Zahid Mahmood	03-mintutes
20.09.2019	Neo News & Geo	Role of PCCC in cotton research & development	Dr.Khalid Abdullah	03-minutes
-do-	-do-	Economic importance of cotton and the varieties developed by the institute.	Dr.Zahid Mahmood	03-mintutes
07.10.2019	Rohi,Express, Channel-24, Abtak	Objectives of World Coton Day (WCD)	Dr.Zahid Mahmood	03-mintutes each channel
09.10.2019	PTV,Multan	Cotton in present scenario	i.Dr.Khalid Abdullah ii.Dr.Zahid Mahmood	28-minutes
03.02.2020	PTV	Causes of decline in cotton production in Pakistan	Dr. Neil Forrester, Cotton Expert from Australia	06-minutes
-do-	Rohi	-do-	-do-	03-minutes
06.02.2020	NeoTV	Cotton Boll Picker Machine against PBW management	Dr.Zahid Mahmood	03-minutes
-do-	Rohi	-do-	-do-	03-minutes
-do-	Rohi,Khait Khalyaan	-do-	-do-	10-minutes
12.02.2020	ARY	Cotton Boll Picker Machine against PBW management	i.Dr.Zahid Mahmood ii.Mr.Sajid Mahmood	05-mintutes
20.02.2020	92- Channel	قدرتی رنگدار کپاس کی تیاری	Dr.Zahid Mahmood	03-minutes
-do-	SAMA TV	-do-	-do-	-do-

7.1.3 Radio Programs

The following radio programs were recorded during the season:

Date	Radio	Topic	Resource Person	Remarks
12.03.2019	Radio, Multan	Talk on "TeleCotton & Free seed germination lab test	Dr. Zahid Mahmood	Recorded 5-minutes
-do-	-do-	Talk on "cotton seed for better yield and selection of varieties"	-do-	Recorded 3-minutes
-do-	-do-	Talk on "Land preparation for cotton cultivation"	Dr.M.Naveed Afzal	Recorded 5-minutes
-do-	-do	Talk on "Soil fertility & importance of soil analysis"	Dr.Fiaz Ahmed	Recorded 3-minutes
21.03.2019	-do-	کپاس کا بیج□اقسام اور ان کی پیداواری □یکنالوجی	Dr.Idrees Khan	Recorded 5-minutes
-do-	-do-	کپاس کی کاشت س□ پ□ل□ زمینی تجزی□ کی ا□میت	Dr.Fiaz Ahmed	-do-
-do-	-do-	کپاس کی گلابی سن□ی کا غیر موسمی تدارک	Mr.Sajid Mahmood	-do-
17.02.2020	-do-	Panel discussion on "Indiscriminate use of pesticides and its effects on crops	i.Dr.Zahid Mahood ii.Dr.Fiaz Ahmed iii. Dr.M.Aslam iv. Fiaz Ahmed	-do-

7.1.4 Media Coverage

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

Media Coverage	
25.02.2019	WWF-Pakistan training program for farmers
05.03.2019	Training program for private sector & NGO's
18.03.2019	WWF-Pakistan training program for farmers
01.04.2019	Awareness Campaign Walk for Cotton/All media participated
08.04.2019	ARSC day 1st / Bol TV & Geo News
09.04.2019	ARSC day 2nd / Rohi Live & Recorded
10.04.2019	ARSC day 3rd / Rohi
12.04.2019	1st meeting of Cotton Crop Management Group (CCMG)

23.04.2019	Training Program PU-Managers WWF
26.04.2019	87th Meeting of PCCC Governing Body
10.06.2019	2nd meeting of Cotton Crop Management Group (CCMG)
26.06.2019	Cotton Crop Revival Committee Meeting
24.07.2019	Punjab Agricultural Research Board (PARB) Meeting/Media Coverage
29.07.2019	3rd meeting of CCMG/Media Coverage & Press Conference
05.09.2019	Cotton Mealybug and its Management Training Program
23.08.2019	4th meeting of CCMG/Media Coverage & Press Conference
05.09.2019	World Cotton Day Program

7.1.5 Press Conference

i. Press Conference with Live Rohi TV regarding the conclusion of three consecutive days meeting of ARSC here at CCRI Multan from April 8-10, 2019 was conducted by Dr. Khalid Abdullah, Cotton Commissioner/VP, PCCC on last day of ARSC meeting.

ii. Media Talk of Malik Nauman Ahmad Langrial, Minister for Agriculture & Mr. Jahangir Khan Tareen, progressive cotton grower on April 12,2019 after CCMG meeting

7.1.6 Media Talk

The section arranged a media talk on January 27, 2020 of Cotton Commissioner/Vice President, PCCC Dr.Khalid Abdullah with Associated Press of Pakistan (APP) regarding the overview of cotton crop 2019-20 and future strategy.

7.1.7 Preparation of Video Clips

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

Date	Topic
25.02.2019	WWF Coton Training Program at CCRI:Report
07.03.2019	کپاس کی سفید مک□ی اور گلابی سن□ی کا کن□رول:□اک□ر ظ□ور احمد
08.03.2019	سی سی آر آئی ملتان می□ □ری□ننگ پروگرام کا احوال
13.03.2019	ب□تر پی□داوار ک□ لئ□ کپاس کی اقسام کا انتخاب:□اک□ر ادری□س خان
14.03.2019	بی □ی اور نان بی □ی کپاس کا فرق معلوم کرنا: □اک□ر خادم حسین
23.03.2019	Importance of soil analysis before cotton cultivation:Dr Fiaz Ahmed
25.03.2019	Importance of soil analysis before cotton cultivation:Dr.Fiaz Ahmed
27.03.2019	CCRI Cotton Varieties and their Production Technology :Dr.Idrees Khan
21.04.2019	CCRI Cotton Varieties:Dr.Idrees Khan
22.04.2019	Seed Treatment before Cotton Cultivation
26.04.2019	Demonstration of delinted seed grader at CCRI Multan.
07.05.2019	Land Preparation for cotton after wheat harvesting:
08.05.2019	Recommendations for cotton cultivation at early days
13.05.2019	Balanced use of fertilizers for cotton crop
14.05.2019	Cotton seed priming
26.06.2019	کا پ□ل گرنا،وجو□ات اور سدباب:□اک□ر فی□اض احمدکپاس

7.1.8 Press Releases

Fifty-Six (56) press releases throughout the season were sent to print media from press time to time for publication.

7.1.9 Articles

Nine (09) Urdu articles with up to date recommendations were composed and sent to the print media for the guidance of cotton growers during the season.

7.1.10 Tele-Cotton SMS Service

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

a. Forty two (42) 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 (2000) clients of Tele-Cotton were registered in database during the season.

Capacity Building Seminar "Scientific Presentation Skills"

CCRI Multan organized a training session on "Scientific Presentation Skills" for the scientific staff of the Institute. Mr. Habib ur Rehman, Technical Manager, BayerCrop Sciences was the resource person.

Training Program

CCRI, Multan organized one-day training program on "Cotton Production Technology" for the technical field staff of Sangtani Women Rural Development Organization (SWRDO) Rajanpur. A group of 22 field staff led by Mr. Abdul Latif, Senior Producer Unit Manager attended the training program.

7.1.11 Posts for Social Media

No. of posts regarding "Recommendations for Cotton Production Technology" were prepared and uploaded on official FB page of the Institute during the season.

7.1.12 Preparation of Leaflet

The section composed & got printed the following leaflet during the season:

Sr#	Leaflets	Nos.
1.	□□□□□ ملتان، □وی□ی□ انس ریسرچ کا□ن سن□رل ایک تعارف	2000
2.	Bt.CIM-343	2000
3.	Bt.CIM-663	2000

7.1.13 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*

7.1.14 Agriculture Exhibitions

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

Date	Organized by	Venue	Resource Persons
October 9-10,2019	MNSUA,Multan	MNSUA,Multan	i. Junaid Ahmad Khan ii. Dr.Khadim Hussain

7.2 Meetings

7.2.1 Agriculture Research Sub-Committee (ARSC)

Three days consecutive meeting of Agriculture Research Sub-Committee (ARSC) of Pakistan Central Cotton Committee (PCCC) was held at Central Cotton Research Institute (CCRI), Multan on April 8-10, 2019 under the chairmanship of Dr. Khalid, Abdullah, Vice President (PCCC)/Cotton Commissioner, MNFSR. The agenda of the meeting was the consideration of Annual Summary Progress Report for the year 2018-19 and the approval of Annual Program of Research Work for the year 2019-20.

The meeting was attended by all members of the subcommittee PCCC offices, other public stakeholders, private seed sector and progressive farmers. The section provided all type of technical facilities to organize the meeting.

7.2.2 Cotton Crop Management Group (CCMG)

Following four (04) Cotton Crop Management Group (CCMG) meetings were held at the Institute during the season:

Date/Venue	Chaired by/Special guests
12.04.2019 CCRI,Multan	i. Malik Nauman Ahmad Langrial, Minister for Agriculture, Punjab ii. Mr. Jahangir Khan Tareen, progressive cotton grower iii.Dr. Khalid Abdullah,Cotton Commissioner, Mintex
10.06.2019 CCRI,Multan	Malik Nauman Ahmad Langrial, Minister for Agriculture, Punjab iii.Dr. Khalid Abdullah,Cotton Commissioner, Mintex
29.07.2019 CCRI,Multan	i.Malik Nauman Ahmad Langrial, Minister for Agriculture, Punjab ii. Mr. Jahangir Khan Tareen, progressive cotton grower iii.Dr. Khalid Abdullah,Cotton Commissioner, Mintex
23.08.2019 CCRI,Multan	i.Malik Nauman Ahmad Langrial, Minister for Agriculture, Punjab ii. Mr. Jahangir Khan Tareen, progressive cotton grower iii.Dr. Khalid Abdullah,Cotton Commissioner, Mintex

Meeting was attended by all the stakeholders of cotton sector 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.

7.2.3 National Assembly Standing Committee

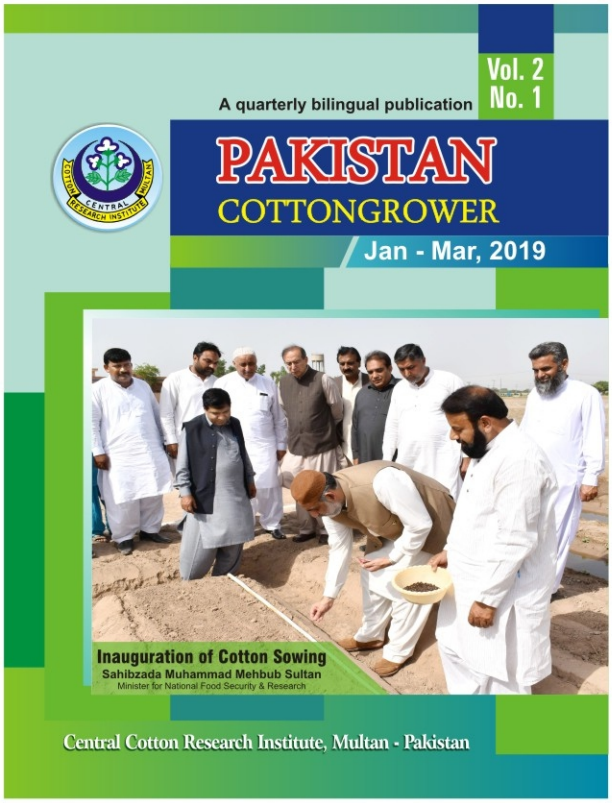
A meeting of the National Assembly Standing Committee on Food Security & Research was held at PARC Islamabad on March 29, 2019. Dr. Zahid Mahmood, Director CCRI Multan attended the meeting with other participants.

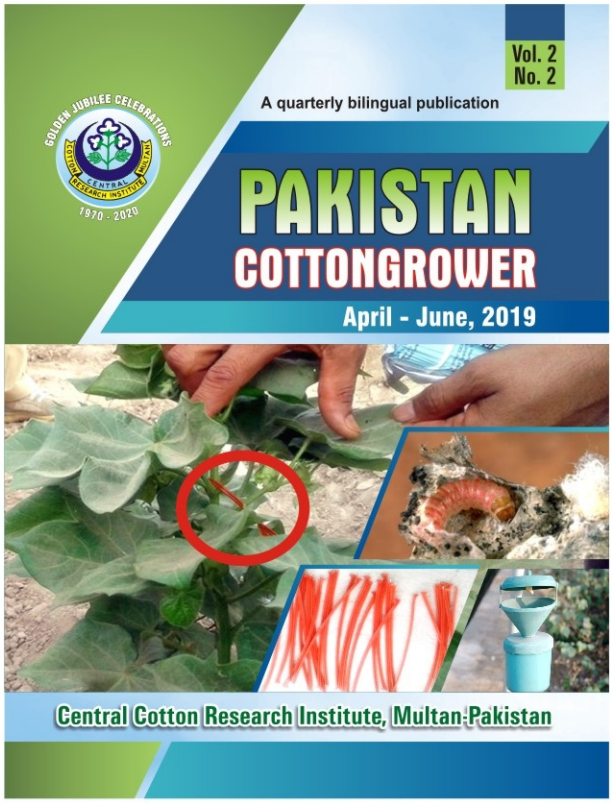
7.2.4 Cotton Crop Assessment Committee (CCAC)

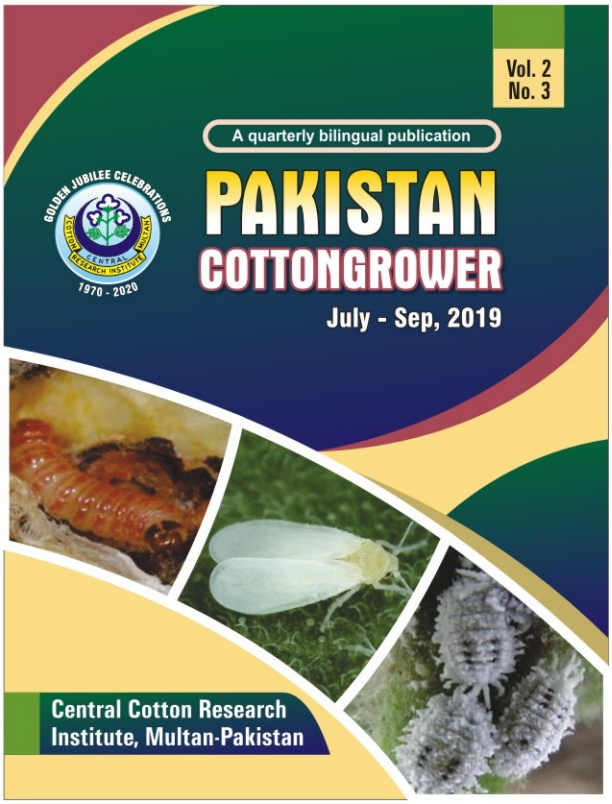
First meeting of Cotton Crop Assessment Committee (CCAC) was held at October 4 2019 under the chairmanship Additional Secretary, Ministry of National Food Security & Research, Islamabad. Representatives of Provincial Governments of Sindh and Punjab, Plant Protection Department (PPD), Trading Cooperation of Pakistan (TCP), Federal Seed Certification & Registration Department (FSC&RD), Pakistan Central Cotton Committee (PCCC), All Pakistan Textile Mills Association (APTMA), Pakistan Cotton Ginners Association (PCGA), Karachi Cotton Association (KCA), and Cotton Growers attended the meeting. The Committee met to assess the volume of current cotton crop in the country. The Chair welcomed the participants and appreciated the stakeholders' interest and participation in the process of cotton crop assessment and described the objectives of the meeting. Dr. Khalid Abdullah, Cotton Commissioner, dilated the overview of cotton production scenario in the country. Challenges faced by the cotton crop especially high input prices, insect pests pressure and higher temperature were discussed in detail. Dr. Zahid Mahmood, Director CCRI Multan appraised the house about cotton crop condition in the Punjab province and status of insect pest pressure.

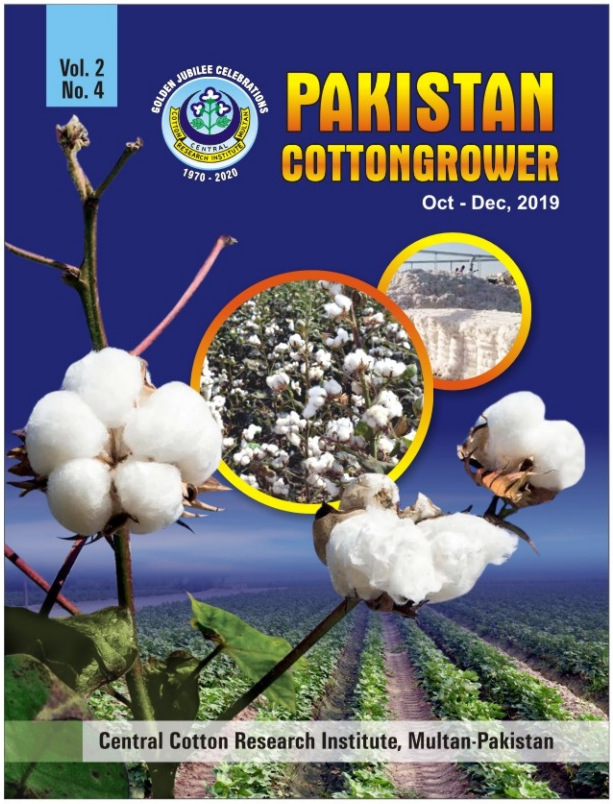
7.2.5 87th meeting of the Governing Body of PCCC

The 87th meeting of the Governing Body of PCCC was held at CCRI Multan on April 26, 2019, under the chairmanship of Sahibzada Muhammad Mehboob Sultan, Minister for National Food Security & Research. Dr. Muhammad Hashim Popalzai, Secretary, MNFS&R also co-chaired the meeting. Dr. Khalid Abdullah, Vice President PCCC apprised the house about the deliberations of various sub-committees, performance of the organization and future program including the restructuring of the PCCC. Moreover, measures for achieving the cotton production target of 15 million bales


Vol. 2
No. 1
A quarterly bilingual publication
PAKISTAN
COTTONGROWER
Jan - Mar, 2019
Inauguration of Cotton Sowing
Sahibzada Muhammad Mehbub Sultan
Minister for National Food Security & Research
Central Cotton Research Institute, Multan - Pakistan


Vol. 2
No. 2
A quarterly bilingual publication
GOLDEN JUBILEE CELEBRATIONS
1970 - 2020
PAKISTAN
COTTONGROWER
April - June, 2019
Central Cotton Research Institute, Multan-Pakistan


Vol. 2
No. 3
A quarterly bilingual publication
GOLDEN JUBILEE CELEBRATIONS
1970 - 2020
PAKISTAN
COTTONGROWER
July - Sep, 2019
Central Cotton Research
Institute, Multan-Pakistan


Vol. 2
No. 4
GOLDEN JUBILEE CELEBRATIONS
1970 - 2020
PAKISTAN
COTTONGROWER
Oct - Dec, 2019
Central Cotton Research Institute, Multan-Pakistan

were also discussed. Dr. Muhammad Hashim Popalzai, Secretary, MNFS&R informed that efforts are underway for reforming PCCC as a vibrant organization and effective functioning of its various units.

7.2.6 Expert Sub-Committee

79th Meeting of Expert Sub Committee of Punjab Seed Council was held at Faisalabad under the chairmanship of Dr. Abid Mahmood,Agri (Research),Punjab at AARI, Faisalabad on July18 ,2019.Dr.Zahid Mahmood, Director of the Institute attended the meeting with other participants. Two varieties i.e CIM-343 & CIM-663 of CCRI Multan were recommended for approval in the meeting.

7.2.7 Cotton Crop Revival Committee

The 1st meeting of the Cotton Crop Revival Committee" was held at CCRI Multan on June 27, 2019 under the chairmanship of Ali Arshad, Additional Secretary (Task Force). The Committee was constituted during the CCMG meeting held on 10.06.2019, while observing the continuous decline in cotton production in the Punjab province. The objective of the Committee is to chalk out short term plan/strategies for the effective management of cotton crop 2019-20 and devise long term strategy for revival of cotton crop in the Punjab province. The participants deliberated upon short and long term strategies for the improvement in cotton productivity. The proposed strategies cover all aspects such as supporting cotton farmers, provision of quality inputs at affordable prices, improvement in cotton research programs etc. The recommendations, thus finalized will be presented to the provincial government and relevant departments for implementation.

7.2.8 Punjab Agricultural Research Board (PARB)

Project review meeting of the PARB-Funded Projects (Cotton Whitefly, Pink Bollworm) was conducted at the institute on July 24, 2019 under the chairmanship of Prof Dr Jalal Arif, Project Manager (PARB) / Chairman, Department of Entomology, University of Agriculture, Faisalabad. The objective of the meeting was to review of research and development activities for the management of Cotton Whitefly and Pink bollworm. Principal Investigators of each component attended the meeting and presented their reports. Dr. Jalal Arif appreciated the work done so far and advised for formation of uniform strategies for the management of these pests.

7.2.9 Meeting of Cotton Leaf Curl Virus

A meeting on "Cotton leaf curl virus disease management" was held at Agriculture House, Lahore on March 8, 2019 under the chairmanship of Malik Nauman Ahmed Langrial, Minister for Agriculture, Punjab. Dr. Albert from USA delivered a presentation on the topic. Dr. Khalid Abdullah, VP PCCC and Dr. Zahid Mahmood, Director CCRI Multan also attended the meeting with other participants.

7.2.10 Kharif Crops 2019

An Expert Committee meeting was held at Agriculture House, Lahore on March 19, 2019 to finalize the Annual Research Program of Adaptive Research for Kharif 2019. Dr. Zahid Mahmood, Director, CCRI Multan attended the meeting and apprised about the cotton planning and measures to be taken for enhancing cotton productivity during the year 2019 in the Punjab province.

7.2.11 Cotton production and its decline

A stakeholder meeting on the "Cotton production and its decline" was held at University of agriculture Faisalabad arranged jointly by Pakistan Central Cotton Committee & Department of Entomology, University of Agriculture Faisalabad on September 20,2019. The meeting was chaired by Former Speaker National Assembly and Kashmir Committee Chairman Syed Fakhar Imam. He said that agriculture sector is a powerful sector that provides employment 43 percent of the total workforce. He said

that neighboring countries are progressing at a fast pace whereas and Pakistan is far-lagging behind in modern agriculture practices coupled with bio technology. He added that no nation can make progress in the modern era without investing in Human Resource Development. UAF Vice Chancellor Dr Muhammad Ashraf said that the climate resilient varieties of the cotton are need of the hour to fight the challenge.

Prof Dr Jalal Arif in this welcome said that on the direction of the Vice Chancellor, the meeting is arranged to come up with viable solution for better cotton production Talking about short term strategies stressed upon the need to availability of Irrigation Water During Sowing Time, training of cotton growers/dealers about production technology of cotton varieties, spraying techniques and installation/usefulness of PB ropes, implementation of off-season management of Pink bollworm and whitefly, local manufacturing and availability of pheromone and PB ropes. Dr. Khalid Abdullah, Cotton Commissioner/Vice President, PCCC stressed the scientists to acquire new technology in cotton research field. He added more we need educated farmers, because agriculture is a science. Dr. Zahid Mahmood, Director of the institute discussed the economic importance of cotton and the varieties developed by the institute. Cotton researchers, agriculture research, extension and plant protection officials, academicians, representatives of private pesticide associations, and progressive cotton growers attended the meeting.

7.2.12 Kharif and Rabi crops

Meeting for fixation of procurement and multiplication targets for Kharif and Rabi crops seed for the year 2019-20 was held on 29th August, 2019 under the chairmanship of Dr. Ghazanfar Ali, Managing Director, Punjab Seed Corporation. The meeting deliberated upon procurement targets of seed for cotton, paddy, mung, maize, sorghum/guar. Dr. Zahid Mahmood, Director CCRI Multan attended the meeting and uprised the house about cotton crop situation in the province.

7.2.13 Cotton Research & Development Board (CR&DB)

A meeting of Cotton Research & Development Board (CR&DB) was held on June 24, 2019 in the seminar room of Mango Research Institute, Multan. The meeting apprised about the current cotton crop situation and measures to develop short and long term strategy for the betterment of cotton production in Punjab province.

Dr. Zahid Mahmood, Director CCRI Multan attended the meeting and deliberated upon initiation of extensive training programs for the cotton farmers, Pink bollworm management and provision of PB Ropes to the farmers and ensuring pesticide availability during the current season. He also ensured that CCRI Multan will work shoulder-to-shoulder with the Agriculture Extension Department for the guidance of farmers.

The meeting was chaired by Mr. Sohail Mehmood Harral, Chairman, Cotton Research & Development Board, Multan and attended by the cotton researchers, academicians, and other stakeholders.

7.2.14 Cotton Production under Changing Climatic Conditions

CCRI Multan in collaboration with Pakistan Meteorological Department organized one-day awareness program about “Cotton Production under Changing Climatic Conditions” on November 18, 2019. Mr. Muhammad Ajmal Shad, Director, Regional Meteorological Center Lahore talked about “Pakistan Meteorological Scenario and Crop Cultivation” while Dr. Shakeel Ahmad, Chairman Agronomy Department, Bahauddin Zakariya University delivered talk on “Adaption to Climate Change”. Dr. Rabia Saeed, Head Entomology CCRI Multan delivered talk about “Impact of Climate on Insect Pest of Cotton”. Prof. Dr. Jalal Arif, Dean, Faculty of Agricultural Sciences, University of Agriculture Faisalabad; Mian Ahsan ul Haq Laleka, Mr. Khurshid Ahmad Kanjo, Seed Association of Pakistan, agriculture extension officials and farmers attended the program.

Dr. Zahid Mahmood, Director CCRI Multan briefed about challenges for cotton production. He described that during the current decade, cotton production has severely been affected due to rising temperatures and onslaught of heavy and prolonged rains.

Collaborative efforts required for proper dissemination of weather advisories and rain forecast at district level so that decisions for pest control and crop irrigation could well be taken.

7.2.15 Cotton Review Committee

While observing the downfall in cotton production during the crop season 2019, the Federal Government constituted "Cotton Review Committee" under the chairmanship of Prof. Dr. Asif Ali, Vice Chancellor, MNSUA, Multan. The Committee was constituted to evaluate the lower production in the year 2019-20 and make recommendations for the coming years. The first meeting was held at MNSUA Multan on Nov 14, 2019. Cotton researchers from Punjab and Sindh; academicians, representative from Federal Plant Protection Department and progressive grower attended the meeting. The second session of meeting was held with stakeholders as well.

Dr Khalid Abdullah, Cotton Commissioner briefed about cotton production scenario in the country. He presented data on decreasing cotton acreage, flare up of Pink bollworm, and marketing issues confronting cotton production. Prof Dr Asif Ali, Vice Chancellor MNSUA Multan stressed for devising solid recommendations for improving cotton productivity and their strict implementation by all stakeholders. He also stressed for technology development and its proper dissemination to the farmers.

7.2.16 Better Cotton Initiative (BCI) for Sustainable Cotton Production in Pakistan"

Dr. Khalid Abdullah, Cotton Commissioner/Vice President, Pakistan Central Cotton Committee (PCCC) chaired the Consultative Meeting on the Project "Better Cotton Initiative (BCI) for Sustainable Cotton Production in Pakistan" at PCCC, HQ, Multan on November 14, 2019. Dr. Zahid Mahmood, Director CCRI Multan, and Mr. Hidayatullah Bhutto, Director CCRI Sakrand also present.

7.2.17 Farmer's Advisory Committee

Fourteen fortnightly Farmer's Advisory Committee meetings were conducted during the season start from April 19, 2019 to December 3, 2019 under the chairmanship of Dr. Zahid Mahmood, Director CCRI Multan The Farmers Advisory Committee(FAC) comprises of Dr. Muhammad Naveed Afzal, Head, Agronomy, Dr. Muhammad Idrees Khan, Head, Plant Breeding; Dr. Fiaz Ahmad, Head Plant Physiology, Ms. Sabahat Hussain ,Head, Pathology, Dr. Rabia Saeed, Head Entomology and Mr. Sajid Mahmood, Head Technology Transfer.

7.3 Seminar

The following seminars were conducted during the the season:

Date/Venue	Title	Organized by	Resource Person	Participants
February 27-28,2019 CCRI, Multan	"2-Community Level Awareness Raising Seminar on Fundamental Principles and Rights at Work (FPRW)"	ILO & CCRI ,Multan	Dr. Zahid Mahmood Sajid Mahmood i03 from ILO	Farmers Male=51 Female = 67
March 21, 2019	High Profile Cotton Seminar 2019	Islamia University of Bahawalpur	Dr. Khalid Abdullah Dr. Zahid Mahmood,	Farmers, Academics,= 1500
March 30,2019/ Shujabad	"Cotton Production Technology"	WWF & CCRI,Multan	Dr. Zahid Mahmood	Farmers=327 WWF Staff =14
April 03, 2019	"Profitable Cotton Production"	FFC	Dr. Zahid Mahmood	Farmers, Academics, Researchers = 65
July 16, 2019	"Sustainable Agricultural Production"	Pedaver Foundation, Lahore & CCRI, Multan	Dr.Zahid Mahmood Mr. Asif Sharif, Chairman, Pedaver Foundation, Lahore	Farmers = 35
August 28, 2019	"Clean Cotton Production"	CCRI Multan and WWF Pakistan	Dr.Zahid Mahmood Mr. Abdul Rasheed Bhutto, WWF	Farmers = 200

7.4 Participation in Workshop/Conference

Date	Workshop/Conference	Venue	Organized by	Participants
March 26-27, 2019	"2-Community Level Awareness Raising Conference on Fundamental Principles and Rights at Work (FPRW)"	Karachi	International Labour Organization (ILO)	Dr.Zahid Mahmood
June 12,2019	Workshop on ""To Review Developed Standards for Harvest & Post-Harvest Operations of Cotton Value Chain"	Multan	WWF-Pakistan	Dr. Zahid Mahmood
November ,12-13 2019	Conference on "Plant Genetic Resources Use in Pre Breeding and Varietal Development Practices"	University of Sargodha	FAO	Dr. Zahid Mahmood Dr.Idrees Khan
January 20-24, 2020	Workshop on "Media Management in Government"	Islamabad	Secretariat Training Institute, Establishment Division, GOP	Mr. Sajid Mahmood

7.5 Visits

a. Dignitaries

Dignitaries/Delegation	Dated
Mr. Bilal Israel Khan and Mr. Ibrahim Khan progressive cotton farmers	01.03.2019
Haji Irfan Ahmad Khan Daha, former minister and Mr. Muhammad Khan Daha, MNA	08.04.2019
2-member agriculture researchers from Pakistan Agriculture Research Council (PARC)	03.05.2019
Prof Dr Idrees Ahmad Nasir, Head, Seed Biotechnology Research Group from Center of Excellence in Molecular Biology (CEMB), Lahore	20.06.2019
Mr. Arif H. Makhdum, Country Manager and Mr. Toheed Ghani Mahesar, Supply Chain Consultant, Cotton Connect Pakistan	26.08.2019
Dr. Abdul Majeed, Country Manager ICARDA; Mr. Muhammad Arshad, Cotton Consultant and Ms Sameera Younas, Consultant, ICARDA	16.09.2019
The delegation from FAO comprising Ms Jessie Fagan, Decent Rural Employmenet Consultant; Ms Ariane Genthon, Child Labour Expert; Dr. Shakeel Ahmad Khan, Seed Sector Consultant and Mr Jam Muhammad Khalid, Participatory CSA Extension Specialist	25.09.2019
4-member delegation from ICI, Pakistan	05.11.2019
9-member Chinese delegation led by Mr. Wen Wanhe, Group Leader, CMEC International, China	06.11.2019
Dr. Muhammad Anjum Ali, Director General Agriculture (Ext.) Punjab	02.12.2019
Mr. Muhammad Yasin, Cotton Botanist CB from Cotton Research Institute, Khan Pur and its team ; Mr. Taj Muhammad, Assistant Agronomist, Dr. Abdul Khaliq, and Mr. Abdul Raoof, ARO.	10.12.2019
Mr. Manzoor Hussain Soomro, Agriculture Specialist SIAPEP, Hyderabad Sindh; Dr. Abdul Sattar Buriro, Coordinator Exposure	15.12.2019
Mr. Muhammad Umar Iqbal, Master Agronomist, BCI,Lahore	14.01.2020
Makhdum Ahmad Alam Anwar, former chairmanship National Assembly Standing Committee on Agriculture	20.01.2020
Mr. Bilal Israel, Progressive Grower & Dr. Muhammad Shakeel, Entomologist	23.01.2020
Mr. Mirpayoz Mirsaatov, Head, Foreign Economic Relations Department, Uzbekistan Agrotech Trading Company	26.01.2020
Dr. Khalid Abdullah, Vice President, PCCC	27.01.2020
Ms Rabia Sultan, progressive cotton farmer from Muzafargarh	02.02.2020
Dr. Neil Forrester, Cotton Expert from Australia along with Cap.(R) Arif Nadeem and Professor Muhammad Aslam Rana,LUMS,Lahore	03.02.2020

b. Student Study Tour

Name of University/Institution	No. of Participants
University of Agriculture, Faisalabad	384
University College of Agriculture, BZU, Multan	27
Agricultural Training Institute, Karor, Layyah	44
Pak German Polytechnic Institute for Agriculture Technology, Chak 5 Faiz, Multan	36
Govt.College of Technology ,Textile department ,DAE	49

c. NIM Delegations

26th Mid-Career Management Course, NIM, Lahore

The officers of 26th Senior Management Course, National Institute of Management, Lahore visited CCRI Multan in connection with Inland Study Tour Program on November 4, 2019. Dr. Zahid Mahmood, Director CCRI Multan briefed about activities of the Institute to the visiting officers. Participants also visited Entomology Laboratories of the Institute and appreciated the research work conducted by the scientists.

28th Mid-Career Management Course, NIM, Karachi

A group of 26 member trainees from 28th Mid-Career Management Course (Inland Study Tour) from National Institute of Management, Karachi visited CCRI Multan on October 17, 2018. Dr. Muhammad Naveed Afzal, Senior Scientific Officer, CCRI Multan briefed about the cotton research & development activities carried out at the Institute. Participants also visited Entomology Laboratories of the Institute and appreciated the research work conducted by the scientists.

d. Other Activities

14th August Ceremony

Hoisting of National Flag ceremony was held on 14th August, 2019. Dr. Muhammad Naveed Afzal, Head/Agronomy Section, CCRI Multan hoisted the national flag. The staff members along with their kids also participated in the ceremony and prayed for the prosperity of the country. National anthem was also sung in the ceremony.

Tree Plantation Campaign

Similar to the rest of the Country, the Prime Minister's Monsoon Tree Plantation Campaign launched at CCRI Multan by planting of Terminalia (Plant) on August 8, 2019. Speaking at the occasion, Dr. Zahid Mahmood, Director CCRI Multan stated that the basic objective of the tree plantation campaign is to improve the environment and economic sustainability. He further added that protection of the environment is a National Cause and tree plantation is imperative to control the growing pollution. Therefore, everybody should contribute in this Nobel cause by planting tree plants.

World Cotton Day Celebration

Cotton scientists, government officials, farmers and other stakeholders celebrated the World Cotton Day (WCD) at CCRI, Multan on October 7, 2019.The institute chalked out an elaborate program in consultation with the Food and Agriculture Organization (FAO), the United Nations Conference on Trade and Development and International Cotton Advisory Committee (ICAC) to celebrate the day in their respective offices. Various programs i.e cotton walk, speech competitions among various school students, tableau and lectures of experts regarding importance of cotton in our economics etc were conducted on this day at the institute.

Awareness Campaign Walk for Cotton

CCRI Multan arranged a walk on 1st April 2019 in front of Multan Press Club with the slogan of "Kapas Ugao, Maeshat Bachao" in collaboration with WWF Shuja Abad. The objective of the walk is to persuade farmers for planting the cotton crop on more area for benefiting farmers as well as the economy of the country. Dr. Zahid Mahmood, Director CCRI Multan led the walk. The staff of CCRI Multan along with cotton farmers participated in the walk.

7.6 Facebook 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.

==========

Pakistan Day Celebrations

CCRI Multan celebrated Pakistan Day by hoisting of National Flag at the building. All staff of the Institute along with with their kids attended the ceremony. National songs and prayers were held for the prosperity of the nation.

Tree Plantation Campaign

Similar to the rest of the Country, the Prime Minister's Monsoon Tree Plantation Campaign has also been launched at CCRI Multan by planting of Terminalia (Plant). Speaking at the occasion, Dr. Zahid Mahmood, Director CCRI Multan stated that the basic objective of the tree plantation campaign is improving the environment and economic sustainability. He further added that protection of the environment is a National Cause and tree plantation is imperative to control the growing pollution. Therefore, everybody should contribute in this Nobel cause by planting tree plants.

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 potassium fertilizer & water stress on quality characteristics of cotton fibre, response of cotton quality characteristics to stress alleviating chemicals under heat stress conditions and saw & roller ginning comparison for cotton fibre quality. The department also conducted the "Quality Survey" in the core cotton producing districts of Punjab to determine the overall cotton fibre quality of the region grown commercially through lint sample collection from the cotton ginning factories of the respective areas. 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 Punjab & Sindh 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})	Micronaire	Color grade	Total
Breeding, CCRI, Multan	14331	14331	14331	0	**42993**
Cytogenetics, CCRI Multan	5668	5668	5668	0	**17004**
Agronomy, CCRI, Multan	60	60	60	0	**180**
Fibre Technology, CCRI, Multan	476	476	476	400	**1828**
Plant Physiology, CCRI, Multan	95	95	95	0	**285**
Director's research material, CCRI, Multan	14492	14492	14492	0	**43476**
CCRI, Sakrand	638	638	638	0	**1914**
CRS, M.P. Khas	146	146	146	0	**438**
CRS, Ghotki	186	186	186	0	**558**
CRS, D.I.Khan	675	675	675	0	**2025**
CRS, Sibbi	223	223	223	0	**669**
CEMB, Lahore	35	35	35	0	**105**
Spot Examination, Faisalabad	90	90	90	0	**270**
Thatha Gurmani Farm	99	99	99	0	**297**
Quality Survey (Sindh)	351	351	351	351	**1404**
Quality Survey (Punjab)	390	390	390	390	**1560**
Director Research PCCC, Multan	154	154	154	0	**462**
Research Sholars (MNSUA)	32	32	32	0	**96**
Total	**38141**	**38141**	**38141**	**1141**	**115564**

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)	Micro-naire (µg inch^{-1})	Fibre Strength (g tex^{-1})	Color grade	Trash (%)	Total
Private Sector	180	180	174	20	22	**576**

8.3 The Effect of Different Moisture Levels on Fibre Characteristics of Cotton

The objective of the experiment was to study the effect of different moisture levels on fibre characteristics of cotton. The control of the moisture content of cotton during testing is important as the hygroscopic nature of cotton allows for many fibre properties to vary in response to the ambient environment. The ASTM standard calls for a temperature of 20±2°C and 65±2% relative humidity for testing of cotton fibre. Long staple cotton was selected for this purpose. The cotton was ginned by saw and roller ginning. Twenty-nine (29) lint samples were given three moisture levels viz., 6%, 8.5% and 10.5% of each ginning type were prepared and tested for various fibre characteristics. The results are presented in Table 8.3.

The findings from different moisture levels are presented in table 8.3 revealed that there were differences between different moisture contents, for fibre length, fibre strength, uniformity index, degree of whiteness and degree of yellowness for each ginning type. The fibre length, uniformity and strength increased, degree of whiteness and yellowness decrease with increase in moisture level for each ginning type. There is no effect of moisture level on micronaire value for each cotton type.

Table 8.3 Fibre characteristics as affected by different moisture levels.

Ginning Type	Saw Ginning			Roller Ginning		
Moisture Level	6.0%	8.5%	10.5%	6.0%	8.5%	10.5%
Fibre Length (mm)	29.2	29.8	31.1	29.9	30.6	31.3
Uniformity Index (%)	81.1	83.8	84.1	82.1	83.4	84.5
Micronaire Value	3.9	3.9	4.0	4.0	3.9	3.9
Strength (g/tex)	30.4	31.3	32.8	31.5	33.8	33.2
Degree of Whiteness (Rd)	64.8	64.9	63.8	63.8	63.2	62.3
Degree of Yellowness(+b)	7.0	6.7	6.7	8.5	7.6	7.0

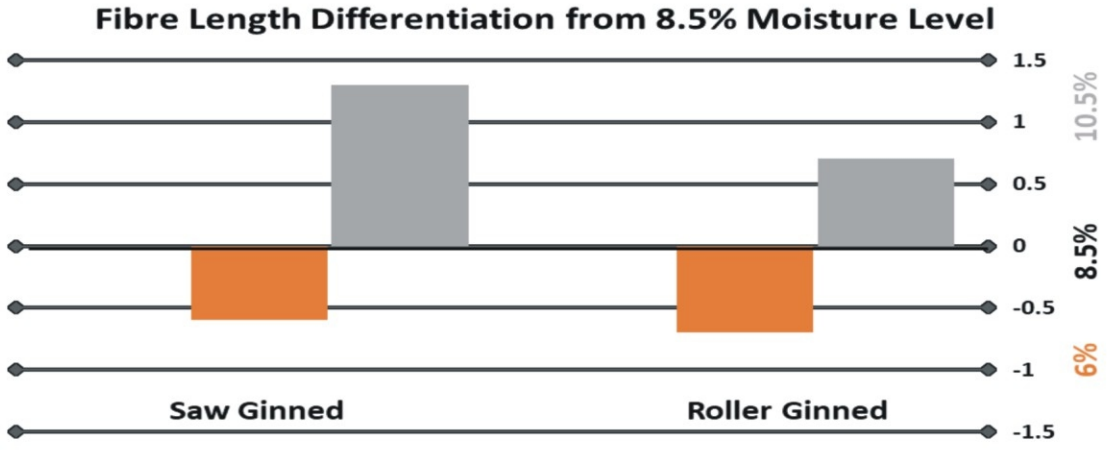


Fig 8.1 Fibre length differentiation from 8.5% moisture level for saw and roller ginning

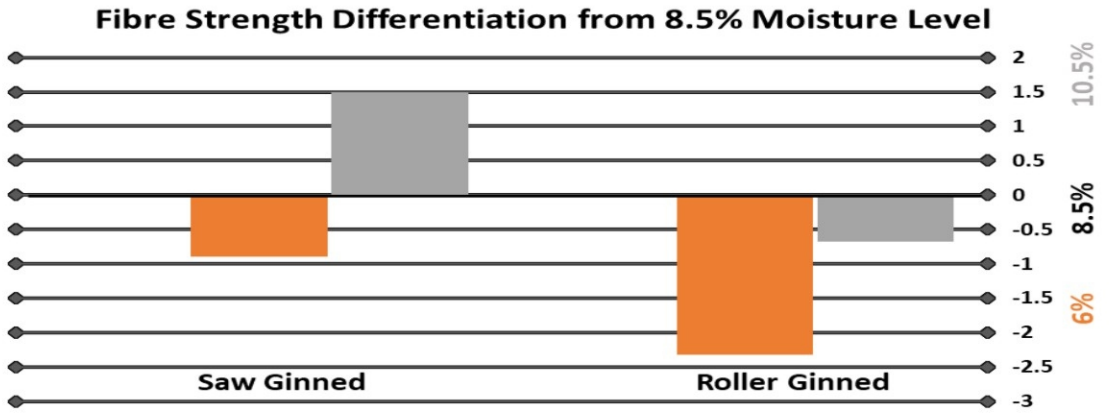


Fig 8.2 Fibre strength differentiation from 8.5% moisture level for saw and roller ginning

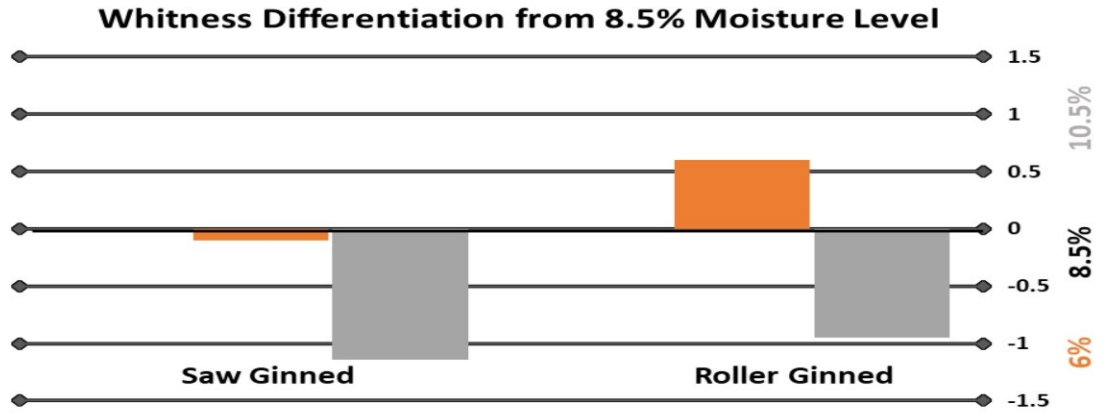


Fig 8.3 Degree of whiteness differentiation from 8.5% moisture level for saw and roller ginning

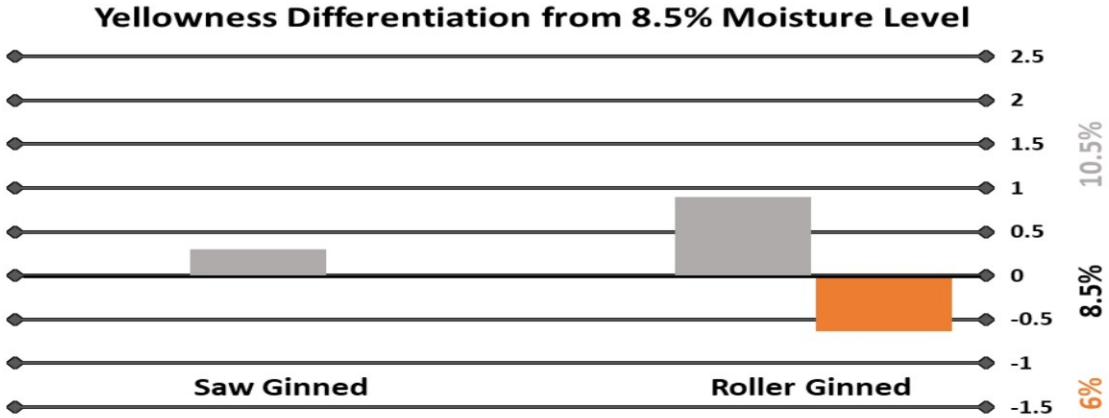


Fig 8.4 Degree of yellowness differentiation from 8.5% moisture level for saw and roller ginning

8.4 To study the effect of Potassium fertilizer & water stress on quality characteristics of cotton fibre.

The objective of this study to evaluate the role of potassium fertilizer on fibre quality characteristics under no stress and water stress conditions. This experiment was conducted with the collaboration of Plant Physiology/Chemistry section. The layout of experiment was split-split block design with three replications. The sowing of cotton and application of potassium fertilizer was done by Plant Physiology/Chemistry section. Five genotypes were selected. The dose of potassium was 0 and 50 kg per hectare. Five plants of all genotypes were tagged from each replication. Picking is 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 were presented in tables 8.4.

Table 8.4 Effect of potassium fertilizer and water stress on quality traits of cotton

Water stress levels (S)	K_2O levels kg/ha (K)	Cotton genotypes (V)	Fibre length (mm)	MIC	Strength (g/tex)	Rd	b	Lint (%)
Stress (S1)	0 (K1)	Cyto-124 (V1)	24.8	3.9	25.7	62.0	7.2	36.4
		Bt.CIM-554 (V2)	25.7	4.8	27.0	61.8	7.9	36.6
		BH-212 (V3)	24.9	4.4	25.6	62.1	7.8	37.2
		BS-13 (V4)	25.0	4.8	26.1	64.3	7.7	37.0
		FH-142 (V5)	23.9	4.7	25.2	61.4	8.2	36.7
	Average		**24.9**	**4.5**	**25.9**	**62.3**	**7.8**	**36.8**
	50 (K2)	Cyto-124 (V1)	24.6	3.5	25.6	60.0	7.4	35.0
		Bt.CIM-554 (V2)	25.0	4.1	26.1	61.1	8.1	37.0
		BH-212 (V3)	24.8	4.8	25.6	60.6	8.0	37.0
		BS-13 (V4)	23.7	4.9	24.7	62.8	7.9	39.4
		FH-142 (V5)	23.7	4.6	24.8	60.9	8.2	38.0
	Average		**24.4**	**4.4**	**25.4**	**61.1**	**7.9**	**37.3**
No Stress (S2)	0 (K1)	Cyto-124 (V1)	25.6	4.3	26.9	64.6	7.4	34.8
		Bt.CIM-554 (V2)	25.8	4.2	27.5	66.5	7.7	37.5
		BH-212 (V3)	26.6	4.9	28.5	67.0	7.7	34.2
		BS-13 (V4)	24.4	4.8	25.7	65.8	8.2	36.2
		FH-142 (V5)	24.5	5.2	26.0	66.0	8.9	35.5
	Average		**25.3**	**4.7**	**26.9**	**66.0**	**8.0**	**35.6**
	50 (K2)	Cyto-124 (V1)	25.7	3.7	27.3	65.8	7.5	33.6
		Bt.CIM-554 (V2)	26.1	4.4	27.4	66.0	7.7	34.6
		BH-212 (V3)	26.3	4.8	27.5	66.7	7.9	34.0
		BS-13 (V4)	25.2	4.7	26.5	66.7	7.7	35.7
		FH-142 (V5)	24.7	5.0	26.3	67.3	8.7	36.3
	Average		**25.6**	**4.5**	**27.0**	**66.5**	**7.9**	**34.8**

The data presented in table 8.4 indicated that all genotypes have better fibre traits at no stress condition. However, the potassium has no significant impact on the fibre traits.

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

The objective of this study is 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. 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 for each replication. Picking is 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 were presented in Table 8.5.

The data presented in table 8.5 indicated that genotype CIM-678 is more responsive towards stress alleviating chemicals than M1-18. There are no significant differences on mostly fibre traits by different stress alleviating chemicals. Fibre length is slightly improved by Hydrogen peroxide treatment in genotype CIM-678 but no impact on length of any treatment on genotype M1-18. Significant difference in genotype CIM-678 by the application of Moringa leaf extract,

micronaire is decreased by this treatment by no impact on another genotype. There is no influence of strength, uniformity index and color grade on both genotypes.

Table 8.5 Fibre characteristics of CIM-678 and M1-18 as affected by different stress alleviating chemicals

Genotype	Treatment	Dose	UHML (mm)	MIC	G/Tex	Uni. Index	Rd	+b
CIM-678	Control	Water	24.6	4.7	25.8	79.2	66.3	7.0
	Selenium (Se)	150 mg/L	24.7	4.4	26.0	79.2	68.0	7.1
	Hydrogen peroxide (H_2O_2)	30 mg/L	25.1	4.7	26.6	80.4	68.1	7.1
	Salicylic Acid (SA)	50 mg/L	24.9	4.3	26.5	80.0	66.3	7.0
	Moringa Leaf Extract (MLE)	30 ml/L	24.9	4.2	26.3	78.9	65.9	6.8
	Ascorbic Acid	150 mg/L	24.6	4.4	25.7	80.0	66.5	7.1
	LSD 5%		**0.48**	**0.21**	**0.88**	**1.17**	**2.94**	**0.42**
M1-18	Control	Water	25.5	5.6	26.5	82.3	62.0	8.2
	Selenium (Se)	150 mg/L	25.3	5.8	26.4	83.0	63.9	8.6
	Hydrogen peroxide (H_2O_2)	30 mg/L	25.1	5.7	26.2	82.5	62.4	8.3
	Salicylic Acid (SA)	50 mg/L	25.3	5.5	26.0	81.6	63.4	8.3
	Moringa Leaf Extract (MLE)	30 ml/L	25.1	5.7	25.8	82.1	61.8	8.2
	Ascorbic Acid	150 mg/L	24.9	5.8	25.9	82.1	62.6	8.2
	LSD 5%		**0.59**	**0.37**	**0.68**	**0.83**	**2.63**	**0.48**

8.6 Quality Survey of Lint Samples from Ginning Factories in Punjab Province

A quality survey was conducted to examine the lint quality of ginning factories during the cotton season 2019-20. The samples were collected by this section from cotton growing area of Punjab province.

Table 8.6 Quality Survey for lint quality of various cities in Punjab province.

District	City		Fibre Length (mm)	Uni. Index (%)	MIC	Strength (g/tex)	SFI (%)	Rd	+b
Khanewal	Khanewal	Max.	27.7	86.4	5.2	28.9	13.4	68.3	12.1
	Kabeerwala	Min.	24.9	79.0	3.2	25.2	5.8	57.5	8.2
	Mianchannu	**Avg.**	**26.4**	**81.9**	**4.5**	**27.4**	**9.3**	**63.8**	**9.6**
Sahiwal		Max.	27.2	83.4	4.9	28.6	13.0	66.6	11.2
	Chichawatni	Min.	24.9	79.4	3.7	25.5	7.3	60.5	9.1
		Avg.	**26.0**	**81.4**	**4.3**	**26.8**	**10.1**	**64.5**	**10.3**
Bahawalpur	Bahawalpur	Max.	28.4	85.1	5.5	29.9	13.2	68.6	14.8
	Hasilpur	Min.	25.3	78.8	3.9	25.4	4.6	56.4	8.8
	Yazman	**Avg.**	**26.8**	**82.6**	**4.9**	**27.7**	**8.2**	**65.3**	**10.5**
Bahwalnagar	AP East Fortabbas Chishtian Bahawalnagar Donga Bonga	Max.	29.7	85.0	5.2	31.0	10.6	68.1	13.6
		Min.	25.9	80.8	4.3	26.0	4.2	61.3	9.1
		Avg.	**27.3**	**83.0**	**4.8**	**28.3**	**7.5**	**65.3**	**11.2**
Multan	Haroonabad Shujabad	Max.	28.1	84.8	5.2	30.7	11.8	69.2	10.6
	Jalalpur	Min.	25.8	80.1	4.4	26.0	5.5	63.7	9.2
		Avg.	**26.9**	**82.8**	**4.8**	**27.9**	**7.9**	**65.9**	**9.8**
Lodhran	Lodhran	Max.	28.1	84.8	5.0	30.9	10.5	67.6	11.0
		Min.	25.8	80.7	4.3	25.7	5.0	61.2	8.8
		Avg.	**26.9**	**82.5**	**4.7**	**27.8**	**8.2**	**64.6**	**10.1**
RY Khan	R.Y. Khan	Max.	31.5	85.7	5.7	31.5	9.6	71.4	12.4
	Liaqat Pur	Min.	25.5	81.7	4.2	25.5	3.7	62.8	8.3
		Avg.	**28.5**	**83.6**	**4.9**	**28.7**	**6.5**	**66.2**	**9.7**

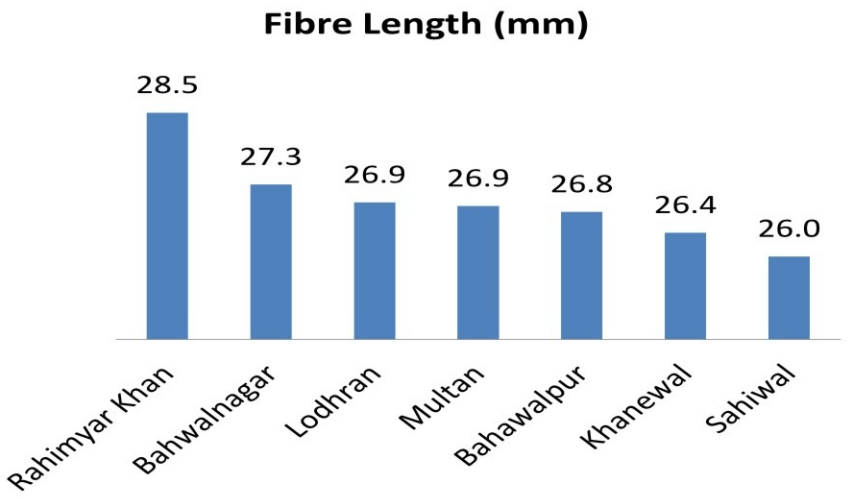


Fig 8.5 Fibre length for various districts of Punjab province

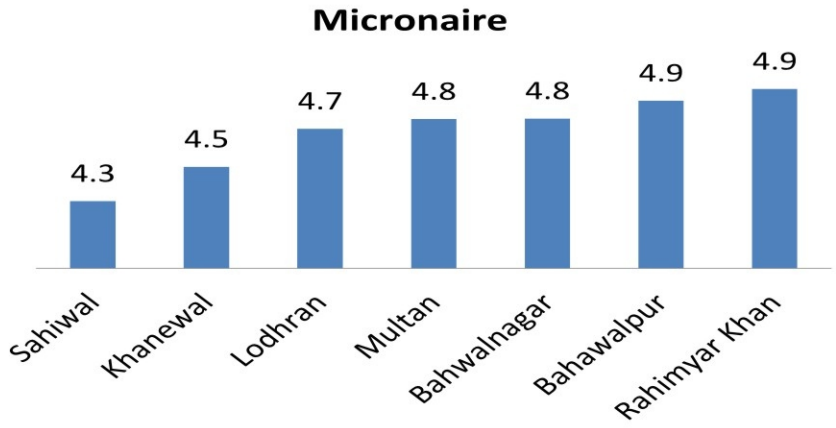


Fig 8.6 Micronaire for various districts of Punjab province

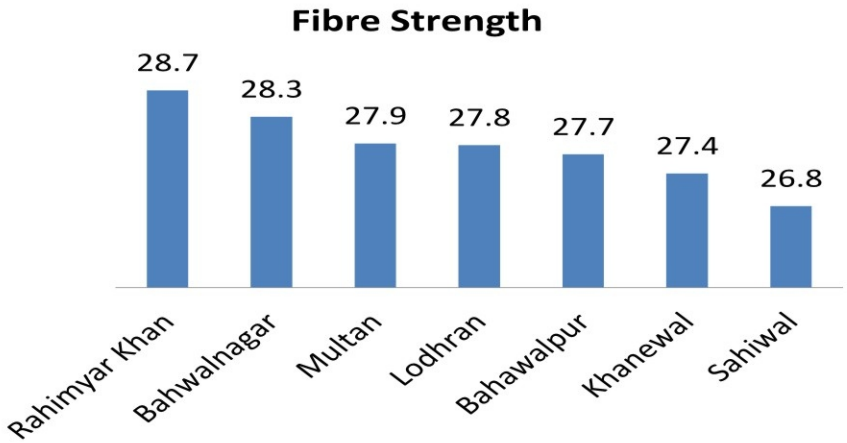


Fig 8.7 Fibre strength for various districts of Punjab province

Distribution of Staple Length, Micronaire & Strength in Surveyed Area
Total No. of Samples Tested=382

i) **Staple Length**

Serial No.	Staple length(mm)	No. of samples	%age
1	≥30	6	1.50
2	28-29.9	32	8.37
3	27-27.9	129	33.76
4	26-26.9	175	45.81
5	24-25.9	40	10.47

ii) **Micronaire**

Serial No.	Micronaire	No. of samples	%age
1	<3	0	-
2	3-3.9	10	2.61
3	4-4.9	296	77.48
4	5-5.9	76	19.89
5	≥6	0	-

iii) **Fibre Strength**

Serial No.	Fibre Strength(g/tex)	No. of samples	%age
1	≥31	2	0.52
2	29-30	26	6.80
3	26-28	345	90.31
4	24-25	9	2.35
5	≤23	0	-

8.7 Saw and Roller Ginning Comparison for Cotton Fibre Quality

The Experiment was design to investigate the effect of Roller & Saw ginning on cotton fibre quality. Longer length genotype was selected and seed cotton was obtained from the field of breeding section. 29 samples were selected for saw ginning and 29 for roller ginning. The ginning was done at laboratory scale machine. After ginning the samples were conditioned for testing. The fibre testing was done at High Volume Instrument (HVI-900A). Seed index was calculated by counting 100 seed per sample. The results of ginning comparison are shown in table 8.9. There are significant differences for fibre length, degree of reflectance and degree of yellowness. Fibre length, strength and degree of yellowness of roller ginned cotton are better than saw ginned cotton while saw ginned cotton gave good degree of reflectance.

Table 8.9 Comparison of saw and roller ginning

Saw Gin	29.8 B	83.8 A	3.9 A	31.3 A	64.9 A	6.7 B
Roller Gin	30.6 A	80.8 A	3.8 A	33.8 A	63.2 B	7.6 A
Difference (Roller-Saw)	**0.80**	**-3.00**	**-0.10**	**2.50**	**-1.70**	**0.90**

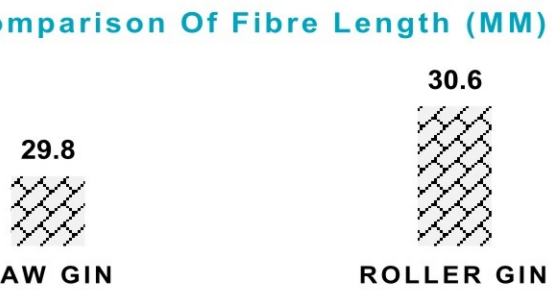


Fig 8.8 Fibre length comparison for saw and roller ginning

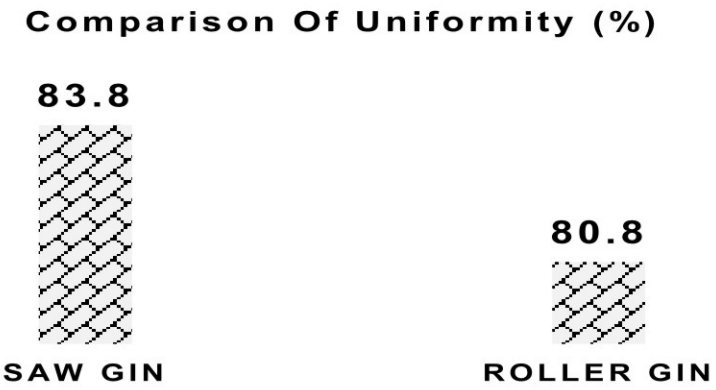


Fig 8.9 Uniformity Index comparison for saw and roller ginning

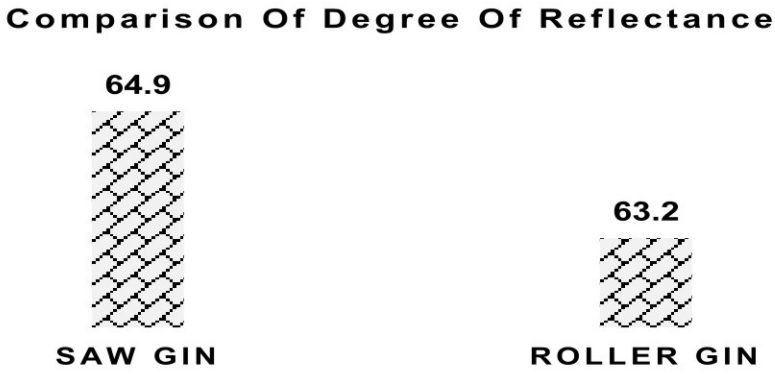


Fig 8.10 Degree of Reflectance comparison for saw and roller ginning

Fig 8.11 Degree of Yellowness comparison for saw and roller ginning

8.8 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 2019. 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 8.8.

Table 8.8 ICA-Bremen Cotton Round Test Program with Faser Institute, Germany

Sample No.	Name of Test	Results of CCRI, Multan (1)	Avg. results Of all Labs (2)	Difference (1-2)
2019/1	**Conventional Instruments**			
	Micronaire	4.3	4.3	0.00
	Pressley Index (0")	8.26	6.94	1.32
	G / tex (1/8")	26.10	24.11	1.99
	Elongation (%)	6.80	6.38	0.42
	HVI-900A			
	U.H.M.L. (mm)	30.50	30.16	0.34
	Uniformity Index (%)	83.60	82.77	0.83
	Micronaire	4.30	4.42	-0.12
	G/tex (1/8")	31.60	31.46	0.14
	Elongation (%)	5.60	6.56	-0.96
	Rd (Reflectance)	78.7	81.45	-2.75
	+b (Yellowness)	9.4	9.1	0.21
2019/2	**Conventional Instruments**			
	Micronaire	4.59	4.52	-0.07
	Pressley Index (0")	7.60	7.22	-0.38
	G / tex (1/8")	17.1	---	---
	Elongation (%)	7.00	---	---
	HVI-900A			
	U.H.M.L. (mm)	29.1	28.57	0.53
	Uniformity Index (%)	83.5	82.79	0.90
	Micronaire	4.58	4.56	0.02
	G/tex (1/8")	29.6	28.98	0.62
	Elongation (%)	5.60	6.60	-1.00
	Rd (Reflectance)	73.3	74.14	-0.84
	+b (Yellowness)	9.0	9.01	-0.01
2019/3	**Conventional Instruments**			
	Micronaire	4.95	4.68	0.27
	Pressley Index (0")	7.54	7.55	-0.01
	G / tex (1/8")	19.1	--	--
	Elongation (%)	6.0	--	--
	HVI-900A			
	U.H.M.L. (mm)	27.3	27.26	0.04
	Uniformity Index (%)	81.8	80.73	1.07
	Micronaire	4.9	4.7	0.2
	G/tex (1/8")	27.5	26.81	0.69
	Elongation (%)	5.1	6.87	-1.77
	Rd (Reflectance)	76.7	77.23	-0.53
	+b (Yellowness)	10.6	10.25	0.35

8.9 Survey of Spinning Industry of Pakistan

Survey of spinning industry was not conducted due to the budget constraints.

RETIREMENTS

Ch. Ikram ul Haq, UDC retired on 31.01.2020

Mr. Ghayyour Hussain, Lab Assistant, Fibre Technology retired on 04.10.2019

Mr. Zakirullah Khalidi, Administrative Officer retired on 02.02.2020

Mr. Muhammad Hanif, Beldar, Farm Management retired on 21.10.2019

Mr. Muhammad Ashraf, Chowkidar retired on 10.03.2020

9. STATISTICS

This Section assisted other sections of the Institute in the experimental design and statistical analysis of experimental data. The layout Plan of National Coordinated Varietal Trial was prepared and statistical analyses were done for Directorate of Research, Pakistan Central Cotton Committee, Multan. The record of cotton statistics and daily market rates of cotton commodities were maintained.

9.1 Experimental Design Layout:

This section provided assistance in designing layout of field experiments conducted by different sections of Central Cotton Research Institute Multan. Randomized complete block design was used in thirty five experiments while split plot and split-split plot was used in 19 and 11 experiments respectively. Furthermore F-pool design was used in 9 experiments with having location at CCRI, Multan and PSC Farms, Khanewal.

9.2 Statistical Analysis

187 set of experimental data were analyzed by Statistics Section during 2019-20 in which twenty one data sets of Breeding & Genetics, five Cytogenetics, twelve Entomology, twenty six Fibre Technology sections of the institute and 118 data sets of National Coordinated Varietal Trail conducted by Directorate of Research, Pakistan Central Cotton Committee, Multan 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	12	---	---	9	---	**21**
Cytogenetics	5	---	---	---	---	**5**
Pathology	---	---	---	---	---	**---**
Entomology	12	---	---	---	---	**12**
Fiber	18	---	13	---	---	**31**
NCVT	118	---	---	---	---	**118**
Total	**165**	**---**	**13**	**9**	**---**	**187**

9.3 Design and analysis of NCVT:

In NCVT 2019 field trials total ninety-seven new lines were tested for yield at fifteen different locations throughout Pakistan. Set A contained twenty-three new Bt. strains with one standard. Set B contained twenty-five new Bt. strains with one standard. Set C contained twenty-four new Bt. strains with one standard. Set D contained twenty-five new lines out of which twenty were Bt. while five were non-Bt. strains with two standards. In total ninety-two new Bt. and five non-Bt. strains were tested. For Bt. lines the CIM-602 and for non-Bt. lines Cyto-124 were used as standards.

Bt. CIM 775 of CCRI Multan got second position in Pakistan while this variety got first position in Punjab and KPK.

9.4 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. 2017-18, 2018-19 and 2019-20 exclusive of upcountry charges are shown in Fig 9.1.

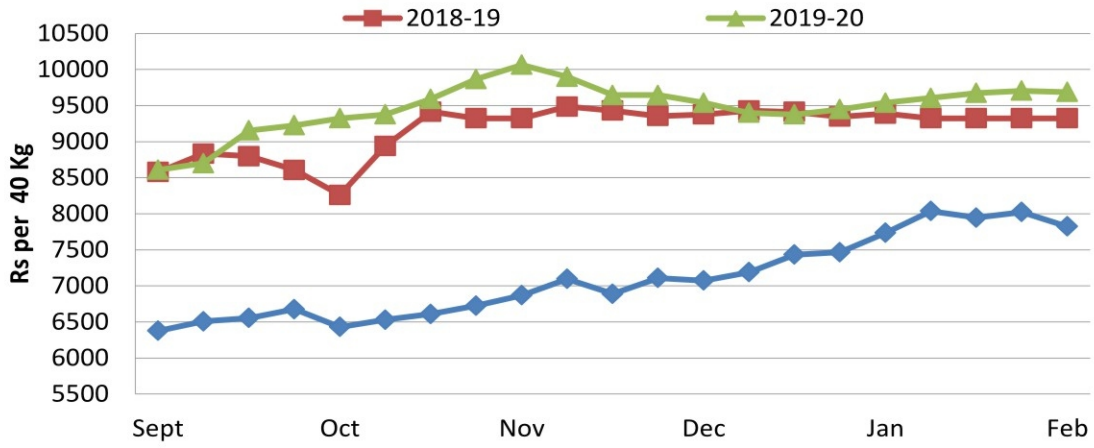


Figure 9.1: Weekly Average Spot Rates of Lint announced by Karachi Cotton Association during Cotton Seasons 2017-18, 2018-19 and 2019-20.

The data presented in figure 9.1 showed the fluctuation of rate during the season of last three years. In year 2019-20 rates were comparatively higher than previous years. In year 2018-19 the average price was at 9173/40 kg with the minimum value 8260 per 40 kg in the month of October 2018 and maximum of 9485 per 40 kg in November 2018 while in 2019-20 the average price was at 9480 per 40 kg with the minimum value 8610 per 40 kg in September 2019 and maximum value 10065 per 40 kg in November 2019.

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 9.6.

Seed-Cotton

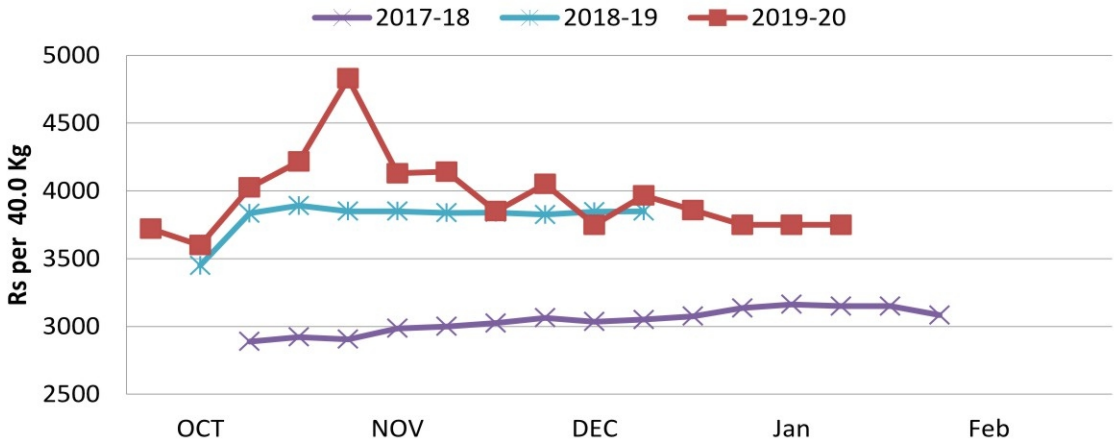


Figure 9.2: Weekly Average Rates (Rs /40Kg.) of Seed-cotton of Khanewal Market during 2017-18, 2018-19 and 2019-20.

The seed-cotton rates are presented in figure 9.2 showed that the rates of 2019-20 are much higher than that of previous years. In 2018-19 the average seed-cotton rates of Khanewal market were at 3807 per 40 kg with minimum of 3450 per 40 kg and maximum 3891 per 40 kg while in 2019-20 the average rate was 3959 per 40 kg with maximum rate was 4830 per 40 kg and minimum rate was 3599 per 40 kg. The percent increase of year 2019-20 average price from 2017-18 is 23.16%, and from 2018-19 is 3.84%.

Cottonseed

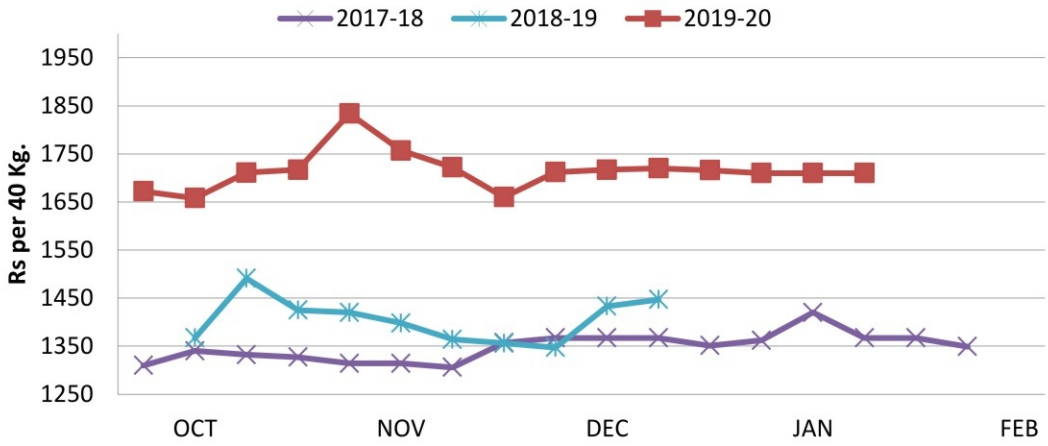


Figure 9.3: Weekly Average Rates (Rs /40Kg.) of Cottonseed of Khanewal Market during 2017-18, 2018-19 and 2019-20.

The cottonseed rates were lower from higher than 2017-18 and 2018-19. The maximum value 1834 was in November 2019 while minimum price 1658 in October 2019. Price comparison from last year revealed that average price 1405 per 40 kg was attained in 2018-19 with minimum price of 1347 per 40 kg and maximum price of 1491 per 40 kg in October 2018 while the average price 1715 per 40 kg was obtained in 2019-20 with maximum price was 1834 per 40 kg and minimum price was 1658 per 40 kg.

Cottonseed Cake

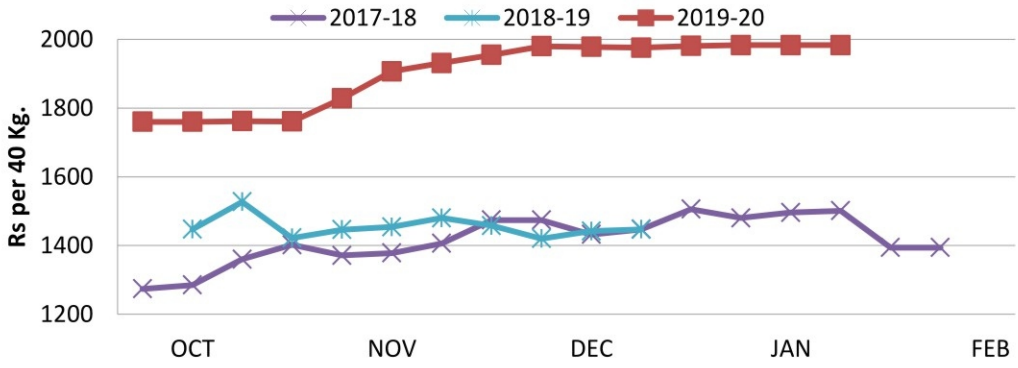


Figure 9.4: Weekly Average Rates (Rs /40Kg.) of Cottonseed Cake of Khanewal Market during 2017-18, 2018-19 and 2019-20.

Cottonseed cake rates of year 2019-20 were higher than year 2017-18 and 2017-18. Average rate of 2018-19 was 1454 per 40 kg with maximum 1527 per 40 kg and minimum 1420 per 40 kg while in 2019-20 the average rate was 1902 per 40 kg with maximum 1983 per 40 kg and minimum 1760 per 40 kg.

9.5 Study of factors affecting the Lint rates in Pakistan.

From 1st February 2019 to 31st January 2020 the rates of lint increased in twenty three weeks, remained same for nine weeks and decreased in twelve weeks. Different factors affected the rates of Lint. The major factors which increased the rates are:

1. Ban on trade with India
2. Depreciation in the value of rupee
3. Low cotton production at National Level

The brief description of these factors are given below

Ban on trade with India:

Due to hostile Indian activities and state terrorism in Indian held Jammu & Kashmir, the Govt. of Pakistan decided to completely ban trade with India. In past, Indian cotton was an economically feasible source of cotton for local industry. With closure of this option the local industry had to start brisk buying in local market which resulted in increased rates of lint as the market rates are dependent on demand and supply. The sharp increase in demand was significantly greater than supply and ultimately the market became positive. The situation provided an opportunity to local farmers to obtain better rates for their crop.

Depreciation in value of Money:

Due to financial condition the Govt. decided to reduce the value of rupee against US dollar and other major currencies. This depreciation in value is accompanied by a sharp increase in inflation and value of all the commodities and products increased. Similarly due to this factor the value of lint increased in Pakistan.

Low cotton production at National level:

Pakistan produced almost 0.85 million bales of cotton as reported by PCGA on 15th February, 2020. It is estimated that local industry requires about 1.5 million bales of cotton annually. Due to drastic increase in production the supply of lint decreased and resultantly it exhibited an upward pressure on lint rates. The competition between local buyers kept the market positive for twenty three weeks during the season. The factors which decreased the lint rates are

1. Imposition of sales tax
2. Uncertainty in the market
3. Shortfall of liquidity

Imposition of Sales Tax:

Govt. decided to levy 17% GST on textile garments and 10% GST on cotton which decreased the activity in textile sector and resulted in putting downward pressure on lint rates. It is normal that when a new tax is applied it always result in shrinking of the market, but nevertheless the taxes are also necessary to generate revenue for meeting Govt. expenses.

Uncertainty in the Market:

The distributors and retailers remained in tussle with FBR on the issue of imposition of ID card on purchase of more than 50000 rupees. Factors like these disturbed the market and activity in the market remained on lower side which decreased the rates of lint. Although it is a positive step that the economy should be documented so that people could not evade taxes. But the local Associations of Retailers have their own agenda, they conduct strikes to put pressure on Govt. Conditions like these are not conducive for business which ultimately decrease the rates of commodities including lint.

Short fall of Liquidity:

The higher interest rate on credit made it difficult for business community to arrange working capital for business which reduced the business activities and ultimately reduced the rates of lint. As the industrial growth decreases the rates of inputs in local market also decreases. The demand of input becomes negative which brings negative trends in rates of inputs. This factor also influenced the rates of lint negatively.

==========

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 (CLCUD, 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 which improves 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 after 2-3 years should be practiced in order to break the hard and plough pan to improve root growth and soil 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-632, *Bt*.CIM-598, *Bt*.CIM-599, *Bt*.CIM-602, *Bt*. Cyto-177, *Bt*. Cyto-178, *Bt*.CIM-600, *Bt*.cyto-179, IR-NIAB-824, FH-118, FH-142, MNH-886, VH-259, IUB-222, BH-178, IUB-2013 Tarzan-1, Tarzan-2, Sitara-008, Sitara-11M, A-555, Saiban-201.	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, GS-1.

- Always purchase 10% more cotton seed than required for re-planting in case of any damage to planting or lower germination.
- Always plant 10-20% area with Non-Bt along with Bt varieties, as refuge crop, to avoid development of resistance in insects.
- Always use delinted seed. One litre concentrated commercial sulphuric acid is sufficient for delinting 10 kg fuzzy cotton seed. Wash thoroughly and dry the seed under dry 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 will 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 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. For the soils showing available phosphorus less than 10 ppm, use 100-150 kg P_2O_5 per hectare at the time of planting or after thinning. If possible, 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 the time the crop makes canopy or by mid-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 in the insecticide spray.

- 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 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.
- 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 as 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

- 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.
- 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.

- Do not start picking early in the morning when there is dew on the crop. Let the dew dry and then start picking.
- Start picking from the bottom to the top. Pick fully opened and fluffy bolls. Seed cotton should be free from weeds and crop trash.
- Use cotton cloth bags for transportation. Do not use plastic or gunny bags.
- Do not place cotton on moist soils in the field.
- 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.
- 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

a) International

1. Adem Bardak, Khezir Hayat, Halil Tekerek, Done Parlak, Sadettin Celik, Rao Sohail Ahmad Khan, Ali Can Sever, Ridvan Ucar, Ramazan Sadet Guvercin, Remzi Ekinci. 2019. Analysis of genetic variability and heritability for seedcotton yield ın a single seed decent population. Fresisensus Environmental Bull. 28(5): 4093-4099.
2. Khezir Hayat, Adem Bardak. 2019. Genetic Variability for Ginning Outturn and Association among Fiber Quality Traits in an Upland Cotton Global Germplasm Collection" Sains Malaysiana. (Accepted for publication).

b) National

1. Ashraf, F., Hayat, K., Imran, H.M., Mahmood, Z. 2019. Development of high yielding and CLCuV tolerant upland cotton variety Cyto-124. Journal of Applied Environmental and Biological Sciences (Accepted for publication).
2. Afzal, M.N., M. Tariq, M. Ahmad, K. Mubeen, M.A. Khan, M.U. Afzal and S. Ahmad. 2019. Dry matter, lint mass and fiber properties of cotton in response to nitrogen application and planting densities. Pak. J. Agri. Res., 33 (2):229-240.
3. Sarwar, M.I. and D. Iqbal. 2019. Qualitative Characteristics of Cotton crop 2017 and 2018 Surveyed from the Cotton Ginning Factories in the Punjab Province. Pakistan Cottongrower Vol. 2(4), Oct-Dec, 2019.
4. Saeed, R., Abbas, N., Mahmood, Z., 2020. Emamectin benzoate resistance risk assessment in *Dysdercus koenigii*: cross-resistance and inheritance patterns. Crop Protection. doi:https://doi.org/10.1016/j.cropro.2019.105069(Impact Factor = 2.172)

KASHMIR SOLIDARITY DAY

Following the directives from the Federal Government, the staff of CCRI Multan also observed the Kashmir Solidarity Day on Friday, the August 30, 2019. Slogans and banners were prepared against the imposition of Article 370 in Indian Occupied Kashmir. A walk was organized in favour of Kashmir as well.

Annexure-I

RESEARCH & DEVELOPMENT STAFF

Dr. Zahid Mahmood
Director
ccri.multan@yahoo.com 0300_6373428

Dr. Muhammad Naveed Afzal
Head (Agronomy)
noveedafzal@yahoo.com
0306-7374257

Dr. Muhammad Idrees Khan
Head (Plant Breeding & Genetics)
peer60000@gmail.com

Dr. Fiaz Ahmad
Head (Plant Physiology & Chemistry)
fiazdrccri@gmail.com
0300-7189101

Ms Sabahat Hussain
Head (Plant Pathology)
sabahat70@yahoo.com

Dr. Rabia Saeed
Head (Entomology)
civilservisesgroup@gmail.com

Ms Farzana Ashraf
Head (Cytogentics)
farzanabalochso@yahoo.com

Mr. Muhammad Ilyas Sarwar
Head (Fibre Technology)
mianilyas222@yahoo.com
0301-7637320

Mr. Mubashir Islam Gill
Head (Statistics)
gillccri@yahoo.com
0347-6370947

Mr. Sajid Mahmood
Head (Transfer of Technology)
skhan.nmc4@yahoo.com
0333-7632851

Dr. Muhammad Ahmad
Scientific Officer (Agronomy)
ahmadfmc@hotmail.com
0334-6714574

Mr. Muhammad Tariq
Scientific Officer (Agronomy)
mtariq131@gmail.com
0346-6500131

Mr. Muhammad Azam Mian
Scientific Officer (Farms)
azam7576537@gmail.com
301-7576537

Mr. Muhammad Akbar
Scientific Officer (Plant Breeding)
malikakbarccri@gmail.com
0300-6810926

Dr. Khadim Hussain
Scientific Officer (Plant Breeding)
khnajam@gmail.com
0333-6142397

Hafiz Abdul Haq
Scientific Officer
(Plant Breeding)

Mr. Saeed Muhammad
Scientific Officer (Plant Breeding)
sdm_jm_143@yahoo.com
0340-6433154

Dr. Fazl-I-Dayim Shehzad
Scientific Officer (Plant Breeding)
ustadjeeaup@yahoo.com
0323-5227076

Dr. Khezir Hayat
Scientific Officer (Cytogenetics)
khezirso@gmail.com
0300-4738489

Hafiz Muhammad Imran
Scientific Officer (Cytogenetics)
imrananjum2005@yahoo.com
0321-6715123

Syed Ishfaq Ali Shah
Scientific Officer (Entomology)
sias337@yahoo.com

Mr. Junaid Khan Daha
Scientific Officer (Entomology)
junaidkhan_daha@yahoo.com
0300-8739892

Ms Shabana Wazir
Scientific Officer (Entomology)
sadia_uca@hotmail.com

Ms Rashida Aslam
Scientific Officer (Cytogenetics)
zain.abidin0615@gmail.com

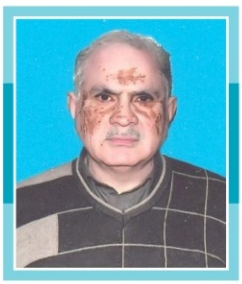
Ms Asia Perveen
Scientific Officer (Plant Physiology)
asiaahs@yahoo.com

Dr. Noor Muhammad
Scientific Officer (Plant Physiology)
noor.1272@yahoo.com
0300-4130606

Mr. Danish Iqbal
Scientific Officer (Fibre Technology)
danish.iqbal@ymail.com
0333-966 6017

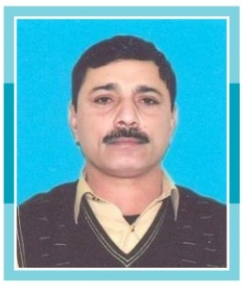
Mr. Naveed Arshad
Networking Administrator
0332-6286777

ADMINISTRATIVE STAFF



Mr. Zakirullah Khalidi
Administrative Officer
0323-8647101

Mr. Nazar Abbas
Superintendent
0308-7377447



Mr. Tahir Abbas Shamsi
Superintendent
0300-2423852

Mr. Zahid Khan
A.P.S.
0333-6170830

Mr. Muhammad Imran
Computer Operator
0321-6341742

Mr. Muhammad Tariq
Photographic Work
0308-5702604

Annexure-II

Comparative Monthly Meteorological Data Recorded at CCRI, Multan during 2018 and 2019

Month	Air Temperature (°C)				Relative Humidity				Average Wind Speed (Km h^{-1})		Rainfall (mm)		Evapo-transpiration (cm day)		Soil Temperature (°C) 0 cm	
	Minimum		Maximum		Minimum		Maximum									
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
January	7.6	8.0	19.7	17.6	73	76	93	97	3.2	4.0	0.0	11.0	0.29	0.18	9.3	9.4
February	12.2	9.9	22.8	19.0	65	66	86	95	4.9	5.0	6.8	25.1	0.39	0.24	13.7	11.1
March	16.7	15.0	30.3	24.1	63	64	79	88	5.0	5.3	0.0	21.0	0.58	0.42	21.0	17.4
April	22.8	23.0	36.1	34.9	47	62	67	84	6.6	6.4	3.0	12.7	0.97	0.73	27.2	26.4
May	27.8	25.8	38.6	37.2	41	47	64	73	6.6	6.1	4.0	11.6	1.10	1.18	31.6	30.3
June	30.3	29.2	38.9	39.9	52	49	78	69	7.2	6.9	2.0	55.5	1.09	1.11	34.6	34.1
July	29.8	30.5	36.6	36.9	59	58	84	77	6.7	7.4	9.0	16.2	0.99	0.96	34.5	35.2
August	28.9	28.9	35.9	35.6	68	62	83	83	6.3	5.7	2.0	37.5	0.97	0.92	34.1	33.2
September	24.8	28.3	34.9	36.1	66	66	88	89	4.9	4.4	0.0	26.3	0.88	0.99	31.5	32.4
October	16.8	20.2	29.3	31.5	66	71	84	89	2.9	2.9	0.0	35.3	0.64	0.42	24.0	23.6
November	9.6	15.1	28.2	24.8	70	67	94	90	2.3	2.9	0.0	5.2	0.42	0.29	17.2	17.2
December	7.3	7.9	21.2	16.9	72	71	99	95	2.8	2.9	0.0	10	0.26	0.17	11.0	10.4

VISITOR'S BOOK

CENTRAL COTTON RESEARCH INSTITUTE, MULTAN.

Date	Name	Address	Remarks if any
3rd Feb 2020	Dr. Neil W. Ernester	7 Iluka Street, Redhead NSW 2290 Newcastle, Australia	Thank you for a very interesting and informative visit. It is always a pleasure to visit such an important institute such as CCRI. Well done!!
13th Oct 2019	Abdul wajid Shaikh.	Director, NIM Karachi.	The visit with the participants of 28th Mid Career Management course was very much learned. We are thankful to the Director & his team of CCRI for warm welcoming. Thanks 13th Oct 2019
4/11/2019	Participants of 26th Senior management Course. NIM Lahore Shahid Javed Malik Course Coordinator.	National institute of Management Lahore	The participants visit central cotton research institute Multan. Dr Zahid gave us very informative and factual presentation. We all are very enlightened after the visit.

Years of Excellence in
Cotton Research & Development

CENTRAL COTTON RESEARCH INSTITUTE

Old Shuja Abad Road, Multan, Pakistan

+92-61-9200340-41 +92-61-9200342

ccri.gov.pk ccri.multan@yahoo.com CCRIM.PK