PAKISTAN CENTRAL COTTON COMMITTEE, MULTAN

ANNUAL SUMMARY PROGRESS REPORT

CENTRAL COTTON RESEARCH INSTITUTE,

MULTAN

2017-2018

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Executive Summary

Central Cotton Research Institute (CCRI), Multan is a premier mono crop multi-disciplinary institution at national level. The Institute has contributed significantly by advancing and generating knowledge in cotton research and development since its establishment in 1970. The current "Annual Summary Progress Report for the year 2017-18" is being published on its 48th year of establishment. Over the years, the institute has advanced by developing high yielding varieties with standard fibre quality characteristics viz., staple length, fineness and strength etc. The fine tuning of production technology at the grass-root level of common farming community to the progressive farmers has made tremendous impact in enhancing cotton productivity.

At the time of establishment of the Institute in 1970, the cotton productivity was 370 kg per hectare which has now risen to the level of 772 kg per hectare during the current year. The continued and untiring research endeavors of the scientists have yielded 26 cotton varieties (19 Non-Bt and 07 Bt). The introduction of efficient water use technologies i.e. bed-furrow sowing technique, identification of water stress & heat tolerant cotton varieties and other water saving techniques were advocated to the farmers to economize cotton production.

One Bt. cotton variety (Bt.CIM-632) and one conventional variety (CIM-610) of CCRI Multan will be approved for general cultivation in the 50th meeting of the Punjab Seed Council. The cotton varieties of CCRI Multan have gained substantial cotton acreage over the years in Sindh province as well. Keeping in view the liking of CCRIM varieties in Sindh province, cases for varieties for commercial cultivation were sent to the Sindh Seed Council and the first public sector cotton variety i.e., Bt.CIM-598 was approved for commercial cultivation in the Sindh province. Moreover, cases for Bt.CIM-602 and Bt. CIM-616 have also been floated for approval which is also expected to be approved in the coming Sindh Seed Council meeting. Moreover cases of 09 Bt. cotton varieties (Cyto-515, CIM-663, CIM-653, CIM-651, CIM-645, CIM-643, CIM-642, CIM-636, CIM-343) have been submitted in the 22nd meeting of the Technical Advisory Committee (TAC), of the National Biosafety Centre, Pakistan Environmental Protection Agency for biosafety clearance and testing under field conditions. All these varieties have high yield potential, excellent lint percentage and other fibre characteristics, desirable to the ginning and textile industry. It is hoped that these varieties will help to boost up the cotton productivity in the province.

Wilt Symptoms were noticed in some farmers' fields during month of August and November. The sudden death of affected plants occurred after appearance of syndrome. Upon examination, the pith wood, bark of lower part of stem was discolored. However, in some samples, the xylem vessels turned black and dried. This phenomenon was recorded in most of the cotton wilted plants identified causal organism was Botryodiplodia and fusarium spp. Fungicides viz., Trifloxystrobin, Azo-oxystrobin Carbendazim + Mencozib were observed effective against identified fungi in vivo.

In the field of plant protection, the invasion of secondary pests like mealybug, dusky cotton bug and red cotton bug have been potential threats to achieve yield targets. A due attention is being made to devise pest management strategies to tackle these emerging pests. In the scenario of extended Bt cotton cultivation, the research has been diverted towards this new dimension for controlling sucking pests and studies on resistance management accrued due to inbuilt bollworm resistance in cotton plant. Moreover, CCRI Multan in collaboration with Department of Pest Warning & Quality Control of Pesticides Punjab and the Department of Agriculture Extension Punjab, carried out extensive training programs for the Agriculture Officers and Field Staff at district level regarding "Off Season Management for Mealybug & Pink Bollworm" and to disseminate to the farmers through Agri Extension and PW&QC force.

The Institute has made tremendous efforts in popularizing the technology for herbicide use in weed management. The continuous research on screening of weedicides and fine tuning of their application techniques (pre- and post-emergence) is another milestone of this Institute. The quantification of optimized fertilizer levels, application methodologies for efficient utilization and exploring the alternate nutrient sources remained a continuous endeavor to achieve yield sustainability. The technique of plant mapping, disseminated from this Institute, for forecasting/ estimating yield potential is being practiced by the various research, academia and government departments.

The research activities / achievements of the Institute are enumerated as under:

AGRONOMY

The section mainly works for development of promising production technology to ensure better yield and profitability. The research carried out showed that planting of cotton in the second week of April is the best choice for achieving higher production. The delay in planting time results in the successive decrease in yield. Genotypes, CIM-620 and CIM-717 produced significantly higher yield over CIM-610. The research findings showed that planting of transgenic cotton on March 01 produced significantly higher yield as compared to other planting dates i.e. March 15, April 01, April 15, May 01 and May 15. Genotype *Bt*.Cyto-313 produced higher seed cotton yield as compared to *Bt*.CIM-343, *Bt.*Cyto-515, *Bt*.CIM-632 and *Bt*.CIM-602 (std). Application of 300 kg N ha^{-1} gave non-significant increase in seed cotton yield over 225 kg N ha^{-1}. The agronomic nitrogen use efficiency (ANUE) was highest at 75 kg nitrogen and decreased with higher doses.

The result revealed that cotton planting as relay crop (75 cm apart rows) produced maximum seed cotton yield (4283 kg ha^{-1}) than fallow land early planting (3965 kg ha^{-1}). Planting of cotton under modified technique (Relay crop 75 cm apart rows) produced 8.0%, 13.7% and 45.9% higher seed cotton yield over fallow land, wide row (150 cm) and after wheat harvesting, respectively.

The narrow plant spacing 15 cm produced 33.6% and 78.0% higher seed cotton yield over 30 and 45 cm spacing, respectively on account of high boll density. Whereas, branch removal practice did not prove an effective strategy for improving seed cotton yield at different plant spacing.

The maximum reduction in seed cotton yield was observed in plots where both narrow and broad leave weeds were left uncontrolled. The narrow leave weeds affected the crop more negatively than broad leave weeds. However, the competitive index as measured by yield loss per weed (m^{-2}) was the maximum in broad leave weeds followed by narrow and all weeds.

Daily weather data is also being maintained by the section. The cost of production for the year 2017-18 was Rs. 76268 ac^{-1}.

PLANT BREEDING & GENETICS

The main focus of the scientists of Breeding and Genetics Section, CCRI, Multan is to evolve and commercialize *Bt*. and non-*Bt*. new cotton varieties with inbuilt resistance/tolerance against the biotic and abiotic stresses along with desirable fibre traits. Development of germplasm has a key role in the process of variety evolution. This section holds its own recognition in this aspect by maintaining & preserving 6030 accessions of the four species of Gossypium. Variety *Bt*.CIM-598 has been approved for general cultivation by Sindh Seed Council for general cultivation in Sindh Province Bt.CIM-632 and CIM-610 has completed its two year in NCVT and their cases were presented in 77th Expert Sub-committee held on 15th March 2018. *Bt.*CIM-663 and *Bt*.CIM-343 completed 1st year in NCVT. Thirty three advanced *Bt*. Strains were evaluated at Multan and Khanewal locations. Fifteen non-*Bt*. strains were also evaluated at Multan and Khanewal locations. All these strains have the desirable fibre characteristics. The crosses with exotic material Mac-07 and AS-0349 from France for induction of CLCuD resistant/tolerance are in different filial generations. Six research papers were published in National & International Journal.

CYTOGENETICS

The intent was to travel around the possibilities of transferring enviable genes of the wild species to the cultivated cotton for commercial exploitation. The research work of Cytogenetics Section encompasses maintenance of *Gossypium* germplasm; to develop promising varieties, through introgression, which are resistant/tolerant to biotic (diseases) and abiotic (drought, heat) stresses with special hub on Burewala Strain of cotton leaf curl virus (CLCuD). Cytological studies of a newly developed inter-specific hybrid were undertaken. The breeding material developed through multiple species hybridization viz [{2(*G.hirs.*x*G.anom.*) x ^{3}G.*hirs*.} x {2 (*G.arbo.* x*G.anom.*) x ^{2}G.*hirs.*}] x *G. hirs.* Conversion of CLCuD tolerant lines into transgenic lines using back cross method & intraspecific hybridization is under observation in different filial generations i.e. F_1, F_2, F_3 , F_4 , F_5 and F_6.

Different shades of brown cotton with petal spot were observed in $F_{2,}$ F_3 & F_4. All these shades have suitable fibre length. Search for aneuploids especially haploids remained in steps forward. Cyto material developed through multiple species hybridization was tested in progeny row trials, micro and varietal trials, zonval varietal trial (ZVT) and National Coordinated Varietal Trial (NCVT) to observe their economic and fibre characteristics.

Three *Bt.* varieties viz., Cyto-177, Cyto178, Cyto-179 was approved from Punjab seed council during 2017 and the cases of Bt.Cyto-313 and Bt.Cyto-515 varieties have been submitted to National Biosafety Committee for the approval of their commercialization. *Bt*. Cyto-313 was tested in NCVT trial during 2017-18.

ENTOMOLOGY

Plant protection measures are prerequisite for successful commercial cotton cultivation under varied agronomic practices and agro-climatic regions across cotton belt. Distinctive research work carried out on various aspects such as evaluating the impact of sowing date on the development of pink bollworm, surveys of cotton growing areas for pink bollworm infestation, assessing impact of first spray on rest of the pest management, monitoring of lepidopterous pests with sex pheromone and light traps, host plant tolerance of CCRI, Multan strains, National Coordinated Varietal Trials on *Bt.*& non-*Bt.* strains, monitoring of insecticide resistance in cotton pests.

The section participated in training programmes, organized by the Institute for the farmers and staff of the Agriculture Extension & Pest Warning & Quality Control (PW&QC) Department. Section also provided internship facilities` to different Universities. Scientists also recorded IPM related programmes in electronic media.

PLANT PATHOLOGY

A survey was conducted during cotton cropping season to record the prevalence of cotton leaf curl (CLCuV) disease in different parts of the Punjab. The incidence of cotton leaf curl disease (CLCuD) was maximum in areas of, Khanewal, Burewala Vehari, and minimum in cotton areas of Multan Shujabad Depal Pur, Lodhran, Kehror Pakka, Kabirwala, Layyah Sahiwal,and Arif Wala. There was no incidence of CLCuD in the areas of Muzzafargarh, Bahawal Pur, Bahawal,Nager Haroon Abad,and Jam Pur. Overall position of CLCuD with crop cultivation period from March to June indicates that the crop cultivated from the month of March to May showed minimums disease incidence and severity level whereas crops cultivated during the month of June showed maximum level of disease incidence and severity. The incidence of boll rot varied from 1 to 2 percent. Boll rot due to secondary pathogens was observed only on a few spots. The occurrence of stunting phenomenon was very low. The prevalence of bacterial blight and leaf spot of cotton was minimal. Blackening of leaves was observed in all spots Wilt Symptoms are noticed in some fields wilt disease was observed in fields at CCRI during the month of August and November. The sudden death of affected plants occurred after appearance of syndrome. Upon examination, the pith wood, bark of lower part of stem was discolored. However, in some samples, the xylem vessels turned black and dried. On isolation and microscopic studies revealed fungus *Botryodiplodia sp*. was infested the internal stem portion whereas another fungus *Fusarium oxysporum* is also identified from the infected roots of cotton plants.

PLANT PHYSIOLOGY / CHEMISTRY

Maintaining soil health is the basic step to ensure profitable and sustainable cotton production. Organic matter content in a soil determines its health status as it promotes microbial activity, water conservation and efficient supply of applied nutrients and water to the plant. Nutrient replenishment in quantities equal to those removed from soil, by previous cop or otherwise, will maintain soil fertility. Integrated nutrient management and judicial use of fertilizers ensure higher yields of the farmland in a cost effective manner. However, the use of fertilizers in cotton crop is neither judicial nor balanced. Development of multiple nutrient deficiencies, of various egrees, are the result of continuous mining without adequate nutrient replenishment. Cotton crop is mainly fertilized with nitrogenous and to some extent with phosphatic fertilizers whereas the use of potassium fertilizers is very minimal. Moreover, magnesium is an essential

secondary macronutrient but it is neither applied nor recommended for cotton crop. In spite of the fact that magnesium stimulates enzyme production required for nutritional balance in soil while involved in chlorophyll formation, protein synthesis, photosynthesis, partitioning and utilization of photo-assimilates within the plan. The deficiency of magnesium leads to interveinal chlorosis of older leaves, impairment to plant growth and yield reduction through adversely affecting critical physiological and biochemical processes in plants. The studies were conducted on Magnesium nutrition of cotton to evaluate its comparative efficacy by applying through fertigation and foliar methods. Foliar applied Mg produced better yield than the Mg application through fertigation.

Biotic and abiotic stresses have adverse effects on production and seed quality of cotton crop. High temperatures in the cotton zones negatively impact the yield performance of cotton genotypes. Genetic variability and identification of stress tolerant material help in mitigating the adverse effects of temperature. Out of 35 genotypes studied, GH-Hadi, Cyto-313 and BH-221 surpassed in yield performance and heat tolerant traits. Amino acids like proline is known to induce abiotic stress tolerance by strengthening the cellular walls in such a way that they attain resistance to unfavorable climatic conditions. The studies carried out by the section revealed that both seed priming and subsequent foliar sprays of 0.1% proline along with B & Zn micronutrients provided advantage in terms of yield and seed quality parameters over other doses. Squeezing irrigation water resources warrant development and identification of drought tolerant cotton varieties on regular basis. A total of 36 varieties were tested under normal irrigation and artificially imposed water stress conditions in the field. The genotypes CIM-343 and FH-Lalazar showed better drought tolerance characteristics by producing higher seed cotton yield.

TRANSFER OF TECHNOLOGY

Transfer of Technology Section played a significant role in the dissemination of latest research practices/findings for profitable cotton production technology to all private and public sectors. The research findings are disseminated with the usage of electronic and print media during the cropping season and also in the off-season. Training/refresher courses were conducted for knowledge enhancement and skill development farmers and field officers of pesticide/seed industry. Cotton Crop Management Group (CCMG) Meetings were regularly held at the institute that helped in reviewing cotton crop situation and the devise of measures which should be adopted at gross root level through the intervention of Agriculture Department. A large number of printed materials were distributed among the extension workers, farmers and visitors of the institute during the season. Furthermore, a number of programs for general awareness/skill development in cotton production were taken up through Radio & TV programs.

FIBRE TECHNOLOGY

The contribution of this section in determination of quality traits of genetic material for development of new varieties is up to the mark. About 102,485 lint samples for fibre length, fibre strength, micronaire and color grade were tested during the year. Apart from lab work, research studies on evaluating the effect of CLCuD and different moisture levels on fibre quality were also carried out. To strengthen the liaison with textile industry and bring together field picture for mutual interest, quality survey was conducted for analyzing the quality in ginning factories of Punjab and Spinning mills were visited for data collection regarding cotton fibre utilization and economic comparatives. Every year participation in International Cotton Check Test Program with Faser Institute, Germany prove the thorough standardization of the laboratory.

STATISTICS

Statistics section helps other sections in designing layout of experiments and analysis of the research data. Experimental data of sub-stations like Cotton Research Stations D.I.Khan and Bahawalpur were analyzed. National coordinated varietal trial (NCVT) data were statistically analyzed for Director Research, PCCC. Daily market rates of cotton commodities are documented.

The generous financial support provided by the Pakistan Central Cotton Committee (PCCC) and Ministry of Commerce & Textile (Textile Division) are gratefully acknowledged and also the financial contribution through “Pak-US Cotton Productivity Enhancement Project” by ICARDA, for the development of CLCuV resistant varieties.

The Institute highly commends the technical assistance of the International Cotton Advisory Committee (ICAC), Washington, DC, USA in regular inflow of technical information and assistance in attending the international cotton conferences and workshops. The Institute appreciates the cooperation extended by the Department of Agriculture, Government of the Punjab in making the research program a success. The facilities provided by the Punjab Seed Corporation (PSC), Lahore for conducting research trials at PSC Farm, Khanewal are highly appreciated. The Institute also acknowledges the facilities provided by the progressive farmers for conducting field experiments at their farms. The Institute also thanks the fertilizer, pesticide and seed industry and other organizations that extended their cooperation in the research/technology transfer activities of the Institute.

I am appreciative of all those who have contributed towards achieving the assigned targets in cotton research and development.

Dr. Zahid Mahmood
Director
Central Cotton Research Institute
Multan

March, 2018

ANNUAL PROGRESS REPORT OF CENTRAL COTTON RESEARCH INSTITUTE, MULTAN FOR THE YEAR 2017-18

I. INTRODUCTION

Since its establishment in 1970 by the Pakistan Central Cotton Committee, the Central Cotton Research Institute has been endeavoring to conduct fundamental research on cotton. The Institute initially started its activities with five disciplines viz. Cytogenetics, Entomology, Plant Pathology, Plant Physiology/ Chemistry and Statistics. The Institute expanded its research horizon to cover applied research with special focus to address the issues faced by cotton farming community regarding production technology and to enhance cotton production through evolving high yielding varieties with desirable fibre parameters. To achive this mandate, new sections such as Plant Breeding and Genetics (1973), Agronomy (1975), Fibre Technology (1976) and Transfer of Technology (1983) were set up in a period of one decade. The Institute has also been recognized as "Centre of Excellence" in Asia Region by the Organization of Islamic Conference (OIC). Presently nine disciplines are working at the Institute in a coordinated manner. The work was focused on the following main objectives:

1. Study the cotton plant from botanical, genetical, production, physiological, chemical, entomological, pathological and other relevant facets in a coordinated manner.
2. Undertake research work of national importance, handle problems of inter-regional nature.
3. To develop cost-effective cotton production technology.
4. Advance knowledge on the cotton plant responses to environment with a view to better cope with the adverse impacts in the changing climate scenario.
5. Provide education and training on cotton production technology to the agriculture research, extension, teaching staff and other stakeholders.
6. Identify problems of cotton growers and advocate remedial measures.
7. Transfer production technology to the cotton growers.
8. Educate and motivate cotton growers and monitor research outcomes.
9. Provide technical support to the Pakistan Central Cotton Committee in coordinating and developing a national programme for cotton research and development.
10. Training manpower across the country and other cotton growing countries on "cotton research and development".
11. Facilitation and research guidance to students at graduate and higher level degree courses.

II. WEATHER AND COTTON CROP CONDITION

1. Weather

The pattern of maximum temperatures during cotton crop season 2017-18 remained lower during May-June while minimum temperature remained parrel to that of last year.The annual average maximum temperature during 2017-18 remained 32.52°C while it was 32.56°C during last year. Similarly the annual average minimum temperature during current year remained at 22.4°C while it was 22.5°C during last year.The average relative humidity remained 78.0% during current season while it was 77.9% during last season. A total of 139 mm rainfall was recorded during the crop season (Apr-Dec) of 2017 as compared to 168.8 mm rainfall during the last year.

The meteorological data for the year 2017 vis-à-vis 2016 recorded at Central Cotton Research Institute, Multan are illustrated in Fig. 1 and Appendix-I.The comparative maximum/minimum temperatures, relative humidity, rainfall for the year 2017 and 2016 are given in Appendix-I.

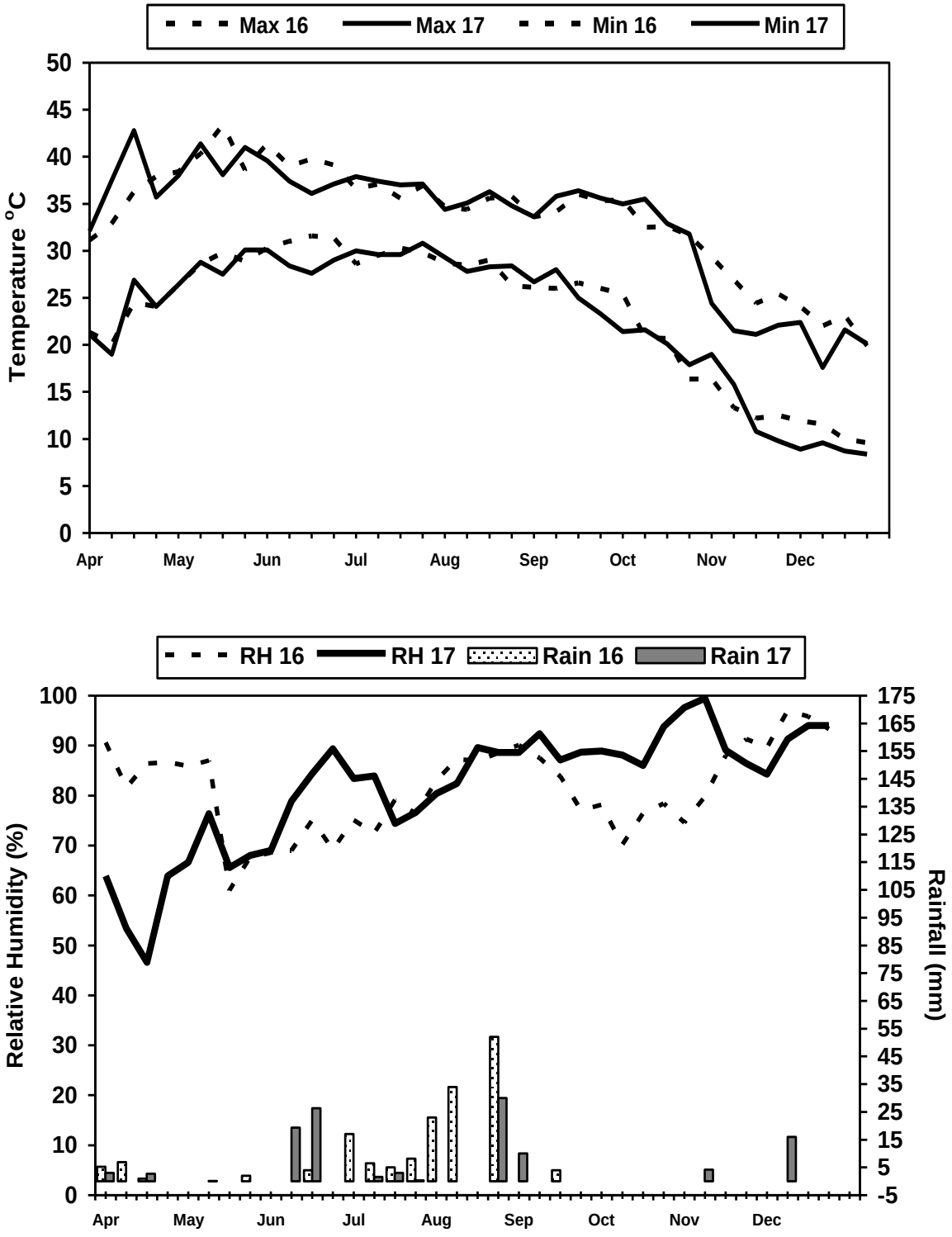

Fig. 1 Weekly Average Temperature, Relative Humidity and Total Rainfall during 2016 and 2017.

2. Cotton Crop Situation

2.1 Cotton Sowing

In the meeting of Federal Committee on Cotton held under the chairmanship of Secretary, Textile Division, Ministry of Commerce & Textile, Islamabad, fixed the cotton sowing targets of 6.0 Million acres for Punjab with production estimates of 10.0 million bales. But sowing was done on 5.306 million acres, which remained 11.57% less than the proposed target and 18.28% more than the previous year as reported by Director General Agriculture (Ext.) in the meeting of Cotton Crop Management Group (CCMG) held on 07.10.2017. The major increase in cotton sowing was witnessed in Vehari, DG Khan, Khanewal, Pak Pattan, Faisalabad, T.T. Singh, and Chiniot. The overall cotton crop size in the province was estimated at 8.8 million bales by the Cotton Crop Assessment Committee (CCAC) meeting held on 02.11.2017. The detail is as under:

(000 acres)

Punjab Area	Targets 2017	Area sown		%age of the Target	%age (+/-) over last year
		2017	2016		
Core Areas	4938.95	4567.00	3841.00	92.47	+ 18.90
Non-Core Areas	763.13	527.00	418.00	69.09	+ 26.08
Marginal Areas	297.92	212.00	227.00	71.16	-6.61
PUNJAB	**6000.00**	**5306.00**	**4486.00**	**88.43**	**+18.28**

Source: CCMG 07.10.2017

The district / division-wise cotton area sown during 2017-18 and 2016-17, as recorded by Crop Reporting Service Department, Government of the Punjab, Lahore, remained as under:-

(Area in 000 acres)

Divisions/Districts	2017-2018	2016-2017
Rawalpindi Division	1	**1**
Attock Rawalpindi Islamabad Jehlum Chakwal	1	1
Sargodha Division	**181**	**211**
Sargodha	12	13
Khushab	5	6
Mianwali	106	119
Bhakkar	58	73
Faisalabad Division	**185**	**178**
Faisalabad	55	46
T.T. Singh	72	60
Jhang	54	68
Chiniot	4	4
Gujranwala Division	**2**	**2**
Gujrat M.B.Din Sialkot Narowal Gujranwala Hafizabad	2	2
Lahore Division	**14**	**15**
Sheikhupura	1	1
Nankana Sahib	1	1
Lahore Kasur	12	13

Sahiwal Division	**250**	**238**
Okara	25	41
Sahiwal	160	138
Pakpattan	65	59
Multan Division	**1803**	**1359**
Multan	389	349
Lodhran	467	373
Khanewal	472	351
Vehari	475	286
D.G.KhanDivision	**1023**	**956**
Muzzafargargh	346	336
Layyah	122	106
D.G. Khan	223	180
RajanPur	332	334
Bahawalpur Division	**1643**	**1526**
Bahawalpur	660	598
R.Y. Khan	389	419
Bahawalnagar	594	509
Punjab	**5102**	**4486**

2.2 Supply of Inputs

Irrigation water supply shortage prevailed through out the cropping season like during previous year and cotton sowing was also delayed in some areas due to delayed canal water availability.The availability of nitrogenous and phophatic fertilizers remained satisfactory and no shortage was reported.

The availability of cotton pest-specific pesticides remained satisfactory during the season. However, flareup of whitefly, jassid and pink bollworm in some areas limited the achieveable yield potential.

Pesticide Availability for Kharif 2017

	Carry over as on 31.12.16 (KG/L)	Planned Import forn2017 (kg/L)	Total expected availability for 2017	Actual sold, during 2012 (Kg/L)	Actual Imports upto 15/4/2017	Total actual availability (includes carryover)	Area to be treated with actual availability (acres)	Area to be treated with expected availability 2017 (acres)
1	2	3	4	5	6	7	9	10
Heliothis Specific (+armyworm)	224,155	1,806,912	2,031,067	1,804,317	400,800	624,955	326,888	3,495,653
Whitefly Specific	516,664	660,275	1,176,939	801,590	-	592,614	3,189,197	5,058,005
Mealy Bug Specific	1,849	88,800	90,649	51,445	88,800	90,649		181,298
Armyworm Specific	61,025	266,765	327,789	237,902	88,235	149,260	700,406	1,381,020
PBW/SBW Specific	479,579	594,450	1,074,030	860,144	4,000	483,579	727,145	3,809,342
Other Sucking	453,949	199,505	653,453	430,779	85,850	539,799	2,714,876	4,708,616
Miticides / Acaricides	122,472	157,234	279,706	210,858	3,010	125,482	30,100	583,492
Weedicides	152,087	-	1,138,087	927,375	523,234	675,321	761,153	1,313,415
Grand Total	2,011,779	3,773,941	6,771,720	5,324,410	1,193,930	3,281,660	8,449,764	20,530,842

Source: Crop Life Pakistan

2.3 Cotton Pests and Disease Situation

The Director General, Pest Warning & Quality Control of Pesticides Punjab reported the cotton insect pests and disease situation in the province which described that the hot spots of Jassid (9.61%), Whitefly (12.04%), CLCuV (14.88%), Mealybug (8.50%), Armyworm (3.32%), and Thrips (2.79%) were observed. More incidence level of Whitefly was observed in Bahawalpur, Lodhran, Multan, Sargodha, and Sahiwal district. Moreover, hotspots of American bollworm were also observed on Bt varieties (0.01%) and non-Bt varieties (0.07%). Spots of PBW were witnessed in Mianwali and Rahim Yar Khan districts. The pheromone trap catches data for Pink

Bollworm moths. Higher incidence of CLCuV was observed in Vehari, Multan, Khanewal, Sahiwal, T.T. Singh, Lodhran and Jhang areas.. The overall summary of cotton insect pests and disease position as compared to previous year is given below:

Sr. No.	Pests & Diseases	2017	2016	2015
1.	Whitefly	4.10	4.97	4.38
2.	Jassid	3.79	1.70	4.38
3.	Thrips	0.00	0.00	0.00
4.	Mealy Bug	7.14	9.83	7.06
5.	Mites	0.00	0.00	0.10
6.	Dusky Cotton Bug	2.08	2.62	0.54
8.	Pink Boll Worm	7.36	11.83	7.06
9.	Army Worm	0.28	1.35	2.24
10.	CLCuV (% Incidence)	6.6	7.21	10.37

Source: PWQC, Punjab

2.4 Cotton Plant Mapping

Plant growth and developed upto 15.10.2017 was reported as under:

Major Yield Component	2017-18	2016-17	2015-16	% Change
Plants / Acre	15086	13811	13439	2.77
Av. Plant Height(cm)	109.02	120.9	114.4	5.68
Av. Squares	3.53	3.01	3.71	-18.9
Av. Flowers	0.40	0.39	0.38	2.63
Bolls /Plant	18.7	18.4	14.9	23.5
Av. Irrigations	10.68	10.5	8.92	17.7
Av. Sprays	6.41	6.21	5.54	12.1
Fruit Damaged By Insects:				
Rotten Bolls Av.	--	0.06	0.13	-53.8
CLCV % Av.	--	0.33	1.59	-79.2
Bolls Damaged Av.		0.21	0.29	-27.6
Av.use of Fertilizer in kgs				
Nitrogen	50.71	47.0	42.9	9.56
Phosphate	16.35	14.4	12.3	17.1

Source: Director, Crop Reporting Service Punjab

2.5 Cotton Market Situation

2.5.1 Cotton Prices

The market prices of seedcotton on overall season basis remained at Rs.2710~3157 per 40 kgs during theyear and the trend of lint prices remained at Rs.6886~7397 per 40 kgs during the year which were higher than the year 2016-17 during the month of October-December.

Month	2017-18	2016-17	2015-16
Jan	6886	6872	5758
Feb	7154	7149	5756
Mar	7244	7245	5616
Apr	7215	7216	5785
May	7239	7227	5986
Jun	7201	7196	5993
Jul	6663	7086	6558
Aug	7082	7100	4880
Sep	6472	6505	4991
Oct	6583	6410	5582
Nov	6945	6469	5698
Dec	7397	6712	5607
Average	**7007**	**6932**	**5684**

2.5.2 Cotton Arrival Position

The cotton arrival position into ginning factories upto 3rd March 2018 reached at 11.524 million bales of cotton showing 7.63 % higher arrivals compared to 10.707 million bales during the corresponding period of last season, according to the latest fortnightly report on cotton arrivals, released by Pakistan Cotton Ginners' Association (PCGA).

Province	2017-18	2016-17	% Change
Punjab	7,271,323	6,920,370	+ 5.07
Sindh	4,253,258	3,786,811	+ 12.32
PAKISTAN	**11,524,581**	**10,707,181**	**+ 7.63**

Source: Pakistan Cotton Ginners Association

III. STAFF POSITION

A total of 131 staff members including 34 officers and 97 other staff members remained at the Institute during the period under report. The position of technical staff during the year 2017-18 is given in **Appendix-II**.

IV. BUDGET

The sanctioned budget from the year 2016-17 to 2017-18 is given below:

(Rs. Million)

Sr. #	Detail	2016-17	2017-18
1.	Pay & Allowances	67.622	**61.860**
2.	Medical	3.413	2.930
3.	Traveling Allowance	1.500	1.800
4.	Group Insurance	0.795	0.617
5.	Utility Bills*	7.060	7.160
6.	Contingencies	25.485	48.200
	Total	**105.875**	**122.567**

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

V. INCOME

The income of the Institute from the year 2016-17 to 2017-18 is given below:

(Rs. Million)

Sr. #	Head	2016-17	2017-18
1.	Farm Produce	3.381	4.000
2.	Non-Farm Produce	1.161	1.200
	Total	**4.548**	**5.200**

* Period from 1st July to 29th February

VI. MAJOR ACCOMPLISHMENTS

a) Varietal Development

The 22nd meeting of the Technical Advisory Committee (TAC), of the National Biosafety Centre, Pakistan Environmental Protection Agency was held at Islamabad on 30th January, 2018 under the chairmanship of Mrs Farzana Altaf Shah, Director General, Pakistan Environmental Protection Agency, Islamabad. Cases of 46 transgenic varieties of various crops were presented in the meeting from the public and private sector institutions for biosafety clearance and testing under field conditions. Dr. Zahid Mahmood, Director CCRI Multan presented cases of the following 09 promising upcoming Bt cotton varieties developed by CCRI Multan and 05 Bt cotton varieties developed by Cotton Research Station, Ghotki for conducting field trials.

Sr. No.	Name of variety	GOT (%age)	Staple Length (mm)	Micronaire Value	Fibre Strength
1.	Cyto-515	39.1	28.0	4.7	29.2
2.	CIM-663	38.6	28.4	4.7	27.4
3.	CIM-653	39.0	28.5	4.5	27.7
4.	CIM-651	37.6	29.2	4.9	28.6
5.	CIM-645	39.2	28.8	4.2	30.6
6.	CIM-643	39.4	28.2	4.8	31.0
7.	CIM-642	38.4	29.0	4.2	30.2
8.	CIM-636	38.9	28.7	4.2	29.5
9.	CIM-343	38.5	29.0	4.6	27.5

Dr. Zahid Mahmood, Director CCRI Multan presented background development phases and performance of these varieties. He stated that these varieties are bollworm resistant, early maturing, possess high yield potential, better fibre characteristics. It is hoped that approval and release of these varieties for commercial cultivation will significantly contribute to the over-all cotton production. He further stated that these varieties will be included in the National Coordinated Varietal Trial 2018, after grant of permission for the field trials, for their testing under various ecological zones. The commission, after reviewing performance of varieties and high level of resistance against bollworms, granted permission for conducting field trials of these varieties.

b) <u>Approval of Projects for Cotton Research and Development</u>

"A Comprehensive Integrated Scientific Approach for the Development of Sustainable Management Strategies of Pink Bollworm (*Pectinophora gossypiella*)": This is a collaborative project involving Central Cotton Research Institute, Multan; University of Agriculture Faisalabad; Entomological Research Institute, Ayub Agricultural Research Institute Faisalabad; Muhammad Nawaz Sharif University of Agriculture Multan; and National Institute for Biotechnology & Genetic Engineering Faisalabad. Moreover, the Agriculture Extension Department and the Department of Pest Warning & Quality of Pesticides Punjab will also be engaged in the project. The project will encompass management of Pink boll worm through integrated pest management, molecular approaches and development of resistant cotton germplasm. The project is funded by the Punjab Agricultural Research Board (PARB) and the project period spans over three years duration starting from October 2017.

"Management of Whitefly by Integrated Strategies and Development of Resistant Cotton Germplasm through Genetic Engineering": This is also a collaborative project involving Central Cotton Research Institute, Multan; Department of Entomology, University of Agriculture Faisalabad; Entomological Research Institute, Ayub Agricultural Research Institute Faisalabad; Muhammad Nawaz Sharif University of Agriculture Multan; Cotton Research Institute (Government of the Punjab) Multan and National Institute for Biotechnology & Genetic Engineering Faisalabad. Moreover, the Agriculture Extension Department and the Department of Pest Warning & Quality of Pesticides Punjab will also be engaged in the project.The project will involve 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 germplasm against whitefly by RNA interference.This project is also funded by the Punjab Agricultural Research Board (PARB) and the project period spans over three years duration starting from October 2017.

"Better Cotton Initiative (BCI) for Sustainable Cotton Production in Pakistan": This project has been included in the Textile Policy 2014-19 developed by the Ministry of Commerce & Textile Industry, Government of Pakistan. The Pakistan Central Cotton Committee (PCCC) has been assigned the task to execute the "Better Cotton" project for three years (2017-2020) in the Punjab and Sindh provinces in coordination with organization of Better Cotton Initiative (BCI), Pakistan and other stakeholders. The project will cover districts of Multan and D.G. Khan in Punjab province and district Shaheed Benazirabad, Naushero Feroze and Dadu in Sindh province. This project will be executed by the CCRI, Multan and CCRI Sakrand through designated Provincial Coordinators. The proposed Better Cotton Production Program of PCCC will help the farmers to produce better quality cotton in Pakistan. The qualitative and quantitative factors involved in cotton production losses will be investigated thoroughly and tackled through better guidance and training of the farmers for cost effective and better quality cotton production in Punjab and Sindh provinces.

Pak-US-ICARDA Cotton Productivity Enhancement Program (CCRI Multan Component): This project was initiated during 2011. The objective of the project was to test and screen exotic cotton germplasm (USDA Material) for evolution of cotton leaf curl virus (CLCuV) resistant/tolerant varieties for enhancing cotton productivity in the country. The Institute has received more than 4000 cotton genotypes which were screened and 67 varieties were found resistant against CLCuV. But out of 67, flowering induced in two varieties, while 65 varieties are still under test and trial basis for the flower induction. This project was terminated during March 2017 but keeping in view the need for further research on the aspect, one year extension has been granted in the project duration. During the crop season 2018-19, two cotton varieties (Bt and non-Bt each) will be tested at national level in the National Coordinated Varietal Trial for testing their resistance / tolerance against the CLCuV at varied ecological zones. Moreover, the project assisted in the development of Cold Room for short, medium and long term storage / preservation of cotton seed.

c) <u>Memorandum of Understandings (MoUs) for Cotton Research & Development</u>

i) WWF Pakistan and CCRI Multan

CCRI Multan inked an MoU with WWF Pakistan to jointly undertake activities to develop and demonstrate sustainable practices to preserve natural attributes of cotton fiber at production and processing level. Both the partners will endeavor to involve each other in areas of mutual interest without any additional liabilities except as covered by this agreement. CCRI Multan will provide technical support to recommend appropriate cotton varieties with improved fiber quality characteristics, provide technical data of relevant research studies, translate research findings for dissemination among different supply chain actors from farm till ginning, provide technical support to develop and review standards for harvest and post-harvest practices, provide technical support to develop communication material, conduct trainings in collaboration with WWF-Pakistan on fiber quality preservation techniques for cotton supply chain actors, host seminars/workshops, and provide fibre testing facility as well. Whereas, WWF Pakistan will provide support for the technical resource persons/ trainers' boarding lodging and refreshment during trainings; as and when required, bear costs of producing communication material i.e. booklets, leaflets etc. pertaining to sustainable quality preservation techniques, organize seminars, workshops to focus the attention of relevant stakeholders' on sustainable fiber quality preservation techniques at different levels of supply chain.

ii) EMS R&D Solutions Ltd, England

Central Cotton Research Institute, Multan is working for the development of colored cotton on regular basis and the scientists have successfully evolved colored cotton with a staple length of 28mm and beyond with different color shades (light brown, brown, light green and dark brown). To explore feasibility of growing naturally-grown colored cotton

with its varying color shades, Skype meeting was organized between Mr. Ejaz Sheikh, Consultant, EMS R&D SOLUTIONS LTD, England, Prof Dr. Asif Ali, Vice Chancellor, Muhammad Nawaz Sharif University of Agriculture (MNSUA), Multan and Dr. Zahid Mahmood, Director CCRI Multan. Mr. Ejaz Sheikh who is working on a project "Water Pollution Prevention" with an objective of preventing water-borne diseases, preserving fast receding precious resource of drinkable water by using less and preventing contaminated water going back into water bed to pollute the rest, reducing pollution, global warming and carbon footprint, earn Pakistan and community prestigious place in the world. While, exploring potential for developing naturally-colored cotton for development of 10-12 colors of Organic Colored Cotton (Cost, Time etc) for guaranteed successful outcome. CCRI Multan offered to participate in such collaborative arrangements for developing naturally-colored cotton with different color shades.

iii) Punjab Agricultural Research Board (PARB)

Central Cotton Research Institute (CCRI) Multan and Punjab Agricultural Research Board (PARB), Lahore Government of the Punjab signed MoU for the general purpose of supporting and promoting cotton research. This Cooperation Program aims to foster advancement in research, commercialization and collaborative research in the areas of mutual interest to enhance sustainable productivity of cotton, reduce poverty, ensure food security through promotion, development and conduct of research mutually through mutual scientific and technical cooperation under PARB identified Research Themes will advance the state of S&T in the country and strengthen the scientific infrastructure. PARB funding for CCRI scientists to attend scientific conferences/ workshops/ seminars, etc. abroad, organizing scientific conferences/ workshops/seminars, etc. at CCRI, Multan, mutual support and cooperation in research projects and the activities for commercialization of their outputs of the PARB projects. Moreover, CCRI Multan will act as one of the evaluators for any of the cotton related research products developed through PARB funding.

iv) International Center for Agricultural Research in Dry Areas (ICARDA)

Central Cotton Research Institute, Multan is collaborating with ICARDA have agreed to enter into a research collaboration Agreement titled, "Improving Resistance to Cotton Leaf Curl Virus (CLCuV) and Supporting Cotton Best Management Practices for Small Farmers." CCRI Multan will be involved in research activities for the development of CLCuV resistant cotton varieties. The activities will include ratooning of resistant accessions for flower induction and to be used in crossing program, Testing of cotton varieties in National coordinated Varietal Trials (NCVT) during 2018-19, Screening of the ratoon crop, resistant/tolerant lines, ginning and fibre quality analysis and germplasm preservation.

c) International Conference "Plant Health for Sustainable Agriculture: A Focused Approach for Food Security under Changing Climate"

Central Cotton Research Institute, Multan organized the 6th International Conference of Pakistan Phytopathological Society on emerging issue *"Plant Health for Sustainable Agriculture: A Focused Approach for Food Security under Changing Climate"* from November 20-22, 2017 in collaboration with Department of Plant Pathology, Bahauddin Zakariya University, Multan. Eminent researchers and scholars attended the conference including 05 foreign delegates. The topics covered in the Conference included climate change and plant diseases, molecular plant pathology, disease resistance, seed pathology, disease modeling, bioinformatics etc.

The inaugural session was chaired by Haji Muhammad Akram Ansari, Minister of State for Commerce & Textile Industry, Government of Pakistan; Prof. Dr. Tahir Amin, Vice Chancellor, Bahauddin Zakariya University Multan; Dr. Zahid Mahmood, Director CCRI Multan; Prof. Dr Rashida Atiq, Chairperson, Department of Plant Pathology, BZU Multan. Researchers, academicians, farmers, and students attended the conference.

The Technical Session of the Conference started with the invited speaker Prof. Dr. Wasantha Kumara from Sri Lanka and Dr. Xifeng Wang, China who presented their talks related to climate change on plant pathogens and transmission mechanism of virus. Other invited speaker included Mounir Abou Haidar, Department of Cell & Systems Biology, University of Toronto, Toronto, Canada, Dr. Herpinder Singh Randhawa, Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada.

The speakers presented their talks on Climate Change and Plant Diseases, Host-Pathogen Interactions, Molecular Plant Pathology, Biosecurity and Plant Quarantine, Plant Disease Management, Disease Resistance, Seed and Post-Harvest Pathology, Disease Modeling and Epidemiology, Taxonomy and Systematics of Plant Pathogens, Bioinformatics, Ecology of plant pathogens, Mycotoxins, Natural and chemical Pesticides, Insects in relation to Plant Diseases, Beneficial Microorganisms.

d) Cotton Seminar "Soil Health Improvement and Nutrition Management in Cotton"

CCRI Multan organized a seminar "Soil Health Improvement and Nutrition Management in Cotton". The seminar was chaired by Haji Muhammad Akram Ansari, Federal Minister of State for Commerce & Textile Industry; Syed Javaid Ali Shah, Federal Minister for Water Resources; Dr. Khalid Khokhar, Member Provincial Assembly Punjab; Prof. Dr. Asif Ali, Vice Chancellor MNSUA; and Dr. Khalid Abdullah, Vice President PCCC. Dr. Fiaz Ahmad, SSO/Head Plant Physiology delivered lecture on Plant Nutrition. Researchers and farmers attended the seminar.

e) Establishment of ICRA Secretariat

The International Cotton Advisory Committee (ICAC) established the International Cotton Researchers Association (ICRA) for the assistance of cotton researchers across the globe. PCCC, Multan was finalized, after going through a strong screening process to host the ICRA Secretariat for 5 Years. In this regard, an MoU signing Ceremony was held at CCRI Multan. Dr. Michel Fok, Chairman, ICRA and Dr. Khalid Abdullah, Vice President, PCCC were the signatories. The Secretariat will coordinate among cotton researchers and provide a platform for building linkages through enhancing membership and addressing cotton issues. Dr. Fiaz Ahmad was nominated as Secretary for this Secretariat.

f) Farmers' Field Day at Kot Addu

CCRI, Multan organized Farmers' Field Day for the awareness of farmers at Dera of Mr. Farooq Ahmad Nolatia, Peer Jaggi More, Kot Addu. The farmers visited the field then they were briefed by Dr. Zahid Mahmood, Director and Dr. Muhammad Idrees Khan Head Plant Breeding & Genetics Section of CCRI Multan about cotton production technology, clean picking, storage and transportation and seed maintenance for growing during next season.

g) Demonstration of Mechanical Cotton Picking at CCRI Multan

CCRI Multan introduced the mechanical picker for picking the cotton in the country. During the crop season 2017-18, the Institute organized a number of practical demonstrations of the mechanical picker for introduction among cotton farmers, field staff of agriculture extension and research, academicians, and executives at national and provincial level. Dr. Zahid Mahmood stated that this will revolutionize the cotton picking practices in the country. Moreover, cotton picker was also used for picking the leftover bolls which could save the crop from Pink bollworm and gather 4-5 maunds of additional seedcotton. Farmers can save cost and time by using mechanical cotton pickers.

h) Publication of Monthly Newsletter

The Institute has also started publication of monthly Newsletter for highlighting major activities and events organized during the crop season 2017-18. The newsletter publication started from the month of October 2017 on regular basis and so far 6 newletters have been published. The soft copies of the newsletters were also emailed to more than 700 researchers, policymakers, farmers and other stakeholders. Moreover, the Newsletter was also placed on the website and facebook account of the Institute as well.

i) TeleCotton

CCRI Multan introduced TeleCotton SMS service for the guidance of the cotton farmers. A short message was sent on daily basis during the crop season 2017-18 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 9152 cotton farmers from all the four provinces were included in the list to receive day to day cotton crop management messages. Moreover, farmers were also replied to their queries with regard to crop management.

j) Website & Social Media

The Institute also introduced highlighting cotton research and development activities carried out during crop season 2017-18, utilizing social media tools, i.e., (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.

The detail of research experiments conducted by different Sections are given in following pages.

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1. AGRONOMY

The agronomy section undertake applied research work in matters of crop production such as soil, water, nutrients, weeds management and planting time optimization for candidates and benchmark varieties (GMO's & Non GMO's) evolved by CCRI keeping in view the climatic vagaries. The practices are developed to ensure higher yield through minimizing the impact of various biotic and abiotic stresses. Furthermore, the productivity of cotton-wheat system is also being tested through innovative approach of relay cropping technology which enables early cotton planting in standing wheat to avoid the practice of leaving land fallow which was otherwise to be used for wheat. The daily record of metrological observations is also with section to be utilized in crop management strategies.

1.1 Effect of time of sowing on productivity of advanced genotypes

Three genotypes i.e. CIM-620, CIM-610 and CIM-717 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. Bed-furrows were prepared after land preparation in dry condition followed by bed shaping and Dual Gold 960 EC @ 2L per hectare was sprayed after sowing on moist beds. Sowing was done with delinted seed by dibbling method followed by irrigation. Nitrogen at the rate of 150 kg ha^{-1} was applied in three split doses. Other cultural practices and plant protection measures were adopted as per need of the crop. Data on plant height, boll number, boll weight, seed cotton yield and CLCuD incidence percentage is given in Table 1.1.

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

Sowing dates	Genotypes	Plant height (cm)	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 105 DAS
April 15	CIM-620	130.5	34	2.68	3391	11.8
	CIM-610	131.4	29	2.93	2999	77.9
	CIM-717	129.1	31	2.80	3079	22.0
May 01	CIM-620	125.3	31	2.70	3020	32.9
	CIM-610	120.7	27	2.95	2718	79.0
	CIM-717	121.0	29	2.83	2910	91.4
May 15	CIM-620	114.3	27	2.73	2650	69.7
	CIM-610	110.4	25	2.97	2478	98.8
	CIM-717	111.9	27	2.85	2690	93.3
June 01	CIM-620	97.5	19	2.75	1896	100.0
	CIM-610	97.0	19	3.00	1923	100.0
	CIM-717	99.2	22	2.89	2212	100.0
June 15	CIM-620	95.2	18	2.77	1660	100.0
	CIM-610	94.4	16	3.02	1556	100.0
	CIM-717	88.1	18	2.91	1699	100.0

DAS* = Days after sowing

Sub-effects

Sowing dates	Plant height (cm)	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 105 DAS
April 15	130.3	31.3	2.80	3156	37.2
May 01	122.3	29.0	2.83	2883	67.8
May 15	112.2	26.3	2.85	2606	87.3
June 01	97.9	20.0	2.88	2010	100.0
June 15	92.6	17.3	2.90	1638	100.0

Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 105 DAS
CIM-620	112.6	25.8	2.73	2523	62.9
CIM-610	110.8	23.2	2.97	2335	91.1
CIM-717	109.9	25.4	2.86	2518	81.3
C.D 5%					
Sowing date (SD)	8.50	2.64	ns	201.90	7.87
Genotype (G)	ns	2.12	0.10	96.60	1.97
SD x G	15.57	4.68	0.39	267.80	8.66

The data presented in Table 1.1 indicated that on overall average basis of sowing dates, CIM-620 and CIM-717 produced significantly higher seed cotton yield as compared to CIM-610. The genotypes CIM-620 and CIM-717 produced 8.1% and 7.8% higher seed cotton yields than CIM-610. The genotype CIM-620 produced 0.20% higher seed cotton yield than CIM-717. Average across the genotypes, plant height decreased as the sowing was delayed (Fig. 1), April 15 and May 01 sown crop produced significantly more number of bolls than other sowing dates (Fig. 2) and seed cotton yield decreased significantly as sowing was delayed (Fig. 4). While, boll weight increased as the sowing was delayed (Fig. 3). Among all sowing dates maximum boll weight was (2.90 g) produced from June 15 sown crop. The maximum bolls per plant (31.3) and seed cotton yield (3156 kg ha^{-1}) were harvested from April 15 sown crop.

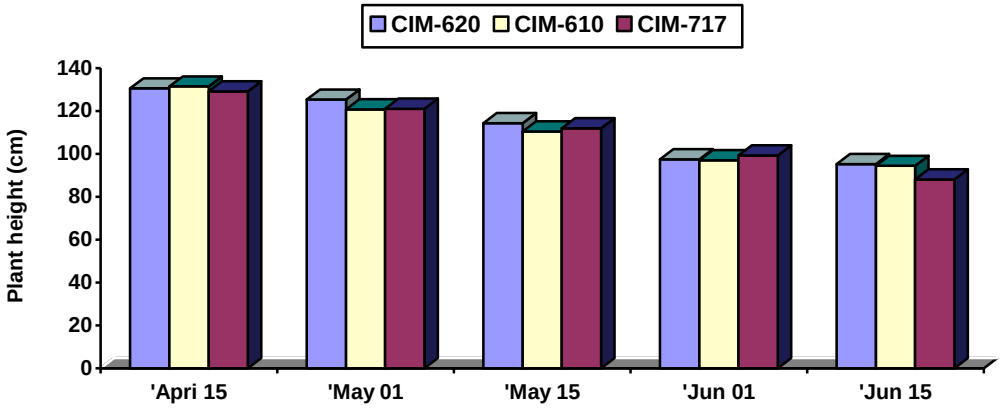

Fig 1 Sowing dates x Genotypes interaction on plant height

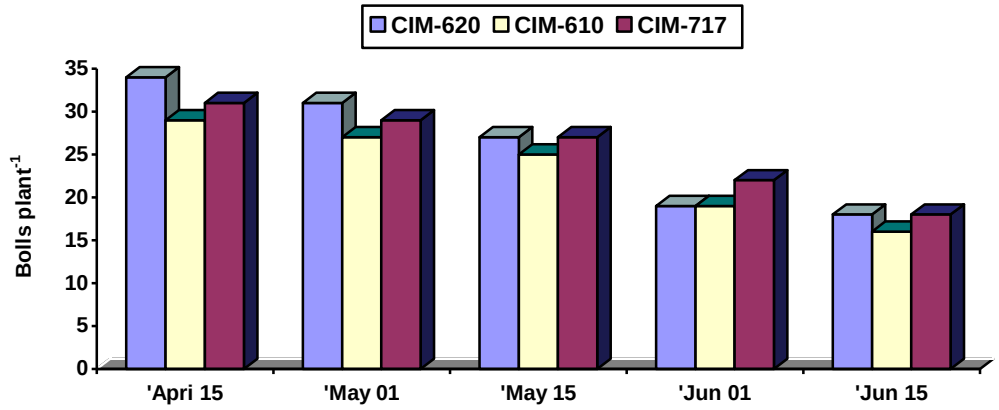

Fig 2 Sowing dates x Genotypes interaction on bolls plant^{-1}

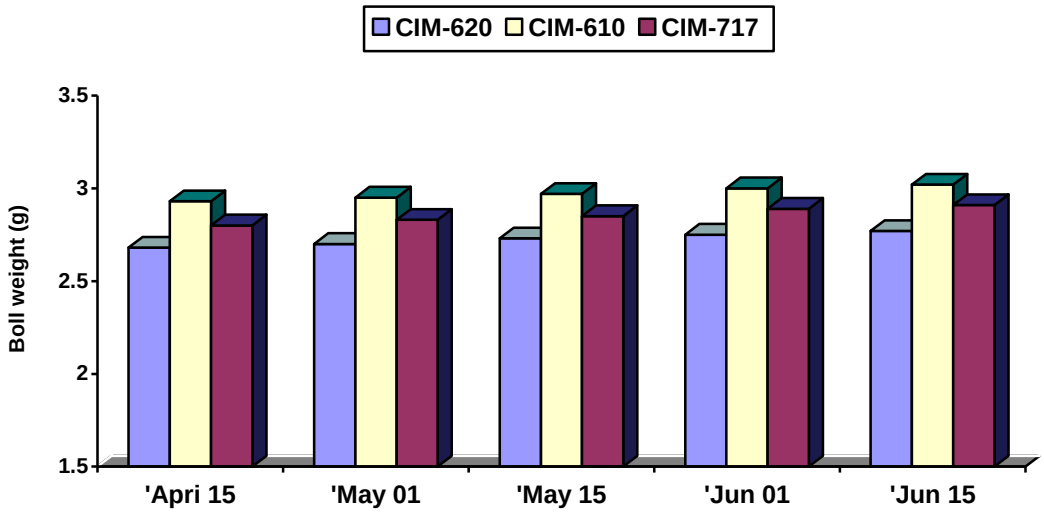

Fig 3 Sowing dates x Genotypes interaction on boll weight

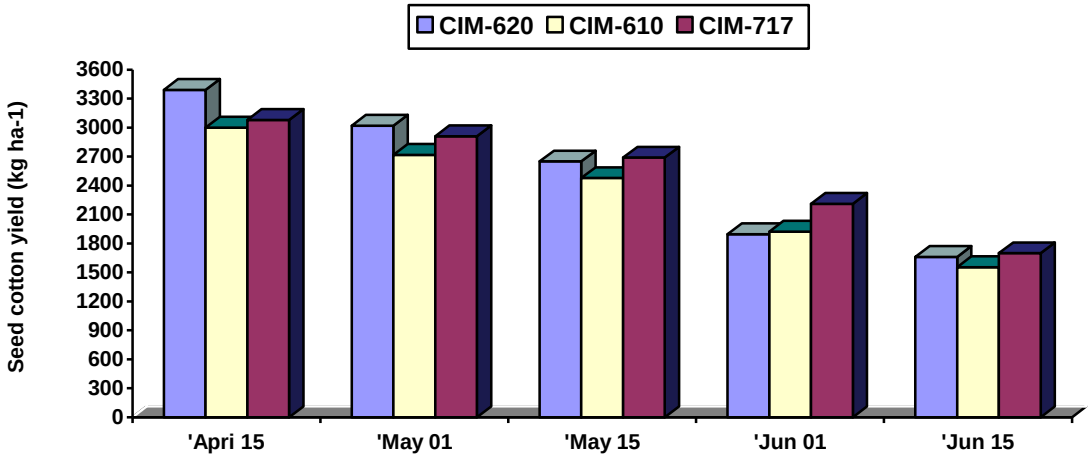

Fig 4 Sowing dates x Genotypes interaction on seed cotton yield

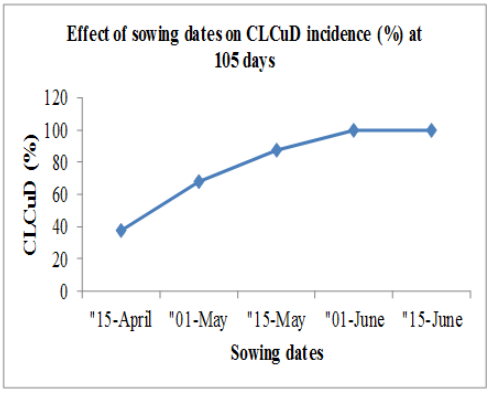

Fig 5. Sowing dates effect on virus infestation at 105 DAS

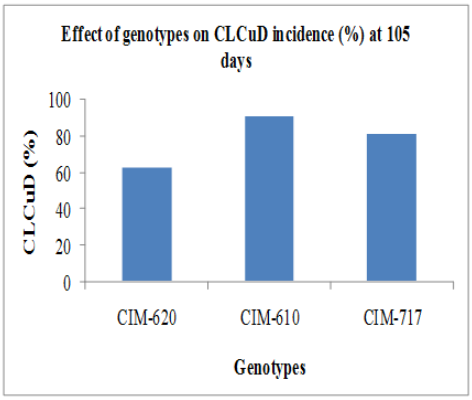

Fig 6. CLCuD Incidence in different genotypes

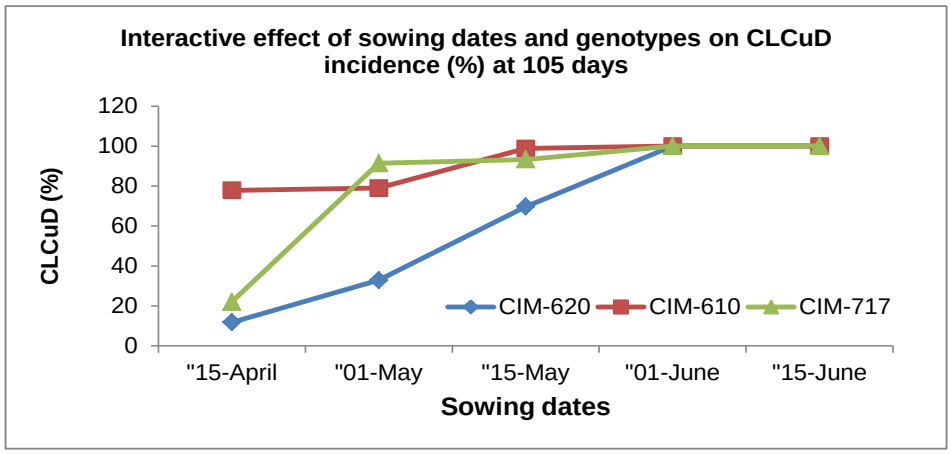

Fig 7. Sowing dates x Genotypes interaction for CLCuD incidence (%) at 105 DAS

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 105 days after sowing was observed 100% in June 01 and June 15 sown crops. Whereas, April 15, May 01 and May 15 showed 37.2%, 67.8% and 87.3% virus infestation, respectively (Fig. 5). On the average basis of sowing dates, genotype CIM-620 showed 18.4% and 28.2% less CLCuD incidence than CIM-717 and CIM-610, respectively (Fig. 6). The interaction between sowing dates and genotypes is illustrated in (Fig. 7).

1.2 Effect of time of sowing on production of transgenic cotton

Five transgenic cotton genotypes i.e. *Bt.*Cyto-515, *Bt.*CIM-632, *Bt.*Cyto-313, *Bt.*CIM-343 and *Bt.*CIM-602 (std) were evaluated at six different sowing dates starting from March 01 to May 15 at fortnightly interval. Experimental design was split plot, sowing dates were kept in main plot and genotypes in sub plots with four repeats. Bed-furrows were prepared after land preparation in dry condition followed by bed shaping and Dual Gold 960 EC @ 2L per hectare was sprayed after sowing on moist beds. Sowing was done by manual dibbling of seeds at 25 cm plant to plant distance followed by irrigation. Other cultural practices and plant protection measures were adopted as per need of the crop. Data on plant height, boll number, boll weight, seed cotton yield and CLCuD incidence percentage recorded is given in Table 1.2.

The plant height, bolls per plant and seed cotton yield were decreased while boll weight was increased with delay in sowing (fig 8, 9, 11 and 10). The maximum plant height (140.3 cm), bolls plant^{-1} (37) and seed cotton yield (3676 kg ha^{-1}) were harvested from March 01 sown crop. Among all sowing dates maximum boll weight (2.92 g) was produced from May 15 sown crop. On overall average basis of sowing dates, *Bt*.Cyto-313 produced 5.0%, 7.6%, 13.7% and 29.4% more seed cotton yield than *Bt*.CIM-343, *Bt*.Cyto-515, *Bt*.CIM-602 and *Bt*.CIM-632, respectively.

The data on CLCuD indicated that the disease incidence increased as the sowing was delayed from March 01 to May 15. The incidence of CLCuD after 105 days was observed 89.7% in May 01 and 96.7% in May 15 sown crop. While, March 01, March 15, April 01 and April 15 sown crops showed 4.3%, 6.1%, 32.9% and 81.8% virus infestation, respectively (Fig. 12). On the average basis of sowing dates, genotype *Bt.*Cyto-515 showed 3.4%, 4.7%, 5.6% and 8.5% less incidence of CLCuD than *Bt*.CIM-343, *Bt*.CIM-632, *Bt.*Cyto-313 and *Bt*.CIM-602, respectively (Fig. 13). The interaction between sowing dates and genotypes is illustrated in Fig. 14.

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

Sowing dates	Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 105 DAS
March 01	*Bt.*Cyto-515	142.7	38	2.92	3788	0.0
	*Bt.*CIM-632	144.4	34	2.64	3304	2.0
	*Bt.*Cyto-313	142.6	40	2.70	4030	4.1
	*Bt.*CIM-343	138.8	38	2.86	3780	4.9
	*Bt.*CIM-602	132.9	35	2.68	3476	10.7
March 15	*Bt.*Cyto-515	139.1	36	2.96	3628	3.6
	*Bt.*CIM-632	140.9	31	2.65	3014	4.1
	*Bt.*Cyto-313	139.5	38	2.73	3826	6.9
	*Bt.*CIM-343	133.2	37	2.93	3676	6.6
	*Bt.*CIM-602	127.9	33	2.70	3338	9.3
April 01	*Bt.*Cyto-515	129.2	31	3.02	3163	26.8
	*Bt.*CIM-632	134.8	27	2.66	2630	39.0
	*Bt.*Cyto-313	127.9	35	2.75	3489	33.3
	*Bt.*CIM-343	125.3	33	3.00	3350	32.4
	*Bt.*CIM-602	123.8	30	2.72	3022	32.8
April 15	*Bt.*Cyto-515	126.0	28	3.04	2874	76.1
	*Bt.*CIM-632	130.3	25	2.69	2347	81.6
	*Bt.*Cyto-313	127.5	32	2.76	3204	86.4
	*Bt.*CIM-343	121.1	29	3.07	2918	72.7
	*Bt.*CIM-602	119.7	28	2.72	2829	92.2
May 01	*Bt.*Cyto-515	122.9	27	3.11	2695	83.8
	*Bt.*CIM-632	127.1	23	2.73	2174	89.2
	*Bt.*Cyto-313	123.1	29	2.78	2875	91.8
	*Bt.*CIM-343	118.7	28	3.13	2827	90.8
	*Bt.*CIM-602	110.5	26	2.76	2604	92.9
May 15	*Bt.*Cyto-515	119.8	25	3.13	2562	94.8
	*Bt.*CIM-632	119.1	22	2.74	2086	97.0
	*Bt.*Cyto-313	120.3	27	2.80	2710	96.1
	*Bt.*CIM-343	116.3	26	3.16	2616	98.0
	*Bt.*CIM-602	104.7	24	2.79	2442	97.9

DAS* =Days after sowing

Sub-effects

Sowing dates	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 105 DAS
March 01	140.3	37.0	2.76	3676	4.3
March 15	136.1	35.0	2.79	3496	6.1
April 01	128.2	31.2	2.83	3131	32.9
April 15	124.9	28.4	2.86	2834	81.8
May 01	120.5	26.6	2.90	2635	89.7
May 15	116.0	24.8	2.92	2483	96.7

Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence (%) at 105 DAS
*Bt.*Cyto-515	130.0	30.8	3.03	3118	47.5
*Bt.*CIM-632	132.8	27.0	2.69	2593	52.2
*Bt.*Cyto-313	130.2	33.5	2.75	3356	53.1
*Bt.*CIM-343	125.6	31.8	3.03	3195	50.9
*Bt.*CIM-602	119.9	29.3	2.73	2952	56.0

C.D 5%

Sowing date (SD)	13.01	2.16	0.13	174.05	5.73
Genotype (G)	7.47	1.98	0.14	155.20	2.79
SD x G	20.88	4.83	0.34	381.70	8.26

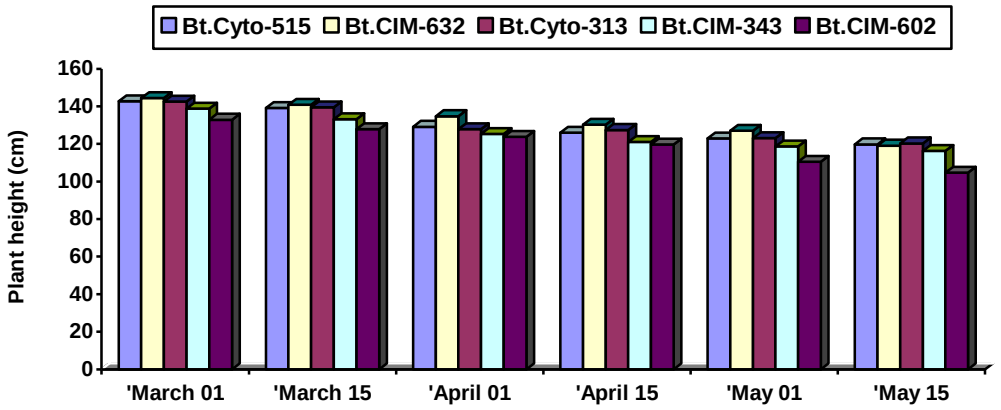

Fig 8 Sowing dates x Genotypes interaction on plant height

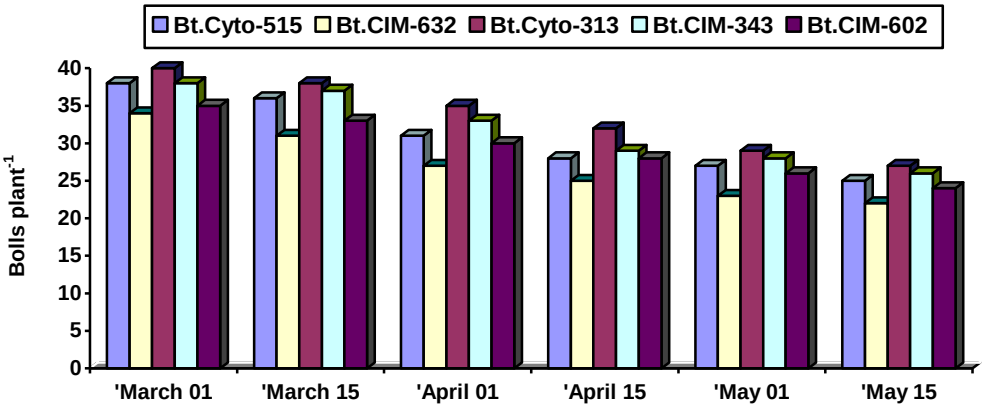

Fig 9 Sowing dates x Genotypes interaction on bolls plant^{-1}

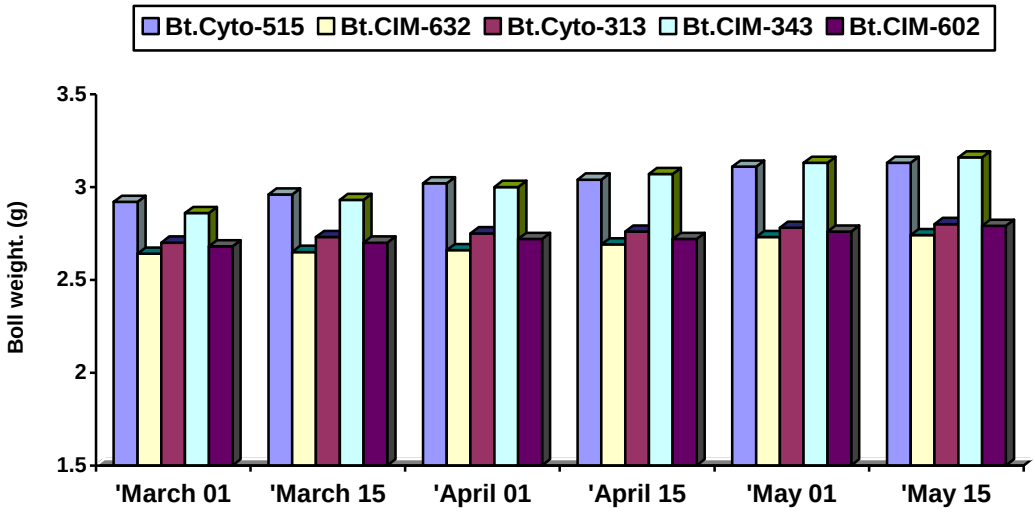

Fig 10 Sowing dates x Genotypes interaction on boll weight

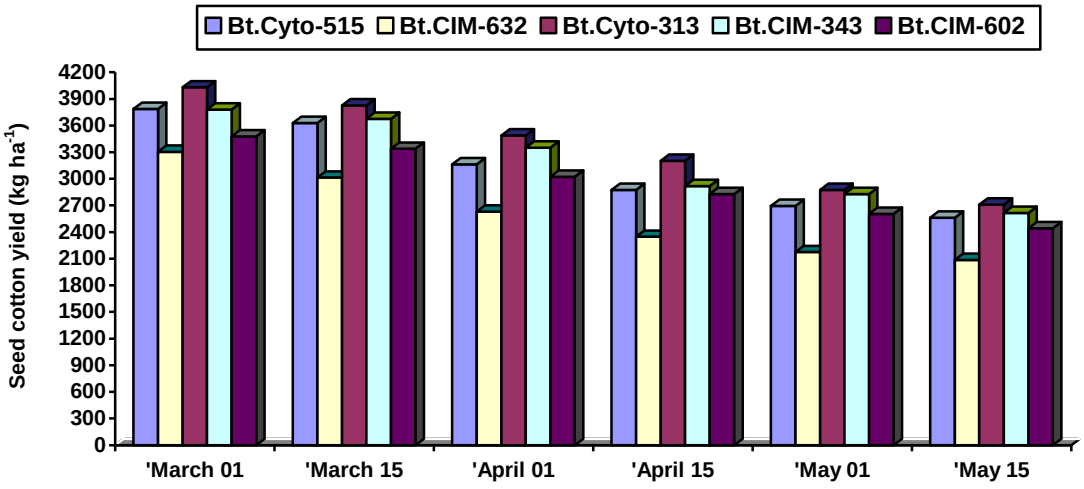

Fig 11 Sowing dates x Genotypes interaction on seed cotton yield

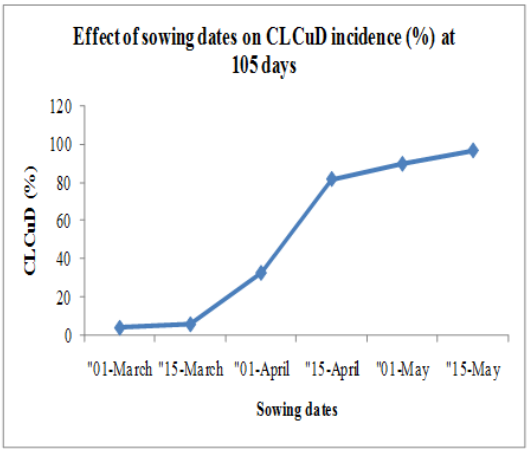

Fig 12. Virus Infestation at 105 DAS at various sowing dates

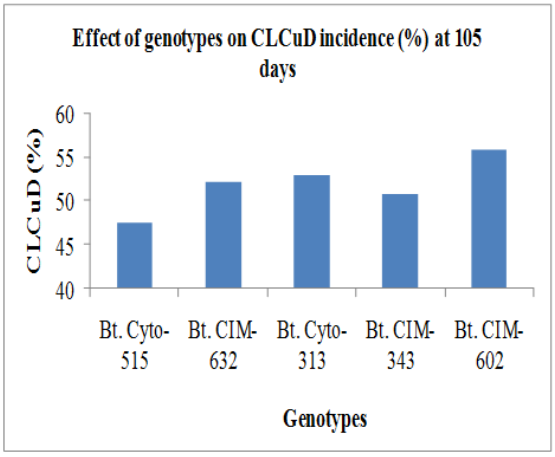

Fig 13. CLCuD Incidence (%) in different genotypes

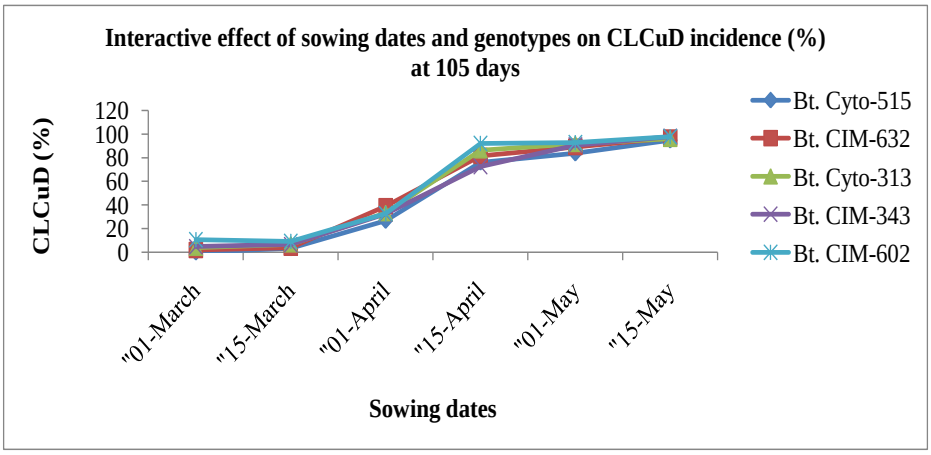

Fig 14. Sowing Dates x Bt. Genotypes Interaction for CLCuD Incidence (%) at 120 DAS

1.3 Yield response and nitrogen use efficiency of transgenic vs. conventional cotton genotypes to nitrogen application

Four genotypes, two from transgenic i.e. *Bt*.CIM-632 & *Bt*.Cyto-313, two from conventional group i.e. CIM-620 & CIM-610 were tested at five levels of nitrogen (0, 75, 150, 225 and 300 kg N ha^{-1}). The design of experiment was split plot with four replications. The nitrogen was kept in main plots and genotypes in sub-plots. Bed-furrows were made after land preparation in dry condition and Dual Gold 960 EC @ 2L per hectare was sprayed after sowing on moist beds. Sowing was done on 17.05.2017 on bed-furrow by dibbling method followed by irrigation. The nitrogen fertilizer (75 to 300 kg N ha^{-1}) was applied in three splits in respective plots. Other cultural practices and plant protection measures were adopted as per need of the crop. Data recorded on plant height, boll number, boll weight, seed cotton yield and agronomic nitrogen use efficiency are given in Table 1.3.

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

Nitrogen dose (kg ha^{-1})	Genotypes	Plant height (cm)	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})	Agronomic nitrogen use efficiency (kg kg^{-1})
0	*Bt.* CIM-632	119.7	17	2.65	1675	-
	Bt. Cyto-313	114.9	19	2.73	1883	-
	CIM-620	108.2	18	2.64	1756	-
	CIM-610	111.1	19	2.71	1864	-
75	*Bt.* CIM-632	124.4	24	2.68	2394	9.59
	Bt. Cyto-313	121.7	26	2.77	2671	10.51
	CIM-620	114.5	25	2.68	2496	9.87
	CIM-610	118.2	26	2.74	2615	10.01
150	*Bt.* CIM-632	130.1	26	2.70	2575	6.00
	Bt. Cyto-313	128.0	30	2.79	2986	7.35
	CIM-620	121.4	28	2.71	2836	7.20
	CIM-610	125.3	29	2.78	2915	7.01
225	*Bt.* CIM-632	134.3	29	2.72	2899	5.44
	Bt. Cyto-313	131.1	32	2.82	3240	6.03
	CIM-620	123.2	30	2.72	2925	5.20
	CIM-610	126.3	30	2.80	2964	4.89
300	*Bt.* CIM-632	137.2	33	2.74	3273	5.33
	Bt. Cyto-313	134.1	34	2.83	3391	5.03
	CIM-620	124.5	31	2.73	3070	4.38
	CIM-610	129.6	31	2.80	3094	4.10

Sub-effects

Nitrogen dose (kg ha^{-1})	Plant height (cm)	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})	Agronomic nitrogen use efficiency (kg kg^{-1})
0	113.5	18.3	2.68	1795	-
75	119.7	25.3	2.72	2544	10.00
150	126.2	28.3	2.75	2828	6.89
225	128.7	30.3	2.77	3007	5.39
300	131.4	32.3	2.78	3207	4.71

Genotypes	Plant height (cm)	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})	Agronomic nitrogen use efficiency (kg kg^{-1})
Bt. CIM-632	129.1	25.8	2.70	2563	6.59
Bt. Cyto-313	126.0	28.2	2.79	2834	7.23
CIM-620	118.4	26.4	2.70	2617	6.66
CIM-610	122.1	27.0	2.77	2690	6.50

C.D 5%

Nitrogen (N)	11.68	1.43	ns	310.5	-
Genotypes (G)	7.24	1.30	ns	181.7	-
N x G	ns	ns	ns	ns	-

The data presented in Table 1.3 showed that plant height, number of bolls and seed cotton yield varied significantly for nitrogen over unfertilized plot. The plant height, number of bolls, boll weight and seed cotton yield were increased from 113.5 to 131.4 (cm), 18.3 to 32.3 (plant^{-1}), 2.68 to 2.78 (g) and 1795 to 3207 (kg ha^{-1}), respectively (fig. 15, 16, 17 and 18). Although, nitrogen application at the rate of 225 and 300 kg ha^{-1} did not produce significant difference for seed cotton yield, however, value of additional seed cotton is higher than the expenses of 75 kg additional nitrogen. The agronomic nitrogen use efficiency (ANUE) was gradually decreased with successive increase in nitrogen application (fig 19.). The significant variations among genotypes were also recorded for number of bolls and seed cotton yield. The genotype *Bt.* Cyto-313 produced the highest number of bolls (28.2 plant^{-1}), boll weight (2.79 g) and seed cotton yield (2834 kg ha^{-1}) followed by non transgenic genotype CIM-610. The *Bt*.Cyto-313 gave the highest agronomic nitrogen use efficiency over rest of the genotypes. Among the both groups (transgenic vs. conventional), the transgenic genotypes produced only 90 kg ha^{-1} additional seed cotton yield. The non-significant interaction between genotypes and nitrogen application rates indicated that there is no difference for nitrogen requirement of genotypes.

Economic analysis:

Nitrogen dose (kg ha^{-1})	Cost of fertilizer (Rs)	Additional seed cotton yield (kg ha^{-1})	Value of additional seed cotton (Rs.)	Net income (Rs.)	BCR
0	-	-	-	-	-
75	4557	749	54303	49746	11.9
150	9114	1033	74893	65779	8.2
225	13671	1212	87870	74199	6.4
300	18228	1412	102370	84142	5.6

The nitrogen application at the rate of 75, 150, 225 and 300 kg ha^{-1} produced 749, 1033, 1212 and 1412 kg additional seed cotton yield over control. The maximum net income (Rs. 84142) was obtained from 300 kg N ha^{-1}. The benefit cost ratio decreased with each increase in nitrogen levels.

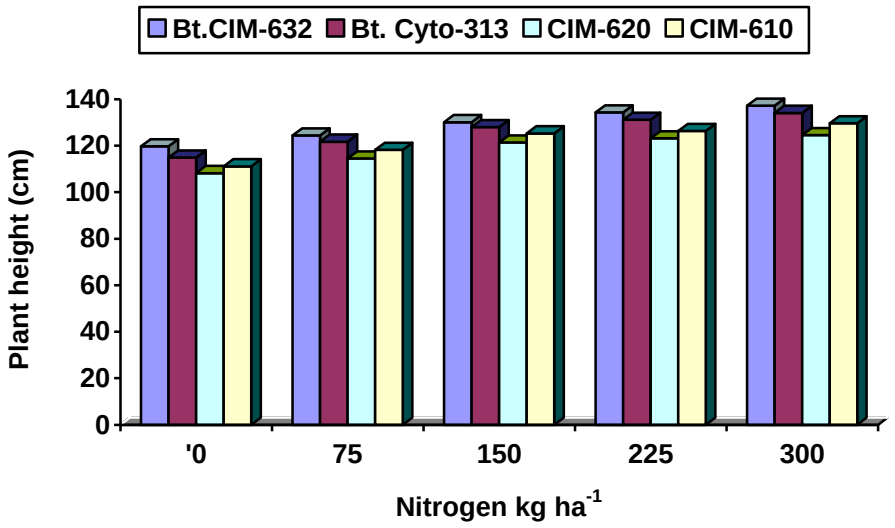

Fig 15 Nitrogen levels X genotypes interaction on plant height

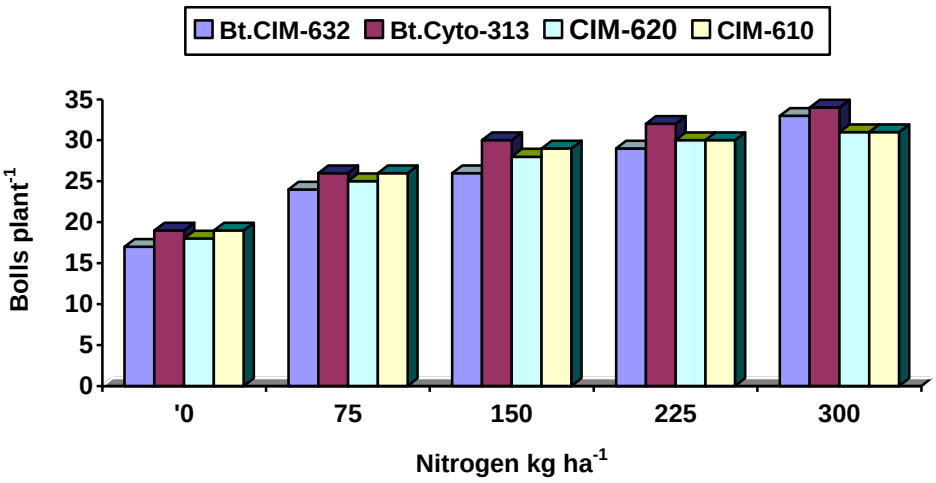

Fig 16 Nitrogen levels X genotypes interaction on bolls plant^{-1}

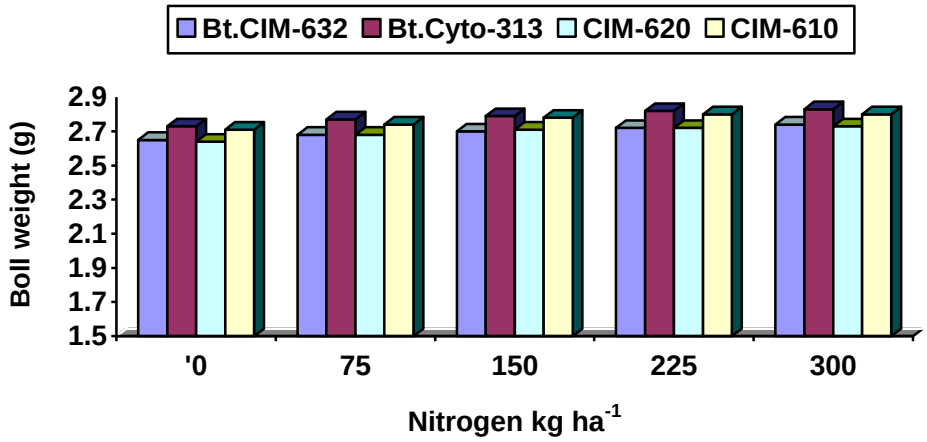

Fig 17 Nitrogen levels X genotypes interaction on boll weight

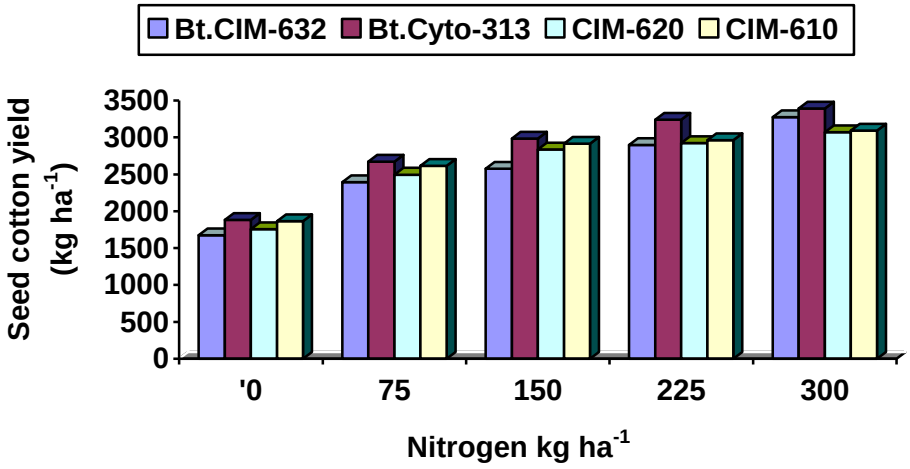

Fig 18 Nitrogen levels X genotypes interaction on seed cotton yield

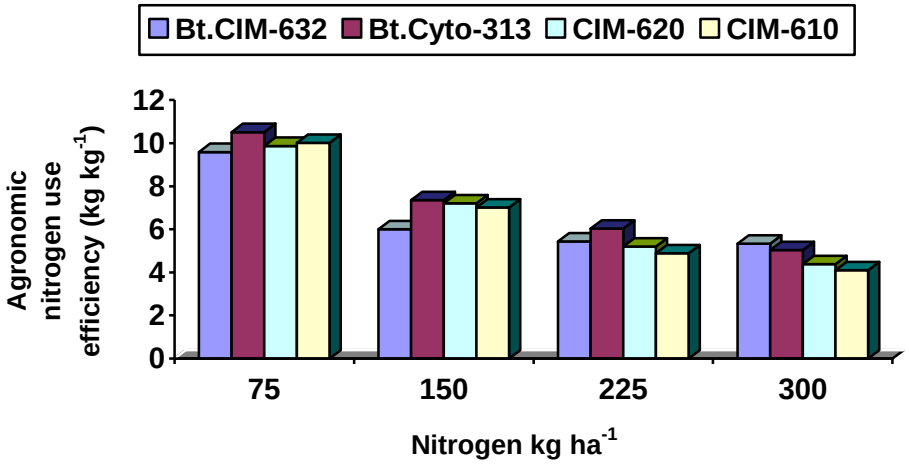

Fig 19 Nitrogen levels X genotypes interaction on agronomic nitrogen use efficiency

1.4 Cotton as Relay Cropping

Cotton cultivar *Bt.* CIM-616 was planted as a test crop in all treatments of the experiment. The crop was sown on 18-03-2017 as sole crop on fallow land (T_1). While, sowing in standing wheat was done on 18-03-2017 as a relay crop 75 cm apart rows (T_2) and 150 cm apart rows (T_3), respectively. Conventional cotton sowing after wheat harvesting was completed on 24-05-2017 (T_4). The design of the experiment was Randomized Complete Block Design. Sowing was done by dibbling seeds at 25 cm plant to plant distance followed by irrigation. The Dual Gold 960 EC @ 2L per ha was sprayed on moist beds after planting in treatment (T_1 and T_4), while in T_2 and T_3, it was applied with irrigation water. Other cultural practices and plant protection measures were adopted as per need of the crop. Data on plant population, plant height, boll number, boll weight and seed cotton yield are given in Table 1.4

Table 1.4: Plant population, plant height, seed cotton yield and yield components

Treatments	Plant population (ha^{-1})	Plant height (cm)	Bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Cotton as sole (fallow land)	50,000	122.3	180	2.70	3965
Cotton sowing in standing wheat (row to row distance 75cm)	65,000	129.2	247	2.69	4283
Cotton sowing in standing wheat (row to row distance 150cm)	49,000	126.0	178	2.72	3766
Cotton planting after wheat harvesting	48,000	110.5	144	2.71	2935
C.D 5%	7649.3	ns	23.95	ns	182.07

The data presented in Table 1.4 indicated that cotton sowing in standing wheat (75 cm apart rows) produced maximum plant height (129.2 cm), bolls (247 m^{-2}) and seed cotton yield (4283 kg ha^{-1}). While, the minimum bolls (144 m^{-2}) and seed cotton yield (2935 kg ha^{-1}) were produced from cotton sown after wheat harvesting. Whereas, the maximum boll weight (2.72 g) produced by the cotton in standing wheat (150 cm apart rows). Planting of cotton under modified technique i.e relay crop 75 cm apart rows produced 8.0%, 13.7% and 45.9% higher seed cotton yield over fallow land, wide row (150 cm) and after wheat harvesting, respectively.

1.5 Full season competitive ability of major weeds in cotton

Cotton cultivar *Bt*. Cyto-179 has been sown on 4th May 2017 to determine the competitive ability of major weeds. The treatments included were weeds free (T_1), all broad leave weeds (T_2), all narrow leaves weeds (T_3) and all weeds (T_4). Experimental design was Randomized Complete Block Design (RCBD) with three replications. Bed-furrows were prepared after land preparation in

dry condition followed by bed shaping. Sowing was done by manual dibbling of seeds at 25 cm plant to plant distance followed by irrigation. Data on plant height, boll number, boll weight and seed cotton yield are given in Table 1.5a

Table 1.5a: Effect of weeds on plant height, seed cotton yield and its components

Treatments	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Weeds free	113.5	32	2.78	3216
Broad leave weeds	104.2	25	2.73	2480
Narrow leave weeds	102.4	23	2.73	2320
All weeds	95.0	17	2.68	1754
C.D 5%	ns	7.81	ns	568.76

The data presented in table 1.5a indicated that presence of weeds drastically reduced plant height, number of bolls, boll weight and seed cotton yield. The maximum reduction was observed in plots where both narrow and broad leave weeds were left uncontrolled. The narrow leave weeds affected the crop more negatively than broad leave weeds. The seed cotton yield was reduced by 23%, 28% and 46% for broad, narrow and both types of weeds, respectively over weed free plots.

Table 1.5b: Weeds competitive indices

Treatments	Weed density (m^{-2})	Relative yield losses (%)	Relative competitive index	Competitive index
Weeds free	-	-	-	-
Broad leave weeds	37	22.9	0.23	1.99
Narrow leave weeds	63	27.9	0.28	1.42
All weeds	107	45.5	0.45	1.37

The data presented in table 1.5b indicated that the maximum yield losses (45.5%) and relative competitive index (0.45) were recorded in plots with presence of both narrow and broad leave weeds. The competitive index represents the yield loss per weed (m^{-2}) which was the maximum in broad leave weeds followed by narrow and all weeds. Although narrow leave weeds density was higher than broad leave weeds, but yield losses per weed was greater in broad leave weeds. Among all weed treatments, the narrow leave weeds are deleterious for yield on account of higher density.

1.6 Topping and branch removal impacts on growth and yield performance of cotton in various plant spacing

Cotton cultivar *Bt*. CIM-616 was sown on 19th May 2017 to determine the suitability of branch removal for various planting densities. The treatments included three planting distances i.e. 15 cm (T_1), 30 cm (T_2) & 45 cm (T_3) and no branch removal (T_1), monopodia removal at 100 cm (T_2), tip removal at 100 cm (T_3) and monopodia and tip removal at 100 cm height (T_4). Experimental design was split plot, plant spacing were kept in main plot and branch removal in sub plots with three repeats. Bed-furrows were prepared after land preparation in dry condition followed by bed shaping and Dual Gold 960 EC @ 2L per hectare was sprayed after sowing on moist beds. Sowing was done by manual dibbling followed by irrigation. The branch removal treatments were applied on acquiring desired plant height. 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 plant spacing and branch removal on plant population, plant height, yield and yield components

Plant Spacing (cm)	Topping treatment	Plant Population (ha^{-1})	Plant height (cm)	Number of bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
15	No branch removal	82333	125.9	172.0	2.71	3722
	Monopodia removal at 100 cm	81884	116.3	139.0	2.71	2950
	Tip removal at 100 cm	82609	106.1	164.0	2.72	3640
	Monopodia and tip removal at 100 cm	82333	103.6	123.0	2.71	2610
30	No branch removal	39333	119.7	112.0	2.72	2751
	Monpodiaremoval at 100 cm	39275	114.8	92.0	2.72	2232
	Tip removal at 100 cm	40609	105.6	108.0	2.74	2672
	Monopodia and tip removal at 100 cm	41275	103.7	88.0	2.72	2088
45	No branch removal	27333	117.8	81.0	2.76	2034
	Monpodiaremoval at 100 cm	27001	110.4	70.0	2.75	1723
	Tip removal at 100 cm	26738	105.2	78.0	2.77	1955
	Monopodia and tip removal at 100 cm	27333	102.9	68.0	2.75	1542

Sub-effects

Plant Spacing (cm)	Plant Population (ha^{-1})	Plant height (cm)	Number of bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
15	82290	113.0	149.5	2.71	3231
30	40123	111.0	100.0	2.73	2436
45	27101	109.1	74.3	2.76	1814

Topping treatment	Plant Population (ha^{-1})	Plant height (cm)	Number of bolls (m^{-2})	Boll weight (g)	Seed cotton yield (kg ha^{-1})
No branch removal	49666	121.1	121.7	2.73	2836
Monopodia removal at 100 cm	49387	113.8	100.3	2.73	2302
Tip removal at 100 cm	49985	105.6	116.7	2.74	2756
Monopodia and tip removal at 100 cm	50314	103.4	93.0	2.73	2080

C.D 5%

Spacing (S)	2511.30	ns	18.13	ns	289.5
Topping (T)	ns	9.88	9.66	ns	187.5
S x T	ns	ns	ns	ns	ns

The data presented in table 1.6 indicated that plant population, number of bolls (m^{-2}) and seed cotton yield was significantly decreased with increasing plant spacing. The narrow plant spacing i.e 15 cm produced 32.6% and 78.1% higher seed cotton yield over 30 and 45 cm plant spacing, respectively on account of high boll density. The topping treatment significantly influenced plant height, number of bolls (m^{-2}) and seed cotton yield. The seed cotton yield and number of bolls (m^{-2}) were decreased in various topping treatments. The maximum reduction was observed where both monopodia and tip was removed together followed by only monopodia removal and only tip removal.

Internship

Agronomy Section provided research facilities to one Ph.D. scholar from faculty of Agricultural Science and Technology, Bahauddin Zakariya University in addition to eleven 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.

Cost of Production of One Acre Cotton for the Year 2017-18

Sr. No.	Operations and Inputs	Number/ Quantity	Rate (Rs)	Amount (Rs.)
1.	Seedbed Preparation			**4062**
	a) Cultivation (Ploughing + planking)	4	500/cultivation	2000.00
	b) Leveling	1	360/leveling	360.00
	c) Bed and furrow making	1	500/acre	500.00
	d) Pre-emergence Herbicide	1.2	960/liter	1152.00
	e) Bund making	1	50/acre	50.00
2.	Seed			**1285.00**
	a. Cost	8 kg.	6000/40 kg	1200.00
	b. Transportation	-	25/bag	5.00
	c. Delinting	-	400/40 kg	80.00
3.	Sowing	2 men day	1116/acre	**1116.00**
4.	Thinning	2 men day	1116/acre	**1116.00**
5.	Interculturing and earthing up	4	500/acre	**2000.00**
6.	Irrigation			**9696.00**
	a. Land preparation (3 hours)	1/3 canal		
	b. *Rouni* (4 hours)	2/3 tubewell	400/hour of tubewell	7464.00
	c. Post planting irrigation (21hours)			
	d. Cleaning of water channel and labour charges for irrigation	4 man day	558/man day	2232.00
8.	*Abiana* (Water rates)	-	85/acre	**85.00**
9.	Fertilizer			**8858.00**
	a. DAP (Di-Amonium Phosphate)	1 bag	2600/bag	2600.00
	b. Urea	4.0 bags	1400/bag	5600.00
	c. Transportation	4.0 bags	25/bag	100.00
	d. Fertilizer Application Charges	1man day	558/day	558.00
10.	Plant Protection			**10650.00**
	a. Sucking	9	750/spray	6750.00
	b. Bollworm	6	650/spray	3900.00
11.	Harvesting (Picking charges)	840 Kg	10.0/kg	**8400.00**
12	Stick Cutting	2 men day	558/man day	+1116.00
12a	Value of cotton sticks			-1116.00
13.	Managerial Charges For 1 acre	7 month	20000/month/100 acre	**1400.00**
14.	Land Rent	7 months	35,000/acre/annum	**20417.00**
16.	Unforeseen Expenses	-	2000/acre	**2000.00**
17.	Production Expenditure	-	-	
	a. Including Land Rent			**71085.00**
	b. Excluding Land Rent			**50668.00**
18.	Mark-up on Investment	7 month	12.5% for one year	
	a. Including Land Rent			**5183.00**
	b. Excluding Land Rent			**3695.00**
19.	Total Expenditure	--		
	a. Including Land Rent			**76268.00**
	b. Excluding Land Rent			**54363.00**
20.	Income of Seed Cotton	840 kg	2900/40 kg	**60900. 00**
21.	Market expenses	840 kg	100/40 kg	**2100. 00**
22.	Cost of Production at Farm level	-		
	a. Including Land Rent		Per 40 kg	**3631.81**
	b. Excluding Land Rent			**2588.71**
23.	Cost of production at Market	-		
	a. Including Land Rent.		Per 40 kg	**3731.81**
	b. Excluding Land Rent.			**2688.71**

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2. PLANT BREEDING & GENETICS SECTION

Plant Breeding & Genetics Section evolves new cotton varieties or lines with desirable fibre properties by utilizing purposeful breeding (crossing) of closely or distantly related individuals. Plants are crossbred to introduce traits/genes from one variety or line into a new genetic background.

The promising hybrids, *Bt*. and non-*Bt*. strains from all the cotton breeders of the country were evaluated under National Coordinated Variety Testing (NCVT) Programme of Pakistan Central Cotton Committee and Provincial Coordinated Cotton Trial (PCCT) of the Punjab Government. The commercial varieties (*Bt*. and non-*Bt*.) of the country were also conducted to test their performance evaluated under local conditions in standard varietal trial. The breeding materials in different filial generations were screened out for further process. Major emphasis was laid on the selection of material having resistance/tolerance to BSCV along with excellent fibre characteristics. Fresh crosses were also attempted to develop resistance/tolerance to BSCV in new *Bt*. & Non-*Bt* breeding material. Pre-basic seed of commercial varieties viz., CIM-496, CIM-620, CIM-554, CIM-573, *Bt.*CIM-598, *Bt.*CIM-600, *Bt.*CIM-599 and *Bt.*CIM-602 were produced for distribution to public and private seed corporations for further multiplication. The genetic stock of World Cotton collections comprising of 5923 cultivars of four *Gossypium* species is being maintained for evaluation, introduction as well as utilization in breeding program by cotton breeders in the country and abroad. Training was also given 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

Six medium long staple promising *Bt*. strains viz., CIM-657, CIM-658, CIM-659, CIM-660, CIM-661, and CIM-662, were evaluated against two *Bt*. commercial varieties i.e. *Bt*.CIM-602 and FH-142 at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal. Data of seed cotton yield and other parameters are given in **Tables 2.1, 2.2** and **2.3**.

Averaged across the two locations, the strain CIM-662 produced the highest seed cotton yield of 3805 kg ha^{-1} followed by CIM-657 having yield 3750 kg ha^{-1} while the standard varieties *Bt*.CIM-602 and FH-142 yielded 2876 and 2811 kg ha^{-1} respectively **(Table 2.1).**

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

Strains	Seedcotton yield (kg ha^{-1})			Lint Yield (kg ha^{-1})	Av. Boll weight (g)	Plant Pop. (ha^{-1})
	Multan (5/5)*	Khanewal (17/5)	Average			
CIM-657	3691	3808	3750	1485	2.8	28066
CIM-658	3428	3333	3381	1349	2.7	28066
CIM-659	2898	3050	2974	1133	3.5	33715
CIM-660	2687	2833	2760	1018	2.5	33177
CIM-661	3507	3423	3465	1441	2.8	29680
CIM-662	3706	3903	3805	1541	3.3	31742
CIM-602	2820	2932	2876	1096	3.2	34701
FH-142	2782	2840	2811	1034	2.7	29321

* = Sowing date 05.05.2017

CD (5%) for seed cotton: Locations (L) = 69.09; Varieties (V) = 88.17, L x V = 108.08

The new strain CIM-661 produced the highest lint percentage of 41.6, followed by CIM-662 having lint percentage values of 40.5 as compared with the standard *Bt*.CIM-602 (38.1%) and FH-142 (36.8%) (**Table 2.2**). The new strain CIM-658 produced the longest staple of 31.0 mm, followed by CIM-661 with 29.7 mm while the standards *Bt*.CIM-602 and FH-142 produced 27.9 and 28.0 mm staple length, respectively **(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
CIM-657	39.2	39.9	39.6	28.6	29.1	28.9
CIM-658	39.7	40.1	39.9	30.8	31.2	31.0
CIM-659	37.5	38.7	38.1	28.9	29.2	29.1
CIM-660	36.4	37.3	36.9	27.7	28.3	28.0
CIM-661	41.1	42.1	41.6	29.1	30.2	29.7
CIM-662	40.2	40.8	40.5	28.6	29.4	29.0
CIM-602	37.8	38.3	38.1	27.5	28.3	27.9
FH-142	36.7	36.9	36.8	27.9	28.1	28.0

All the new strains possess desirable micronaire value ranging from 4.3 to 4.7 μg inch^{-1} in comparison to *Bt*.CIM-602 with 4.7 μg inch^{-1}.The fiber strength of all the new strains and standards are in the desirable range, i.e., 28.4 to 31.4 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 (μg inch^{-1})			Fibre strength (g/tex)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
CIM-657	4.4	4.3	4.4	28.8	28.7	28.8
CIM-658	4.7	4.2	4.5	31.6	31.2	31.4
CIM-659	4.9	4.1	4.5	29.6	29.3	29.5
CIM-660	4.4	4.2	4.3	29.1	28.9	29.0
CIM-661	4.9	4.3	4.6	29.5	29.2	29.4
CIM-662	4.8	4.3	4.6	30.0	29.8	29.9
CIM-602	4.9	4.5	4.7	28.6	28.1	28.4
FH-142	4.5	4.1	4.3	29.5	29.3	29.4

2.1.2 Varietal Trial-2

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

Ten new strains with medium-long staple viz., CIM-650, CIM-651, CIM-652, CIM-653, CIM-656, CIM-664, CIM-665, CIM-666, CIM-667 and CIM-668 were tested at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal against two commercial varieties CIM-602 and FH-142.

Data presented in **Table 2.4** showed that averaged across locations the new strain CIM-653 produced the highest seed cotton yield of 4004 kg ha^{-1}, followed by CIM-652 with 3599 kg ha^{-1} and CIM-667 with 2884 kg ha^{-1} while the standard varieties *Bt*.CIM-602 and FH-142 produced 2352 kg ha^{-1} and 2452 kg yield ha^{-1} respectively.

The strain CIM-665 and CIM-668 had the highest lint percentage of 40.0, followed by 39.7% of CIM-656 in comparison to the commercial varieties CIM-602 and FH-142 produced 37.2 lint percentages. The strain CIM-664 produced the longest staple of 30.4 mm followed by CIM-651 and CIM-650 having 29.2 and 28.7 mm respectively. **(Table 2.5)**

All the strains possess desirable micronaire values ranging from 3.9 to 4.9 μg inch^{-1}**.** The fibre strength of the strains ranged from 26.6 to 31.5 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 (28/4)*	Khanewal (17/5)*	Average			
CIM-650	2531	2654	2593	980	3.0	37481
CIM-651	3577	2152	2865	1077	3.1	41067
CIM-652	3253	3945	3599	1353	3.2	39274
CIM-653	4034	3974	4004	1562	3.1	38915
CIM-656	3293	2224	2759	1095	2.9	32370
CIM-664	2611	2654	2633	961	3.6	40709
CIM-665	3286	2439	2863	1145	2.7	33356
CIM-666	3328	2224	2776	1049	3.2	39991
CIM-667	3400	2367	2884	1078	3.6	39633
CIM-668	2921	2798	2860	1144	3.3	37570
CIM-602	2466	2238	2352	875	2.7	39991
FH-142	2322	2582	2452	912	3.1	36943

* = Sowing date 28.04.2017

CD (5%) for seed cotton: Locations (L) = 29.53; Varieties (V) = 72.34; L x V = 102.31

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
CIM-650	37.5	38.1	37.8	28.7	28.7	28.7
CIM-651	37.7	37.4	37.6	28.9	29.5	29.2
CIM-652	37.7	37.4	37.6	28.4	28.5	28.5
CIM-653	39.0	39.0	39.0	28.5	28.4	28.5
CIM-656	39.3	40.1	39.7	27.4	26.8	27.1
CIM-664	36.4	36.5	36.5	30.6	30.2	30.4
CIM-665	39.7	40.2	40.0	28.6	28.0	28.3
CIM-666	37.1	38.4	37.8	28.5	28.1	28.3
CIM-667	37.3	37.4	37.4	28.3	28.5	28.4
CIM-668	39.9	40.0	40.0	28.2	28.0	28.1
CIM-602	37.6	36.7	37.2	27.7	27.5	27.6
FH-142	37.0	37.3	37.2	26.5	26.7	26.6

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

Strains	Micronaire value (μg inch^{-1})			Fibre strength (g/tex)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
CIM-650	4.7	4.3	4.5	29.9	30.2	30.1
CIM-651	5.0	4.8	4.9	28.2	28.9	28.6
CIM-652	5.1	4.3	4.7	27.4	28.2	27.8
CIM-653	4.7	4.3	4.5	29.1	26.2	27.7
CIM-656	5.1	4.7	4.9	27.8	25.5	26.7
CIM-664	4.0	3.7	3.9	32.6	30.3	31.5
CIM-665	4.8	4.6	4.7	29.6	29.1	29.4
CIM-666	4.7	4.1	4.4	29.7	28.6	29.2
CIM-667	4.6	3.9	4.3	29.8	29.8	29.8
CIM-668	5.1	4.4	4.8	28.5	28.6	28.6
CIM-602	4.4	4.1	4.3	28.8	27.7	28.3
FH-142	4.8	4.8	4.8	27.0	26.1	26.6

2.1.3 Varietal Trial-3

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

Seven medium staple promising non *Bt*. Strains CIM-610, CIM-722, CIM-723, CIM-725, CIM-726, CIM-727 and CIM-728 were evaluated against commercial variety CIM-573 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 CIM-726 produced the highest seed cotton yield of 3493 kg ha^{-1} followed by CIM-725 having yield of 2892 kg ha^{-1} while the standard variety CIM-573 yielded 2624 kg ha^{-1} seed cotton yield **(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 (3/5)*	Khanewal (17/5)	Average			
CIM-610	2593	3080	2837	1143	2.9	40888
CIM-722	2737	2291	2514	817	3.1	39991
CIM-723	2628	2599	2614	991	2.8	38736
CIM-725	2990	2794	2892	1076	3.0	39005
CIM-726	3725	3260	3493	1369	4.3	37301
CIM-727	2802	2787	2795	1090	2.9	38646
CIM-728	2755	2890	2823	1081	2.7	39184
CIM-573	2618	2629	2624	1057	2.7	36853

* = Sowing date 03.05.2017

CD (5%) for seed cotton: Locations (L) = 63.91; Varieties (V) = 127.81; L x V = 180.75

The new strains CIM-610 produced the highest lint percentage of 40.3, followed by CIM-726 having lint percentage values of 39.2 while standard CIM-573 produced 40.3 % of lint **(Table 2.8).** The new strains CIM-722 & CIM-725 produced the longest staple of 31.0 mm, respectively followed by CIM-723 with 30.3 mm while the standards CIM-573 produced 29.8 mm staple length **(Table 2.8).**

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
CIM-610	39.8	40.8	40.3	29.0	30.0	29.5
CIM-722	31.9	33.0	32.5	30.5	31.5	31.0
CIM-723	37.5	38.2	37.9	29.8	30.8	30.3
CIM-725	36.7	37.7	37.2	30.5	31.4	31.0
CIM-726	38.7	39.7	39.2	28.8	29.5	29.2
CIM-727	38.5	39.5	39.0	28.3	29.4	28.9
CIM-728	37.8	38.8	38.3	27.9	28.2	28.1
CIM-573	39.8	40.8	40.3	29.7	29.9	29.8

All the new strains possess desirable micronaire values ranging from 4.3 to 4.9 μg $inch^{-1}$ except CIM-727 & CIM-728 which have Micronaire value above the standard i.e. 5.2 & 5.4 μg $inch^{-1}$ respectively in comparison to CIM-573 with 4.4 μg $inch^{-1}$. The fibre strength of all the new strains and standards is in the desirable range, i.e. 26.7 to 32.7 g/tex **(Table 2.9).**

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

Strains	Micronaire value (µg inch^{-1})			Fibre strength (g/tex)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
CIM-610	4.9	4.9	4.9	30.7	30.8	30.8
CIM-722	4.5	4.6	4.6	32.6	32.8	32.7
CIM-723	4.3	4.3	4.3	31.6	31.8	31.7
CIM-725	4.3	4.4	4.4	32.1	32.6	32.4
CIM-726	4.5	4.6	4.6	29.0	29.2	29.1
CIM-727	5.1	5.2	5.2	28.8	28.8	28.8
CIM-728	5.4	5.4	5.4	26.6	26.7	26.7
CIM-573	4.4	4.4	4.4	30.8	30.9	30.9

2.1.4 Varietal Trial-4

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

Nine newly bulked medium long staple *Bt.* strains i.e. CIM-636, CIM-637, CIM-638, CIM-640, CIM-644, CIM-645, CIM-646, CIM-672 and CIM-343 were tested against a commercial variety FH-142 at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal. Data on seed cotton yield and other parameters are given in **Tables 2.10, 2.11** and **2.12**.

Average across locations, the strain CIM-638 produced the highest seed cotton yield of 3228 kg ha^{-1} followed by CIM-343 having yield of 3160 kg ha^{-1} while the standard variety FH-142 yielded 2608 kg ha^{-1} seed cotton yield **(Table 2.10).**

Table 2.10 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 (3/5)*	Khanewal (17/5)	Average			
CIM-636	3220	3032	3126	1257	3.8	39991
CIM-637	2814	2507	2661	1032	3.4	38646
CIM-638	3811	2645	3228	1262	3.4	38377
CIM-640	2484	2668	2576	1010	3.5	37660
CIM-644	2596	2363	2480	927	3.0	40260
CIM-645	2782	2650	2716	1046	3.0	37212
CIM-646	2669	3080	2875	1150	3.0	38108
CIM-672	3067	2865	2966	1091	3.0	41605
CIM-343	3420	2900	3160	1220	3.3	40081
FH-142	2637	2578	2608	1006	3.4	39812

* = Sowing date 03.05.2017

CD (5%) for seed cotton: Locations (L) = 149.67; Varieties (V) = 66.94; L x V = 211.67

The new strains CIM-636 produced the highest lint percentage of 40.2, followed by CIM-646 having lint percentage values of 40.0 while standard FH-142 produced 38.6% of lint **(Table 2.10).** The new strains CIM-672 & CIM-640 produced the longest staple of 29.7 and 29.6 mm, respectively followed by CIM-638 with 29.1 mm while the standards FH-142 produced 27.5 mm staple length **(Table 2.11).**

Table 2.11 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
CIM-636	38.9	41.5	40.2	28.7	29.0	28.9
CIM-637	37.7	39.9	38.8	28.8	28.7	28.8
CIM-638	39.1	39.0	39.1	29.1	29.1	29.1
CIM-640	38.9	39.4	39.2	30.3	28.9	29.6
CIM-644	37.2	37.6	37.4	27.8	26.3	27.1
CIM-645	39.2	37.8	38.5	28.8	28.7	28.8
CIM-646	39.4	40.6	40.0	28.0	27.1	27.6
CIM-672	36.3	37.2	36.8	29.6	29.7	29.7
CIM-343	38.5	38.7	38.6	29.0	28.9	29.0
FH-142	38.6	38.5	38.6	27.3	27.6	27.5

All the new strains possess desirable micronaire values ranging from 3.9 to 4.6 μg inch^{-1} in comparison to FH-142 with 4.5 μg inch^{-1}. The fibre strength of all the new strains and standards are in the desirable range, i.e. 27.4 to 30.4 g/tex **(Table 2.12).**

Table 2.12 Micronaire value and fibre strength of advanced strains in Varietal Trial-4 at two locations

Strains	Micronaire value (μg inch^{-1})			Fibre strength (g/tex)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
CIM-636	4.2	4.2	4.2	29.5	29.3	29.4
CIM-637	4.2	4.2	4.2	30.1	29.6	29.9
CIM-638	3.9	4.3	4.1	27.9	28.3	28.1
CIM-640	3.9	4.0	3.9	30.0	29.8	29.9
CIM-644	4.2	3.9	4.1	29.6	27.9	28.8
CIM-645	4.2	4.2	4.2	30.6	29.6	30.1
CIM-646	4.6	4.6	4.6	29.4	27.8	28.6
CIM-672	4.5	4.5	4.5	30.0	30.7	30.4
CIM-343	4.6	4.3	4.5	27.5	27.2	27.4
FH-142	4.3	4.6	4.5	28.0	27.7	27.9

Sowing date = 03.05.2017; CD (5%) for seed cotton: Strains = 211.67; CV %5. = 4.51

2.1.5 Varietal Trial-5

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

Seven newly bulked medium long staple *Bt.* strains i.e. CIM-641, CIM-642, CIM-643, CIM-663, CIM-669, CIM-670 & CIM-671 were tested against two commercial varieties FH-142 and *Bt*.CIM-602 at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal. Data on seed cotton yield and other parameters are given in **Tables 2.13, 2.14** and **2.15**.

Averaged across locations, the strain CIM-670 produced the highest seed cotton yield of 3657 kg ha^{-1} followed by CIM-642 having yield of 3554 kg ha^{-1} while the standard variety FH-142 and CIM-602 yielded 2989 kg ha^{-1} and 2919 kg ha^{-1} seed cotton yield **(Table 2.13).**

Table 2.13 Performance of advanced strains in Varietal Trial-5 at two locations

Strains	Seed cotton yield (kg ha^{-1})			Lint Yield (kg ha^{-1})	Av. Boll weight (g)	Plant Pop. (ha^{-1})
	Multan (3/5)*	Khanewal (17/5)	Average			
CIM-641	3425	3085	3255	1351	3.0	35149
CIM-642	3750	3357	3554	1422	2.4	35777
CIM-643	3027	2511	2769	1022	2.7	32101
CIM-663	3755	3041	3398	1312	3.8	37391
CIM-669	2259	1851	2055	832	2.8	26003
CIM-670	4072	3242	3657	1459	2.8	38915
CIM-671	3568	2826	3197	1218	3.2	36584
CIM-602	3255	2582	2919	1095	2.9	39902
FH-142	3223	2755	2989	1193	3.5	40260

* = Sowing date 03.05.2017

CD (5%) for seed cotton: Locations (L) = 39.12; Varieties (V) = 65.04; L x V = 110.02

The new strain CIM-641 produced the highest lint percentage of 41.5 followed by CIM-669 having lint percentage values of 40.5 while standard FH-142 and CIM-602 produced 39.9% and 37.5 of lint respectively **(Table 2.14).** The new strain CIM-643 produced the longest staple of 28.8 mm followed by CIM-642 and CIM-671 with 28.6 mm while the standards FH-142 and CIM-602 produced 27.4 mm and 27.7 mm staple length **(Table 2.14).**

Table 2.14 Lint percentage and staple length of advanced strains in Varietal Trial-5 at two locations

Strains	Lint (%age)			Staple length (mm)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
CIM-641	40.2	42.8	41.5	27.6	26.0	26.8
CIM-642	38.4	41.6	40.0	29.0	28.2	28.6
CIM-643	34.3	39.4	36.9	29.4	28.2	28.8
CIM-669	39.5	41.5	40.5	26.8	27.2	27.0
CIM-670	36.6	43.1	39.9	26.7	26.3	26.5
CIM-671	35.2	40.9	38.1	29.1	28.0	28.6
CIM-663	37.3	39.9	38.6	25.5	26.4	26.0
CIM-602	35.5	39.5	37.5	28.4	26.9	27.7
FH-142	39.6	40.2	39.9	26.1	28.7	27.4

All the new strains possess micronaire values ranging from 4.0 to 5.0 μg inch^{-1} in comparison to FH-142 and CIM-602 with 4.4 μg inch^{-1} and 4.0 μg inch^{-1}. The fibre strength of all the new strains and standards is in the desirable range, i.e. 26.9 to 30.8 g/tex **(Table 2.15).**

Table 2.15 Micronaire value and fibre strength of advanced strains in Varietal Trial-5 at two locations

Strains	Micronaire value (μg inch^{-1})			Fibre strength (g/tex)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
CIM-641	4.5	4.7	4.6	28.3	26.4	27.4
CIM-642	4.2	4.2	4.2	31.0	30.0	30.5
CIM-643	5.1	4.8	5.0	30.2	30.4	30.3
CIM-669	4.3	4.0	4.2	28.6	28.4	28.5
CIM-670	5.2	4.6	4.9	28.5	27.8	28.2
CIM-671	4.8	4.0	4.4	31.4	30.1	30.8
CIM-663	5.3	4.7	5.0	26.3	27.4	26.9
CIM-602	4.1	3.9	4.0	29.4	28.0	28.7
FH-142	4.8	4.0	4.4	27.4	30.2	28.8

Sowing date = 03.05.2017; CD (5%) for seed cotton: Strains = 473.441; CV %5. = 8.12

2.1.6 Varietal Trial-6

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

Eight newly bulked medium long staple strains i.e. CIM-717, CIM-729, CIM-730, CIM-731, CIM-732, CIM-733, CIM-734 and CIM-735 were tested against a commercial variety CIM-620 at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal. Data on seed cotton yield and other parameters are given in **Tables 2.16, 2.17** and **2.18**.

Average across locations, the strain CIM-733 produced the highest seed cotton yield of 3539 kg ha^{-1} followed by CIM-732 having yield of 3461 kg ha^{-1} while the standard variety CIM-620 yielded 2664 kg ha^{-1} seed cotton yield **(Table 2.16).**

Table 2.16 Performance of advanced strains in Varietal Trial-6 at two locations

Strains	Seed cotton yield (kg ha^{-1})			Lint Yield (kg ha^{-1})	Av. Boll weight (g)	Plant Pop. (ha^{-1})
	Multan (3/5)*	Khanewal (17/5)	Average			
CIM-717	3855	2841	3348	1373	3.3	39095
CIM-729	3569	2640	3105	1220	2.9	39722
CIM-730	3790	3085	3438	1303	2.9	40888
CIM-731	3508	2640	3074	1196	2.9	36046
CIM-732	3794	3128	3461	1291	3.2	37481
CIM-733	3807	3271	3539	1320	2.5	33177
CIM-734	3169	2367	2768	1116	2.5	35329
CIM-735	3030	2625	2828	1063	2.7	32639
CIM-620	2845	2482	2664	980	2.6	39274

* = Sowing date 03.05.2017

CD (5%) for seed cotton: Locations (L) = 39.12; Varieties (V) = 65.04; L x V = 110.02

The new strains CIM-717 produced the highest lint percentage of 41.0, followed by CIM-734 having lint percentage values of 40.3 while standard CIM-620 produced 36.8% of lint **(Table 2.17).** The new strains CIM-733 produced the longest staple of 28.7 mm followed by CIM-735 with 27.7 mm while the standards CIM-620 produced 28.0 mm staple length **(Table 2.17).**

Table 2.17 Lint percentage and staple length of advanced strains in Varietal Trial-6 at two locations

Strains	Lint (%age)			Staple length (mm)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
CIM-717	40.9	41.0	41.0	27.0	25.8	26.4
CIM-729	38.0	40.6	39.3	28.1	26.3	27.2
CIM-730	36.7	39.1	37.9	26.7	27.0	26.9
CIM-731	37.8	39.9	38.9	26.8	27.1	27.0
CIM-732	33.8	40.8	37.3	27.3	26.7	27.0
CIM-733	36.7	37.9	37.3	28.4	29.0	28.7
CIM-734	38.3	42.2	40.3	28.1	26.4	27.3
CIM-735	36.2	38.9	37.6	27.7	27.6	27.7
CIM-620	35.3	38.3	36.8	28.3	27.6	28.0

All the new strains possess desirable micronaire values ranging from 4.2 to 4.9 μg inch^{-1} in comparison to CIM-620 with 4.7 μg inch^{-1}. The fibre strength of all the new strains and standards is in the desirable range, i.e. 26.6 to 30.1 g/tex **(Table 2.18).**

Table 2.18 Micronaire value and fibre strength of advanced strains in Varietal Trial-6 at two locations

Strains	Micronaire value (μg inch^{-1})			Fibre strength (g/tex)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
CIM-717	4.9	4.6	4.8	26.2	26.9	26.6
CIM-729	5.3	4.4	4.9	28.3	28.4	28.4
CIM-730	4.6	3.8	4.2	27.5	29.0	28.3
CIM-731	5.0	4.3	4.7	27.3	28.2	27.8
CIM-732	5.4	4.3	4.9	28.0	28.5	28.3
CIM-733	4.9	4.4	4.7	28.9	31.2	30.1
CIM-734	4.8	4.6	4.7	28.7	28.7	28.7
CIM-735	4.4	4.4	4.4	29.9	29.6	29.8
CIM-620	4.7	4.6	4.7	29.8	29.6	29.7

2.1.7 Micro Varietal Trial-1

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

Nine newly bulked strains numbering from 1/17 to 9/17 were tested against commercial variety *Bt*.CIM-602 at CCRI, Multan. The new strain 5/17 surpassed all the strains and standard variety in seed cotton yield by producing 3767 kg ha^{-1}, followed by 9/17 with 3659 kg ha^{-1} and 3/17 having 3561 kg ha^{-1} compared with 3033 yield of *Bt.*CIM-602 **(Table 2.19).**

The strain 9/17 produced the highest lint percentage of 41.1, followed by 38.9 percent lint in 1/17 while the commercial variety *Bt*.CIM-602 produced the lint percentage of 38.2. The strain 6/17 produced the longest staple of 30.9 mm, followed by 30.0 mm in 7/17 compared with the fibre length of 28.0 mm in commercial variety *Bt*.CIM-602. All the strains 3, 4 & 5 were having undesirable micronaire values while the remaining all the strains were having micronaire value ranging from 4.1 to 4.9 μg inch^{-1}. The strain 7/17 maintained the maximum fibre strength of 31.6 g/tex, followed by 31.0 g/tex in 6/17 while standard *Bt.*CIM-602 had 29.5 g/tex.

Table 2.19 Performance 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 (µg inch^{-1})	Fibre strength (g/tex)	Av. boll wt. (g)	Plant Pop. (ha^{-1})
1/17	2692	1047	38.9	28.9	4.3	28.1	2.7	39991
2	2729	1072	39.3	28.4	4.1	30.0	2.7	40350
3	3561	1318	37.0	28.0	5.0	29.1	3.4	41247
4	3391	1282	37.8	27.8	5.0	28.2	3.4	41426
5	3767	1454	38.6	27.5	5.1	28.2	3.0	39453
6	3279	1220	37.2	30.9	4.3	31.0	3.6	39812
7	3080	1192	38.7	30.0	4.9	31.6	3.0	42143
8	3512	1306	37.2	28.5	4.5	29.1	3.6	41247
9/17	3659	1504	41.1	29.0	4.2	28.7	3.4	41091
CIM-602	3033	1186	38.2	28.0	4.4	29.5	2.8	40529

Sowing date = 13.05.2017; CD (5%) for seed cotton: Strains = 236.55; CV % = 7.20

2.1.8 Micro Varietal Trial-2

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

Seven newly bulked strains numbering from 929/17 to 935/17 were tested against commercial variety *Bt*.CIM-602 at CCRI, Multan. The new strain 931/17 surpassed all the strains and standard variety in seed cotton yield by producing 3956 kg ha^{-1}, followed by 930/17 with 3813 kg ha^{-1} and 933/17 having 3645 kg ha^{-1} compared with 2836 yield of *Bt.*CIM-602 **(Table 2.20).**

The strain 934/17 produced the highest lint percentage of 43.3, followed by 38.7 percent lint in 931/17 while the commercial variety *Bt*.CIM-602 produced the lint percentage of 37.2. The strain 930/17 produced the longest staple of 28.4 mm, followed by 28.2 mm in 935/17 compared with the fibre length of 28.3 mm in commercial variety *Bt*.CIM-602. All the strains have micronaire values ranging from 4.1 to 5.7 µg inch^{-1}. The strain 932/17 maintained the maximum fibre strength of 28.4 g/tex, followed by 28.2 g/tex in 930/17 while standard *Bt.*CIM-602 had 29.9 g/tex.

Table 2. 20 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 (µg inch^{-1})	Fibre Strength (g/tex)	Av. boll wt. (g)	Plant Pop. (ha^{-1})
929/17	2349	860	36.6	26.9	5.1	25.9	2.7	37481
930	3813	1380	36.2	28.4	5.3	28.2	2.7	34253
931	3956	1531	38.7	26.3	5.7	25.4	2.8	38198
932	3235	1203	37.2	27.5	4.6	28.4	2.1	37481
933	3645	1403	38.5	27.4	5.7	26.7	3.0	36405
934	3519	1524	43.3	27.0	5.0	26.9	3.0	38377
935/17	3270	1194	36.5	28.2	4.9	27.5	3.2	31921
CIM-602	2836	998	37.2	28.3	4.1	29.9	2.8	40350

Sowing date = 03.05.2017 ; CD (5%) for seed cotton = 185.606; CV. % = 3.18

2.1.9 Micro Varietal Trial-3

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

Eight newly bulked strains numbering from 1412/17 to 1419/17 were tested against commercial variety CIM-602 at CCRI, Multan. Data presented in **Table 2.21** indicated that the new strain 1417/17 surpassed all the new strains yielding 3283 kg ha^{-1}, followed by strains 1413/17 and 1419/17 which produced 2849 and 2332 kg ha^{-1} seed cotton respectively while the standard CIM-602 yielding 1951 kg ha^{-1}. The new strain 1418/17 produced the highest lint percentage of 39.2 followed by 38.9% in 1419/17, 38.3 % in 1414/17 in comparison to CIM-602 having 37.4 lint percentages. The strains 1419/17 has the longest staple of 31.4 mm followed by 1412/17 and 1415/17 with the staple of 29.8 mm and 29.6 mm and 29.4 mm in 1413/17 compared with the staple length of 28.1 mm in standard variety CIM-602. The genotypes 1415/17 and 1417/17 have undesirable micronaire values while all other have desirable micronaire value ranging from 4.3 to 4.9 µg $inch^{-1}$. All the strains were showing fibre strengths ranging from 29.3 to 33.6 g/tex.

Table 2.21 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)	Micronaire value (µg $inch^{-1}$)	Fibre Strength (g/tex)	Av. boll weight (g)	Plant Pop. (ha^{-1})
1412/17	1892	708	37.4	29.8	4.6	31.4	2.6	40171
1413	2849	1006	35.3	29.4	4.6	30.6	3.1	36225
1414	1686	646	38.3	28.2	4.6	29.7	2.9	29590
1415	1749	642	36.7	29.6	5.1	30.3	3.2	32459
1416	2051	775	37.8	29.1	4.8	30.4	3.4	25824
1417	3283	1198	36.5	28.9	5.2	29.4	2.5	35867
1418	1865	731	39.2	28.5	4.9	29.9	3.0	39991
1419/17	2332	907	38.9	31.4	4.5	33.6	3.1	31921
CIM-602	1951	730	37.4	28.1	4.3	29.3	2.7	34432

Sowing date = 24.05.2017;

2.1.10 Micro-Varietal Trial-4

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

Eight newly bulked elite *Bt*. strains from 2803/17 to 2810/17 were tested against commercial variety *Bt.*CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.22**.

The strain 2804/17 out-yielded all the strains and standard variety by producing 3579 kg ha^{-1} seed cotton, followed by 2803/17 having seed cotton yields of 3493 against commercial variety *Bt.*CIM-602 which produced 2517 kg ha^{-1} seed cotton. The strain 2810/17 produced the higher lint percentage of 39.4% followed by 2809/17 with 38.8 and 2803/17 with 38.0 %.compared with that of 36.7% by *Bt.*CIM-602.

The strain 2807/17 produced the longest staple of 29.0 mm, followed by the 28.8 mm of strain 2810/17 compared with the 28.0 mm of *Bt.*CIM-602. All the strains have desirable micronaire values ranging from 3.7 to 4.9 µg $inch^{-1}$. The fibre strength of all the new strains is observed within the range i.e. 29.5 to 30.7.

Table 2.22 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)	Micronaire value (µg inch^{-1})	Fibre Strength (g/tex)	Av. boll weight (g)	Plant pop. (ha^{-1})
2803/17	3493	1327	38.0	28.4	4.5	30.1	3.5	34073
2804	3579	1267	35.4	27.9	4.2	30.0	3.3	36225
2805	3392	1272	37.5	27.8	4.7	29.9	3.1	38198
2806	3470	1301	37.5	28.6	4.9	30.0	2.9	35329
2807	3039	1143	37.6	29.0	3.7	30.7	2.7	33894
2808	3063	1078	35.2	28.6	4.5	30.2	2.6	39633
2809	2716	1054	38.8	28.1	4.5	30.2	2.8	38198
2810/17	3381	1332	39.4	28.8	4.5	29.9	2.6	37481
CIM-602	2517	924	36.7	28.0	4.3	29.5	2.5	36943

Sowing date = 23.05.2017; CD (5%) for seed cotton = 552.34; CV. % = 10.02

2.1.11 Micro-Varietal Trial-5

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

Eight newly bulked elite strains 2811/17 to 2818/17 were tested against commercial variety *Bt.*CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.23.**

The strain 2811/17 out-yielded all the strains and standard variety by producing 3778 kg ha^{-1} seed cotton, followed by 2814/17 and 2818/17 having seed cotton yields of 3455 and 3419 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 2829 kg ha^{-1} seed cotton. The strains 2812/17 and 2813/16 produced the higher lint percentage values of 39.6 and 38.4 respectively compared with that of 36.1% by *Bt.*CIM-602.

The strain 2811/17 produced the longest staple of 29.1 mm, followed by 28.7 mm in 2814/17 compared with the fibre length of 27.3 mm in commercial variety *Bt*.CIM-602. All strains have desirable micronaire values ranging from 4.4 to 4.8 µg inch^{-1} except 2818/17 & 2814/17 which have 5.0 & 5.2 µg inch^{-1} respectively. The strain 2811/17 maintained the maximum fibre strength of 29.7 g/tex, followed by 2814/17 with 29.4 g/tex while standard *Bt.*CIM-602 had 28.0 g/tex fibre strength.

Table 2.23 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)	Micronaire value (µg inch^{-1})	Fibre Strength (g/tex)	Av. boll weight (g)	Plant pop. (ha^{-1})
2811/17	3778	1424	37.7	29.1	4.7	29.7	2.5	36943
2812	3006	1190	39.6	27.5	4.7	29.1	2.7	32997
2813	3324	1276	38.4	28.0	4.7	29.3	2.4	37660
2814	3455	1258	36.4	28.7	5.2	29.4	2.4	38377
2815	3275	1133	34.6	27.3	4.8	28.8	2.5	37122
2816	3222	1157	35.9	28.6	4.8	29.2	2.6	37301
2817	3042	1110	36.5	27.2	4.6	28.2	2.2	38377
2818/17	3419	1241	36.3	28.4	5.0	29.3	2.4	35329
CIM -602	2829	1021	36.1	27.3	4.4	28.0	2.5	38198

Sowing date = 23.05.2017; CD (5%) for seed cotton = 380.06; CV. % = 6.73

2.1.12 Micro-Varietal Trial-6

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

Eleven newly bulked elite strains (3192/17 to 3202/17) were tested against commercial variety Bt.CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in Table **2.24.**

The strain 3199/17 out-yielded all the strains and standard variety by producing 3742 kg ha^{-1} seed cotton, followed by 3192/17 and 3196/17 having seed cotton yields of 3415 and 3111 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 2335 kg ha^{-1} seed cotton. The strains 3197/17 produced the higher lint percentage values of 39.5 followed by 3198/17 and 3199/17 with 39.3% lint compared with that of 36.7% by *Bt.*CIM-602.

The strain 3202/17 produced the longest staple of 31.1 mm, followed by 30.5 mm in 3200/17 compared with the staple length of 28.4 mm in commercial variety *Bt*.CIM-602. All strains have desirable micronaire values raging from 4.0 mm to 4.9 mm. The strain 3202/17 produced the maximum fibre strength (32.8 g/tex) followed by 32.4 g/tex of 3200/17 as compared to the 30.0 g/tex of standard Bt. CIM-602.

Table 2.24 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)	Micronaire value (µg $inch^{-1}$)	Fibre Strength (g/tex)	Av. boll weight (g)	Plant pop. (ha^{-1})
3192/17	3415	1274	37.3	29.6	4.5	31.4	2.6	39633
3193	2927	1103	37.7	28.6	4.6	30.5	2.8	38557
3194	2680	1018	38.0	29.0	4.5	29.4	2.7	36405
3195	2562	989	38.6	29.3	4.7	31.6	2.9	39453
3196	3111	1173	37.7	30.0	4.5	30.9	3.2	41247
3197	2468	975	39.5	29.7	4.9	31.3	2.3	34791
3198	3059	1202	39.3	30.0	4.6	31.8	2.5	39633
3199	3742	1471	39.3	30.0	4.8	31.8	2.6	41067
3200	2937	1078	36.7	30.5	4.7	32.4	3.2	39274
3201	2488	950	38.2	29.2	4.5	31.5	2.6	41785
3202/17	2828	1041	36.8	31.1	4.0	32.8	2.7	41247
CIM-602	2335	857	36.7	28.4	4.5	30.0	2.8	36584

Sowing date: 23.05.2017, CD (5%) for seed cotton: Strains = 282.75, CV% = 5.80

2.1.13 Micro-Varietal Trial-7

Objective*:* Testing of medium long staple *Bt*. strains with high lint percentage to develop commercial varieties

Ten newly bulked elite strains (3203/17 to 3212/17) were tested against commercial variety *Bt*.CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.25**.

The strain 3207/17 out-yielded all the strains and standard variety by producing 4011 kg ha^{-1} seed cotton, followed by 3211/17 and 3210/17 having seed cotton yields of 3885 and 3641 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 2507 kg ha^{-1} seed cotton. The strains 3203/17 produced the maximum lint percentage values of 38.8 followed by 3205/17 which produced 38.3% lint and 37.2% by *Bt.*CIM-602.

The strains 3208/17 produced the longest staple of 30.5 mm, followed by 30.4 mm in 3207/17 compared with the fibre length of 27.7 mm in commercial variety *Bt*.CIM-602. All strains have desirable micronaire values ranging from 4.2 to 4.9 except 3203/17 &3204/17. The strain 3208/17 maintained the maximum fibre strength of 31.4 g/tex, followed by 31.1 g/tex in 3210/17 while standard *Bt.*CIM-602 had 29.6 g/tex fibre strength.

Table 2.25 Performance of advanced strains in Micro-Varietal Trial-7 at CCRI, Multan

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micronaire value (µg inch^{-1})	Fibre Strength (g/tex)	Av. boll weight (g)	Plant pop. (ha^{-1})
3203/17	2653	1029	38.8	28.0	5.0	28.3	2.6	37301
3204	1976	749	37.9	28.1	5.2	28.5	2.6	35867
3205	3183	1219	38.3	27.7	4.6	28.7	2.7	39633
3206	2883	1096	38.0	29.2	4.2	30.5	2.7	37122
3207	4011	1424	37.5	30.4	4.9	30.3	3.3	39095
3208	2795	1048	37.5	30.5	4.8	31.4	3.0	36763
3209	3441	1297	37.7	29.4	4.8	29.0	3.3	37481
3210	3641	1365	37.5	29.7	4.9	31.1	2.9	36763
3211	3885	1480	38.1	29.7	4.8	29.3	3.0	36046
3212/17	2457	936	38.1	28.7	4.9	30.2	2.2	33356
CIM-602	2507	933	37.2	27.7	4.4	29.6	2.5	38736

Sowing date: 23.05.2017; CD (5%) for seed cotton: Strains = 402.32; CV% = 7.77

2.1.14 Zonal Varietal Trial-1

Objective: **Testing of promising strains.**

Five promising strains were evaluated at CCRI, Multan. Data presented in **Table 2.26** revealed that V-5 produced the maximum seed cotton yield of 5165 kg ha^{-1}, followed by V-1 with 4573 kg ha^{-1} while V-2 produced lowest seed cotton yield of 2044 kg ha^{-1}.

Table 2.26 Performance of new strains in Zonal Varietal Trial-1 at CCRI, Multan

Strains	Seed cotton yield (kg ha-1)
V-1	4573
V-2	2044
V-3	3551
V-4	3739
V-5	5165

2.1.15 Zonal Varietal Trial-II

Objective: **Testing of promising strains.**

Five promising strains were evaluated at CCRI, Multan. Data presented in **Table 2.27** revealed that V-5 produced the maximum seed cotton yield of 5138 kg ha^{-1}, followed by V-2 with 4708 kg ha^{-1} while V-4 produced lowest seed cotton yield of 2798 kg ha^{-1}.

Table 2.27 Performance of new strains in Zonal Varietal Trial-II at CCRI, Multan

Strains	Seed cotton yield (kg ha-1)
V-1	3228
V-2	4708
V-3	3201
V-4	2798
V-5	5138

2.1.16 Zonal Varietal Trial-III

Objective: **Testing of promising strains.**

Four promising strains were evaluated at CCRI, Multan. Data presented in **Table 2.28** revealed that V-4 produced the maximum seed cotton yield of 5676 kg ha^{-1}, followed by V-3 with 3739 kg ha^{-1} while V-1 produced lowest seed cotton yield of 2744 kg ha^{-1} .

Table 2.28 Performance of new strains in Zonal Varietal Trial-III at CCRI, Multan

Strains	Seed cotton yield (kg ha^{-1})
V-1	2744
V-2	3174
V-3	3739
V-4	5676

2.1.17 Zonal Varietal Trial-IV

Objective: **Testing of promising strains.**

Five promising strains were evaluated at CCRI, Multan. Data presented in **Table 2.29** revealed that V-2 produced the maximum seed cotton yield of 4143 kg ha^{-1}, followed by V-5 with 3820 kg ha^{-1} while V-1 produced lowest seed cotton yield of 2018 kg ha^{-1} .

Table 2.29 Performance of new strains in Zonal Varietal Trial-IV at CCRI, Multan

Strains	Seed cotton yield (kg ha^{-1})
V-1	2018
V-2	4143
V-3	2287
V-4	2260
V-5	3820

2.2 Coordinated Variety Testing Programme

2.2.1 National Coordinated Varietal Trial (Set-A)

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

The cotton seed of thirteen strains under coded numbers were received from Director Research (PCCC) for evaluation against a commercial variety. Data on seed cotton production and other parameters are presented in **Table 2.30**.

The results indicated that the strain Tipu-2 produced maximum yield 2654 kg ha^{-1} followed by CIM-717 and CIM-610 with 2427 kg ha^{-1} of seed cotton yield respectively while TH-17 produced lowest yield that is 529 kg ha^{-1} against the standard CIM-620 (1870 kg ha^{-1})

The strain CIM-717 produced the highest lint percentage of 41.3%, followed by NIAB-444 with 39.9%. The strain Cyto-225 produced the highest value of staple length 31.2 mm, followed by CIM-610 which has staple length of 29.5 mm. All the strains were having the desirable micronaire value except GS-Ali-7, Thakkar-214, CIM-620, NIAB-444, MPS-61 and PB-896. All values of fibre strength were above the required standard except PB-896.

2.2.2 National Coordinated Varietal Trials (Set-B)

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

Twenty two strains from different cotton breeders of the country were evaluated against two commercial varieties FH-142 and *Bt.*CIM-602 at CCRI Multan.

The data presented in **Table 2.31** showed that the D-19 produced the highest seed cotton yield of 3100 kg ha^{-1}, followed by *Bt*.CIM-632 having 3089 kg ha^{-1} seed cotton yield while NS-181 produced lowest yield 1789 kg ha^{-1} . The standards i.e. FH-142 and CIM-602 produced 2567 and 2460 kg ha^{-1} seed cotton yield respectively.

Data also revealed that the strain GH-Mubarak produced the highest lint percentage of 39.9, followed by CEMB-88 with 39.5%. The strain *Bt.*CIM-632 produced the longest staple with 29.5 mm length and, followed by *Bt*.CIM-625 with 29.4 mm.

The ranging of micronaire value is from 4.4 to 5.7 μg inch^{-1}. Maximum fibre strength was maintained by FH-152 having 30.3 g/tex, followed by Sitara-15 with 30.1 g/tex fibre strength.

Table 2.30 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 (µg inch^{-1})	Fibre Strength (g/tex)	Plant Pop. (ha^{-1})
Th-17	529	188	35.5	26.0	4.3	26.0	39924
GS-Ali-7	2033	710	34.9	27.4	5.1	26.1	39685
NIA-887	1085	347	32.0	25.9	4.7	24.6	13746
CRIS-613	1188	435	36.6	27.2	4.7	26.6	38012
Cyto-225	2169	811	37.6	31.2	4.9	29.8	41598
CIM-717	2427	1002	41.3	28.3	4.6	26.1	39685
TH-88/11	1248	446	35.7	25.4	4.8	24.3	41000
Tipu-2	2654	841	31.7	26.5	4.8	25.6	40522
Thakkar-214	1628	606	37.2	23.9	6.5	21.9	38968
CIM-620 (Std)	1870	720	38.5	28.2	4.8	28.0	28808
NIAB-444	2191	874	39.9	26.4	5.1	25.3	35023
MPS-61	1987	686	34.5	25.3	5.0	23.7	39087
CIM-610	2427	964	39.7	29.5	4.7	26.9	39326
PB-896	1838	658	35.8	25.4	5.4	24.9	39087

Sowing date = 16.05.2017

Table 2.31 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)	Micronaire value (µg inch^{-1})	Fibre strength (g/tex)	Plant Pop. (ha^{-1})
CEMB-3	2158	829	38.4	25.9	5.7	26.4	38131
B-2	2627	977	37.2	28.1	4.7	28.5	38490
GH-Deebal	2586	1001	38.7	28.4	4.7	28.4	39446
FH-152	2425	875	36.1	29.1	4.7	30.3	35023
Eagle-2	2795	1059	37.9	26.9	5.2	27.7	39566
Cyto-313	3078	1167	37.9	27.8	4.7	29.1	38490
Crystal-12	2742	1031	37.6	28.7	4.7	28.3	38251
CRIS-600	1968	707	35.9	26.4	4.7	26.5	37294
FH-142 (Std)	2567	1014	39.5	27.2	5.4	27.3	33708
CIM-632	3089	1205	39.0	29.5	4.7	29.3	35262
CEMB-55 (DG)	2232	882	39.5	26.0	5.4	26.2	33111
BH-201	2331	886	38.0	27.3	5.3	26.8	39326
Bakhtawar-1	2330	836	35.9	27.1	5.2	26.7	31676
Bahar-07	2185	850	38.9	25.4	5.5	24.5	36219
Sitara-15	2766	1048	37.9	28.9	4.8	30.1	33350
SAU-1	1853	680	36.7	27.3	5.3	23.7	41239
CIM-602 (Std)	2460	918	37.3	28.3	4.4	28.7	35262
NS-181	1789	660	36.9	27.4	4.9	28.3	26178
D-19	3100	1147	37.0	27.8	4.8	28.6	36338
IUB-65	2881	1121	38.9	27.9	4.9	28.9	37653
GH-Mubarak	2909	1161	39.9	26.9	5.4	26.8	38968
CIM-625	2734	1055	38.6	29.4	4.7	28.7	40761
CEMB-88 (DG)	2622	1036	39.5	26.7	5.3	27.5	37414
AGC-Nazeer-1	2884	1038	36.0	27.0	5.5	27.2	40402

Sowing date = 28.04.2017

2.2.3 National Coordinated Varietal Trials (Set-C)

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

The cotton seed of twenty two candidate varieties was provided by the Director Research PCCC for evaluation against two commercial varieties *Bt.*CIM-602 and FH-142 at CCRI Multan. The data presented in **Table 2.32** showed that the strain BS-18 produced the highest seed cotton yield of 3581 kg ha^{-1}, followed by RH-662 with 3478 kg ha^{-1} seed cotton yield while AA-933 was at bottom position in respect of seed cotton yield (1821 kg ha^{-1}).

Data presented in **Table 2.32** revealed that VH-Gulzar produced the highest lint percentage 40.7 followed by BS-18 with 40.5%.

The staple length of all the genotypes was less than the desired standard i.e. 28.0 mm. The range of Micronaire value was 4.5 to 5.7 µg $inch^{-1}$. All the strains were except Ghauri-1, Cotton-2, BS-18, Bahar-2017, Wealage-1606 and VH-Gulzar having the desirable fibre strength.

Table 2.32 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 (g/tex)	Fibre strength (g/tex)	Plant Pop. (ha^{-1})/
Ghauri-1	2549	948	37.2	24.6	5.4	24.0	33148
CEMB Klean Cotton-2	2264	874	38.6	24.8	5.3	24.7	37336
CEMB-100	2746	1046	38.1	26.4	5.5	25.2	36977
BS-80	2286	821	36.9	25.5	5.0	25.0	36139
BS-18	3581	1450	40.5	24.7	5.7	23.5	37695
BH-221	2826	1099	38.9	25.4	5.1	25.2	36857
Bahar-2017	2604	977	37.5	25.0	5.3	24.2	35182
Badar-1	3116	1200	38.5	25.6	5.1	25.2	40806
FH-142 (Std-2)	3103	1207	38.9	25.4	5.1	24.8	38533
Auriga -216	2769	1022	36.9	25.6	5.4	25.3	39490
AA-933	1821	690	37.9	25.6	5.2	25.8	39610
Weal ag-1606	2661	1043	39.2	25.5	5.1	24.3	39011
VH-gulzar	2485	1011	40.7	24.4	5.4	23.8	35900
Tipu-1	2636	1023	38.8	25.5	5.4	25.3	39131
Thakkar-808	2759	1068	38.7	24.6	5.2	24.2	38293
Tarzan-5	3077	1074	36.9	26.6	5.5	26.8	40447
CIM-602 (Std-1)	2197	793	36.1	27.0	4.5	26.0	35661
Shaheen-1	3077	1080	35.1	25.7	4.9	25.2	40567
RH-662	3478	1308	37.6	27.6	4.8	27.5	38174
RH-668	2277	758	35.3	26.7	5.1	27.2	40926
N-BT-2	2661	899	35.8	25.5	5.2	26.7	31831
N-1048	2899	1142	39.4	26.2	4.8	25.3	36738
N-545	3171	1221	38.5	25.2	5.1	25.1	35062
MNH-1016	2976	1155	38.8	25.6	5.2	26.2	35062

Sowing date = 28.04.2017

2.2.4 Klean Cotton Trial

Objective: Testing of promising GMOs strains of CEMB

Nine cotton genotypes from CEMB-1 to CEMB-9 were tested at CCRI, Multan. Sowing was done on 24th May, 2017 in a randomized complete block design (RCB) with three replications. Data were recorded on the agronomic, yield and fiber traits and all the agronomic and plant protection measurements were applied. Basically the trial was Glyphosate resistant and was conducted to observe the effects of Weedicides on crop plant as well as on weeds. First dose of Weedicide was applied thirty days after sowing on 24th June, 2017. For this purpose, a weedicide i.e. CLEAN UP (Tarzan) was applied

@ 1000 ml per acre to all the replications equally. Mortality data was recorded seven days and twelve days after spraying. The data showed that no effect of the spray was observed on the genotypes and all the genotypes were found highly tolerant against Glyphosate. The second dose of Weedicide was applied on 27 of July, 2017 at same rate. The results show that all of the nine genotypes were GMOs having complete resistance/tolerance to Glyphosate. Yield and fiber data of these strains are given in **Table 2.33**.

The data showed that CEMB-3 produced the highest seed cotton yield of 1856 kg ha^{-1}, followed by CEMB-5 with 1799 and CEMB-2 with 1705 kg ha^{-1} while CEMB-7 produced lowest yield of 1471 kg ha^{-1} among these strains.

The strain CEMB-1 produced the highest lint percentage of 38.8 followed by CEMB-4 with 37.8% and CEMB-5 with 37.5%.

The staple length of all strains were below the standard raging from 24.4 to 25.5 mm. Micronaire values of all the strains were undesirable and were ranged from 5.0 to 5.3 μg $inch^{-1}$. Maximum fibre strength of 26.3 was revealed by the strains CEMB-3 and CEMB-4.

Table 2.33 Performance of different strains in Klean Cotton at CCRI Multan

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (%age)	Staple length (mm)	Micro-naire value (μg $inch^{-1}$)	Fibre strength (g/tex)	Av. boll weight (g)	Plant Pop. (ha^{-1})
CEMB-1	1621	629	38.8	24.4	5.3	25.3	2.9	38452
CEMB-2	1705	612	35.9	25.3	5.1	25.6	3.4	37122
CEMB-3	1856	677	36.5	25.1	5.0	26.3	3.3	41247
CEMB-4	1483	561	37.8	25.3	5.2	26.3	3.1	39274
CEMB-5	1799	675	37.5	24.9	5.0	25.7	2.9	36046
CEMB-6	1661	608	36.6	24.8	5.1	25.5	2.5	37739
CEMB-7	1471	549	37.3	24.5	5.1	25.6	3.2	40350
CEMB-8	1713	634	37.0	25.5	5.2	25.6	2.7	37839
CEMB-9	1705	631	37.0	24.7	5.3	25.6	3.3	37481

Sowing dated = 24.05.2017, C.V= 6.30% C.D= 250.66 and 181.93

2.2.5 Provincial Coordinated Cotton Trials

Provincial Coordinated Cotton Trial-I (*Bt.*)

Objective: **Testing of promising strains of different cotton breeders of the Punjab.**

Thirty eight promising strains of different cotton breeders from the Punjab were evaluated along with standards at CCRI, Multan. Data presented in **Table 2.34** revealed that PC-7 produced the maximum seed cotton yield of 2630 kg ha^{-1}, followed by PC-17 with 2526 kg ha^{-1} while PC-36 (1602 kg ha^{-1}) was at the bottom of the conducted trial.

The Strain PC-8 produced the highest lint percentage of 40.3 followed by PC-23 having 40.1 lint percentages. The strain PC-12 produced the longest staple having 27.5 mm length, followed by the variety PC-3 with 27.2 mm and while the lowest value was recorded for PC-38 (22.9 mm) staple length. Micronaire value of strains PC-1, PC-4, PC-5, PC-6, PC-14, PC-16, PC-17, PC-18, PC-19, PC-20, PC-21, PC-22, PC-24, PC-25, PC-26, PC-27, PC-28, PC-29, PC-30, PC-31, PC-37, PC-39 and PC-40 were above the standard values. The fibre strength of PC-23, PC- 25, PC- 26, PC-29, PC-30, PC-31, PC-32, PC-37 and PC-39 were below standard.

Table 2.34 Performance of new *Bt.* strains in Provincial Coordinated Cotton Trial-I at CCRI, Multan

Strains	Seed cotton Yield (kg ha^{-1})	Lint Yield (kg. ha^{-1})	Lint (% age)	Staple length (mm)	Micronaire value (µg inch^{-1})	Fibre Strength (g/tex)	Plant Pop. (ha^{-1})
PC-1	2128	815	38.3	25.8	5.0	25.3	30128
PC-2	2143	778	36.3	25.4	4.8	25.9	36405
PC-3	2467	915	37.1	27.2	4.4	28.3	32280
PC-4	2143	799	37.3	24.7	5.2	25.1	35149
PC-5	2042	751	36.8	25.0	5.1	25.0	38557
PC-6	2228	813	36.5	25.8	5.2	26.1	35329
PC-7	2630	994	37.8	26.8	4.5	26.8	35149
PC-8	2214	892	40.3	26.1	4.9	26.3	34270
PC-9	2292	912	39.8	25.1	4.9	25.6	35508
PC-10	2335	873	37.4	26.7	4.6	27.7	36046
PC-11	1744	628	36.0	25.2	4.9	25.6	38198
PC-12	2088	712	34.1	27.5	4.4	28.9	34532
PC-13	2279	761	33.4	25.7	4.6	26.1	36046
PC-14	2522	968	38.4	25.2	5.0	25.2	36584
PC-15	2522	921	36.5	26.9	4.7	27.0	34432
PC-16	2032	638	31.4	26.2	5.0	26.5	38198
PC-17	2526	912	36.1	25.7	5.3	25.8	32639
PC-18	2279	777	34.1	26.4	5.1	26.9	36405
PC-19	2097	774	36.9	25.3	5.0	25.3	37301
PC-20	2219	861	38.8	24.5	5.0	23.6	37839
PC-21	2100	750	35.7	25.6	5.2	25.1	36945
PC-22	2175	779	35.8	25.1	5.2	25.1	38198
PC-23	2347	941	40.1	24.3	4.9	24.1	37301
PC-24	2392	880	36.8	24.4	5.0	25.0	34611
PC-25	2382	858	36.0	24.7	5.0	24.8	37301
PC-26	2030	725	35.7	24.8	5.1	24.7	36943
PC-27	2454	876	35.7	25.9	5.1	25.3	37839
PC-28	2153	846	39.3	25.3	5.0	25.3	36943
PC-29	2283	886	38.8	24.5	5.3	24.0	33894
PC-30	1926	703	36.5	23.4	5.0	22.2	34970
PC-31	2452	902	36.8	24.5	5.2	23.8	33894
PC-32	2460	891	36.2	25.1	4.8	24.8	36943
PC-33	2053	719	35.0	25.4	4.5	25.7	34791
PC-34	2183	795	36.4	24.8	4.3	25.7	34432
PC-35	2191	819	37.4	25.8	4.6	26.1	36763
PC-36	1602	636	39.7	26.3	4.6	26.5	36225
PC-37	2250	839	37.3	24.6	5.0	23.3	34970
PC-38	1668	622	37.3	22.9	4.8	22.2	36225
PC-39	2304	834	36.2	24.9	5.0	24.9	34253
PC-40	2272	866	38.1	24.8	5.3	25.5	34791

Sowing date = 20.05.2017

2.2.6 Provincial Coordinated Cotton Trial-II

Objective: **Testing of promising strains of different cotton breeders of the Punjab.**

Three promising strains of different cotton breeders included from the Punjab along with a standard were evaluated at CCRI, Multan. Data presented in **Table 2.35** revealed that PC-4 produced the maximum seed cotton yield of 3167 kg ha^{-1}, followed by PC-3 with 3090 kg ha^{-1} while PC-1 produced lowest yield of 1990 kg ha^{-1}.

The strain PC-2 produced the highest lint percentage of 38.9%, followed by the PC-1 with 37.2 lint percentage. All the strains have staple length below the required standard. Micronaire values of all the strains were above the required limit except PC-1. Fibre strength of the PC-3 was above the standard.

Table 2.35 Performance of new *Bt.* strains in Provincial Coordinated Cotton Trial-II at CCRI, Multan

Strains	Seed cotton yield (kg ha^{-1})	Lint yield (kg ha^{-1})	Lint (%age)	Staple Length (mm)	Micronaire Value (µg inch^{-1})	Fibre Strength (g/tex)	Plant Pop. (ha^{-1})
PC-1	1990	740	37.2	23.2	4.9	21.6	41247
PC-2	2324	904	38.9	25.8	5.2	25.1	35149
PC-3	3090	958	31.0	26.8	5.0	27.0	42143
PC-4	3167	982	31.0	26.0	5.3	25.2	43219

Sowing date = 16.05.2017

2.3 Testing of Commercial Varieties

2.3.1 Standard Varietal Trial-1

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

Twenty six commercial varieties of the country were tested at CCRI, Multan. Data recorded on seed cotton yield and other parameters are presented in **Table 2.36**. The results indicated that variety CIM-446 excelled among all varieties by producing seed cotton yield 3174 kg ha^{-1} followed by the variety CIM-608 with 3120 kg ha^{-1} and NIAB-111 with 2905 kg ha^{-1} seed cotton production. Variety CIM-496 had the highest lint percentage of 38.5, followed by varieties CIM-534 having lint percentage of 38.1. The variety CIM-608 maintained the longest staple of 31.5 mm, followed by the variety the Cyto-124 with 29.5 mm staple length.

Table 2.36 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 (µg inch^{-1})	Fibre Strength (g/tex)	Av. Boll wt. (g)	Plant Pop. (ha^{-1})
Gomal-93	1993	2529	885	35.0	25.6	5.0	26.4	2.5	31592
CIM-446	1998	3174	1184	37.3	27.4	4.6	29.3	2.6	32310
FH-901	2000	1775	607	34.2	27.2	4.9	28.6	3.1	33028
CIM-482	2000	2206	790	35.8	27.6	4.1	30.5	3.2	35182
CIM-554	2000	1883	670	35.6	25.2	3.5	26.6	2.6	36259
Marvi	2001	2636	883	33.5	26.6	4.0	28.4	2.6	35541
CIM-473	2002	2475	893	36.1	26.2	4.4	27.7	2.6	38054
CRIS-134	2004	1883	712	37.8	26.5	4.7	28.4	2.5	35541
BH-160	2004	1560	590	37.8	26.4	4.9	27.3	2.6	31592
CIM-506	2004	1937	713	36.8	27.9	4.3	28.7	2.8	38413
NIAB-111	2004	2905	1057	36.4	26.2	4.6	28.0	2.7	40208
CIM-707	2004	2260	805	35.6	28.4	3.9	30.4	2.9	39849
CIM-496	2005	2636	1015	38.5	26.1	3.9	27.6	3.0	38772
NIBGE-2	2006	1937	723	37.3	27.2	5.0	26.9	2.6	35900
MNH-786	2006	2744	971	35.4	27.3	5.0	28.8	2.8	29079
CIM-534	2006	2044	779	38.1	26.5	4.0	28.4	2.5	30515
CRSM-38	2009	1722	585	34.0	26.5	4.3	28.1	2.7	36259
NIAB-777	2009	2152	760	35.3	27.2	5.0	28.2	2.5	34105
CRIS-342	2010	1829	662	36.2	25.6	4.4	27.4	2.6	32669
Malmal	2010	2582	891	34.5	23.8	5.3	26.7	2.7	36259
CIM-573	2012	1937	680	35.1	27.8	4.3	30.0	2.7	32310
CIM-608	2013	3120	1161	37.2	31.5	4.8	31.5	2.5	36977
Cyto-124	2015	1775	659	37.1	29.5	4.4	30.9	2.9	33028
Gomal-105	2015	1883	674	35.8	26.6	4.6	28.9	2.6	25848
CRIS-129	2016	2529	893	35.3	24.4	4.4	26.2	3.0	31592
CIM-620	2016	1668	624	37.4	26.7	4.9	28.4	2.5	36259

Sowing date: 05.05.2017; C.D. (5%) for seed cotton 150.81 CV% = 5.6

Micronaire value of all the varieties is according to the required standard except NIBGE-2, CIM-554, MNH-786, Gomal-93, Malmal and NIAB-777. Fibre strength of all the genotypes was in the desirable range.

2.3.2 Standard Varietal Trial-2

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

Eighteen *Bt*. commercial varieties of the country were tested at CCRI, Multan. Data recorded on seed cotton yield and other parameters are presented in **Table 2.37**. The results indicated that variety AA-703 excelled among all varieties by producing seed cotton yield of 2345 kg ha^{-1}, followed by the variety *Bt*.CIM-599 with 2323 kg ha^{-1} while *Bt*. CIM-600 produced lowest (1349 kg ha^{-1}) seed cotton production. Variety IR-3701 had the highest lint percentage of 44.3, followed by Bt-121 (39.5%) while MNH-886 had the lowest (32.1%) lint percentage. Staple lengths of all the varieties were below the standard. Micronaire of A-555, IR-3701, Sitara-008, FH-114, FH-142, CEMB-33 and FH-Lalazar were above the standard. Fibre strength of all the varieties except IR-3701, Sitara-008, *Bt*.121, *Bt*.CIM-600 and FH-142 were up to the standard.

Table 2.37 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 (µg $inch^{-1}$)	Fibre Strength (g/tex)	Av. Boll wt. (g)	Plant Pop. (ha^{-1})
AA-703	2010	2345	800	34.1	27.5	4.7	26.2	2.8	41598
AA-802	2010	1773	672	37.9	25.1	4.5	25.5	2.7	38012
IR-3701	2010	2050	908	44.3	23.9	5.9	22.2	3.0	39805
Sitara-008	2010	1516	549	36.2	25.0	5.0	24.0	3.1	37294
Bt.N-121	2010	1910	754	39.5	24.8	4.9	22.3	3.0	39087
FH-113	2010	1775	611	34.4	26.8	4.5	26.4	3.0	40522
MNH-886	2012	2064	663	32.1	26.0	4.4	25.3	3.8	29405
Bt.N-141	2012	1369	497	36.3	27.0	4.0	28.2	2.7	41954
FH-114	2012	1444	487	33.7	25.8	5.2	25.3	2.7	38370
Bt.CIM-598	2012	1490	539	36.2	25.0	4.2	25.8	2.2	35501
Bt.CIM-599	2013	2323	702	37.8	26.2	4.3	27.0	2.7	40880
Bt.CIM-602	2013	1873	609	32.5	27.4	4.0	26.1	2.9	34426
A-555	2013	2219	825	37.2	25.3	5.5	25.7	3.5	39446
CEMB-33	2013	1556	878	37.8	26.5	5.3	26.5	3.1	40880
IUB-222	2013	2187	811	37.1	27.4	4.8	26.1	3.9	39446
FH-142	2013	1966	749	38.1	24.9	5.4	24.4	3.3	34067
FH-Lalazar	2015	1756	636	36.2	26.0	5.3	25.0	3.8	34067
CIM-600	2016	1349	514	38.1	25.8	4.9	25.2	2.5	38729

Sowing date: 16.05.2017

2.4 Breeding Material

2.4.1 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 a biotic stresses. The detail of breeding material planted and number of plants selected during 2017-18 is given in **Table 2.38**.

2.5 Maintenance of Genetic Stock of World Cotton Collection

2.5.1 Maintenance/Preservation of Cotton Genetic Stock at CCRI Multan

Five thousand nine hundred and twenty three genotypes arer being maintained at the Cold Room of CCRI Multan for Long (100 years), medium (50 years) and short term (25years). 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 2.39. The** seed of genetic stock were also supplied, locally and abroad, to different

scientists, cotton growers, academia and different institutes/research stations for their research/breeding programs. The detail is given in **Table 2.40.**

Table 2.38 Detail of single plants selected from breeding material

Generation/Trial	No. of plants Selected	Range	
		Lint (%age)	Staple length (mm)
VT	274	40.6-45.8	29.6 - 31.5
MVT	369	39.6-44.8	29.6 - 31.5
PRT	474	39.6-45.8	29.3 - 31.3
F_{6-7} single lines	993	39.0-44.8	29.0 - 31.0
F_5 single lines	1290	38.9-44.1	28.0 - 31.0
F_4 generation	1434	38.4-43.3	28.9 - 30.7
F_3 generation	1794	38.0-42.0	28.5 - 30.5
F_2 generation	1991	37.5-42.1	28.2 - 30.0
Others	1134	37.3-46.5	28.0 - 32.1

Table 2.39 Detail of Genetic Stock of World Cotton Collection

Local genotypes	1090
Exotic genotypes	4833
Total	**5923**
Species-Wise Detail	
Gossypium herbaceum L.	546
Gossypium arboreum L.	1025
Gossypium hirsutum L.	4243
Gossypium barbadence L.	109

Table 2.40 List of scientists/researchers whom received the cotton germplasm 2017-18

Sr. #	Name of Institute / Research Scientists	No. of stock
1	Dr. Muhammad Kamran Qureshi, Associate Professor, Department of PB&G Faculty of Agricultural Science and Technology, Bahauddin Zakariya University, Multan	13
2	Dr. Ummad-ud-Din, Assistant Professor, Department of Plant Pathology, BZU, Multan	03
3	Dr. Mehmoob-u-Rehman, Principal Scientist, National Institute for Biotechnology & Genetics Engineering (NIBGE), Faisalabad.	123
4	Mr. Abdul Razaq Soomro, Manager Seed, V-Gro Seed, Sadiqabad.	24
5	Dr. Safdar Ali, Assistant Professor, Department of Plant Pathology, University of Agriculture, Faisalabad.	20
6	Dr. Muhammad Tehseen Azhar, Lecturer, Department of Plant Breeding & Genetics University of Agriculture, Faisalabad.	37
7	Dr. Wajid Nazeer, Assistant Professor, Department of Plant Breeding & Genetics, Muhammad Nawaz Shareef University of Agriculture, Multan	42
8	Dr. Saghir Ahmad, Director, Cotton Research Institute, Old Shujabad Road, Multan	47
9	Mr. Sawan Laghari, Deputy chief Scientist, Cotton Group Leader, Nuclear Institute of Agriculture, Tandojam	07
10	Ch. Muhammad Hanif, Deputy General Manger Seed, Four Brothers, Seed Corporation Pakistan, Al-Quresh Housing Scheme, Phase-I, Sher Shah Road, Multan	07
11	Dr. Muhammad Asif Saleem, Assistant Professor/Field Incharge, Department of Plant Breeding & Genetics, Faculty of Agricultural Sciences & Technology, BZU Multan	91
12	Prof. Dr. Shazia Anjum, Director, Cholistan Institute of Desert Studies, The Islamia University, Bahawalpur.	04
13	Dr. Shehzadi Mahpara, Head, Department of Plant Breeding & Genetics Faculty of Agricultural Sciences, Ghazi University, Dera Ghazi Khan.	10
14	Dr. Niaz Ahmad, Assistant professor, Department of Soil Science, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan	04
15	Dr. Amir Suakeel, Assistant Professor, Department of Plant Breeding & Genetics, University of Agriculture, Faisalabad.	50
16	Director, Central Cotton Research Institute, The National Highway Sakrand, District Nawab Shah, Sindh	13
17	Mr. Asghar Ali, Bahaar Seed Corporation, Manthar Road, Sadiqabad.	20
18	Mr. Khalid Iqbal, Plant Pathologist, Onion Research Station, Husri Hyderabad.	02
19	Dr. Rana Haroon Maqsood, Assistant Prof ,Department of PB&G MNSUA Multan	27

Sr. #	Name of Institute / Research Scientists	No. of stock
20	Mr. Muhammad Salman, Assistant Professor, Department of PB&G, MNSUA Multan	25
21	Mr. Zaka Ahmad, Executive Technical Seed, R&D Kanzo Quality Seed, Multan	36
22	The Plant Pathologist, Plant Pathology Section, Plant Pathology Research Institute, Ayub Agri. Research Institute, Faisalabad.	08
23	Mr. Muhammad Tahir Jan, Officer Incharge, Cotton Research Station, Bahawalpur.	23
24	The Chairman, Department of Plant Breeding & Genetics, BZU Multan	51
25	Dr. Muhammad Mansoor, Principal Scientific Officer, Pakistan Agricultural Research Council (Arid Zone Research Centre), Dera Ismail Khan	07
26	Dr. Zulfiqar Ali, Professor, Department of Plant Breeding & Genetics, MNSUSA Multan.	04
27	Mr. Karim Bakhsh Sial,. Officer Incharge, CRS Sibi Model Farm, Johar Road, Sib Balochistan	02
28	Dr. Waqas Malik, Associate Professor, Department of PBG, BZU Multan	10
29	Dr. Muhammad Iqbal, Chairman, Department of Plant Breeding & Genetics, University College of Agriculture & Environmental Sciences, Islamia University, Bahawalpur	10
30	Dr. Ghulam Muhammad Ali, Senior Director, National Agricultural Research Centre, National Institute for Genomics and Advanced Biotechnology, Park Road, PO NIH, Islamabad	81
31	Muhammad Yousuf Memon, Director, Pakistan Atomic Energy Commission, Nuclear Institute of Agriculture (NIA), Tandojam-Sindh	12

2.5.2 Production of pre-basic seed of commercial varieties

Pre-basic seed of seven commercial cotton varieties of CCRI, Multan viz., CIM-496, CIM-506, CIM-554, CIM-573, *Bt*.CIM-598, *Bt*.CIM-599 *Bt*.CIM-602 and *Bt.*CIM-600, CIM-620, was produced. The detail is given in **Table 2.41**.

Table 2.41 Detail of pre-basic seed produced during 2017-18

Variety	Pre-basic seed produced (kg)
CIM-496	67
CIM-506	35
CIM-554	409
CIM-573	151
*Bt.*CIM-598	124
*Bt.*CIM-599	10
Bt.CIM-602	267
CIM-620	436

2.6 Pak-US ICARDA Cotton Project-1198-1 at CCRI Multan

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

In US cotton germplasm imported through Pak –US ICARDA Cotton Project a total of 86 accessions out of 3277 were found to be resistant against CLCuV. These 86 accessions were ratooned at CCRI Multan from the last 4 years. Out of these 86 accessions flower induction were started in only five accessions in the month of December – January 2018 as detailed below:

Sr. No.	Set No.	Year	No of total Accessions	Resistant accessions	Accessions having buds and flower formation
1	C	2013	200	9	0
2	D	2013	200	25	0
3	K	2014	200	5	1
4	N	2014	600	47	4
		Total	**1200**	**86**	**5**

All these accessions are maintaining properly in field condition for proper buds and flower formation. Few accessions have some buds and flowers formation has been started recently in 2018 which are given as In Set K only one accession i.e. USG-618/14 are having flowers and bolls formations while in Set N there were 4 accessions i.e. USG-2131/14 having only one plant which has flower formations.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 all the pollens of these flowers were unfertile. However all these accessions are under observation in field conditions and efforts are made to get fertile flower which will be immediately used in our breeding programs.

2.7 Biotechnology Group

A working group on Biotechnology was constituted by the Director CCRI, Multan with the following composition:

1.	Dr. Muhammad Idrees Khan, SSO/Head, PB&G Section	Group Leader
2.	Ms. Sabahat Hussain, SSO/Head, Plant Pathology Section	Member
3.	Mr. Khamdim Hussain, SO (Breeding)	Member
4.	Madam Farzana Ashraf, SO (Cytogenetics)	Member
5.	Dr. Fazl-I- Dayim Shehzad, SO (Breeding)	Member
6.	Hafiz Muhammad Imran, SO (Cytogenetics)	Member

The major objectives of the biotechnology are as follow:

i) Identification of DNA markers linked to various traits of cotton
ii) Utilization of DNA markers for MAS
iii) Quantification of *Bt*. Toxin in various genotype
iv) Karyotyping.

Objective achieved

1. Stream line the equipments and the required chemicals.
2. Calibration of different equipments.
3. Repair of equipments which were out of order.
4. Established the protocols for different procedures like DNA extraction, gel electrophoresis etc.
5. Preparation of different stock solution and working solution.
6. Genomic DNA extraction from cotton leaves.
7. Gel electrophoresis for DNA analysis.
8. DNA quantification on the Spectrophotometer.
9. Qualitative and quantification testing of cotton sample through ELISA for Cry1Ac. testing of seed cotton for GMO status.

2.8 National Technology Testing Trial at CCRI Multan 2017-18

2.8.1 Research Team:

1.	Dr. Zahid Mahmood	:	Director/Chairman
2.	Dr. Muhammad Idrees Khan Head, Plant Breeding & Genetics Section	:	Convener
3.	Dr. Muhammad Naveed Afzal Head, Agronomy Section	:	Member
4.	Dr. Rabia Saeed Head, Entomology Section	:	Member
5.	Madam Sabahat Hussain Head, Plant Pathology Section	:	Member
6.	Hafiz Abdul Haq Scientific Officer, Plant Breeding & Genetics Section	:	Member

2.8.2 Introduction

Cotton (*G. hirsutum L*) is the most economically important crop of our country upon which total economy of our country relies directly or indirectly. Cotton is the silver gold of Pakistan's agriculture which earns a good fortune for the country in the form of foreign exchange. The demand for high yield and better fiber quality has been increased with the changing patron of globalization of cotton production. The development of new cotton varieties is one of the most important factors for increasing cotton yield, early maturing with desirable fiber traits and

resistant/tolerant to insect pest, diseases and having low input cost specially in eradication of weeds.

There are so many yield limiting factors in cotton. Weeds are one of them which are unwanted plants that comprise about 0.1% of the agro system of the world flora. Weed acts as a major factor for declining crop yield by competing for resources such as water, light and nutrients. Approximately 30% of yield losses in cotton are caused by weeds. Therefore the control of weeds remains a major concern for crop producers. In past, application of multiple chemicals was required to manage weed by different conventional means like hand weeding, crop rotations and polyculture because no synthetic chemicals were available at that time. The control methods then shifted towards high input and targeted oriented methods after the discovery of synthetic herbicides in 1930. In cotton Glyphosate resistant was first commercialized in 1997 by Monsanto and later on the cultivated land for the Glyphosate Resistant Cotton (GRC) was increased spectacularly. The adoption of transgenic crops also known as GMOs and biotech crops has been rapid and impressive worldwide. Adoption of Glyphosate resistant crops has also significant economic efforts in agriculture. Herbicide resistant cotton (Gossypium hirsutum) comprises one of the largest genetically modified crops. Cotton yield has been badly affected by the crop weed competition during the first few weeks after planting. For this purpose a trial was design by Directorate of Research PCCC Multan to test new strains developed by different scientist throughout the country through conventional/molecular breeding and transformations which have Glyphosate tolerant/resistant genes (GTG). To check out the performance of these strains, a trial with the name of National Technology Testing Trial (NTTT) at CCRI Multan was conducted. Detail study of the trial is given as under.

2.8.3 Material and Methods

National Technology Testing Trail (NTTT) of Pakistan central cotton committee was conducted at CCRI, Multan during 2017-18 under the supervision of Directorate of Research. Ten cotton genotypes including GMOs and non GMOs were tested in coded form. Basically the trial was design to test the Glyphosate resistant genotypes and to know the effect of the weedicides on the crop plant as well as on the weeds. Sowing was done on 28th May 2017 in a Randomized Complete Block Design (RCB) with three replications. Plot size was kept as 20×10 with 75 cm row to row distance and 12 cm plant to plant distance. Data were recorded on the agronomic, yield and fiber traits and standard agronomic and plant protection measures were applied. Detail is given in Table-1.

Table 1 Field operation of National Technology Testing Trial at CCRI Multan 2017-18

Trial	Operation
NTTT	NTTT-1 - NTTT-10
Sowing date	28/5/2017
Location	CCRI, Multan
Number of genotypes	10
Replications	03
Design/Layout	RCBD
Plot size	20'x10' =1/538.2 ha

2.8.3 Germination percentage

‘ The repeat-wise germination percentage data (as given in Table-2) shows that NTTT-2, NTTT-5 and NTTT-6 were having very good seed germination in percentage. Similarly NTTT-3, NTTT-4, NTTT-7, NTTT-8, NTTT-9 and NTTT-10 have good performance in term of seed germination percentage while NTTT-1 was having poor germination percentage.

Table 2 Germination Percentages of NTTT at CCRI, Multan during 2017-18

Sr. No.	Varieties	Repeats			Average
		1	2	3	
1	NTTT-1	V. Poor	V. Poor	Good	Poor
2	NTTT-2	Excellent	V. Good	V. Good	V. Good
3	NTTT-3	V. Good	Good	Good	Good
4	NTTT-4	Excellent	Good	Good	Good
5	NTTT-5	V. Good	V. Good	V. Good	V. Good
6	NTTT-6	V. Good	V. Good	V. Good	V. Good
7	NTTT-7	Poor	Good	Good	Good
8	NTTT-8	Good	Good	Good	Good
9	NTTT-9	Good	Good	Good	Good
10	NTTT-10	Good	V. Good	Good	Good

Very poor = <30%, Poor = 30-49%, Good = 50-75%, V. good = 80-90, & Excellent = >90%,

2.8.4 Stunting data

Stunting data of the plants were taken just after 20 days of sowing. Stunting data were recorded using to the formula given below.

% age of stunted plants = number of stunted plant /total number plant per plot × 100

According to the results, maximum stunting percentage of 2.46% were observed in genotype NTTT-1 followed by NTTT-4 and NTTT-8 with 0.85 and 0.65% respectively. While the remaining all the genotypes were having 0.00% stunted plants Table 3.

Table 3 Stunting percentage of NTT Trial at CCRI, Multan 2017-18

S. No.	Genotypes	Total plants	Stunted plants	Percentage
1	NTTT-1	81	2	2.46
2	NTTT-2	465	0	0.00
3	NTTT-3	489	0	0.00
4	NTTT-4	351	3	0.85
5	NTTT-5	416	0	0.00
6	NTTT-6	546	0	0.00
7	NTTT-7	585	0	0.00
8	NTTT-8	456	3	0.65
9	NTTT-9	516	0	0.00
10	NTTT-10	564	0	0.00

2.8.5 Pathological study (CLCuV)

Pathological study of the National Technology Testing trial relating to cotton leaf curl virus disease were taken by the pathology section of Central Cotton Research Institute Multan. The data was first recorded 60, 90 and 120 days after sowing as shown in Table 4. For this purpose disease percentage was calculated first on 60, 90 and 120 days based data and then the disease severity and disease index in percentage were calculated by using the formula

$$\text{Disease index \%} = \frac{\text{Disease incidence} \times \text{Disease severity}}{4}$$

While disease incidence is the sum of all diseased plants divided by total number of plants multiplied by hundred or can simply be calculated by the following formula

$$\text{Disease incidence} = \frac{\text{Sum of all diseased plants}}{\text{Total number of plants}} \times 100 \quad \text{and}$$

$$\text{Disease severity} = \frac{\text{Disease rating scale i.e. 0 - 4} \times \text{number of diseased plants}}{\text{Sum total of diseased plants}}$$

According to the data recorded on all 60, 90 and 120 days bases, maximum disease index was found as 56.74% in NTTT-6 and minimum was found as 51.77 % in NTTT-7 while the remaining all the genotypes were having the percentage of disease index ranging from 52.09 to 56.10 which shows that all the genotypes were highly susceptible against cotton leaf curl virus after 120 days of sowing details are given in Table-3.

Table 3 Screening of NTTT genotypes against CLCuV disease after 60, 90 and 120 days of sowing.

Treatments	Disease (%) 60 DAS	Disease (%) 90DAS	Disease (%) 120 DAS	Av. Disease Severity (%)	Disease Index (%)	Category
NTTT-1	-	-	-	-	-	-
NTTT-2	-	-	-	-	-	-
NTTT-3	36.83	97.14	100	2.08	52.09	H.S
NTTT-4	-	-	-	-	-	-
NTTT-5	-	-	-	-	-	-
NTTT-6	56.09	97.62	100	2.27	56.74	H.S
NTTT-7	33.57	96.97	100	2.07	51.77	H.S
NTTT-8	35.28	88.51	100	2.17	54.26	H.S
NTTT-9	38.67	88.61	100	2.19	54.83	H.S
NTTT-10	38.70	87.14	100	2.21	55.22	H.S

Note; Immune = 0, highly tolerant = 0-10, Tolerant = 10-30, Susceptible = 30-50, highly susceptible = > 50.

2.8.6 Weedicides application

1st spray

Weedicides application was carried out to check out the performance of the genotypes against weeds and to identify the presence of the Glyphosate resistance gene in these genotypes. For this purpose 25 days after sowing on 25th June 2017 "CLEAN UP" (TARZAN) was applied at the rate of 1000 ml per acre to replication 1, 2 and 3 respectively. Mortality data was recorded seven days and twelve days after spraying. The data showed that late effect of the weedicides was observed on the genotypes and four genotypes i.e. NTTT-1, NTTT-2, NTTT-4 and NTTT-5 were more affected while very less effect were observed on NTTT-8. The remaining five genotypes i.e. NTTT-3, NTTT-6, NTTT-7, NTTT-9 and NTTT-10 were not affected at all and shows complete resistance /tolerance against weedicide which confirmed the existence of Glyphosate tolerant gene (GTG) in these genotypes as shown in Table-4

Table 4 Applications of CLEAN UP (1st) Weedicide on NTT trial during 2017-18

Weedicide dose (1000ml per acre)			Remarks
Not effect	**Less effected**	**More effected**	
NTTT-3	NTTT-8	NTTT-1	Late effect were observed
NTTT-6	-	NTTT-2	
NTTT-7	-	NTTT-4	
NTTT-9	-	NTTT-5	
NTTT-10	-	-	

Note: - 1st Weedicide spray was carried out on 25th of June 2017 at the rate of 1000 ml in all the repeats
Not affected=0-5%., Less affected = 10-50% and severely affected = >60

2.8.7 Mortality data

Data on number of plant damaged/killed by the weedicides and recovery of the plants seven and twelve days after weedicides application was recorded with the help of the agronomy section. For this purpose total number of plant per dibble in a plot were counted and then the effected plants and their mortality percentage was calculated as

Mortality percentage = Number of effected plants /total number of plants.

On average base in all the three replications maximum mortality percentage was observe in genotypes i.e. NTTT-1, NTTT-2, NTTT-4 and NTTT-5 while in genotypes NTTT-8 few damaged plants were observed. Less than 1 percent damaged plant was recorded in genotypes NTTT-3, 6, 7, 9 and NTTT-10. Detail is given in Table-5.

2.8.8 Agronomic studies

Weeds data

Data on number of weeds and weed type and their dry weight was recorded by the agronomy section of the institute. The data were recorded 55 days after sowing after the application of first spray of weedicide. Similarly weed types were also identified by separating narrow leaf and broad leaf weeds and dry weight was calculated. Mostly deela, itset, Qulfa and Tandla weeds were found in the whole field, Detail is given in Table-5.

Table 5 Mortality percentage Data after 7 and 12 days of Spray in NTT Trial 2017-18

Genotypes	Total plants	Affected plants after 7 days	Mortality percentage	Dead plants after 12 days	Mortality percentage
NTTT-1	81	70	86.4	70	86.4
NTTT-2	465	320	68.8	320	68.8
NTTT-3	489	3	0.61	1	0.2
NTTT-4	351	280	79.7	280	79.7
NTTT-5	416	342	82.2	342	82.2
NTTT-6	546	5	0.9	1	0.2
NTTT-7	585	5	0.8	2	0.3
NTTT-8	456	15	3.2	7	1.5
NTTT-9	516	3	0.5	2	0.3
NTTT-10	564	3	0.5	1	0.2

Table 5 Weed intensity observed 55 days after sowing in NTTT at CCRI, Multan during 2017-18

Plot No.	Genotypes	Dry Weight Of narrow leaves ($g\ m^{-2}$)	Dry Weight of Broad Leaf ($g\ m^{-2}$)
1	NTTT-1	80.6	19.6
2	NTTT-2	78.5	25.6
3	NTTT-3	83.9	27.1
4	NTTT-4	73.7	15.8
5	NTTT-5	80.0	33.3
6	NTTT-6	74.0	35.4
7	NTTT-7	63.5	32.6
8	NTTT-8	72.5	35.0
9	NTTT-9	80.0	36.8
10	NTTT-10	42.5	36.8

2nd spray

Another spray was applied on 25th July 2017 within 60 days after sowing at the rate of 1000 ml $acre^{-1}$ in all the three repeats. An early effect of the spray was observed on all types of weeds and all the weeds were killed. As a result, four genotypes i.e. NTTT-1, NTTT-2, NTTT-4 and NTTT-5 were severely affected and completely damaged in all three repeats which indicate the absence of the GT genes in these lines (Table 6). After the spray, these genotypes did not show any resistance against weedicides while the remaining genotypes survived which shows the presence of Glyphosate tolerant (GT) genes in these genotypes.

Table 6 Application of CLEAN UP (2nd) Spray on NTT Trial at CCRI Multan 2017-18

Weedicide dose (1000ml per acre)			Remarks
Not affected	Less affected	Severely affected	
NTTT-3	-	NTTT-1	Early effect were observed
NTTT-6	-	NTTT-2	
NTTT-7	-	NTTT-4	
NTTT-8	-	NTTT-5	
NTTT-9	-	-	
NTTT-10	-	-	

Note: 2nd Weedicides spray was applied on 25th of July, 2017 at the rate of 1000ml/acre to all the three replications. Not affected = 0%, severely affected = 80-100%.

2.8.9 ENTOMOLOGICAL STUDY

Insect/Pest Situation

In this trial, 10 cotton strains were evaluated for tolerance/susceptibility to insect pest complex. Population of Jassid remained below ETL during July and August. Whitefly population remained below ETL in the strains during July and August except NTTT-3. Thrips population remained below ETL on all the testing strains during study period (Table 7).

Table 7 Seasonal population of sucking insect pests on different strains in NTTT 2017-18

Strains	Number of sucking insect pests per leaf					
	Jassid		Whitefly		Thrips	
	July	August	July	August	July	August
NTTT-1	0.0	0.0	0.2	0.0	0.0	0.0
NTTT-2	0.0	0.0	0.1	0.0	0.0	0.0
NTTT-3	0.0	0.2	0.2	5.7	0.0	0.8
NTTT-4	0.4	0.0	0.2	0.0	0.0	0.0
NTTT-5	0.0	0.0	0.2	0.0	0.0	0.0
NTTT-6	0.0	0.0	0.6	2.4	0.0	0.3
NTTT-7	0.8	0.1	0.3	2.7	0.3	0.8
NTTT-8	0.2	0.1	0.5	3.8	0.0	0.5
NTTT-9	0.4	0.0	0.6	2.3	0.0	0.4
NTTT-10	0.5	0.0	0.1	1.8	0.0	3.1

Spotted/American bollworm infestation and live larvae remained zero on all tested strains during the study period. Moreover, pink bollworm infestation and live larvae were also zero in all strains table 8 and 9.

Table 8 Spotted/ American bollworms damage and larval population on different strains of NTTT during 2017-18 at CCRI Multan.

Strains	Bollworm damage % age		Spotted bollworm larvae /25 plant	
	Imm	Mat	Imm	Mat
NTTT-1	0.0	0.0	0.0	0.0
NTTT-2	0.0	0.0	0.0	0.0
NTTT-3	0.0	0.0	0.0	0.0
NTTT-4	0.0	0.0	0.0	0.0
NTTT-5	0.0	0.0	0.0	0.0
NTTT-6	0.0	0.0	0.0	0.0
NTTT-7	0.0	0.0	0.0	0.0
NTTT-8	0.0	0.0	0.0	0.0
NTTT-9	0.0	0.0	0.0	0.0
NTTT-10	0.0	0.0	0.0	0.0

Table 9 Pink bollworms damage and larvae population on different strains in NTTT during 2017-18 at CCRI Multan

Strains		
	Pink Bollworm damage % age	Pink Bollworm larval % age
NTTT-1	0.0	0.0
NTTT-2	0.0	0.0
NTTT-3	0.0	0.0
NTTT-4	0.0	0.0
NTTT-5	0.0	0.0
NTTT-6	0.0	0.0
NTTT-7	0.0	0.0
NTTT-8	0.0	0.0
NTTT-9	0.0	0.0
NTTT-10	0.0	0.0

2.8.10 Plant characters

Data were recorded on various qualitative and quantitative plant characters i.e. plant hairiness, leaf size and color, boll size, bolls shape and boll opening, segregation/uniformity, earliness, plant shape and plant height (Table 10). The data shows that almost all of the genotypes were found hairy; leaf size ranged from small to small medium, leaf color ranged from light green to green or dark green. Boll size was small to medium, boll shapes were rounds and boll opening were normal. Among the study traits plant shape were found as compact and monopodial while plant stature were observed as medium for all the genotypes. No earliness was seen among any of the studied genotype and almost all were found as late in term of maturity while uniformity was found among all the genotypes.

Table 10 Plant characteristics of NTTT at CCRI Multan during 2017-18

Verity Code	Hairi-ness	Leaf size	Leaf color	Boll size	Segrega-tion/ uniformity	Boll shape	Boll Opening	Plant shape	Early/ late	Plant stature/ height
NTTT-1	-	-	-	-	-	-	-	-	-	-
NTTT-2	-	-	-	-	-	-	-	-	-	-
NTTT-3	Hairy	Small	Green	Medium	Uniform	Round	Medium	Compact	Late	Medium
NTTT-4	-	-	-	-	-	-	-	-	-	-
NTTT-5	-	-	-	-	-	-	-	-	-	-
NTTT-6	Hairy	Medium	D. Green	Medium	Uniform	Round	Medium	Compact	Late	Medium
NTTT-7	Hairy	Medium/ Broad	D. Green	S.Medium	Uniform	Round	Medium	Monopodial	Late	Medium
NTTT-8	Hairy	Small/ Medium	L. Green	S.Medium	Uniform	Round	Medium	Monopodial	Late	Medium
NTTT-9	Hairy	Small/ Medium	Green	Medium	Uniform	Round	Medium	Monopodial	Late	Medium
NTTT-10	Hairy	Small/ Medium	Green	Medium	Uniform	Round	Medium	Monopodial	Late	Medium

2.8.11 Boll weight (g)

For average boll weight from each repeat, 25 good bolls were taken and then weighted for average boll weight Table 11.

$$\textit{Boll weight (g)} = \frac{\textit{Total weight of 25 bolls (g)} \times 100}{\textit{Number of bolls}}$$

The results showed that maximum average boll weights of 3.0 g were revealed by the genotypes NTTT-9 and NTTT-10 respectively. Minimum boll weight of 2.6 g was recorded in genotype NTTT-6 while the genotypes NTTT-3 with 2.8 g and NTTT-7 and NTTT-8 with 2.9 g respectively were having the medium boll weight.

Table 11 Average Boll weight of NTTT at CCRI Multan during 2017-18

Varieties	Repeats			Total	Average
	1	2	3		
NTTT-1	-	-	-	-	-
NTTT-2	-	-	-	-	-
NTTT-3	2.8	2.7	2.8	8.3	2.8
NTTT-4	-	-	-	-	-
NTTT-5	-	-	-	-	-
NTTT-6	2.6	2.7	2.5	7.8	2.6
NTTT-7	3.0	2.9	2.8	8.7	2.9
NTTT-8	2.9	2.9	2.8	8.6	2.9
NTTT-9	3.1	3.0	3.0	9.1	3.0
NTTT-10	2.9	3.0	3.1	9.0	3.0

2.8.12 Seed cotton yield (kgh^{-1})

Repeat wise data of seed cotton yield in kgha^{-1} is given in Table-12. A look into the data table shows that the average yield performance of the genotype NTTT-7 was the best among all the genotypes which produced 1540 kg yield. NTTT-10 with 1483 kg was found as the second best genotype in term of yield followed by the genotypes NTTT-9 with 1368, NTTT-8 with 1320 and NTTT-3 with 1248 kgs of seed cotton yield respectively. Minimum seed cotton yield of 1054 kg was observed for the genotype NTTT-6.

Table-12 Consolidate data of seed cotton yield in kg h^{-1} of NTTT at CCRI Multan 2017-18

Varieties	Repeats			Average
	1	2	3	
NTTT-1	-	-	-	-
NTTT-2	-	-	-	-
NTTT-3	1393	1221	1130	1248
NTTT-4	-	-	-	-
NTTT-5	-	-	-	-
NTTT-6	1130	947	1087	1054
NTTT-7	1603	1512	1506	1540
NTTT-8	1367	1361	1232	1320
NTTT-9	1517	1420	1167	1368
NTTT-10	1598	1453	1399	1483

2.8.13 Plant population

After picking the repeat wise data of number of plant hectare^{-1} is given in Table-13. The data shows that maximum average numbers of plants were recorded as 34073 per hectare in NTTT-7 followed by NTTT-10 with 33177 plants. While, 32459 and 30666 number of plants per hectare were recorded in NTTT-6 and NTTT-7 respectively. Minimum and least number of 26721 plants was recorded in NTTT-8.

Table 13 Consolidated data of Plant populations (No. of plants h^{-1}) of NTTT 2017-18

Varieties	Repeats			Average
	1	2	3	
NTTT-1	-	-	-	-
NTTT-2	-	-	-	-
NTTT-3	31204	29052	26900	29052
NTTT-4	-	-	-	-
NTTT-5	-	-	-	-
NTTT-6	34970	33356	29052	32459
NTTT-7	35508	33356	33356	34073
NTTT-8	27438	27976	24748	26721
NTTT-9	32280	30666	29052	30666
NTTT-10	34970	32280	32280	33177

2.8.14 Lint percentage (GOT %)

A look at the data presented in Table-14 shows that on average bases, the genotype NTTT-8 was having maximum lint percentage of 38.1 % followed by NTTT-9 with 38.0%. Among the studied genotypes for the said character, NTTT-3 was having 37.8 % GOT and that of NTTT-10 was found 37.6 %. Minimum average lint percentages of 37.2 % were observed for the genotypes NTTT-6 and NTTT-7 respectively.

Table 14 Average GOT% of NTTT at CCRI Multan during 2017-18

Varieties	Repeats			Average
	1	2	3	
NTTT-1	-	-	-	-
NTTT-2	-	-	-	-
NTTT-3	37.9	36.6	38.8	37.8
NTTT-4	-	-	-	-
NTTT-5	-	-	-	-
NTTT-6	36.6	37.1	38.0	37.2
NTTT-7	38.1	37.8	35.8	37.2
NTTT-8	38.4	37.2	38.6	38.1
NTTT-9	38.8	38.2	37.1	38.0
NTTT-10	38.1	37.7	37.1	37.6

2.8.15 Other Fibre Characters

In addition to staple length, other fibre characters like micronaire value and fibre strength were also determined from the composite sample of the replicated National Technology Testing trial at the fiber technology section. The details of these characteristics are given below.

Staple Length

The average data of three replications presented in Table-15 from the composite samples of the trial revealed that maximum staple length of 26.0 mm was illustrated by the genotype NTTT-8 followed by NTTT-10 with 25.7 mm, NTTT-9 with 25.6 mm and NTTT- 3 with 25.0 mm of staple length. Minimum staple length of 24.5 mm and 24.9 mm were recorded for NTTT-6 and NTTT-7 respectively. The data shows that all the genotypes were having staple length below the standard (28.00 mm) as recommended by Punjab seed council for the approval of a variety.

Table 15 Average staple length (mm) of NTTT at CCRI Multan during 2017-18

Varieties	Repeats			Average
	1	2	3	
NTTT-1	-	-	-	-
NTTT-2	-	-	-	-
NTTT-3	25.0	24.9	25.2	25.0
NTTT-4	-	-	-	-
NTTT-5	-	-	-	-
NTTT-6	24.1	23.8	25.5	24.5
NTTT-7	24.9	24.8	25.0	24.9
NTTT-8	26.3	25.9	25.8	26.0
NTTT-9	26.1	25.5	25.1	25.6
NTTT-10	24.9	26.2	25.9	25.7

Micronaire value

The data of micronaire value presented in Table-16 shows that all the genotypes were having the micronaire values ranging from 5.1 to 5.3 µg inch^{-1} which is almost above the standard i.e. from 3.8 to 4.9 µg inch^{-1} which shows that these genotypes were having the coarse fiber. Repeat wise average data for the fiber fineness (micronaire value) of all the genotypes is given below in Table -16.

Table 16 Consolidated data of Micronaire value in (µg inch^{-1}) of NTTT 2017-18

Varieties	Repeats			Average
	1	2	3	
NTTT-1	-	-	-	-
NTTT-2	-	-	-	-
NTTT-3	5.2	5.2	5.3	5.2
NTTT-4	-	-	-	-
NTTT-5	-	-	-	-
NTTT-6	5.3	4.9	5.1	5.1
NTTT-7	5.3	5.4	5.2	5.3
NTTT-8	5.3	5.2	4.8	5.1
NTTT-9	5.2	5.2	5.4	5.3
NTTT-10	5.1	5.1	5.5	5.2

Fibre strength

The data presented in Table-17 revealed that on the basis of three replications average, genotype NTTT-10 had maximum 26.1 fibre strength G/Tex followed by 25.9, 25.6, 25.5 and 25.2 G/Tex of NTTT-8, NTTT-3 NTTT-9 and NTTT-7 respectively. Minimum fibre length of 24.9 G/Tex was shown by the genotype NTTT-6. The remaining four genotypes i.e. NTTT-1, NTTT-2, NTTT-4 and NTTT-5 were already smashed by the Glyphosate spray.

Table 17 Consolidated data of Fibre Strength in (G/Tex) of NTTT during 2017-18

Varieties	Repeats			Average
	1	2	3	
NTTT-1	-	-	-	-
NTTT-2	-	-	-	-
NTTT-3	25.8	26.0	25.0	25.6
NTTT-4	-	-	-	-
NTTT-5	-	-	-	-
NTTT-6	24.4	23.7	26.5	24.9
NTTT-7	26.0	24.8	24.9	25.2
NTTT-8	26.2	25.8	25.8	25.9
NTTT-9	25.1	26.0	25.3	25.5
NTTT-10	25.8	27.1	25.5	26.1

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3. CYTOGENETICS

Cytogenetics section is working to combat diverse upcoming biotic and abiotic intimidation. The main objectives include 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*. During the past many years, cotton leaf curl virus (CLCuV) has been the most damaging biotic factor in Pakistan that results in severe production losses, but now pink boll worm is also second most threatening factor in cotton growing areas. Dusky and red cotton bugs are also becoming major pests of cotton. On trivial lands raising drought tolerant varieties is a far cry. Keeping in view all these factors, Cytogenetics section is working on introgression to transfer the disease resistance, insect resistance, drought tolerance, heat tolerance and better fiber quality from wild species in cultivated cotton.

Specie Name	Special features
G. arboreum	Biotic & a biotic resistance
G. anomalum	Biotic & a biotic resistance with better fibre strength
G. herbaceum	Biotic resistance
G. somalence	Biotic resistance
G. areysianum	Biotic resistance
G. longicalyx	Biotic resistance
G. tomentosum	Biotic & a biotic resistance
G. australe	Gossypol free oil, better fibre quality, a biotic resistance, disease resistance
G. bickii	Gossypol free oil,
G. aridum	A biotic resistance,
G. herkensii	A biotic resistance,
G. captis viridis	Disease resistance,
G. stockii	Better fibre quality, drought resistance
G. klotzchianum	Pest resistance
G. armorianum	Disease resistance
G. ramondii	Better fibre quality, disease resistance, a biotic resistance, boll worm resistance, pest resistance

Cytological studies of newly developed inter-specific hybrids were undertaken. Conversion of CLCuD resistant/tolerant lines in high yielding and big boll with desirable fibre traits using back cross method is under observation in different filial generations i.e. F_1, F_2, F_3, F_4, F_5 and F_6. Besides different lint shades; material is developed which are in F_1, F_2 and F_3 generations having desirable fibre traits. Search for aneuploids especially haploids remained in steps forward. Cyto material developed through interspecific hybridization was tested in single lines, micro varietal trials and varietal trials to evaluate their yield performance and other desirable characteristics.

For the year 2018-19, two Bt varieties viz., Cyto-313 & Cyto-515 and one non *Bt* variety (Cyto-225) of this section were included in National Coordinated Varietal Trials (NCVT). The case of both Bt varieties has been already submitted to National Biosafety Committee for the permission of their field trials.

3.1 Maintenance of *Gossypium* Germplasm

Twenty species of *Gossypium* (cultivated and wild) are being maintained in living herbarium at CCRI, Multan for exploitation in hybridization program. Among them sixteen species viz., *G. anomalum* B_1, *G. capitis viridis* B_4, *G. harknessii* $D_{2\text{-}2}$, *G. aridum* D_4, *G. gossypioides* D_6, *G. lobatum* D_7, *G. laxum* D_9, *G. stocksii* E_1, *G. somalense* E_2, *G. areysianum* E_3, *G. incanum* E_4, *G*. *longicalyx* F_1, & *G. nelsonii* G_3 are diploid wild species. While *G. tomentosum* $(AD)_3$ & *G. mustelinum* $(AD)_4$ are tetraploid wild species. The species *G. herbaceum* A_1 & *G. arboreum* A_2, (diploid); *G. hirsutum* $(AD)_1$ is (tetraploid) are the cultivated species. In addition; twenty five interspecific hybrids (five diploid, six triploid, five tetraploid, two pentaploids and four hexaploid interspecific hybrids) and 3 tri species combinations are also maintained.

For the strengthening of *Gossypium* species in living herbarium at CCRI, Multan seeds of twelve 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-3.1.

Approach grafting has been done to maintain the already existing wild species as well as the cuttings of all the species were planted in glass house to maintain the precious material. The detail is given in Table 3.2. Twenty grafts of eight wild species were prepared during month of September, 2017. All these grafted plants will be transplanted in field during the month of March, 2018.

Table 3.1. List of wild species planted in glass house through seed during 2017-18

Sr. No.	Name of Species	No. of seeds planted	No. of seeds germinated
1	*G.davidsonii*	5	0
2	*G.areysinum*	4	1
3	*G.costulatum*	5	1
4	*G.trilobum*	5	0
5	*G.aridum*	5	2
6	*G.australe*	5	1
7	*G.raimondii*	5	1
8	*G.longicalyx*	5	1
9	*G.sturtianum*	5	1
10	*G.marchanti*	5	1
11	*G.bickii*	5	2
12.	*G.klotzchianum*	3	1
Total		**57**	**12**

Table 3.2. List of wild Species maintained through approach grafting during 2017-18

Sr. No.	Name of species	No. of grafts
1	*G.somalense*	3
2	*G.incanum*	4
3	*G.tomentosum*	3
4	*G.bickii*	2
5	*G.nelsonii*	2
6	*G.anomalum*	2
7	*G.capitis viridis*	2
8	*G.longicalyx*	2
	Total	**20**

Fig 1. Approach grafting in *G. somalence and G.bickii*

A total of 401 cuttings of interspecific material were grown in permanent herbarium to maintain this precious material. Detail is given below in Table 3.3.

Table: 3.3 Cuttings of interspecific material

Sr. No	Name of interspecific material	No. of cuttings
1.	*G. herbacium (Red)*	17
2.	*G.aridum*	10
3.	*G.gossypiodes*	15
4.	*G.laxum*	17
5.	*G.lobatum*	19
6.	*G.anomalum*	37
7.	*G.captis viridis*	22
8.	*G.tomentusum*	11
9.	*G.incanum*	10
10.	*G.lanceolatum*	30
11.	*G.areysianum*	11
12.	2(*G.hirs.*x anom.) (6n)	16
13.	2(*G.hirs.*x anom.) x *G.barba* (5n)	16
14.	*G.hirs* x 2(*G.hirs.*x *anom.)* (4n)	15
15.	*G.arbo.*x *G.somalense* (2n)	15
16.	2(*G.hirs.*x *G.anom.)* x *G.hirs.*	16
17.	*G.hirs.*(Red)x *G.herkensii 3n*	18
18.	2(*G.arbo.*x *G.australe*) (4n)	24
19.	2(*G.arbo.*x *G.australe*) (2n)	10
20.	2(*G.arbo.*x *G.anom.*) (4n)	20
21.	2(*G.hirs.*x *G.bikii)* 6n	10
22.	*G.arbo.*x *G.thurberii* (2n)	18
23.	*G.hirs.*x *G.gossypiodes 6n*	24
Total		**401**

3.2 Hybridization

Inter-specific & Intraspecific hybridization

Inter-specific hybridization for integration of precious wild species genes (especially the genes for resistance against CLCuD) into the upland cotton were undertaken during the season. In intraspecific hybridization, conversion of CLCuD resistant/tolerant lines to high yielding and big boll with desirable fibre traits were carried out using back crossing during the cropping season. The detail of species hybridization is given in Table 3.4.

Table 3.4 Detail of Intra and Inter-specific crosses attempted during 2017-18

Sr. No.	Parentage	No. of Pollinations attempted	No. of Bolls set
1	SL-12 × SL-19	61	22
2	SL-12 × SL-20	44	5
3	SL-12 × SL 58	89	6
4	SL-12 × SL64	50	10
5	SL-12 × SL-65	62	10
6	SL-18 × SL-19	67	3
7	SL-18 × SL-20	45	3
8	SL-18 × SL-58	15	1
9	SL-18 × SL- 64	44	2
10	SL-18 × SL-65	58	10
11	SL-79 × SL-19	87	17
12	SL-79 × SL-20	66	5
13	SL-79 × SL-58	40	11
14	SL-79 × SL-64	57	10
15	SL-79 × SL-65	25	7
16	SL-369 × SL-19	61	15
17	SL-369 × SL-20	84	5
18	SL-369 × SL-58	86	3
19	SL-369 × SL-64	77	4
20	SL-369 × SL-65	44	10
21	SL-369 × SL-19	68	3
22	SL-369 × SL-20	60	5
23	SL-369 × SL-58	65	2

Sr. No.	Parentage	No. of Pollinations attempted	No. of Bolls set
24	SL-369 × SL-64	55	8
25	SL-369 × SL-65	30	2
26	Cyto-179 × Bahar 07	22	16
27	Cyto-179 × IR-NIBGE-08	22	8
28	Cyto-179 × C-7	25	12
29	Cyto-179 × C-9	30	7
30	Cyto-179 × C-18	34	7
31	Cyto-313 × Bahar07	25	9
32	Cyto-313 × IR-NIBGE08	27	6
33	Cyto-313 × C-7	30	4
34	Cyto-313 × C-9	30	5
35	Cyto-313 × C-18	39	3
36	Cyto-313 × Deebal	35	5
37	Cyto-313 × CIM-616	25	3
38	Cyto-313 × CIM-629	25	6
39	Cyto-515 × Bahar 07	45	17
40	Cyto-515 × IR-NIBGE08	37	9
41	Cyto-515 × C-7	34	11
42	Cyto-515 × C-9	41	11
43	Cyto-515 × C-18	43	11
44	Cyto-515 × CIM-616	46	16
45	Cyto-515 × CIM-629	40	12
46	Cyto-305 × CIM-516	52	1
47	Cyto-305 × MVT-1	32	9
48	Cyto-305 × MV-6	35	4
49	Cyto-305 × MV-2	36	3
50	Cyto-177 × C-18	25	5
51	Cyto-178 × 179-5/17	19	4
52	Cyto-178 × C-18	42	8
53	Cyto-179 × 142-5/17	20	3
54	Cyto-177 × C-9	26	3
55	Cyto-178 × C-9	36	7
56	Cyto-313 × C-12	29	3
57	Cyto-313 × C-9	10	1
58	Cyto-177 × Cyto-515	25	5
59	Cyto-178 × Cyto-515	30	4
60	Cyto-161 × Cyto-124	15	2
61	Cyto-161 × C-18	40	8
62	2(*G.arbo.* x *G.anom*.) × *G. hir*	260	40*
63	2(*G.hir*. × *G.anom*) × *G.bar*	280	9
64	(*G.hir* × *G. hark*) × *G. hir*	80	15**
65	Brown lint cotton × FH-Lalazar	90	25
66	Brown lint cotton × Cyto-225	50	8
67	L -1681 × C4	50	10
68	L-1681 × Cyto-225	60	8
69	Cyto-313 × Cyto-225	70	6
70	Cyto-515 × Cyto-225	80	10
71	L-1681 × C4	80	10
72	Cyto-313 × C4	90	11
73	Cyto-515 × C4	80	7
74	SL.4 × C4	120	16
75	Cyto-161 × Cyto-313	90	10
76	Cyto-124 × Cyto-313	70	20
77	Cyto-124 x Cyto-313	70	20
Total		**4187**	**597**

* mutes formation only ** empty bolls

A total of 4187 pollinations were attempted in 77 combinations. The boll setting was obtained in all combinations whereas in few 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.2. Conversion of drought resistant interspecific hybrids into high yielding with desirable fibre traits through back crossing

Fig.3. Conversion of CLCuV resistant interspecific hybrids into high yielding with desirable fibre traits through back crossing

3.3 Chromosomal Studies

A. Some early and CLCuV resistant plants were observed in interspecific hybrid i.e {*G.hirsutum* x 2(*G.arboreum* x G.*anomalum*)} x *.*^{4}*G.hirsutum.* Buds were fixed in Carnoy's solution and preserved in 70% alcohol. The chromosomal studies were carried out at Metaphase-1. The results are given below.

Chromosomal configurations

PMC No.	I's	II's	III's	IV's	Total	Remarks
3	-	26	-	-	52	Plant was fertile
4	-	26	-	-	52	
Ave.	-	26	-	-	52	

The chromosomal configuration for the above combination at Metaphase-1 is depicted in Fig. 4.

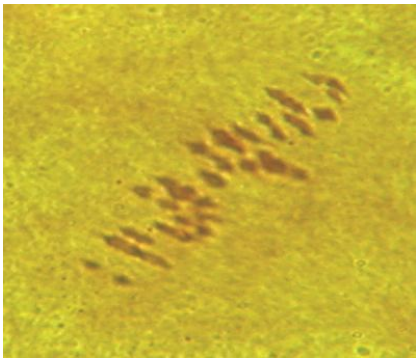


Fig-4. 126 II's = 52

Fig 4. Chromosomal configurations of {*G.hirsutum* x 2(*G.arboreum* x G.*anomalum*)} x *.*^{4}*G.hirsutum* at Metaphase-1

Morphology

1) Plant shape = Erect.
2) Petal colour = i). Light pink with yellow pollen.
3) Ii).Creamy petals with purple spot
4) Boll size = good.
5) Boll opening = Very good with extra white staple.

Economic and fibre characteristic's

Plant yield (g)	GOT (%)	Fibre length (mm)	Mic. (ug/inch)	Strength g/tex
56.3-215.5	34.3-45.1	25.9-33.1	3.3-5.2	27.0-33.6

B. Buds of *G.arboreum* treated with 0.02% colchicine for 24 hours were checked but the plant was still diploid (Fig-5). Buds were fixed in Carnoy's solution, preserved in 70% ethanol and studied at metaphase-1.

Chromosomal configurations of *G.arboreum*

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

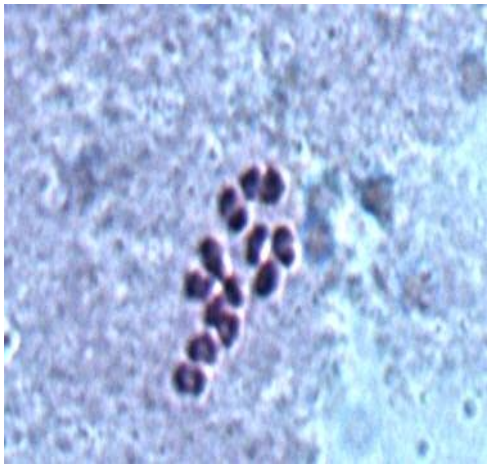


Fig 5. (*G.arboreum treated with cholchicine)*

3.4. Performance of Filial Generations 2017-18

Single plants with CLCuV Tolerence, good yield and fibre quality traits were selected from the breeding material during 2017-18. The detail of each filial generation is as follows:

Table 3.5 Detail of single plants selected from breeding material

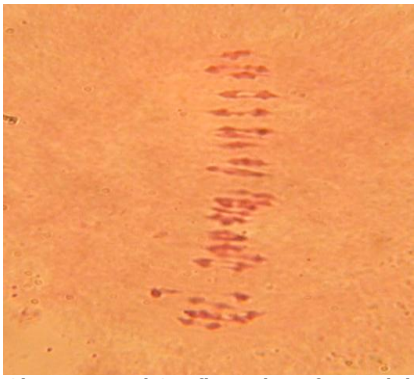
Filial Generation	No of Plant Selected	YieldPlant $^{-1}$ (g)	GOT (%)	Staple Length (mm)	Uni. Index	Mic	Fibre Strength
		Range					
F_1	184	106.4-209.5	39.2-40.3	28.7-29.7	82.1-84.5	4.2-4.9	27.8-28.6
F_2	425	64.8-240.1	37.0-44.6	28.0-32.5	78.9-82.9	4.0-4.8	27.3-31.9
F_3	939	75.3-220.9	36.9-40.7	28.3-31.3	82.1-84.8	3.5-4.2	29.6-31.4
F_4	424	44.6-2038	38.8-42.3	27.7-31.5	82.5-85.2	4.1-4.7	25.8-30.3
F_5	534	50.9-224.2	38.0-42.4	28.5-32.5	83.0-85.3	4.1-4.9	29.9-32.4
F_6	126	75.4-164.8	39.7-40.8	30.0-30.8	84.2-85.5	3.9-4.7	28.5-30.7

3.5 Search for aneuploids/ haploids

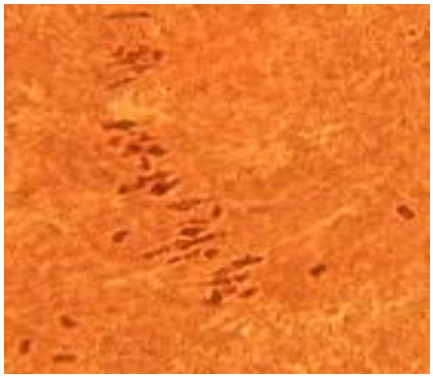
In the nature, there is spontaneous occurrence of aneuploids and haploids in *G. hirsutum.* Therefore, efforts continued for search for monosomes to identify individual chromosomes and haploids to make homozygous lines in cotton.

Thirteen obviously abnormal plants were observed in field no 4/18, 4/19 in interspecific Cyto breeding material. Only one plant was hexaploid. Two plants were normal diploids and remaining ten plants were tetraploid. Three normal tetraploid plants were transplanted in permanent block for crossing purpose. The studies on morphology and cytology of these abnormal plants during the season were carried out.

Cytological studies



A.Chromosomal Configuration of tetraploid plant



B. Chromosomal Configuration of hexaploid plant

Chromosomal configurations of abnormal plants

Plant No	I's	II's	III's	IV's	Total	Remarks
A	0	26	0	0	52	All plants were normal tetraploids

Plant No.	I's	II's	III's	IV's	Total	Remarks
B	10	24	1	1	65	Plant was hexaploid

3.6 Progeny Row Trial

3.6.1 Trial-1

Objective: Testing of promising progenies for long staple

Fourteen single plants possessing good fibre traits selected from F_5 and F_6 generation 2016 were planted in non-replicated progeny row trial along with one standard Cyto-179 during crop season 2017-18. The detail is given in Table 3.6. Data showed that maximum seed cotton yield was produced by progeny-3 (3073 kg ha^{-1}) followed by progeny (2891 kg ha^{-1}) compared with standard Cyto-179 (2872 kg ha^{-1}). Maximum lint % was produced by progeny-3 (39.3%) followed by progeny-5 (39.2%) compared with Cyto-179 (38.8%).

The progeny-1 produced longest fibre (32.8 mm) followed by progeny-2 (32.5 mm) and compared with 28.2 mm of Cyto-179. All the progenies have desirable micronaire values ranging from 4.0 to 4.8 µg $inch^{-1}$. The maximum fibre strength (38.8 g/tex) produced by progeny-2 followed by progeny-1 (35.4 g/tex) and 27.0 g/tex compared with standard Cyto-179.

Table 3.6 Performance of long staple progenies at CCRI, Multan during 2017-18.

Progeny	Yield (kg ha^{-1})	GOT %	Staple length (mm)	Micronaire (µg $inch^{-1}$)	Uniformity index %	Fibre strength (g tex^{-1})
1	1930	36.9	32.8	4.0	86.0	35.4
2	2063	35.8	32.5	4.6	86.2	38.8
3	3073	39.3	30.9	4.1	84.9	33.1
4	2371	34.9	31.4	4.4	85.0	32.4
5	2508	39.2	31.0	4.5	85.0	32.6
6	2719	35.3	31.3	4.5	84.4	32.4
7	2891	34.3	30.3	4.3	81.8	31.8
8	2300	35.9	31.1	4.4	82.8	31.5
9	2161	37.2	30.4	4.8	83.5	30.6
10	2763	37.8	29.9	4.1	83.3	32.0
11	1484	33.4	30.0	4.5	83.7	32.1
12	2156	35.3	30.0	4.4	83.0	31.9
13	2723	35.1	31.5	4.2	85.2	33.4
14	2250	37.7	30.2	4.2	82.3	31.8
Cyto-179 (Std)	2872	38.8	28.2	4.9	82.7	27.0

3.6.2 Trial-2

Objective: Testing of promising progenies for long staple length.

Fourteen single plants possessing good fibre traits selected from F_5 and F_6 generation 2016 were planted in non-replicated progeny row trial alongwith one standard Cyto-179 during crop season 2017-18. The detail is given in Table 3.7.

Data showed that maximum seed cotton yield was produced by progeny-21 (3560 kg ha^{-1}) followed by progeny-16 (2980 kg ha^{-1}) compared with standard Cyto-179 (2960 kg ha^{-1}). Maximum G.O.T% produced by progeny-29 (43.1%) followed by progeny-25 (42.2%) compared with Cyto-179 (39.5%).

The progeny-25 produced longest fibre (31.1 mm) followed by progeny-16 (30.9 mm) and compared with 28.1mm of Cyto-179. All the progenies have desirable micronaire values ranging from 3.6 to 4.5 µg $inch^{-1}$. The maximum fibre strength (32.9.8 g/tex) produced by progeny-22 compare with 27.0 g/tex of standard Cyto-179.

Table 3.7 Performance of long staple progenies at CCRI, Multan during 2017-18.

Progeny	Yield kg ha^{-1}	GOT %	Staple length (mm)	Micronaire (µg $inch^{-1}$)	Uniformity index %	Fibre strength (g/tex)
16	2980	36.4	30.9	4.5	83.4	29.8
17	2140	37.7	28.8	4.3	81.0	29.6
18	2780	40.4	29.2	4.3	81.7	29.2
19	2240	39.9	30.3	4.1	82.9	32.2
20	2145	40.9	30.4	4.1	85.1	31.4
21	3560	38.6	28.8	3.8	83.5	31.6
22	2960	38.8	30.9	3.9	83.2	32.9
23	2590	40.6	30.3	3.6	83.0	32.8
24	2040	42.0	29.3	4.4	82.0	30.6
25	2190	42.2	31.1	4.2	83.1	32.7
26	2090	39.7	30.2	4.3	82.5	31.4
27	2090	39.9	29.1	4.2	83.1	30.9
28	2040	40.4	29.9	3.9	81.0	30.4
29	2623	43.1	28.4	4.4	83.5	30.9
Cyto-179 (Std)	2960	39.5	28.1	4.4	82.7	27.2

3.7 Performance of New Cyto-strains

Micro Varietal Trial-1

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

Six *Bt*. strains having tolerance against cotton leaf curl virus (CLCuD) viz., Cyto-520, Cyto-521, Cyto-522, Cyto-523, Cyto-524 and Cyto-525 were tested in replicated micro-varietal trial on plot size 15' ×10' along with FH-142 and Cyto-179 as standard varieties. The performance of this material is given in Table 3.8.

Table 3.8. Performance of Cyto-strains in Micro Varietal Trial -1 during 2017-18

Strain	Yield (kg ha^{-1})	Plant Population (ha^{-1})	Boll weight (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg $inch^{-1}$)	Strength g/tex
Cyto-520	4304	46624	2.93	38.0	29.5	4.2	29.5
Cyto-521	3443	42320	3.57	38.7	28.9	4.3	27.6
Cyto-522	1291	37299	2.64	42.0	27.5	4.6	28.4
Cyto-523	2869	38016	2.61	39.2	28.7	4.5	28.5
Cyto-524	3587	37299	3.09	38.9	28.6	3.8	28.6
Cyto-525	2870	42320	2.61	40.8	29.5	4.7	30.7
FH-142 (Std)	2726	38016	3.48	39.3	26.9	4.9	26.2
Cyto-179 (Std)	3443	38016	3.42	39.7	28.0	4.8	25.7

C.D. (5%) for seed cotton Yield = 197.10 CV% = 3.74

Table 3.8 showed that maximum seed cotton yield was produced by Cyto-520 (4304 kg ha^{-1}) followed by Cyto-524 (3587 kg ha^{-1}) and Cyto-521 (3443 kg ha^{-1}) compared with standards FH-142 (2726 kg ha^{-1}) and Cyto-179 (3443 kg ha^{-1}). Maximum lint % produced by Cyto-522 (42.0%) followed by Cyto-525 (40.8%) compared with standards FH-142 (39.3%) and Cyto-179 (39.7%).

The strain Cyto-520 and Cyto-525 produced the medium long staple of 29.5 mm followed by Cyto-521(28.9 mm) and Cyto-523 (28.7mm) compared with 26.9 mm of FH-142 and 28.0 mm of Cyto-179. All the strains have desirable micronaire values ranging from 3.8 to 4.9µg $inch^{-1}$. The maximum fibre strength (30.7g/tex) produced by Cyto-525 followed by Cyto-520 (29.5 g/tex) and Cyto-524(28.6 g/tex) compared with 26.2 and 26.7 g/tex of standards FH-142 and Cyto-179, respectively.

Micro Varietal Trial-2

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

Six cotton leaf curl virus tolerant *Bt*. strains viz., Cyto-526, Cyto-527, Cyto-528, Cyto-529, Cyto-530 and Cyto-531 were tested in replicated micro-varietal trial on plot size 15' ×10' alongwith FH-142 and Cyto-179 as standard varieties. The performance of this material is given in Table 3.13.

Data presented in Table 3.9 exhibited that maximum seed cotton yield was produced by Cyto-528 (3107 kg ha^{-1}) followed by Cyto-527 (2868 kg ha^{-1}) compared with standards FH-142 (2629 kg ha^{-1}) and Cyto-179 (2828 kg ha^{-1}). Maximum lint % produced by Cyto-528 (39.5%) followed by Cyto-527 (39.3%) compared with standards FH-142 (38.6%) and Cyto-179 (39.0%).

The strain Cyto-529 produced longest staple (30.7 mm) followed by Cyto-530 (30.2 mm) compared with FH-14 (27.4 mm) and Cyto-179 (28.2 mm). All the strains have desirable micronaire values ranging from 4.3 to 4.9 µg $inch^{-1}$. The maximum fibre strength (31.1 g/tex) produced by Cyto-526 followed by Cyto-530 (30.3 g/tex) and Cyto-527(30.2 g/tex) compared with 25.3 and 27.2 g/tex of standards FH-142 and Cyto-179.

Table 3.9. Performance of advanced strains in Micro Varietal Trial-2 during 2017-18

Strain	Yield (kg ha^{-1})	Plant population (ha^{-1})	Boll wt. (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg $inch^{-1}$)	Strength g tex^{-1}
Cyto-526	2629	45171	3.5	39.2	29.5	4.7	31.1
Cyto-527	2868	45888	3.2	39.3	28.5	4.5	30.2
Cyto-528	3107	42737	3.1	39.5	28.8	4.3	29.2
Cyto-529	2629	41322	3.0	37.2	30.7	4.3	30.7
Cyto-530	2031	40605	3.2	38.9	30.2	4.6	30.3
Cyto-531	2270	42171	3.3	36.8	28.8	4.9	28.8
FH-142 (Std)	2629	44171	3.4	38.6	27.4	4.9	25.3
Cyto-179 (Std)	2828	43737	3.3	39.0	28.2	4.7	27.2

C.D. (5%) for seed cotton Yield = 108.52 CV% = 2.36

Micro Varietal Trial-3

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

Six new Bt strains having tolerance against cotton leaf curl virus CLCuD tolerant viz., Cyto-532, Cyto-533, Cyto-534, Cyto-535, Cyto-536 and Cyto-537 were tested in replicated micro-varietal trial on plot size 15' ×10' along with FH-142 and Cyto-179 as standard varieties. The performance of this material is given in Table 3.15.

Data presented in Table-3.10 manifested that maximum seed cotton yield was produced by Cyto-537 (3270 kg ha^{-1}) followed by Cyto-533 (3068 kg ha^{-1}) compared with standards FH-142 (2852 kg ha^{-1}) and Cyto-179 (2867 kg ha^{-1}). Maximum boll weight (3.9 g) was produced by Cyto-536 followed by Cyto-535 (3.4 g) compared with 3.3 g and 3.2 g of FH-142 and Cyto-179

respectively. Maximum lint % produced by Cyto-537 (41.0%) followed by Cyto-533 (40.6%) and Cyto-532 (40.2%) compared with standards FH-142 (38.3%) and Cyto-179 (39.5%).

Table 3.10 Performance of Cyto-strains in Micro Varietal Trial -3 during 2017-18

Strain	Yield (kg ha^{-1})	Plant Population (ha^{-1})	Boll weight (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg/inch)	Strength g tex
Cyto-532	2435	43554	2.9	40.2	28.7	4.5	28.4
Cyto-533	3068	43080	2.8	40.6	30.0	4.7	30.6
Cyto-534	2540	42670	3.3	36.6	29.3	4.6	29.5
Cyto-535	2490	41625	3.4	37.2	28.8	4.6	29.7
Cyto-536	2352	44989	3.9	37.4	28.8	4.5	29.6
Cyto-537	3270	45106	2.9	41.0	30.0	4.8	30.1
FH-142 (Std)	2852	45708	3.3	38.3	27.9	4.9	27.3
Cyto-179 (Std)	2867	46298	3.2	39.5	28.1	4.9	27.0

C.D. (5%) for seed cotton Yield = 117.81 CV% = 2.46

The strains Cyto-533 and Cyto-537 produced the longest staple length of 30.0mm, followed by 29.3 mm of Cyto-534 compared with 27.9 mm of FH-142 and 28.1 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.5 to 4.9 µg inch^{-1}. The maximum fibre strength (30.6 g/tex) produced by Cyto-533 followed by Cyto-537 (30.1 g/tex) and Cyto-535 (29.7 g/tex) compared with 27.3 and 27.0 g/tex of standards FH-142 and Cyto-179 respectively.

3.8 Varietal Trial

3.8.1 Varietal Trial-1

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

Five CLCuD tolerant *Bt*. strains viz., Cyto-515, Cyto-516, Cyto-517, Cyto-518 and Cyto-519 were tested in replicated varietal trial on plot size 35' ×10' alongwith FH-142 and Cyto-179 as standard varieties. The performance of this material is given in Table 3.16.

Data presented in Table 3.11 exhibited that maximum seed cotton yield was produced by Cyto-515 (3907.8 kg ha^{-1}) followed by Cyto-518 (3360.9 kg ha^{-1}) and Cyto-516 (3074 kg ha^{-1}) compared with standards FH-142 (2500 kg ha^{-1}) and Cyto-179 (2869 kg ha^{-1}). Maximum lint % produced by Cyto-515 (39.1%) and Cyto-518 (39.1%) compared with standards FH-142 (38.7%) and Cyto-179 (38.8%).

Table 3.11 Performance of Cyto-strains in VT-1during 2017-18

Strain	Yield (kg ha^{-1})	Plant population (ha^{-1})	Boll wt. (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg inch^{-1})	Strength g tex^{-1}
Cyto-515	3908	43959	3.6	39.1	28.0	4.9	26.2
Cyto-516	3074	43037	4.3	39.9	28.1	4.7	27.0
Cyto-517	3002	43652	3.7	38.1	27.9	4.8	26.1
Cyto-518	3361	44574	4.1	39.1	28.3	4.7	27.6
Cyto-519	2254	44574	3.2	38.3	29.5	4.1	29.5
FH-142	2500	44574	3.4	38.7	27.2	4.9	26.2
Cyto-179 (Std)	2869	41807	3.8	38.8	27.8	4.7	25.8

C.D. (5%) for seed cotton Yield = 287.91 CV% = 5.40

The strain Cyto-519 produced the medium long staple of 29.5mm followed by 28.3 mm of Cyto-518 compared with standards FH-142 (27.2 mm) and Cyto-179 (27.8 mm). All the strains have desirable micronaire values ranging from 4.1 to 4.9µg inch^{-1}. The maximum fibre strength (29.5 g/tex) produced by Cyto-519 followed by Cyto-518 (27.6 g/tex) compared with 26.2 and 25.8 g/tex of standards FH-142 and Cyto-179, respectively.

3.8.2 Varietal Trial-2

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

Four CLCuD tolerant non-*Bt* strains viz.,Cyto-120, Cyto-122, Cyto-161and Cyto-164 were in replicated varietal trial on plot size 35' ×10' alongwith Cyto-124 and CIM-608 as standard varieties. The performance of this material is given in Table 3.12.

Data showed that maximum seed cotton yield was produced by Cyto-122 (3916 kg ha^{-1}) followed by Cyto-161 (3343 kg ha^{-1}) and Cyto-164 (3247 kg ha^{-1}) compared with standards Cyto-124 (3152 kg ha^{-1}) and CIM-608 (2820 kg ha^{-1}). Maximum lint % was produced by Cyto-164 (37.8%) followed by Cyto-161 (37.6%) compared with standards Cyto-124 (37.1%) and CIM-608 (36.4%).

Table 3.12. Performance of Cyto-strains in VT-2 during 2017-18

Strain	Yield (kg ha^{-1})	Plant population(ha^{-1})	Boll wt. (g)	Lint (%)	Fiber Length (mm)	Micronaire (µg $inch^{-1}$)	Strength g tex^{-1}
Cyto-120	2865	40075	3.1	36.1	29.3	4.5	30.8
Cyto-122	3915	40563	3.1	35.6	28.5	4.1	29.2
Cyto-161	3342	41328	2.9	37.6	26.4	4.6	29.1
Cyto-164	3246	40189	2.7	37.8	29.1	4.2	29.2
Cyto-124 (Std.)	3151	40084	2.9	37.1	28.5	4.4	28.8
CIM-608 (Std.)	2820	40989	2.9	36.4	29.0	4.3	30.9

C.D. (5%) for seed cotton = 258.78 CV% = 4.44

The strain Cyto-120 produced longest staple of 29.3 mm followed by Cyto-122 (28.5 mm) compared with Cyto-124 (28.5 mm) and CIM-608 (29.0mm). All the strains have desirable micronaire values ranging from 4.1 to 4.6 µg $inch^{-1}$. All the strains have desirable micronaire values ranging from 4.1 to 4.6 µg $inch^{-1}$. The maximum fibre strength (30.8 g/tex) produced by Cyto-120 followed by Cyto-122 and Cyto-164 (29.2 g/tex) compared with 28.8 g/tex of standards Cyto-124 and 30.9 g/tex of CIM-608.

Production of Pre Basic seed produced during 2017-18.

Pre-basic seed of six approved and upcoming g cotton varieties of cyto section viz., CIM-608, Cyto-124, Cyto-177, Cyto-178, Cyto-179 and Cyto-313 was produced. The detail is given in Table 3.13.

Table 3.13. detail of pre basic seed produced during 2017-18.

Variety	Pre-basic seed produced (kg)
CIM-608	63
Cyto-124	60
Cyto-177	80
Cyto-178	66
Cyto-179	34
Cyto-313	90

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4. ENTOMOLOGY

The research carried out on various aspects under field and lab conditions was focused on 1) sowing date impact on the development of pink bollworm, 2) surveys of cotton growing areas for pink bollworm infestation, 3) assessing impact of first spray on rest of the pest management, 4) monitoring of lepidopterous pests with sex pheromone and light traps, 5) host plant tolerance of CCRI, Multan strains, 6) National Coordinated Varietal Trials on *Bt.* & non-*Bt.* strains, 7) monitoring of insecticide resistance in cotton pests. Efforts were continued to develop mass rearing techniques for pink bollworm along with rearing and maintaining natural enemies of cotton pests for the use in the lab and for release in the field. Section also provided internship facilities` to students of different Universities. The section 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 related programmes in 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. The Set-1 (Early-March) was planted on 6th March, Set-II (Mid-March) on 17th March, Set-III (Early-April) on 1st April, Set-IV (Mid-April) on 15th April and Set-V (Early-May) on 2nd May. Five sowing dates were planned to be evaluated, but unfortunately Mid-April planted cotton was adversely affected by unusual weather condition and completely destroyed at seedling stage. Three Bt varieties (CIM-616, CIM-598 & Cyto-178) and two non Bt varieties (Cyto-124 & CIM-620) were sown in RCBD with three replicates.

Prevalence of PBW infestation and live larvae in Set-I and Set-II was detected in August and in Set-III and Set-V 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 August, September and October 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	Set V	Avr	Set I	Set II	Set III	Set V	Avr
CIM-616	13.3	13.3	3.3	0.0	7.5	11.7	10.0	5.0	0	6.7
CIM-598	3.3	6.7	6.7	0.0	4.2	3.3	2.5	4.0	0	2.5
Cyto-178	16.7	3.3	3.3	3.3	6.7	16.7	6.7	3.3	5.0	7.9
Cyto-124(Non Bt)	25.0	3.3	3.3	5.0	9.2	10.0	5.0	3.3	7.5	6.5
CIM-620 (Non Bt)	10.0	6.7	1.7	3.3	5.4	6.7	6.7	2.5	2.5	4.6
Average	13.7	6.7	3.3	2.7		9.7	6.2	3.6	3.0	

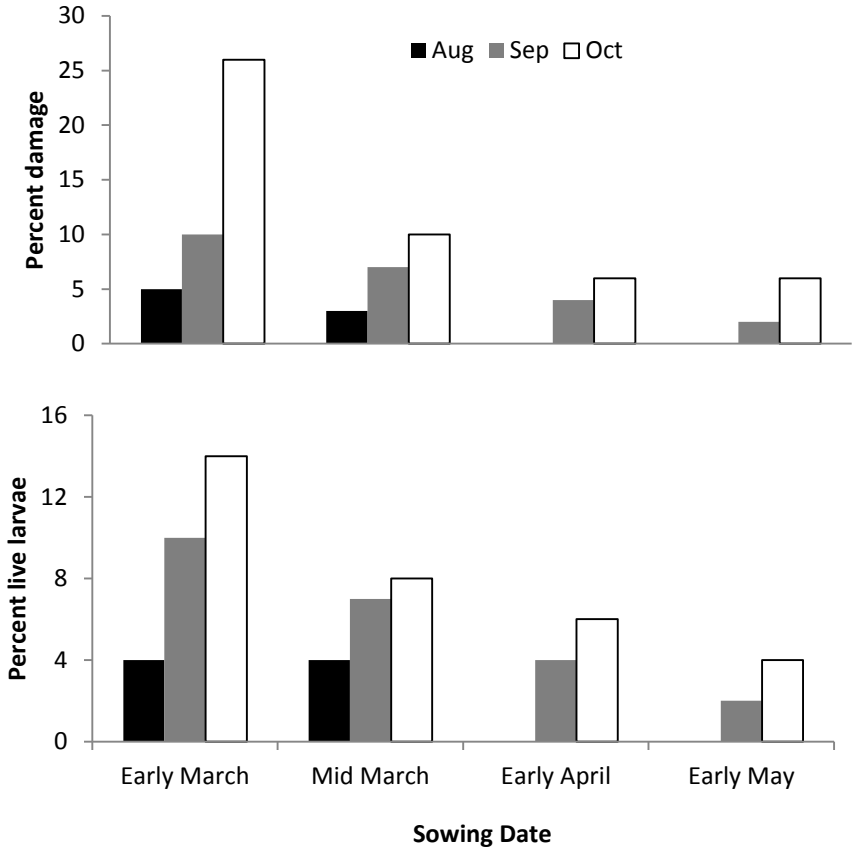

Fig. 4.1 Impact of sowing dates on pink bollworm damage and live larvae

Maximum pink bollworm damage percentage in Set-I, Set-II, Set-III and Set-V was recorded in Cyto-124, CIM-616, CIM-598 and Cyto-124 respectively. However, percentage of live larvae in Set-I was higher in Cyto-178, in Set II & Set-III it was higher in CIM-616 and in Set-V maximum percentage was observed in Cyto-124. On the whole, infestation and live larval percentage was lower in CIM-598 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-V). So the farmers are advised to avoid planting cotton before 1st April.

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

Pink bollworm and whitefly remained the hot topic in the current year therefore surveys were conducted in major cotton growing districts (Lodhran, Khanewal, Multan, Bahawalpur and Vehari) for crop development and population dynamics of insect pests of cotton. Pink bollworm infestation recorded in the bolls collected from the surveyed area during October is presented here.

All the cotton growing areas were infested with pink bollworm and maximum boll infestation and live larvae were observed in district Lodhranfollowed by Khanewalas compared to other district **(Table-4.2)**.

All the surveyed varieties/strains were found to be susceptible against pink bollworm and maximum pink bollworm damage percentage was recorded in IUB-2013 & MNH-886. Larval percentage was higher in MNH-886 as compared to other tested varieties (**Fig. 4.2**).

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

Districts	% Boll damage	% Larvae
Lodhran	37.1	28.1
Khanewal	25.3	23.5
Multan	21.0	11.0
Bahawalpur	19.4	18.5
Vehari	23.1	22.5

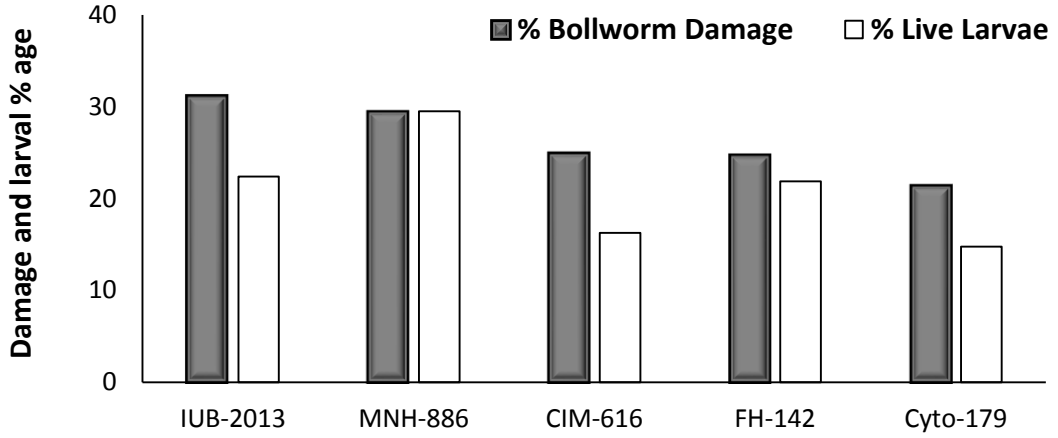

Fig. 4.2 Pink bollworm damage and live larvae recorded from major cotton growing districts

4.2 Implications of insecticides induced hormesis of insects

Decision to initiate the spray application for sucking insect pest is very important because certain group of insecticide induced outbreak of secondary pest. For the purpose a trial was conducted to investigate the causes of insect pest resurgence and secondary pest outbreaks after pesticide applications.

Three groups of insecticides viz; neonicotinoide, thiourea, organophosphate, and insect growth regulators (IGR) were selected, these groups are normally used for first spray application.

The trial was planted in early May with plot size of (50' X 100') with three replications using RCBD. **Neonicotinoids group,** Imidacloprid 50 WP @ 100 ml/acre, Acetamiprid 40 WDG @ 60 ml/acre, Oshin 20 SG @ 100 gm/acer, Nitenpyrem 60 WDG @ 100 ml/acre; **Thiourea group**, Polo 500 SC @ 200 ml/acre; **Organophosphate group,** Acephate 75 SP @ 250 gm/ml, Dimethoate 40 EC @ 400 ml/acre &**Insect growth regulator group (IGR),** Pyriproxyfen 10.8 EC @ 500 ml/acre & Buprofezin 25 SP @ 600 ml/acre was sprayed on 20th June when population of jassid reached at ETL and same insecticide was repeated on the same plots on 5th July. Percent mortality was calculated by using following formula.

$$\boldsymbol{Percent\ Mortality} = \mathbf{1} - \left[\frac{(\textbf{Pre population in control X Post population in treatment})}{(\textbf{Post population in control X Pre population in treatment})}\right] \boldsymbol{X}\ \mathbf{100}$$

Mortality of jassid after 72hrs of 1st and 2nd spray in acephate treated plots was 62.55% and 72.15% respectively whereas in dimethoate it was 63.32% & and 73.70% respectively. Mortality of whitefly in acephate treated plots was -192.26% and -213.64% respectively, whereas in dimethoate it was -61.32% & and -97.22% respectively, 72hrs after the 1st and 2nd spray. Mortality of jassid in oshin treated plots was highest while lowest in imidacloprid treated plots. Mortality of whitefly in IGR's treated plots was higher as

compared to other tested insecticides. Mortality of thrips was higher in both the organophospates and imidacloprid after the 2nd spray.

Table 4.3 Efficacy of different groups of insecticides against sucking insect pest of cotton

Treatments	Group	Dose/ acre (ml/acre)	% mortality 72-hrs after spray					
			Jassid		Whitefly		Thrips	
			1st	2nd	1st	2nd	1st	2nd
Imidacloprid 50 WP	Neonic otinoid	100	24.22	40.82	22.22	31.25	52.24	62.47
Acetamiprid 40 WDG		60	25.55	28.36	39.96	44.74	54.46	61.31
Oshin 20SG		100	52.85	63.83	38.72	43.18	53.33	60.16
Nitenpyrem 60WDG		100	36.85	42.93	20.99	30.95	37.41	45.39
Acephate 75SP	Organo phosphate	250	62.55	72.15	-192.26	-213.64	65.95	71.69
Dimethoate 40EC		400	63.32	73.70	-61.32	-97.22	56.67	61.36
Polo 500SC	Thiourea	200	21.41	34.24	48.15	59.38	41.67	45.73
Pyriproxyfen 10.8 EC	IGR	500	33.69	48.21	71.19	75.00	35.00	44.51
Buprofezin 25 SP		600	29.27	37.33	42.96	52.50	31.39	35.26

Apparently, the early spray with organophosphates enhanced the population of whitefly therefore; use of OP's should be avoided at early season of the crop **(Table 4.3).**

4.3 Monitoring of lepidopterous pests with sex pheromone traps

Male moth activity of *Pectinophoragossypiella*, *Earias insulana,Earias vittella, Helicoverpaarmigera, 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 the declining population trend was noted in *S. litura* and*H. armigera* at both locations and *P.gossypiella* at CCRI, Multan. While increasing trend was recordedin *P.gossypiella* and *S. exigua* at farmer's field and in *Earias* species at both locations ascompared to last year. Comparatively, male moth catches of all the species were higher at farmer's field than at CCRI, Multan **(Table-4.4).** Weekly male moth catch activities are given in **Fig. 4.3 (a-f).**

4.3.1 *Pectinophora gossypiella* (Pink bollworm)

Male moth's activity remained zero from January to 1st week of March and during last fortnight of December as compared to last year 2016. Moth's population showed fluctuating trend throughout the season, with its peak intensity in 3rd week of April at CCRI, Multan and 3rd week of September at farmer's field. Comparatively, the moth catches were 84.6% higher at farmer's field than at Multan **(Fig. 4.3a)**. Overall male moth catches were 144.4% lower at Multan and 47.3% higher at farmer's field to that of last year **(Table-4.4).**

4.3.2 *Earias vittella* (Spotted bollworm)

Male moth catches remained zero upto 2nd week of March at CCRI, Multan and 2nd week of April at farmer's field. Moth activity was not consistent and reached at its peak in 3rd week of August at CCRI, Multan and 1st week of November at farmer's field. Moth catches at farmer's field were 41.6% higher than at Multan **(Fig. 4.3b).** Overall, male moth catches were 67.1% and 63.9% higher at Multan and farmer's field respectively as compared to last year **(Table-4.4).**

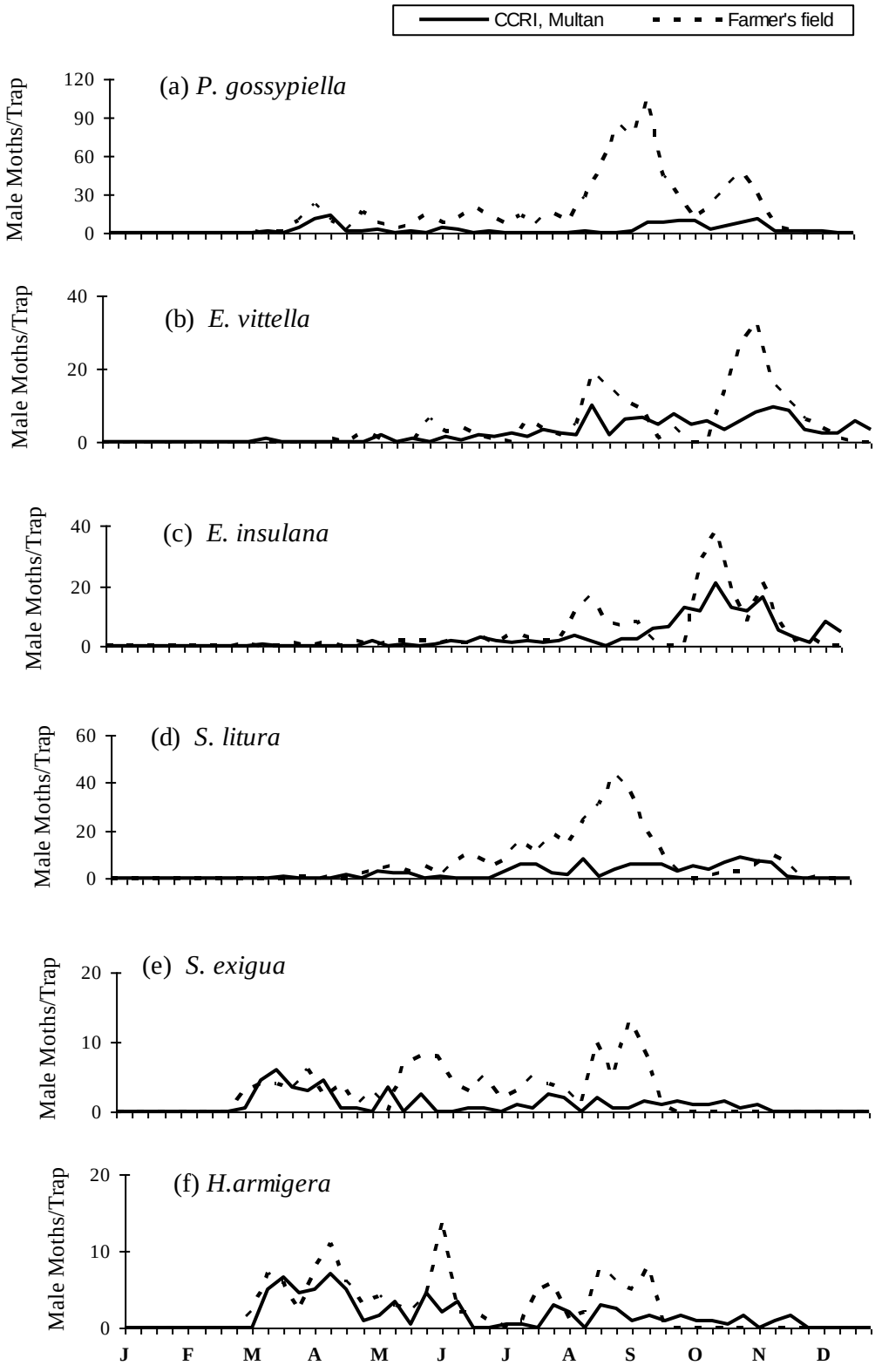

Fig.4.3 Weekly male moth catches of Lepidopterous pests in sex pheromone traps at CCRI, Multan and farmer's field (Khanewal).

4.3.3 *Earias insulana* (Spiny bollworm)

Male moth catches remained zero upto 2nd week of March at CCRI, Multan and 1st week of March at farmer's field. There was a fluctuating trend in moth activity and maximum catches were recorded in 4th week of October at both locations. Moth catches were 29.2% higher at farmer's field than at Multan **(Fig. 4.3c).** Overall male moth catches were 69.3% and 77.8% higher at Multan and farmer's field respectively as compared with last year **(Table-4.4).**

4.3.4 *Spodoptera litura* (Armyworm)

Male moth catches were zero upto 3rd and 4th week of March at CCRI, Multan, and farmer's field, respectively. Moth activity reached at peak in 1st week of November at CCRI, Multan and 1st week of September at farmer's field with fluctuated trend afterwards. Moth catches at farmer's field were comparatively 67.7% higher than at Multan **(Fig. 4.3d)**. Overall male moth catches were 252.0% and 24.0% lower than that of last year at Multan and farmer's field respectively **(Table-4.4).**

4.3.5 *Spodoptera exigua* (Beet armyworm)

The population of male moths was almost zero in January, February, November and December at both the locations. Moth activity started from 1st week of March with fluctuating trend afterwards. Catches were 60.3% higher at farmer's field than at Multan **(Fig. 4.3e)**. Overall male moth catches were 40.5% higher at farmer's field as compared to last year **(Table-4.4).**

4.3.6 *Helicoverpa armigera* (American bollworm)

Male moth activity remained zero upto 1st week of March at CCRI, Multan and last week of February farmer's field. Moth population increased afterwards with fluctuating trend and maximum catches were recorded in 2ndweek of April and 1st week of June at CCRI, Multan and farmer's field, respectively. Afterwards population declined and moth activity finished upto last week of November at CCRI, Multan and mid-September at farmer's field. Moth catches were comparatively 39.1% higher at farmer's field than Multan **(Fig. 4.3f)**. Overall, male moth catches were about 30.3% and 21.0% lower at Multan and farmer's field respectively as compared to last year **(Table-4.4).**

Table-4.4 Comparison of male moth catches of lepidopterous pests in sex pheromone traps

Insect pest	CCRI, Multan			Farmer' field		
	2016	2017	± %age	2016	2017	± %age
P. gossypiella	290.1	118.7	**-144.4**	406.5	772.0	**47.3**
E. vittella	40.0	121.5	**67.1**	75.0	208.0	**63.9**
E. insulana	45.0	146.6	**69.3**	46.0	207.0	**77.8**
S. litura	352.0	100.0	**-252.0**	384.5	310.0	**-24.0**
S. exigua	48.0	48.0	**0.0**	72.0	121.0	**40.5**
H. armigera	94.5	72.5	**-30.3**	144.0	119.0	**-21.0**

4.4 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 trend of all the pests was almost same as monitored in sex pheromone baited traps at CCRI, Multan. Increasing population trend was observed in case of *Earias* spp. and *S. Exigua* while decreasing trend in case of *H. armigera* and *S. litura***(Table-4.5).** Moth catches on weekly basis are given in **Fig. 4.4 (a-e).**

4.4.1 *Earias vittella* (Spotted bollworm)

Moth catches of this species were zero upto 1st week of May and during June. Afterwards pest activity started at low level with its peak in 1st week of November **(Fig. 4.4a).** Total number of moths was 64.5% higher than that of last year **(Table-4.5).**

4.4.2 *Earias insulana* (Spiny bollworm)

Male moth catches remained zero from January to 1st week of March. Afterwards population increased with fluctuating trend and reached at peak in last week of October **(Fig. 4.4b).** Overall number of moth catches was 67.8% higher than last year **(Table-4.5).**

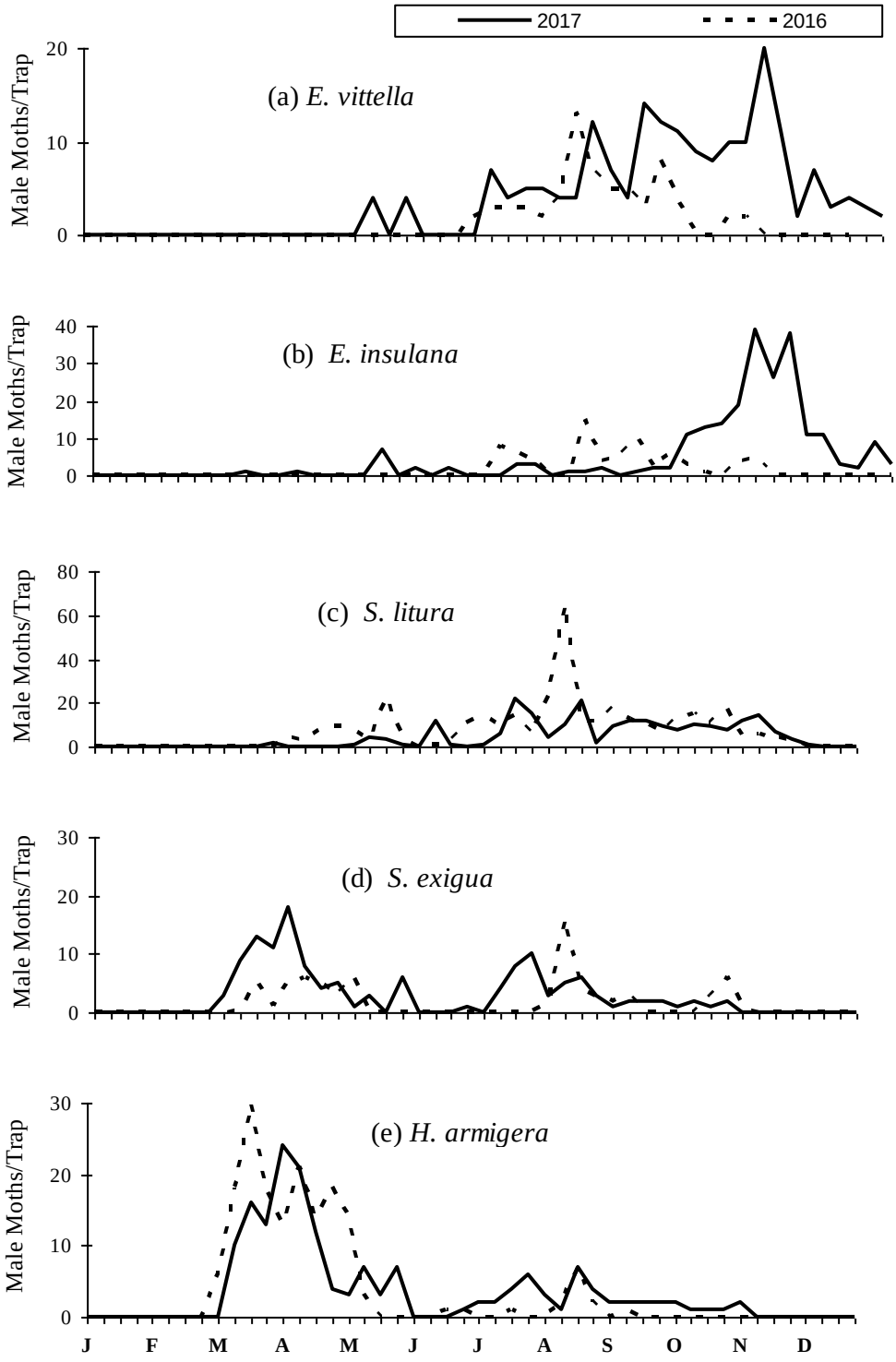

Fig. 4.4 Weekly moth catches of lepidopterous pests in light traps at CCRI, Multan

4.4.3 *Spodoptera litura* (Armyworm)

Moth catches of *S. litura* appeared in last week of March, after that their activity remained zero upto end-April. Moth activity again started in 1st week of May and reached to its maximum during 3rd week of July. Population declined afterwards with fluctuating trend upto 1st week of December **(Fig. 4.4c)**. Overall moth catches were 61.2% lower than the last year **(Table-4.5).**

4.4.4 *Spodoptera exigua* (Beet armyworm)

Moth catches remained zero during January-February and November-December. Moth's activity started in 1st week of March with inconsistent trend and reached to its maximum during 1st week of April **(Fig. 4.4d)**.Overall moth catches were 46.5% higher than last year **(Table-4.5).**

4.4.5 *Helicoverpa armigera* (American bollworm)

Moth activity of *H.armigera* started in 2nd week of March with peak catches during 1st week of April. Later on population declined with fluctuating trend upto 2nd week of November **(Fig. 4.4e)**. Overall moth catches were 3.0% lower as compared to last year **(Table-4.5).**

Table-4.5 Comparison of moth catches of lepidopterous pests in light traps based on total catches during the year/trap

Insect pest	2016	2017	% change (±)
Earias vittella	66.0	186.0	**64.5**
Earias insulana	73.0	227.0	**67.8**
Spodoptera litura	353.0	219.0	**-61.2**
Spodoptera exigua	71.7	134.0	**46.5**
Helicoverpa armigera	170	165.0	**-3.0**

4.5 National Coordinated Varietal Trials (NCVT)

4.5.1 Pest situation in set-A

In this set fifteen non-*Bt* strains were tested for their tolerance/susceptibility to insect pest complex. Jassid and whitefly remained dominant among sucking pests. Jassid population was below ETL on all the strains except on Cyto-225 & Thakkar-214 during August and its intensity was highest on NIAB-444 followed by Cyto-225 & Tipu-2 and lowest on GS-All-7 and NIA-887 in July. Whitefly population remained below ETL during growing season on all the testing strains except on CRIS-129 and NIAB-444. Its intensity was highest on NIAB-444 followed by CRIS-129 while lowest on TH-14 & NIA-887 in August. Thrips remained below ETL throughout the season on all the strains while its population was highest on Thakkar-214 followed by MPS-61 & Cyto-225 in August **(Table-4.6)**. Bollworm infestation in immature fruiting parts was higher in PB-896 followed by CIM-610 & Thakkar-214 while no bollworm larvae were observed in all the strains **(Tabl-4.7)**.

Table-4.6 Seasonal population of sucking insect pests on different non-*Bt* strains

Strains	Number of sucking insect pests per leaf					
	Jassid		Whitefly		Thrips	
	July	Aug	July	Aug	July	Aug
TH-14	0.20	0.20	0.50	1.20	0.00	1.20
GS-ALL-7	0.10	0.10	0.75	3.80	0.00	2.80
NIA-887	0.10	0.40	0.65	1.20	0.00	4.40
CRIS-613	0.20	0.30	0.90	2.50	0.00	1.50
Cyto-225	0.75	1.90	1.20	1.90	0.00	5.40
CIM-717	0.30	0.10	0.90	5.40	0.00	3.60
TH-88/11	0.30	0.40	1.60	3.00	0.00	3.90
Tipu-2	0.75	0.20	1.30	3.60	0.00	4.00
Thakkar-214	0.15	1.40	1.10	3.20	0.00	7.60
CIM-620 (Std)	0.30	0.50	1.10	3.00	0.00	2.10
NIAB-444	1.20	0.40	0.50	6.30	0.00	5.00
MPS-61	0.20	0.10	1.00	2.20	0.00	6.60
CIM-610	0.20	0.20	1.20	3.70	0.00	1.60
PB-896	0.15	0.30	0.75	2.60	0.00	4.10

Table-4.7 Spotted/American bollworms damage and larval population on different non-*Bt* strains

Strains	Bollworm damage % age		SBW larvae/ 25 plants	
	Imm	Mat	Imm	Mat
TH-14	0.00	0.00	0.00	0.00
GS-ALL-7	0.00	0.00	0.00	0.00
NIA-887	0.00	0.00	0.00	0.00
CRIS-613	0.00	0.00	0.00	0.00
Cyto-225	0.00	0.00	0.00	0.00
CIM-717	0.00	0.00	0.00	0.00
TH-88/11	0.00	0.00	0.00	0.00
Tipu-2	0.00	0.00	0.00	0.00
Thakkar-214	3.61	0.00	0.00	0.00
CIM-620 (Std)	1.35	0.00	0.00	0.00
NIAB-444	0.00	0.00	0.00	0.00
MPS-61	0.00	0.00	0.00	0.00
CIM-610	4.17	0.00	0.00	0.00
PB-896	5.56	0.00	0.00	0.00

Pink bollworm infestation was observed in susceptible bolls on GS-All-7, Cyto-225 & PB-896 while no bollworm larvae were observed on the all strains **(Table-4.8)**.

Table-4.8 Pink bollworm damage and larval population on different non-*Bt* strains

Strains	PBW damage %age	PBW larval %age
TH-14	0.00	0.00
GS-ALL-7	3.33	0.00
NIA-887	0.00	0.00
CRIS-613	0.00	0.00
Cyto-225	3.33	0.00
CIM-717	0.00	0.00
TH-88/11	0.00	0.00
Tipu-2	0.00	0.00
Thakkar-214	0.00	0.00
CIM-620 (Std)	0.00	0.00
NIAB-444	0.00	0.00
MPS-61	0.00	0.00
CIM-610	0.00	0.00
PB-896	3.33	0.00

4.5.2 Pest situation in Set-B

In this set 22 Bt cotton and two standards (CIM-602 & FH-142) were tested for their tolerance/susceptibility to insect pest complex. Jassid population was above ETL on Cyto-313 & BH-201 in July while it remained below ETL in August on all the tested strains. Its maximum number was recorded on BH-201followed by Cyto-313 and minimum on B-2, CIM-632, SAU-1, NS-181 & CEMB-88(DG). Population of whitefly remained below ETL during July on all strains except CEMB Klean Cotton-1 (CEMB-3). Its intensity was highest on CEMB Klean Cotton-1 (CEMB-3) followed by Eagle-2 and lowest on CRIS-600 during July. While in August it remained above ETL on all strains except GH-Deebal, CEMB-55(DG), Bahar-07 & SAU-1 in addition its intensity was higher on Crystal-12 followed by BH-201 & NS-181 and lower on SAU-1 followed by GH-Deebal & Bahar-07. Thrips population was found below ETL during July and August on all the testing strains and its intensity was highest on CEMB-88(DG) and lowest on Bahar-07 **(Table-4.9)**.

Spotted bollworm infestation in immature fruiting parts was higher on GH-Deebal followed by CEMB-55(DG) & AGC-Nazeer-1 and its live larvae were observed on FH-142, CEMB-55(DG), Sitara-15 & CEMB-88(DG) in immature fruiting parts. While no

bollworms damage/larva was found in mature fruiting parts of any strain **(Table-4.10)**. Pink bollworm damage was found in CEMB Klean Cotton-1 (CEMB-3) & FH-152 while no pink bollworm larvae were observed in all strains **(Table-4.11)**.

Table-4.9 Seasonal population of sucking insect pests *Bt* strains

Strains	Number of sucking insect pests per leaf					
	Jassid		Whitefly		Thrips	
	July	Aug	July	Aug	July	Aug
CEMB Klean Cotton-1 (CEMB-3)	0.30	0.40	4.60	5.30	2.30	1.40
B-2	0.20	0.10	0.70	4.60	0.20	3.50
GH-Deebal	0.60	0.20	2.30	3.60	1.90	2.10
FH-152	0.40	0.80	1.00	8.10	1.90	4.00
Eagle-2	0.30	0.10	3.40	7.50	0.20	4.50
Cyto-313	1.00	0.20	1.90	6.70	1.20	1.70
Crystal-12	0.30	0.20	2.40	14.70	1.30	2.60
CRIS-600	0.70	0.60	0.30	6.00	1.20	2.80
FH-142 (Std-2)	0.80	0.50	1.30	8.20	5.40	3.80
CIM-632	0.20	0.00	1.30	7.10	2.10	4.50
CEMB-55(DG)	0.50	0.20	1.40	3.90	1.50	5.40
BH-201	1.50	0.00	1.60	9.40	2.00	2.90
Bakhtawar-1	0.50	0.10	0.60	5.80	0.20	3.00
Bahar-07	0.70	0.20	1.10	3.60	0.40	2.00
Sitara-15	0.70	0.20	2.30	4.50	2.30	0.60
SAU-1	0.20	0.20	0.70	2.50	2.70	3.50
CIM-602 (Std-1)	0.40	0.00	2.00	5.80	0.40	4.30
NS-181	0.20	0.50	1.20	9.40	2.30	5.00
D-19	0.40	0.10	2.50	7.90	0.0	4.20
IUB-65	0.30	0.30	0.50	5.0	0.40	5.00
GH-Mubarak	0.90	0.40	1.50	8.60	2.40	5.00
CIM-625	0.50	0.10	1.10	5.10	0.10	3.00
CEMB-88(DG)	0.20	0.10	0.40	7.30	4.50	8.70
AGC-Nazeer-1	0.50	0.20	1.90	5.30	0.10	2.70

Table-4.10 Spotted bollworm damage and larval population on different *Bt* strains

Strains	Bollworm damage % age		SBW larvae/ 25 plants	
	Imm	Mat	Imm	Mat
CEMB Klean Cotton-1 (CEMB-3)	1.49	0.00	0.00	0.00
B-2	7.27	0.00	0.00	0.00
GH-Deebal	12.31	0.00	0.00	0.00
FH-152	0.00	0.00	0.00	0.00
Eagle-2	0.00	0.00	0.00	0.00
Cyto-313	0.00	0.00	0.00	0.00
Crystal-12	1.18	0.00	0.00	0.00
CRIS-600	3.16	0.00	0.00	0.00
FH-142 (Std-2)	7.27	0.00	0.23	0.00
CIM-632	0.00	0.00	0.00	0.00
CEMB-55(DG)	9.68	0.00	0.40	0.00
BH-201	0.00	0.00	0.00	0.00
Bakhtawar-1	0.00	0.00	0.00	0.00
Bahar-07	0.00	0.00	0.00	0.00
Sitara-15	2.99	0.00	0.37	0.00
SAU-1	0.00	0.00	0.00	0.00
CIM-602 (Std-1)	0.00	0.00	0.00	0.00
NS-181	6.94	0.00	0.00	0.00
D-19	0.00	0.00	0.00	0.00
IUB-65	1.18	0.00	0.00	0.00
GH-Mubarak	1.47	0.00	0.00	0.00
CIM-625	0.00	0.00	0.00	0.00
CEMB-88(DG)	0.93	0.00	0.23	0.00
AGC-Nazeer-1	9.09	0.00	0.00	0.00

Table-4.11 Pink bollworm damage and larval population on different *Bt* strains

Strains	PBW damage %age	PBW larval %age
CEMB Klean Cotton-1 (CEMB-3)	3.33	0.00
B-2	0.00	0.00
GH-Deebal	0.00	0.00
FH-152	3.33	0.00
Eagle-2	0.00	0.00
Cyto-313	0.00	0.00
Crystal-12	0.00	0.00
CRIS-600	0.00	0.00
FH-142 (Std-2)	0.00	0.00
CIM-632	0.00	0.00
CEMB-55(DG)	0.00	0.00
BH-201	0.00	0.00
Bakhtawar-1	0.00	0.00
Bahar-07	0.00	0.00
Sitara-15	0.00	0.00
SAU-1	0.00	0.00
CIM-602 (Std-1)	0.00	0.00
NS-181	0.00	0.00
D-19	0.00	0.00
IUB-65	0.00	0.00
GH-Mubarak	0.00	0.00
CIM-625	0.00	0.00
CEMB-88(DG)	0.00	0.00
AGC-Nazeer-1	0.00	0.00

4.5.3 Pest situation in Set-C

In this set 22 Bt strains and two standards (CIM-602 & FH-142) were tested for their tolerance/susceptibility to insect pest complex. Jassid and whitefly remained dominant among sucking insect pests. Jassid population was above ETL on Ghauri-1(CEMB-3), Auriga-216, AA-933, Weal-Ag-1606, Thakkar-808, CIM-602 & NIAB-Bt-2 in July while it remained below ETL in August on all the tested strains. Its intensity was higher on NIAB-Bt-2 followed by Thakkar-808 and minimum on BS-80 & RH-668. Population of whitefly remained above ETL during July on CEMB-100(DG), BH-221, Badar-1(CEMB-2), FH-142, VH-Gulzar, Thakkar-808, Tarzan-5, RH-662, NIAB-Bt-2, NIAB-545 & MNH-1016 and its maximum number was recorded on CEMB-100(DG) and lowest on NIAB-1048. While in August it remained above ETL on all strains and its number was higher on CEMB-100(DG) followed by RH-662 & Tarzan-5 and lower on NIAB-1048. Thrips population remained below ETL during July and August on all the tested strains and its intensity was higher on CIM-602 and lower on NIAB-545 **(Table-4.12)**.

Spotted bollworm infestation in immature fruiting parts was higher in CEMB-100(DG) followed by Tipu-1and spotted bollworm larvae were observed in NIAB-Bt-2. While no bollworms damage/larva was observed in mature fruiting parts of all strains **(Table-4.13)**. Pink bollworm infestation was found in Weal-Ag-1606, VH-Gulzar, Thakkar-808, NIAB-Bt-2 & NIAB-545 while no pink bollworm larvae were observed in any strain **(Table-4.14)**.

4.5.4 Pest situation in Set-CEMB

In this set 9 Bt cotton strains were evaluated for their tolerance/susceptibility to insect pest complex. Population of jassid remained below ETL during the July and August. Its population was highest on CEMB-4 followed by CEMB-6 While minimum on CEMB-3 during July. Population of whitefly found below ETL almost on all the strains during July and August. Overall its intensity was highest on CEMB-7 followed by CEMB-4

and CEMB-5 while lowest on CEMB-1 during August. Thrips population remained below ETL on all the testing strains. Overall its population was highest on CEMB-5 followed by CEMB-9 **(Tabl-4.15).**

Table-4.12Seasonal population of sucking insect pests on different *Bt* strains

Strains	Number of sucking insect pests per leaf					
	Jassid		Whitefly		Thrips	
	July	Aug	July	Aug	July	Aug
Ghauri-1(CEMB-3)	1.20	0.60	1.50	4.70	1.60	3.90
CEMB Klean	0.80	0.30	3.40	5.90	1.60	4.30
CEMB-100(DG)	0.90	0.50	15.10	10.50	1.60	4.50
BS-80	0.20	0.00	2.40	5.30	0.90	3.40
BS-18	0.70	0.30	2.60	5.00	0.40	2.30
BH-221	0.90	0.40	4.80	7.30	0.50	2.50
Bahar-217	0.50	0.30	1.70	4.70	1.50	4.00
Badar-1(CEMB-2)	0.40	0.10	5.90	7.80	1.80	4.00
FH-142(std-2)	0.40	0.10	4.70	6.90	0.50	2.50
Auriga-216	2.00	0.90	1.90	4.80	2.40	4.90
AA-933	1.60	0.70	2.30	5.10	0.00	1.80
Weal-Ag-1606	1.80	0.80	1.80	4.80	1.20	3.60
VH-Gulzar	0.60	0.10	4.40	6.70	1.70	4.30
Tipu-1	0.40	0.20	2.40	5.50	1.80	4.30
Thakkar-808	2.30	0.20	4.40	6.90	1.20	3.70
Tarzan-5	0.70	0.20	6.80	8.40	1.70	4.50
CIM-602(std-1)	1.90	0.80	2.50	5.10	2.60	6.10
Shaheen-1	0.40	0.10	1.30	4.50	1.40	4.20
RH-662	0.80	0.20	7.40	8.90	0.80	3.10
RH-668	0.20	0.40	2.80	5.70	1.50	4.20
NIAB-Bt-2	2.50	0.90	5.30	6.80	0.40	2.90
NIAB-1048	0.30	0.10	1.00	4.30	0.70	3.20
NIAB-545	0.80	0.40	4.80	6.30	0.00	1.90
MNH-1016	0.80	0.40	4.80	6.90	0.90	3.10

Table-4.13 Spotted bollworm damage and larval population on different *Bt* strains

Strains	Bollworm damage % age		SBW larvae/ 25 plants	
	Imm	Mat	Imm	Mat
Ghauri-1(CEMB-3)	2.33	0.00	0.00	0.00
CEMB Klean	0.00	0.00	0.00	0.00
CEMB-100(DG)	13.95	0.00	0.00	0.00
BS-80	0.00	0.00	0.00	0.00
BS-18	5.77	0.00	0.00	0.00
BH-221	10.14	0.00	0.00	0.00
Bahar-217	0.00	0.00	0.00	0.00
Badar-1(CEMB-2)	0.00	0.00	0.00	0.00
FH-142(std-2)	0.00	0.00	0.00	0.43
Auriga-216	0.00	0.00	0.00	0.00
AA-933	9.68	0.00	0.00	0.00
Weal-Ag-1606	8.51	0.00	0.00	0.00
VH-Gulzar	3.36	0.00	0.00	0.00
Tipu-1	13.46	0.00	0.00	0.00
Thakkar-808	4.84	0.00	0.00	0.00
Tarzan-5	8.62	0.00	0.00	0.00
CIM-602(std-1)	0.00	0.00	0.00	0.00
Shaheen-1	0.00	0.00	0.00	0.00
RH-662	0.00	0.00	0.00	0.00
RH-668	1.54	0.00	0.00	0.00
NIAB-Bt-2	1.39	0.00	0.69	0.00
NIAB-1048	0.00	0.00	0.00	0.00
NIAB-545	0.00	0.00	0.00	0.00
MNH-1016	0.00	0.00	0.00	0.00

Table-4.14 Pink bollworm damage and larval population on different *Bt* strains

Strains	PBW damage %age	PBW larval %age
Ghauri-1(CEMB-3)	0.00	0.00
CEMB Klean	0.00	0.00
CEMB-100(DG)	0.00	0.00
BS-80	0.00	0.00
BS-18	0.00	0.00
BH-221	0.00	0.00
Bahar-217	0.00	0.00
Badar-1(CEMB-2)	0.00	0.00
FH-142(std-2)	0.00	0.00
Auriga-216	0.00	0.00
AA-933	0.00	0.00
Weal-Ag-1606	3.33	0.00
VH-Gulzar	3.33	0.00
Tipu-1	0.00	0.00
Thakkar-808	3.33	0.00
Tarzan-5	0.00	0.00
CIM-602(std-1)	0.00	0.00
Shaheen-1	0.00	0.00
RH-662	0.00	0.00
RH-668	0.00	0.00
NIAB-Bt-2	3.33	0.00
NIAB-1048	0.00	0.00
NIAB-545	3.33	0.00
MNH-1016	0.00	0.00

Table-4.15 Seasonal population of sucking insect pests on different CEMB strains

Strains	Number of sucking insect pests per leaf					
	Jassid		Whitefly		Thrips	
	July	Aug	July	Aug	July	Aug
CEMB 1	0.30	0.40	1.20	0.70	0.00	6.00
CEMB 2	0.50	0.60	0.80	3.70	0.80	6.60
CEMB 3	0.00	0.30	0.50	4.40	0.00	3.60
CEMB 4	0.20	0.40	0.80	5.40	0.00	5.40
CEMB 5	0.70	0.00	0.40	5.10	0.50	8.10
CEMB 6	0.60	0.30	0.70	3.60	0.00	6.60
CEMB 7	0.30	0.10	0.70	5.50	0.00	5.30
CEMB 8	0.20	0.10	1.10	4.60	0.60	4.40
CEMB 9	0.50	0.20	1.10	4.50	0.40	6.80

Table-4.16 Spotted bollworm damage and larval population on different CEMB strains

Strains	Bollworm damage % age		SBW larvae/ 25 plants	
	Imm	Mat	Imm	Mat
CEMB 1	0.00	0.00	0.00	0.00
CEMB 2	0.00	0.00	0.00	0.00
CEMB 3	0.00	0.00	0.00	0.00
CEMB 4	0.00	0.00	0.00	0.00
CEMB 5	0.00	0.00	0.00	0.00
CEMB 6	0.00	0.00	0.00	0.00
CEMB 7	0.00	0.00	0.00	0.00
CEMB 8	0.00	0.00	0.00	0.00
CEMB 9	0.00	0.00	0.00	0.00

Table-4.17 Pink bollworm damage and larval population on different CEMB strains

Strains	PBW damage %age	PBW larval %age
CEMB 1	0.00	0.00
CEMB 2	0.00	0.00
CEMB 3	0.00	0.00
CEMB 4	0.00	0.00
CEMB 5	0.00	0.00
CEMB 6	0.00	0.00
CEMB 7	0.00	0.00
CEMB 8	0.00	0.00
CEMB 9	0.00	0.00

Infestation and live larvae remained zero on all tested strains for spotted bollworm **(Table-4.16)** and pink Bollworm **(Table-4.17)**.

4.5.5 Pest situation in Set-NTTT

In this set 10 cotton strains were evaluated for their tolerance/susceptibility to insect pest complex. Population of jassid remained below ETL during the July and August. Whitefly population remained below ETL on all the strains during study period except on NTTT-3 in August. Thrips population remained below ETL on all the testing strains during study period **(Table-4.18).**

Table-4.18 Seasonal population of sucking insect pests on different strains in Set-NTTT

Strains	Number of sucking insect pests per leaf					
	Jassid		Whitefly		Thrips	
	July	Aug	July	Aug	July	Aug
NTTT-1	0.0	-	0.2	-	0.0	-
NTTT-2	0.0	-	0.1	-	0.0	-
NTTT-3	0.4	0.2	0.2	5.7	0.0	0.8
NTTT-4	0.0	-	0.2	-	0.0	-
NTTT-5	0.0	-	0.2	-	0.0	-
NTTT-6	0.0	0.0	0.6	2.4	0.0	0.3
NTTT-7	0.8	0.1	0.3	2.7	0.3	0.8
NTTT-8	0.2	0.1	0.5	3.8	0.0	0.5
NTTT-9	0.4	0.0	0.6	2.3	0.0	0.4
NTTT-10	0.5	0.0	0.1	1.8	0.0	3.1

- = Plants were severely effected in these treatments

Table-4.19 Spotted bollworms damage and larval populationon different strains in Set-NTTT

Strains	Bollworm damage % age		SBW larvae/ 25 plants	
	Imm	Mat	Imm	Mat
NTTT-1	-	-	-	-
NTTT-2	-	-	-	-
NTTT-3	0.00	0.00	0.00	0.00
NTTT-4	-	-	-	-
NTTT-5	-	-	-	-
NTTT-6	0.00	0.00	0.00	0.00
NTTT-7	0.00	0.00	0.00	0.00
NTTT-8	0.00	0.00	0.00	0.00
NTTT-9	0.00	0.00	0.00	0.00
NTTT-10	0.00	0.00	0.00	0.00

- = Plants were severely effected in these treatments

Table-4.20 Pink bollworms damage and larval population on different strains in Set-NTTT

Strains	PBW damage %age	PBW larval %age
NTTT-1	-	-
NTTT-2	-	-
NTTT-3	0.00	0.00
NTTT-4	-	-
NTTT-5	-	-
NTTT-6	0.00	0.00
NTTT-7	0.00	0.00
NTTT-8	0.00	0.00
NTTT-9	0.00	0.00
NTTT-10	0.00	0.00

-= Plants were severely effected in these treatments

Infestation and live larvae remained zero on all tested strains for spotted bollworm **(Table-4.19)** and pink Bollworm **(Table-4.20)**.

4.6 Host plant tolerance studies of CCRI strains

4.6.1 Studies on conventional strains

Two conventional promising strains viz. Cyto-122 and Cyto-225 developed by CCRI, Multan were tested for their tolerance/susceptibility against major insect pests. Cultivar Cyto-124 was kept as standard. The trial was sown on May 16, 2017 using RCBD with three sets. Each set was replicated three times having plot size of 16'x30'. Set-I was sprayed for only sucking pests. In Set-II, bollworms were controlled and sucking pests were allowed to develop till harvest, while in Set-III both sucking pests and bollworms were controlled with insecticides. Data on population of sucking pests and damage cause by bollworms were recorded from Set-I and Set-II, respectively. Crop was harvested to quantify production potential **(Table-4.21)**.

Table-4.21 Jassid Population per leaf in Non-Bt Varieties (Set-II)

Observation Dates	Jassid Population per leaf		
	Cyto-122	Cyto-225	Cyto-124
29.06.2017	2.96	3.30	3.56
13.07.2017	0.30	0.23	0.30
20.07.2017	0.56	0.56	0.60
27.07.2017	0.13	0.46	0.33
03.08.2017	0.76	1.10	0.96
10.08.2017	0.43	0.42	0.43
Average			
June	**2.96**	**3.30**	**3.56**
July	**0.33**	**0.42**	**0.41**
August	**0.60**	**0.76**	**0.70**

In Set-II, in 4th week of June all three strains attained economic threshold level (ETL) with relatively higher population on Cyto-124. Afterwards all strains were below economic threshold level (ETL) in the month of August with relatively higher population on Cyto-225 in 1st week of August. The population remained fluctuating during the 2nd week of July and August on all strains. Over all pest pressure was higher on Cyto-124 & lower on Cyto-122. Whitefly remained below economic threshold level (ETL) during June which increased afterward and in the 3rd and 4th week of august population remained fluctuating on all strain. Over all pest pressure was higher on Cyto-122 and lower on Cyto-124 **(Table-4.22)**.

Table-4.22 Whitefly Population per leaf in Non-Bt Varieties (Set-II)

Observation Dates	Whitefly Population per leaf		
	Cyto-122	Cyto-225	Cyto-124
29.06.2017	1.90	1.06	1.20
13.07.2017	0.96	1.30	1.36
20.07.2017	3.20	4.13	2.56
27.07.2017	4.20	4.60	2.80
03.08.2017	1.80	2.30	1.90
10.08.2017	3.56	3.03	4.86
Average			
June	**1.90**	**1.06**	**1.20**
July	**2.79**	**3.34**	**2.24**
August	**2.68**	**2.67**	**3.38**

Thrips remained below economic threshold level (ETL) thorough out the season on all tested cultivars **(Table-4.23)**.

In Set-I, spotted bollworm was the major pest and initially its infestation was higher on Cyto-225 and Cyto-124 respectively and its infestation was on its peak in Cyto-122 & Cyto-225 during 1st week of October. During October, its infestation was lower on Cyto-124. Overall pest infestation was maximum on Cyto-225 and minimum on Cyto-124 **(Fig. 4.5).**

Table-4.23 Thrips Population per leaf in Non-Bt Varieties (Set-II)

Observation Dates	Thrips Population per leaf		
	Cyto-122	Cyto-225	Cyto-124
29.06.2017	0.00	0.23	0.03
13.07.2017	1.80	1.23	1.63
20.07.2017	3.60	2.20	4.86
27.07.2017	1.70	0.20	1.36
03.08.2017	3.10	3.40	2.50
10.08.2017	5.83	6.50	5.43
Average			
June	**0.00**	**0.23**	**0.03**
July	**2.37**	**1.21**	**2.62**
August	**4.47**	**4.95**	**3.97**

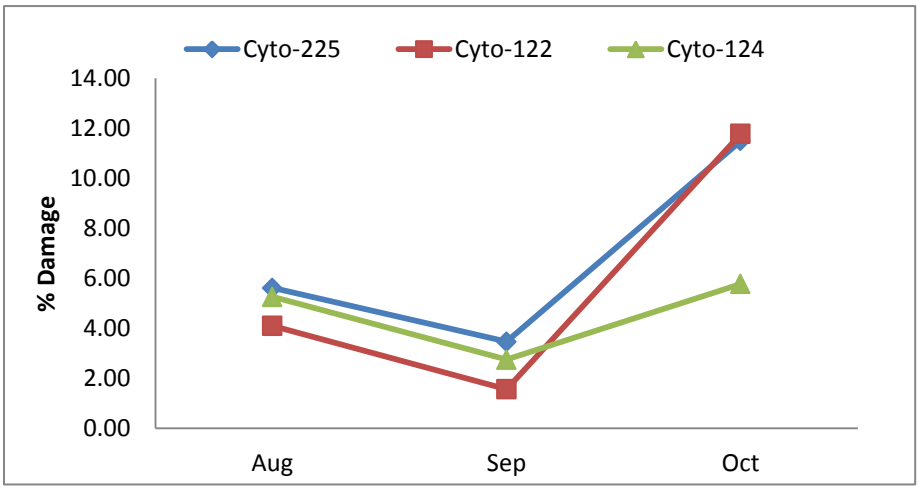

Fig 4.5 Bollworms trend in Non-Bt Promising Varieties

In Set-I, Cyto-225 produced maximum and Cyto-124 minimum seed cotton yield, while in Set II, Cyto-122 gave higher yield. Whereas in Set III, maximum seed cotton yield was recorded where both sucking pests and bollworms were controlled, among the strains maximum yield was obtained in Cyto-122 followed by Cyto-225. Reduction in seed cotton yield was higher due to the attack of bollworms compared to the sucking pests in Set-II **(Table-4.24)**.

Pink bollworm infestation was also observed in green bolls in mid-September and October from Set-I where bollworms were allowed to develop. Among the testing strains, all were highly susceptible to this pest and its damage/larval survival percentage ranged 3.33-20.0.

Table-4.24 Pink bollworm damage/larvae in green bolls and seed cotton yield in different sets

Strain	Seed cotton yield (kg ha^{-1})			% pink bollworm (Set-I) Sep		% pink bollworm (Set-I) Oct	
	Set-I	Set-II	Set-III	Damage	Larvae	Damage	Larvae
Cyto-225	2242	1869	2541	20.00	16.67	6.67	3.33
Cyto-122	2093	2168	2616	3.33	3.33	6.67	3.33
Cyto-124	1943	2018	2168	13.33	6.67	3.33	3.33
CD at 5%	**973.41**	**748.27**	**794.79**	**11.95**	**17.22**	**15.11**	**13.08**

4.6.2 Studies on *Bt* strains

Three *Bt* promising strains viz.Cyto-305, Cyto-307& Cyto-313 developed by CCRI, Multan were tested for their tolerance/susceptibility against major insect pests. Cyto-179 was kept as standard. The trial was sown on May 16, 2017 using RCBD with two sets. Each set was replicated three times having plot size of 40'x20'. Set-II was kept unsprayed for sucking pests, while in Set-I sucking pests controlled with insecticides. Data on population of sucking pests and percentage bollworms damage were recorded. Crop was harvested to quantify production potential.

In Set-II, jassid and whitefly were the major pests. Jassid reached ETL on all tested strains in the 4th week of June and decreased afterwards in July and August. Overall its intensity was comparatively higher on Cyto-305 and lower on Cyto-313 **(Table-4.25).**

Table-4.25 Jassid Population per leaf in Bt Varieties (Set-II)

Observation Dates	Jassid Population per leaf			
	Cyto-305	Cyto-307	Cyto-313	Cyto-179
29.06.2017	7.63	7.70	6.56	7.60
06.07.2017	0.23	0.00	0.43	0.23
13.07.2017	0.00	0.26	0.46	0.10
20.07.2017	0.30	0.30	0.50	0.20
03.08.2017	0.70	0.70	0.83	1.50
10.08.2017	0.43	0.33	0.46	0.53
Average				
June	**7.63**	**7.60**	**6.56**	**7.60**
July	**0.18**	**0.19**	**0.46**	**0.18**
August	**0.57**	**0.52**	**0.65**	**1.02**

Whitefly remained below ETL from June to mid-July which increased afterwards from 1st week of July to 2nd week of August on all the strain. Its population remained fluctuating throughout the cropping seasons. Overall Cyto-305 proved most and Cyto-313 least preferred strain for this pest **(Table-4.26).**

Thrips population remained below the ETL during the July and its population remained fluctuating upto crop termination. Overall Cyto-313 proved most and Cyto-179 least preferred strain for this pest **(Table-4.27)**.

Table-4.26 Whitefly Population per leaf in Bt Varieties (Set-II)

Observation Dates	Whitefly Population per leaf			
	Cyto-305	Cyto-307	Cyto-313	Cyto-179
29.06.2017	0.16	0.30	0.36	0.50
06.07.2017	2.56	2.26	1.36	2.63
13.07.2017	0.90	0.83	0.76	1.26
20.07.2017	2.20	1.40	1.50	1.80
03.08.2017	3.10	2.60	2.00	3.60
10.08.2017	4.60	2.50	2.76	2.76
Average				
June	**0.16**	**0.30**	**0.36**	**0.50**
July	**1.89**	**1.50**	**1.21**	**1.90**
August	**3.85**	**2.55**	**2.38**	**3.18**

Table-4.27Thrips Population per leaf in Bt Varieties (Set-II)

Observation Dates	Thrips Population per leaf			
	Cyto-305	Cyto-307	Cyto-313	Cyto-179
29.06.2017	0.00	0.13	0.00	0.00
06.07.2017	0.00	0.00	0.00	0.00
13.07.2017	18.00	0.13	0.10	0.00
20.07.2017	1.60	3.80	1.80	1.30
03.08.2017	5.50	4.20	7.60	2.70
10.08.2017	3.20	5.50	5.20	3.40
Average				
June	**0.00**	**0.13**	**0.00**	**0.00**
July	**6.53**	**1.31**	**0.63**	**0.43**
August	**4.35**	**4.85**	**6.40**	**3.05**

Pink bollworm was the major and only pest observed throughout the fruiting seasons on all the tested strains. Its infestation and larval survival were observed in green bolls. It was below ETL in both sets but its intensity was higher in Set-I where sucking pests were allowed to develop. Among the strains, its intensity was highest on Cyto-307 and lowest on Cyto-179 in September in Set-I **(Table-4.28)**.

Table-4.28 Pink bollworm damage/larvae in green bolls

Strain	PBW damage %age Sep		PBW larval %age Sep		PBW damage %age Oct		PBW larval %age Oct	
	Set-I**	Set-II*	Set-I**	Set-II*	Set-I**	Set-II*	Set-I**	Set-II*
Cyto-305	6.67	0.00	0.00	0.00	0.00	0.00	3.33	0.00
Cyto-307	13.33	6.67	10.00	3.33	6.67	3.33	3.33	3.33
Cyto-313	6.67	6.67	6.67	3.33	0.00	3.33	0.00	3.33
Cyto-179	10.00	3.33	6.67	0.00	3.33	0.00	0.00	0.00
CD at 5%	**7.45**	**7.45**	**8.81**	**8.81**	**7.45**	**8.81**	**8.81**	**8.81**

** = Sucking pests controlled at ETL* = Sucking pests allowed

In Set-II, seed cotton yield was comparatively higher where sucking insect pests were controlled than set-I where they were allowed to develop. Among the cultivars, Cyto-305 produced highest seed cotton yield, whereas, Cyto-179 gave the lowest yield in both sets **(Table-4.29)**.

Table-4.29 Seed cotton yield in different sets

Strain	Seed cotton yield (kg ha^{-1})	
	Set-I**	Set-II*
Cyto-313	2736	2377
Cyto-307	2198	2467
Cyto-305	2781	2512
Cyto-179	2198	2153
CD at 5%	**580.69**	**709.79**

* = Sucking pests allowed ** = Sucking pests controlled at ETL

4.7 Insecticide resistance monitoring in *Dysdercus koenigii*

Dysdercus koenigii, Red cotton bug collected from cotton fields at Multan and Makhdoom-Rashid were exposed to five insecticides viz. acetamiprid, lambda-cyhalothrin, deltamethrin, emamcetin benzoate and tracer using seed dip method.Third instars of red cotton bugs were exposed and observations on mortality were taken 48 h after treatment. Resistance ratio (RR) was calculated by dividing LC^{50} of field population with LC^{50} of susceptible population (Lab-Sus).

Very high level of resistance to acetamiprid was detected in tested populations of both locations as compared to the Lab-Sus population. Very low to moderate levesl of resistance were observed for spinosad. *D. koenigii* showed moderate level of resistance to Emamectin benzoate and very low to moderate levels of resistance to spinosad compared to the Lab-Sus. While no to very low levels of resistance to Pyrethroids (lambdacyhalothrin and deltamethrin) were observed in field populations of both locations.

Among the locations, Multan population showed higher $LC^{50}$and RR values for acetamiprid and emamectin benzoate compared to Makhdoom-Rashid population **(Table-4.30)**.

Table-4.30 Response of *Dysdercus koenigii* (Red cotton bug) to different insecticides collected from cotton

Insecticide	Location	Slope ± SE	LC50 (ppm)	95% fiducial limits	RR
Acetamiprid	Lab-Sus	0.94 ± 0.22	0.79	0.35–1.63	1
	Multan	1.48 ± 0.27	162.25	99.46–281.53	205.4
	Makhdoom-Rashid	1.58 ± 0.28	151.30	94.57–252.76	191.5
Lambda-cyhalothrin	Lab-Sus	0.81± 0.15	0.009	0.004 – 0.019	1
	Multan	1.54± 0.30	0.019	0.010– 0.031	2.1
	Makhdoom-Rashid	1.33± 0.23	0.034	0.018– 0.056	3.8
Deltamethrin	Lab-Sus	0.85± 0.14	0.009	0.004– 0.017	1
	Multan	1.74± 0.39	0.017	0.009– 0.027	1.9
	Makhdoom-Rashid	0.85± 0.19	0.021	0.006– 0.044	2.3
Spinosad	Lab-Sus	0.60± 0.12	0.84	0.29– 2.03	1
	Multan	1.01± 0.28	8.06	3.27– 17.20	9.6
	Makhdoom-Rashid	1.24± 0.31	22.90	12.71– 59.23	27.3
Emamectin benzoate	Lab-Sus	0.55± 0.21	0.93	0.04– 2.90	1
	Multan	1.63 ±0.39	32.34	19.70–73.29	34.8
	Makhdoom-Rashid	1.05 ±0.30	27.42	13.80–1110.30	29.5

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5. PLANT PATHOLOGY SECTION

Research studies were carried out on the prevalence, management and control strategy of various cotton diseases, viz., cotton leaf curl (Burewala Strain of Cotton Virus), boll rot, and wilting of cotton. Experiments were conducted under greenhouse and field conditions. The promising strains under 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 Estimation of Cotton Diseases

A survey was conducted during cotton cropping season to record the prevalence of cotton leaf curl (CLCuV) disease in different parts of the Punjab. The incidence of cotton leaf curl disease (CLCuD) was maximum in areas of, Khanewal, Burewala Vehari, and minimum in cotton areas of Multan Shujabad Depal Pur, Lodhran, Kehror Pakka, Kabirwala, Layyah Sahiwal,and Arif Wala. There was no incidence of CLCuD in the areas of Muzzafar Garh, Bahawal Pur, Bahawal,Nager Haroon Abad,and Jam Pur..Overall position of CLCuD with crop cultivation period from March to June indicates that the crop cultivated from the month of March to May showed minimums disease incidence and severity level whereas crops cultivated during the month of June showed maximum level of disease incidence and severity.

The incidence of boll rot varied from 1 to 2 percent. Boll rot due to secondary pathogens was observed only on a few spots. The occurrence of stunting phenomenon was very low. The prevalence of bacterial blight and leaf spot of cotton was minimal. Blackening of leaves was observed in all spots

5.2 Screening of Breeding Material against CLCuD

5.2.1 Screening under field conditions

The advanced strains/genotypes of this Institute included in varietal, micro varietal trials and various national coordinated varietal trials were screened for their reaction to CLCuD under field conditions. One hundred eighteen families were screened during the year. One hundred fifteen families of breeding material, showed symptoms of the CLCuD under filed conditions. However, three families showed resistance against CLCuD, in VT-4(CM-43) and in VT-5 (CM-50) Where as in MVT-3 (1413/7,) showed resistance against the disease (Table 5.1).

Table 5.1 Screening of 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	69.7 ~ 81.0	
VT-2	12	0	16.46 ~73.53	
VT-3	8	0	45.68~ 76.52	*
VT-4	10	0	**6.93**~75.03	
VT-5	9	1	**0.00**~81.08	CM-43
VT-6	9	1	**0.00** ~ 77.98	CM-50
MVT-1	10		33.70~79.22	
MVT-2	7	0	**1.53** ~ 76.10	
MVT-3	8	1	**0.00** ~ 80.18	1413/7
MVT-4	8	0	48.66 ~78.66	
MVT-5	8	0	46.73 ~76.98	^
MVT-6	11	0	36.62~ 78.09	
MVT-7	10	0	60.35 ~82.48	
NCVT-A	15	0	72.33 ~79.37	
NCVT-B	24	0	48.7~78.2	
NCVT-C	24	0	73.02~77.01	
NCVT-D	24	0	44.55~79.38	
NCVT-E	22	0	74.01~78.84	
PCCC-I	40	0	73.00~81.48	
PCCC-II	4	0	71.55~74.31	
SVT-I	26	0	34.30~**84.64**	
SVT-II	18	0	73.98~79.41	
Total	**118**	**3**		

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

Six NTTT strains out of ten germinated All these strains found highly susceptible to cotton leaf curl disease. Minimum disease severity and index was recorded in strain 7. Maximum disease index (56.74 %) was observed in strain 6. (Table 5.2)

Table 5.2 Evaluation of National Technology Testing Trial against CLCuV

Strains	60 DAP	90 DAP	120DAP	D.S	D.I
1	-				
2					
3	36.83	97.14	100.00	2.08	52.09
4					
5					
6	**56.09**	**97.62**	**100.00**	**2.27**	**56.74**
7	33.57	96.97	100.00	2.07	51.77
8	35.28	88.51	100.00	2.17	54.26
9	*38.67*	*88.61*	*100.00*	*2.19*	*54.83*
10	38.70	87.14	100.00	2.21	55.22
Max	**56.09**	**97.62**	**100.00**	**2.27**	**56.74**
Min	**33.57**	**87.14**	**100.00**	**2.07**	**51.77**

Immune=0 Highly Tolerant=0-10 Tolerant=10-30 Susceptible=30-50 Highly Susceptible

5.3 Evaluation of National Coordinated Varietal Trial against Different Diseases

National coordinated Varietal Trial were planted in four sets, Set-A fifteen strains (non-Bt), Set-B and Set-C twenty-two Bt strains/lines were tested against stunting, boll rot and Cotton Leaf Curl Disease under field conditions.

NCVT-Set-A

All the NCVT strains found highly susceptible to cotton leaf curl disease. Minimum disease severity and index was recorded in CIM-620(std). Maximum disease index, boll rot (5.41%) and stunting (3.19%) was observed in TH 17. (Table 5.3)

NCVT-Set-B

All the NCVT strains found highly susceptible to cotton leaf curl disease. Minimum disease incidence and disease index was recorded in NS 181. Maximum CLCuD severity and disease index was observed in CRIS-600. Incidence of boll rot was recorded in strain 20 (2.49%). whereas stunting was recorded in all strains in traces (Table-5.4).

NCVT-Set-C

All the NCVT strains observed highly susceptibility to cotton leaf curl disease. Minimum disease severity and disease index was recorded in BS-18. Maximum, disease severity and disease index was observed in NIAB-545. Maximum boll rot incidence was recorded in Auriga-216 (2.68%) stunting was recorded only in Gauri-1(CEMB-3) and Bahar-217 i-e (1.72 &0.78) respectively (Table-5.5)

Table-5.3 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	
TH-17	**3.19**	100	**3.2**	**79.4**	**5.41**
GS-Ali-7	0.00	100	3.1	77.1	0.96
NIA-887	1.96	100	3.1	76.9	0.56
CRIS-616	0.00	100	3.2	79.4	2.07
Cyto-225	0.00	100	3.0	75.0	1.52
CRIS-129(std)	-				-
CIM-717	0.00	100	3.2	78.9	1.02
TH-88/11	1.70	100	3.1	77.0	0.36
Tipu-2	0.55	100	3.0	75.7	0.33
Thakkar-214	0.00	100	3.2	79.4	2.04
CIM-620(std)	0.00	100	**2.9**	**72.3**	0.59
NIAB-444	0.00	100	3.0	75.0	0.66
MPS-61	0.00	100	3.1	77.1	0.71
CIM-610	0.00	100	3.0	75.1	2.63
PB-896	0.00	100	3.0	74.7	2.25

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-5.4 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	
CEMB-Klean	1.39	100	3.03	75.63	1.74
B-2	0.00	100	2.92	73.05	0.57
GH-Deebal	0.00	100	2.92	72.96	1.09
FH-192	0.00	100	2.95	73.69	1.08
Eagle-2	0.00	100	2.92	72.99	1.66
Cyto-313	1.89	100	2.91	72.70	1.29
Crystle-12	0.00	81.5	2.95	60.19	1.81
CRIS-600	0.00	100	**3.13**	**78.19**	1.87
FH-142(std-2)	0.00	100	3.00	75.04	1.75
CIM-632	0.00	100	2.91	72.70	0.76
CEMB-55(DG)	0.00	100	2.95	73.76	1.18
BH-201	1.79	100	2.99	74.70	2.00
Bakhtawar-1	0.00	100	2.96	74.08	0.85
Bahar-07	1.89	100	2.97	74.37	1.37
Sitara-15	0.00	100	2.96	73.98	0.26
SAU-1	0.55	100	2.92	73.04	2.30
CIM-602(std-1)	0.00	100	2.89	72.27	1.81
NS-181	0.00	**66.7**	**2.92**	**48.72**	1.35
D-19	0.00	100	3.01	75.14	0.59
IUB-65	0.00	100	2.93	73.25	**2.49**
GH-Mubarik	0.64	100	2.94	73.52	1.65
CIM-625	0.00	100	2.92	73.06	1.17
CEMB-88(DG)	0.00	100	2.99	74.69	1.34
AGC.Nazeer-1	1.39	100	2.92	72.93	2.28

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-C

NCVT Set C Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
Ghauri-1(CEMB-3)	1.52	100	3.06	76.60	0.53
CEMB Klean	0.00	100	2.97	74.27	0.00
CEMB-100(DG)	0.00	100	3.07	76.66	1.57
BS-80	0.00	100	3.03	75.73	0.30
BS-18	0.00	100	**2.92**	**73.02**	0.52
BH-221	0.00	100	3.01	75.35	0.82
Bahar-217	0.78	100	2.98	74.51	0.62
Badar-1(CEMB-2)	0.00	100	2.99	74.78	0.56
FH-142(std-2)	0.00	100	3.04	75.91	1.16
Auriga-216	0.00	100	3.03	75.74	**2.68**
AA-933	0.00	100	3.04	76.08	1.17
Weal-Ag-1606	0.00	100	3.05	76.21	0.94
VH-Gulzar	0.00	100	3.06	76.58	1.25
Tipu-1	0.00	100	3.01	75.31	1.03
Thakkar-808	0.00	100	3.03	75.80	0.28
Tarzan-5	0.00	100	2.94	73.54	0.31
CIM-602(std-1)	0.00	100	3.01	75.27	0.60
Shaheen-1	0.00	100	2.99	74.82	0.88
RH-662	0.00	100	3.03	75.77	0.62
RH-668	0.00	100	2.94	73.53	0.57
NIAB-Bt-2	0.00	100	3.05	76.34	0.56
NIAB-1048	0.00	100	3.08	77.01	0.28
NIAB-545	0.00	100	**3.13**	**78.23**	0.00
MNH-1016	0.00	100	2.98	74.55	1.70

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

5.4 Epidemiological Studies on CLCuD

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

(a) Effect of sowing dates on *Bt*-Strains

Four advanced genotypes i.e.CIM-515, CIM-632, Cyto-313and CIM-343 with one standard CIM-602 were tested at six different sowing dates to observe the response to CLCuD with collaboration of Agronomy section of the Institute. The planting was done from 1st March till 15th May 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 from each planting date during the season. The results are given in **Fig-5.1**.

It is seen from the Fig-5.1 that the disease did not appear on crop planted from 1st March to 15th April with in 60 DAP The disease incidence remained low up to end of May (1.2 %) and reached maximum level (100 %) on 15th September in 1st March planting. Where as in 15th March planting CLCuD started to appear during the month of August (0.5 %) and then rapidly increase and attained its maximum level (100 %) during the mid of September.

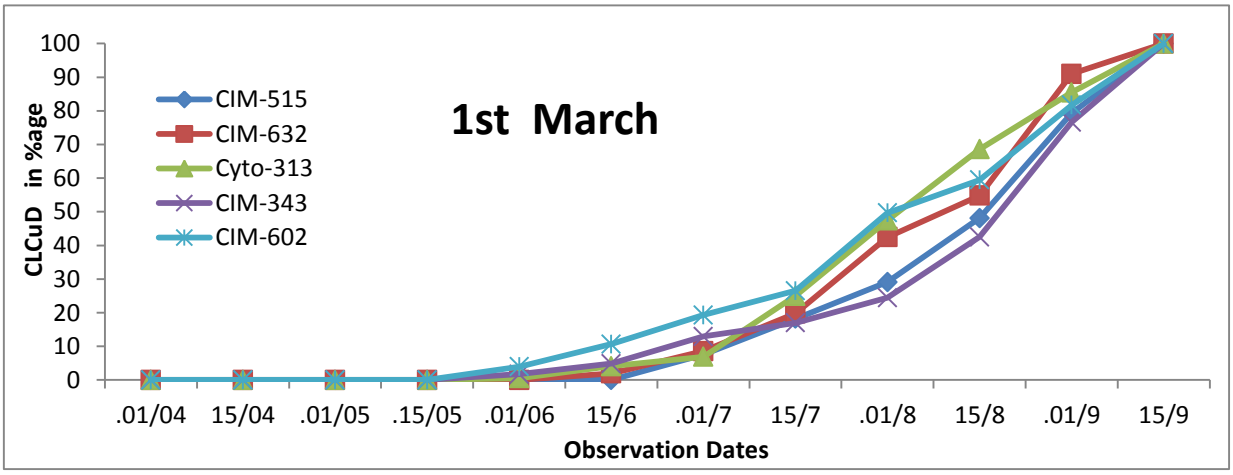
In 1st April planting, disease incidence was 8.4 in the mid of June and reached 100% at the mid of September. Whereas in 15th April planting disease incidence was 14.2 % at the mid of June, 89.9 % during mid of August and reached 100 % at the mid of September,

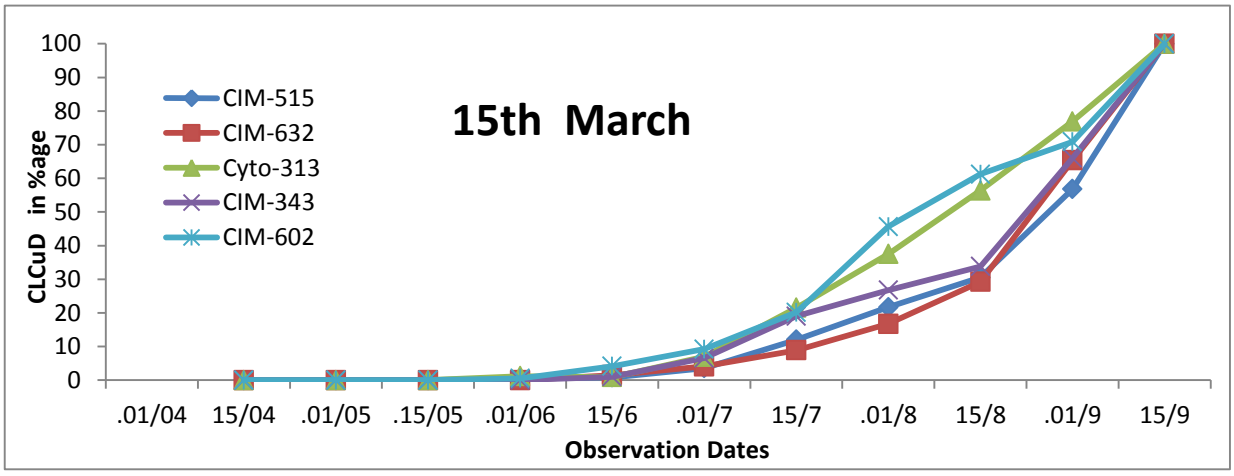
In 1st May planting incidence started within 60 DAP (end of June) then increased sharply i.e. 93.0 to 100% during mid of August to mid of September whereas in 15th May planting disease symptoms appeared 4.2% within 30 days and disease incidence recorded 100% during the month of September (within 65 DAP).

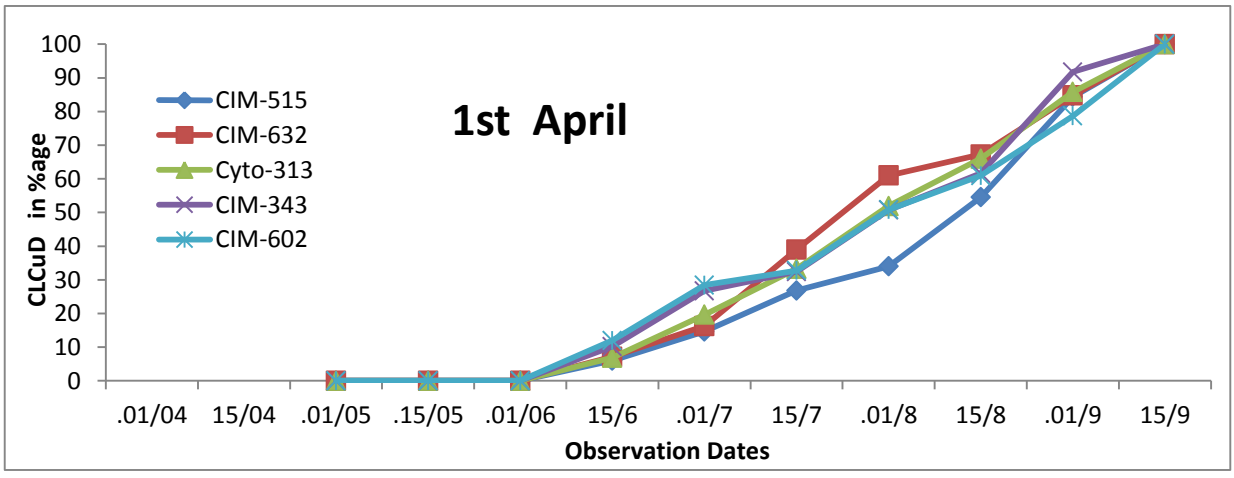
Those crops which were planted earlier showed less disease incidence till July. All the cultivars showed maximum level of incidence when planted during the month of 15th March. All the varieties showed minimum level of disease when planted during the month of March to 1st April when compared to others which were planted during 15th April shows 40% incidence during the end of July and reached up to 100% at the end of the season. Whereas in 1st May and 15th May planting all the cultivars showing highly susceptibility (89 to 100 %) at the end of August (Fig-5.1).

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

Data on incidence and severity were recorded during the end of September from each treatment and computed for disease index. The level of disease index was 64% on the crop planted on 1st March to 15th March. The disease index increased with the delay in sowing and it reached up to 72.9 and 75.7 % in crop sown on 15th April to 15th May respectively (Table-5.8). There is no varietal difference in all sowing dates.


1st March
CIM-515
CIM-632
Cyto-313
CIM-343
CIM-602
CLCuD in %age
100
90
80
70
60
50
40
30
20
10
0
.01/04
15/04
.01/05
.15/05
.01/06
15/6
.01/7
15/7
.01/8
15/8
.01/9
15/9
Observation Dates


15th March
CIM-515
CIM-632
Cyto-313
CIM-343
CIM-602
CLCuD in %age
100
90
80
70
60
50
40
30
20
10
0
.01/04
15/04
.01/05
.15/05
.01/06
15/6
.01/7
15/7
.01/8
15/8
.01/9
15/9
Observation Dates


1st April
CIM-515
CIM-632
Cyto-313
CIM-343
CIM-602
CLCuD in %age
100
90
80
70
60
50
40
30
20
10
0
.01/04
15/04
.01/05
.15/05
.01/06
15/6
.01/7
15/7
.01/8
15/8
.01/9
15/9
Observation Dates

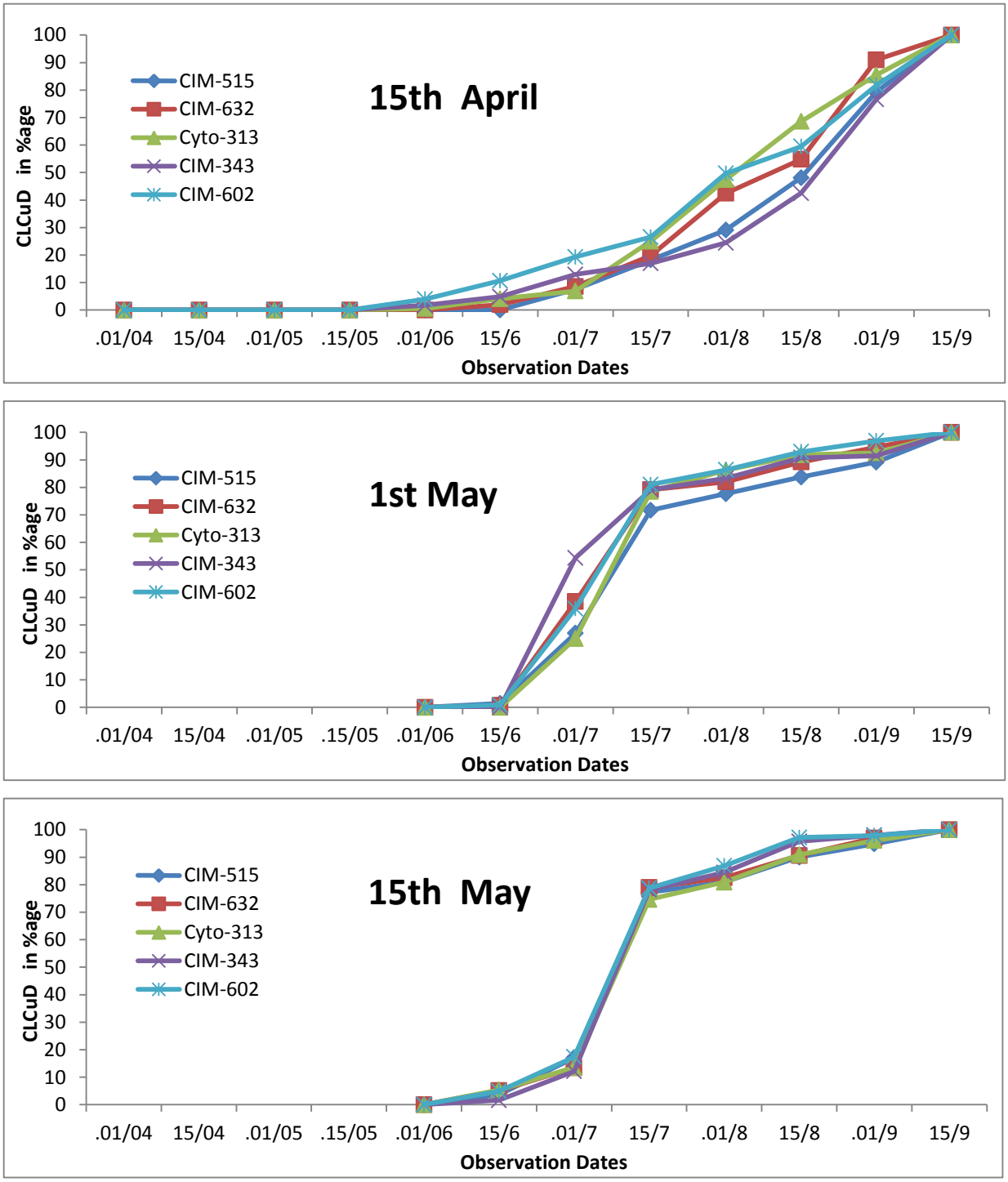


Fig-5.1 Incidence of CLCuD as influenced by planting Dates and strains on Bt-cotton.

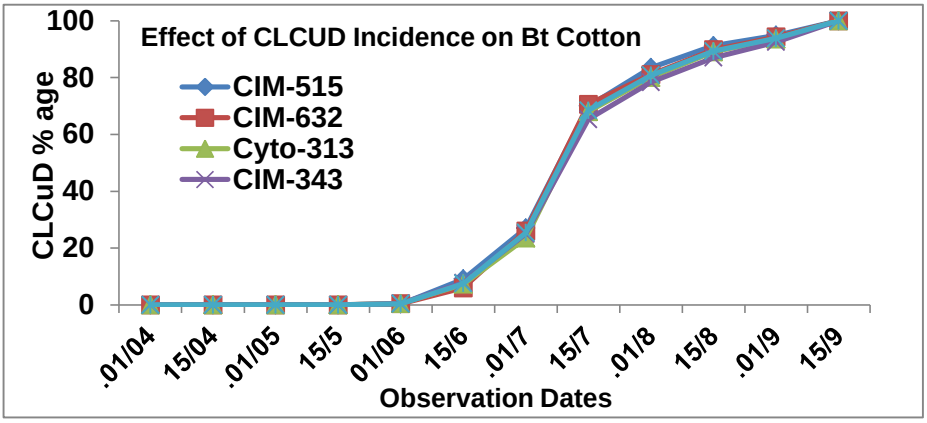


Fig-5.2 Effect of CLCuD Incidence as influenced by planting dates and Bt-strain

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 64.9 and 64.8 % was recorded on crop planting on 1stand 15th March respectively as compare to other planting dates. Average planting dates, minimum disease index level (65.7 %) was recorded on genotype CIM-632 Table-5.8

Table 5.8 Disease index of Cotton Leaf Curl on cultivars planted at different times

	Planting Dates						Average
	1st March	15th March	1st April	15th April	1st May	15th May	
CIM-515	57.2	71.2	73.4	73.0	72.1	73.1	70.0
CIM-632	75.1	34.3	65.8	74.4	70.6	74.2	65.7
Cyto-313	78.6	74.3	76.5	73.7	73.4	76.1	75.4
CIM-343	35.6	68.2	74.0	72.2	72.7	75.7	66.4
CIM-602	77.8	75.7	72.5	71.1	74.7	79.7	70.6
Average	64.9	64.8	72.4	72.9	72.7	75.7	

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

On an average basis of sowing dates, maximum level of fortnightly increase of disease was recorded from end July to end August. Among environmental parameters the maximum temperature range was 34.8~ 37.1°C minimum temperature 28.0 ~ 30.0°C with the relative humidity 75.5%~89.1 % during the above mentioned period. It's indicated that during that period the late sown crop was more affected than earlier (Table-5.9).

Table.5.9 Relationships between Fortnightly Increase in CLCuD and Temperature and humidity on Bt-Cotton

Sowing Date	16-31/3	1-15/4	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
1st March		0	0	0	0	1.2	3.1	6.7	10.3	17.3	16.1	28.1
15th March			0	0	0	0.5	1.2	4.4	10.3	13.3	12.6	25.0
1st April				0	0	0	8.4	12.7	11.7	16.8	12.4	23.0
15th April					0	0	14.2	15.9	38.3	13.4	8.1	4.4
1st May					0	0	0.6	35.5	41.7	5.2	6.6	3.3
15th May							0	10.5	62.8	5.6	9.8	3.9
Average		0	0	0	0	0.3	4.6	12.5	18.7	11.0	9.3	14.0
Max C		31.3	34.8	39.2	39.7	39.7	37.6	38.5	36.6	37.6	34.8	35.5
Min C		19.4	20.1	25.5	27.6	28.8	29.3	28.3	29.8	30.2	28.5	28.3
Difference		11.8	14.7	13.7	12.1	10.9	9.2	8.3	7.8	6.9	6.3	7.2
RH %age		70.4	58.6	55.2	71.5	66.8	73.9	86.9	83.7	75.5	81.4	89.1

(b) Effect of Sowing Time on Non Bt. Strains

In the changing climate scenarios establishment of superior germplasm and its acclimatization is the dire need of time. It is hypothized that sowing of newly evolved diverse cotton genotypes at different sowing dates will give best sowing dates of each genotype for management against CLCuD.

Seeds of two elite cotton genotypes i-e CIM-610 and CIM-717 along with one standard variety CIM-620 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.

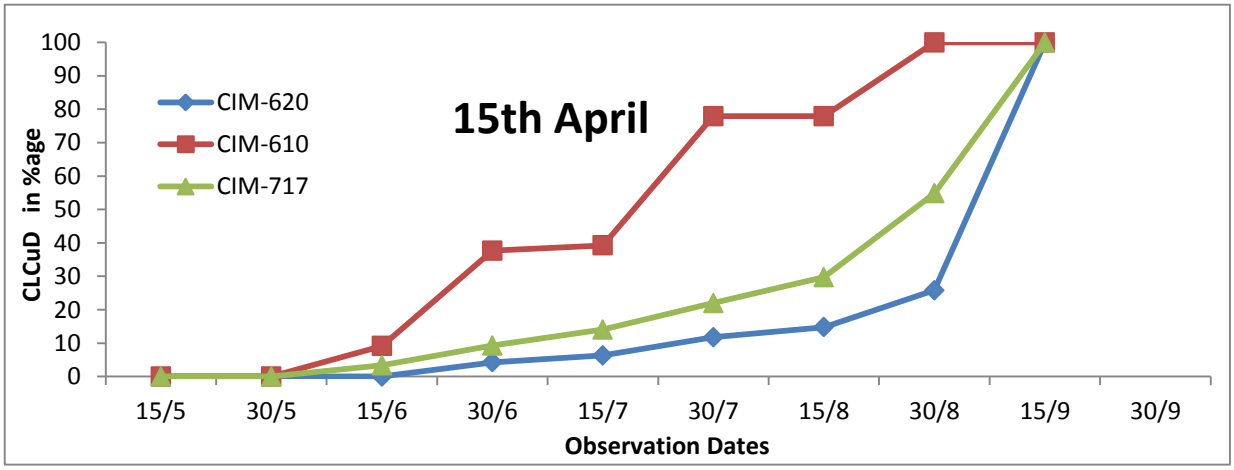
Effect of appearance of cotton leaf curl disease and its progression different significantly with sowing dates. Minimum CLCuD infestation was observed in 15thApril Planting in early July data i.e. 17.1%. With the advancement of age the infestation level reached 100 % during the mid of September.

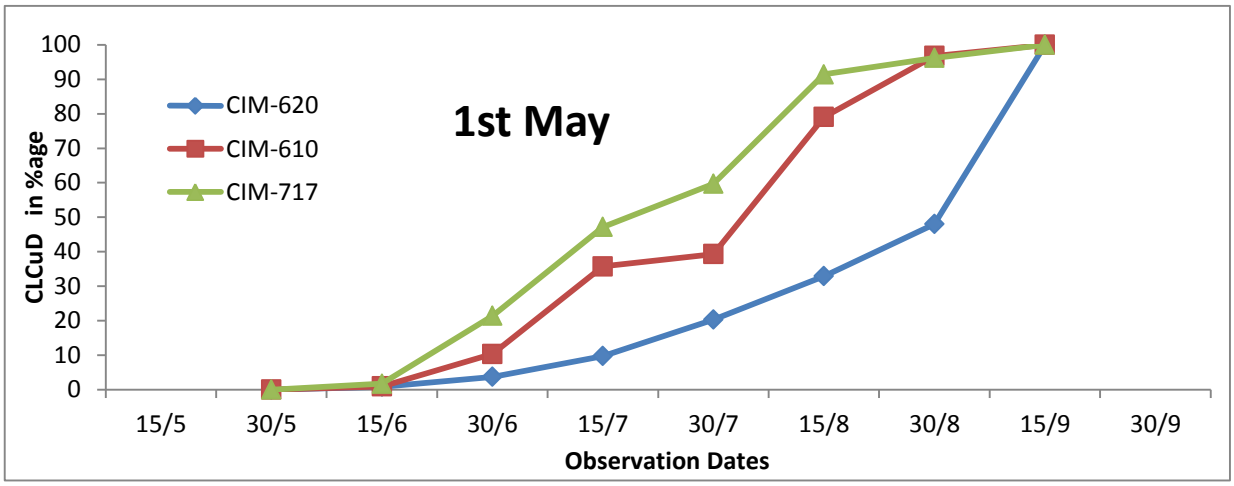
A gradual increase in CLCuD incidence was observed in 1st May planting date. The disease started in first week of July with minimum level of incidence of 1.1% which increased moderately and reached to 100% at the mid of September.

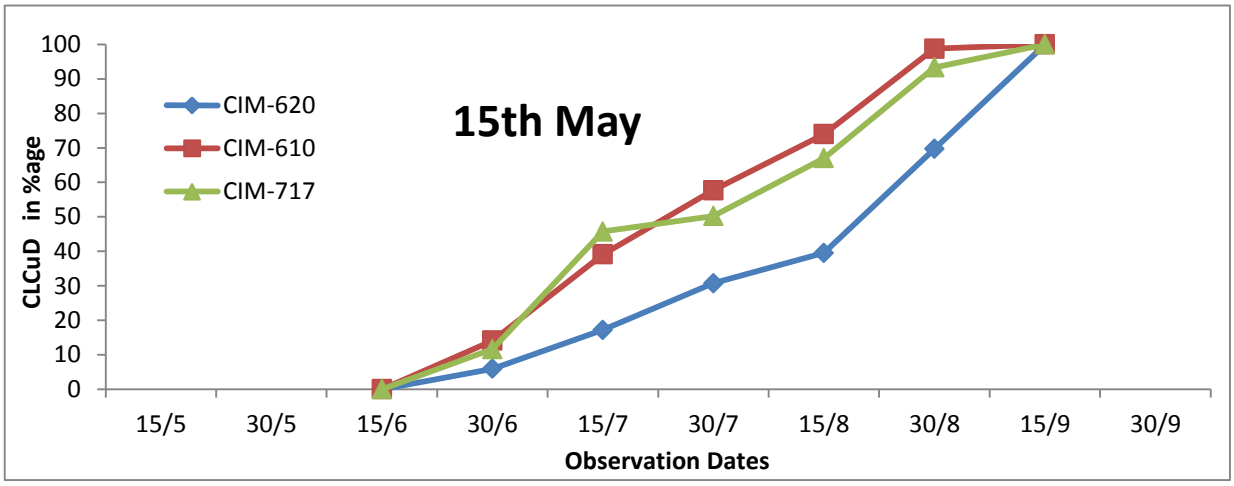
Similarly in case of 15thMay planting CLCuD incidence was 10.5 % in the first week of July and got its maximum level 100 % in the mid of September (135DAP).

In 1stJune and 15thJune planting the disease started from mid-July (29.8% and 60.7 %) and reached up to 100 % respectively at the mid of September.

The level of disease incidence in CIM-620 showed less in 15th April and 1st May planting as compare to CIM-610 and CIM-717 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 April
CIM-620
CIM-610
CIM-717
CLCuD in %age
100
90
80
70
60
50
40
30
20
10
0
15/5
30/5
15/6
30/6
15/7
30/7
15/8
30/8
15/9
30/9
Observation Dates


1st May
CIM-620
CIM-610
CIM-717
CLCuD in %age
100
90
80
70
60
50
40
30
20
10
0
15/5
30/5
15/6
30/6
15/7
30/7
15/8
30/8
15/9
30/9
Observation Dates


15th May
CIM-620
CIM-610
CIM-717
CLCuD in %age
100
90
80
70
60
50
40
30
20
10
0
15/5
30/5
15/6
30/6
15/7
30/7
15/8
30/8
15/9
30/9
Observation Dates

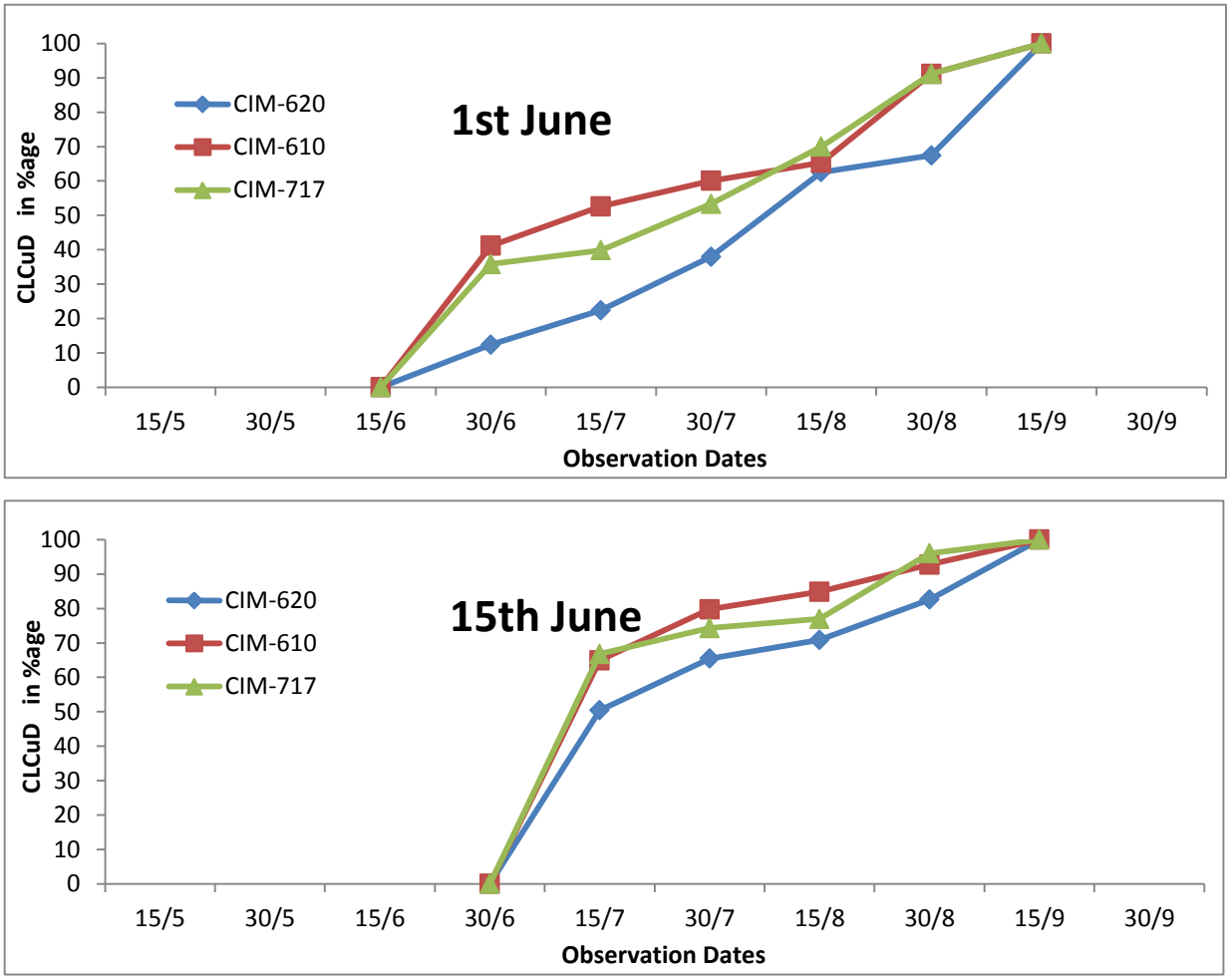


Fig-5.3Effect of CLCuD Incidence as influenced by planting dates and strain

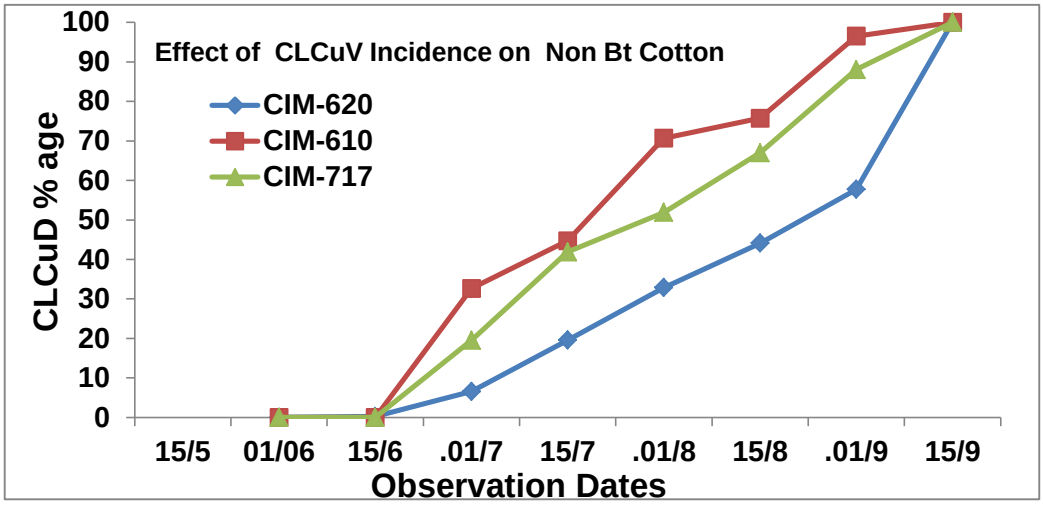


Fig-5.4 Incidence of CLCuD as influenced by planting Dates and strain on Non-Bt-cotton

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 52.3 % was recorded on crop planting on 15th April as compare to other planting dates. Average planting dates, minimum disease index level (60.2%) was recorded on genotype CIM-620 Table-5.10

Table-5.10 Disease Index of CLCuD (%) on sowing date trial

Cultivars	Planting Dates					Average
	15th April	1st May	15th May	1st June	15th June	
CIM-620	39.0	45.7	69.2	72.9	74.4	60.2
CIM-610	76.5	53.9	78.7	82.2	84.3	75.1
CIM-717	63.87	77.7	81.8	84.8	83.9	74
Average	52.3	59.1	76.6	80.0	80.9	

D.I = Disease Index, Disease incidence x Severity/ maximum severity value (4)
CD 5% Sowing Dates = 8.68 Varieties = 5.44

On an average basis of sowing dates, maximum level of fortnightly increase of CLCuD was recorded from early July to mid of September .Among environmental parameters the maximum temperature range was 34.8~37.1°C minimum temperature 28.0~30.0°C with the relative humidity 75.5 %~89.1 % during the above mentioned period. Difference between maximum and minimum temperature was less and humidity was maximum during the month of August which boost up the disease level. It was also confirmed that late sown crops were more affected than early sown due to plant vigor (Table-5.11).

Table 5.11 Relationship between fortnightly increases in CLCuD with weather parameters during 2017

Sowing dates	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 April	0.0	0.0	4.2	12.9	2.8	17.4	3.6	19.4	39.8
1st May		0.0	1.1	10.7	19.1	8.9	28.0	12.5	19.7
15th May			0.2	10.5	23.5	12.2	13.9	27.1	12.7
1st June				0.0	8.5	12.2	15.5	17.3	16.8
15th June					24.1	12.5	4.4	12.9	9.6
Average	0.00	0.00	1.84	8.53	**15.59**	**12.62**	**13.09**	**17.84**	**19.70**
Max. °C	39.2	39.7	39.7	37.6	38.5	36.6	37.6	34.8	35.5
Min. °C	25.5	27.6	28.8	29.3	28.3	29.8	30.2	28.5	28.3
Difference	13.7	12.1	10.9	9.2	8.3	7.8	6.9	6.3	7.2
RH%	55.2	71.5	66.8	73.9	86.9	83.7	75.5	81.4	89.1

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5.5 Boll Rot of Cotton

5.5.1 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 1st March, 15th March, 1st April, 15th April, 1st May and 15th May. The results are given in Table 5.12

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. Averaged across sowing dates, the variety CIM-343 showed comparatively more boll rot as compared to others. The boll rot disease ranged from 0.35 to 1.54% in all sowing dates on an average basis (Table 5.12).

(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 5.13.

Averaged across sowing dates, cultivar CIM-602 showed maximum boll rot disease incidence.as compare to other cultivars. On an average basis, the crop planted during 15th May was less affected by boll rot as compared to other planting times. On an average basis, boll rot disease ranged from 0.31 to 0.96% in different sowing dates (Table-5.13).

Table-5.12 Effect of Boll Rot of Cotton Disease (%) on cultivars planted at different times

Cultivars	1st March*	15th March	1st April	15th April	1st May	15th May	Average
CIM-515	1.20	0.54	0.56	1.20	0.29	0.24	0.67
CIM-632	0.45	0.44	0.48	0.55	0.26	0.63	0.47
Cyto-313	1.60	1.08	0.87	0.56	0.34	0.27	0.79
CIM-343	3.48	1.47	1.00	1.80	0.57	0.30	1.44
CIM-602	0.98	0.57	0.83	0.83	0.32	0.29	0.64
Average	1.54	0.82	0.75	0.99	0.36	0.35	0.80

Table-5.13 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-620	1.02	1.33	0.67	1.54	0.71	1.05
CIM-610	1.61	0.83	0.26	0.42	0.79	0.78
CIM-717	0.00	0.74	0.00	0.41	0.41	0.31
Average	0.88	0.96	0.31	0.79	0.64	

5.6 Wilt of Cotton

Wilt Symptoms are noticed in some fields wilt disease was observed in fields at CCRI during the month of August and November. The sudden death of affected plants occurred after appearance of syndrome. Upon examination, the pith wood, bark of lower part of stem was discolored. However, in some samples, the xylem vessels turned black and dried. This phenomenon was recorded in most of the cotton wilted plants Identified causal organism was Botryodiplodia and fusarium spp Trifloxystrobin ,Azo-oxystrobin Carbendazim+ Mencozib fungicide @ 2.8gm/lit affected against identified fungi in vivo.

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6. PLANT PHYSIOLOGY /CHEMISTRY SECTION

Studies were carried out on plant nutrition, seed physiology, plant-water relationships and thermal stress.

6.1 Plant nutrition

6.1.1 Cotton response to Magnesium application by fertigation and foliar methods

Balanced crop nutrition management is a primitive step to sustain cotton production. Apart from nitrogen, phosphorus and potassium, magnesium (Mg), a secondary macronutrient, is essentially required by all crop plants for optimum performance. Magnesium plays important role in soil by production of enzymes required to maintain soil nutrient balance. Many essential plant functions which require adequate Mg supplies include root formation, chlorophyll formation, protein synthesis, photosynthesis, partitioning and utilization of photo-assimilates. Intensive cropping without nutrient replenishment has deteriorated soil health and fertility through continuous mining leading to multiple nutrient deficiencies. The deficiency of magnesium results in yellowing in the form of interveinal chlorosis of older leaves, impairment to plant growth and yield reduction through adversely affecting critical physiological and biochemical processes in plants. Magnesium nutrient is rarely added to cotton crop as a sole fertilizer source. Therefore, the present study was proposed to evaluate the response of cotton crop to different levels of applied magnesium through foliar and fertigation methods.

The crop was sown on 5th of May 2017 in a Randomized Complete Block Design with Split Plot arrangement. Magnesium sulphate for Mg source was applied either through foliar @ 0, 3, 6 kg ha^{-1} or by fertigation @ 0, 10, 20 kg ha^{-1}. Cotton genotypes CIM-616 (Bt) and CIM-554 (non-Bt) 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, extractable phosphorus, extractable potassium and available magnesium (Table 6.1).

Table 6.1 Physical and chemical characteristics of soil at pre- planting

Characteristics	Values
pH	8.11
ECe (dSm^{-1})	2.04
Organic matter (%)	0.96
$NaHCO_3$-P (mg kg^{-1})	10.4
NH_4OAc-K (mg kg^{-1})	106
Available Mg (mg kg^{-1})	48
Textural class	silt loam

Data on plant structure and development were recorded at maturity. A comparison of both application methods revealed that the main stem height and inter-nodal length remained higher in plots where Mg was applied through fertigation while the number of nodes on main stem did not vary among the application methods (Table 6.2). The main stem height, on average basis, varied from 117.2 to 126.9 cm in foliar application and 118.8 to 132.8 cm in fertigation method. Among different treatments. A positive response of both cotton genotypes was observed to applied Mg doses showing concurrent increase in main stem height and number of nodes on main stem with the increase in quantity of Mg fertilizer. Among both genotypes, CIM-554 produced greater height, more number of nodes on main stem and larger inter-nodal length than CIM-616, irrespective of Mg application methods.

Table 6.2 Effect of applied magnesium sulfate on plant structure development at maturity in two cotton genotypes

Foliar applied ($MgSO_4$ kg ha^{-1})	CIM-616	CIM-554	Average	Fertigated ($MgSO_4$ kg ha^{-1})	CIM-616	CIM-554	Average
	Main stem height (cm)						
Control	106.5	127.8	117.2	Control	108.6	129.0	118.8
3.0	112.5	135.7	124.1	10	118.3	140.7	129.5
6.0	114.8	139.0	126.9	20	123.0	142.5	132.8
Average	111.3	134.2		Average	116.6	137.4	
	Nodes on main stem						
Control	41	42	42	Control	40	43	42
3.0	44	46	45	10	43	47	45
6.0	45	48	47	20	45	49	47
Average	43	45		Average	43	46	
	Inter-nodal length						
Control	2.60	3.04	2.82	Control	2.72	3.00	2.86
3.0	2.56	2.95	2.75	10	2.75	2.99	2.87
6.0	2.55	2.90	2.72	20	2.73	2.91	2.82
Average	2.57	2.96		Average	2.73	2.97	

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 the increasing dose of Mg fertilizer both in foliar and fertigation methods. Total dry matter yield remained higher in CIM-616 as compared with CIM-554 that varied from 880 gm^{-2} to 948g m^{-2} in different treatments with an average value of 919 gm^{-2} as compared to 863 gm^{-2} to 938 gm^{-2} in CIM-554 in different treatments with an average value of 906 gm^{-2} in plots where Mg was applied through foliar method (Table 6.3).

Table No.6.3 Effect of applied magnesium sulfate on dry matter production at maturity in two cotton genotypes

Foliar applied ($MgSO_4$ kg ha^{-1})	CIM-616	CIM-554	Average	Fertigated ($MgSO_4$ kg ha^{-1})	CIM-616	CIM-554	Average
	Leaves (gm^{-2})						
Control	147	122	135	Control	152	127	140
3.0	160	134	147	10	167	141	154
6.0	165	138	152	20	170	146	158
Average	158	131		Average	163	138	
	Stalk (gm^{-2})						
Control	236	245	241	Control	232	241	237
3.0	251	259	255	10	253	257	255
6.0	257	264	261	20	257	267	262
Average	248	256		Average	247	255	
	Fruit (gm^{-2})						
Control	501	486	493	Control	489	464	477
3.0	529	516	522	10	521	507	514
6.0	540	528	534	20	535	513	524
Average	523	510		Average	515	495	
	Total (gm^{-2})						
Control	880	863	871	Control	862	840	851
3.0	929	916	923	10	922	915	918
6.0	948	938	943	20	954	928	941
Average	919	906		Average	913	894	

The uptake of Mg by cotton plant organs were determined from the oven dried plant material. Data revealed that Mg uptake in leaf samples varied from 1.52 to 1.95 kg ha^{-1} with average value of 1.75 kg ha^{-1} in Bt.CIM-616 and 1.50 to 1.86 kg ha^{-1} with average value of 1.69 kg ha^{-1} in CIM-554 in plots with magnesium sulfate applied through foliar method. The corresponding Mg uptake values under fertigated plots were relatively lower which ranged from 1.50 to 1.88 kg ha^{-1} with average value of 1.70 kg ha^{-1} in

Bt.CIM-616 and from 1.49 to 1.82 kg ha^{-1} with average value of 1.66 kg ha^{-1} in CIM-554. The trend of Mg uptake was similar in stalk and fruit portions of plants. The Mg uptake by cotton plant increased with the increasing dose of applied Mg. The maximum Mg uptake was observed in fruit portion. The Mg uptake followed the order fruit > leaves > stalk. The maximum total uptake of Mg 9.05 kg ha^{-1} was observed in Bt.CIM-616 with 6.0 kg magnesium sulfate dose applied through foliar method (Table 6.4).

Table 6.4 Effect of foliar applied and fertigated magnesium sulfate on Mg uptake by Bt.CIM-616 and CIM-554

Foliar applied ($MgSO_4$ kg ha^{-1})	**CIM-616**	**CIM-554**	**Average**	**Fertigated** ($MgSO_4$ kg ha^{-1})	**CIM-616**	**CIM-554**	**Average**
	Leaves (kg ha^{-1})						
Control	1.52	1.50	1.51	Control	1.50	1.49	1.50
3.0	1.77	1.72	1.75	10	1.71	1.66	1.69
6.0	1.95	1.86	1.91	20	1.88	1.82	1.85
Average	1.75	1.69		Average	1.70	1.66	
	Stalk (kg ha^{-1})						
Control	1.38	1.35	1.37	Control	1.37	1.35	1.36
3.0	1.44	1.40	1.42	10	1.42	1.38	1.40
6.0	1.49	1.44	1.47	20	1.46	1.40	1.43
Average	1.44	1.40		Average	1.42	1.38	
	Fruit (kg ha^{-1})						
Control	5.21	5.11	5.16	Control	5.20	5.11	5.16
3.0	5.45	5.37	5.41	10	5.32	5.30	5.31
6.0	5.60	5.48	5.55	20	5.43	5.40	5.42
Average	5.42	5.32		Average	5.32	5.27	
	Total (kg ha^{-1})						
Control	8.11	7.96	8.04	Control	8.07	7.95	8.01
3.0	8.66	8.49	8.58	10	8.45	8.34	8.40
6.0	9.05	8.79	8.92	20	8.77	8.62	8.70
Average	8.61	8.41		Average	8.43	8.30	

Seed cotton yield, number of bolls per plant and boll weight varied among different Mg doses, cotton genotypes and the application methods. Seed cotton yield and its components increased with the concurrent increase in Mg doses. The maximum seed cotton yield was observed with higher dose of Mg both in foliar applied and fertigated methods. A comparison of the Mg application methods revealed that seed cotton yield did not vary greatly among the both methods. The plots with foliar applied Mg produced slightly higher yield in the range of 2475 to 3040 kg ha^{-1} seed cotton, 25 to 29 bolls per plant and 2.63 to 2.87g boll weight as compared to Mg fertigated plots where the yield ranged from 2466 to 2960 kg ha^{-1}, bolls per plant from 25 to 28 and boll weight from 2.60 to 2.81g, irrespective of cotton genotypes (Table 6.5). Chlorophyll SPAD values did not vary greatly with the Mg doses, cotton genotypes and application methods. The chlorophyll SPAD values varied from 42.0 to 49.7 in foliar applied Mg and from 41.7 to 48.7 in Mg fertigated methods (Table 6.6)

Table No. 6.5 Effect of applied magnesium through foliar and fertigation methods on cotton productivity two cotton genotypes

$MgSO_4$ (kg ha^{-1})	Foliar application			$MgSO_4$ (kg ha^{-1})	Fertigation		
	CIM-616	CIM-554	Average		CIM-616	CIM-554	Average
	Seed cotton yield (kg ha^{-1})						
Control	2530	2420	2475	Control	2518	2413	2466
3.0	2920	2790	2855	10	2879	2740	2810
6.0	3084	2995	3040	20	3000	2920	2960
Average	2845	2735		Average	2799	2691	
LSD	Application dose		113**				127**
	Genotype		158**				103**
	Interaction		ns				ns
	No of bolls per plant						
Control	22	27	25	Control	22	27	25
3.0	25	30	28	10	25	29	27
6.0	26	31	29	20	26	30	28
Average	24	29		Average	24	29	
LSD	Application dose		1.08*				1.10*
	Genotype		1.36**				1.29**
	Interaction		ns				ns
	Boll weight (g)						
Control	2.94	2.31	2.63	Control	2.93	2.27	2.60
3.0	3.12	2.37	2.75	10	3.10	2.30	2.70
6.0	3.18	2.55	2.87	20	3.13	2.49	2.81
Average	3.08	2.41		Average	3.05	2.35	
LSD	Application dose		ns				ns
	Genotypes		0.49*				0.51*
	Interaction		ns				ns

Table 6.6 Chlorophyll content (SPAD values) in response to applied magnesium through foliar and fertigation methods

Foliar application ($MgSO_4$ kg ha^{-1})	CIM-616	CIM-554	Average	Fertigation ($MgSO_4$ kg ha^{-1})	CIM-616	CIM-554	Average
Control	40.6	43.4	42.0	Control	40.4	43.0	41.7
3.0	45.5	48.9	47.2	10	44.9	46.8	45.9
6.0	48.9	50.4	49.7	20	47.8	49.5	48.7
Average	45.0	47.6		Average	44.4	46.4	

6.2 Seed physiology

6.2.1 Optimizing the dose and efficacy of proline in conjunction with or without boron and zinc micronutrients

Agricultural production is adversely affected by biotic and abiotic stresses world-wide. Abiotic stresses (drought and heat) are the major causes of decline in agricultural production. Under stress conditions the exogenous application of proline may also contribute to the detoxification of the active oxygen species. The proposed role of proline is as osmoregulator and it contributes in the maintenance of membrane integrity as an adaptation to conditions of any stress. Proline helps in fertility of pollen, in enhancing the biomass production, net photosynthetic rate, stomatal conductance, internal CO_2 concentration, nutrient uptake in roots and shoots under water deficit conditions, enhanced plant transpiration rate and reduce the inhibitory effects of NaCl on seed germination. Therefore, overall outcome is the plant growth, yield and superior seed germination.

Boron (B) is one of the important essential mineral elements. Application of boron regulates several vital physiological processes including cell division and elongation, carbohydrate metabolism, assimilate translocation and cell wall development.

Boron also plays a key role in pollen germination, pollen tube growth, floret fertility and boll development.

Zinc (Zn) is involved in several enzymes driven metabolic processes in plants, such as protein synthesis, membrane integrity and tryptophan biosynthesis, photosynthate mobilization, uptake and metabolism of nitrogen (N), phosphorus (P), and potassium (K).

The aim of this investigation was to study the response of cotton to seed priming with proline alone or in combination with its foliar sprays with and without added boron and zinc on yield and quality parameters of cotton seed. Seed priming with 0.1% proline was done prior to sowing and foliar sprays were started when the crop reached 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:

Proline levels (%)	**Foliar application**
T1(Control)	Foliar spray of water alone Foliar spray of B & Zn
T2 (0.05)	Foliar spray of proline alone Foliar application of proline + B & Zn
T3 (0.10)	Foliar spray of proline alone Foliar application proline + B &Zn
T4 (0.15)	Foliar spray of proline alone Foliar application of proline + B &Zn
T5 (0.20)	Foliar spray of proline alone Foliar application of proline + B &Zn

Data on plant structure development in different treatments was recorded at maturity. The results indicated that main stem height, nodes on main stem and inter-nodal length varied among different treatments. Main stem height varied from 112 to 135 cm, number of nodes on main stem from 42 to 48 and inter-nodal length from 2.57 to 2.93 cm in different treatments. The maximum height and number of nodes on main stem were observed in treatment that received foliar application of 0.1% proline along with B & Zn (Table 6.7).

The seed cotton yield varied from 2580 to 3104 kg ha^{-1} in different treatments. The maximum seed cotton yield was observed in treatment that received foliar applications of 0.1% proline with B & Zn. However, on overall average basis seed cotton yield did not differ significantly among the treatments with or without foliar spray of B and Zn. The main effects of proline levels revealed significant increase in seed cotton yield over control at applied levels of proline viz. 0.10% (T3), 0.15% (T4) and 0.20% (T5). The proline levels 0.10%, 0.15% and 0.20% did not differ significantly among themselves in terms of seed cotton production. The ginning outturn varied from 38.2 to 44.8% in different treatments (Table 6.8).

The assessment of seed quality parameters was done from the mature seed. Results indicated that seed priming alone or in combination with foliar sprays of 0.1% proline with and without B & Zn improved parameters such as seed germination, seed index, oil and crude protein content and maintained free fatty acids within safe limits. Seed germination varied from 41- 73%, seed index from 5.4 – 7.0g, oil content from 14.1 to 22.3 % and crude protein from 19.6 to 27.4 % in different treatments (Table 6.9).

Table 6.7 Effect of seed priming plus foliar spray of proline with and without micronutrients on vegetative and reproductive of cotton plant at maturity

Proline levels (%)	Foliar application	Main stem height (cm)	Nodes on main stem	Inter-nodal length (cm)
T1(Control)	Foliar spray of water alone	113	44	2.57
	Foliar spray of B & Zn	112	42	2.67
T2 (0.05)	Foliar spray of proline alone	118	43	2.74
	Foliar application of proline + B & Zn	122	43	2.84
T3 (0.10)	Foliar spray of proline alone	129	47	2.74
	Foliar application proline + B &Zn	135	48	2.81
T4 (0.15)	Foliar spray of proline alone	128	45	2.84
	Foliar application of proline + B &Zn	129	45	2.87
T5 (0.20)	Foliar spray of proline alone	126	43	2.93
	Foliar application of proline + B &Zn	129	45	2.84
B & Zn effects				
Foliar spray without B & Zn		123	44.4	2.76
Foliar spray with B & Zn		125	44.6	2.84
Proline levels				
Control		113	43	2.63
0.05		120	43	2.79
0.10		132	48	2.75
0.15		129	45	2.87
0.20		128	44	2.91
LSD	Proline levels	6.39**	1.95**	ns
	Spray vs non-spray of B & Zn	ns	ns	ns
	Interaction	ns	ns	ns

**significant at p<0.01
ns = non-significant

Table 6.8 Effect of seed priming plus foliar spray of proline with and without micronutrients on seed cotton yield at 150 DAP

Proline levels (%)	Foliar application	seed cotton yield(kg ha^{-1})	GOT%
T1(Control)	Foliar spray of water alone	2580	44.8
	Foliar spray of B & Zn	2627	41.3
T2 (0.05)	Foliar spray of proline alone	2667	43.9
	Foliar application of proline + B & Zn	2726	42.7
T3 (0.10)	Foliar spray of proline alone	2932	42.6
	Foliar application proline + B &Zn	3104	41.1
T4 (0.15)	Foliar spray of proline alone	2939	40.7
	Foliar application of proline + B &Zn	3091	42.1
T5 (0.20)	Foliar spray of proline alone	2912	44.8
	Foliar application of proline + B &Zn	3085	38.2
B & Zn effects			
Foliar spray without B & Zn		2806	43.3
Foliar spray with B & Zn		2927	41.1
Proline levels			
Control		2604	43.1
0.05		2696	43.3
0.10		3018	41.9
0.15		3015	41.4
0.20		2998	41.5
LSD	Proline levels	379.4**	1.18**
	Spray vs non-spray of B & Zn	ns	0.63**
	Interaction	ns	1.39**

**significant at p<0.01
ns = non-significant

Table 6.9 Effect of seed priming plus foliar spray of proline with and without micronutrients on seed quality parameters in different treatments

Proline levels (%)	Foliar application	pH	EC (µS cm^{-1})	Na (%)	K (%)	Seed index (g)	Germi-nation (%)	Oil (%)	Free fatty acid (%)	Crude protein (%)
T1(Control)	Foliar spray of water alone	5.9	93	0.60	1.24	5.4	41	14.1	0.94	19.6
	Foliar spray of B & Zn	5.9	83	0.50	1.16	5.9	45	16.3	0.87	23.8
T2 (0.05)	Foliar spray of proline alone	6.0	103	0.62	1.29	5.6	47	15.1	0.82	21.7
	Foliar application of proline + B & Zn	5.9	100	0.55	1.18	6.0	52	17.7	0.81	24.6
T3 (0.10)	Foliar spray of proline alone	6.2	108	0.71	0.92	6.3	66	18.5	0.53	23.4
	Foliar application proline + B &Zn	6.1	122	0.61	0.87	7.0	73	22.3	0.47	27.4
T4 (0.15)	Foliar spray of proline alone	6.1	95	0.55	1.14	6.2	64	17.2	0.66	24.7
	Foliar application of proline + B &Zn	6.1	104	0.45	1.09	6.6	68	21.0	0.62	26.7
T5 (0.20)	Foliar spray of proline alone	6.1	94	0.45	1.05	5.9	54	16.6	0.70	22.8
	Foliar application of proline + B &Zn	6.1	92	0.35	0.98	6.2	55	19.3	0.68	23.2
B & Zn effects										
Foliar spray without B & Zn		6.07	99	0.59	1.12	5.9	54	16.1	0.73	22.4
Foliar spray with B & Zn		6.00	100	0.49	1.07	6.4	59	19.3	0.69	24.9
Proline levels										
Control		5.9	88	0.55	1.20	5.7	43	15.2	0.90	21.7
0.05		6.0	102	0.59	1.23	5.8	50	16.4	0.81	23.7
0.10		6.2	115	0.66	0.90	6.6	70	20.4	0.50	24.9
0.15		6.1	100	0.50	1.11	6.4	66	19.1	0.64	24.7
0.20		6.1	93	0.40	1.02	6.1	55	17.9	0.69	23.5
LSD	Proline levels	ns	13.54*	ns	0.06**	0.25**	11.2**	0.64**	0.10**	1.47**
	Spray vs non-spray of B & Zn	ns	ns	ns	0.05**	0.17**	4.67**	0.86**	0.06*	1.15**
	Interaction	ns	ns	ns	0.07*	ns	ns	ns	ns	2.58*

**significant at p<0.01
ns = non-significant

6.3 Soil-Plant-Water Relationships

6.3.1 Screening of advanced genotypes for drought tolerance

Irrigation water resources are squeezing day by day due to intensified agriculture. Non-judicious use of irrigation water for crop production increases cost of production on one hand whereas scarcity of water has adverse effects on crop production. Moreover, higher temperatures during the fruiting phase and irregular rains cause considerable losses in agricultural production. Although cotton plant is genetically xerophyte yet it requires regular supply of irrigation water for optimum production. Shortage of water results in poor plant growth, increased fruit abscission, lower yields and poor fibre quality in cotton. Cotton cultivars differ in acclimation to water stress environment owing to their morphology and genetic make-up. Tall statured and deep rooted genotypes coupled with efficient gas exchange characteristics may suffer less and show better performance under water stress conditions. Screening of advanced genotypes on the basis of physiological parameters of stress tolerance may provide a guideline to policy makers for varietal zoning and also for the breeders to develop varieties which may perform efficiently under water stress conditions.

Therefore, a field experiment was conducted at the experimental area of Central Cotton Research Institute, Multan during the cotton crop season 2017-18. A total of thirty-six cotton genotypes viz. BH-184, BH-201, BH-212, BH-221, BZU-05, CIM-343, CIM-616, CIM-632, CIM-663, CIM-717, CRIS-578, CYTO-313, CYTO-515, DEEBAL, DNH-40, FH-142, BAGHDADI, GH-HADI, HAMMAD, LAALZAR, MUBARIK, NIAB-878, NIAB-1042, NIAB-1048, NIAB-1064, NIAB-1089, NIAB-444, NIAB-545, SLH-19, SLH-33, SLH-377, SLH-378, SLH-381, SLH-6, VH-363 and ZAKRAYIA-01 were evaluated for their performance under normal irrigated viz. -1.6 $\pm$ 0.2 MPa leaf water potential (ψ_w) and water stressed (-2.4 $\pm$ 0.2 MPa ψ_w) conditions.

The treatments were laid out in RCBD with split-plot arrangement (water stress main plots; genotypes: sub-plots). Crop was sown on April 30, 2017. Water stress was imposed at squaring phase i.e. at 30 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 3012 m^3 in normal irrigated plots and 2610 m^3 in water stressed plots. A total precipitation of 94.8 mm (May-November) was received during the crop season.

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 stress treatments and among the genotypes. Main stem height varied from 77 cm to 155 cm, nodes on main stem from 36 to 54 and inter-nodal length from 2.02 to 3.07 cm in different genotypes. Averaged across genotypes, main stem height varied from 96 to 117 cm, nodes on main stem from 40 to 44 and inter-nodal length from 2.43 to 2.67 cm. Imposition of water stress caused a decrease of 18% in main stem height, 9% both in nodes on main stem and inter-nodal length. Averaged across the water stress treatment, main stem height varied from 89 cm to 122 cm, nodes on main stem from 37 to 46 and inter-nodal length from 2.29 cm to 2.93 cm in different genotypes (Table 6.10).

Data on seed cotton yield and its components revealed that seed cotton yield, number of bolls per plant and boll weight varied significantly with water stress and among genotypes. The number of bolls per plant varied from 13 to 35, boll weight from 2.12 to 4.33 g and seed cotton yield varied from 1211 to 3135 kg ha^{-1}, in different genotypes, irrespective of water regimes. Seed cotton yield, number of bolls per plant and boll weight decreased with the imposition of water stress. Consequently, seed cotton yield decreased from 2133 to 1759 kg ha^{-1}, bolls per plant from 22 to 19 and boll weight from 2.94 to 2.81g irrespective of the genotypes. The decrease, due to water stress, was 17.5% in seed cotton yield, 13.6% in bolls per plant and 4.4% in boll weight. Averaged across the water stress treatments, the seed cotton yield varied from 1263 to 2751 kg ha^{-1}, bolls per plant from 14 to 30 and boll weight from 2.24 to 4.29g in different genotypes. The genotype CIM-343 produced the maximum seed cotton yield (3135 kg ha^{-1}) with 28 bolls per plant and boll weight of 3.15g in normal irrigated plots. The genotype CIM-343 also surpassed in yield over all other genotypes irrespective of water stress treatments. In water stressed plots, although NIAB-878 produced the highest seed cotton yield of 2444 kg ha^{-1} however, it did not vary statistically from CIM-343. On overall basis, maximum average number of bolls per plant (30) were produced by NIAB-1089 while the maximum average boll weight (4.29g) was produced both by LALAZAR and BZU-05 (Table 6.11). The positive interactions among water stress treatments 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.

The observations regarding gas exchange characteristics like stomatal conductance (C), transpiration rate *(E)* and net photosynthetic rate *(P_N)* varied significantly with water stress and among the genotypes. Averaged across genotypes, C varied from 134 to 179 m mol CO_2 m^{-2} s^{-1}**,** *E* from 6.76 to 7.48 m mole H_2O $m^{-2}s^{-1}$ and P_N from 25.9 to 34.5 µ mol CO_2 $m^{-2}s^{-1}$. Imposition of water stress caused 25% decrease in C, 9.6% decrease in *E* and 25% decrease in P_N. Among the genotypes, C varied from 83 to 230 mmol CO_2 $m^{-2}s^{-1}$, *E* from 4.49 to 9.03 m mol H_2O $m^{-2}s^{-1}$, P_N from 15.2 to 59.2 µ mol CO_2 $m^{-2}s^{-1}$, irrespective of water stress treatments. Averaged across the water stress treatments, the genotype SLH-33 maintained the highest stomatal conductance while BH-221 maintained the highest net photosynthetic rate (Table 6.12). The P_N/E varied from 2.76 to 6.88 µ mol CO_2/ m mole H_2O in different genotypes and decreased from 4.70 to 3.89 µ mol CO_2/ m mole H_2O with the imposition of water stress (Table 6.13).

Table 6.10 Plant structure development in different cotton genotypes under two water regimes

Variety Name	Main stem height (cm)			Nodes on main stem			Inter-nodal length (cm)		
	No stress	Water stress	Mean	No stress	Water stress	Mean	No stress	Water stress	Mean
SLH-377	95	82	89	37	39	38	2.59	2.15	2.37
BH-184	98	96	97	39	37	38	2.53	2.58	2.56
BH-212	98	95	97	39	42	41	2.49	2.27	2.38
DEEBAL	101	84	93	38	36	37	2.64	2.32	2.48
NIAB-444	102	103	103	39	39	39	2.61	2.68	2.65
CIM-663	102	91	96	41	40	40	2.48	2.30	2.39
CRIS-578	103	96	100	42	39	41	2.44	2.48	2.46
BAGHDADI	103	102	103	42	38	40	2.44	2.71	2.58
SLH-378	105	83	94	43	39	41	2.44	2.14	2.29
NIAB-1042	109	107	108	47	46	46	2.34	2.34	2.34
BH-201	109	98	104	40	39	40	2.70	2.51	2.61
DNH-40	110	101	106	43	41	42	2.54	2.45	2.50
ZAKRAYIA-1	110	82	96	41	38	40	2.66	2.17	2.41
GH-Hadi	111	97	104	41	42	41	2.73	2.31	2.52
CIM-632	111	86	99	42	38	40	2.63	2.25	2.44
BH-221	113	82	98	45	37	41	2.50	2.23	2.36
N-878	115	100	108	48	42	45	2.40	2.38	2.39
SLH-33	116	109	112	41	38	39	2.85	2.87	2.86
FH-142	116	100	108	50	41	46	2.31	2.43	2.37
SLH-19	117	103	110	44	42	43	2.63	2.45	2.54
NIAB-545	117	93	105	43	41	42	2.71	2.28	2.49
NIAB-1089	118	119	119	48	44	46	2.47	2.72	2.59
SLH-381	118	93	106	41	39	40	2.92	2.40	2.66
CYTO-313	123	109	116	40	39	40	3.07	2.80	2.93
BZU-5	123	94	108	43	40	41	2.85	2.37	2.61
NIAB-1048	123	89	106	46	39	43	2.70	2.26	2.48
NIAB-1064	127	109	118	45	41	43	2.79	2.71	2.75
HAMMAD	127	90	109	45	37	41	2.82	2.47	2.65
CIM-616	130	108	119	46	43	45	2.81	2.52	2.66
MUBARIK	133	86	109	45	40	43	2.93	2.15	2.54
CIM-343	136	102	119	49	39	44	2.75	2.60	2.67
SLH-6	137	103	120	49	36	43	2.80	2.87	2.84
LAALZAR	137	77	107	47	38	43	2.89	2.02	2.45
CIM-717	138	95	117	48	39	43	2.91	2.47	2.69
VH-363	139	105	122	47	40	44	2.95	2.60	2.78
CYTO-515	155	79	117	54	38	46	2.89	2.07	2.48
Mean	117	96		**44**	**40**		**2.67**	**2.43**	
LSD Irrigation level	287**			3.97**			0.20**		
LSD Genotypes	172**			4.02**			0.24**		
LSD Interaction	244**			5.68^{ns}			0.34*		

No stress = (-1.6 ± 0.2 MPa ψ_w)
Water stress = (-2.0 ± 0.2 MPa ψ_w)

* Significant at p<0.05 level
**Significant at p<0.01 level
ns = non-significant

Table 6.11 Seed cotton production by different genotypes under normal and water stressed irrigation

Variety Name	Seed cotton yield (kg ha^{-1})			Bolls per plant			Boll weight (g)		
	No stress	Water stress	Mean	No stress	Water stress	Mean	No stress	Water stress	Mean
CIM-343	3135	2367	2751	28	23	26	3.15	2.76	2.96
LALAZAR	3057	2230	2644	21	17	19	4.32	4.25	4.29
CYTO-313	2774	2166	2470	30	25	28	2.43	2.37	2.40
CIM-616	2724	1979	2352	24	19	22	3.32	3.23	3.28
CYTO-515	2719	2351	2535	25	22	24	3.20	3.06	3.13
NIAB-878	2672	2444	2558	30	23	27	2.42	2.27	2.35
MUBARIK	2571	1915	2243	24	20	22	3.40	3.33	3.37
SLH-6	2512	1742	2127	19	18	19	4.13	4.06	4.10
NIAB-1048	2492	1726	2109	24	18	21	2.68	2.65	2.67
NIAB-1089	2465	1806	2136	35	24	30	2.09	2.06	2.08
DEEBAL	2436	1842	2139	28	23	26	2.88	2.51	2.70
GH-HADI	2403	2348	2376	21	20	21	3.51	3.31	3.41
CIM-663	2399	1985	2192	21	20	21	3.03	2.72	2.88
VH-363	2274	2116	2195	22	20	21	3.12	3.10	3.11
BZU-05	2270	2116	2193	17	16	17	4.33	4.25	4.29
NIAB-545	2225	1930	2078	24	18	21	2.54	2.49	2.52
FH-142	2180	1671	1926	22	16	19	2.90	2.88	2.89
BH-184	2124	2055	2090	21	20	21	3.09	3.02	3.06
NIAB-1064	2047	1327	1687	22	17	20	2.58	2.56	2.57
CIM-632	2009	1677	1843	23	19	21	2.99	2.80	2.90
DNH-40	2000	1533	1767	21	18	20	2.62	2.25	2.44
BH-221	1915	1573	1744	19	18	19	2.83	2.73	2.78
BAGHDADI	1877	1789	1833	22	21	22	2.80	2.78	2.79
HAMMAD	1858	1522	1690	21	18	20	2.74	2.53	2.64
SLH-33	1833	1610	1722	17	16	17	2.99	2.59	2.79
SLH-378	1806	1231	1518	22	16	19	2.73	2.63	2.68
NIAB-444	1780	1731	1756	22	21	22	2.53	2.49	2.51
ZAKRAYIA-01	1775	1491	1633	21	18	20	3.02	2.89	2.96
SLH-381	1626	1425	1526	17	16	17	2.92	2.81	2.87
CIM-717	1620	1419	1520	17	15	16	2.73	2.67	2.70
BH-212	1606	1461	1534	17	15	16	2.87	2.76	2.82
SLH-19	1600	1432	1516	19	17	18	2.63	2.60	2.62
NIAB-1042	1596	1412	1504	21	20	21	2.36	2.12	2.24
BH-201	1573	1367	1470	19	18	19	2.67	2.64	2.66
CRIS-578	1537	1319	1428	19	17	18	2.44	2.20	2.32
SLH-377	1314	1211	1263	15	13	14	2.86	2.82	2.84
Mean	**2133**	**1759**		**22**	**19**		**2.94**	**2.81**	
LSD Irrigation level	287**			1.86**			0.11**		
LSD Genotypes	172**			2.24**			0.18**		
LSD Interaction	244**			3.17*			0.24**		

No stress = (-1.6 $\pm$ 0.2 MPa ψ_w); Water stress = (-2.0 $\pm$ 0.2 MPa ψ_w)
*significant at p<0.05 level; **significant at p<0.01 level

Table 6.12 Interactive effects of genotypes and water stress on gas exchange characteristics

Variety Name	Net photosynthetic rate P_N (µmol CO_2 $m^{-2}s^{-1}$)			Transpiration rate E (mmol H_2O $m^{-2}s^{-1}$)			Stomatal conductance C (mmol CO_2 $m^{-2}s^{-1}$)		
	No stress	Water stress	Mean	No stress	Water stress	Mean	No stress	Water stress	Mean
CIM-343	45.3	26.3	35.8	9.03	6.54	7.79	188	136	162
LAALZAR	44.4	27.6	36.0	7.08	6.84	6.96	196	121	159
CYTO-313	50.0	26.1	38.1	7.95	6.48	7.21	212	172	192
CIM-616	43.5	25.4	34.5	8.17	6.94	7.56	196	92	144
CYTO-515	36.2	27.3	31.8	7.80	7.01	7.40	179	144	162
N-878	46.4	25.3	35.9	5.25	5.14	5.20	192	144	168
MUBARIK	26.6	17.0	21.8	7.94	7.46	7.70	156	134	145
SLH-6	36.8	29.3	33.1	7.18	7.81	7.50	187	129	158
NIAB-1048	30.1	28.2	29.2	6.83	6.89	6.86	145	119	132
NIAB-1089	31.9	23.8	27.9	5.32	6.32	5.82	157	123	140
DEEBAL	28.2	17.3	22.8	7.89	5.15	6.52	201	168	185
GH-HADI	29.7	24.0	26.9	6.16	4.49	5.33	195	142	169
CIM-663	35.5	31.2	33.4	7.17	8.87	8.02	168	108	138
VH-363	33.1	30.5	31.8	6.56	4.60	5.58	174	132	153
BZU-05	37.2	28.6	32.9	7.55	6.48	7.02	143	174	159
NIAB-545	47.9	43.6	45.8	8.04	7.75	7.89	186	158	172
FH-142	34.7	21.7	28.2	7.85	7.99	7.92	173	134	154
BH-184	29.8	25.6	27.7	6.44	5.29	5.87	141	115	128
NIAB-1064	22.2	18.9	20.6	8.16	6.57	7.37	193	114	154
CIM-632	34.1	24.7	29.4	6.95	6.56	6.75	175	105	140
DNH-40	30.8	25.3	28.1	7.43	6.45	6.94	153	115	134
BH-221	59.2	33.0	46.1	8.59	8.09	8.34	175	154	165
BAGHDADI	32.6	29.4	31.0	8.67	7.35	8.01	180	152	166
HAMMAD	36.6	24.4	30.5	8.39	7.97	8.18	211	105	158
SLH-33	38.0	34.2	36.1	7.19	6.71	6.95	230	182	206
SLH-378	28.4	20.5	24.5	7.76	6.85	7.30	179	83	131
NIAB-444	26.1	15.2	20.7	8.01	6.73	7.37	175	155	165
ZAKRAYIA-01	36.6	30.2	33.4	8.89	7.92	8.41	171	145	158
SLH-381	28.6	26.8	27.7	7.89	5.92	6.91	154	124	139
CIM-717	28.8	25.3	27.1	8.59	7.73	8.16	194	149	172
BH-212	22.7	24.4	23.6	6.95	6.44	6.69	178	117	148
SLH-19	27.1	25.9	26.5	7.48	6.87	7.18	164	139	151
NIAB-1042	36.5	26.1	31.3	4.59	6.11	5.35	191	153	172
BH-201	26.4	21.4	23.9	8.16	7.63	7.90	161	142	152
CRIS-578	26.4	23.3	24.9	7.21	6.64	6.93	154	125	140
SLH-377	33.4	23.6	28.5	8.10	6.93	7.52	198	126	162
Mean	34.5	25.9		7.48	6.76		179	134	
LSD Irrigation level		287**			1.86**			0.11**	
LSD Genotypes		172**			2.24**			0.18**	
LSD Interaction		244**			3.17*			0.24*	

*significant at p<0.05 level; **significant at p<0.01 level

Table 6.13 Physiological water use efficiency of different genotypes in normal irrigated and water stressed plots

Variety Name	P_N/E (µmol CO_2 / mmol H_2O)		
	No stress (-1.6 ± 0.2 MPa ψ_w)	Water stress (-2.0 ± 0.2 MPa ψ_w)	Mean
CIM-343	5.02	4.02	4.52
LAALZAR	6.27	4.04	5.15
CYTO-313	6.29	4.03	5.16
CIM-616	5.32	3.66	4.49
CYTO-515	4.64	3.89	4.27
N-878	8.84	4.92	6.88
MUBARIK	3.35	2.28	2.81
SLH-6	5.13	3.75	4.44
NIAB-1048	4.41	4.09	4.25
NIAB-1089	6.00	3.77	4.88
DEEBAL	3.57	3.36	3.47
GH-HADI	4.82	5.35	5.08
CIM-663	4.95	3.52	4.23
VH-363	5.05	6.63	5.84
BZU-05	4.93	4.41	4.67
NIAB-545	5.96	5.63	5.79
FH-142	4.42	2.72	3.57
BH-184	4.63	4.84	4.73
NIAB-1064	2.72	2.88	2.80
CIM-632	4.91	3.77	4.34
DNH-40	4.15	3.92	4.03
BH-221	6.89	4.08	5.49
BAGHDADI	3.76	4.00	3.88
HAMMAD	4.36	3.06	3.71
SLH-33	5.29	5.10	5.19
SLH-378	3.66	2.99	3.33
NIAB-444	3.26	2.26	2.76
ZAKRAYIA-01	4.12	3.81	3.97
SLH-381	3.62	4.53	4.08
CIM-717	3.35	3.27	3.31
BH-212	3.27	3.79	3.53
SLH-19	3.62	3.77	3.70
NIAB-1042	7.95	4.27	6.11
BH-201	3.24	2.80	3.02
CRIS-578	3.66	3.51	3.59
SLH-377	4.12	3.41	3.76
Mean	**4.70**	**3.89**	

6.4 Heat Tolerance

6.4.1 Adaptability of genotypes to temperature stress

Current rise in temperature is likely to continue during this century and extreme events associated with this rise are also expected to increase in frequency, intensity and persistence increasing the uncertainty in sustainable crop production. An optimum temperature range of 20 to 30°C has been reported for cotton, but cotton is successfully grown at temperatures in excess of 40°C in Pakistan. Climatic anomalies will play an important role in increasing the uncertainties in cotton production. Productivity of cotton genotypes falls markedly at high temperatures. Higher night temperatures give rise to increase in respiration hence reducing the net gain of cotton yield. Sudden shoot up of air temperatures in cotton crop at reproductive stage of their life cycle causes significant reductions in the cotton yield despite affecting the apparent health of the crops. There is no clear consensus about the optimum temperature for cotton as plant response varies with developmental stage and plant organ. 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 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 have been well documented. Although adverse temperatures can affect all stages of development, the crop seems to be particularly sensitive to adverse temperatures during reproductive development. The arid areas of Pakistan where the evapo-transpiration rate is already high and water table is shallow, an increase in air temperature may cause loss of water rapidly and consequently the aridity would increase which are the major threats to agriculture and food security. Therefore, the screening of advanced strains for thermal stress tolerance provides basic guidelines to the breeders as well as for the purpose of varietal zoning. Screening is carried out by planting cotton genotypes during mid-April to coincide their fruiting phase with the hottest period of season. Thirty-five genotypes were planted for screening under heat stress conditions.

Genotypes showed wide variation in various physiological parameters conferring to heat tolerance in cotton. Genotype GH-Hadi excelled in heat tolerance considering each trait compared with the other genotypes. Genotype SLH-377 was found to be the most susceptible genotype to heat stress (Table 6.14).

Physiological traits having relevance to heat tolerance were recorded in the genotypes. Results showed that there were positive correlations of pollen viability (r=0.97), percent boll set on first (r=0.91) and second (r=0.90) positions along sympodia with seed cotton yield. There were negative correlations of cell injury (r= -0.98) and electrical conductivity (r= -0.90) with the seed cotton yield. It is suggested that these traits may be taken into account while selecting future genotypes to overcome heat stress problems (Table 6.15).

The dehiscence of anthers declined during the month of July and started to increase gradually from 1st week of August reaching upto maximum later in the month of September. The dehiscence of anthers during the season for three genotypes is depicted in Fig. 6.1.

Genotypes differed greatly in their yield performance. The genotype GH-Hadi produced the highest seed cotton yield than the other genotypes tested. Seed cotton yield of different genotypes ranged from 1564 to 3075 kg ha^{-1} (Table 6.16).

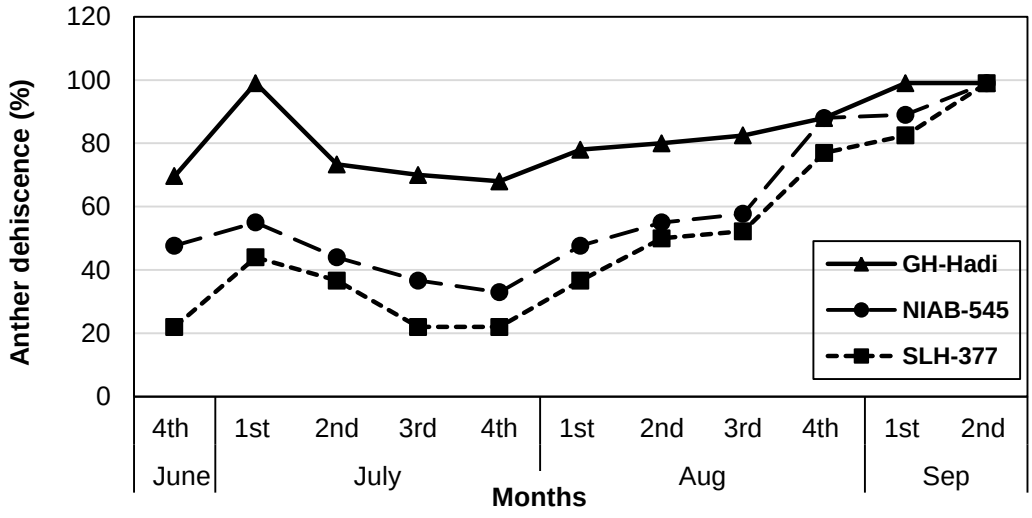

Fig. 6.1 Dehiscence of anthers during the season for three genotypes

Table 6.14 Physiological traits for determining heat tolerance in different genotypes

Genotypes	AD (%)	PV (%)	FSNN	FSNH	SNNFB	SNHFB	% BSFP	% BSSP	RCIL (%)	EC (µS cm^{-1})
GH-Hadi	95	96	13	10	16	19	44	32	32	175
CYTO-313	92	94	16	10	17	21	37	31	34	199
BH-212	91	93	17	9	18	20	33	27	36	266
HAMMAD	90	91	16	9	17	21	32	22	37	185
CYTO-515	89	92	15	9	16	20	26	22	40	295
NIAB-545	89	91	14	8	18	22	24	20	40	243
BZU-5	85	90	16	8	19	23	23	19	41	279
N-878	84	90	13	7	14	19	23	19	41	231
LAALZAR	84	89	12	8	14	20	23	19	43	261
NIAB-1048	84	88	12	8	16	20	22	18	43	301
CIM-343	82	85	15	9	18	21	22	18	43	308
BH-221	81	82	16	9	17	19	21	18	44	331
CIM-663	81	82	16	10	17	21	21	17	44	363
MUBARIK	80	83	12	9	15	20	20	17	44	272
NIAB-1089	80	83	15	9	16	20	20	17	46	342
ZAKRAYIA-1	79	80	16	8	17	20	20	16	48	327
DEEBAL	78	81	16	10	17	22	20	16	52	334
FH-142	77	82	14	9	15	19	20	16	53	367
VH-363	74	80	16	10	17	20	19	15	53	365
SLH-6	72	78	11	7	13	18	19	15	55	331
BH-184	67	77	14	9	17	21	17	14	56	359
NIAB-1064	66	78	14	9	16	20	17	14	56	380
DNH-40	65	79	18	10	19	21	17	14	58	383
CRIS-613	65	75	13	9	14	20	16	14	60	375
CIM-717	64	72	15	9	16	23	16	14	65	387
SLH-33	64	70	15	9	16	18	15	13	67	389
BAGHDADI	62	71	15	9	16	21	14	13	72	384
SLH-378	62	73	14	9	16	20	14	13	73	396
NIAB-444	61	70	15	9	19	24	13	13	75	403
SLH-381	59	67	15	8	17	23	13	12	75	393
BH-201	57	66	14	8	15	18	12	12	76	397
NIAB-1042	56	63	12	9	13	18	11	12	76	406
SLH-19	55	62	15	9	18	23	10	10	85	402
CRIS-578	54	60	15	9	17	21	10	9	88	408
SLH-377	50	60	14	8	15	20	10	8	92	412
LSD	9.77**	12.84**	5.1**	3.00**	5.74**	5.09**	8.20**	5.51**	8.04**	10.08**

***significant at p<0.01*

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

Table 6.15 Correlations between seed cotton yield and physiological traits determining heat tolerance

	AD%	PV(%)	%BSFP	%BSSP	RCIL (%)	EC	NBPP	BW (g)
PV (%)	0.97**							
% BSFP	0.90**	0.89**						
% BSSP	0.88**	0.88**	0.98**					
RCIL (%)	-0.97**	-0.97**	-0.86**	-0.84**				
EC (µS cm^{-1})	-0.90**	-0.88**	-0.90**	-0.89**	0.85**			
NBPP	0.60**	0.58**	0.58**	0.60**	-0.59**	-0.54**		
BW (g)	0.12^{ns}	0.15^{ns}	0.08^{ns}	0.10^{ns}	-0.12^{ns}	-0.08^{ns}	-0.34**	
SCY(kg ha^{-1})	0.99**	0.97**	0.91**	0.90**	-0.98**	-0.90**	0.60**	0.11^{ns}

AD : Anther Dehiscence
PV : Pollen viability
BSFP : Boll Set on First Position
BSSP : Boll Set on Second Position
RCIL : Relative ell Injury Level
EC : Electrical Conductivity
NBPP : Number of Bolls Per Plant
BW : Boll Weight
SCY : Seed Cotton Yield

Table 6.16 Seed cotton yield in different genotypes planted in mid-April

Genotypes	Seed cotton yield (kg ha^{-1})	Number of bolls per plant	Boll weight (g)
GH-Hadi	3075	25	3.12
CYTO-313	3028	32	2.41
BH-212	2779	26	2.99
HAMMAD	2730	27	2.65
CYTO-515	2722	26	2.80
NIAB-545	2693	27	2.26
BZU-5	2692	20	4.15
N-878	2685	29	2.24
LAALZAR	2640	17	4.14
NIAB-1048	2632	24	2.62
CIM-343	2623	24	2.75
BH-221	2613	24	2.58
CIM-663	2557	24	2.87
MUBARIK	2460	18	2.97
NIAB-1089	2423	34	2.56
ZAKRAYIA-1	2394	20	2.49
DEEBAL	2390	21	2.88
FH-142	2304	20	3.63
VH-363	2296	18	2.81
SLH-6	2291	16	2.54
BH-184	2238	21	2.75
NIAB-1064	2120	20	3.00
DNH-40	2070	19	2.77
CRIS-613	2027	27	2.52
CIM-717	2011	26	2.06
SLH-33	1982	20	2.03
BAGHDADI	1921	18	3.03
SLH-378	1887	18	2.65
NIAB-444	1817	17	2.87
SLH-381	1795	16	2.38
BH-201	1721	16	2.83
NIAB-1042	1712	19	3.84
SLH-19	1678	18	2.87
CRIS-578	1609	20	2.26
SLH-377	1564	16	2.70
LSD	105.7**	7.79**	0.39**

**significant at p<0.01

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7. TRANSFER OF TECHNOLOGY SECTION

Transfer of Technology Section is playing a significant role to disseminate the research findings/ practices for the development of new cotton production & seed technology to farming community & other stakeholders through electronic and print media.

7.1 Human Resource Development

7.1.1 Training Programs

The following training programs were arranged during the season:

i) Agronomy of the cotton crop
ii) Cotton Production Technology
iii) Advanced breeding techniques for variety evolution
iv) Production Technology of new approved commercial cotton varieties
v) Seed Technologies
vi) Seed Health and nutrient management
vii) Interspecific hybridization in cotton: Present status at CCRI, Multan
viii) Better management of CCRI varieties
ix) Performance of cotton varieties and their production technology
x) Pesticide industries management, new chemistry of pesticides and integrated pest management
xi) Management of cotton diseases
xii) Cotton crop management
xiii) New challenges of insect pest of cotton
xiv) Causes of fibre traits deterioration in Pakistan
xv) Management of PBW & sucking insect pests
xvi) Application of PB-Rope & Sucking Insect Pest Management
xvii) Use of PB Rope for the management of Pink Bollworm & field demonstration on "Application of PB-Rope"

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

Date	Organized/ Coordinated by	Venue	Resource Person	Participants
27.04.2017	CCRI, Multan	CCRI, Multan	i.Dr. Zahid Mahmood ii. Dr. Fiaz Ahmad iii. Dr. Naveed Afzal iv. Ms. Rehana Anjum v.Dr. Idrees Khan vi. Dr. M Naveed vii.Ms. Sabahat Hussain viii. M Ilyas Sarwar	**Total=19** Field officers of Pesticides, Seed & Fertlizer Industries
28.04.2017	Agr. Ext.Deptt. Multan	Moza Feroz Pur ,Multan	Dr. Muhammad Naveed	**Total= 72** Farmers = 59 Director Ext. =01 Deputy Director Ext. =01 F.A =11
10.05.2017	CCRI, Multan	CCRI, Multan	i.Dr. Muhammad Naveed ii. Dr. Fiaz Ahmad iii Dr. M. Naveed Afzal	**Total=15** Officers Pesticides Company, Sygenta
15.05.2017	-do-	-do-	-do-	**Total=159** Technical staff of Agri. Extension & Pest Warning & Quality Control of different districts of Punjab

Date	Organized/ Coordinated by	Venue	Resource Person	Participants
May 17-19,2017	PCCC	CCRI, Multan	i. Dr. Muhammad Naveed ii. Dr. Fiaz Ahmad iii Ms. Rehana Anjum	**Total=05** Extension & Research officers from KPK & Baluchistan
30.05.2017	CCRI, Multan	Dr. Mehboob Ali Auditorium	Dr. Muhammad Naveed	**Total=147** Technical staff of Agri. Extension & Pest Warning & Quality Control of different districts of Punjab
08.07.2017	Pakistan Kissan Forum (PKF)	Mian Chanuu	i. Dr. Zahid Mahmood ii. Dr. M. Naveed iii. Dr. Idrees Khan	**Total=52** Farmers =47 NGO's Staff =05
01.09.2017	PCSI, Multan	CCRI, Multan	Dr. Muhammad Naveed Afzal	**Total=23** Cotton Selectors
13.09.2017	Agri. Ext. Dept. Lodhran	Lodhran	Dr. Muhammad Naveed	**Total = 511** Farmers = 500 EDO = 01 DDO = 01 DO = 01 A.O = 03 F.A = 05
15.12.2017	Agri.Ext.Sindh & South Asian Conservation Agriculture	CCRI ,Multan	i. Dr. Zahid Mahmood ii. Dr. Fiaz Ahmad iii. Dr. Idrees Khan	**Total = 22** P.Farmers = 18 M.Trainee = 04
22.02.2018	PCSI. Multan	CCRI, Multan	i. Dr. Zahid Mahmood ii. Dr. M.Naveed Afzal	**Total =20** Cotton Selectors
02.03.2018	PCSI, Multan	PCSI, Multan	Danish Iqbal	**Total =20** Cotton Selectors

7.1.2 Training Program of FAO

Following two training programs by FAO were conducted at CCRI, Multan during the season:

Date	Venue	Title	Organized by	Participants
22.08.2017	CCRI, Multan	"Training of Trainers (ToT) Program on Field Inspection of Cotton and Rice Seed Crops and Early Generation Seed (EGS) Production"	Food and Agriculture Organization (FAO)	Dr. Zahid Mahmood, Director CCRI Multan delivered lecture on "Procedure and Guidelines for Early Generation Seed Production in Cotton Crop". to representative from FSCR&D and other private sector organizations(37)
25.10.2017	-do-	-do-	-do-	-do-

7.1.3 Farmers Field Day Program

Farmers Field Day Program was organized on 28th September, 2017 at the institute in collaboration with CCRI Multan and M/s Kanzo AG group for field demonstration of cotton varietal performance and application of insecticides for pest management. Around 150 farmers attended the program. Director CCRI Multan, Dr.Zahid Mahmood delivered the lecture to the farmers for better cotton production technology.

7.1.4 TV Programs

The following TV programs were conducted during the season:

Date	TV Channel	Topic	Resource Person	Remarks/Timing
04.09.2017	Rohi, Multan	Affects of rain on Cotton & precautionary measures against pests	Dr. Zahid Mahmood	Recorded/5Minutes
08.09.2017	-do-	Yield potential and performance of upcoming cotton varieties of CCRI	Dr. Zahid Mahmood	Recorded/4Minutes
14.09.2017	-do-	Role of PCCC Varieties and their performance	Dr. M. Idrees Khan	Recorded/4Minutes
-do-	-do-	Cotton research activities & steps taken for the solution of crop issues	i. Dr. Fiaz Ahmed ii. Ms. Sabahat Hussain	Live Broadcast
20.10.2017	Rohi, Multan	Future of Zarat in Pakistan regarding with new Dams and other water reservoirs	Syed Javed Ali Shah	Recorded/10Minutes
-do-	-do-	Govt. Policies for the promotion of cotton in Pakistan	Haji M. Akram Ansari	Recorded/15Minutes
-do-	-do-	Current situation of cotton crop	Dr. Khalid Abdullah, VP,PCCC	Recorded/15Minutes
01-11-2017	Rohi, Multan	Impact of Smog on Crops	Dr. Zahid Mahmood	Recorded/10Minutes
21-11-2017	Waseb, Multan	Introduction of Mechanical Picking at the institute	Dr. Zahid Mehmood	Recorded/3-Minutes
-do-	-do-	Crops prepared for Mechanical Picking	Dr. M.Idrees Khan	Recorded/3-Minutes
30.11.2017	PTV, Multan	Mechanical Picking	Dr. Zahid Mahmood	Recorded/03Minutes
05.12.2017	PTV, Multan *Kissan Bethak*	Development of Agriculture Sector	i. Prof. Dr. Asif Ali ii. Dr. Zahid Mahmood iii. Mr. Asif Majeed	Recorded/35Minutes
07.12.2017	-do-	CCRI Achievements in Cotton Research & Development	Dr. Zahid Mehmood	Recorded/3-Minutes
26.12.2017	AbTak, Multan	Mechanical Picking	Dr. Zahid Mahmood	Recorded/05Minutes
-do-	-do-	Cotton Production Technology for Mechanical Picking	Dr. M. Idrees Khan	Recorded/03Minutes

7.1.5 TV/Press Coverage

The section arranged media coverage for various meetings/seminar during the season:

Date	Media Coverage
24.03.2017	Seminar on “Pink Boll Worm & its Management”
Mar 28-30, 2017	Agriculture Research Sub-Committee (ARSC) Meeting
28.03.2017	Meeting of National Assembly Standing Committee on Textile Industry
10.04.2017	Seminar on **“**Cotton Production Technology & CLCuV Management”
27.04.2017	Cotton Crop Management Group (CCMG) Meeting
09-10-2017	MoU Signing Ceremony b/w PCCC & ICRA
14.10.2017	**“**Cotton Travelling Seminar 2017 at CCRI Multan”
20.10.2017	Seminar on "Soil Health Improvement and Nutrition Management”
Nov 21-22, 2017	6th International Conference of Pakistan Phytopathological Society "Plant Health for Sustainable Agriculture
30.11.2017	Demonstration of Mechanical Cotton Picking

7.1.6 Preparation of Video Clips

Following video clips were prepared for farmer's advice/information during the season:

Date	Topic	Remarks
13.08.2017	Recommendations to avoid cotton fruit fall	Uploaded on CCRI FB official page
14.09.2017	Cotton Travelling Seminar 2017 at CCRI Multan	-do-
16.09.2017	Mealy bug Identification & its Management	-do-
26.09.2017	سی سی آر آئی ملتان کے تجرباتی کھیتوں میں لگی کپاس کی نئی اقسام کی کارکردگی	-do-
28.09.2017	سی سی آر آئی ملتان میں فارمرز فیلڈ ڈے پروگرام	-do-
09.10.2017	MoU Signing Ceremony b/w PCCC & ICRA	-do-
12.10.2017	Dr. Michael Fok ,Chairman ICRA visiting to Progressive Farmers in Mailsi &Vehari	-do
25.10.2017	پاکستان کی تاریخ میں پہلی مرتبہ کپاس کی مشینی چنائی کا عملی مظاہرہ	-do-
29.10.2017	کپاس 2017 کی صورتحال پر تبصرہ: کاٹن کمشنر ڈاکٹر خالد عبداللہ	-do-
14.11.2017	Goats grazing in the cotton fields after last picking	-do
27.11.2017	Cotton Variety Bt-343: Interview Director CCRI Multan	-do-

7.1.7 Radio Programs

The following Radio programs were recorded during the season:

Date	Radio	Topic	Resource Person	Remarks
03.04.2017	Radio Pakistan, Multan	Talk on "پانی کی کمیابی کے تناظر میں کپاس کی بہتر پیداوار"	Dr. Fiaz Ahmad	Recorded & on air 5-minutes
-do-	-do-	Talk on " کپاس کی بہتر پیداوار کے لیے زمین کے تجزیہ کی اہمیت"	-do-	Recorded & on air 5-minutes
-do-	-do-	Talk on" Control of sucking insect pest at early stage of cotton"	Dr. Muhammad Naveed	Recorded & on air 5-minutes
13.04.2017	Radio Pakistan Multan	Talk on "Pink Bollworm Management"	Dr. Muhammad Naveed	Recorded & on air 5-minutes
-do-	-do-	Talk on "Use of fertilizer and irrigation requirement for cotton crop"		
17.04.2017	FM-Solo 88, Multan	Talk on "Management strategy against Pink Bollworm in collaboration with agri. extension dept. (Punjab), PW&QC and CCRI, Multan"	Dr. Muhammad Naveed	Recorded & on air 5-minutes
-do-	-do-	Talk on "Management of sucking insect pests at early stage of Cotton"	Dr. Muhammad Naveed	Recorded & on air 5-minutes
-do-	-do	Talk on "Dusky cotton bug, mode of damage & its control"	Ms. Shabana Wazir	Recorded & on air 4-minutes
-do-	-do	Talk on "Management of CLCuV"	Ms. Sabahat Hussain	Recorded & on air 5-minutes
19.04.2017	Radio Pakistan ,Multan	Talk on "Climatic change and cotton"	Ms. Asiya Perveen	Recorded & on air 5-minutes
21.04.2017	Radio Pakistan, Multan	Talk on "Climatic Change & Cotton"	Ms. Asia Perveen	Recorded & on air 5-minutes
26.04.2017	FM 98, Multan	Talk on "Selection of cotton for core and non-core zones of cotton"	Dr. Muhammad Idrees Khan	Recorded & on air 7-minutes
30.05.2017	FM SOLO-88, Multan	Group discussion on "Early protection for sucking insect pests of cotton"	Muhammad Naveed Rabia Saeed s. Shabana Wazir	Recorded & on air 30-minutes

13.07.2017	Radio Pakistan, Multan	Talk on " کپاس کی بیماریاں اور ان کا تدارک"	Ms. Sabahat Hussain	Recorded & on air 5-minutes
13.01.2018	FM-101,Multan	Interview on "Cotton seed purity issues & their solutions	Hafiz M.Imran,SO	Recorded /05Minutes

7.1.8 Preparation of a documentary film by Radio Pakistan, Multan

A documentary film on "Research activities of CCRI Multan" was prepared by the section in coordination with Radio Pakistan, Multan on October 27, 2017 during the season.

7.1.9 Press Releases

Forty one (41) press releases throughout the season were sent to the press time to time for publication.

7.1.10 Articles

Three (03) Urdu articles with up to date recommendations were composed and sent to the press for the guidance of cotton growers during the season.

7.1.11 Cotton Review 2017

On the request of Daily Jang, Multan, a cotton review 2017 report was prepared by the section and sent for publish on December 20,2017.

7.1.12 Tele-Cotton SMS Service

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

a. Fifty Eight (58) Tele-Cotton SMS were sent to more than 10,000 cotton growers, extension workers and other stakeholders regarding better crop management during the season.
b. Almost Six Thousand (6000) clients of Tele-Cotton were registered in database during the season.

7.1.13 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.

7.1.14 Preparation of Leaflet

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

Leaflet	Nos.
Management of PBW by PB-Rope کپاس کی گلابی سنڈی کا تدارک بزریعہ پی بی - روپ	2000
Cyto-124	800
Cyto-179	800
CIM-573	800
CIM-620	800
Bt.CIM-598	800
Bt.CIM-599	800
Bt.CIM-602	800
Recommendations for better seed germination	800

7.1.15 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*

7.1.16 Demonstration of Mechanical Picking

Date	Participants	Briefed by
30.11.2017	Media personals of national newspapers ,Radio & TV	Dr. Zahid Mahmood, Director
26.12.2017	Large no. of Growers, Stakeholders and Media Personals	-do-

7.2 Meetings

7.2.1 Agriculture Research Sub-Committee (ARSC)

Three days annual meeting of Agriculture Research Sub-Committee (ARSC) of Pakistan Central Cotton Committee (PCCC) was held at Central Cotton Research Institute (CCRI), Multan on March 28-30, 2017 under the chairmanship of Dr. Khalid, Abdullah, Vice President (PCCC)/Cotton Commissioner, MinTex. The agenda of the meeting was the consideration of Annual Summary Progress Report for the year 2016-17 and the approval of Annual Program of Research Work for the year 2017-18. 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 Six (06) Cotton Crop Management Group (CCMG) meetings were held at Central Cotton Research Institute, Multan/other venues during the season:

Date/Venue	Chaired by/Special guests
27.04.2017 CCRI, Multan	i. Mr. Naeem Akhtar Khan Bhaba, Minister for Agriculture, Punjab ii. Mr. Muhammad Mahmood, Secretary Agriculture, Punjab ii. Syed Fakhar Imam, Makhdum Ahmad Alam Anwar
15.05.2017 CCRI, Multan	i. Mr. Naeem Akhtar Khan Bhaba, Minister for Agriculture, Punjab ii. Mr. Muhammad Mahmood, Secretary Agriculture, Punjab, iii.Dr. Khalid Abdullah,Cotton Commissioner, Mintex
15.06.2017 CCRI, Multan	i. Abdul Rehman Ijaz Gondal, Additional Secretary Agriculture (Task Force) Punjab
20.07.2017 CCRI, Multan	i. Mr. Muhammad Mahmood, Secretary Agriculture, Punjab
17.08.2017 Bahawalpur	i. Mr. Muhammad Mahmood, Secretary Agriculture, Punjab ii. Syed Fakhar Imam, Ex. Speaker National Assembly iii. Dr. Khalid Abdullah, Cotton Commissioner, Mintex
07.10.2018 Jalal Pur Pirwala	i. Mr. Muhammad Naeem Akhtar Khan Bhaba, Agriculture Minister Punjab ii. Syed Fakhar Imam, Ex. Speaker National Assembly

Meeting was attended by all the stakeholders of cotton economy including Vice Chancellor, MNSUA, Multan, Director Generals (DGs) Extension, PW&QC, Research,

information and agri scientists, district officers' agriculture extension from Multan, Sahiwal, Bahawalpur and DG Khan Divisions, and senior officials of water management and energy, chief engineers of irrigation department, Punjab, representative of MEPCO, Multan and progressive growers, pesticides & fertilizers' companies' representatives were also there to share their opinions with the participants on different issues related to cotton. The section provided technical facilities to assist the meeting.

7.2.3 National Assembly Standing Committee on Textile Industry

The National Assembly Standing Committee on Textile Industry, held a meeting at the Institute on March 28, 2017 regarding activities of the PCCC in cotton promotion. Dr. Khalid Abdullah, Cotton Commissioner, Ministry of Textile Industry briefed the Committee in details about the cotton crop situation in all aspects. The Committee appreciated the efforts of the PCCC for encouraging the growth of cotton by using modern techniques and methods and recommended that massive awareness should be given to the cotton growers and farmers through electronic and press media which could be helpful to increase the cotton growth in the Country. The members of committee also visited various laboratories of the institute. The members of the Committee highly appreciated the research work conducted by the scientists of the institute. MNAs, Sardar Muhammad Shafqat Hayat Khan, Ms. Ghulam Bibi Bharwana, Malik Shakir Bashir Awan, Mr. Abdul Rashid Godil, Malik Abdul Ghaffar Dogar, Mr. Jamshaid Ahmed Dasti, attended the meeting, besides the officials of the PCCC & CCRI, Multan.

7.2.4 6th Meeting of Federal Cotton Committee

6th meeting of Federal Committee on Cotton (FCC) was held under the chairmanship of Dr. Khalid Abdullah, Cotton Commissioner, Ministry of Textile Industry, and Government of Pakistan on March 25, 2017. Representatives of Pakistan Central Cotton Committee (PCCC), Pakistan Metrological Department, Federal Plant Protection Department, Ministry of National Food Security & Research, Pakistan Bureau of Statistics, Zarai Tarqiati Bank Limited (ZTBL), National Fertilizer Development Corporation (NFDC), Federal Seed Certification & Registration Department (FSCR&D), Agriculture Department from Punjab, Sindh &Khyber Pakthun khawa and cotton farmers attended the meeting. The house unanimously agreed to fix the cotton area and production target. The section provided all type of technical facilities to organize this meeting.

7.2.5 Cotton Crop Assessment Committee Meeting

Following two meetings of Cotton Crop Assessment Committee (CCAC) were attended by the Director of the Institute held at Islamabad during the season:

Date	Chaired by
10.08.2017	Mr. Hassan Iqbal, Federal Secretary, Ministry of Textile Industry, Islamabad
02.11.2017	Mr. Hassan Iqbal, Federal Secretary, Ministry of Textile Industry, Islamabad

7.2.6 Steering Committee Meeting

A significant meeting of steering committee regarding Research Grants-Round-III under USAID was convened at Faisalabad on May 20, 2017 under the chairmanship of Prof Dr. Iqrar Ahmad Khan, Vice Chancellor University of Agriculture, Faisalabad. In presenting Session, Dr. Naveed, SSO/Head & Dr. Rabia Saeed.SO of Entomology Section of the Institute defended their research proposal "Insecticide Resistance Management of Pink Bollworm"

7.2.7 Better Cotton Initiative (BCI) meeting with ginners

Dr. Shafiq Ahmed, Head, Better Cotton Initiatives (BCI), coordinated a meeting with Cotton Ginners, farmers and refuse at CCRI, PCCC, Multan on July 6,2017. Agenda of the meeting was registration of to register the Cotton ginners of Multan and Muzaffargarh Districts to act as stakeholder with PCCC which will work as Implementing

Partner with BCI in both districts of Punjab province. Registration process for the growers for Better Cotton Production will also be done soon. Ministry of Textile Industry is financing this three years project through PSDP. 2-3 districts will also be taken on board in Sindh province. In coming years BC production program shall be expanded to whole cotton belt.

7.2.8 Project Steering Committee meeting

Project Steering Committee meeting of the PARB-Funded Project held at CCRI Multan on 22 September 2017 under the chairmanship of Prof. Dr. Muhammad Jalal Arif, Chairman, Department of Entomology, University of Agriculture, Faisalabad. The representative from collaborating partners of the project e.g., UAF, MNSUA, CCRI Multan attended the meeting. The project major activities include collaborative efforts for the management and control of Pink bollworm and cotton whitefly in the Punjab. Later the participants visited cotton fields of the Institute.

7.2.9 Cotton Production Plan 2018-19 Meeting

Dr. Zahid Mahmood, Director CCRI Multan attended meeting regarding "Cotton Production Plan 2018-19" held on 14.12.2017 under the chairmanship of Ch. Abdul Ghaffor, Director Agriculture Coordination (Farms & Training), Punjab Lahore at Ayub Agricultural Research Institute, Faisalabad. Dr. Zahid Mahmood proposed various measures for improvement and fine-tuning of cotton production technology brochures, stressed for continuation of off-season management of Pink bollworm and regular participation of scientists from CCRI Multan in farmers training programs.

7.2.10 Annual Review of Cotton Experiments

Annual review of cotton experiments was held at the institute on October 31, 2017. Dr. Zahid Mahmood, Director CCRI Multan inspected the performance of cotton experiments conducted by the Agronomy Section and Cytogenetics Section. Dr. Muhammad Naveed Afzal,Head Agronomy and Ms Rehana Anjum, Head, Cytogenetics briefed about the performance of various experiments conducted by the Sections. All scientific staff of the Institute was present on this occasion.

7.3 Seminars

7.3.1 National Seminar

The following seminars were conducted during the season:

Date/Venue	Title	Organized by	Participants
24.03.2017 CCRI, Multan	"Pink Boll Worm & its Management"	CCRI, Multan	Dr, Khalid Abdullah, Cotton Commissioner MinTex/ Vice President, PCCC, Khursheed Khan Kanjoo, Ex MPA, Khalid Khokhar, President Pakistan Kissan Ittehad, , Dr. Jasuu Paul ,Chairman PCGA Asif Majeed, Kanzo AG and other public stakeholders, private seed sector progressive farmers from all provinces attended this seminar. Almost more than 200 farmers attended this seminar.
10.04.2017 CCRI, Multan	**"**Cotton Production Technology & CLCuV Management"	CCRI, Multan	Naeem Akhtar Khan Bhaba, minister agriculture, Punjab chaired the seminar. Mr. Hassan Iqbal, Federal Secretary, Ministry of Textile, Industry, Dr, Khalid Abdullah, Cotton Commissioner MinTex/ Vice President, PCCC, Dr. Noor ul Islam, Chief Executive , PARB, Dr. Asif Ali , Vice Chancellor, MNSUA, Zafaryab Haidar, Director General Agriculture Extension(Punjab), and other public stakeholders, private seed sector progressive farmers from all provinces attended this seminar. Almost more than 250 farmers attended this seminar.

03.06.2017 Lodhran	“Use of PB Rope for PBW Management”	Agri. Extension Deptt. Lodhran	Deputy Commissioner Lodhran, Raja Khurram Shehzad, Chairman District Council Lodhran Mian Rajan Sultan Pirzada and large number of progressive cotton farmers attended the seminar. Dr. Naveed Cotton Entomologist CCRI, Multan delivered lecture on "Management of Pink Bollworm by using PB-Rope" to the participants of seminar.(Farmers=211)
01.08.2017 Piplan, Mianwali	“Management of Pink Bollworm”	Pakistan Crop Protection Association (PCPA)	Cap.(R) Muhammad Mahmood, Secretary Agriculture Punjab was the Chief Guest of the Seminar. Director General Extension Sayyed Zafaryab Haider Naqvi, DG Research, Dr Abid, Director Cotton Dr. Sagheer Ahmad. Rao Shahid, Secretary PCPA & Mr. Asif Majeed, Chairman Evoyl group attended the seminar. More than 1500 farmers attended the event. Dr.Muhammad Naveed, Entomologist of the institute delivered the lecture to the participants. All participants appreciated the presentation. (Farmer=283)
20.10.2017 CCRI, Multan	"Soil Health Improvement and Nutrition Management in Cotton"	CCRI, Multan	The seminar was attended by Haji Muhammad Akram Ansari, State Minister for Commerce & Textile Industry, Syed Javaid Ali Shah, Federal Minister for Water Resource was the co-chairman of the seminar Muhammad Ali Khokhar, Member Provincial Assembly Punjab, Prof. Dr. Asif Ali, Vice Chancellor MNSUA, Dr. Khalid Abdullah, Vice President PCCC and no. of agri. Scientists from various institutions & representatives of private sectors were also present in the seminar. Dr. Zahid Mahmood, Director CCRI Multan & Dr.Fiaz Ahmed,Head,Plant Physiology & Chemistry section delivered the lectures to the participants. Almost 100 cotton growers of various cotton zone areas attended the seminar.
26.10.2017 Ghotki	"Strategies to Manage Pink Bollworm and Methods of Clean Cotton Picking"	CRS,Ghotki	Dr. Zahid Mahmood, Director CCRI Multan, Dr. Waris Sanjrani, Director CCRI Sakrand, Mr. Aziz Ahmad Memon, Officer Incharge, CRS Ghotki and almost 300 progressive farmers attended the seminar.

7.3.2 International Seminar

Date	Seminar	Venue	Organized by	Participants
May 11 to May 31,2017	Seminar on “ Climate change and agricultural sustainable development for developing countries”	Beijing, China	Foreign Economic Cooperation Center, China	Hafiz Muhammad Imran
June 27 to July 17,2017	Seminar on “ Modern Agriculture management for belt & road countries	-do-	Foreign Economic Cooperation Center, Ministry of Agriculture, China	Mr.Danish Iqbal
27th June to 17th July,2017	Seminar on “ Modern Agriculture management for belt & road countries	-do-	Ministry of Commerce ,China	Dr.Muhammad Ahmed
July11 to August 11, 2017	Seminar on “National Ecological Civilization and climatic change for the belt & road countries in 2017”	Yangling, China	International exchange center Yangling, China	Ms. Asia Perveen
August 18 to September 7,2017	Seminar on “ Management of agriculture and agricultural products for Pakistan”	Xinjiang, China	Dept. of commerce Xinjiang, China	Dr.Muhammad Naveed Afzal

1st October to 22nd October,2017	Seminar on "Planning & Development for Pakistan and China"	Beijing, China	China	Dr.Fazal-i-Dayam Shehzad

7.3.3 Traveling Seminar

The scientists of traveling seminar visited the Institute on September 14, 2017. Mr.Muhammad Saeed Khan, SO, PBG & Hafiz. Abdul Haq, SO, Plant Breeding Section of the Institute participated in the seminar along with other Agri. Scientists of all provinces. Dr.Tassawar Husain Malik. Director Research PCCC was the organizer of this traveling seminar.

7.4 MoU Signing Ceremony b/w PCCC & ICRA

The International Cotton Advisory Committee (ICAC) established the International Cotton Researchers Association (ICRA) for the cotton researchers across the globe. PCCC was selected after competition for hosting of the ICRA Secretariat and was finally selected to host the Secretariat for 5 Years. In this regard, a MoU signing Ceremony between PCCC & ICRA was held at CCRI Multan on 9th October, 2017. Dr. Michael Fok, Chairman, ICRA and Dr. Khalid Abdullah, Vice President, PCCC signed the MoU. The Secretariat will coordinate among cotton researchers and provide a platform for building linkages through enhancing membership and addressing cotton issues. Dr. Fiaz Ahmad was nominated as Secretary and Mr. Zahid Khan was nominated as Assistant Secretary for this Secretariat.

7.5 Participation in Workshop/Conference

Date	Workshop/Conference	Venue	Organized by	Participants
April 23-27, 2017	Workshop on "emerging roles of producer & farmers associations/cooperatives	Dhaka, Bangladesh	National Productivity Organization, Ministry of Industries, Bangladesh	Mr. Sajid Mahmood
May 2 to May 4,2017	1st International Conference on "Climate Change and Biodiversity"	IUB	Cholistan Institute of Desert Studies (CIDS)	i.Mr.Muhammad Naveed Afzal ii.Mr.Muhammad Tariq
May8 to May 11	Conference on " Dynamics trends in plant sciences: Fostering Enviroment-2017	Quetta	Pakistan Botanical Society	Dr.Muhammad Ahmed
August 3-4, 2017	Workshop on "Field Inspection of Seed Crops and Early Generation Seed (EGS) Production)"	CCRI, Multan	Food and Agriculture Organization (FAO)	Dr. Zahid Mahmood, Director CCRI Multan
October 22 to December 2,2017	Workshop on " Integrated agriculture and rural development through the participation of local farmers	Japan	JICA, Japan	Ms. Shabana Wazir
November 11-15,2017	International Conference on " Tackling climate change through Plant Breeding"	RWP	Dept. of PBG PMAS-Asia Agriculture	Mr.Muhammad Tariq
November 20-22, 2017	6th International Conference of Pakistan Phytopathological Society "Plant Health for Sustainable Agriculture "	CCRI, Multan & B.Z.U	CCRI, Multan & B.Z.U	Around 500 participants (local 475, international 25) attended the conference

7.6 Visitors

a)

Dignitaries/Delegation	Dated
Mr. Naeem Akhtar Khan Bhaba, Minister for Agriculture, Punjab	27.04.2017
Mr. Muhammad Mahmood, Secretary Agriculture, Punjab	27.04.2017
Syed Fakhar Imam, Makhdum Ahmad Alam Anwar	27.04.2017
Dr. Khalid Abdullah, Cotton Commissioner, Mintex	15.05.2017
Dr M. Sarwar, Principal Scientist/Entomologist, NIBGE	23.05.2017
Dr. Shakeel Khan, FAO Seed Sector Consultant	17.08.2017
Dr. Michael Fok, Chairman, ICRA	09.10.2017
Haji Muhammad Akram Ansari, State Minister for Commerce & Textile Industry	20.10.2017
Syed Javaid Ali Shah, Federal Minister for Water Resource	20.10.2017
Mr. Kaleem Khalid, Mr. Mahmood and Mr. Muhammad Kamil from Federal Audit Department; Lahore	07.11.2017
Six member Chinese cotton researcher led by Prof. Dr. Madam Qu Yan Ying, Director, Research Group of Cotton Molecular Breeding	07.12.2017
22-member delegation comprising of farmers and extension officials from Sindh province led by Dr. Nisar Memon, Director, Water Resources Improvement Project, World Bank and Dr. Mushtaq Gill, Chief Executive Engineer, South Asian Conservation Agriculture Network, Sindh	15.12.2017
MNAs, Sardar Muhammad Shafqat Hayat Khan, Ms. Ghulam BibiBharwana, Malik Shakir Bashir Awan, Mr. Abdul Rashid Godil, Malik Abdul GhaffarDogar, Mr. Jamshaid Ahmed Dasti etc member of National Standing Committee,MinTex	28.03.2017
Mr. Khursheed Khan Kanjoo, Ex MPA	24.03.2017
Khalid Khokhar ,President Pakistan KissanIttehad,	24.03.2017
Dr. Jasuu Paul ,Chairman PCGA	24.03.2017
Mr. HassaIqbal, Federal Secretary, Ministry of Textile,	10.04.2017
Dr. Noor ul Islam, Chief Executive , PARB	10.04.2017
Mr. Moazzam Sheikh, CEO, Sanifa	19.10.2017

b) Student Study Tour

Name of University/Institution	No. of Participants
University of Agriculture, Faisalabad	300
University College of Agriculture, BZU, Multan	18
Muhammad Nawaz Sharif University of Agri. Multan(MNSUA)	35
Islamia University, Bahawalpur	41
Govt. College of Layyah	49
Multan Garrison Army Public School	85
Joint Degree Program of Sukkur IBA and UAF	62

c) Visit of Senior Management Course, NMC, Lahore

A group of 10 participants from 22nd Senior Management Course of National Management College Lahore visited CCRI Multan on December 4, 2017. Dr. Zahid Mahmood, Director CCRI Multan briefed the participants about cotton research and development programs carried by the Institute. The participants were later visited field and laboratories and appreciated the research work of the Institute. The participants also appreciated the introduction of mechanical cotton picker for the growers in Pakistan.

7.6 Face book Page CCRI, Multan

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

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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 CCRI Sakrand, CRS Ghotki, CRS D.I.Khan, CRS Mirpur Khas, CRS Lasbella, CRS Sibbi and to other relevant public and private parties as well. Research activities were focused to study the effects of cotton leaf curl virus disease incidence & different moisture content levels on fibre characteristics of cotton. 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. For this purpose, 851 samples were drawn from 211 ginning factories. Moreover, the spinning industry of Punjab province was also visited to accumulate information regarding the utilization of cotton fibre with special reference of the cotton fibre traits and others fibres as well in industry along with imported cotton. 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 and private textile industry 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 analysed at Fibre Technology Section to publish a comprehensive report entitled "Quality Survey of Pakistan Cottons" which reflect a true picture of commercially grown cotton at different locations and this report is fruitful for cotton Breeders, Ginners, Spinners & exporters.
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)	Micro-naire (µg inch^{-1})	Fibre Strength g tex^{-1}	Fibre Strength Tppsi	Color grade	Total
Breeding, CCRI, Multan	15224	15224	15224	633		46305
Cytogenetics, CCRI Multan	11666	11666	11666	35		35033
Agronomy, CCRI, Multan	478	478	478			1434
Fibre Technology, CCRI, Multan	278	278	278		200	1034
Plant Physiology, CCRI, Multan	80	80	80			240
CCRI, Sakrand	1181	1181	1181			3543
CRS, Lasbella	126	126	126			378
CRS, Ghotki	970	970	970			2910
CRS, M.P. Khas	152	152	152			456
CRS, D.I.Khan	1230	1230	1230			3690
CRS, Sibbi	103	103	103			309
CRS, NIA, Tandojam	39	39	39			117
Students	51	51	51			153
Quality Survey (PICRT)	847	847	847		847	3388
Quality Survey (Punjab)	851	851	851		851	3404
Private Sector	30	30	30		1	91
Total	**33306**	**33306**	**33306**	**668**	**1899**	**102485**

03 samples received from private sectre were also spun

8.2 Effects of Cotton Leaf Curl Virus (CLCuD) Disease Incidence on Fibre Characteristics of Two Cotton Varieties

The objective of the experiment was to study the effects of cotton leaf curl virus disease incidence on different fibre characteristics of cotton varieties. Two cotton varieties were selected, viz., *Bt.*CIM-616 and VH-327 sown at five different sowing dates viz., 1st March 2017, 15th March 2017, 1st April 2017, 15th April 2017 and 1st May 2017. To identify the severity levels of virus disease, the technical support was provided by Plant Pathology Section of the Institute.

Table 8.2 Fibre characteristics of variety *Bt*. CIM-616 as affected by different virus severity levels

Characteristics	1st March 2017				15th March 2017				1st April 2017				15th April 2017				1st May 2017				
	Healthy	Mild	Medium	*DOH	Healthy	Mild	Medium	DOH	Healthy	Mild	Medium	DOH	Healthy	Mild	Medium	DOH	Healthy	Mild	Medium	Severe	DOH
GOT %	39.6	39.4	38.8	**0.80**	39.2	38.4	37.4	**1.80**	39.2	37.0	36.8	**2.40**	38.7	36.2	35.9	**2.80**	37.3	36.4	35.2	33.9	**3.40**
Length (mm)	27.5	27.3	27.0	**0.50**	27.6	27.5	26.5	**1.10**	27.9	27.8	27.5	**0.40**	28.1	27.8	27.6	**0.50**	27.9	27.6	27.3	27.0	**0.90**
Unif. Index %	81.2	80.5	79.0	**2.20**	83.5	82.7	81.5	**2.00**	80.6	79.9	79.4	**1.20**	81.9	81.5	81.5	**0.40**	80.1	79.6	79.4	79.0	**1.10**
Micronaire	4.5	5.1	5.2	**-0.70**	4.3	4.6	4.8	**-0.50**	4.3	5.0	5.0	**-0.70**	4.1	4.6	4.6	**-0.50**	3.8	4.1	4.1	4.6	**-0.80**
Strength (G tex^{-1})	28.9	28.2	28.2	**0.70**	29.7	28.6	26.7	**3.00**	30.2	28.6	27.5	**2.70**	28.5	28.2	27.3	**1.20**	28.4	28.0	28.0	27.6	**0.80**

Table 8.3 Fibre characteristics of variety VH-327 as affected by different virus severity levels

Characteristics	1st March 2017				15th March 2017				1st April 2017				15th April 2017					1st May 2017				
	Healthy	Mild	Medium	DOH	Healthy	Mild	Medium	DOH	Healthy	Mild	Medium	DOH	Healthy	Mild	Medium	Severe	DOH	Healthy	Mild	Medium	Severe	DOH
GOT %	38.9	37.8	37.7	**1.20**	40.1	39.3	38.7	**1.40**	37.9	37.5	36.9	**1.00**	37.4	36.7	35.8	35.7	**1.70**	37.0	36.5	36.3	35.2	**1.80**
Length (mm)	27.9	27.0	26.9	**1.00**	27.7	27.4	27.2	**0.50**	28.0	27.9	27.6	**0.40**	28.1	27.5	27.4	27.0	**1.10**	27.4	27.0	26.7	26.0	**1.40**
Unif. Index %	84.2	82.0	82.1	**2.10**	83.8	80.4	80.3	**3.50**	82.5	82.0	81.1	**1.40**	82.4	82.1	82.0	81.0	**1.40**	81.9	80.9	80.3	80.0	**1.90**
Micronaire	4.3	4.6	4.7	**-0.40**	4.3	4.5	4.9	**-0.60**	4.1	4.2	4.4	**-0.30**	4.2	4.4	4.7	4.8	**-0.60**	3.9	4.0	4.3	4.6	**-0.70**
Strength (G tex^{-1})	29.7	29.1	28.5	**1.20**	29.3	28.0	28.0	**1.30**	30.2	29.4	28.4	**1.80**	31.4	27.9	27.8	26.5	**4.90**	27.5	27.4	26.9	26.5	**1.00**

***DOH = Maximum decrease over healthy**

Five healthy & five virus effects plants of each severity levels i.e., mild, medium and severe were tagged. Opened cotton bolls were picked from healthy plants and virus affected plants. The seed cotton was ginned. The lint samples were tested for various fibre characteristics. The results are presented in Tables 8.2 to 8.3 showed that how cotton leaf curl virus disease affected fibre characteristics.

Ginning out turn % was affected by CLCuD of both test varieties. The maximum decrease over healthy in GOT % was found in variety *Bt*.CIM-616 (3.40) at 1st May, 2017 sowing date and minimum decrease over healthy also found in same variety (0.80) at 1st March, 2017 sowing date. Fibre length was influenced by the virus disease incidence for both varieties. The maximum decrease over healthy in length was found in variety VH-327 (1.40) at 1st May, 2017 sowing date and minimum decrease over healthy in variety *Bt*.CIM-616 (0.40) at 1st April, 2017 sowing date. Uniformity index was also influenced by the virus disease incidence for both varieties. The maximum decrease over healthy in uniformity was found in variety VH-327 (3.50) at 15th March, 2017 sowing date and minimum decrease over healthy in variety *Bt*.CIM-616 (0.40) at 15th April, 2017 sowing date. Micronaire value was positively affected by CLCuD of both varieties. The maximum increase over healthy in micronaire was found in variety *Bt*.CIM-616 (-0.80) at 1st May, 2017 sowing date and minimum increase over healthy in variety VH-327 (-0.30) at 1st April, 2017 sowing date. Fibre strength was influenced by the virus disease incidence for both varieties. The maximum decrease over healthy in strength was found in variety VH-327 (4.90) at 15th April, 2017 sowing date and minimum decrease over healthy in variety *Bt*.CIM-616 (0.70) at 1st March, 2017 sowing date.

Fig. 1-4 depicts the interactive effects of virus severity levels on different fibre quality traits.

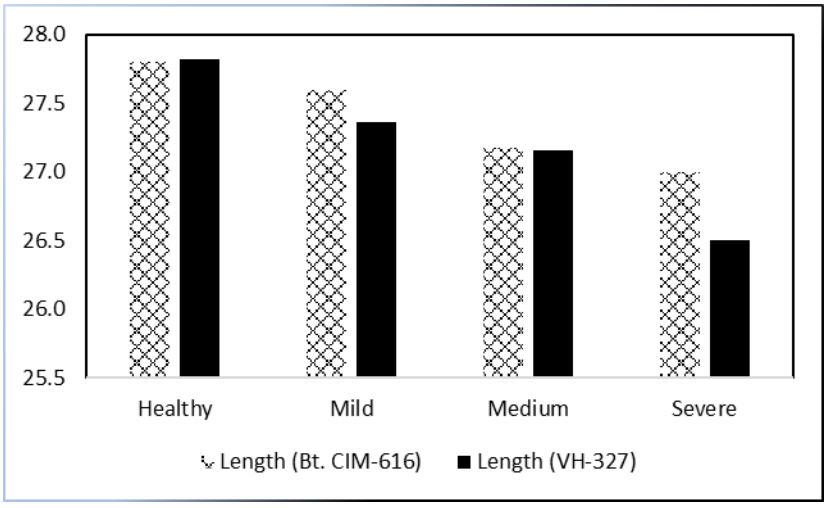

Fig. 1 Interactive effect of virus severity levels on fibre length (mm)

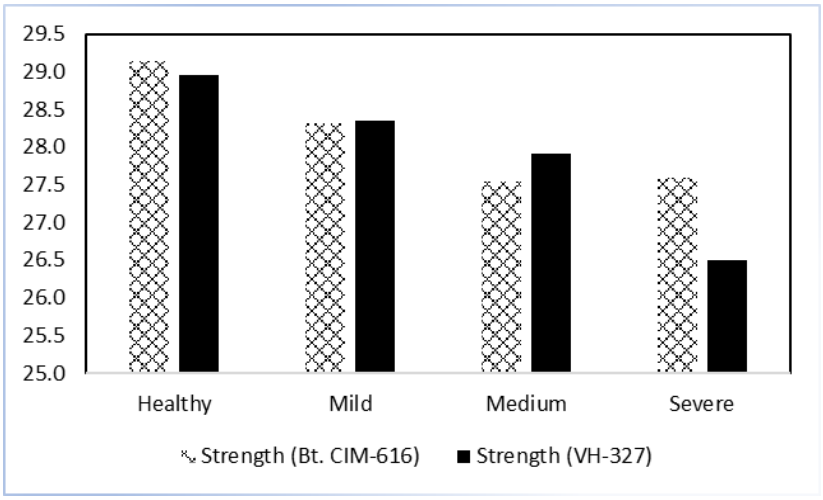

Fig. 2 Interactive effect of virus severity levels on fibre strength (g tex^{-1})

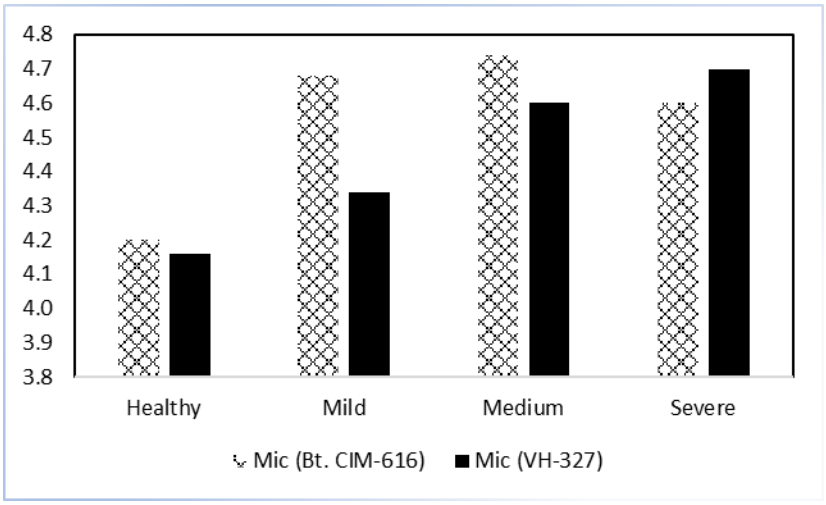

Fig. 3 Interactive effect of virus severity levels on micronaire value

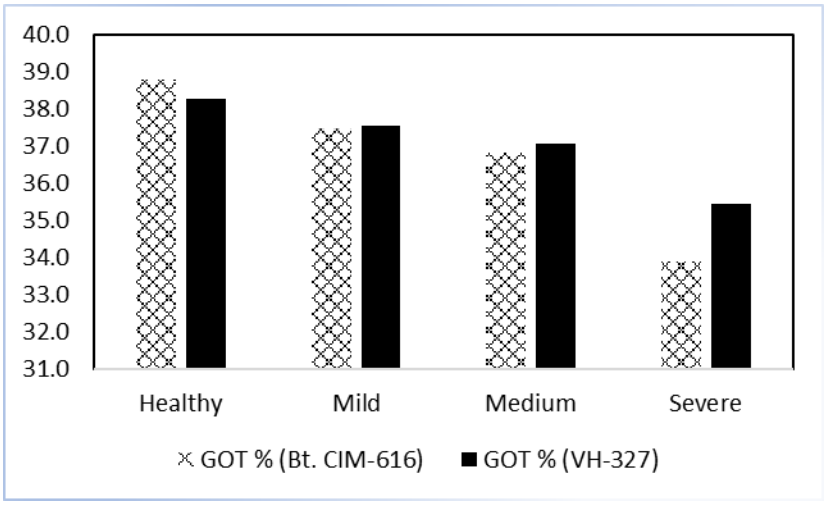

Fig. 4 Interactive effect of virus severity levels on ginning out turn (%)

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 fiber 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. The three cotton fibre types were selected i.e., long staple, medium staple and lower medium staple for the experiment. The 20 lint samples of each moisture level viz., 6%, 8.5% and 11% of each type were prepared and tested for various fibre characteristics. The results are presented in Table 8.4.

The findings from different moisture levels are presented in Table 8.4 revealed that there were significant differences between different moisture contents, for fibre length, fibre strength, uniformity index, degree of whiteness and degree of yellowness for each cotton type. The fibre length, uniformity and strength increased, degree of whiteness and degree of yellowness decrease with increase in moisture level for each cotton type. There is no significant effect of moisture level on micronaire value for each cotton type.

Table 8.4 Fibre characteristics as affected by different moisture contents

	Long Staple			Medium Staple			Lower Medium Staple		
Moisture Level	**6.0%**	**8.5%**	**11.0%**	**6.0%**	**8.5%**	**11.0%**	**6.0%**	**8.5%**	**11.0%**
Fibre Length (mm)	31.4 c	32.1 b	32.9 a	28.5 c	29.4 b	30.1 a	26.9 c	27.9 b	28.8 a
Uniformity Index (%)	84.5 ab	84.2 b	84.7 a	82.6 b	82.6 b	83.9 a	81.4 c	82.1 b	83.1 a
Micronaire Value	4.3 a	4.3 a	4.3 a	4.1 b	4.2 a	4.2 a	3.9 a	3.8 b	3.9 a
Strength (g/tex)	33.2 b	34.5 a	34.9 a	30.0 c	31.6 b	32.4 a	29.0 c	30.2 b	30.7 a
Degree of Whiteness (Rd)	70.6 a	69.2 b	66.8 c	70.2 a	69.2 b	66.3 c	70.7 a	69.9 b	67.6 c
Degree of Yellowness (+b)	13.0 a	12.3 b	8.30 c	13.0 a	12.5 b	8.60 c	13.2 a	12.6 b	8.70 c

Values with different letters in each row for each trait are significant at p<0.05%

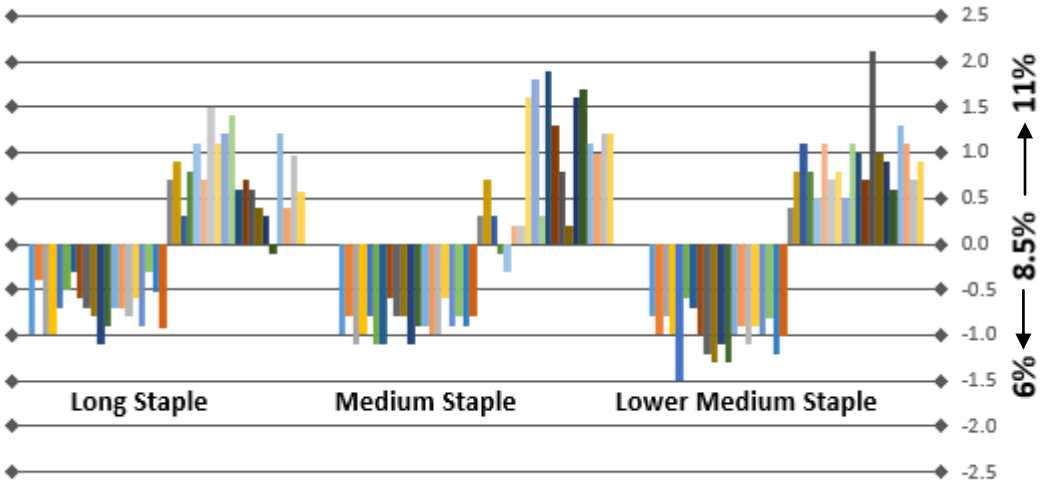

Fig. 5 Fibre Length differentiation from 8.5% moisture level

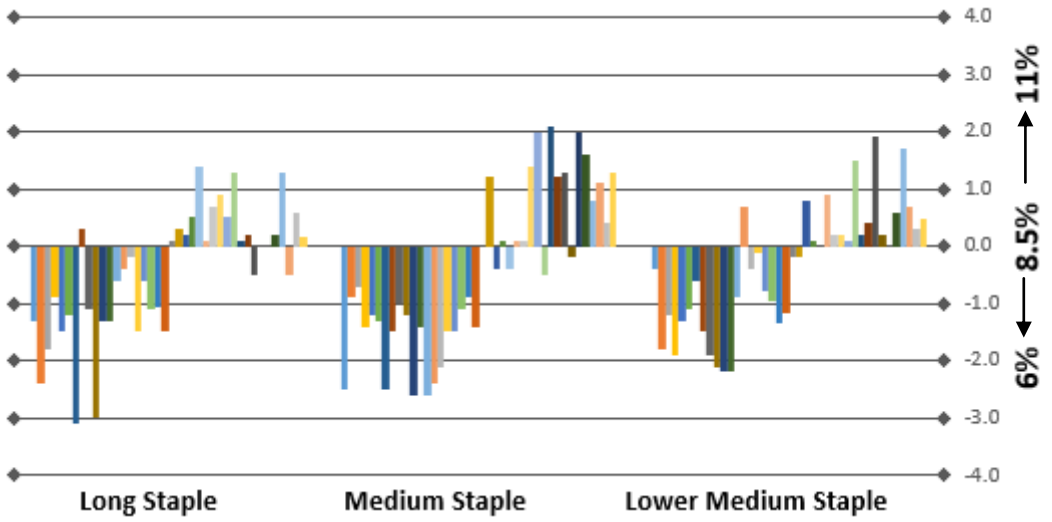

Fig. 6 Fibre strength differentiation from 8.5% moisture level

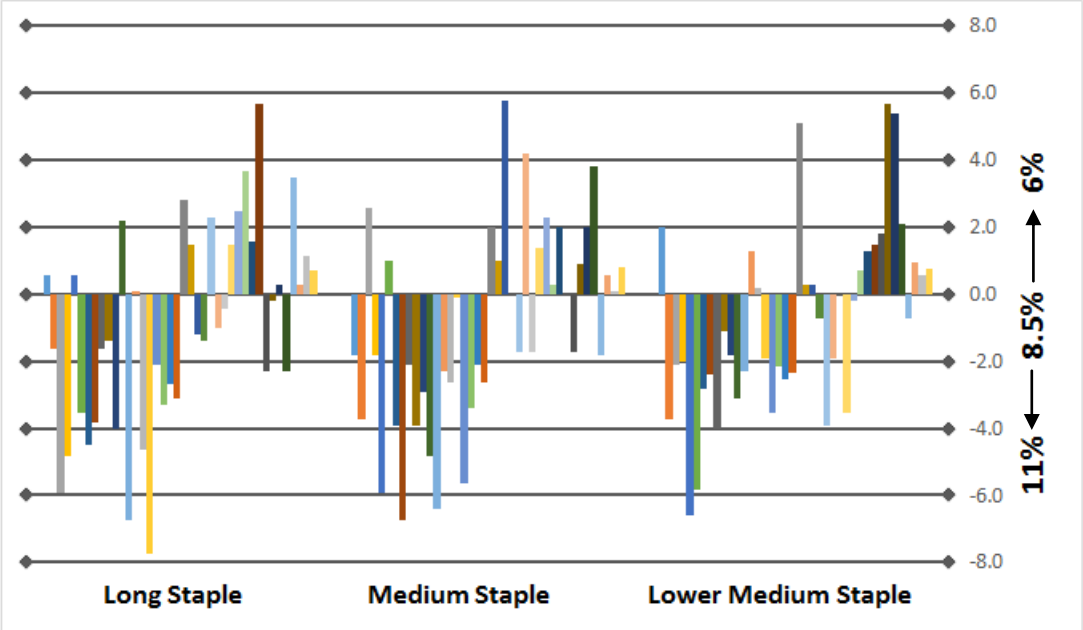

Fig. 7 Differentiation of whiteness from 8.5 % moisture level

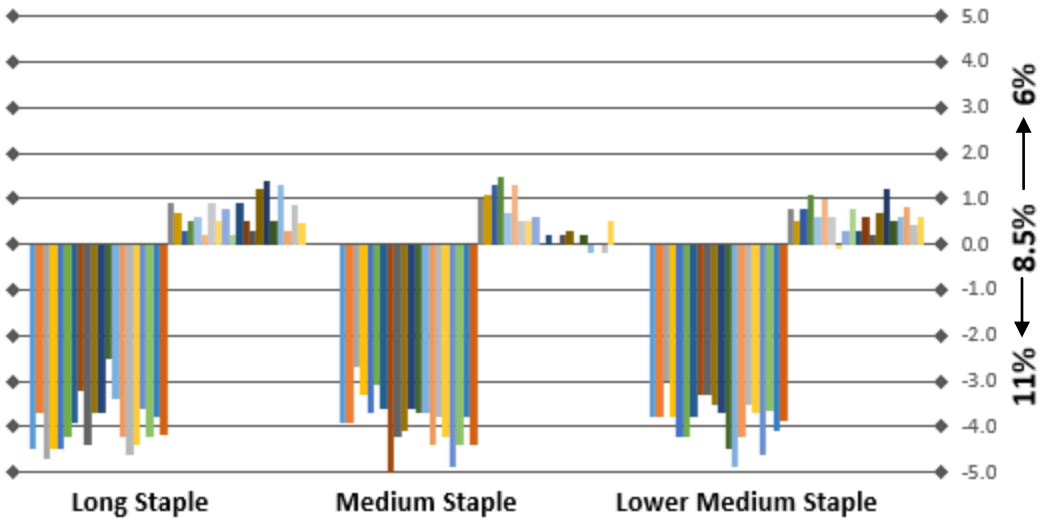

Fig. 8 Differentiation of Yellowness from 8.5 moisture level

8.4 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 2017-18. The samples were collected from different cities of Punjab province. Total 36 cities were visited and 851 samples drawn from 211 factories during survey. The quality of lint in different cities during the crop season 2017-18 is given in Table 8.5. The graphically representation of different fibre parameters is shown in fig -9 to fig-11.

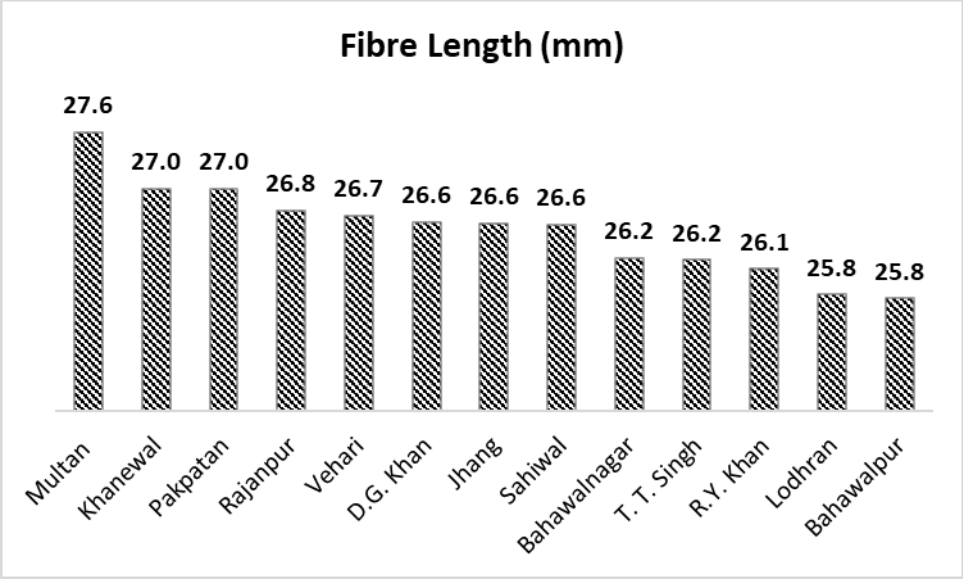

Fig. 9 Fibre Length (mm) for various districts in Punjab province.

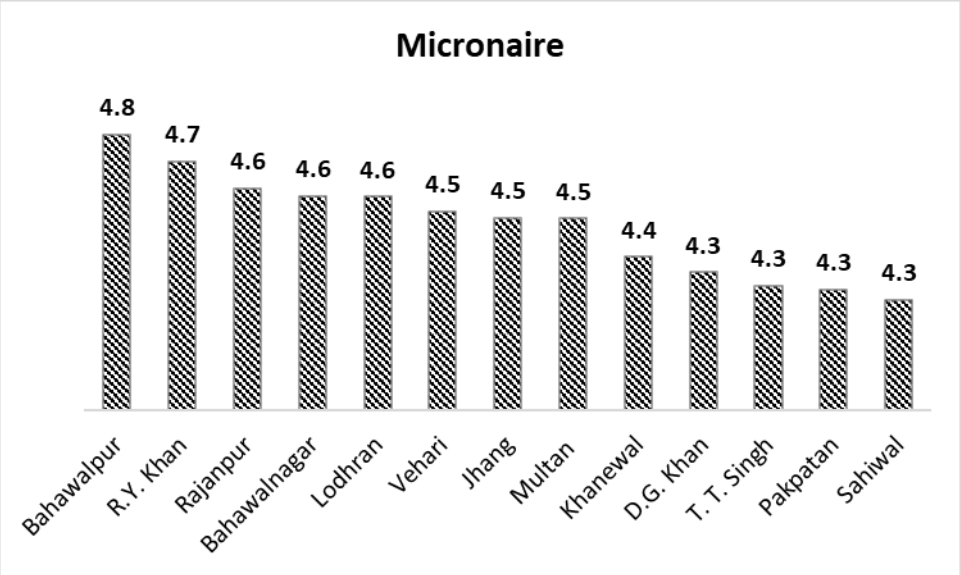

Fig. 10 Micronaire for various districts in Punjab province.

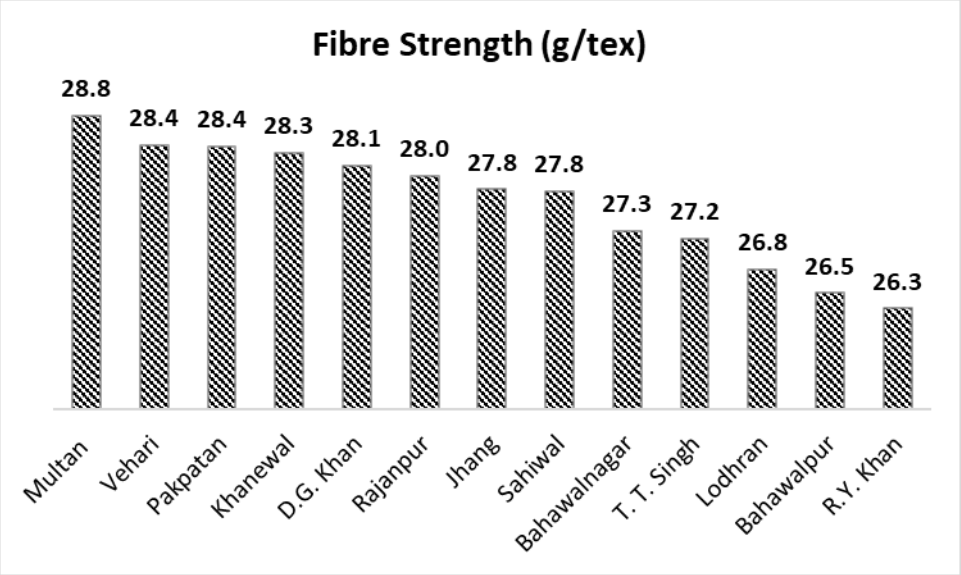

Fig. 11 Fibre Strength (g/tex) for various districts in Punjab province.

Table 8.5 Quality Survey for lint quality of various cities in Punjab province.

District	City	Fibre Characteristics							
		Fibre Length (mm)	Micronaire	Strength (g/tex)	Uniformity Index (%)	Elongation (%)	SFI	Rd	+b
Bahawalnagar	Faqeer Wali	26.2	4.7	27.2	81.6	4.7	9.8	68.4	9.2
	Fort Abbas	26.7	4.7	27.2	82.3	4.5	8.6	68.8	9.0
	Haroonabad	26.2	4.6	27.0	81.9	4.6	9.4	69.1	9.4
	Bahawalnagar	26.1	4.4	27.9	81.5	4.4	9.9	69.8	9.9
	Chishtian	26.0	4.6	27.4	82.1	4.4	9.2	70.0	9.9
	Average	**26.2**	**4.6**	**27.3**	**81.9**	**4.5**	**9.4**	**69.2**	**9.5**
	Range	**27.9-24.7**	**4.2-5.0**	**29.8-25.2**	**-**	**-**	**-**	**-**	**-**
Bahawalpur	Bahawalpur	25.7	4.6	26.9	82.9	5.1	8.3	66.6	8.9
	Yazman	25.3	4.9	25.3	82.2	4.9	9.5	64.7	9.0
	Ahmadpur East	25.5	4.9	25.6	79.5	5.0	9.3	64.7	9.2
	Hasilpur	26.6	4.7	27.8	82.7	4.4	8.2	68.0	10.3
	Average	**25.8**	**4.8**	**26.5**	**81.8**	**4.8**	**8.8**	**66.0**	**9.3**
	Range	**27.6-23.9**	**4.0-5.5**	**29.6-23.2**	**-**	**-**	**-**	**-**	**-**
Khanewal	Khanewal	27.2	4.5	28.7	83.6	4.7	7.6	68.5	9.2
	Kabeerwala	27.2	4.4	28.4	83.4	4.7	7.1	67.7	9.3
	Abdul Hakeem	26.6	4.4	28.2	82.5	4.2	8.3	67.6	10.1
	Mian Channu	26.4	4.3	27.4	82.0	4.3	9.2	68.4	9.6
	Average	**27.0**	**4.4**	**28.3**	**82.9**	**4.5**	**8.0**	**68.0**	**9.6**
	Range	**28.3-25.0**	**4.0-4.9**	**29.6-23.2**	**-**	**-**	**-**	**-**	**-**
Vehari	Vehari	26.8	4.4	28.6	82.8	4.3	8.0	68.2	9.6
	Buray Wala	26.9	4.4	28.2	82.9	4.4	7.8	67.4	10.3
	Gaggo Mandi	26.6	4.5	28.0	82.2	4.8	8.8	66.4	10.9
	Mailsi	26.6	4.8	27.4	83.2	4.4	7.6	67.4	9.8
	Average	**26.7**	**4.5**	**28.4**	**82.8**	**4.5**	**8.1**	**67.3**	**10.2**
	Range	**29.2-25.9**	**4.2-5.1**	**30.6-26.0**	**-**	**-**	**-**	**-**	**-**
R.Y. Khan	Liaqatpur	26.0	4.8	25.7	82.9	5.1	8.3	67.2	8.9
	Khanpur	25.9	4.8	26.2	82.9	5.1	8.3	68.0	9.2
	R.Y. Khan	26.1	4.7	26.4	83.1	5.3	7.9	67.8	9.2
	Sadiq Abad	26.1	4.7	26.5	82.7	5.4	8.4	68.3	9.2
	Average	**26.1**	**4.7**	**26.3**	**82.9**	**5.2**	**8.2**	**67.8**	**9.1**
	Range	**28.3-23.9**	**3.6-6.0**	**29.8-23.2**	**-**	**-**	**-**	**-**	**-**
T. T. Singh	Toba Tek Singh	26.5	4.0	28.1	81.9	4.6	9.2	69.3	9.6
	Peer Mehal	26.2	4.3	27.2	81.8	4.5	9.6	68.5	10.1
	Gojra	26.2	4.3	27.1	81.5	4.5	9.7	68.8	9.9
	Average	**26.2**	**4.3**	**27.2**	**81.7**	**4.5**	**9.5**	**68.9**	**9.8**
	Range	**27.0-25.4**	**3.8-4.8**	**28.9-25.6**	**-**	**-**	**-**	**-**	**-**
D.G. Khan	Muzaffar Garh	26.6	4.5	28.3	82.8	4.2	8.0	66.4	9.3
	D.G. Khan	26.6	4.2	28.0	83.1	4.5	8.4	72.0	9.0
	Average	**26.6**	**4.3**	**28.1**	**82.9**	**4.4**	**8.2**	**69.2**	**9.2**
	Range	**27.9-25.7**	**3.7-4.9**	**29.7-25.5**	**-**	**-**	**-**	**-**	**-**
Multan	Shujabad	27.8	4.5	28.9	84.2	4.5	5.9	68.4	9.1
	Jalalpur P.W	27.5	4.5	28.6	83.9	4.3	6.6	68.7	9.3
	Average	**27.6**	**4.5**	**28.8**	**84.0**	**4.4**	**6.2**	**68.5**	**9.2**
	Range	**28.4-26.8**	**4.2-4.8**	**30.8-26.3**	**-**	**-**	**-**	**-**	**-**
Rajanpur	Jampur	26.9	4.6	27.5	83.6	4.6	8.1	67.5	9.3
	Rajanpur	26.6	4.6	27.7	83.4	4.3	9.5	68.0	9.3
	Average	**26.8**	**4.6**	**28.0**	**83.5**	**4.4**	**8.8**	**67.8**	**9.3**
	Range	**27.7-25.5**	**4.2-5.0**	**30.3-25.3**	**-**	**-**	**-**	**-**	**-**
Sahiwal	Sahiwal	26.5	4.3	27.0	81.3	4.4	10.0	69.3	9.8
	Chicha Watni	26.6	4.3	27.9	81.8	4.3	9.4	68.9	9.8
	Average	**26.6**	**4.3**	**27.8**	**81.5**	**4.3**	**9.7**	**69.1**	**9.8**
	Range	**27.6-25.5**	**4.1-4.6**	**29.8-26.1**	**-**	**-**	**-**	**-**	**-**
Jhang	Jhang	26.5	4.5	27.5	82.0	4.7	9.0	70.1	8.8
	Shorkot	26.7	4.5	28.2	82.4	4.4	8.4	67.4	9.9
	Average	**26.6**	**4.5**	**27.8**	**82.2**	**4.5**	**8.7**	**68.8**	**9.3**
	Range	**27.3-26.0**	**4.2-4.8**	**29.8-26.4**	**-**	**-**	**-**	**-**	**-**
Lodhran	**Average**	**25.8**	**4.6**	**26.8**	**83.0**	**5.1**	**8.2**	**66.7**	**9.2**
	Range	**26.7-25.0**	**4.2-5.0**	**28.8-25.5**	**-**	**-**	**-**	**-**	**-**
Pakpatan	**Average**	**27.0**	**4.3**	**28.4**	**82.7**	**4.2**	**8.0**	**68.8**	**9.7**
	Range	**27.7-26.5**	**4.0-4.5**	**29.7-27.2**	**-**	**-**	**-**	**-**	**-**

8.5 Survey of Spinning Industry of Pakistan

Survey of spinning industry was conducted to collect data regarding the utilization of cotton fibre with special reference of the cotton fibre traits and others fibers as well in industry and to focus the economics comparatives. 08 spinning units were visited in the Punjab to ascertain the cotton fibre and yarn quality being consumed by the spinning industry. The data collected are presented in Table 8.6.

Table 8.6 Survey of Spinning Industry

Unit No.	No. of Spindles	Production Capacity (100 lb bags /day)	Types of Fibre	Average count	Counts Spun from Pak Cotton	Counts Spun from Imported Cotton
1	32640	220	Cotton, Viscose Rayon	48s	30s, 40s, 52s	60s, 80s
2	46104	800	Cotton, Viscose Rayon, Acrylic	45s	20s, 30s, 40s	52s, 80s
3	35000	700	Cotton, Nylon, Polyester, Modal, Tencel, Bamboo, Viscose Rayon	28s	32s	40s
4	26688	375	Cotton, Polyester	32s	PC + CVC (20s, 30s, 40s, 45s)	-
5	4000 rotors	770	Cotton, Polyester	10s	PC (6s to 16s)	-
6	46000	1500	Cotton	12s	4.5 to 20	4.5 to 20
7	21168	275	Cotton, Polyester, Viscose Rayon	25	12 to 40	-
8	25000	500	Cotton, Viscose Rayon, Acrylic, Tencel	28s	10s to 40 s	68s

Moreover, comparative study was also made with regard to yarn spun and fibre quality from local viz-a-viz imported cotton. The Pakistani cotton easily fulfills the requirement for spinning of medium to fine counts. On overall average basis, there was significant difference of fibre quality of local vs imported cotton being consumed for the spinning of extra fine counts yarn. The comparative fibre analysis for cotton from different regions are presented in Table 8.7.

Table 8.7 Fibre Traits of Pakistani Cotton vs Imported Cotton

Country	Fibre Length (mm)	U.I. %	Strength (g/tex)	Micronaire	Moisture %	Trash %
Pakistan	27.4	82.3	29.5	4.6	8.8	9.1
Turkey	36.1	85.6	38.6	4.3	6.7	7.6
Egypt (Giza)	32.8	83.7	42.1	4.3	6.7	5.7
U.S (Pima)	35.5	86.6	48.6	4.2	5.1	3.7
India	29.1	88.8	29.1	3.9	7.1	6.2
Argentina	28.9	83.1	31.5	4.6	6.6	4.7
Brazil	28.3	-	28.8	4.3	-	-

The comparative study in graphical form for each parameter is given in fig-12 to fig-14:

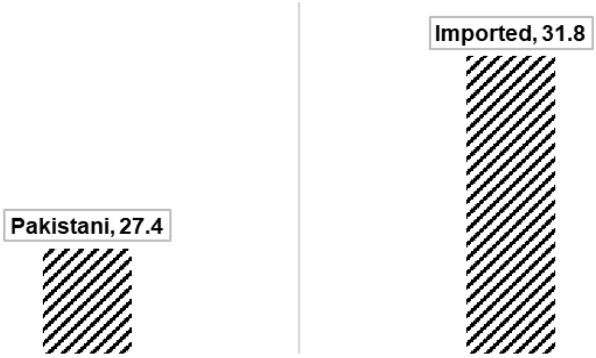

Fig. 12 Comparison of fibre length

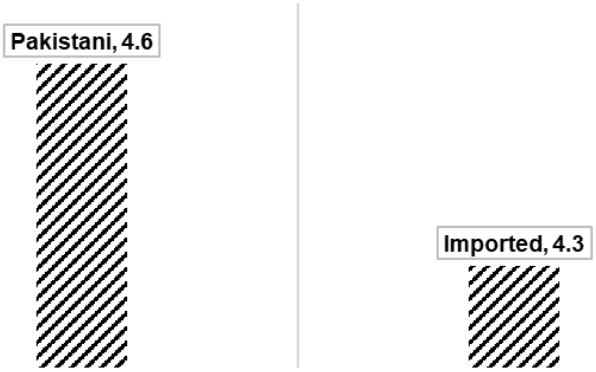

Fig. 13 comparison of Micronaire

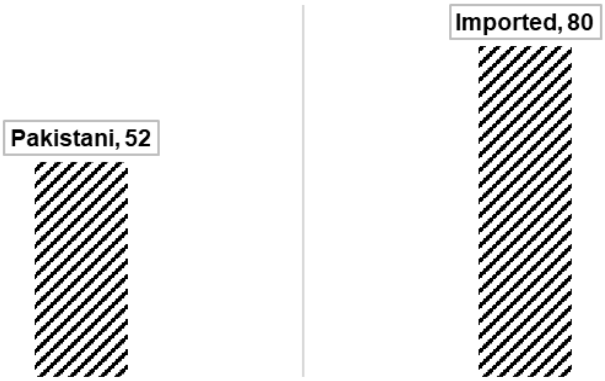

Fig. 14 comparison of count spun

8.6 ICA-Bremen Cotton Round Test Program

The Fibre Technology Section participated in the ICA-Bremen Cotton Round Test Program under Faser Institute, Germany to keep the fibre testing equipment in calibrated form. Three lint samples were received during the year 2017. 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

Date of Test	Sample No.	Name of Test	Results of CCRI, Multan (1)	Avg. results Of all Labs (2)	Difference (1-2)
14.03.17	**2017/1**	**Conventional Instruments**			
		Micronaire	3.40	3.42	-0.02
		Pressley Index (0")	8.36	8.36	0.78
		G / tex (1/8")	22.4	23.84	-1.44
		Elongation (%)	5.00	6.22	-1.22
		HVI-900A			
		U.H.M.L. (mm)	29.3	29.1	0.20
		Uniformity Index (%)	83.5	82.5	1.00
		Micronaire	3.40	3.42	-0.02
		G/tex (1/8")	32.3	31.5	-0.80
		Elongation (%)	6.00	5.85	0.15
		Rd (Reflectance)	71.2	71.9	-0.70
		+b (Yellowness)	13.4	13.1	0.30
14.07.17	**2017/2**	**Conventional Instruments**			
		Micronaire	4.40	4.33	0.07
		Pressley Index (0")	8.80	8.02	0.78
		G / tex (1/8")	19.4	21.8	-2.40
		Elongation (%)	5.50	5.63	-0.13
		HVI-900A			
		U.H.M.L. (mm)	29.4	29.1	0.30
		Uniformity Index (%)	83.2	82.3	0.90
		Micronaire	4.30	4.43	-0.13
		G/tex (1/8")	29.1	29.2	-0.10
		Elongation (%)	5.90	6.15	-0.25
		Rd (Reflectance)	72.0	72.9	-0.90
		+b (Yellowness)	13.5	13.2	0.30
14.11.17	**2017/3**	**Conventional Instruments**			
		Micronaire	4.20	4.20	0.00
		Pressley Index (0")	8.99	7.80	1.19
		G / tex (1/8")	18.9	20.2	-1.30
		Elongation (%)	5.50	5.40	0.10
		HVI-900A			
		U.H.M.L. (mm)	28.8	27.95	0.85
		Uniformity Index (%)	82.4	81.0	1.40
		Micronaire	4.10	4.29	-0.19
		G/tex (1/8")	29.8	27.0	2.80
		Elongation (%)	4.60	6.20	-1.60
		Rd (Reflectance)	66.5	67.8	-1.30
		+b (Yellowness)	11.5	10.9	0.60

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9. STATISTICS

The prime responsibility of this section is to support other sections of the institute in designing layout of experiments and analysis of research data. These facilities are also provided to Directorate of Research PCCC, and other stations of Pakistan Central Cotton Committee. The data of National Coordinated Varietal Trial are statistically analyzed. The rates of cotton commodities are also documented daily.

9.1 Statistical Analysis

Statistics section performed analysis of 241 set of experimental data during 2017-18. (Table 9.1)

Table 9.1 Detail of Statistical Analyses.

Sections	RCBD	Split	Split-Split	F-Pool	Regression	Total
Agronomy	28	18	8			**54**
Physiology						**---**
Breeding	30			18		**48**
Cytogenetics	5					**5**
Pathology						**---**
Entomology	30	16	11		3	**60**
Fiber	12				6	**18**
NCVT	56					**56**
Total	**161**	**34**	**19**	**18**	**9**	**241**

9.2 Prices of Seedcotton and its Components

Daily Spot Rates of Cotton (lint) were documented. The average weekly price for Base Grade cotton per 40 kg for the four cotton seasons i.e. 2014-15, 2015-16, 2016-17 and 2017-18 exclusive of upcountry charges are shown in **Fig 9.1**.

Rates of Seedcotton, Cottonseed, Cottonseed Cake, Cottonseed Oil and Cotton Lint were collected from Market Committee Multan. The Prices are provided for Rs per 40kg, temporal trend of rates for four years on weekly basis is illustrated in **Fig. 9.2**.

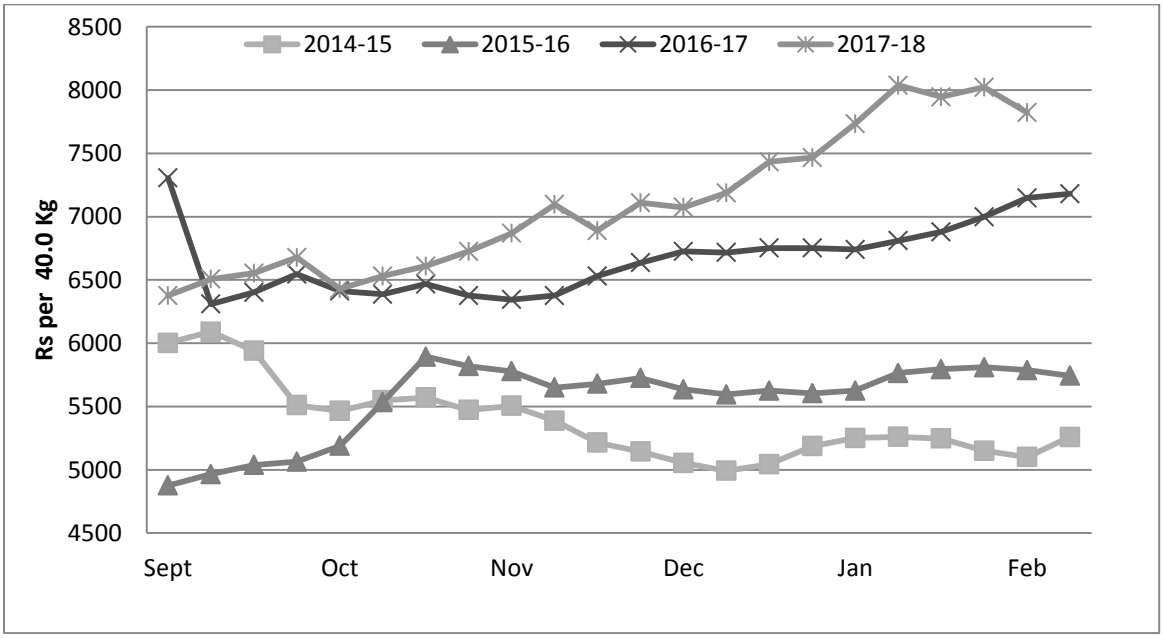
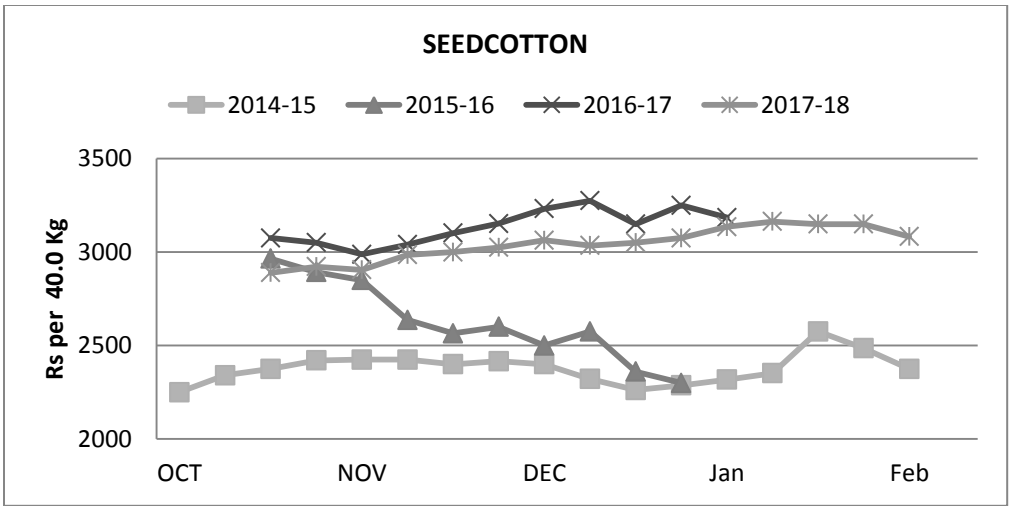
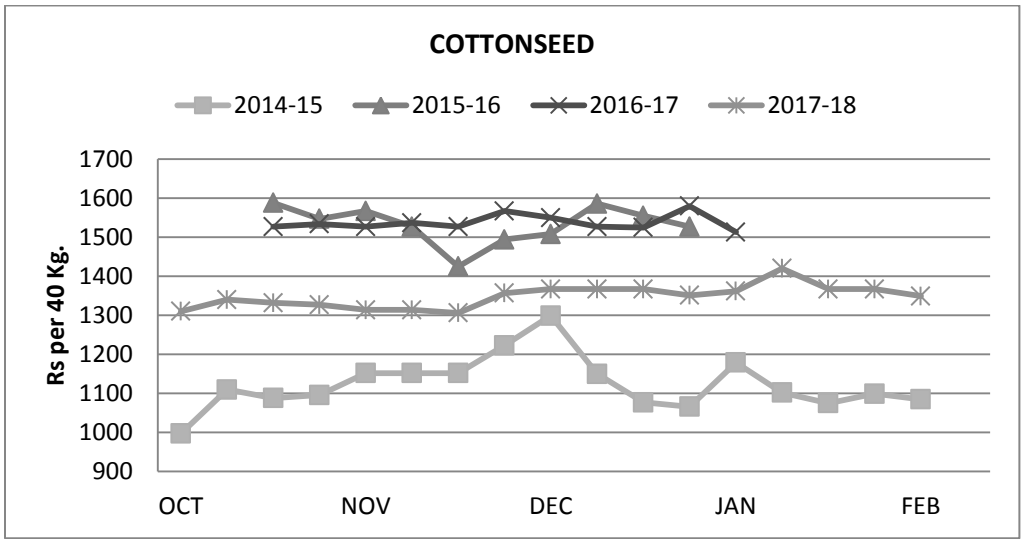
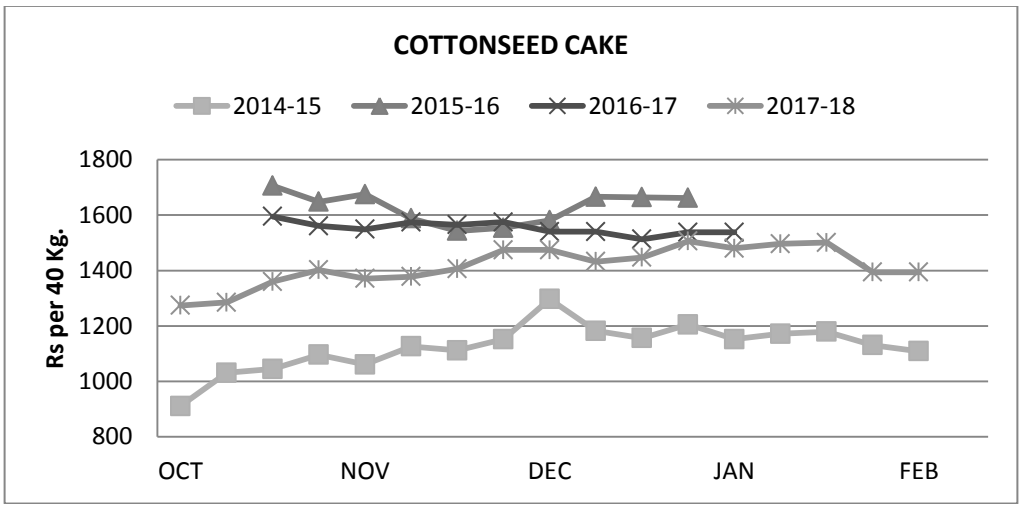
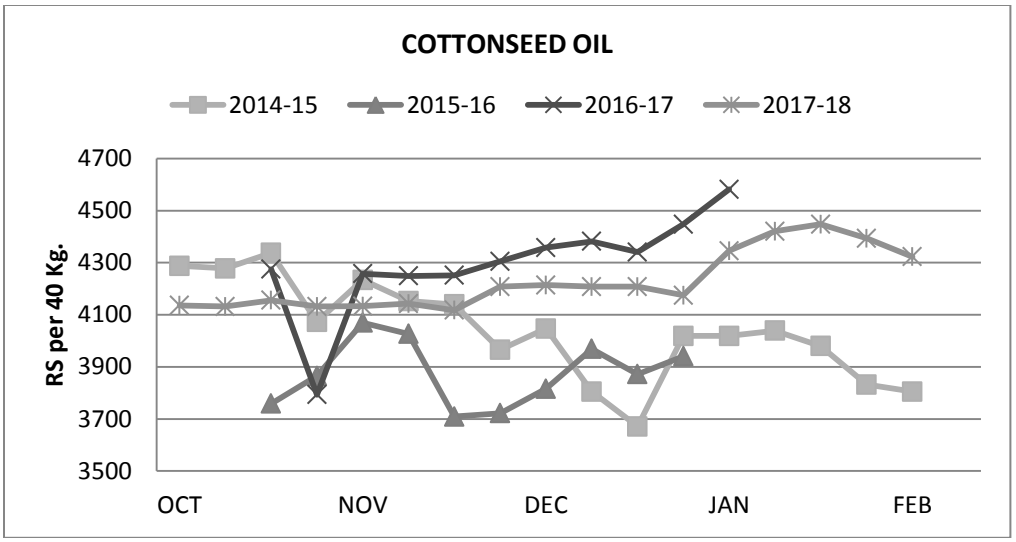


Figure 9.1: Weekly Average Spot Rates of Lint announced by Karachi Cotton Association during Cotton Seasons 2014-15, 2015-16, 2016-17 and 2017-18.


SEEDCOTTON
2014-15
2015-16
2016-17
2017-18
Rs per 40.0 Kg
3500
3000
2500
2000
OCT
NOV
DEC
Jan
Feb


COTTONSEED
2014-15
2015-16
2016-17
2017-18
Rs per 40 Kg.
1700
1600
1500
1400
1300
1200
1100
1000
900
OCT
NOV
DEC
JAN
FEB


COTTONSEED CAKE
2014-15
2015-16
2016-17
2017-18
Rs per 40 Kg.
1800
1600
1400
1200
1000
800
OCT
NOV
DEC
JAN
FEB



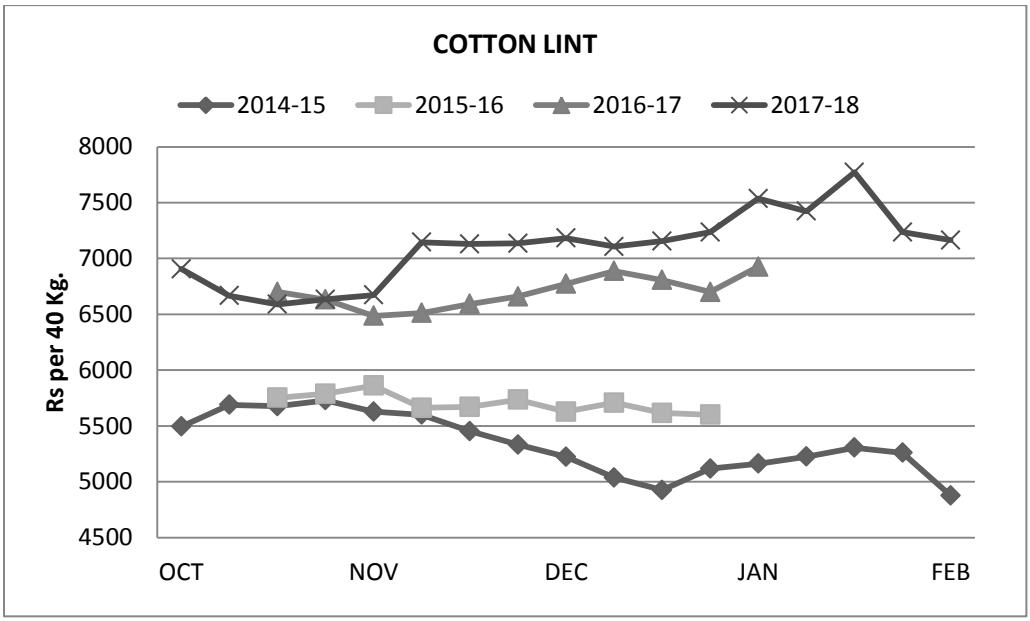


Figure 9.2: **Weekly Average Rates (Rs /40Kg.) of Seed Cotton, Cotton Seed, Cotton Seed Cake, Cotton Seed Oil and Cotton Lint of Multan Market during 2014-15, 2015-16, 2016-17 and 2017-18.**

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VII. 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, squeezing 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, 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 cost of production through additional use of pesticides but also limit 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 in ready condition for efficient and timely operations.
- Where plant growth is restricted and downward penetration of water in the soil is slow, 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. Green manuring crops should be buried into the soil at tender stage 3-4 weeks ahead of cotton planting for timely decomposition and soil conditioning. For rapid decomposition of buried green matter apply ½ bag urea followed by irrigation.
- 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 instead of rotavator followed by irrigation along with ½ bag urea per acre must be used.
- 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, alkaline, 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 32% irrigation water over conventional planting (flat cultivation). It also saves the crop from the damages of untimely and heavy rains. Apply second irrigation after sowing on bed-furrow to ensure better seedling emergence and growth. Afterwards, apply irrigation as per need of the crop. Weeds are the major problems in bed-furrow planting, therefore, use pre-emergence herbicides to control weeds.
- To sustain the good physical soil conditions, always cultivate the fields in '*wattar*' condition (workable condition) and never cultivate in dry condition.
- Level the fields properly for uniform and economized application of irrigation water.

- Apply ½ bag of urea at the time of land preparation for efficient and accelerated decomposition of previous crop residues because white-ant problem may increase and damage plant population if plant residues are not properly decomposed.
- Apply single '*rouni'* on well-leveled fields for flat (conventional) planting due to scarcity of canal water.
- After wheat harvesting, apply one heavy irrigation for land and seedbed preparation simultaneously for conventional as well as bed-furrow cotton planting to avoid possible delay in planting as early planting after wheat produces better yields.

Recommendation of cotton varieties for general cultivation

- Recommendation of *Bt*. & Non *Bt* cotton varieties for general cultivation in core and non-core cotton of the Punjab

Bt Varieties	Non-Bt Varieties
Bt.CIM-598, *Bt*.CIM-599, *Bt*.CIM-602, *Bt*. Cyto-177, *Bt*. Cyto-178, *Bt*.CIM-600, *Bt*.cyto-179, IR-3701, IR-1524, 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-620, Cyto-124, CIM-496, CIM-506, CIM-554, CIM-573, NIAB-777, NIAB-Kiran, NIAB-112, FH-942, MNH-786, CRSM-38, 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.
- While cultivating Bt varieties, always plant 10-20% area with Non-Bt cotton 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 after delinting under the sunlight and not under shade. Always store cotton seed in gunny bags or cloth bags in such a way that air could pass across the bags from bottom to top. Do not store cotton seed in plastic bags.
- Check seed germination before planting. Use delinted seed @ 6-8 kg/acre with 80 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 Southern Punjab is from 15th April to 31st 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 potential 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 23000-24000 plants per acre. On bed-furrow planting, thinning should be completed when plants are 10cm (4") in height. Remove weak or virus affected plants, if any, while thinning.
- A uniform early good crop stand ensures profitable cotton production.

WEED CONTROL

- 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 germination. 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 the cotton plants are protected with shield.
- Grasses especially "*Swanki*" and "*Madhana*" at 3 to 4 leaf stage can be controlled by spraying Haloxifop @ 400ml/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

- To flat (conventional) planting, apply first irrigation 30-40 days after sowing keeping in view the variety, soil type, crop and weather conditions. Subsequent irrigation should be applied according to crop need. There should be no 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 even after 24 hours causes shedding of the fruit. Be sure that white flower should not appear at the top of the plant which is an indication of water stress to the crop especially before the month of September.
- In bed-furrow planting, after the application of irrigation for germination subsequent irrigation should be given at 8-10 days interval.
- Last irrigation should be given by 1st week of October to avoid delay in crop maturity and late season pest attack.
- In case of excessive vegetative growth, mepiquat chloride @ 400 ml per acre in 3-4 split doses (if needed) during the months of July and August may be used to regulate the plant growth so that plant should start bearing the fruit.

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. 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 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.
- 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.
- ✪ Initiation of insecticidal 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.
- ✪ 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	Localized chemical treatment

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, around 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.

PICKING

- Seed cotton on the plant is a precious silver fiber. Maintaining its quality during picking, storing and transportation from the field or from store to the ginning factories is helpful to get quality price.
- Pick seed cotton 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 of the plant and go upward to the top. Pick well 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 keep picked cotton on moist soils in the field.
- Store seed cotton in ventilated stores in heaps of pyramid shape for proper aeration. The floor of the store should be of concrete and free from moisture.
- Moisture content in the seed cotton should be less than 12% otherwise the seed cotton will be heated in the stores. This will deteriorate lint as well as cotton seed quality.

VIII. PUBLICATIONS

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2. Kalimullah, M. I. Khan, Z. Mahmood, T. Iqbal, S. Muhammad, H. A. Haq, A. Ahmad, S. Hussain. 2017. Response of Yield and Related Attributes of Upland Cotton to Weather Variables. American Journal of Plant Sciences, V.08. Pp: 1711-1720. http://www.scirp.org/journal/ajps.
3. Khan. M. I , Khadim Hussain, Muhammad Akbar & Hafiz Abdul Haq. 2017. Evolution of Cotton (*Gossypium hirsutum* L.) Variety Bt.CIM-598 Equipped with Wider Adaptability Traits, CLCuV Tolerant and Desirable Fibre Traits. Jour.Pl. Agric. & Basic Sci. Vol. 28.PP:2518-4210. http://www.jabsjournal.com.
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2. Tariq, M., M. N. Afzal and M. Ahmed. 2017. Impact of elevated temperature in climate change scenario on cotton and management consideration published in 6th Int. Conference of Pakistan Phyto-pathological Society "Plant Health for Sustainable Agriculture, a focused approach for food security under changing climate" from 20-11-2017 to 22-11-2017, organized by Department of Plant Pathology, Bahaudin Zakariya University and Central Cotton Research Institute, Multan. PP.35
3. Mubeen K., M. N. Afzal, M. Tariq and M. Ahmed. 2017. Sowing dates influence cotton leaf curl disease (CLCuD) incidence and productivity of cotton cultivars published in "Sino-Pak International Conference on Innovation in Cotton Breeding and Biotechnology" from 22-11-2017 to 24-11-2017, organized by Muhammad Nawaz Sharif University of Agriculture, Multan. PP.51
4. Tariq, M., M. N. Afzal and M. Ahmed. 2017. Climate change trend of 21st century in cotton zone and adaptation through varietal development published in Int. Conference on "Tackling Climate Change through Plant Breeding" from 13-11-2017 to 15-11-2017 organized by Department of Plant Breeding, PMAS-Arid Agriculture University, Rawalpindi. PP. 22-23
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Annexure-I

Comparative Monthly Meteorological Data Recorded at CCRI, Multan during 2016 and 2017

Month	Air Temperature (ºC)				Relative Humidity				Average Wind Speed (Km h^{-1})		Rainfall (mm)		Evapo-transpiration (cm day)		Soil Temperature (ºC)	
	Minimum		Maximum		Minimum		Maximum								0 cm	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
January	9.9	8.5	16.4	17.0	76	60	96	98	2.6	6.7	0.9	11.7	0.18	0.16	12.0	12.4
February	10.7	11.1	23.2	21.8	58	62	90	91	2.5	3.4	0.1	11.0	0.31	0.31	13.1	15.4
March	17.8	16.6	26.1	26.9	70	58	84	79	4.8	4.3	20.1	0.0	0.36	0.51	22.2	21.2
April	22.5	22.8	34.5	37.2	85	51	86	56	5.0	5.5	13.1	5.7	0.73	0.98	30.3	28.5
May	28.5	28.3	40.2	39.7	73	57	75	69	6.5	6.7	2.0	0.1	1.17	1.12	38.2	32.6
June	31.1	28.7	39.8	37.5	67	69	70	80	6.8	7.5	4.0	45.6	1.11	1.09	54.9	33.2
July	29.5	30.0	36.5	37.3	70	67	75	79	6.3	7.2	36.2	4.9	1.02	1.15	42.3	35.3
August	28.1	28.4	35.1	35.2	82	60	86	85	4.6	7.7	109.0	30.0	1.07	0.99	39.6	34.9
September	26.2	25.8	34.8	35.4	80	65	84	89	3.9	4.3	4.0	10.0	1.17	0.77	37.9	30.3
October	20.8	20.3	33.0	33.7	62	66	75	89	2.7	2.4	0.0	0.0	1.16	0.80	35.6	25.4
November	13.5	13.8	26.4	22.2	55	70	83	93	2.1	2.7	0.0	4.2	0.28	0.20	19.5	16.3
December	10.7	8.9	22.2	20.4	62	59	94	91	1.8	2.1	0.0	16.0	0.16	0.22	14.3	10.1

Annexure-II

List of Officers at Central Cotton Research Institute, Multan (2017-18)

Discipline/ Designation	Incumbent	Qualification	Effective Date
DIRECTORATE			
Director	Dr. Zahid Mahmood	M.Sc. (Hons.) Agri., Ph.D	01.02.17
Farm Officer	Mr. Muhammad Azam Mian	M.Sc. (Hons.) Agri.	17.03.10
Administrative Officer	Mr. Zakirullah Khalidi	B.A.	20.05.14
Accountant	Mr. Nazir Ahmad[1]	B. Com.	11.12.00
APS	Mr. Zahid Khan	B.Com., M.A. (Economics)	02.02.14
Superintendent	Tahir Abbas Shamsi	B.A.	03.05.16
Superintendent	Nazar Abbas	B.A.	03.05.16
AGRONOMY			
SSO	Dr. Muhammad Naveed Afzal	M.Sc. (Hons.) Agri., Ph.D.	20.05.14
SO	Dr. Muhammad Ahmad	M.Sc. (Hons.) Agri., Ph.D.	05.05.16
SO	Mr. Muhammad Tariq	M.Sc. (Hons.) Agri.	29.05.14
BREEDING AND GENETICS			
SSO	Dr. Muhammad Idrees Khan	M.Sc.(Hons). Agri., Ph.D	20.05.14
SO	Mr. Muhammad Akbar	M.Sc. (Hons.) Agri.	17.03.10
SO	Mr. Khadim Hussain	M.Sc. (Hons.) Agri.	17.03.10
SO	Hafiz Abdul Haq	M.Sc. (Hons.) Agri.	14.05.14
SO	Mr. Saeed Muhammad	M.Sc. (Hons.) Agri.	16.05.14
SO	Dr. Fazal-i-Dayam Shehzad	M.Sc. (Hons.) Agri., Ph.D	15.05.14
CYTOGENETICS			
SSO	Ms Rehana Anjum**	M.Sc. (Hons.) Agri.	20.05.14
SO	Mrs. Farzana Ashraf	M.Sc. (Hons.) Agri.	22.03.10
SO	Dr. Khezir Hayat	M.Sc. (Hons.) Agri., Ph.D.	22.03.10
SO	Hafiz Muhammad Imran	M.Sc. (Hons.) Agri.	16.05.14
SO	Mrs. Rashida Aslam	M.Sc. (Hons.) Agri.	15.05.14

[1] On ex-Pakistan leave from 20.01.16
** Transferred to CCRI Sakrand

Discipline/ Designation	Incumbent	Qualification	Effective Date
ENTOMOLOGY			
SO	Dr. Rabia Saeed	M.Sc. (Hons.) Agri., Ph.D.	17.03.10
SO	Syed Ishfaq Ali Shah[2]	M.Sc. (Hons.) Agri.	22.03.10
SO	Mrs. Shabana Wazir	M.Sc. (Hons.) Agri.	14.05.14
PLANT PATHOLOGY			
SSO	Mrs. Sabahat Hussain	M.Sc. (Hons.) Agri.	20.05.14
PLANT PHYSIOLOGY / CHEMISTRY			
SSO	Dr. Fiaz Ahmad	M.Sc. (Hons.) Agri. Ph.D. (UK)	20.05.14
SO	Mrs. Asia Parveen	M. Phil (Biochemistry).	18.03.10
SO	Mr. Noor Muhammad[3]	M.Sc. (Hons.) Agri.	15.05.14
FIBRE TECHNOLOGY			
SO	Mr. Muhammad Ilyas Sarwar	M.Sc. Fibre Technology	14.05.14
SO	Mr. Danish Iqbal	M.Sc. Fibre Technology	19.05.14
TRANSFER OF TECHNOLOGY			
SO	Mr. Sajid Mahmood	M.A. (Mass Comm.)	11.12.06
Network Administrator	Mr. Muhammad Naveed Arshad	MS (Computer Science)	11.08.14
STATISTICS			
SO (Marketing)	Mr. Mubashir Islam Gill	M.B.A.	08.12.06

[2] Study Leave from 01.09.15, [3] Study Leave from 15.09.14,

SSO : Senior Scientific Officer **SO :** Scientific Officer **APS:** Assistant Private Secretary

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