PAKISTAN CENTRAL COTTON COMMITTEE, MULTAN

ANNUAL SUMMARY PROGRESS REPORT

CENTRAL COTTON RESEARCH INSTITUTE,

MULTAN

2016-2017

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Executive Summary

Central Cotton Research Institute (CCRI), Multan is a premier 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 2016-17" is being published on its 47th year of establishment. Over the years, many achievements have been made in the development of high yielding varieties with standard fibre quality characteristics like 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 on 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 743 kg per hectare during the current year. The continuous and untiring research endeavors of the scientists have yielded 22 cotton varieties (19 Non-Bt and 03 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.

Three Bt. cotton varieties (Bt.Cyto-177, Bt.Cyto-179, Bt.CIM-600) of CCRI Multan were approved for general cultivation in the 48th meeting of the Punjab Seed Council held on 06-03-2017 under the Chairmanship of Minister for Agriculture, Punjab. Moreover, two conventional cotton varieties (CIM-620, Cyto-124) were also approved for general cultivation in Punjab province. 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-602 was approved for commercial cultivation in the Sindh province. Moreover, recently, case for Bt.CIM-598 has also been floated for approval which is also expected to be approved in the coming Sindh Seed Council meeting. 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.

Sudden drying (New wilt) Symptoms are noticed in some fields after drought followed by rains or irrigation Cotton 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. On isolation and microscopic studies revealed fungus *Botryodiplodia sp*. was infested the internal stem portion. as a secondary pathogen. Spray with Nativo 75 WG, a formulation containing both fungicides (trifloxystrobin 250 **+** tebuconazole 500 g) @10mg/liter (10ppm) on affected plants within few hours of onset of symptoms gave an effective control against this fungus.

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

Cotton agronomy aims to efficient resource management to achieve sustainable cotton production goals in challenging environment of various agro-ecological zones. The research carried out showed that planting of cotton in the second week of April is the best choice for achieving higher production. The delaying in planting time results in the successive decrease in yield. Genotypes Cyto-124 produced higher yield over Cyto-122 and FH-942. Application of 200 kg N ha^{-1} to non *Bt.* cotton gave non-significant increase in seed cotton yield over 150 kg N ha^{-1}. The research findings showed that planting of transgenic cotton on 1st March produced significantly higher yield as compared to other planting dates i.e. 15th March, 1st April, 15th April, 1st May and 15th May. Genotype *Bt*. CIM-632 produced higher seed cotton yield as compared to *Bt*. Cyto-313 and *Bt*. CIM-602 (std). Nitrogenous fertilizer @ 400 kg ha^{-1} produced significantly higher seed cotton yield in transgenic cotton over 300 kg N ha^{-1}.

The result revealed that cotton planting as relay crop (75 cm apart rows) produced maximum seed cotton yield (4489 kg ha^{-1}) than fallow land early planting (4055 kg ha^{-1}). Planting of cotton under modified technique (Relay crop 75 cm apart rows) produced 10.7%, 8.4% and 48.5% higher cotton over fallow land, wide row (150 cm) and after wheat harvesting, respectively.

Potassium application @ 200 Kg K_2O in four equal splits (sowing, 30, 45 and 60 DAP) produced the highest seed cotton yield (4289 kg ha^{-1}). Furthermore, four foliar sprays of 2% K_2SO_4 (30, 45, 60 and 75 DAP) in combination with 200 kg ha^{-1} soil applied K_2O produced 7.1% more seed cotton yield over split application of 200 kg K_2O ha^{-1} alone. Daily weather data is also being maintained by the section. The cost of production for the year 2016-17 was Rs. 78003 ac^{-1}.

PLANT BREEDING & GENETICS

The main focus of the scientists of Breeding and Genetics Section, CCRI, Multan is to develop 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 development. This section holds its own recognition in this aspect. Variety CIM-620 has been approved for general cultivation by Punjab Seed Council and one while the case of Bt variety *Bt*.CIM-598 is in approval process in Sindh Seed Council for general cultivation in Sindh Province Bt.CIM-625 has completed its two year in NCVT while Bt.CIM-632 completed 1st year in NCVT. Twenty Seven advanced *Bt*. and non- Bt. Strains were evaluated at Multan and Khanewal locations. The new strain *Bt*.CIM-632 gave best performance at both the locations. The strain had the lint percentage of 41.2 with the staple length of 29.0 mm and micronaire of 4.1 µg $inch^{-1}$. The fibre strength of the strain is very good upto 30.2 g/tex. Seven advanced non-*Bt*. strains were also evaluated at Multan and Khanewal locations. The new strain CIM-723 produced the highest seed cotton yield on overall basis. All these strains have the desirable fibre characteristics. The crosses with exotic material Mac-7 and AS-0349 from France for induction of CLCuD resistant/tolerance are in different filial generations.

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. Cytological studies of a newly developed inter-specific hybrid was undertaken. The material industrial 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 , $F_4$and F_5.

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, varietal trials, ZVT and NCVT to observe their economic and fibre characteristics.

Three *Bt.* varieties viz., Cyto-177, Cyto178 and Cyto-179 were approved from Punjab seed council during 2016 and 2017 and the case of these varieties has been already submitted to National Biosafety Committee for the approval of their commercialization. *Bt*. Cyto-313 was tested in NCVT trial during 2016-17 and secured 6th position (2783 kg ha^{-1} average seed cotton yield) in overall Pakistan.

ENTOMOLOGY

Pink bollworm remained the hot topic of research during the study period. Sowing period impact on the development of pink bollworm, evaluation of new chemistry, survey conducted at major cotton growing districts, section also attempted to develop rearing technique on artificial diet. Studies were also conducted to see the impact of first spray on the 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, development of natural enemies of sucking pests on treated and untreated seed of GM cotton at different planting dates of cotton. Rearing and maintaining natural enemies for the use in the lab and for release in the field.

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

Plant Pathology Section conducted a survey during cotton crop season to record the prevalence of cotton leaf curl disease (CLCuD) and other cotton diseases in different parts of the Punjab. The maximum CLCuD was recorded in Bahawalpur, 71%. The average severity level of disease and natural incidence was less in D.G. Khan 16.8 when compared to other districts. All the varieties showed symptoms of CLCuD in surveyed areas. The maximum incidence was recorded in IUB-2015 (54%) with disease severity 2.0. 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 some spots However early sown rain fed crop was affected by wilting syndrome, in most of the cotton growing areas. Sudden drying (New wilt) Symptoms are noticed in some fields after drought followed by rains or irrigation Cotton 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. On isolation and microscopic studies revealed fungus *Botryodiplodia sp*. was infested the internal stem portion. as a secondary pathogen. Spray with Nativo 75 WG, a formulation containing both fungicides (trifloxystrobin 250 **+** tebuconazole 500 g) @10mg/liter (10ppm) on affected plants within few hours of onset of symptoms gave an effective control against this fungus.

PLANT PHYSIOLOGY / CHEMISTRY

Soil health management is the key to fetch profitable cotton production on sustained. This can be achieved by enriching soil organic matter content and replenishing all necessary nutrient elements. Integrated nutrient management and judicial use of fertilizers ensures higher yields of the farmland in a cost effective manner. However, the use of fertilizers in cotton crop is neither judicial nor balanced. As a result the production per unit area has not increased in line with the fertilizer consumption in cotton crop. To cope with the growing needs of the ever increasing population, the agricultural production has to be increased at an equal rate. This can only be achieved by replenishing all the nutrient needs of the crop in an optimized and integrated manner using alternate nutrient sources without compromising the soil health. Thus, there is a need to break the yield stagnation barriers by improving soil health and nutrient use efficiency through incorporation of different sources (inorganic and/or organic) in judicial manner to achieve desired yield goals. For this purpose multi location field studies were carried out for the third year to evaluate the appropriate nutrient requirement of Bt cotton as well as traditional non-Bt cotton in Multan Division. The studies revealed that the cotton genotypes (Bt & non-Bt) responded positively to incremental levels of fertilizers. The use of alternate resources of nutrients such as Farm Yard Manure (FYM) and micronutrients in conjunction with lower levels of NPK fertilizers can provide equally comparable and more economical yield than the higher doses of fertilizers alone.

Biotic and abiotic stresses have adverse effects on production and seed quality of cotton crop. Apart from exploring the inbuilt tolerance in genotypes, there is need to explore the efficacy of different bio-chemicals which may help in mitigating the adverse effects of stress environments on production and seed quality parameters. For example 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

Irrigation water shortage coupled with high atmospheric temperature has become crucial yield limiting factor in the current unfavorable climate change scenario. The section is regularly monitoring and screening the promising genotypes for water stress tolerance. A total of 12 varieties were tested under normal irrigation and artificially imposed water stress conditions in the field. The genotype NIAB-878 surpassed the other varieties in yield performance both under non-water stress and water stressed conditions. Among the 21 genotypes investigated for thermal stress tolerance, genotypes NIAB-878, NIAB-1064 and Deebal surpassed the other genotypes by maintaining greater anther dehiscence and producing highest 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 success of development of new varieties rests with the determination of quality characteristics of genetic material. The efforts made by the section are laudable towards this end. During the year, about 68,343 lint samples for fibre length, micronaire, fibre strength, color grade and for spinning potential were tested. Apart from lab work, research studies on evaluating the effect of environment on fibre quality were also carried out. Moreover, studies were also conducted to check the effect of CLCuV on various fibre parameters. The section also participated in the International Cotton Test Check Test programme with the Faser Institute, Germany.

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 Textile Industry (MinTex) 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, 2017

ANNUAL PROGRESS REPORT OF CENTRAL COTTON RESEARCH INSTITUTE, MULTAN FOR THE YEAR 2016-17

I. INTRODUCTION

Central Cotton Research Institute, Multan was established in 1970 by Pakistan Central Cotton Committee for conducting research on fundamental aspects of cotton crop. The Institute initially started functioning with five sections viz., Cytogenetics, Entomology, Plant Pathology, Plant Physiology/Chemistry and Statistics. To unravel the cotton production problems faced by the farmers and to increase production by evolving high yielding cotton varieties, the Institute expanded its horizon to cover applied research aspects as well. Consequently, sections of Plant Breeding & Genetics (1973), Agronomy (1975), Fibre Technology (1976) and Transfer of Technology (1983) were setup 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). The Institute now comprises of nine disciplines. Main objectives of the Institute are as follows:

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 2016-17 remained higher throughout cotton season (from second week of May to mid Novmber) while a different pattern was witnessed for minimum temperatures which remained higher during May to end of July and it remained lower for the rest of the season. The annual average maximum temperature during 2016/17 remained 32.6°C while it was 32.3°C during last year. Similarly the annual average minimum temperature during current year remained at 22.5°C while it was 22.3°C during last year. The average relative humidity remained 77.0% during current season while it was 77.5% during last season. A total of 168.8 mm rainfall was recorded during the crop season (Apr-Dec) of 2015 as compared to 282.8 mm rainfall during the last year.

The meteorological data for the year 2015 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 2015 and 2016 are given in Appendix-I.

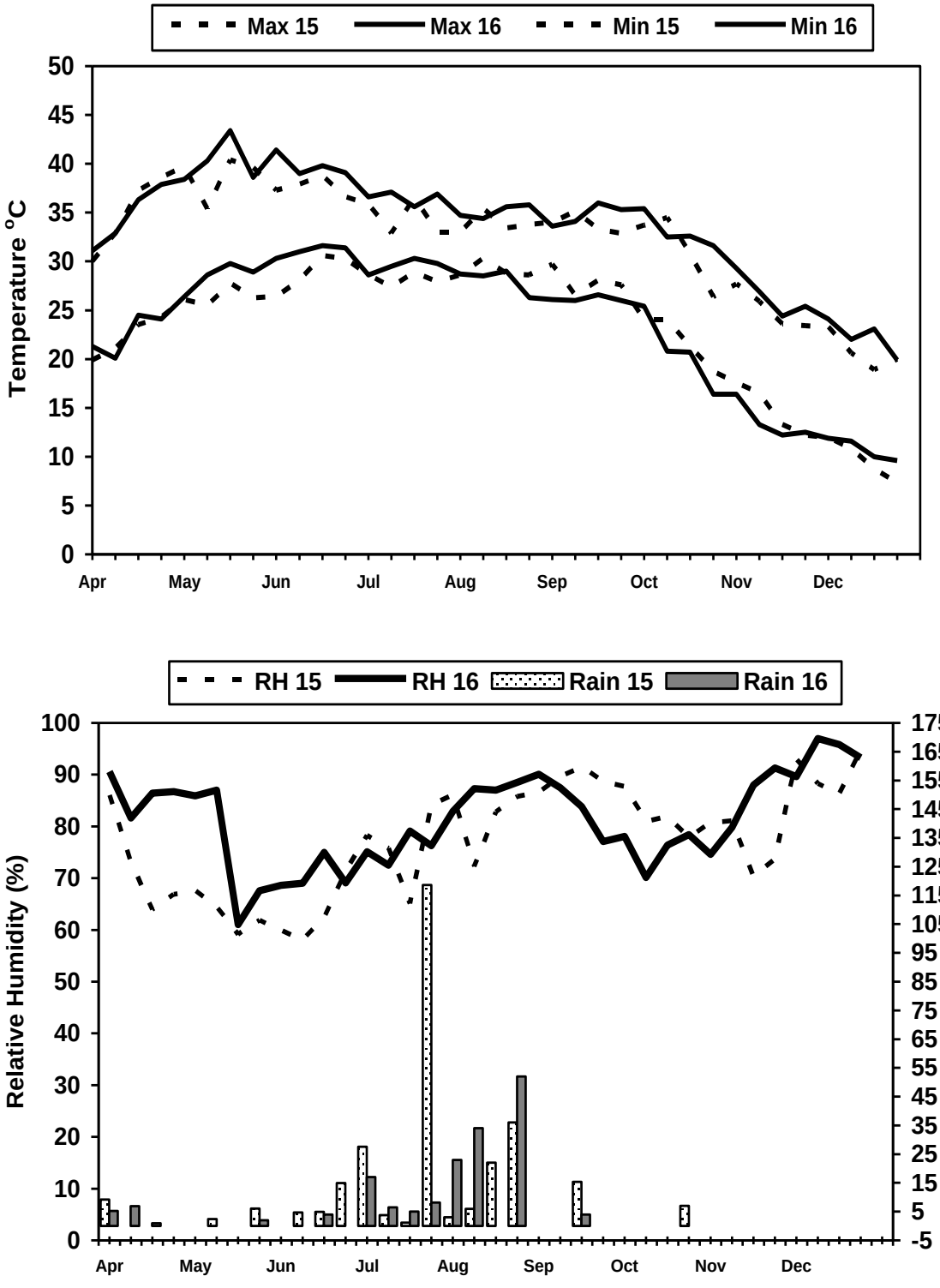

Fig. 1 Weekly Average Temperature, Relative Humidity and Total Rainfall during 2015 and 2016.

2. Cotton Crop Situation

2.1 Cotton Sowing

In the meeting of Federal Committee on Cotton held under the chairmanship of Secretary Ministry of Textile Industry Islamabad, fixed the cotton sowing targets of 5.7 Million acres for Punjab with production estimates of 9.5 million bales. But sowing was done on 4.388 million acres, which remained 23% less than the proposed target and 20.82% less than the previous year. Major decrease of 38% in cotton area has been observed in non-core areas (Sahiwal, Jhang, Chiniot, Pak Pattan, TT Singh, Faisalabad, Okara). Likewise, significant reduction in cotton cultivation was witnessed in Multan and Bahawalpur divisions which is the core-cotton belt of the Punjab. The trend of cotton yield remained 18-23 maunds /acre during last 10 years but previous year it dipped to 14 maunds/acre due to adverse environmental condition. Moreover, the changing climate condition and alternative crop is also affecting the sowing area of cotton crop.

(000 acres)

Punjab Area	Targets 2016	Area sown		%age(+/-) of the Target	%age(+/-) over last year
		2015	2016		
Core Areas	4692.150	4608	3776	80.47	-18.06
Non-Core Areas	725.010	639	394	54.34	-38.34
Marginal Areas	282.850	295	218	77.07	-26.10
PUNJAB	**5700.010**	**5542**	**4388**	**76.98**	**-20.82**

Source: CCMG 19.10.2016

The major reasons which can be attriubuted for the decrease in cotton area in the Punjab are:

- Low cotton prices during 2015-16 (Rs.1800-2200 per 40 kgs of seedcotton).
- Forecast of 20% more rains during 2016 than last year.
- Increased cultivation of sugarcane (+15%), maize (+16%), moong (+46%) and fodder crops in core cotton areas, compared with last year.

Cotton production in the Punjab province, during the year 2016, is expected to reach 6.9 million bales with yield of around 20 mds per acre.

2.2 Supply of Inputs

The overall certified seed availability in the Punjab province remained at 19,499 metric tons which was 63% of the total seed requirement of 31,000 metric tons for the Punjab province. However, there were few complaints about the quality of seed in various cotton growing areas.

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.

Availability & Off-take of Urea during Kharif 2016

(000 tons)

Description	APR	MAY	JUN	JUL	AUG	SEPT	TOTAL
Opening Inventory	1202	1252	1202	1052	1002	1052	**1202**
Imported Supplies	0	0	0	0	0	0	**0**
Domestic Production	450	450	450	450	450	450	**2700**
Total Availability	1652	1702	1652	1502	1452	1502	**3902**
Off-take	400	500	600	500	400	500	**2900**
Write Off/On	0	0	0	0	0	0	**0**
Estimated Inventory	1252	1202	1052	1002	1052	1002	**1002**

Source: Director General Agriculture (Ext.), Punjab, Lahore

Availability & Off-take of DAP During Kharif 2016

(000 tons)

Description	APR	MAY	JUN	JUL	AUG	SEPT	TOTAL
Opening Inventory	285	283	255	175	146	168	285
Imported Supplies	0	0	0	0	0	0	0
Domestic Production	68	72	70	71	72	68	421
Total Availability	353	355	325	246	218	236	706
Off-take	70	100	150	100	50	50	520
Write Off/On	0	0	0	0	0	0	0
Estimated Inventory	283	255	175	146	168	186	186

Source: Director General Agriculture (Ext.), Punjab, Lahore

The availability of cotton pest-specific pesticides remained satisfactory during the season. However, due to heavy rains and sudden flare up of Pink bollworm, Armyworm and other pests; farmers could not spray crop which damages cotton crop substantially.

PESTICIDE AVAILABILITY FOR KHARIF 2016

Pest wise category	Carryover as on 31.12.2015	Planned imports 2016	Total expected availability for 2016 Col. (2+3)	Actual sold 2015	Actual imports 2016	Total actual availability including carryover Col. (2+6)	Planned vs Actual Import (% Ratio)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
A) CROPLIFE PAKISTAN (Updated 16.05.2016 received on 25.05.2016)							
Heliothis Specific	275,023	1,598,627	1,873,650	1,511,444	870,750	1,145,773	54
Whitefly Specific	299,718	1,040,873	1,340,591	1,129,325	577,742	877,460	56
Melay Bug Specific	0	0	0	54,129	0	0	0
Armyworm Specific	123,042	200,000	323,042	263,852	104,588	227,630	52
Pink / Spotted Bollworm Specific	199,438	894,533	1,093,971	902,293	694,422	893,860	78
Others	108,515	400,524	509,039	384,999	237,194	345,709	59
Miticides / Acaricides	47,508	175,995	223,503	213,915	6,888	54,396	4
Weedicides	160,344	1,269,836	1,430,180	1,242,679	850,140	1,010,484	67
TOTAL	**1,213,588**	**5,580,388**	**6,793,976**	**5,702,636**	**3,341,724**	**4,555,312**	**60**
B) PAKISTAN CROP PROTECTION ASSOCIATION (Updated 20.05.2016 received on 25.05.2016							
Heliothis Specific	309,925	2,617,120	2,927,045	2,095,425	680,451	990,376	26
Whitefly Specific	3,850	5,856,000	5,859,850	5,560,000	3,045,120	3,048,970	52
Melay Bug Specific	16,905	490,710	507,615	931,300	68,699	85,604	14
Armyworm Specific	112,700	1,635,700	1,748,400	1,862,600	588,852	701,552	36
Pink / Spotted Bollworm Specific	-	1,427,000	1,427,000	1,280,538	285,400	285,400	20
Others	120,120	4,330,470	4,450,590	11,552,638	1,688,883	1,809,003	39
Miticides / Acaricides	376,500	325,680	702,180	578,560	58,622	435,122	18
Weedicides	435,600	2,157,000	2,592,600	2,384,500	2,135,430	2,571,030	99
TOTAL	**1,375,600**	**18,839,680**	**20,215,280**	**26,245,561**	**8,551,457**	**9,927,057**	**45**
SUMMARY (CROP LIFE + PCPA)							
Heliothis Specific	584,948	4,215,747	4,800,695	3,606,869	1,551,201	2,136,149	37
Whitefly Specific	303,568	6,896,873	7,200,441	6,689,325	3,622,862	3,926,430	53
Melay Bug Specific	16,905	490,710	507,615	985,429	68,699	85,604	14
Armyworm Specific	235,742	1,835,700	2,071,442	2,126,452	693,440	929,182	38
Pink / Spotted Bollworm Specific	199,438	2,321,533	2,520,971	2,182,831	979,822	1,179,260	42
Others	228,635	4,730,994	4,959,629	11,937,637	1,926,077	2,154,712	41
Miticides / Acaricides	424,008	501,675	925,683	792,475	65,510	489,518	13

Weedicides	595,944	3,426,836	4,022,780	3,627,179	2,985,570	3,581,514	87
TOTAL	**2,589,188**	**24,420,068**	**27,009,256**	**31,948,197**	**11,893,181**	**14,482,369**	**49**

Source: Director General Agriculture (Ext.), Punjab, Lahore

2.3 Cotton Pests and Disease Situation

The Director General, Pest Warning & Quality Control of Pesticides Punjab reported that whitefly population was found maximum in the month of September and it raised up to 28 adults/leaf due to which yield of cotton crop was affected. Moreover, the population of Spotted bollworm, Pink bollworm and American bollworm was observed during the month of August and September. American bollworm population and incidence of Cotton Leaf Curl Virus (CLCuV) was found on all the cotton varieties. Some spots of cotton mealy bug were reported and its population was high in Multan district. However, the population of dusky cotton bug was found less than the previous year. Army worm population was also observed in different patches throughout the season. The overall summary of cotton insect pests and disease position as compared to previous year is given below:

Sr. No.	Pests & Diseases	2016	2015	2014
1.	Whitefly	4.97	4.38	5.25
2.	Jassid	1.70	4.38	4.23
3.	Thrips	0.00	0.00	--
4.	Mealy Bug	9.83	7.06	11.87
5.	Mites	0.00	0.10	--
6.	Dusky Cotton Bug	2.62	0.54	4.33
8.	Pink Boll Worm	11.83	7.06	1.24
10.	Army Worm	1.35	2.24	--
11.	CLCuV (% Incidence)	7.21	10.37	12.10

Source: PWQC, Punjab

2.4 Cotton Plant Mapping

The Director, Crop Reporting Service Punjab presented the cotton plant mapping data up to 15.10.2016 as below:

Major Yield Component	2016-17	2015-16	% Change
Av. Days After Sowing	148.4	147.4	0.68
Plants / Acre	13811	13439	2.77
Av. Plant Height (cm)	120.9	114.4	5.68
Av. Squares	3.01	3.71	-18.9
Av. Flowers	0.39	0.38	2.63
Bolls /Plant	18.4	14.9	23.5
Av. Irrigations	10.5	8.92	17.7
Av. Sprays	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	47.0	42.9	9.56
Phosphate	14.4	12.3	17.1

The bolls per plant, plant height and plant population was better than the previous year which transformed into better seed cotton yield per acre.

2.5 Cotton Market Situation

2.5.1 Cotton Prices

The market prices of seedcotton on overall season basis remained at Rs.2688 per 40 kgs as compared to Rs.2513 during last year. Similar trend was also seen in case of lint prices which averaged at Rs.6213 against Rs.5485 during last year. Better prices of seedcotton and lint were observed during current year as compared to previous year.

Month	2014	2015	2016
June	7277	5200	5984
July	6521	5197	6630
August	5779	4883	6780
September	6050	5133	6445
October	5648	5739	6653
November	5504	5699	6702
December	5076	5607	6715
January	5238	5377	5762
February	5236	5723	5728
March	5398	5620	5620
April	5310	5802	5818
May	5255	5615	5717
Average	5731	5485	6213

2.5.2 Cotton Arrival Position

The cotton arrival position into ginning factories upto 15th February, 2017, as reported by Pakitan Cotton Ginners Assocaition, showed an increase of 10.3% in the country than that of last year whereas Punjab province showed an increase arrival of 6.899 million bales against 5.927 million bales of 2015 showing an overall increase of 16.39% increase in the arrival over the previous year.

Province	2016-17	2015-16	% Change
Punjab	6,899,312	5,927,372	+ 16.39
Sindh	3,785,942	3,759,746	+ 0.69
PAKISTAN	**10,685,254**	**9,687,118**	**+ 10.30**

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 2016-17 is given in **Appendix-II**.

IV. BUDGET

The sanctioned budget from the year 2013-14 to 2016-17 is given below:

(Rs. Million)

Sr. #	Detail	2013-14	2014-15	2015-16	2016-17
1.	Pay & Allowances	47.072	66.464	68.470	67.622
2.	Medical	2.607	3.465	2.00	3.413
3.	Traveling Allowance	0.179	0.500	1.500	1.500
4.	Group Insurance	0.167	0.641	0.987	0.795
5.	Utility Bills*	4.723	6.610	6.750	7.060
6.	Contingencies	5.750	11.755	21.22	25.485
	Total	**60.498**	**89.435**	**103.928**	**105.875**

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

V. INCOME

The income of the Institute from the year 2013-14 to 2016-17 is given below:

(Rs. Million)

Sr. #	Head	2013-14	2014-15	2015-16	2016-17*
1.	Farm Produce	5.634	1.871	2.880	2.778
2.	Non-Farm Produce	0.018	0.000	1.183	0.778
	Total	**5.652**	**1.871**	**4.063**	**3.556**

* Period from 1st July to 29th February

VI. MAJOR ACCOMPLISHMENTS

i) Approval of Cotton Varieties by the Punjab Seed Council

Five cotton varieties of CCRI Multan were approved for general cultivation in the 48th meeting of the Punjab Seed Council held on 06-03-2017 under the Chairmanship of Minister for Agriculture, Punjab. While two conventional varieties have already approved for general cultivation in Punjab provice.

Characteristics	Bt Varieties			Non-Bt Varieties	
	Bt.Cyto-177	Bt.Cyto-179	Bt.CIM-600	CIM-620	Cyto-124
Ginning out-turn (%)	40.8	40.2	42.8	40.2	427.
Staple length (mm)	29.0	28.2	28.8	28.9	30.5
Micronaire value (μg inch^{-1})	4.3	4.2	4.6	4.6	4.3
Fibre strength (tppsi)	105.2	107.6	96.7	93.0	98.6

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.

ii) Approval of Cotton Varieties by the Sindh Seed Council

The cotton varieties of CCRI Multan has 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-602 was approved for commercial cultivation in the Sindh province. Moreover, recently, case for Bt.CIM-598 has also been floated for approval which is also expected to be approved in the coming Sindh Seed Council meeting.

Characteristics	Varieties	
	Bt.CIM-602	Bt.CIM-598
Ginning out-turn (%)	40.7	40.1
Staple length (mm)	29.0	28.3
Micronaire value (μg inch^{-1})	4.3	4.2
Fibre strength (tppsi)	95.0	96.1

iii) Training of Field Staff of Agriculture Extension & Pest Warning & Quality Control of Pesticides Department, Punjab on Off-Season Management of Pink Bollworm and Mealybug

Dr. Muhammad Naveed, Head Entomology, 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. Accordingly, a comprehensive meeting was held with Secretary & Additional Secretary of Agriculture Task Force, Punjab on 02.01.2017 at Agriculture Secretariat, Lahore. Dr. Muhammad Naveed, and Mr. Khalid Ch. Director, General, PW&QC attended the meeting. Accordingly, a common management strategy was devised during the meeting for "Production plan of Cotton for 2017-18" held on 03.01.2017 at Ayub Agriculture Research Institute, Faisalabad. The Head,

Entomology, conducted training programs for the off-season management of Pink bollworm and Mealybug in the following districts.

Date	Districts	Participants
16.01.2017	Khanewal	21
16.01.2017	Sahiwal	24
17.01.2017	Vehari	92
17.01.2017	Bahawalnagar	106
18.01.2017	Bahawalpur	24
18.01.2017	Lodhran	39
19.01.2017	Multan	35
21.01.2017	Bhakkar	48
21.01.2017	Layyah	46
23.01.2017	Muzaffargarh	43
23.01.2017	D.G.Khan	48
	TOTAL	**526**

The participants in all the above training programmes included Directors of Agriculture (Ext); Deputy Director Agriculture, Assistant Director, Agriculture Officer, Field Assistant & Cotton Inspector from Agriculture Extension Department and Pest Warning & Quality Control of Pesticides, Department, Punjab.

iv) 75th Plenary Meeting of the ICAC

The Pakistan Central Cotton Committee (PCCC) and the Ministry of Textile Indsustry, Government of Pakistan organized 75th Plenary Meeting of the ICAC (International Cotton Advisory Committee) at Islamabad from October 30 to November 4, 2016. The theme of the Conference was "Emerging Dynamics in Cotton: Enhancing Sustainability in Cotton Value Chain". Around 500 national and international participants attended the meeting. The scientists/staff of CCRI Multan remained proactive in organizing the Conference and installed an Exhibition Stall, assisted in various Organizing Committees (Reception, Registration, Transport, Conference Hall, Presentation, Recommendations/Report Writing etc). Moreover, following two scientists also presented papers in the meeting as well:

Scientist	Title of Paper
Dr. Muhammad Naveed, Head, Entomology	New Pests New Challenges
Mr. Ilyas Sarwar, Head, Fibre Technology	Challenges to Cotton due to Fibre Mix

v) Consultative Meeting for Enhancing Cotton Production in the Punjab Province

In compliance to the directives of the Ministry of Textile Industry, Government of Pakistan for holding meetings at provincial level along with cotton stakeholders to get feedback about issues related to cotton growers with special reference to:

i) Expanding the Area
ii) Increasing Yield of Cotton
iii) Improving Quality

Accordingly, a meeting on the subject with cotton stakeholders was held under the chairmanship of Dr. Zahid Mahmood, Director, CCRI Multan on February 2, 2017. The representatives from Pakistan Cotton Ginners Association, Seed and Pesticide Industry and cotton growers attended the meeting. A comprehensive report, in consultation with stakeholders, was prepared with regard to enhance cotton production in the Punjab province and submitted to the Ministry of Textile Industry for implementation by the federal government.

vi) Cotton wilt

The fungus responsible for cotton wilt disease was isolated in laboratory by Plant Pathology Section of the Institute and identified as *Botryodiplodia sp.*

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

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1. AGRONOMY

The agronomy's major fields of research are core issues of production factors such as soil, water, nutrients and various approaches of weed management and climate impacts on candidates and benchmark varieties (GMO's & Open pollinated) evolved by CCRI. In addition to crop management, relay cropping technology is also in progress with the objective of improving the profitability of wheat-cotton cropping systems through minimum tillage and cultural management of CLCuD. The importance of potassium fertilization in cotton nutrition programme and strategies to improve the efficiency of soil applied potassium through split and supplemental foliar spray is part of agronomic experimentation.

1.1 Effect of time of sowing on productivity of advanced genotypes

Three genotypes i.e. Cyto-124, FH-942 and Cyto-122 were tested at five sowing dates starting from April 15th to June 15th 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. Fertilizer at the rate of 150 kg N 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 (%age) 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 %age 105 DAS
April 15	Cyto-124	118.4	32.0	2.55	3009	2.4
	FH-942	116.8	30.0	2.60	2880	41.7
	Cyto-122	130.0	33.0	2.53	3206	2.3
May 01	Cyto-124	113.3	31.0	2.56	2922	2.3
	FH-942	107.4	28.0	2.62	2758	39.5
	Cyto-122	124.8	30.0	2.53	2850	6.4
May 15	Cyto-124	108.7	27.0	2.59	2616	34.6
	FH-942	104.8	26.0	2.62	2550	70.9
	Cyto-122	119.6	27.0	2.55	2592	15.1
June 01	Cyto-124	104.3	22.0	2.60	2064	17.8
	FH-942	100.2	20.0	2.64	1896	100.0
	Cyto-122	108.6	21.0	2.56	1978	29.9
June 15	Cyto-124	97.0	18.0	2.62	1736	62.7
	FH-942	93.4	16.0	2.65	1616	100.0
	Cyto-122	97.2	17.0	2.58	1616	78.0

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 %age
April 15	121.7	31.7	2.56	3032	15.5
May 01	115.2	29.7	2.57	2843	16.1
May 15	111.0	26.7	2.59	2586	40.2

June 01	104.4	21.0	2.60	1979	49.2
June 15	95.9	17.0	2.62	1656	80.2

Genotypes	Plant height (cm)	Number of Bolls plant^{-1}	Boll Weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence %age
Cyto-124	108.3	26.0	2.58	2469	23.96
FH-942	104.5	24.0	2.63	2340	70.42
Cyto-122	116.0	25.6	2.55	2448	26.34

C.D 5%

Sowing date (SD)	8.37	2.25	ns	124.61	5.05
Genotype (G)	6.09	ns	ns	ns	2.87
SD x G	ns	ns	ns	ns	6.42

The data presented in Table 1.1 indicated that on overall average basis of sowing dates, Cyto-124 produced higher seed cotton yield as compared to Cyto-122 and FH-942. The genotype Cyto-124 produced 0.86 and 5.51% higher seed cotton yield than Cyto-122 and FH-942, respectively. Average across the genotypes, plant height decreased as the sowing was delayed, April 15 and May 01 sown crop produced significantly more number of bolls than other sowing dates and seed cotton yield decreased significantly as sowing was delayed (Fig.1, 2 & 4). While, boll weight increased as the sowing was delayed (Fig. 3). Among all sowing dates maximum boll weight was (2.62) produced from 15th June sown crop. The maximum bolls per plant (32) and seed cotton yield (3032 kg ha^{-1}) were harvested from April 15 sown crop.

The data on CLCuD showed that the disease incidence gradually increased as the sowing was delayed from April 15 up to June-15 (Fig. 5). The incidence of CLCuD at 105 days after sowing was observed 49.2% in June 01 and 80.2% in June 15 sown crops. Whereas, April 15, May 01 and May 15 showed 15.5%, 16.1% and 40.2% virus infestation, respectively. On the average basis of sowing dates, genotype Cyto-124 showed 2.38% and 46.46% less CLCuD incidence than Cyto-122 and FH-942, respectively (Fig. 6). The interaction between sowing dates and genotypes is illustrated in (Fig. 7).

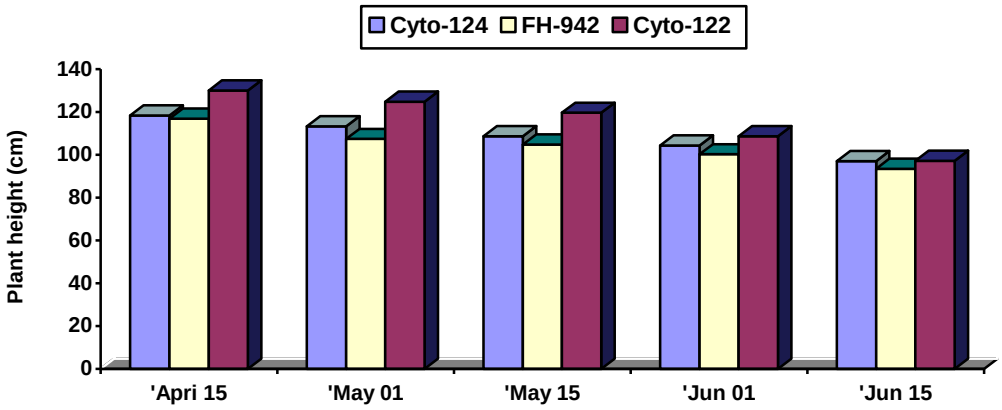


Fig 1 Sowing dates x Genotypes interaction on plant height

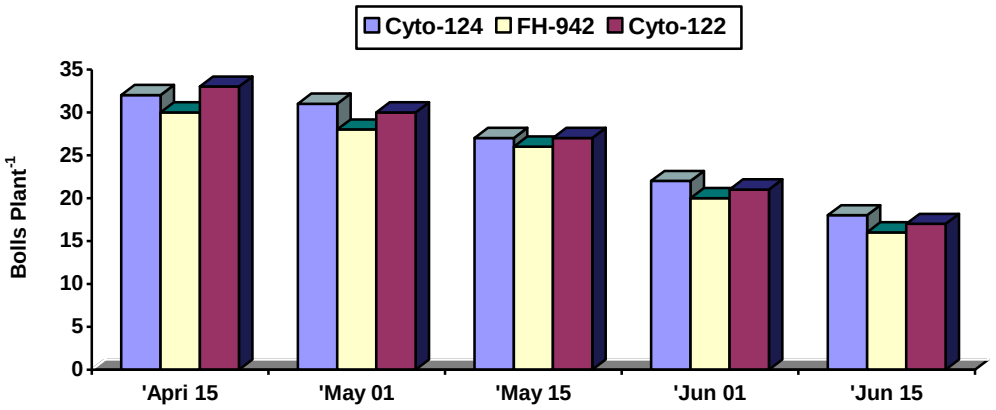


Fig 2 Sowing dates x Genotypes interaction on bolls plant^{-1}

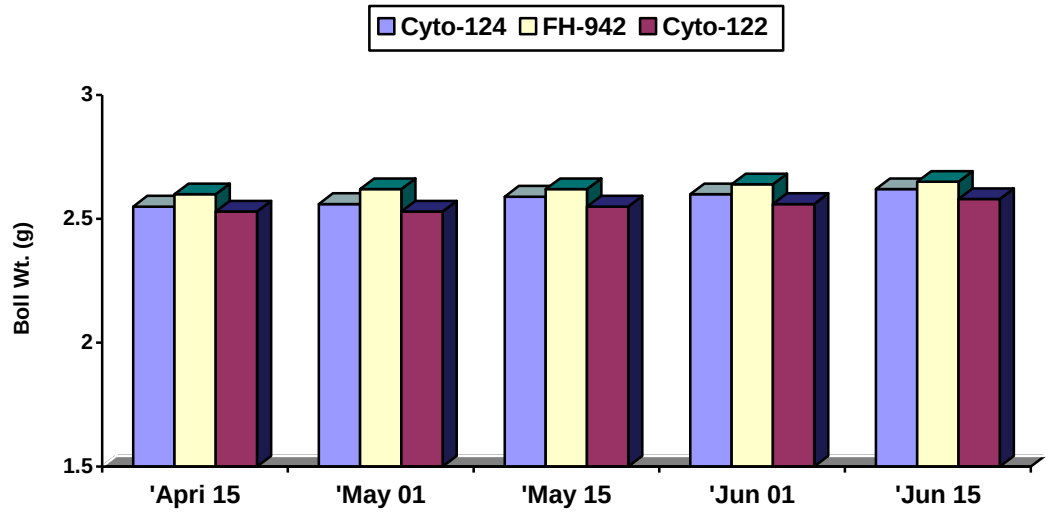


Fig 3 Sowing dates x Genotypes interaction on boll weight

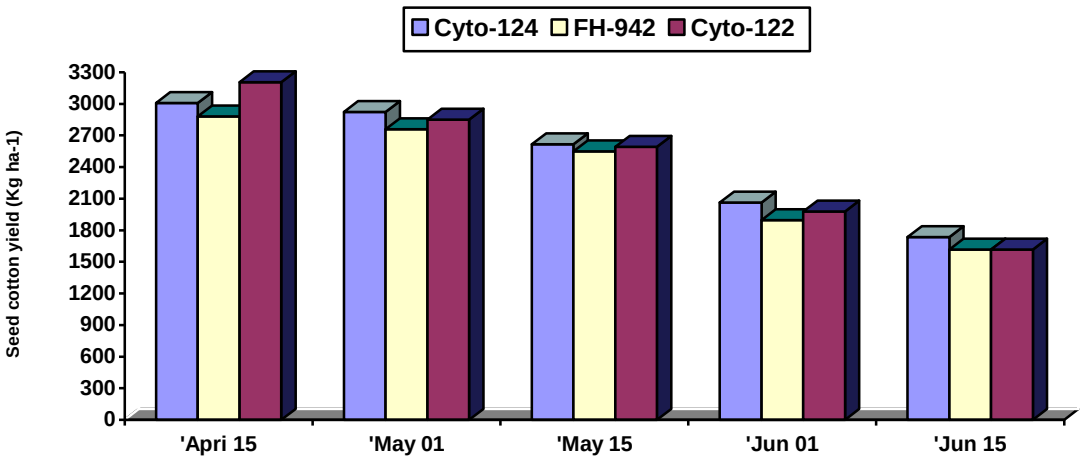
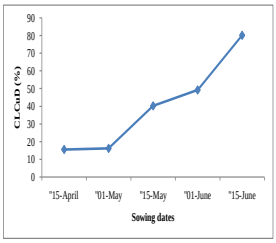


Fig 4 Sowing dates x Genotypes interaction on seed cotton yield



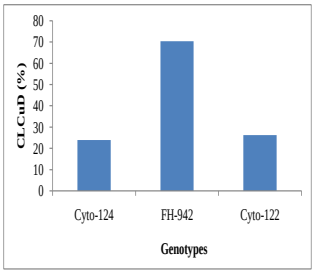


Fig 5. Sowing dates effect on virus infestation at 105 DAS

Fig 6. CLCuD Incidence in different genotypes

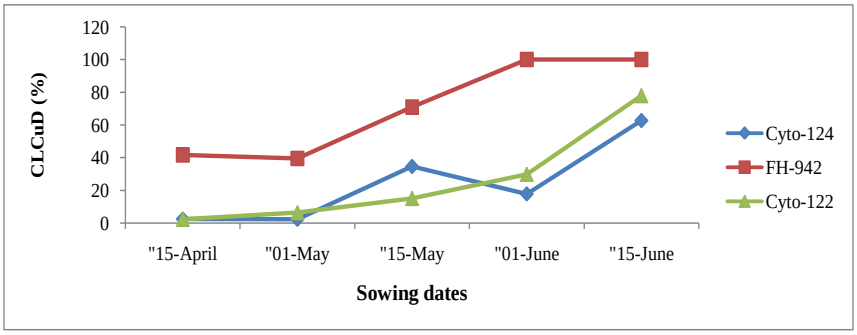


Fig 7. Sowing dates x Genotypes interaction for CLCuD incidence (%) at 105 DAS

1.2 Effect of time of sowing on production of transgenic cotton

Three transgenic cotton genotypes i.e. *Bt.*CIM-632, *Bt.*Cyto-313 and *Bt.*CIM-602 (std) were evaluated at six different sowing dates starting from March 1st to May 15th at fortnightly interval. Experimental design was split plot, sowing dates were kept in main plot and genotypes in sub plots with four repeats. Bed-furrow 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 (%age) recorded are given in Table 1.2.

The plant height, bolls per plant and seed cotton yield was decreased and boll weight was increased with delay in sowing (fig 8, 9, 10 and 11). The maximum plant height (137.4 cm), bolls plant^{-1} (37) and seed cotton yield (3549 kg ha^{-1}) were harvested from March 1st sown crop. Among all sowing dates maximum boll weight (2.64 g) was produced from 15th May sown crop. On overall average basis of sowing dates, *Bt*.CIM-632 produced 1.15% and 3.12% more seed cotton yield than *Bt*.Cyto-313 and *Bt*.CIM-602, respectively.

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 %age 120 DAS
March 01	*Bt.*CIM-632	143.4	38	2.53	3611	0.00

	Bt.Cyto-313	138.9	37	2.55	3560	1.23
	Bt.CIM-602	130.0	36	2.53	3475	1.45
March 15	*Bt*.CIM-632	141.3	35	2.57	3366	1.12
	Bt.Cyto-313	137.8	35	2.55	3348	2.02
	Bt.CIM-602	128.7	33	2.59	3232	3.00
April 01	*Bt*.CIM-632	131.3	32	2.60	3035	44.52
	Bt.Cyto-313	128.2	31	2.56	2979	13.36
	Bt.CIM-602	125.5	32	2.62	3056	11.65
April 15	*Bt*.CIM-632	120.5	29	2.62	2789	85.27
	Bt.Cyto-313	117.5	30	2.60	2880	80.39
	Bt.CIM-602	119.1	29	2.63	2777	81.49
May 01	*Bt*.CIM-632	105.9	26	2.61	2468	100.00
	Bt.Cyto-313	102.8	25	2.59	2379	89.35
	Bt.CIM-602	99.2	24	2.66	2320	96.71
May 15	*Bt*.CIM-632	96.0	23	2.64	2190	100.00
	Bt.Cyto-313	93.1	23	2.61	2118	100.00
	Bt.CIM-602	90.5	21	2.66	2070	100.00

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 %age
March 01	137.4	37	2.54	3549	0.89
March 15	135.9	34	2.57	3315	2.05
April 01	128.3	32	2.59	3023	23.18
April 15	119.0	29	2.62	2815	82.38
May 01	102.6	25	2.62	2389	95.35
May 15	93.2	22	2.64	2126	100.0

Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence %age
Bt.CIM-632	123.1	31	2.60	2910	55.15
Bt.Cyto-313	119.7	30	2.58	2877	47.73
Bt.CIM-602	115.5	29	2.62	2822	49.05

C.D 5%

Sowing date (SD)	10.39	3.16	ns	215.39	2.86
Genotype (G)	5.34	ns	ns	ns	2.96
SD x G	ns	ns	ns	ns	7.25

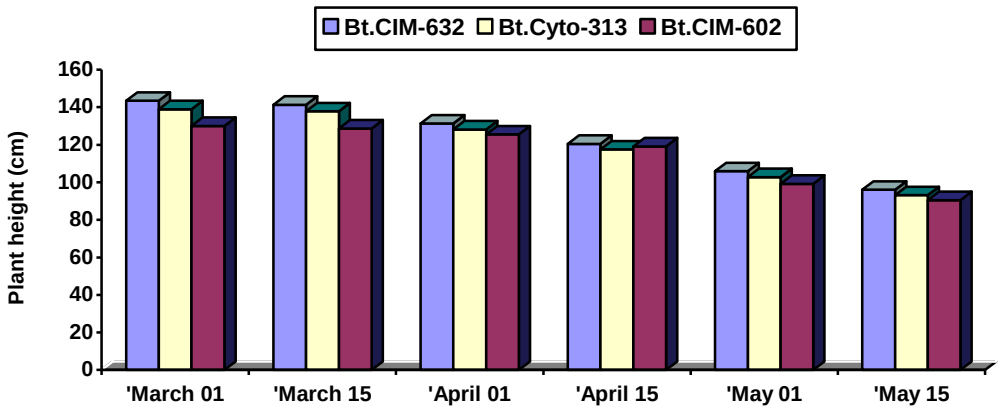


Fig 8 Sowing dates x Genotypes interaction on plant height

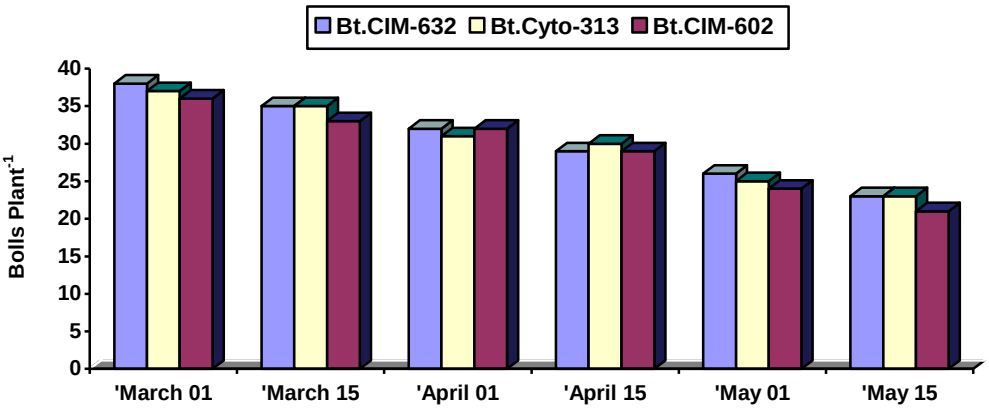


Fig 9 Sowing dates x Genotypes interaction on bolls plant^{-1}

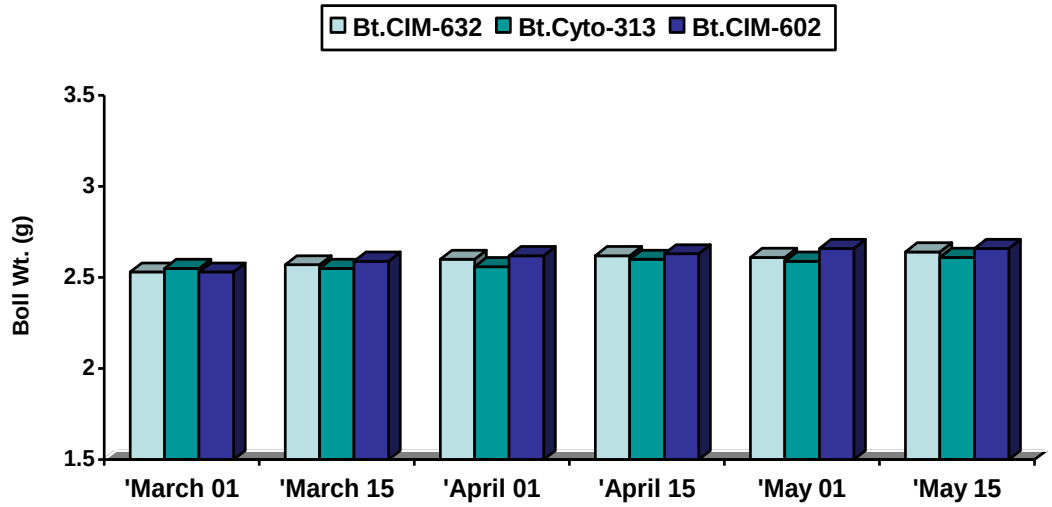


Fig 10 Sowing dates x Genotypes interaction on boll weight

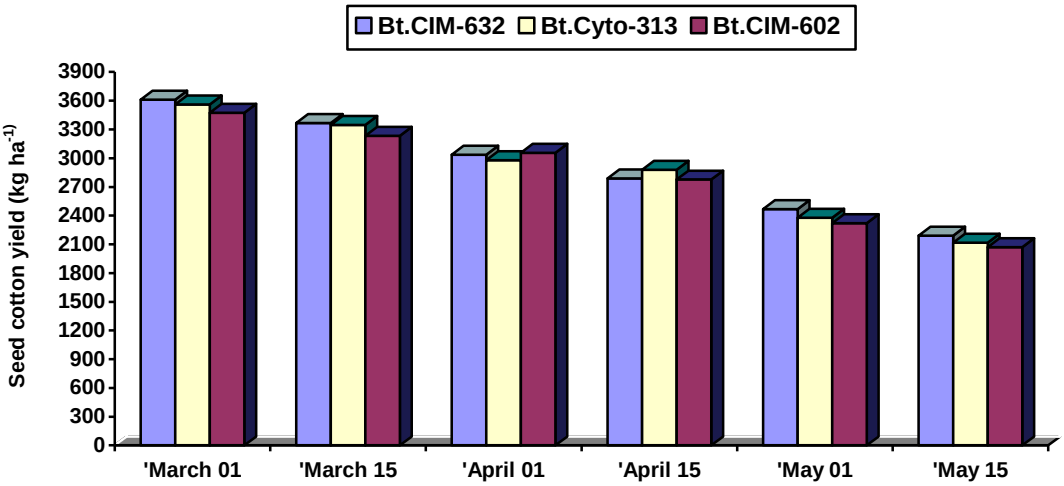
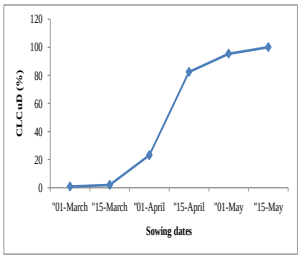


Fig 11 Sowing dates x Genotypes interaction on seed cotton yield



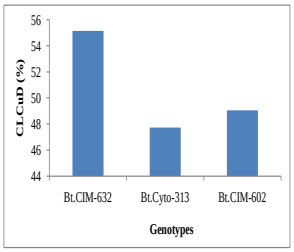


Fig 12. Virus Infestation at 120 DAS at various sowing dates

Fig 13. CLCuD Incidence (%) in different genotypes

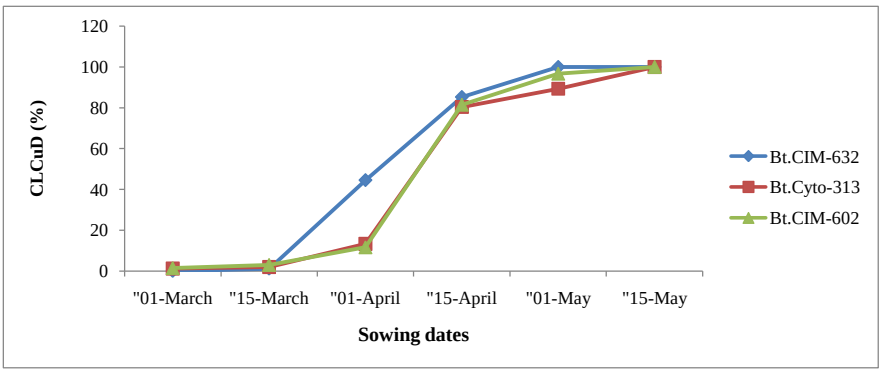


Fig 14. Sowing Dates x Bt. Genotypes Interaction for CLCuD Incidence (%) at 120 DAS

The data on CLCuD indicated that the disease incidence increased as the sowing was delayed from March 01 to May 15 (Fig. 12). The incidence of CLCuD after 120 days was observed 95.35% in May 01 and 100% in May 15 sown crop. While, March 01, March 15, April 01 and April 15 sown crops showed 0.89%, 2.05%, 23.18% and 82.38% virus infestation, respectively. On the average basis of sowing dates, genotype *Bt.*Cyto-313 showed 1.32% and 7.42% less incidence of CLCuD than *Bt.*CIM-602 and *Bt.*CIM-632, respectively (Fig. 13). The interaction between sowing dates and genotypes is illustrated in Fig. 14.

1.3 Evaluation of new genotypes at different levels of nitrogen fertilizer

Three genotypes i.e. CIM-620, Cyto-122 and CIM-554 (std) were tested at five levels of nitrogen (0, 50, 100, 150 and 200 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. Stomp 455CS @ 2.5 L ha^{-1} was sprayed at the time of bed shaping in dry condition. Sowing was done on 13.05.2016 on bed-furrow by dibbling method followed by irrigation. The nitrogen fertilizer (50 to 200 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 and seed cotton yield are given in Table 1.3.

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

Nitrogen dose (kg ha^{-1})	Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll Weight (g)	Seed cotton yield (kg ha^{-1})
0	Cyto-122	114.2	17	2.33	1524
	CIM-620	118.1	19	2.35	1681
	CIM-554	120.2	18	2.36	1599
50	Cyto-122	122.8	22	2.35	2010
	CIM-620	129.7	24	2.38	2190
	CIM-554	130.9	22	2.40	2067
100	Cyto-122	128.1	25	2.37	2424
	CIM-620	134.4	27	2.40	2566
	CIM-554	136.2	26	2.43	2505
150	Cyto-122	135.4	29	2.40	2684
	CIM-620	139.2	30	2.44	2802
	CIM-554	142.7	29	2.46	2739
200	Cyto-122	138.2	29	2.41	2702
	CIM-620	140.6	31	2.46	2969
	CIM-554	144.9	30	2.46	2818

Sub-effects

Nitrogen (kg ha^{-1})	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
0	117.5	18	2.35	1601
50	127.8	23	2.38	2089
100	132.9	26	2.40	2498
150	139.1	29	2.43	2742
200	141.2	30	2.44	2830

Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Cyto-122	127.7	24	2.37	2269
CIM-620	132.4	26	2.41	2442
CIM-554	135.0	25	2.42	2 346

C.D 5%

Nitrogen (N)	6.52	2.92	0.042	204.18
Genotype (G)	5.36	ns	0.037	108.33
N x G	ns	ns	ns	ns

The data presented in Table 1.3 indicated that an increase in nitrogen application rates produced improved figures for plant height, seed cotton yield and yield components over control. The maximum values for these traits were recorded with 200 kg N ha^{-1} followed by 150 kg (fig 15, 16, 17 and 18). However, non-significant differences between 150 and 200 kg nitrogen was observed for recorded parameters. Therefore, nitrogen fertilization at the rate of 150 kg N ha^{-1} is recommended for general cultivation to harvest maximum economic returns. The genotypes differed significantly for plant height, boll weight and seed cotton yield. The genotype CIM-620 was characterized the best among other genotypes for seed cotton yield. Whereas, tested genotypes did not differ in nitrogen requirement which can be visualized from absence of nitrogen into genotype interaction.

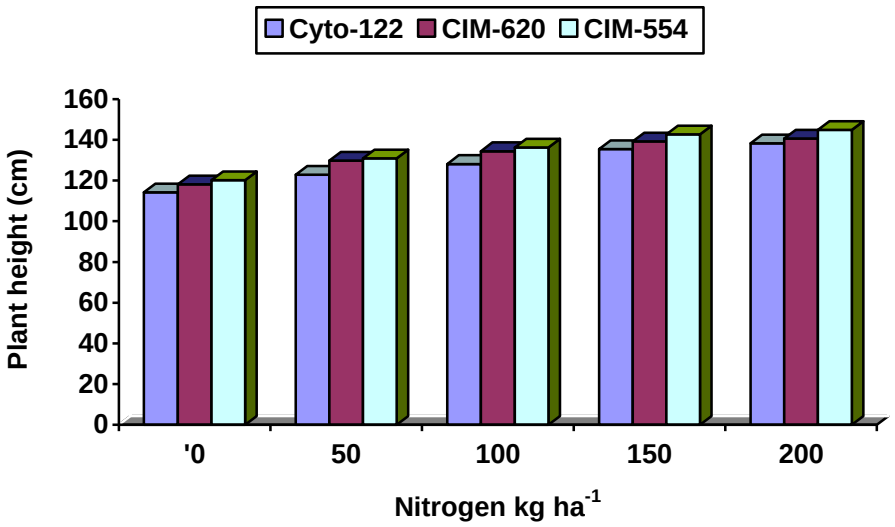


Fig 15 Nitrogen levels X genotypes interaction on plant height

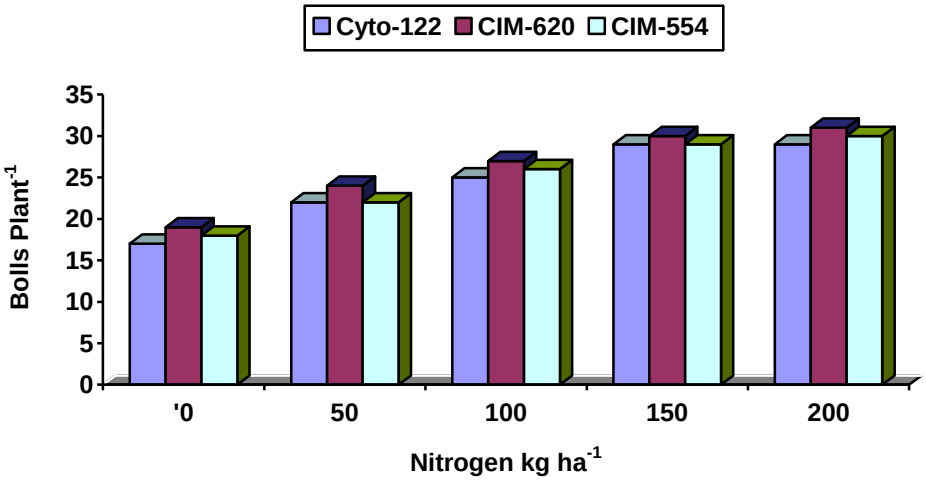


Fig 16 Nitrogen levels X genotypes interaction on bolls plant^{-1}

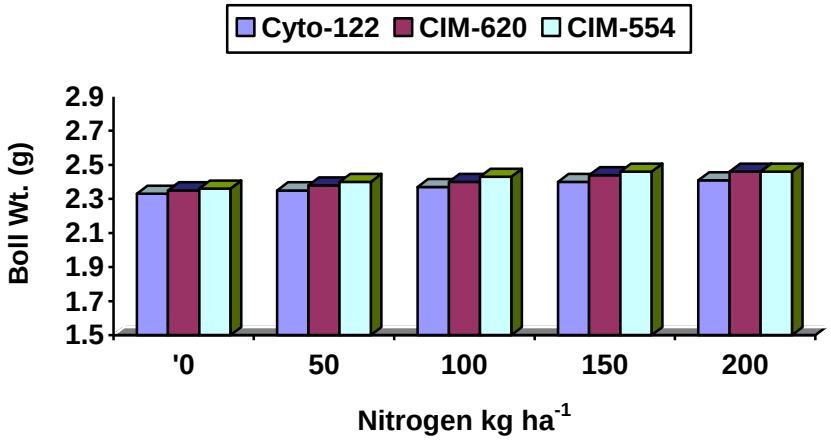


Fig 17 Nitrogen levels X genotypes interaction on boll weight

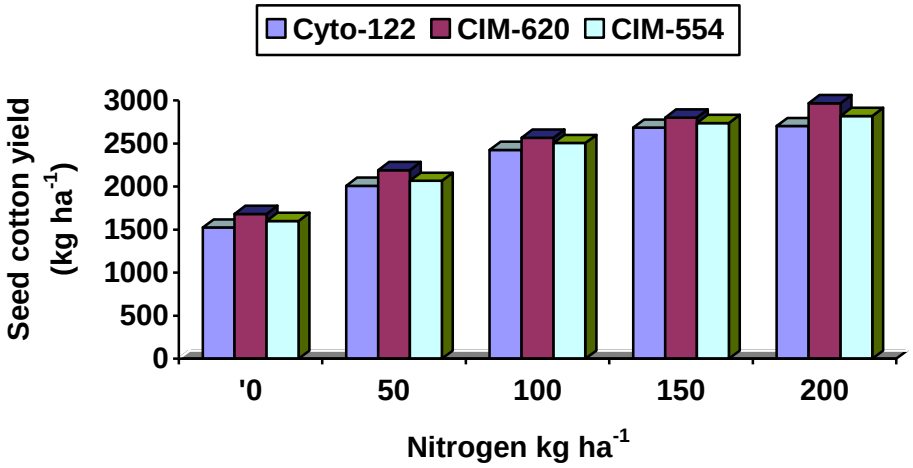


Fig 18 Nitrogen levels X genotypes interaction on seed cotton yield

1.4 Evaluation of transgenic cotton at different levels of nitrogen fertilizer

Three genotypes i.e *Bt.*CIM-632, *Bt.*Cyto-313 and *Bt.*CIM-602 (std) were tested at five levels of nitrogen (0, 100, 200, 300 and 400 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. Dual Gold 960 EC @ 2L per hectare was sprayed after sowing on moist beds. Sowing was done on 11.05.2016 on bed-furrow by dibbling method followed by irrigation. The nitrogen fertilizer (100 to 400 kg N ha^{-1}) was applied in four splits in their respective plots. Other cultural practices and plant protection measures were adopted as per need of the crop. Data on plant height, boll number, boll weight and seed cotton yield are given in Table 1.4.

Table 1.4 Interactive effects of nitrogen fertilizer and transgenic cotton on plant height, seed cotton yield and yield parameters

Nitrogen dose (kg ha^{-1})	Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
0	*Bt*. CIM-632	120.8	19	2.58	1793
	Bt.Cyto-313	109.8	18	2.55	1707

	Bt.CIM-602	113.2	17	2.55	1653
100	*Bt*. CIM-632	125.5	27	2.62	2565
	Bt.Cyto-313	122.2	26	2.60	2473
	Bt.CIM-602	121.2	24	2.64	2314
200	*Bt*. CIM-632	132.4	31	2.65	2887
	Bt.Cyto-313	127.2	30	2.64	2811
	Bt.CIM-602	125.8	28	2.66	2626
300	*Bt*. CIM-632	135.6	33	2.71	3103
	Bt.Cyto-313	132.1	32	2.68	3026
	Bt.CIM-602	129.6	31	2.71	2984
400	*Bt*. CIM-632	138.4	35	2.72	3379
	Bt.Cyto-313	136.2	34	2.70	3224
	Bt.CIM-602	131.5	33	2.74	3187

Sub-effects

Nitrogen (kg ha^{-1})	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
0	114.6	18	2.56	1718
100	123.0	26	2.62	2451
200	128.5	30	2.65	2775
300	132.4	32	2.70	3038
400	135.4	34	2.72	3263

Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Bt.CIM-632	130.5	29.0	2.66	2745
Bt.Cyto-313	125.5	28.0	2.63	2648
Bt.CIM-602	124.3	26.6	2.66	2553

C.D 5%

Nitrogen (N)	6.81	3.17	0.048	148.29
Genotype (G)	ns	1.83	ns	116.11
N x G	ns	ns	ns	ns

The plant height, yield and yield components were significantly affected by nitrogen application (Table 1.4). The highest figures for recorded traits were observed at 400 kg N ha^{-1} followed by 300 kg (Fig 19, 20, 21 and 22). The difference between 400 & 300 and 200 & 100 kg N ha^{-1} were non-significant with each other for plant height and bolls weight. The significant differences among genotypes were recorded only for number of bolls and seed cotton yield. The genotype *Bt*. CIM-632 produced maximum number of bolls and seed cotton yield followed by *Bt*. Cyto-313 and *Bt*. CIM-602. The genotype *Bt.*CIM-632 produced 3.7% and 7.5% higher seed cotton yield over *Bt.*Cyto-313 and *Bt.*CIM-602. Non-significant interaction was observed for recorded parameters, indicating that genotypes did not differ for nitrogen requirement.

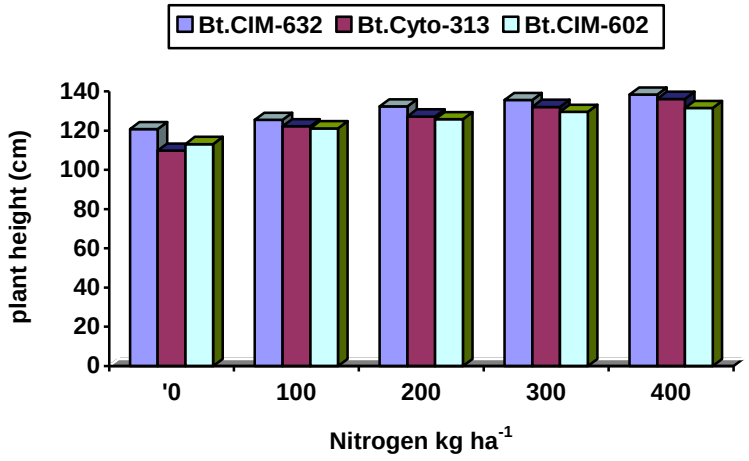


Fig 19 Nitrogen levels X genotypes interaction on plant height

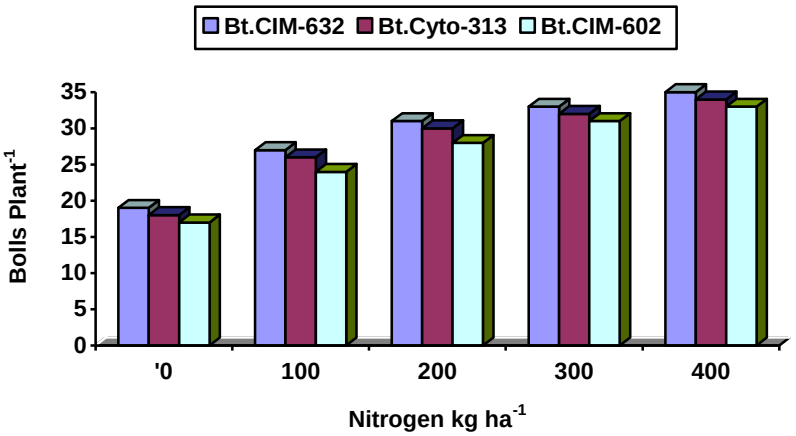


Fig 20 Nitrogen levels X genotypes interaction on bolls plant^{-1}

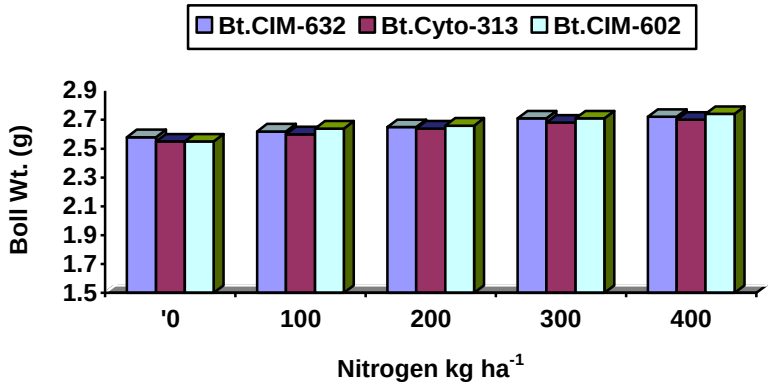


Fig 21 Nitrogen levels X genotypes interaction on boll weight

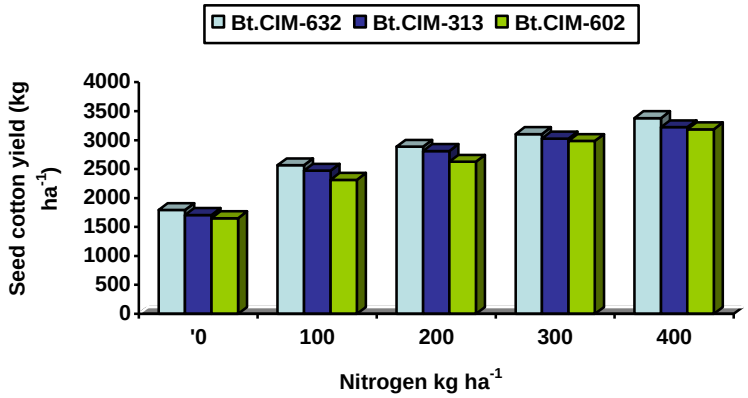


Fig 22 Nitrogen levels X genotypes interaction on seed cotton yield

1.5 Response of cotton to potassium fertilizer

Studies were conducted to determine potassium requirement of transgenic cotton with different doses in combination with foliar application. In set-I, three potassium doses i.e. 0, 100 and 200 kg K_2O ha^{-1} were applied to soil either as full dose at pre-plant, two splits (pre-planting and 45 DAP) and four splits (pre-plant, 30, 45 and 60 DAP). In set-II, the potassium doses i.e. 0, 100 and 200 kg K_2O ha^{-1} were applied to soil at pre-plant and supplemented with four foliar sprays of KNO_3 at 30, 45, 60 and 75 DAP. Experimental design was Randomized Complete Block Design (RCBD) with four replications. Bed-furrows were prepared after land preparation in dry condition followed by bed shaping and application of Dual Gold 960 EC @ 2 lit ha^{-1}. Cotton cultivar *Bt*.CIM-616 was dibbled on 18-04-2016. Sowing was done by dibbling seeds at 25cm plant to plant distance followed by irrigation. Data on plant height (cm), number of bolls per plant, boll weight (g), and seed cotton yield was recorded which is given in Table 1.5.1.

Table 1.5.1: Potassium application strategies impact on plant height, yield and its components

Potassium Fertilizer (kg K_2O ha^{-1})	Time of application	Plant height (cm)	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})
0	Control	146.3	34	2.52	3223
100	Full at sowing	155.4	41	2.59	3971
	Two splits	157.4	42	2.60	4111
200	Full at sowing	162.1	44	2.62	4225
	Four splits	165.2	45	2.62	4289
CD 5%		2.35	.94	.096	850.60

Data presented in table 1.5.1 showed that main stem height, number of bolls per plant, boll weight (g) and seed cotton yield varied significantly with K-fertilization. Soil application of K either as full dose or in splits increased the above parameters over control. Split application produced improved figures for plant height, yield and yield related attributes over respective pre-plant application. Main stem height increased from 146.3 to 165.2 cm as the K dose was increased from 0 to 200 kg ha^{-1}. The number of bolls per plant, boll weight and seed cotton yield was improved from 34 to 45, 2.52 to 2.62 (g) and 3223 to 4289 kg ha^{-1} with the increase in potassium application from 0 to 200 kg K_2O ha^{-1}.

Data presented in table 1.5.2 indicated that main stem height, number of bolls, boll weight and seed cotton yield varied with K-fertilization. Soil application of K increased plant height, yield and yield related parameters while foliar application caused further improvement. Foliar application of 2% KNO_3 was equally effective for improving plant structure and yield at control and potassium fertilized plots. Main stem height increased from 150.5 to 166.1 cm as the K dose was increased from 0 to 200 kg K_2O ha^{-1} with foliar spray of 2% KNO_3. The bolls per plant, boll weight and seed cotton yield was improved from 34 to 47, 2.53 to 2.63 (g) and 3269 to 4595 kg ha^{-1}, respectively, with the increase in potassium application from 0 to 200 kg K_2O ha^{-1} in combination with foliar spray of 2% KNO_3. Non-significant difference between 100 and 200 kg K_2O ha^{-1} without foliar application was obtained for seed cotton yield. However, potassium application with 100 kg K_2O ha^{-1} supplemented with four foliar sprays of 2% KNO_3 is better choice to harvest good economic returns.

Table 1.5.2: Enhancing efficiency of soil applied potassium fertilizer in cotton through exogenous KNO_3 application

Potassium Application (kg K_2O ha^{-1})	Foliar Spray	Plant height (cm)	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})

0	No spray	150.5	34	2.53	3269
	Water spray	151.0	34	2.53	3275
	2% KNO_3 spray	157.2	36	2.55	3437
100	No spray	160.2	43	2.59	4225
	Water spray	160.7	43	2.59	4237
	2% KNO_3 spray	162.2	44	2.60	4302
200	No spray	164.0	45	2.62	4471
	Water spray	164.2	45	2.62	4485
	2% KNO_3 spray	166.1	47	2.63	4595
CD 5%		7.86	4.73	0.06	291.3

1.6 Cotton as Relay Cropping

Cotton cultivar *Bt.* CIM-616 was used as a test crop in all treatment of the experiments. The crop was sown on 20-04-2016 as sole crop on fallow land (T_1). While, sowing in standing wheat was done on 18-03-2016 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 10-05-2016 (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. Application of stomp 455 CS @ 2.5 liter per hectare was applied as pre-emergence in treatments of T_1 and T_4 while Dual Gold 960 EC @ 800 ml / acre in T_2 and T_3 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 1.6

Table 1.6: 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)	54000	146.2	212	2.86	4055
Cotton sowing in standing wheat (row to row distance 75cm)	70000	154.8	328	2.84	4489
Cotton sowing in standing wheat (row to row distance 150cm)	65000	160.5	306	2.82	4140
Cotton planting after wheat harvesting	50000	138.6	175	2.85	3022
C.D 5%	10928	ns	34.54	ns	722.62

The data presented in Table 1.6 indicated that cotton sowing in standing wheat (75 cm apart rows) produced maximum bolls (328 m^{-2}) and seed cotton yield (4489 kg ha^{-1}). While, the minimum bolls (175 m^{-2}) and seed cotton yield (3022 kg ha^{-1}) were produced from cotton sown after wheat harvesting. The maximum plant height (160.5 cm) was produced from cotton sown in standing wheat (150 apart rows). Whereas, the maximum boll weight (2.86 g) produced by the cotton crop sown as sole. Planting of cotton under modified technique (Relay crop 75 cm apart rows) produced 8.4, 10.7 and 48.5% higher seed cotton yield over wide row (150 cm), fallow land and after wheat harvesting, respectively.

1.7 Internship

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

1.8 Cost of Production of One Acre Cotton for the Year 2016-17

Sr. No.	Operations and Inputs	Number/ Quantity	Rate (Rs)	Amount (Rs.)
1.	Land Preparation			**2210.00**
	a) Leveling	1	360/leveling	360.00
	b) Cultivation	3	600/cultivation	1800.00
	c) Bund making	1	50/acre	50.00

2.	Seedbed Preparation a. Rambar b. Ploughing + planking c. Pre-emergence Herbicide	 1 4 1.2 litre	 300/acre 600/cultivation 1080/1.2litre	**3780.00** 300.00 2400.00 1080.00
3.	Seed a. Cost b. Transportation c. Delinting	 8 kg. - -	 6000/40 kg 25/bag 400/40 kg	**1285.00** 1200.00 5.00 80.00
4.	Sowing by drill	1	600/acre	**600.00**
5.	Thinning	2	480/acre	**960.00**
6.	Interculturing and earthing up	4	600/acre	**2400.00**
7.	Irrigation a. Land preparation (3 hours) b. *Rouni* (4 hours) c. Post planting irrigation (21hours) d. Cleaning of water channel and labour charges for irrigation	 1/3 canal 2/3 tubewell 4 man day	 500/hour of tubewell 480/man day	**11253.00** 9333.00 1920.00
8.	*Abiana* (Water rates)	-	85/acre	**85.00**
9.	Fertilizer a. DAP (Di-Amonium Phosphate) b. Urea c. Transportation d. Fertilizer Application Charges	 1 bag 3.0 bags 4.0 bags 1man day	 2600/bag 1400/bag 25/bag 480/day	**7380.00** 2600.00 4200.00 100.00 480.00
10.	Plant Protection a. Sucking b. Bollworm	 8 5	 700/spray 600/spray	**8600.00** 5600.00 3000.00
11.	Harvesting (Picking charges)	800 Kg	10.0/kg	**8000.00**
12 12a	Stick Cutting Value of cotton sticks	2 man day	480/man day	+960.00 -960.00
13.	Managerial Charges For 1 acre	8 month	20000/month/100 acre	**1600.00**
14.	Ushar	-	120/acre	**120.00**
15.	Land Rent	8 months	30,000/acre/annum	**20000.00**
16.	Unforeseen Expenses	-	2000/acre	**2000.00**
17.	Production Expenditure a. Including Land Rent b. Excluding Land Rent	-	-	**70273.00** **50273.00**
18.	Mark-up on Investment a. Including Land Rent b. Excluding Land Rent	8 month	11% for one year	**7730.00** **5530.00**
19.	Total Expenditure a. Including Land Rent b. Excluding Land Rent	--		**78003.00** **55803.00**
20.	Income of Seed Cotton	800 kg	3000/40 kg	**60000. 00**
21.	Market expenses	800 kg	100/40 kg	**2000. 00**
22.	Cost of Production at Farm level a. Including Land Rent b. Excluding Land Rent	-	Per 40 kg	**3900.15** **2790.15**
23.	Cost of production at Market a. Including land rent. b. Excluding land rent.	-	Per 40 kg	**4000.15** **2890.15**

2. PLANT BREEDING & GENETICS SECTION

Plant Breeding & Genetics Section produces new cotton varieties or lines with desirable fibre properties by utilizing purposeful interbreeding (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. The breeding materials in different segregating 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*. breeding material. Pre-basic seed of commercial varieties viz., CIM-496, CIM-620, CIM-554, CIM-573, *Bt.*CIM-598, *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 collections comprising of 5923 cultivars of four *Gossypium* species is being maintained for evaluation, introduction as well as utilization in breeding programme 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-629, CIM-630, CIM-632, CIM-641, CIM-642 and CIM-643, were evaluated against two *Bt*. commercial varieties i.e. 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 2.1, 2.2** and **2.3**.

Averaged across locations, the strain CIM-642 produced the highest seed cotton yield of 3991 kg ha^{-1} followed by CIM-632 having yield 3709 kg ha^{-1} while the standard varieties FH-142 and *Bt*.CIM-602 yielded 3053 and 2616 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 (19/4)*	Khanewal (17/5)*	Average			
CIM-629	3052	2989	3021	1151	3.3	41695
CIM-630	3020	3118	3069	1295	2.9	43309
CIM-632	3118	4300	3709	1528	2.8	40709
CIM-641	3356	2580	2968	1229	3.1	41785
CIM-642	3789	4193	3991	1628	3.1	41785
CIM-643	3167	2688	2928	1148	3.2	40440
FH-142	2773	3333	3053	1200	3.7	42054
CIM-602	2652	2580	2616	981	3.1	39274

* = Sowing date 19.04.2016

CD (5%) for seed cotton: Locations (L) = 52.04; Varieties (V) = 98.80; L x V = 130.90

The new strain CIM-630 produced the highest lint percentage of 42.2, followed by CIM-641 and CIM-632 having lint percentage values of 41.4 and 41.2, respectively as compared with the standard FH-142 (39.3%) and *Bt*.CIM-602 (37.5%) (**Table 2.2**). The new strain CIM-643 produced the longest staple of 29.4 mm, followed by CIM-632 with 29.0 mm while the standards FH-142 and *Bt*.CIM-602 produced 27.0 and 28.1 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-629	37.0	39.1	38.1	26.0	27.2	26.6
CIM-630	41.0	43.3	42.2	27.4	28.1	27.8
CIM-632	41.1	41.2	41.2	28.2	29.8	29.0
CIM-641	39.4	43.3	41.4	27.5	27.7	27.6
CIM-642	39.8	41.8	40.8	27.9	29.6	28.8

CIM-643	38.1	40.3	39.2	28.5	30.3	29.4
FH-142	38.8	39.7	39.3	26.0	27.9	27.0
CIM-602	36.4	38.6	37.5	27.2	29.0	28.1

All the new strains possess desirable micronaire values ranging from 3.8 to 4.6 μg inch^{-1} in comparison to FH-142 with 4.4 μg inch^{-1} and *Bt*.CIM-602 with 3.9 μg inch^{-1}. The fiber strength of all the new strains and standards is in the desirable range, i.e., 27.5 to 30.9 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-629	4.3	4.1	4.2	29.4	28.4	28.9
CIM-630	4.3	3.9	4.1	29.2	28.3	28.8
CIM-632	4.1	4.1	4.1	31.5	28.8	30.2
CIM-641	4.6	4.5	4.6	27.6	27.3	27.5
CIM-642	4.0	3.6	3.8	30.2	30.7	30.5
CIM-643	4.1	4.4	4.3	32.3	29.5	30.9
FH-142	4.6	4.1	4.4	27.2	28.5	27.9
CIM-602	3.9	3.8	3.9	28.5	28.1	28.3

2.1.2 Varietal Trial-2

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

Seven new strains with medium-long staple viz., CIM-610, CIM-717, CIM-719, CIM-720, CIM-721, CIM-722 and CIM-723 were tested at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal against a commercial variety CIM-573.

Data presented in **Table 2.4** showed that the new strain CIM-723, averaged across locations, produced the highest seed cotton yield of 2775 kg ha^{-1}, followed by CIM-722 with 2675 kg ha^{-1} and CIM-721 with 2662 kg ha^{-1} while the standard variety CIM-573 produced 2304 kg ha^{-1}.

The strain CIM-717 had the highest lint percentage of 40.1, followed by 39.2% of CIM-610 in comparison to the commercial variety CIM-573 which produced 38.6 lint percentages. The strain CIM-723 produced the longest staple of 31.4 mm followed by CIM-719 and CIM-722 having 30.1 mm each and 30.0mm of CIM-573. **(Table 2.5).**

All the strains possess desirable micronaire values ranging from 4.2 to 4.6 μg inch^{-1}**.** The fibre strength of the strains ranged from 29.1 to 31.9 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 (20/5)*	Khanewal (17/5)*	Average			
CIM-610	2104	3010	2557	1002	3.1	37391
CIM-717	2582	2580	2581	1035	2.5	36943
CIM-719	2312	1720	2016	770	2.8	39633
CIM-720	2075	2924	2500	950	2.6	38646
CIM-721	2486	2838	2662	1036	3.0	38915
CIM-722	2188	3161	2675	1030	3.1	38736
CIM-723	2045	3505	2775	1055	2.9	34701
CIM-573	1705	2903	2304	889	2.4	37122

* = Sowing date 20.05.2016

CD (5%) for seed cotton: Locations (L) = 61.09; Varieties (V) = 103. 81; L x V = 120.60

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-610	37.6	40.8	39.2	28.3	29.0	28.7
CIM-717	38.0	42.2	40.1	28.2	28.4	28.3
CIM-719	38.1	38.2	38.2	30.1	30.1	30.1
CIM-720	38.0	38.0	38.0	28.2	29.6	28.8
CIM-721	37.9	39.9	38.9	28.8	27.5	28.2
CIM-722	37.9	39.0	38.5	29.7	30.5	30.1
CIM-723	37.5	38.5	38.9	31.2	31.4	31.4
CIM-573	37.8	39.3	38.6	28.7	30.4	30.0

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-610	4.3	4.0	4.2	30.4	29.0	29.7
CIM-717	4.7	4.5	4.6	28.8	29.3	29.1
CIM-719	4.0	4.3	4.2	31.9	30.9	31.4
CIM-720	4.2	4.1	4.2	29.5	30.3	29.9
CIM-721	4.4	4.2	4.3	29.3	30.1	29.7
CIM-722	3.9	4.5	4.2	31.5	32.1	31.8
CIM-723	4.0	4.4	4.2	31.1	32.6	31.9
CIM-573	4.1	4.2	4.2	32.3	32.7	32.5

2.1.2 Varietal Trial-3

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

Six medium staple promising CIM-636, CIM-637, CIM-638, CIM-640, CIM-644 and CIM-645 were evaluated against *Bt*. commercial variety 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 2.7, 2.8** and **2.9**.

Averaged across locations, the strain CIM-636 produced the highest seed cotton yield of 3448 kg ha^{-1} followed by CIM-645 having yield of 3322 kg ha^{-1} while the standard variety FH-142 yielded 3636 kg ha^{-1} and *Bt*.CIM-602 produced 2797 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 (19/4)*	Khanewal (17/5)*	Average			
CIM-636	3219	3677	3448	1379	3.4	40709
CIM-637	2878	2946	2912	1130	3.0	41069
CIM-638	2862	2817	2840	1119	2.9	41247
CIM-640	2868	2666	2767	1137	3.6	41067
CIM-644	3162	3139	3101	1207	3.3	41874
CIM-645	3224	3419	3322	1365	3.0	40170
FH-142	3508	3763	3636	1505	2.8	41605
CIM-602	2863	2731	2797	1082	2.9	40171

* = Sowing date 19.04.2016

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

The new strains CIM-640 and CIM-645 produced the highest lint percentage of 41.1, followed by CIM-636 having lint percentage values of 40.0 while standard FH-142 produced 41.4 and *Bt*.CIM-602 produced 38.7 % of lint **(Table 2.8).** The new strain CIM-640 produced the longest staple of 30.2 mm, followed by CIM-645 and CIM-638 with 29.4 mm and 29.0 mm respectively while the standards FH-142 produced 27.9 mm and standard *Bt*.CIM-602 produced 28.7 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-636	38.3	41.7	40.0	28.6	28.9	28.7
CIM-637	38.1	39.5	38.8	29.0	28.9	28.9
CIM-638	38.0	40.9	39.4	28.4	29.6	29.0
CIM-640	39.6	42.7	41.1	30.1	30.4	30.2
CIM-644	38.0	38.6	38.3	28.7	28.6	28.6
CIM-645	40.3	41.9	41.1	29.5	29.4	29.4
FH-142	39.9	42.9	41.4	27.3	28.6	27.9
CIM-602	38.5	38.9	38.7	27.0	29.7	28.3

All the new strains possess desirable micronaire values ranging from 4.1 to 4.2 μg inch^{-1} in comparison to FH-142 with 4.0 and Bt.CIM-602 with 4.3 μg inch^{-1} respectively. The fibre strength of all the new strains and standards is in the desirable range, i.e., **(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-636	4.1	4.1	4.1	29.3	29.1	29.2
CIM-637	4.2	4.2	4.2	30.3	29.1	29.7
CIM-638	4.1	4.0	4.1	27.8	27.3	27.5
CIM-640	4.2	4.2	4.2	29.4	29.0	29.2
CIM-644	4.1	4.1	4.1	31.2	29.9	30.5
CIM-645	4.1	4.1	4.1	29.5	29.4	29.4
FH-142	4.2	3.9	4.0	28.0	29.1	28.5
CIM-602	4.4	4.3	4.3	27.5	28.0	27.7

2.1.3 Varietal Trial-4

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

Ten newly bulked medium long staple *Bt.* strains from CIM-647 to CIM-656 were tested against a commercial variety *Bt*.CIM-602 at CCRI, Multan. Data presented in **Table 2.10** showed that the new strain CIM-653 produced the highest seed cotton yield of 3329 kg ha^{-1} followed by strains CIM-651 and CIM-656 with seed cotton yield of 3278 and 2875 kg ha^{-1}, respectively compared to yield of 1886 kg ha^{-1} of variety *Bt*.CIM-602.

The new strain CIM-656 produced the highest lint percentage of 40.8 followed by CIM-650 having 38.4 and CIM-648 with 38.3 lint %age compared with the variety *Bt*.CIM-602 which produced 37.3% lint. The strain CIM-655 produced the longest staple of 30.9 mm, followed by CIM-649 having 30.8 mm staple length against the commercial variety *Bt*.CIM-602 having 27.6 mm staple length.

All the strains have desirable micronaire values ranging from 3.8 to 4.8 μg inch^{-1}. All the new strains had the desirable fibre strength ranging from 27.3 to 33.1 g/tex where as *Bt*.CIM-602 has 29.5 g/tex fibre strength.

Table 2.10 Performance of advanced strains in Varietal Trial-4 at CCRI, Multan

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micro-naire value (μg inch^{-1})	Fibre strength (g/tex)	Av. boll wt. (g)	Plant Pop. (ha^{-1})
CIM-647	2160	823	38.1	28.6	4.6	28.7	3.0	41964
CIM-648	2661	1019	38.3	28.9	4.6	28.7	3.1	41067
CIM-649	2088	798	38.2	30.8	4.0	29.8	3.7	40081
CIM-650	2431	934	38.4	29.3	4.2	30.1	3.6	39991
CIM-651	3278	1246	38.0	29.4	4.6	29.0	3.9	39095
CIM-652	2564	979	38.2	28.9	4.8	27.3	3.9	39812
CIM-653	3329	1258	37.8	28.0	3.9	28.7	3.5	40171
CIM-654	2041	780	38.2	29.6	4.0	32.9	3.6	38108
CIM-655	2352	896	38.1	30.9	3.8	33.1	3.8	40260
CIM-656	2875	1173	40.8	28.0	4.6	27.5	3.7	40440
CIM-602	1886	703	37.3	27.6	3.9	29.5	3.2	36494

Sowing date = 06.05.2016; CD (5%) for seed cotton: Strains = 222.83; CV %5. = 5.2

2.1.4 Micro Varietal Trial-1

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

Nine newly bulked strains numbering from 456/16 to 464/16 were tested against commercial variety *Bt*.CIM-602 at CCRI, Multan. The new strain 464/16 surpassed all the strains and standard variety in seed cotton yield by producing 3712 kg ha^{-1}, followed by 462/16 with 3658 kg ha^{-1} and 460/16 having 3461 kg ha^{-1} compared with 2493 yield of *Bt.*CIM-602 **(Table 2.11).**

The strain 457/16 produced the highest lint percentage of 42.0, followed by 40.2 percent lint in 461/16 while the commercial variety *Bt*.CIM-602 produced the lint percentage of 36.0. The strain 463 produced the longest staple of 29.1 mm, followed by 28.9 mm in 456/16 compared with the fibre length of 27.5 mm in commercial variety *Bt*.CIM-602. All the strains have desirable micronaire values ranging from 3.8 to 4.8 μg inch^{-1}. The strain 456/16 maintained the maximum fibre strength of 32.0 g/tex, followed by 30.9 g/tex in 464/16 while standard *Bt.*CIM-602 had 29.4 g/tex.

Table 2.11 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})
456/16	3067	1156	37.7	28.9	3.9	32.0	3.1	37839
457	3389	1423	42.0	28.6	4.8	27.5	2.9	36584
458	3407	1366	40.1	28.6	4.4	28.0	2.9	33894
459	2816	1070	38.0	28.4	3.9	27.5	2.9	33356
460	3461	1301	37.6	28.3	3.8	28.4	2.9	35329
461	3228	1298	40.2	28.0	4.4	28.0	3.0	37481
462	3658	1372	37.5	28.0	4.2	30.3	2.9	38377
463	2887	1083	37.5	29.1	4.0	29.3	2.7	35508
464/16	3712	1396	37.6	28.3	4.0	30.9	3.5	37481
Bt.CIM-602	2493	897	36.0	27.5	3.7	29.4	2.3	26003

Sowing date = 13.05.2016; CD (5%) for seed cotton: Strains = 236.55; CV % = 7.20

2.1.5 Micro Varietal Trial-2

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

Seven newly bulked strains numbering from 680/16 to 686/16 were tested against commercial variety *Bt*.CIM-602 at CCRI, Multan. The new strain 685/16 surpassed all the strains and standard variety in seed cotton yield by producing 4190 kg ha^{-1}, followed by 482/16 with 3899 kg ha^{-1} and 480/16 having 3432 kg ha^{-1} compared with 2724 yield of *Bt.*CIM-602 **(Table 2.12).**

The strain 681/16 produced the highest lint percentage of 40.0, followed by 38.0 percent lint in 686/16 while the commercial variety *Bt*.CIM-602 produced the lint percentage of 35.6. The strain 685/16 produced the longest staple of 29.3 mm, followed by 28.3 mm in 682/16 compared with the fibre length of 27.3 mm in commercial variety *Bt*.CIM-602. All the strains have desirable micronaire values ranging from 3.5 to 4.8 µg inch^{-1}. The strain 681/16 maintained the maximum fibre strength of 28.4 g/tex, followed by 30.1 g/tex in 680/16 while standard *Bt.*CIM-602 had 29.2 g/tex.

Table 2.12 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})
680/16	3432	1301	37.9	27.5	3.5	30.1	3.0	42681
681	2838	1135	40.0	27.4	4.6	28.4	3.0	43100
682	3899	1470	37.7	28.3	4.8	30.0	3.3	40350
683	2739	1013	37.0	27.4	4.7	29.1	3.6	40171
684	3024	1052	34.8	27.7	4.5	28.7	3.6	41605
685	4190	1529	36.5	29.3	4.6	29.0	3.3	38198
686/16	2839	1079	38.0	27.3	4.3	29.1	3.8	40529
CIM-602	2724	970	35.6	27.3	3.7	29.2	3.0	39991

Sowing date = 19.04.2016; CD (5%) for seed cotton =248.55; CV. % = 7.62

2.1.6 Micro Varietal Trial-3

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

Twelve newly bulked strains numbering from 1119/16 to 1130/16 were tested against commercial variety CIM-602 at CCRI, Multan. Data presented in **Table 2.13** indicated that the new strain 1128/16 surpassed all the new strains yielding 4394 kg ha^{-1}, followed by strains 1123/16 and 1120/16 which produced 3934 and 3827 kg ha^{-1} seed cotton respectively while the standard CIM-602 yielding 2628 kg ha^{-1}. The new strain /15 1119/16 produced the highest lint percentage of 38.8 followed by 38.4% in 1121/16 38.1

% in 1123/16 in comparison to CIM-602 having 37.8 lint percentage. The strains 941/15 and 1129/16 produced the longest staple of 27.4 mm followed by 27.1 mm in 1127/16 compared with the staple length of 26.9 mm in standard variety CIM-602. The genotypes 1120/16 have undesirable micronaire value while all other have desirable micronaire value ranging from 3.7 to 4.9. . All these strains showing fibre strengths ranging from 27.0 to 29.9.

Table 2.13 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})
1119/16	3826	1484	38.8	26.3	4.9	28.4	2.7	43757
1120	3827	1420	37.1	27.1	3.7	29.9	2.8	44654
1121	3677	1412	38.4	25.8	4.9	27.0	2.8	43040
1122	2832	957	33.8	25.8	4.6	28.5	2.3	44116
1123	3934	1499	38.1	26.3	4.7	28.6	2.6	44295
1124	2819	1068	37.9	26.9	4.5	29.4	2.9	44116
1125	3705	1249	33.7	26.5	3.9	28.9	2.7	44654
1126	2679	1018	38.0	27.0	4.6	29.1	3.3	43757
1127	2426	900	37.1	27.1	4.3	29.4	2.7	44116
1128	4394	1635	37.2	26.9	4.1	29.2	2.7	43937
1129	2479	940	37.9	27.4	3.9	28.7	2.9	43757
1130/16	3799	1247	36.7	26.5	4.3	29.4	3.0	43219
CIM-602	2668	1009	37.8	26.9	3.9	27.7	2.6	42860

Sowing date = 20.05.2016; CD (5%) for seed cotton = 180.03; CV. % = 7.75

2.1.7 Micro-Varietal Trial-4

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

Nine newly bulked elite *Bt*. strains from 1131/16 to 1139/16 were tested against commercial variety *Bt.*CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.14**.

The strain 1133/16 out-yielded all the strains and standard variety by producing 4343 kg ha^{-1} seed cotton, followed by 1136/16 and 1138/16 having seed cotton yields of 4234 and 4130 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 2892 kg ha^{-1} seed cotton. The strains 1133/16 produced the higher lint percentage of 38.4% followed by 1135/16 with 38.0 and 1132/16 with 37.7 %.compared with that of 33.0% by *Bt.*CIM-602.

The strain 1131/16 produced the longest staple of 29.2 mm, followed by the 28.6 mm of strain 1137/16 compared with the 28.5 mm of *Bt.*CIM-602. All the strains have desirable micronaire values ranging from 3.8 to 5.1 μg inch^{-1}. The fibre strength of all the new strains is observed within the range i.e. 29.7 to 30.8.

Table 2.14 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})
1131/16	3248	1201	37.0	29.2	4.6	30.0	2.9	38377
1132	3074	1159	37.7	28.4	4.3	30.3	2.4	41247
1133	4343	1668	38.4	27.7	4.6	30.4	2.4	40529
1134	2968	1006	33.9	28.4	3.8	30.6	2.7	40170
1135	3917	1488	38.0	28.1	4.4	29.7	2.4	36225
1136	4234	1554	36.7	28.3	4.6	30.2	2.7	40529
1137	2814	1007	35.8	28.6	5.1	29.9	2.6	39632
1138	4130	1412	34.2	27.9	4.2	30.4	2.4	37122
1139/16	3720	1317	35.4	28.4	4.3	30.8	3.0	42143
CIM-602	2892	954	33.0	28.5	4.0	30.0	2.7	40888

Sowing date = 19.05.2016; CD (5%) for seed cotton = 410.91; CV. % = 8.65

2.1.8 Micro-Varietal Trial-5

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

Nine newly bulked elite strains 1812/16 to 1820/16 were tested against commercial variety *Bt.*CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.15.**

The strain 1819/16 out-yielded all the strains and standard variety by producing 3735 kg ha^{-1} seed cotton, followed by 1813/16 and 1820/16 having seed cotton yields of 3132 and 3029 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 2304 kg ha^{-1} seed cotton. The strains 1812/16 and 1814/16 produced the higher lint percentage values of 42.4 and 39.9 respectively compared with that of 36.6% by *Bt.*CIM-602.

The strain 1817/16 produced the longest staple of 28.9 mm, followed by 28.7 mm in 1813/16 and 1816/16 compared with the fibre length of 27.7 mm in commercial variety *Bt*.CIM-602. All strains have desirable micronaire values ranging from 3.8 to 4.9 µg inch^{-1}.

The strain 1817/16 maintained the maximum fibre strength of 29.9 g/tex, followed by 1813/16 with 29.8 g/tex while standard *Bt.*CIM-602 had 28.7 g/tex fibre strength.

Table 2.15 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})
1812/16	2645	1121	42.4	27.8	4.4	27.5	3.1	39095
1813	3132	1243	39.7	28.7	4.1	29.8	2.7	40171
1814	2512	1002	39.9	27.8	4.4	28.5	2.6	38736
1815	2798	1108	39.6	27.4	4.4	28.2	2.7	36943
1816	1948	731	37.5	28.7	4.5	29.5	2.7	36763
1817	1802	690	38.3	28.9	4.3	29.9	2.8	26362
1818	2660	1040	39.1	27.7	4.3	29.0	2.7	37660
1819	3735	1449	38.8	28.3	4.2	28.7	2.6	36584
1820/16	3029	1196	39.5	27.8	4.1	28.7	2.7	36405
CIM -602	2304	843	36.6	27.7	3.8	28.7	2.8	39274

Sowing date = 19.04.2016; CD (5%) for seed cotton =493.82; CV. % = 10.84

2.1.9 Micro-Varietal Trial-6

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

Eight newly bulked elite strains (2380/16 to 2387/16) were tested against commercial variety Bt.CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in Table **2.16.**

The strain 2385/16 out-yielded all the strains and standard variety by producing 3809 kg ha^{-1} seed cotton, followed by 2384/16 and 2382/16 having seed cotton yields of 3433 and 3421 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 3193 kg ha^{-1} seed cotton. The strains 2381/16 and 2380/16 produced the higher lint percentage values of 43.5 and 41.0, respectively compared with that of 36.9% by *Bt.*CIM-602.

The strain 2385/16 produced the longest staple of 28.7 mm, followed by 28.4 mm in 2382/16 compared with the staple length of 27.0 mm in commercial variety *Bt*.CIM-602. All strains have desirable micronaire values raging from 4.0 mm to 4.9 mm. the strain 2385/16 produced the maximum fibre strength (29.1 g/tex) followed by 28.0 g/tex of 2382/16 as compared to the 27.7 g/tex of standard Bt. CIM-602.

Table 2.16 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})
2380/16	390	160	41.0	28.1	4.6	27.8	3.3	36405
2381	2250	979	43.5	27.0	4.9	26.6	3.1	39633
2382	3421	1355	39.6	28.4	4.5	28.0	3.1	39274
2383	2825	1028	36.4	28.0	4.0	27.9	3.1	36225
2384	3433	1277	37.2	27.0	4.5	27.0	3.3	35329
2385	3809	1337	35.1	28.7	4.6	29.1	3.7	32459
2386	2843	1058	37.2	28.0	4.8	27.8	3.0	38019
2387/16	3071	1099	35.8	27.1	4.7	26.4	3.5	39274
CM 602	3193	1178	36.9	27.0	3.4	27.7	3.0	33894

Sowing date: 20.04.2016, CD (5%) for seed cotton: Strains = 175.90, CV% = 7.30

2.1.10 Micro-Varietal Trial-7

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

Eleven newly bulked elite strains (2492/16 to 2502/16) were tested against commercial variety *Bt*.CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.17**.

The strain 2498/16 out-yielded all the strains and standard variety by producing 3730 kg ha^{-1} seed cotton, followed by 2493/16 and 2497/16 having seed cotton yields of 3533 and 3479 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 2331 kg ha^{-1} seed cotton. The strains 2499/16 produced the maximum lint percentage values of 39.8 followed by 2501-02/16 which produced 38.9% lint and 36.5% by *Bt.*CIM-602.

The strains 2494/16, 2502/16 produced the longest staple of 29.0 mm, followed by 28.8 mm in 2501/16 compared with the fibre length of 25.6 mm in commercial variety *Bt*.CIM-602. All strains have desirable micronaire values ranging from 3.8 to 4.5. The strain 2502/16 maintained the maximum fibre strength of 30.8 g/tex, followed by 30.5 g/tex in 2501/16 while standard *Bt.*CIM-602 had 28.5 g/tex fibre strength.

Table 2.17 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})
2492/16	3300	1244	37.7	28.4	4.3	29.5	3.1	41964
2493	3533	1314	37.2	28.4	4.3	28.6	3.1	41247
2494	2690	1036	38.5	29.0	4.4	29.4	3.1	41426
2495	2636	999	37.9	28.6	3.9	30.4	3.0	41067
2496	2905	1066	36.7	28.1	4.3	27.0	3.2	42323
2497	3479	1298	37.3	28.2	4.1	29.3	3.8	43578
2498	3730	1399	37.5	28.0	4.0	29.6	3.0	37839
2499	2672	1063	39.8	28.6	4.1	29.6	3.2	41785
2500	2905	1127	38.8	28.2	3.8	30.1	2.4	42323
2501	2959	1151	38.9	28.8	4.5	30.5	2.7	41067
2502/16	2475	963	38.9	29.0	3.9	30.8	2.9	37660
CIM-602	2331	851	36.5	25.6	3.6	28.5	2.7	37660

Sowing date: 13.05.2016; CD (5%) for seed cotton: Strains = 175.90; CV% = 7.15

2.1.11 Micro-Varietal Trial-8

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

Nine newly bulked elite strains (2388/16 to 2396/16) were tested against commercial variety CIM-573 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.18**.

The strain 2390/16 out-yielded all the strains and standard variety by producing 3601 kg ha^{-1} seed cotton, followed by 2389/16 and 2392/16 having seed cotton yields of 3576 and 3330 kg ha^{-1}, respectively against commercial variety CIM-573 which produced 2160 kg ha^{-1} seed cotton. The strains 2391/16 produced the maximum lint percentage values of 39.7 followed by 2392/16 and 2394/16 which produced 38.7% and 38.6% lint respectively while , the standard CIM-602 had the length percentage 36.5 %.

The strain 2389/16 produced the longest staple of 29.6 mm, followed by 28.8 mm in 2396/16 compared with the fibre length of 28.9 mm in commercial variety.CIM-573. All strains have desirable micronaire values ranging from 4.0 to 4.6. The strain 2389/16 maintained the maximum fibre strength of 32.3 g/tex, followed by 32.0 g/tex in 2395/16 while standard CIM-573 had 32.0 g/tex fibre strength.

Table 2.18 Performance of advanced strains in Micro-Varietal Trial-8 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})
2388/16	2734	1028	37.6	28.7	4.6	30.3	3.0	41247
2389	3576	1366	38.2	29.6	4.0	32.3	2.9	41605
2390	3601	1379	38.3	28.3	4.0	30.2	2.9	40171
2391	2434	966	39.7	27.8	4.3	30.2	3.0	40350
2392	3330	1288	38.7	28.5	4.5	29.5	3.9	40529
2393	3046	1151	37.8	28.2	4.2	31.8	2.9	37481
2394	2950	1139	38.6	28.5	4.3	30.7	2.8	35508
2395	2223	856	38.5	28.4	4.1	32.0	2.0	36943
2396/16	1955	739	37.8	28.8	4.4	29.0	2.4	35915
CIM-573	2160	810	37.5	28.9	4.0	32.0	2.6	41067

Sowing date: 20.05.2016; CD (5%) for seed cotton: Strains = 280.90; CV% = 4.25

2.1.12 Micro-Varietal Trial-9

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

Ten newly bulked elite strains (3391/16 to 3400/16) were tested against commercial variety *Bt*.CIM-598 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.19**.

The strain 3392/16 out-yielded all the strains and standard variety by producing 3246 kg ha^{-1} seed cotton, followed by 3396/16 and 3398/16 having seed cotton yields of 3217 and 3066 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-598 which produced 1112 kg ha^{-1} seed cotton. The strains 3399/16 produced the maximum lint percentage values of 39.2 followed by 3397/16 which produced 39.0% lint and 37.2% by *Bt.*CIM-598.

The strains 3391/16 produced the longest staple of 30.2 mm, followed by 29.3 mm in 3396/16 compared with the fibre length of 27.4 mm in commercial variety *Bt*.CIM-598. All strains have desirable micronaire values ranging from 3.8 to 4.5. The strain 3391/16 maintained the maximum fibre strength of 30.5 g/tex, followed by 29.9 g/tex in 3396/16 while standard *Bt.*CIM-598 had 28.7 g/tex fibre strength.

Table 2.19 Performance of advanced strains in Micro-Varietal Trial-9 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})
3391/16	2437	924	37.9	30.2	4.1	30.5	3.8	33553
3392	3246	1220	37.6	28.4	4.4	27.7	3.0	42502
3393	2806	1075	38.3	28.0	4.5	28.7	3.4	37301
3394	1910	722	37.8	27.9	3.9	28.2	3.3	37301
3395	2942	1133	38.5	28.2	4.5	28.8	3.8	41785
3396	3217	1219	37.9	29.3	4.0	29.9	3.5	31921
3397	2925	1141	39.0	28.4	3.9	28.3	4.0	38198
3398	3066	1159	37.8	28.4	3.8	28.8	3.5	36405
3399	1774	695	39.2	27.9	4.5	29.4	3.7	25645
3400/16	2446	917	37.5	28.0	4.5	29.8	3.0	33535
CIM-598	1112	414	37.2	27.4	4.1	28.7	2.7	29949

Sowing date: 18.05.2016; CD (5%) for seed cotton: Strains = 293.75; CV% = 6.81

2.1.13 Micro-Varietal Trial-10

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

Nine newly bulked elite strains (3401/16 to 3409/16) were tested against commercial variety *Bt*.CIM-598 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.20**.

The strain 3405/16 out-yielded all the strains and standard variety by producing 3552 kg ha^{-1} seed cotton, followed by 3403/16 and 3406/16 having seed cotton yields of 3472 and 3179 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-598 which produced 1450 kg ha^{-1} seed cotton. The strains 3406/16 produced the maximum lint percentage values of 41.6 followed by 3401/16 which produced 39.9% lint and 37.4% by *Bt.*CIM-598.

The strains 3403/16 produced the longest staple of 29.1 mm, followed by 29.0 mm in 3406/16 compared with the fibre length of 27.6 mm in commercial variety *Bt*.CIM-598. All strains have desirable micronaire values ranging from 3.9 to 4.4. The strain 3406/16 maintained the maximum fibre strength of 29.5 g/tex, followed by 29.4 g/tex in 3402/16 while standard *Bt.*CIM-598 had 28.7 g/tex fibre strength.

Table 2.20 Performance of advanced strains in Micro-Varietal Trial-10 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})
3401/16	2382	950	39.9	28.6	4.1	28.7	3.2	39095
3402	1998	749	37.5	28.0	4.1	29.4	3.1	29411
3403	3472	1375	39.6	29.1	4.0	29.0	3.8	31383
3404	2997	1154	38.5	28.9	3.9	28.6	3.5	38915
3405	3552	1375	38.7	28.7	4.0	28.3	4.8	41426
3406	3179	1322	41.6	29.0	4.4	29.5	3.4	38736
3407	2059	776	37.7	28.2	4.2	29.1	3.2	30487
3408	2194	829	37.8	28.5	4.4	29.0	3.1	38019
3409/16	2482	943	38.0	28.3	4.0	28.5	3.1	36405
CIM-598	1450	542	37.4	27.6	4.0	28.7	2.8	29949

Sowing date: 18.05.2016; CD (5%) for seed cotton: Strains = 362.80; CV% = 8.21

2.1.14 Testing of advance strains at farmers' fields

2.1.14.1 Zonal Varietal Trial-1 (*Bt*. Strains)

Objective*:* Evaluation of advance *Bt*. strains at farmers' fields

Two medium-long staple *Bt.* strains viz., *Bt*.CIM-632 and *Bt*.CIM-625 were tested against commercial variety *Bt*.CIM-602 at fourteen locations of government as well as private sector farms. Averaged across the locations, strain *Bt*.CIM-632 produced the highest seed cotton yield of 3993 kg ha^{-1} compared with the yield of 3903 kg ha^{-1} of *Bt*.CIM-602 **(Table 2.21).**

Data presented in **Table 2.22** show that the strain *Bt*.CIM-632 produced the highest lint percentage of 41.7 with staple length of 29.0 mm **(Table-2.23).**

Table-2.21 Yield performance (kg ha^{-1}) of advanced *Bt*. strains in Zonal Varietal Trial-1 at farmers' fields

Sr. No.	Name of cotton grower and location	Seed cotton (kg ha^{-1})		
		***Bt*.CIM-632**	***Bt*.CIM-625**	***Bt*.CIM-602**
1	Mian Muhammad Amjid Zia, Khanewal	3950	3854	3624
2	Mr. Nazar Muhammad, Lodhran	3480	4142	3254
3	Ch. Rehmat Ali, 88/10-R, Khanewal	4126	3842	3170
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	3590	3340	2754
5	Ch. Muhammad Hanif 108/7R, Sahiwal	4052	3730	3140
6	Haji Allah Ditta, Kukar Hatta, Khanewal	4215	4040	3100
7	Mr. Iftikhar Shah, D. G. Khan	3871	4121	3020
8	**Haji Zulfiqar Ali Haroonabad**	4200	4007	3370
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	3870	4228	3524
10	Ch. Ramzan Ahmad, Hasilpur	4256	4028	2877
11	Ch. Zia-ur-Rehman, Liaquat Pur	4052	3856	3147
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	3999	3750	3429
13	Ch. Khuda Bux, 19 Kasi, Multan	3980	3810	3250
14	Ch. Hafeez, Rajan Pur	4260	3890	3100
	Average	3993	3903	3197

Table-2.22 Lint percentage of advanced *Bt*. strains in Zonal Varietal Trial-1 at farmers' fields

Sr. No.	Name of cotton grower and location	Lint (%)		
		***Bt*.CIM-632**	***Bt*.CIM-625**	***Bt*.CIM-602**
1	Mian Muhammad Amjid Zia, Khanewal	41.8	40.3	40.1
2	Mr. Nazar Muhammad, Lodhran	42.3	39.6	39.0
3	Ch. Rehmat Ali, 88/10-R, Khanewal	41.5	40.9	39.7
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	41.9	38.9	39.8
5	Ch. Muhammad Hanif 108/7R, Sahiwal	42	40.7	40.3
6	Haji Allah Ditta, Kukar Hatta, Khanewal	43.8	41.0	40.7
7	Mr. Iftikhar Shah, D. G. Khan	41	40.3	39.9
8	**Haji Zulfiqar Ali Haroonabad**	42.3	39.7	38.9
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	39.8	40.1	39.5
10	Ch. Ramzan Ahmad, Hasilpur	41.6	38.5	40.7
11	Ch. Zia-ur-Rehman, Liaquat Pur	42.9	40.6	40.3
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	40.8	40.0	40.5
13	Ch. Khuda Bux, 19 Kasi, Multan	39.8	39.0	39.3
14	Ch. Hafeez, Rajan Pur	42.3	41.0	40.4
	Average	41.7	40.0	39.9

Table-2.23 Staple length of advanced *Bt*. strains in Zonal Varietal Trial-1 at farmers' fields

Sr. No.	Name of cotton grower and location	Staple length (mm)		
		***Bt*.CIM-632**	***Bt*.CIM-625**	***Bt*.CIM-602**
1	Mian Muhammad Amjid Zia, Khanewal	29.0	28.8	28.5
2	Mr. Nazar Muhammad, Lodhran	28.9	28.4	28.2
3	Ch. Rehmat Ali, 88/10-R, Khanewal	28.5	28.1	28.4
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	29.4	29.3	28
5	Ch. Muhammad Hanif 108/7R, Sahiwal	29.0	28.7	28.4
6	Haji Allah Ditta, Kukar Hatta, Khanewal	28.7	28.7	28.6
7	Mr. Iftikhar Shah, D. G. Khan	28.3	28.5	28.1
8	**Haji Zulfiqar Ali Haroonabad**	29.5	28.4	28.4
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	29.1	28.7	28.6
10	Ch. Ramzan Ahmad, Hasilpur	29.0	28.2	28.6
11	Ch. Zia-ur-Rehman, Liaquat Pur	28.8	28.2	28.3
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	29.1	29.2	28.1
13	Ch. Khuda Bux, 19 Kasi, Multan	29.4	29.0	28.4
14	Ch. Hafeez, Rajan Pur	29.3	28.7	28.2
	Average	29.0	28.6	28.3

2.1.14.2 Zonal Varietal Trial-2

Objective*:* Evaluation of advanced strains at farmers' fields

One medium-long staple strain viz., CIM-610 was tested at fourteen locations at government as well as private sector farms against the commercial variety CIM-573. Average data of 14 locations indicate that the strain CIM-610 produced the highest seed cotton yield of 2855 kg ha^{-1} compared with 2192 kg ha^{-1} of CIM-573 **(Table 2.24).**

Data presented in **Table 2.25** showed that the strain CIM-610 had the lint percentage of 38.6 as compared with 38.9 percent lint of CIM-573. Moreover, the new strain CIM-610 produced the staple length of 28.6 mm, compared with the staple length of 29.3 mm in CIM-573 **(Table 2.26).**

Table-2.24 Yield performance of advanced strains in Zonal Varietal Trial-2 at farmers' fields

Sr. No.	Name of cotton grower and Location	Seed cotton (kg ha^{-1})	
		CIM-610	CIM-573
1	Mian Muhammad Amjid Zia, Khanewal	3042	2250
2	Mr. Nazar Muhammad, Lodhran	2941	2310
3	Ch. Rehmat Ali, 88/10-R, Khanewal	3216	2450
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	2650	2000
5	Ch. Muhammad Hanif 108/7R, Sahiwal	3200	2430
6	Haji Allah Ditta, Kukar Hatta, Khanewal	2806	2120
7	Mr. Iftikhar Shah, D. G. Khan	3506	2690
8	**Haji Zulfiqar Ali Haroonabad**	3000	2100
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	2950	1899
10	Ch. Ramzan Ahmad, Hasilpur	3110	2300
11	Ch. Zia-ur-Rehman, Liaquat Pur	2125	1680
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	2801	2050
13	Ch. Khuda Bux, 19 Kasi, Multan	1980	2150
14	Ch. Hafeez, Rajan Pur	2640	2263
	Average	2855	2192

Table-2.25 Lint percentage of advanced strains in Zonal Varietal Trial-2 at farmers' fields

Sr. No.	Name of cotton grower and Location	Lint (%)	
		CIM-610	CIM-573
1	Mian Muhammad Amjid Zia, Khanewal	38.8	39.2
2	Mr. Nazar Muhammad, Lodhran	39.1	38.9
3	Ch. Rehmat Ali, 88/10-R, Khanewal	37.8	39.1
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	38.6	38.7
5	Ch. Muhammad Hanif 108/7R, Sahiwal	39.4	39.0
6	Haji Allah Ditta, Kukar Hatta, Khanewal	37.9	39.4
7	Mr. Iftikhar Shah, D. G. Khan	38.1	39.8
8	**Haji Zulfiqar Ali Haroonabad**	40.0	40.1
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	38.6	38.7
10	Ch. Ramzan Ahmad, Hasilpur	39.1	37.9
11	Ch. Zia-ur-Rehman, Liaquat Pur	38.4	38.2
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	37.8	38.4
13	Ch. Khuda Bux, 19 Kasi, Multan	38.6	39.6
14	Ch. Hafeez, Rajan Pur	38.8	38.0
	Average	**38.6**	**38.9**

Table-2.26 Staple length of advanced strains in Zonal Varietal Trial-2 at farmers' fields

Sr. No.	Name of cotton grower and Location	Staple length (mm)	
		CIM-610	CIM-573
1	Mian Muhammad Amjid Zia, Khanewal	28.5	29.4
2	Mr. Nazar Muhammad, Lodhran	28.9	29.0
3	Ch. Rehmat Ali, 88/10-R, Khanewal	28.0	29.4
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	28.1	30.1
5	Ch. Muhammad Hanif 108/7R, Sahiwal	29.1	30.4
6	Haji Allah Ditta, Kukar Hatta, Khanewal	29.2	28.9
7	Mr. Iftikhar Shah, D. G. Khan	28.4	29.5
8	**Haji Zulfiqar Ali Haroonabad**	28.0	29.5
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	28.6	28.7
10	Ch. Ramzan Ahmad, Hasilpur	29.3	29.6
11	Ch. Zia-ur-Rehman, Liaquat Pur	28.7	29.1
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	28.2	28.6
13	Ch. Khuda Bux, 19 Kasi, Multan	28.8	28.5
14	Ch. Hafeez, Rajan Pur	28.3	29.0
	Average	**28.6**	**29.3**

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 cottonseed of strains under coded number was supplied by the Director Research (PCCC) for evaluation against a commercial variety CIM-573. Data on seed cotton production and other parameters are presented in **Table 2.27**.

The results indicated that the strain NIAB-844 produced maximum yield 2769 kg ha^{-1} followed by CIM-610 having 2563 kg ha^{-1} of seed cotton yield while TH-17 produced lowest yield that is 320 kg ha^{-1}.

The strain CIM-610 produced the highest lint percentage of 38.8%, followed by GS-Ali-1 with 37.1%. The standard CIM-573 produced the highest value of staple length 28.5 mm, followed by CIM-610 which has staple length of 26.4 mm. All the strains have desirable micronaire value except Thakkar-214 and GS.Ali-1 (5.3 and 5.0 µg $inch^{-1}$) while TH-17 had a micronaire value below standard (3.6 µg $inch^{-1}$). All values of fibre strength were above the required limit.

Table 2.27 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})
CIM-573(Std)	1874	637	34.0	28.5	3.9	31.5	36458
Tipu-2	2086	655	31.4	24.3	4.1	26.5	40044
Thakkar-214	2077	748	36.0	23.3	5.3	22.8	40283
TH-20	2483	809	32.6	24.7	4.3	26.0	41478
TH-17	320	118	36.8	23.7	3.6	26.8	40880
Tahafuz-7	2480	823	33.2	24.7	4.8	26.6	42315
RH-667	1996	655	32.8	26.0	4.1	26.8	42912
PB-896	2235	702	31.4	25.1	4.3	29.0	37892
NIAB-844	2769	1024	37.0	25.7	4.5	26.9	41956
MPS-61	1904	634	33.3	24.1	4.0	27.0	25586
MPS-29	2106	689	32.7	24.0	4.0	27.4	37773
GS. Ali-5	1901	703	36.9	24.9	5.0	27.2	42195
GS. Ali-1	1859	690	37.1	24.4	4.4	26.9	39924
GS. Hammad	1703	559	32.8	25.0	3.8	27.7	41956
CIM-610	2563	994	38.8	26.4	4.9	28.2	36458
CRIS-543	2531	888	35.1	23.8	4.8	25.5	42434

Sowing date = 19.05.2016

2.2.2 National Coordinated Varietal Trials (Set-B)

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

Eighteen 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 2.28** showed that the Eagle-2 produced the highest seed cotton yield of 2870 kg ha^{-1}, followed by BS-15 having 2739 kg ha^{-1} seed cotton yield while CRIS-600 produced lowest yield 1439 kg ha^{-1} . The standards i.e FH-142 and CIM-602 produced 2451 and 2068 kg ha^{-1} seed cotton yield respectively.

Data also revealed that the strain BPC-10 produced the highest lint percentage of 40.2, followed by CIM-632 with 39.8%. The strain CIM-632 produced the longest staple with 29.4 mm length and, followed by CIM-625 with 28.9 mm.

All the strains had the micronaire value ranging from 3.5- 4.8 µg $inch^{-1}$. Maximum fibre strength was maintained by standard (CIM-602) having 31.2 g/tex, followed by CIM-632 with 30.6 g/tex fibre strength. All the strains have fibre strength above the required limit.

Table 2.28 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})
FH-142 (S-2)	2451	929	37.9	25.7	3.9	28.4	39207
CIM-602 (S-1)	2068	757	36.6	28.8	3.8	31.2	37414
FH-326	2468	834	33.8	27.1	3.7	30.4	42076
FH-152	2276	787	34.6	27.3	4.8	29.5	41717
EAGLE-2	2870	1079	37.6	26.5	4.4	29.5	37773
Deebal	2656	1028	38.7	26.1	4.0	29.7	40522
Cyto-313	2577	956	37.1	26.4	4.1	29.8	29525
Cyto-179	2668	1003	37.6	26.2	3.5	29.8	42195
Crystal-12	2577	1008	39.1	25.7	4.2	28.8	39924
CIM-625	2284	888	38.9	28.9	3.9	29.8	38609
CEMB-88	2444	931	38.1	25.7	4.1	29.4	41717
CEMB-55-S	2107	813	38.6	25.8	4.1	29.1	40522
CRIS-600	1439	496	34.5	26.3	3.8	28.9	42195
CIM-632	2539	1011	39.8	29.4	4.2	30.6	38609
BS-15	2739	1055	38.5	25.3	4.5	28.3	38848
BPC-11	2339	861	36.8	25.0	4.2	28.1	41239
BPC-10	2162	869	40.2	25.1	4.8	28.2	40522
BH-201	2066	771	37.3	26.2	4.1	28.7	28449
Bakhtawar-1	2333	833	35.7	26.8	4.3	29.8	41239
Bahar-07	2378	916	38.5	24.9	4.5	27.6	42434

Sowing date = 19.05.2016

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 candidate varieties was supplied by the Director Research of PCCC for evaluation against two commercial varieties *Bt.*CIM-602 and FH-142 at CCRI Multan. The data presented in **Table 2.29** showed that the variety NIAB-878B produced the highest seed cotton yield of 3501 kg ha^{-1}, followed by MNH-1016 with 3366 kg ha^{-1} seed cotton yield while GH-Mubarak was at bottom position in respect of seed cotton yield.

Data presented in **Table 2.29** revealed that NIAB-545 produced the highest lint percentage 41.0 followed by the NIAB-878B with 40.8%.

The staple length of all the genotypes was less than minimum standard i.e. 28.0 mm. Micronaire value of two genotypes CIM-602 and RH-662 was not within desirable limits. Fibre strength of all the strains was from 25.2 to 30.1.

Table 2.29 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})/
FH-142 (S-2)	3171	1221	38.5	25.8	4.2	26.6	42123
CIM-602 (S-1)	2655	1009	38.0	27.7	3.7	27.3	40806
SAU-1	2076	747	36.0	24.2	4.3	25.2	41405
Saim-32	3370	1206	35.8	25.8	4.8	27.0	42362
Sahara-Buraq	2936	1139	38.8	26.3	4.0	28.8	40806
RH-668	2652	952	35.9	26.8	4.7	26.5	42841
RH-662	2884	1087	37.7	27.8	3.8	30.1	41644
QM-IUB-65	2889	1080	37.4	27.5	4.2	29.5	41883
NS-181	2946	1090	37.0	26.1	4.3	27.6	39969
NIAB-Bt.-2	2177	810	37.2	24.1	4.2	26.1	41405
NIAB-878-B	3501	1428	40.8	26.7	4.4	25.4	40208
NIAB-545	3180	1304	41.0	26.4	4.3	25.3	39729
NIAB-1048	3092	1228	39.7	26.9	4.5	26.7	41644
NIA-86	2534	907	35.8	23.5	4.0	25.6	41883
MNS-992	3077	1160	37.7	25.8	4.3	27.1	42242
MNH-1016	3366	1313	39.0	25.5	4.5	26.6	42123
IR-NIBGE-9	3330	1229	36.9	27.2	3.9	29.6	39969
IR-NIBGE-8	3162	1173	37.1	27.4	3.9	29.8	41285
GH-Mubarak	1410	525	37.2	26.2	4.3	27.4	40567
FH-Kahkashan	2951	1086	36.8	26.3	4.7	26.9	42601

Sowing date = 19.05.2016

2.2.4 National Coordinated Varietal Trials (Set-D)

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

Seventeen strains and two standard varieties were tested at CCRI Multan. The data on seed cotton production and other parameters are presented in **Table 2.30**. The data showed that VH-Gulzar produced the highest seed cotton yield of 3004 kg ha^{-1}, followed by Zakariya-1 with 2827 kg ha^{-1} while Tassco-1000 produced lowest yield among these strains under the trial.

The strain VH-Gulzar produced the highest lint percentage of 39.3, followed by Sun Crop Hybrid-1 which had 39.2%.

The variety CIM-602 produced the longest staple of 27.6 mm, followed by Sitara-14 with 27.0 mm. Micronaire values of all the strains were up to the standard and were ranged from 3.9 to 4.7 except CIM-602 was below the limit. Fibre strength of all strains was up to standard.

Table 2.30 Performance of different strains in National Coordinated Varietal Trials (Set-D) at CCRI Multan

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (%age)	Staple length (mm)	Micro-naire value (µg inch^{-1})	Fibre strength (g/tex)	Plant Pop. (ha^{-1})
Thakkar-808	2170	814	37.5	24.3	3.9	28.1	42554
Shaheen-1	2141	754	35.2	26.1	4.6	29.4	40522
Tipu-1	2247	849	37.8	25.5	4.2	28.6	41359
Sitara-14	2014	749	37.2	27.0	3.9	30.3	41598
VH-363	2135	790	37.0	25.2	4.3	28.1	41000
Sitara-15	2111	771	36.5	27.0	3.7	30.5	41956
VH-GULZAR	3004	1181	39.3	25.9	3.9	28.6	42434
SLH-12	2815	1008	35.8	26.5	4.1	29.1	41478
Weal-AG-1606	2686	1026	38.2	25.9	4.0	28.9	41239
Suncrop-4	2440	949	38.9	25.4	4.6	27.8	42793
Weal-AG-Gold	2181	844	38.7	25.8	4.7	28.7	42315
Suncrop-Hybrid-1	1862	730	39.2	24.1	4.2	26.9	35501
Weal-AG-Shahkar	2431	890	36.6	25.7	4.2	28.6	39805
Thahfuz-5	2385	863	36.2	25.0	4.5	28.5	41837
Zakariya-1	2827	1088	38.5	26.1	4.4	29.3	42076
Tarzan-5	2584	902	34.9	26.6	4.7	29.4	41478
CIM-602 (S-1)	2476	896	36.2	27.6	3.7	30.2	42315
Tassco-1000	1016	341	33.6	24.7	4.2	28.0	42673
FH-142 (S-2)	2651	999	37.7	25.0	4.4	29.0	41956

Sowing dated = 20.05.2016

2.2.5 Technology Testing Trial of PCCC (Klean Cotton)

Objective: Testing of promising GMOs strains of CEMB

Technology testing trial of Pakistan Central Cotton Committee was conducted at CCRI, Multan during 2016-17. Thirteen cotton genotypes from CEMB-1 to CEMB-13 including GMOs and non GMOs were tested. Sowing was done on 25th May, 2016 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 weedicide on crop plant as well as on weeds. First dose of weedicide was applied thirty days after sowing on 24th June, 2016. For this purpose, Galaxy (FMC) was applied at the rate of 1500 ml per acre to replication 2 and 1900 ml to R3 while, the replication 1st was kept as control. Mortality data was recorded seven days and twelve days after spraying. The data showed that late effect of the weedicide was observed on the genotypes and four genotypes i.e. CEMB-10, CEMB-11, CEMB-12 and CEMB-13 were more affected while very less effect were observed on the remaining seven genotypes i.e. CEMB-2, CEMB-3, CEMB-4, CEMB-6, CEMB-7, CEMB-8 and CEMB-9. The only genotype which was found as the most tolerant and no effect of the weedicide observed was CEMB-5. The second dose of weedicide was applied on 4th August, 2016 at the rate of 1900 and 2500 ml in R_2 and R_3 respectively. Non GMOs and weeds were severely affected on application of second weedicide at the rate of 1900 and 2500 ml while the GMO genotypes were less affected i.e. CEMB-2,3,4,6,7,8 and 9 recorded in seven to twelve days after application of the weedicide **Table 2.31**. Only one genotype i.e. CEMB-5 showed resistance to the weedicide. These results show that the seven genotypes were GMOs having resistance/tolerance to glyphosate and the remaining four genotypes were non GMOs as mention above.

Table 2.31 Results of Galaxy (Weedicide) on Klean Cotton Trial at Central Cotton Research Institute, Multan during 2016-17

R-2 Weedicide (1900ml per acre)			Remarks
Not effect	Less effected	More effected	**Late effect were observed**
CEMB-5	**CEMB-2**	**CEMB-10**	
	CEMB-3	**CEMB-11**	
	CEMB-4	**CEMB-12**	
	CEMB-6	**CEMB-13**	
	CEMB-7		
	CEMB-8		
	CEMB-9		
R-3 Weedicide (2500ml per acre)			
Not effect	Less effected	More effected	
CEMB-5	**CEMB-2**	**CEMB-10**	
	CEMB-3	**CEMB-11**	
	CEMB-4	**CEMB-12**	**Early effect were observed**
	CEMB-6	**CEMB-13**	
	CEMB-7		
	CEMB-8		
	CEMB-9		

Thirteen strains were tested at CCRI Multan. The data on seed cotton production and other parameters are presented in **Table 2.32**. The data showed that CEMB-9 produced the highest seed cotton yield of 1381 kg ha^{-1}, followed by CEMB-5 with 1322 and CEMB-6 with 1285 kg ha^{-1} while CEMB-10 produced lowest yield among these strains under the trial.

The strain CEMB-10 produced the highest lint percentage of 39.1, followed by CEMB-8 which had 38.8% and CEMB-11 with 38.7%.

The staple lengths of all strain were below the standard however, CEMB-13 produced the longest staple of 26.3 mm, followed by CEMB-12 with 25.1mm. micronaire values of all the strains were up to the standard and were ranged from 4.2 to 4.8 $\mu g\ inch^{-1}$. Fibre strength of all strains was up to standard.

Table 2.32 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)	Plant Pop. (ha^{-1})
CEMB-1	982	373	38.0	23.5	4.2	27.4	31204
CEMB-2	1257	474	37.7	23.1	4.3	26.3	37839
CEMB-3	952	363	38.1	23.2	4.6	26.7	37840
CEMB-4	1021	373	36.5	23.6	4.5	27.7	35329
CEMB-5	1322	505	38.2	23.8	4.8	26.7	37481
CEMB-6	1285	493	38.4	23.0	4.3	27.0	39812
CEMB-7	1110	413	37.2	23.0	4.4	26.1	37481
CEMB-8	1047	406	38.8	23.3	4.4	26.5	33715
CEMB-9	1381	529	38.3	23.2	4.2	25.9	37839
CEMB-10	391	153	39.1	24.5	4.6	26.9	32280
CEMB-11	699	271	38.7	24.6	4.6	27.4	36584
CEMB-12	522	190	36.4	25.1	4.6	27.5	33177
CEMB-13	377	141	37.5	26.3	4.6	29.9	33493

Sowing dated = 26.05.2016

2.2.6 Provincial Coordinated Cotton Trials

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

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

Thirty one promising strains of different cotton breeders from the Punjab were evaluated along with two standards CEMB-55 and FH-142 at CCRI, Multan. Data presented in **Table 2.33** revealed that NIAB-878B produced the maximum seed cotton yield of 2549 kg ha^{-1}, followed by NIAB-1011/48 with 2531 kg ha^{-1} and RH-626 with 2519 kg ha^{-1} seed cotton production while NIBGE-8 was at the bottom of the conducted trial.

The Strain SH-Buraq produced the highest lint percentage of 40.3 followed by FH-444 having 39.8 lint percentages.

The strain Sitara-15 produced the longest staple having 30.2 mm length, followed by the variety Sitara-14 with 29.2 mm and NIAB-1011/48 which produced 28.7 mm staple length. Micronaire value of all the strains was up to standard except SLH-12 and NIBGE-8. All the strains have desirable fibre strength except Sitara-15.

Table 2.33 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)	Micro Naire Value ($\mu g\ inch^{-1}$)	Fibre Strength (g/tex)	Plant Pop. (ha^{-1})
CIM-622	1687	601	35.6	27.7	4.3	30.1	38370
FH-152	2116	736	34.8	28.4	4.4	29.9	40402
Bahar-07	1643	629	38.3	25.9	4.8	26.6	40522
CEMB-55 (S)	1811	723	39.9	27.4	4.7	27.5	41717
Sitara-15	2311	839	36.3	30.2	4.2	21.2	38012
Sitara-14	2129	749	35.2	29.2	4.1	30.3	38131
SH-Buraq	1941	782	40.3	27.5	4.4	28.0	39326
NIAB-1011/48	2531	987	39.0	28.7	4.1	28.2	41000
NIAB-545	2165	851	39.3	27.8	4.2	27.6	40163
FH-444	1575	627	39.8	28.5	4.9	28.3	39566
Weal-AG-Shahkar	2054	770	37.5	27.5	4.5	28.2	42076
SLH-12	1822	650	35.7	28.3	3.7	30.0	32274
NIAB-878B	2549	1012	39.7	28.4	4.7	26.9	40880
MNH-992	2057	743	36.1	27.2	4.0	29.4	37414
Wea-AG-1606	1910	741	38.8	27.3	4.2	28.9	40402
NS-181	1943	699	36.0	27.8	4.7	29.3	38131
RH-668	2280	730	32.0	28.2	4.9	29.7	40163
RH-626	2519	985	39.1	27.9	4.7	29.2	40283
NIBGE-8	572	208	36.3	28.1	3.7	29.1	19843
IR-NIBGE-9	1688	636	37.7	28.5	4.3	28.9	26656
Cyto-179	1867	709	38.0	27.4	4.1	30.1	30601
VH-363	1695	619	36.5	27.6	4.3	29.6	37653
FH-142 (S)	1870	722	38.6	27.1	4.3	28.2	35023
FH-Kehkashan	1825	631	34.6	28.4	4.3	29.5	38012
Silky -3	1820	628	34.5	26.8	4.5	27.7	41717
IUB-65	2058	778	37.8	27.6	4.2	29.1	40761
BH-201	1450	539	37.2	27.2	4.1	29.0	32752
MNH-1016	2177	823	37.8	28.1	4.2	28.7	39924
Weal-AG-Gold	1832	702	38.3	27.7	4.5	28.8	38490
VH-Gulzar	2251	864	38.4	27.7	4.2	31.0	32752
Thakkar-808	2293	899	39.2	26.8	4.7	27.0	41478
BS-15	1579	584	37.0	27.4	4.5	28.3	35740
BS-80	1177	401	34.1	28.3	4.2	29.0	31676

Sowing date = 17.05.2016

2.2.7 Provincial Coordinated Cotton Trial-II

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

Three promising strains of different cotton breeders from the Punjab along with a standard i.e MNH-786 were evaluated at CCRI, Multan. Data presented in **Table 2.34** revealed that NIAB-844 produced the maximum seed cotton yield of 2832 kg ha^{-1}, followed by VR-Thakar with 2138 kg ha^{-1} while RH-667 produced lowest yield of 1783 kg ha^{-1} which was lower than the standard also.

The strain NIAB-844 produced the highest lint percentage of 37.1%, followed by the RH-667 with 36.6 lint percentage. All the strains have staple length below the required standard. Micronaire values of VR-Thakar and MNH-786 (standard) were above the required limit. Fibre strength of NIAB-844 and RH-667 was above the standard while VR-Thakar was below the standard.

Table 2.34 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})
VR-Thakar	2138	763	35.7	23.9	5.1	23.3	41409
NIAB-844	2832	1051	37.1	25.6	4.2	27.4	35323
RH-667	1783	653	36.6	27.2	4.2	30.1	36158
MNH-786(Std)	1911	713	37.3	21.8	5.5	22.1	35323

Sowing date = 17.05.2016;

2.2.8 Provincial Coordinated Cotton Trial-III (Non *Bt*.)

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

Two promising strains of different cotton breeders from the Punjab along with one standard variety were evaluated at CCRI, Multan. Data presented in **Table 2.35** revealed that both the entries produced less seed cotton yield than the standard (FH-142) which produced 2517 kg. ha^{-1}. The strain BPC-11 produced the highest lint %age 39.1 followed by the BPC-10 with 38.1%.

The standard FH-142 has staple length 25.3 mm which is high than the entries micronaire value of all strains was ranging from 4.4 to 4.5 **μg $inch^{-1}$**. Fibre strength of all the genotypes was from 26.7 to 27.5 g/tex.

Table 2.35 Performance of new *Bt.* strains in Provincial Coordinated Cotton Trial-III 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})
BPC-11	1569	613	39.1	24.5	4.4	27.0	41359
FH-142 (Std)	2517	939	37.3	25.3	4.5	27.5	42554
BPC-10	1339	510	38.1	24.2	4.5	26.7	34904

Sowing date = 19.05.2016;

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 three 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 CRIS-134 excelled among all varieties by producing seed cotton yield 2798 kg ha^{-1} followed by the variety NIBGE-2 with 2744 kg ha^{-1} and Cyto-608 with 2475 kg ha^{-1} seed cotton production. Variety CIM-496 had the highest lint percentage of 40.7, followed by varieties CIM-554 having lint percentage of 40.5. The variety Cyto-608 maintained the longest staple of 30.3 mm, followed by the variety the Cyto-124 with 28.8 mm staple length.

Table 2.36 Performance of commercial varieties in Standard Varietal Trial-I at CCRI, Multan

Varieties	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})
Cyto-608	2475	926	37.4	30.3	3.6	30.4	2.7	33894
CIM-473	1991	761	38.2	26.0	3.0	30.2	2.3	32280
CRIS-134	2798	1013	36.2	27.9	4.0	29.4	3.0	37122
CRSM-38	1775	687	38.7	26.6	4.0	29.6	2.7	38736
NIBGE-2	2744	1002	36.5	27.9	3.6	30.0	3.0	19368
FH-901	1614	600	37.2	26.7	4.5	29.0	2.4	37660
CIM-573	1291	494	38.3	27.1	3.4	30.0	2.4	40350
MNH-786	1991	763	38.3	26.5	4.8	29.8	3.1	40888
CIM-534	2206	816	37.0	27.7	3.4	29.5	2.5	42502
BH-160	1991	761	38.2	27.6	5.1	28.9	2.6	41964
CIM-482	1775	690	38.9	26.8	4.6	28.8	3.1	32280
CIM-506	1399	546	39.0	27.0	4.7	28.5	2.8	26362
NIAB-111	2421	893	36.9	26.7	4.0	29.2	3.3	41426
CIM-446	1829	679	37.1	27.5	4.2	30.4	2.6	43040
CIM-707	1829	697	38.1	28.4	3.6	30.4	3.0	38736
CIM-496	807	328	40.7	27.1	3.8	29.9	3.0	27976
CIM-554	2152	872	40.5	26.9	3.3	30.0	2.4	29052
Gomal-93	2206	829	37.6	27.7	5.0	25.0	2.3	40350
CRIS-342	2260	827	36.6	27.0	4.2	29.6	2.6	41426
Malmal	1829	668	36.5	27.1	4.0	30.6	2.3	24748
Marvi	1775	616	34.7	27.2	3.2	30.9	3.1	37660
NIAB-777	1829	699	38.2	27.4	4.6	30.7	3.1	26900
Cyto-124	1237	469	37.9	28.8	4.3	30.5	2.4	32280

Sowing date: 13.05.2016; C.D. (5%) for seed cotton 138.69 CV% = 4.85

Micronaire value of all the varieties is according to the required standard. 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 *Bt.* CIM-602 excelled among all varieties by producing seed cotton yield of 2028 kg ha^{-1}, followed by the variety IR-3701 with 2022 kg ha^{-1} and *Bt*. CIM-600 with 1992 kg ha^{-1} seed cotton production. Variety IR-3701 had the highest lint percentage of 41.6, followed by varieties CEMB-33 and FH-142 having lint percentage of

40.6% and 39.7% respectively. The variety Bt. FH-113 and FH-Lalazar maintained the staple length of 27.7 mm, followed by the variety the *Bt.*CIM-602 with 27.1 mm staple length.

Table 2.37 Performance of commercial varieties in Standard Varietal Trial-2 at CCRI, Multan

Varieties	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)2	Plant Pop. (ha^{-1})
Bt.CIM-598	1236	417	33.7	25.6	2.7	27.5	2.2	40402
Bt.CIM-599	1689	591	35.0	25.5	3.9	25.0	2.2	38131
Bt.CIM-602	2028	702	34.6	27.1	3.8	28.7	3.0	40522
AA-703	1380	498	36.1	26.3	3.9	29.7	2.6	12029
AA-802	1381	497	36.0	24.8	3.9	28.2	3.0	35980
A-555	1677	624	37.2	24.6	4.7	24.5	2.9	40522
IR-3701	2022	841	41.6	23.6	5.2	24.7	3.0	40163
CEMB-33	1668	677	40.6	25.1	4.4	26.6	3.0	40761
IUB-222	1304	480	36.8	26.4	4.1	28.5	2.9	41171
MNH-886	1657	548	33.1	25.4	4.0	27.1	3.3	39924
Sitara-008	1729	662	38.3	23.7	4.5	25.9	2.6	38251
Bt.-121	1628	630	38.7	24.7	4.0	25.5	2.8	17691
Bt.-141	1369	467	34.1	24.9	2.6	28.8	2.3	39924
FH-113	1753	601	34.3	27.7	3.6	29.8	2.6	32394
FH-114	1658	554	33.4	25.0	4.6	23.5	2.4	39087
FH-142	1986	788	39.7	25.0	3.8	28.5	3.1	35860
CIM-600	1992	711	35.7	26.0	3.6	29.1	2.7	18647
FH-Lalazar	1807	651	36.0	27.7	4.1	30.0	3.6	20082

Sowing date: 17.05.2016 C.D. (5%) for seed cotton 222.43, CV% = 6.95

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 Burewala strain of cotton leaf curl virus (BSCV). The detail of breeding material planted and number of plants selected during 2016-17 is given in **Table 2.38**.

Table 2.38 Detail of single plants selected from breeding material

Generation/Trial	No. of plants Selected	Range	
		Lint (%age)	Staple length (mm)
Progeny row trial	210	38.6-46.8	27.4-31.5
F_6 single lines	290	38.8-45.9	27.5-31.6
F_5 single lines	510	38.6-46.0	28.1-31.8
F_4 generation	540	38.5-46.7	27.5-31.6
F_3 generation	1600	38.7-47.3	27.6-31.3
F_2 generation	2110	38.8-48.7	27.3-31.8

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 are being maintained at the Institute. Half 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 was also supplied, locally and abroad, to different scientists, cotton growers, and academics of different institutes / research stations / universities for their research / breeding program. The detail is given in **Table 2.39.**

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.	556
Gossypium arboreum L.	1025
Gossypium hirsutum L.	4243
Gossypium barbadence L.	109

Table 2.40 List of scientists/researchers whom received the cotton germplasm 2016-17

Sr. #	Name of Institute / Research Scientists	No. of stock
1	Mr. Arif Nadeem, Director, SANIFA Agri Services Ltd, 16-3/A Eden Homes Main Gulberug, Near MCB House Jail Road,Lahore.	15
2	Dr. Muhammad Asif, Assistant Professor, PBG Department, University College of Agriculture, BZU, Multan	52
3	Muhammad Majid Yar, PhD Student, Department of Plant Breeding and Genetics, University College of Agriculture & Environmental Science, Islamia University, Bahawalpur	59
4	Dr. Zulfiqar Ali, Professor and Chairman, Department of PBG, Muhammad Nawaz Shareef University of Agriculture, Multan	07
5	Dr. Saghir Ahmad, Cotton Botanist Cotton Research Station Multan	12
6	Cotton Botanist, Agriculture Research Institute, Tandojam-Sindh	10
7	Ch. Irshad Ali, Cotton Botanist, Cotton Research Station, Sahiwal.	06
8	Ch. Muhammad Hanif, Chief Scientist, Four Brothers, Seed Corporation Pakistan Al-Quresh Housing Scheme, Phase-1, Sher Shah Road, Multan	04
9	Dr. Shahzadi Mahpara, Assistant Professor/Head Department, Plant Breeding and Genetics, Ghazi University, D.G. Khan	05
10	Mr. Arif Nadeem Director, SANIFA Agri Services Ltd, 16-3/A Eden Homes, Main Gulberg, Near MCB House, Jail Road, Lahore.	15
11	Dr. Rashida Atiq, Chairperson, Department of Plant Pathology, BZU, Multan.	15
12	Dr. Amir Shakeel, Assistant Professor Department of Plant Breeding & Genetics, University of Agriculture, Faisalabad.	18
13	Dr. Shahid Mansoor, Director, National Institute for Biotechnology & Genetic Engineering, (NIBGE), Faisalabad.	**2**
14	Dr. Waqas Mali, Assistant Professor, PBG Department, University, BZU, Multan	85
15	Muhammad Noaman Khali, M.Sc. (Hons.), Research Officer, Neelum Seeds Chak No. 166/WB, Chowk Maitla, Jahanian.	04
16	Dr. Ghulam Muhammad Ali, Chief Scientific Officer / Sr. Director National Institute for Genomics and Advanced Biotechnology, National Agricultural Research Centre, Park Road, Islamabad	80
17	Dr. Muhammad Azeem, Assistant Professor, Department of Botany, University of Karachi.	04

18	Prof. Dr. Muhammad Baber, Director Institute of Molecular Biology and Biotechnology BZU, Multan	80
19	Dr. Aftab Ahmad, Assistant Professor, Department of Biochemistry, University of Agriculture, Faisalabad.	06
20	The Chairman, Department of Plant Breeding & Genetics, Bahauddin Zakariya University, Multan.	**90**
21	Dr. Muhammad Binyameen, Associate Professor Entomology, Department of Agriculture Entomology, Faculty of Agricultural Science and Technology, BZU, Multan	**01**
22	Dr. Ummad Ud Din Umar, Assistant Professor, Department of Plant Pathology, Bahauddin Zakariya University, Multan	**01**

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 and *Bt*.CIM-602 was produced. The detail is given in **Table 2.41**.

Table 2.41 Detail of pre-basic seed produced during 2016-17

Variety	Pre-basic seed produced (kg)
CIIM-496	80
CIM-620	70
CIIM-506	15
CIIM-554	110
CIIM-573	50
*Bt.*CIIM-598	20
*Bt.*CIIM-599	15
Bt.CIIM-602	150

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3 CYTOGENETICS

Cytogenetics section is working to combat diverse upcoming biotic and abiotic intimidation. Intent was to overtake the potential of 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, CLCuV is the most appalling biotic factor in Pakistan that results in severe production losses. Along with this threatening viral disease, bollworms are also the second most troubling factor during its reproductive phase. 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 all these dimensions i.e. disease resistance, insect resistance, drought resistance, heat resistance and better fiber quality through introgression.

Cytological studies of a newly developed inter-specific hybrid were undertaken. Conversion of CLCuD resistant/tolerant lines in transgenic lines 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, varietal trial, and ZVTs to evaluate their yield performance and other desirable characteristics.

Three *Bt.* varieties viz., Cyto-177, Cyto178 and Cyto-179 were approved from Punjab seed council during 2016 and 2017 and the case of these varieties has been already submitted to National Biosafety Committee for the approval of their commercialization. *Bt*. Cyto-313 was tested in NCVT trial during 2016-17 and secured 6th position (2783 kg ha^{-1} average seed cotton yield) in overall Pakistan.

3.1 Maintenance of *Gossypium* Germplasm

Eighteen species of *Gossypium* (cultivated and wild) are being maintained 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 two interspecific hybrids (five diploid, six triploid, five tetraploid, two pentaploid, four hexaploid interspecific hybrids) and 3 tri species combinations are also maintained.

For the maintenance of *Gossypium* species in living herbarium at CCRI, Multan more plants of available species were produced through seeds, cuttings and grafting approach. The seeds of thirteen wild species, two cultivated tetraploids and two interspecfic hybrids were germinated in an incubator at 32 $\pm$ 2^{0}C in the month of October, 2016. After germination, sixty nine seedlings of different species were transferred in earthen pots and shifted in greenhouse for further growth. List of species is given in Table-3.1.

Through cutting approach, eleven *Gossypium* wild species and eighteen interspecific hybrids were grown in permanent herbarium as well as in glasshouse in earthen pots to maintain the precious material. The detail is given in Table 3.2. As regards grafting approach; twenty one grafts of seven wild species were prepared during reporting period (Table 3.3). All these plants will be transplanted in field conditions in the month of March, 2017.

3.2 Inter-specific hybridization

Inter-specific hybridization for integration of precious wild species genes (especially the genes or resistance against CLCuD) into the upland cotton were undertaken during the season. Conversion of elite inter-specific hybrids into transgenic lines was also carried out using back crossing during the cropping season. The detail of species hybridization is given in Table 3.4.

Table-3.1. Detail of species/interspecific hybrids planted during 2016-17

Sr. No.	Name of Species	No. of seeds planted	No. of seeds germinated
1	*G.herbaceum* (Red)	18	4
2	*G.arboreum* (Red)	42	16
3	*G.anomalum*	28	0
4	*G.barbosanum*	15	0
5	*G.sturtianum*	30	7
6	*G.nelsonii*	18	0
7	*G. thurberi*	45	3
8	*G.aridum*	6	0
9	*G.raimondii*	6	4
10	*G.stocksii*	20	7
11	*G. Somalense*	22	0
12	*G.bickii*	31	2
13	*G.australe*	10	4
14	*G.hirsutum* (Brown)	33	6
15	*G.barbadense*	196	8
16	*G. arbo*.x *G.anom.*	31	4
17	*G. arbo*.x *G.incanum*	7	3
Total		**558**	**68**

Table-3.2 Species/Interspecifc hybrids maintained through cutting approach

Sr. No	Species/Interspecific Hybrids	Cuttings in pots and field
1.	*G.aridum*	12
2.	*G.gossypioides*	9
3.	*G.laxum*	12
4.	*G.anomalum*	12
5.	*G.tomentusum*	12
6.	*G.incanum*	12
7.	*G.lanceolatum*	3
8.	*G.areysianum*	12
9.	*G.harknessii*	9
10.	*G.somalense*	9
11.	W19 A	6
12.	58-1/15	6
13.	T-DD-2	12
14.	2(*G.hirsutum* x *G.bickii*) (6n)	6
15.	2(*G.hirsutum* x *G.anomalum*) (6n)	6
16.	*2(G.hirsutum* x *G.anomalum)* x *G.hirsutum* (5n)	6
17.	2(*G.hirsutum* x *G.anomalum*) x *G.barbadense*(5n)	6
18.	2(*G.arbo.* x *G.anomulum*) x *G.hirsutum* (4n)	6
19.	2(*G.arbo.x G.stocksii*) x *G.hirsutum* (4n)	6
20.	*G.hirsutum* x *G.stocksii (4n)*	30
21.	*G.hirsutum (red)* x *G.harknessii* (3n)	6
22.	*G.hirsutum* x *G.harknessii* (3n)	6
23.	*G.hirsutum* x *G.aridum*(3n)	6
24.	*(G.arboreum* x *G.thurberii*) x *G.hirsutum*(3n)	6
25.	*G.arborerum* x *G.anomalum* (2n)	6
26.	*G.arboreum* x *G.australe* (2n)	6
27.	*G.arboreum* x *G.herbecium* (2n)	6
28.	*G.arboreum* x *G.thurberii* (2n)	6
29.	*G.arboreum* x *G.capitis viridis* (2n)	9
	Total	**237**

Table-3.3 Species maintained through Grafting approach during 2016-17

Sr. No.	Name of species	No. of grafts
1	*G.somalense*	3
2	*G.incanum*	6
3	*G.tomentosum*	4
4	*G.aridum*	2
5	*G.nelsonii*	2
6	*G.anomalum*	2
7	*G.captis viridis*	2
	Total	**21**

Table 3.4 Detail of Intra and Inter-specific crosses attempted during 2016-17

Sr. No.	Cross No.	Parentage	No. of Pollinations	No. of Bolls Picked
1.	M1	(*G.hirsutum* x *G.stocksii*) 4n x 79-4/16	22	0
2.	M2	(*G.hirsutum* x *G.stocksii*) 4n x 380-3/16	14	0
3.	M3	(*G.hirsutum* x *G.stocksii)* 4n x Cyto-305	17	0
4.	M4	(*G.hirsutum* x *G.stocksii)* 4n x 4-1/16	7	1
5.	M5	(*G.hirsutum* x *G.stocksii*) 4n x cyto-307	5	2
6.	S1	*G.hirsutum* x *G. harknessii*	**120**	2
7.	S2	*G.hirsutum* x *G. gossypioides*	30	1
8.	S3	*G.hirsutum* x *G. laxum*	10	0
9.	S4	*G.hirsutum* x *G. aridum*	25	0
10.	1A	W16A (P1) x Cyto-305	12	2
11.	2A	W16A (P2) x Cyto-305	25	3
12.	3A	W16A (P1) x Cyto-307	10	2
13.	4A	W16A (P2) x Cyto-307	20	1
14.	HT-48	Cyto-305 x 79/14	258	1
15.	HT-49	Cyto-179 x 79/14	110	5
16.	HT-50	Cyto-313 x Cyto-305	145	1
17.	HT-51	Cyto-120 x Cyto-305	110	3
18.	HT-52	Cyto-124 x Cyto-305	107	3
19.	HT-53	609 4/17x Cyto-307	114	7
20.	HT-54	Cyto-305 x GMO	279	8
21.	HT-55	Cyto-305 x 620-4	130	10
22.	HT-56	1-1/16 x CIM-629	167	10
23.	HT-57	2-1/16 x CIM-629	211	12
24.	HT-58	3-1/16 x CIM-629	140	14
25.	HT-59	4-1/16 x CIM-629	204	11
26.	HT-60	12-1/16 x CIM-629	208	13
27.	HT-61	13-1/16 x CIM-629	214	13
28.	HT-62	Cyto-307 x Cyto-305	144	13
29.	HT-63	22-1/16 x 20-1/16	201	10
30.	HT-64	15-1/16 x 3-1/16	233	10
31.	HT-65	32-1/16 x12-1/16	279	14
32.	HT-66	23-1/16 x16-1/16	101	15
33.	HT-67	Cyto-124 x 84-3/16	141	12
34.	HT-68	436-4/16 x Cyto-305	30	2
35.	HT-69	Cyto-122 x 84-3/16	55	0
36.	HT-70	Cyto-305 x 84-3/16	175	0
37.	HT-75	26-1/16 x Cyto-305	35	1
38.	HT-76	14-1/16 x 4-1/16	22	1
39.	HT-77	9-1/16 x Cyto-305	11	2
40.	HT-78	25-1/16 x 4-1/16	10	4
41.	HT-79	Cyto-177 x Cyto-305	17	1
42.	HT-80	Cyto-178 x Cyto-305	14	2
43.	HT-81	Cyto-179 xCyto-305	13	0
44.	HT-82	593-3/16 x Cyto-305	17	1
45.	HT-83	Cyto-305 x 609-3/16	35	1
46.	HT-84	Cyto-305 x 593-3/16	13	2

47.	HT-85	Cyto-305 x 266-3/16	17	0
48.	HT-86	Cyto-305 x 272-3/16	11	1
49.	HT-87	Cyto-305 x 263-3/16	20	3
50.	HT-88	Cyto-305 x 275-3/16	11	0
51.	HT-89	Cyto-305 x 488-3/16	41	2
52.	HT-90	Cyto-305 x 603-3/16	21	2
53.	HT-91	Cyto-305 x 614-3/16	33	2
54.	HT-92	Cyto-124 x 609-3/16	26	1
55.	HT-93	Cyto-124 x 593-3/16	16	2
56.	HT-94	Cyto-124 x 488-3/16	21	3
57.	HT-95	441-3/16 x Cyto-305	14	5
58.	HT-96	442-3/16 x 609-3/16	16	2
59.	HT-97	443-3/16 x 274-3/16	123	5
60.	HT-98	444-3/16 x 488-3/16	101	13
61.	HT-99	445-3/16 x 620-4/16	93	2
62.	HT-100	446-3/16 x 84-3/16	84	2
63.	HT-101	Cyto-305 x 79-4	39	3
64.	HT-102	Cyto-305 x 79-4A	47	1
65.	HT-103	Cyto-305 x 443-3	111	5
66.	C-1	Cyto-124 x 82-3/16	11	2
67.	C-2	443-4/16 x 82-3/16	22	3
68.	C-3	Cyto-305 x 82-3/16	31	5
	Total		**5169**	**280**

A total of 5169 pollinations were attempted in 68 combinations. The boll setting was obtained in 58 combinations whereas in other combinations boll setting could not be achieved 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.

3.3 Chromosomal Studies

a) Flowering buds of *G.hirsutum* x *G.harknessii* (triploid) from permanent block were fixed in Carnoy's solution, preserved in 70% ethanol and studied at metaphase-1.

Table-3.5 Chromosomal configurations

Hybrid	PMC No.	I's	II's	III's	IV's	Total
G.hirsutum x *G.harknessii* (triploid)	2	5	15	-	1	39
"	3	4	16	1	-	39
"	1	9	15	-	-	39
Mean		**5.2**	**15.5**	**0.5**	**0.38**	
Range	-	**4-9**	**15-16**	**0-1**	**0-1**	

b) Flowering buds of *G.arboreum* were fixed in Carnoy's solution, preserved in 70% ethanol and studied at metaphase-1.

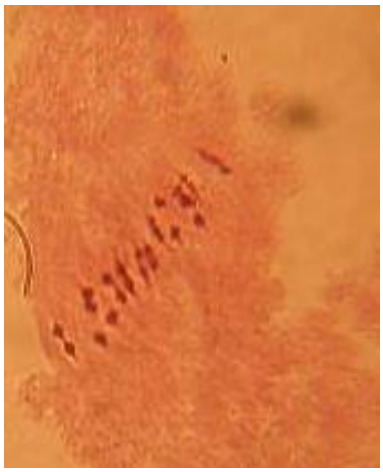

Fig 1 Chromosomes pairing in triploid **Fig 2 *G.arboreum* 13 bivalents at MI=26**

3.4. Research Work in Glass House

During the reporting period work also conducted in glass house in off season. F_0 seed of fresh crosses of 2016 which have one or two set bolls were planted in the month of December, 2016. 2 to 3 seeds per pot of thirteen crosses were planted to raise the F_1 hybrids. In addition some back crosses and distinguished material such as insect resistant, red colour boll, big boll and long staple length (32mm) plants were also planted for their shifting in field and further utilization in crossing program. All 149 plants will be shifted in field at the end of March, 2017.

3.5. Performance of filial generation during 2016-17

i). F_1

Forty seven cross combinations of Single, double and three way crosses of interspecific crosses were sown under field conditions to check their performance. The ginning out turn % is given below.

Table-3.6 Economic and fibre characteristics of F1 (developed through introgression) during 2016-17

Family No	Seed cotton Yield Plant^{-1} (g)	GOT%
	Ranges	
21-1/16	49.4-242.4	31.9-44.2
22-1/16	35.3-207.8	37.1-44.4
23-1/16	30.1-156.3	35.8-39.9
25-1/16	28.8-176.6	33.6-40.7
26-1/16	31.8-126.3	29.8-42.1
28-1/16	20.2-134.2	34.1-45.2
29-1/16	42.3-218.8	34.9-40.3
32-1/16	46.7-166.6	35.8-40.0
33-1/16	30.1-79.5	32.6-41.2
34-1/16	35.9-100.7	33.6-40.0
35-1/16	38.7-76.9	35.2-39.5
36-1/16	16.1-133.9	36.8-39.6
37-1/16	31.3-114.6	36.1-41.8
39-1/16	19.2-71.0	35.4-62.5
40-1/16	31.2-93.8	38.7-42.2
41-1/16	40.5-174.7	34.3-41.1
42-1/16	56.4-128.6	34.0-38.3
44-1/16	28.7-43.0	35.8-43.2
47-1/16	21.6-133.8	33.4-44.1
FH-142	**-**	**38.7**
CIM-602	**-**	**37.4**

ii). F_2 Generation

Two hundred plants were selected from F_1 during 2015-16 crop season. These plants possessing a distinguished morphological character of coloured petals with petal spots were sown as F_2 in crop season 2016-17. Lay out was plant to progeny row trial. Different shades of brown cotton were observed in F_2.

Table 3.7 Performance of F_2 interspecific hybrids lines during 2016-2017

Family	Seed cotton Yield plant^{-1} (g)	GOT%
	Ranges	
1-2/16	29.7-53.2	37.7-41.5
2-2/16	47.6-114.1	38.2-41.6
7-2/16	31.6-130.0	38.9-41.7
8-2/16	51.2-158.3	32.3-42.9
9-2/16	31.3-188.8	34.3-45.1
10-2/16	29.4-153.9	29.6-35.4
11-2/16	85.7-184.6	29.6-33.4
13-2/16	49.6-119.0	25.7-35.3
16-2/16	37.4-90.9	31.5-39.8
17-2/16	44.1-134.6	33.1-40.5
18-2/16	43.0-128.2	28.8-37.9
19-2/16	30.3-243.4	28.5-46.3
21-2/16	34.6-92.1	33.1-41.7
22-2/16	56.3-157.3	38.0-42.1
23-2/16	20.2-107.9	36.7-41.6
26-2/16	32.3-149.9	33.5-41.5
27-2/16	27.0-94.8	33.9-43.3
28-2/16	34.1-130.8	31.0-42.5
29-2/16	35.0-75.3	36.7-42.0
30-2/16	20.7-163.8	35.6-42.6
31-2/16	18.4-66.1	39.5-40.8
32-2/16	28.1-114.0	29.6-46.7
33-2/16	39.0-101.1	35.2-44.6
34-2/16	37.4-175.1	31.1-46.7
35-2/16	54.8-105.4	39.1-45.0
38-2/16	42.2-76.5	39.7-43.6
47-2/16	43.0-111.3	36.6-42.7
48-2/16	34.5-133.6	30.2-37.6
49-2/16	43.6-93.4	33.3-43.8
51-2/16	40.4-132.6	34.1-36.4
53-2/16	51.5-162.7	33.7-40.4
58-2/16	31.3-126.7	39.9-43.0
62-2/16	63.4-176.9	33.1-41.0
63-2/16	34.3-162.9	34.6-43.8
64-2/16	73.8-205.2	39.0-48.4
68-2/16	56.7-129.6	35.9-41.2
72-2/16	47.7-219.6	35.9-40.4
73-2/16	40.0-108.4	35.9-41.9
74-2/16	44.2-65.6	35.6-37.1
75-2/16	57.3-127.2	36.3-38.7
76-2/16	32.7-109.7	34.7-43.1
77-2/16	39.5-156.8	37.5-43.7
78-2/16	47.4-144.7	34.4-43.4
79-2/16	31.9-106.9	31.8-43.0
80-2/16	38.7-102.7	33.8-40.7
81-2/16	51.6-105.7	36.9-41.2
85-2/16	52.6-136.4	37.2-41.0
86-2/16	52.0-106.7	36.8-39.6
87-2/16	45.5-150.4	36.6-39.5
88-2/16	42.0-93.5	36.3-41.7

89-2/16	60.8-170.6	38.3-48.7
93-2/16	30.5-147.2	33.6-42.7
94-2/16	19.5-111.6	31.6-43.2
95-2/16	36.2-143.8	39.4-43.2
101-2/16	47.0-123.4	36.6-42.5
102-2/16	77.4-154.1	33.8-40.5
104-2/16	23.1-138.7	35.1-42.1
105-2/16	35.0-116.9	35.8-41.0
106-2/16	35.9-124.5	33.5-39.3
108-2/16	42.2-181.5	36.6-40.4
109-2/16	43.5-267.5	36.6-40.7
110-2/16	35.5-234.8	38.4-43.9
115-2/16	42.5-133.5	38.7-40.9
116-2/16	58.0-309.7	33.5-44.5
117-2/16	43.9-137.2	35.9-44.8
118-2/16	43.1-93.9	32.5-45.1
119-2/16	77.0-164.8	37.7-43.3
120-2/16	33.3-85.8	36.1-42.9
122-2/16	44.0-132.5	36.8-45.2
123-2/16	30.3-157.7	36.4-45.1
124-2/16	47.9-138.3	38.2-43.7
125-2/16	56.1-165.5	36.8-44.0
127-2/16	44.8-132.3	36.2-45.3
128-2/16	25.6-93.7	34.5-40.1
129-2/16	36.5-124.9	33.8-45.2
130-2/16	15.7-144.8	37.3-45.3
135-2/16	24.9-238.5	38.9-47.4
136-2/16	70.2-225.9	41.6-45.2
139-2/16	48.7-157.5	36.9-45.1
140-2/16	59.5-231.2	36.4-44.8
141-2/16	58.5-116.4	34.7-43.9
146-2/16	34.9-214.8	38.0-43.6
147-2/16	53.9-163.1	38.3-46.2
157-2/16	83.9-176.9	39.6-44.2
158-2/16	54.1-148.7	34.8-43.7
161-2/16	59.8-105.8	39.2-43.5
163-2/16	77.1-227.2	38.6-45.7
170-2/16	44.1-151.1	38.5-42.5
171-2/16	41.9-157.5	39.3-45.9
177-2/16	44.8-112.9	37.4-41.2
180-2/16	41.6-194.6	39.5-42.0
181-2/16	57.6-84.0	33.8-39.0
184-2/16	48.4-139.1	27.7-34.2
185-2/16	31.0-159.4	24.6-35.9
187-2/16	37.2-132.4	22.2-36.7
188-2/16	25.4-160.5	24.1-35.8
189-2/16	31.4-297.9	27.6-36.9
192-2/16	28.9-118.4	34.1-39.1
194-2/16	66.3-116.6	33.8-40.7
196-2/16	48.2-125.6	34.3-38.8
197-2/16	48.2-119.2	36.1-42.3
198-2/16	62.8-130.9	35.7-40.6
201-2/16	54.5-197.6	29.1-38.5
FH-142	**-**	**39.1**
CIM-602	**-**	**38.0**

The data revealed that the material in F_2 had wide range of lint percentage due to interspecific crossing as compared to standard FH-142 and CIM-602

iii) F_3 Generation

Six hundred and sixty seven plants were selected from F_2 generation 2015 on the basis of high yield potential, cotton leaf curl virus (CLCuV) disease resistance/tolerance

and desirable fibre traits and planted as F_3 in crop season 2016-17. Lay out was plant to progeny row trial. Performance of F_3 converted into transgenic lines is given in Table 3.8.

Table-3.8 Economic and fibre characteristics of elite F_3 Generation during 2016-17

Family	Yield plant^{-1} (g)	G.O.T (%)
1-3/16	23.6-79.9	37.7-42.6
2-3/16	51.0-124.8	37.9-39.0
3-3/16	62.0-124.6	38.5-39.7
5-3/16	35.4-144.8	34.4-40.8
6-3/16	32.0-122.7	33.8-37.0
7-3/16	76.9-119.9	38.2-40.2
8-3/16	28.7-126.3	38.6-39.7
9-3/16	29.8-99.6	36.9-38.3
11-3/16	26.5-111.8	31.4-39.4
12-3/16	46.3-277.9	34.6-37.8
14-3/16	40.0-87.4	22.6-40.5
15-3/16	33.9-117.9	36.2-39.2
16-3/16	32.9-103.6	34.1-40.4
17-3/16	81.6-116.3	37.5-39.4
18-3/16	53.8-132.5	33.7-44.5
20-3/16	42.4-160.5	27.4-41.9
21-3/16	32.7-53.4	34.9-42.2
23-3/16	26.8-84.6	30.5-41.1
24-3/16	42.0-99.1	34.7-41.6
25-3/16	75.4-170.4	37.9-42.2
28-3/16	46.0-81.7	39.1-40.3
29-3/16	51.9-98.7	40.2-43.1
32-3/16	70.1-187.6	36.0-48.2
33-3/16	58.5-198.6	36.5-41.5
34-3/16	51.6-165.9	40.6-43.6
45-3/16	49.8-156.7	38.9-45.6
47-3/16	36.1-139.4	37.9-45.3
52-3/16	59.2-116.9	40.8-43.9
54-3/16	103.5-143.5	44.5-45.0
60-3/16	61.3-158.9	36.5-43.8
63-3/16	92.8-247.8	43.5-46.6
65-3/16	84.5-123.4	40.9-44.7
66-3/16	64.3-147.7	35.2-39.6
67-3/16	58.1-171.6	28.8-37.8
71-3/16	45.7-95.1	34.3-40.4
73-3/16	58.2-76.6	35.5-41.6
75-3/16	41.2-155.1	30.0-46.0
77-3/16	54.2-288.0	29.8-40.6
83-3/16	55.1-194.6	29.9-48.05
84-3/16	40.4-121.8	33.7-40.9
88-3/16	68.2-171.2	32.9-39.1
89-3/16	45.6-113.7	30.6-38.1
90-3/16	58.2-196.6	30.1-39.3
96-3/16	78.4-132.4	31.5-37.6
114-3/16	91.4-21936	40.8-44.8
127-3/16	56.3-138.3	38.7-41.6
128-3/16	65.9-114.2	39.7-40.7
129-3/16	75.9-146.0	35.9-42.3
130-3/16	57.3-159.2	41.6-44.6
135-3/16	95.0-198.4	40.4-42.8
136-3/16	73.6-198.6	31.4-44.4
137-3/16	57.2-114.4	41.1-44.9
145-3/16	68.7-111.3	38.8-44.4
146-3/16	39.2-155.3	37.0-41.3
147-3/16	60.9-138.4	34.8-41.6
148-3/16	45.4-140.2	36.8-41.1
149-3/16	47.2-91.6	37.7-43.7
150-3/16	29.6-149.0	37.9-40.5
151-3/16	78.4-174.2	36.3-41.8
152-3/16	37.3-212.9	35.8-44.1
153-3/16	81.1-181.7	37.2-45.2
155-3/16	45.6-120.5	31.2-43.9
156-3/16	44.4-114.5	34.9-41.9
157-3/16	62.7-128.7	38.4-43.7
158-3/16	42.3-147.1	36.0-42.9
159-3/16	67.0-292.0	38.2-41.6
161-3/16	52.8-180.5	37.8-42.2
164-3/16	68.8-128.3	37.6-41.2
165-3/16	83.9-241.9	34.6-38.4
166-3/16	87.8-172.8	36.2-41.7
167-3/16	86.1-153.5	37.8-39.9
168-3/16	50.1-152.6	36.9-40.1
169-3/16	50.1-134.0	38.6-42.4
171-3/16	78.3-111.6	39.4-44.1
173-3/16	28.8-158.1	39.9-42.3
175-3/16	32.0-102.8	36.2-38.0
176-3/16	74.2-139.2	35.0-42.5

The data revealed that the material in F_3 had wide range of lint percentage due to interspecific crossing as compared to standard FH-142 and CIM-602.

iv).

F_4 Generation.

Six

hundred sixty plants were selected from F_3 during 2015-16 crop season. These plants were sown as F_4 in crop season 2016-17. Lay out was plant to progeny row trial. Performance of F_4 converted into transgenic lines is given in Table 3.9.

Table-3.9 The economic and fibre characteristics of elite F_4 during 2016-17

Family	Yield/Plant (g)	GOT %	*Staple Length* (mm)	Micronaire (µg/inch)	Strength (g tex $^{-1}$)
11-4/16	49.1-107.9	37.8-43.2	25.9-28.6	3.3-4.9	24.0-27.9
14-4/16	9.4-106.9	36.8-37.9	26.6-31.1	3.3-4.5	25.5-29.6
15-4/16	73.9-188.5	38.5-39.7	27.0-27.6	3.9-4.0	26.4-27.2
16-4/16	40.7-115.3	38.1-40.7	26.1-28.3	3.3-5.0	26.1-27.9
17-4/16	55.9-177.7	33.1-36.5	25.5-30.3	2.7-4.0	26.7-30.5
18-4/16	75.3-199.7	32.9-37.6	28.4-32.0	2.5-4.0	29.0-31.8
19-4/16	11.8-150.7	34.6-38.2	30.2-32.3	2.5-3.9	28.0-32.9
20-4/16	52.1-144.6	32.7-41.6	26.0-32.2	2.9-5.1	26.0-30.2
22-4/16	102.3-122.6	41.1-44.8	26.3-28.2	3.5-4.2	26.1-28.2
23-4/16	52.8-74.9	36.2-38.5	26.0-28.0	4.6-5.1	24.1-28.3
24-4/16	50.0-95.7	41.3-42.0	24.7-25.6	5.0-5.8	23.5-24.9
25-4/16	36.3-69.5	35.0-38.1	25.8-29.0	3.8-5.4	24.1-28.1
27-4/16	58.8-164.6	40.7-41.2	25.7-27.3	3.4-4.2	25.1-27.0
30-4/16	88.1-170.8	40.1-42.5	24.6-27.2	4.8-5.3	23.4-26.8
31-4/16	59.4-142.8	41.0-41.9	25.5-26.5	4.4-5.5	25.3-26.7
32-4/16	85.0-178.3	38.8-39.5	25.5-27.2	4.1-5.0	25.5-26.5
34-4/16	66.7-123.1	40.2-91.8	25.9-27.0	4.5-5.3	24.9-27.8
40-4/16	71.5-114.1	37.3-41.3	24.6-26.6	4.4-4.9	24.6-26.7
42-4/16	50.7-109.0	38.7-42.9	24.3-30.6	2.8-4.8	24.7-29.7
49-4/16	59.8-174.2	37.3-39.9	25.5-28.4	3.1-4.8	28.6-32.0
50-4/16	81.4-158.1	33.7-44.4	28.1-29.5	3.2-4.5	28.1-33.0
51-4/16	55.8-220.8	37.3-45.5	26.0-30.4	4.0-5.1	26.0-32.5
52-4/16	63.4-197.6	39.0-42.2	26.8-29.2	3.8-4.4	26.0-32.6
53-4/16	72.0-161.4	40.0-43.7	27.5-29.2	4.1-4.9	28.6-30.9
54-4/16	51.2-83.4	41.2-50.9	29.1-29.3	4.0-4.7	31.4-33.5
55-4/16	78.6-127.7	30.7-39.0	27.8-29.8	4.0-4.5	29.6-32.3
62-4/16	19.4-155.0	39.4-43.6	26.5-30.6	4.0-5.3	26.0-30.8
63-4/16	43.7-115.3	33.3-39.9	25.9-28.7	3.3-4.6	26.3-30.5
64-4/16	69.4-129.0	33.3-39.7	25.6-30.0	3.5-4.4	28.2-31.9
65-4/16	26.1-228.3	37.5-43.3	24.6-30.2	3.4-4.5	26.3-31.6
72-4/16	52.0-221.5	37.5-42.7	26.5-32.0	3.2-5.0	28.0-32.8
74-4/16	63.4-153.1	38.3-42.7	26.9-30.4	3.9-5.2	27.5-31.0
75-4/16	59.8-223.5	36.7-46.4	28.7-31.3	4.1-4.8	29.4-30.8
78-4/16	57.0-128.2	37.0-42.7	28.6-30.7	3.1-4.4	29.0-32.7
79-4/16	25.8-104.4	38.4-39.4	25.5-27.0	3.2-4.2	26.9-30.5
83-4/16	69.7-102.5	38.6-42.2	28.5-29.2	3.8-5.0	29.6-30.0
87-4/16	68.3-117.8	40.6-42.4	29.0-31.9	4.2-4.5	29.6-31.8
88-4/16	87.8-141.7	37.6-44.6	27.0-32.4	3.6-5.0	28.6-30.7
89-4/16	74.4-127.8	36.6-41.9	29.4-30.0	3.6-4.5	29.2-30.9
93-4/16	94.5-193.7	35.6-40.2	28.8-29.6	3.8-4.2	29.3-30.6
94-4/16	54.9-137.7	37.7-40.7	27.4-30.0	3.2-4.1	29.6-31.1
95-4/16	114.5-156.7	37.2-39.3	30.0-31.1	3.3-4.2	30.9-32.2
98-4/16	51.3-184.4	36.6-38.8	29.1-31.2	3.7-4.3	30.4-32.9
100-4/16	62.9-134.1	35.5-39.2	28.5-30.0	4.1-5.0	28.5-32.7
101-4/16	105.4-206.1	36.5-41.0	28.8-30.3	3.8-4.2	28.0-33.8
103-4/16	26.0-51.0	39.7-41.5	27.4-30.3	4.0-4.3	29.9-31.7
104-4/16	45.4-175.8	35.0-42.0	28.7-29.9	3.7-4.7	30.0-34.2
109-4/16	73.8-124.4	36.8-42.6	28.2-30.3	4.4-5.3	29.4-32.2
110-4/16	51.0-137.6	35.1-39.3	28.1-30.3	4.0-5.0	29.9-32.5
111-4/16	67.5-144.5	38.7-40.3	28.1-30.5	3.9-4.7	29.7-31.7
115-4/16	65.5-198.7	35.5-39.0	28.0-29.8	4.1-4.7	30.2-32.9
116-4/16	41.0-221.6	36.5-40.1	28.5-30.5	3.7-4.5	30.7-32.9
117-4/16	80.1-144.1	39.0-40.9	28.5-30.9	3.4-4.6	28.4-33.3
120-4/16	76.0-194.0	38.0-41.4	29.2-31.8	3.8-4.4	29.4-31.9

121-4/16	76.6-128.4	37.9-41.1	29.7-31.5	4.0-4.5	29.7-30.4
123-4/16	53.2-152.6	40.3-46.7	28.9-31.0	3.2-4.6	29.0-33.0
125-4/16	45.4-102.9	39.5-41.6	29.6-31.1	3.9-4.2	29.2-31.5
126-4/16	84.4-131.0	40.7-42.5	30.8-31.3	4.1-4.5	29.2-31.8
136-4/16	84.2-191.3	37.5-41.3	29.0-31.0	4.0-4.9	28.2-32.4
140-4/16	44.7-168.0	36.9-40.5	29.7-31.9	3.6-4.5	28.3-31.5
142-4/16	34.8-75.2	36.6-42.6	28.4-30.2	4.2-5.2	27.6-32.2
143-4/16	60.0-104.6	38.1-44.3	29.0-30.6	4.1-4.8	28.2-32.1
145-4/16	52.6-132.5	37.0-39.7	28.9-30.3	2.9-4.1	28.1-32.4
146-4/16	82.1-192.6	40.7-42.3	27.4-28.1	3.0-4.5	27.4-28.4
147-4/16	54.7-155.8	38.2-44.3	28.0-30.3	3.8-4.8	27.3-30.5
148-4/16	97.5-192.2	38.5-42.0	27.5-28.5	4.4-4.7	27.6-28.6
153-4/16	70.8-212.1	17.6-40.0	26.6-28.8	3.7-4.4	26.7-28.7
154-4/16	72.9-130.4	41.2-43.5	28.7-30.2	3.5-4.6	28.7-30.5
155-4/16	40.1-197.5	38.0-39.2	29.8-31.3	3.6-4.7	28.0-33.6
156-4/16	58.1-138.4	37.2-41.5	28.8-30.1	3.6-4.6	28.8-31.9
157-4/16	62.8-147.7	39.2-41.3	28.7-30.0	4.0-4.6	28.0-30.7
159-4/16	92.5-177.2	36.7-40.9	29.2-30.6	3.8-4.6	29.4-30.4
161-4/16	112.2-186.6	43.1-42.9	27.5-28.6	4.3-5.0	27.1-29.7
162-4/16	64.3-270.9	37.1-42.9	26.7-29.7	3.5-4.8	27.3-29.5
165-4/16	120.6-147.0	38.3-40.5	27.1-28.0	4.3-5.2	27.1-28.5
167-4/16	95.2-119.2	37.8-39.2	27.2-29.0	3.9-4.9	27.7-29.4
182-4/16	121.1-221.3	41.4-42.3	28.1-29.6	4.1-4.6	30.9-31.5
183-4/16	97.5-176.6	39.8-44.4	26.4-28.7	4.1-5.1	27.8-30.4
191-4/16	64.8-211.4	29.3-34.9	27.5-29.4	3.1-3.9	29.4-31.0
193-4/16	92.0-141.2	39.1-40.1	27.0-29.7	3.8-4.5	28.3-30.6
195-4/16	115.2-150.3	38.6-40.3	28.5-29.6	4.0-4.6	26.8-29.1
199-4/16	105.3-221.3	36.4-45.6	27.4-29.1	3.9-4.7	27.0-29.4
200-4/16	81.6-141.7	35.8-38.9	28.6-29.5	4.1-4.8	27.7-30.3
201-4/16	123.1-285.9	36.5-39.9	27.5-29.1	4.2-4.8	27.2-29.2
208-4/16	69.2-215.4	38.4-42.0	26.1-27.2	3.1-4.5	26.6-29.1
212-4/16	72.3-154.4	35.0-38.4	25.8-28.5	3.4-4.4	25.9-29.5
216-4/16	63.3-134.8	39.8-41.6	28.0-28.9	4.3-5.0	28.7-29.5
218-4/16	50.8-158.4	30.3-41.4	27.9-29.5	4.0-4.8	27.7-29.3
226-4/16	115.9-211.0	36.3-42.1	27.1-28.8	3.7-4.3	37.7-30.5
229-4/16	56.4-226.8	37.6-40.1	20.3-30.7	3.2-4.5	26.3-31.2
230-4/16	68.0-141.6	37.0-42.3	25.5-27.5	2.9-4.6	26.0-29.9
232-4/16	52.8-106	38.4-41.0	28.0-28.3	3.7-4.6	27.5-30.4
235-4/16	94.1-156.0	37.4-42.7	26.0-27.0	3.5-4.5	26.5-28.7
240-4/16	69.7-141.0	35.0-37.9	27.6-29.3	3.8-4.3	27.0-30.5
248-4/16	100.0-178.5	36.9-38.7	26.4-27.6	3.8-4.8	25.6-28.9
250-4/16	132.6-191.7	33.4-36.4	27.7-29.2	3.4-4.4	27.8-30.9
252-4/16	115.4-158.5	36.6-45.3	28.1-29.0	4.6-4.9	28.6-29.6
253-4/16	92.3-120.7	36.4-43.7	26.5-29.4	3.6-4.6	27.1-29.5
254-4/16	91.1-205.2	39.3-42.2	26.8-28.4	4.3-5.1	27.2-30.7
258-4/16	73.1-119.0	5.7-41.6	26.6-28.7	4.1-5.5	27.5-30.1
260-4/16	58.9-138.1	38.9-41.8	27.5-29.9	4.2-4.9	28.0-31.5
277-4/16	63.4-89.3	35.8-38.8	25.9-27.0	3.7-4.2	27.2-29.1
285-4/16	62.9-157.2	22.3-38.3	27.5-30.0	4.1-4.8	28.3-32.0
291-4/16	127.1-174.8	35.0-38.0	28.1-29.3	4.0-4.9	29.1-32.2
294-4/16	73.3-116.7	37.4-42.3	28.2-29.5	4.4-4.5	28.5-31.0
298-4/16	104.9-111.5	37.6-39.7	28.7-29.8	3.9-4.3	31.4-32.5
300-4/16	83.6-168.0	37.6-44.8	27.6-29.1	3.9-4.4	30.7-31.4
302-4/16	59.5-124.4	40.0-44.4	27.5-28.8	3.1-4.3	30.1-30.8
305-4/16	77.7-161.5	37.2-41.7	28.2-28.4	3.8-4.6	29.8-30.6
306-4/16	117.9-198.4	42.2-45.3	27.6-29.2	4.2-5.1	29.2-32.0
307-4/16	94.5-152.3	41.5-43.4	27.4-28.8	4.1-5.1	27.8-31.9
308-4/16	78.8-149.2	42.7-44.1	25.7-28.2	4.2-5.2	27.5-30.0
309-4/16	169.1-224.0	35.4-40.0	27.9-29.4	3.8-4.7	28.7-32.6
314-4/16	70.8-151.5	37.7-42.	28.4-30.4	4.0-4.6	30.0-32.7
315-4/16	82.1-189.4	38.9-39.3	26.9-28.7	3.6-4.0	28.2-30.8
318-4/16	46.3-89.2	37.0-37.8	30.1-30.8	4.9-5.0	32.1-32.6
319-4/16	73.2-139.0	36.5-40.5	28.3-29.6	3.7-4.1	30.5-32.9

321-4/16	59.2-127.5	38.0-40.2	25.4-29.8	3.3-4.0	27.1-31.3
323-4/16	102.3-159.8	39.7-41.7	27.2-29.	3.4-4.5	29.3-32.4
324-4/16	39.3-110.3	42.3-43.9	25.2-28.9	2.9-5.3	27.9-30.8
325-4/16	94.6-152.3	37.6-40.5	27.3-28.5	4.1-4.8	30.7-30.9
327-4/16	92.2-131.2	37.0-42.6	26.6-29.1	4.4-5.2	28.3-32.7
331-4/16	104.1-250.7	38.7-41.5	28.9-30.2	4.1-4.9	30.5-33.4
333-4/16	75.3-128.4	41.7-43.4	27.1-29.3	5.2-5.3	29.6-32.1
334-4/16	193.4-250.7	35.5-38.0	29.2-30.2	3.9-4.4	32.0-32.4
339-4/16	115.6-165.6	36.2-39.6	27.1-28.9	3.6-4.6	30.8-32.7
341-4/16	37.2-191.2	37.9-38.9	26.6-29.6	3.6-5.0	28.0-30.7
342-4/16	92.6-142.8	40.2-42.3	28.6-28.9	3.7-4.1	30.0-30.4
343-4/16	66.2-150.3	41.3-42.9	27.7-29.0	3.8-4.3	29.1-32.6
346-4/16	60.3-168.8	40.3-46.3	27.5-29.5	3.6-4.5	29.3-31.3
347-4/16	109.2-118.8	38.2-48.9	27.6-29.7	4.0-4.5	30.1-31.2
348-4/16	72.7-208.0	43.1-45.5	26.0-28.3	4.3-5.0	28.0-31.4
349-4/16	55.5-145.4	34.5-43.1	26.8-28.9	4.1-4.5	28.2-30.6
351-4/16	83.5-100.7	37.6-39.1	28.2-29.0	4.2-5.1	30.0-31.7
352-4/16	54.2-178.0	36.8-38.5	27.8-29.3	4.9-5.1	29.2-32.9
353-4/16	95.0-141.5	36.2-39.2	27.6-29.4	4.2-5.4	29.0-31.0
354-4/16	93.1-140.5	35.6-39.9	27.4-29.5	3.8-5.2	29.2-31.4
355-4/16	115.9-164.0	39.2-41.9	29.4-29.6	4.2-4.5	31.3-31.9
356-4/16	79.8-186.8	39.3-42.0	28.0-29.9	3.8-4.3	30.2-31.5
358-4/16	70.3-156.0	39.5-42.3	26.9-29.7	4.0-4.4	28.5-31.9
360-4/16	86.0-114.9	34.3-41.7	28.3-29.0	3.6-3.9	30.6-31.6
361-4/16	73.7-117.4	35.6-39.4	29.3-29.6	3.4-3.9	31.0-32.6
369-4/16	94.6-127.5	37.8-42.1	28.2-29.3	4.0-4.9	30.0-32.4
373-4/16	65.7-138.7	36.8-39.1	26.8-30.2	3.8-4.5	28.4-32.4
375-4/16	78.9-179.1	36.3-37.3	30.1-31.8	3.1-4.5	32.1-33.8
376-4/16	116.6-139.0	37.2-38.2	29.1-30.5	4.3-4.7	32.0-33.2
377-4/16	103.9-160.2	36.7-38.4	29.8-30.4	3.5-4.1	31.4-33.7
379-4/16	99.5-220.4-	35.0-36.1	29.5-29.9	3.4-4.4	31.2-31.9
383-4/16	75.0-175.2	33.5-41.8	26.9-30.6	3.7-4.9	28.7-33.6
386-4/16	102.1-195.2	38.9-41.9	28.9-29.7	3.7-4.4	30.4-32.3
388-4/16	110.5-150.1	37.4-39.6	28.6-30.0	3.5-4.3	30.2-32.8
390-4/16	78.7-123.4	38.5-40.1	28.6-29.9	3.1-4.1	29.3-32.8
392-4/16	41.2-206.6	38.8-41.9	28.6-29.6	3.5-4.3	30.0-31.7
394-4/16	54.6-119.8	38.7-42.8	27.3-28.9	3.4-4.3	29.2-31.9
395-4/16	85.0-130.4	35.0-41.1	27.1-29.4	3.5-4.2	27.8-31.4
397-4/16	58.2-138.0	38.7-41.2	28.5-30.1	3.2-3.6	30.7-32.8
399-4/16	448-184.6	37.2-39.9	29.1-30.3	3.2-3.6	31.0-32.6
400-4/16	87.6-161.8	38.2-41.8	27.2-29.4	3.3-3.9	27.5-32.7
401-4/16	78.7-163.7	38.0-42.3	28.3-29.6	3.9-4.6	28.2-30.5
404-4/16	67.6-93.8	34.1-37.4	28.2-28.8	3.7-4.7	29.9-30.9
408-4/16	93.9-216.9	36.5-38.2	28.6-30.4	4.4-5.0	30.1-32.7
410-4/16	125.0-161.8	38.4-41.7	29.0-29.6	3.4-4.3	30.3-33.5
413-4/16	112.6-123.6	40.8-42.8	27.8-29.8	3.6-4.2	31.1-32.1
414-4/16	112.3-219.6	37.1-40.5	29.1-30.1	3.7-4.2	31.0-33.3
415-4/16	138.6-180.7	39.4-40.9	28.5-29.7	3.9-4.1	30.4-31.3
416-4/16	59.8-164.1	36.5-39.9	25.8-29.5	3.7-4.5	28.4-33.2
420-4/16	73.4-165.8	39.0-41.8	29.1-29.4	3.8-4.1	28.9-31.2
423-4/16	82.1-111.1	37.8-39.9	27.1-28.7	4.8-5.0	29.2-30.6
424-4/16	74.0-171.9	33.3-37.7	27.5-30.4	3.5-4.9	29.1-32.4
425-4/16	81.5-167.1	35.0-39.1	28.1-29.7	4.0-4.6	29.6-30.9
426-4/16	79.1-126.5	37.0-42.6	28.3-29.2	3.7-4.5	30.2-31.3
427-4/16	36.3-98.0	37.3-41.1	27.2-29.3	3.8-4.4	28.2-30.2
429-4/16	86.9-213.3	38.2-41.1	27.9-29.2	4.2-4.9	29.2-30.9
430-4/16	82.3-1584	37.0-39.7	28.7-30.1	3.7-4.3	28.2-32.8
431-4/16	63.6-141.2	39.0-42.9	27.3-30.5	3.8-5.1	27.4-32.3
433-4/16	9607-175.4	42.3-42.8	27.8-29.0	3.9-4.8	29.8-30.8
FH-142	121.2-229.6	37.2-41.4	26.2-28.0	3.5-4.1	27.6-30.7
CIM-602	117.9-160.5	37.2-41.4	26.2-28.0	3.5-4.1	27.0-30.5
435-4/16	71.0-176.0	35.9-40.1	29.1-31.3	4.0-4.5	32.0-32.8
436-4/16	63.3-216.8	35.9-39.2	26.6-29.7	3.6-4.6	28.7-31.9

437-4/16	85.5-220.0	35.7-38.7	27.5-28.7	3.5-4.6	29.2-31.2
438-4/16	40.0-308.2	35.4-40.0	26.3-29.2	3.4-4.9	27.2-30.9
440-4/16	56.7-136.6	38.4-40.4	27.7-30.5	4.1-4.7	29.8-30.6
-441-4/16	50.0-174.1	38.6-42.1	29.0-30.8	4.1-4.7	29.5-31.8
442-4/16	74.4-115.1	38.6-41.9	26.8-30.3	4.0-4.9	28.3-30.9
443-4/16	73.4-228.2	35.3-40.4	27.7-28.9	4.2-5.1	28.9-29.4
449-4/16	30.3-141.5	39.3-42.9	27.1-29.2	4.1-4.8	29.9-30.7
450-4/16	69.2-134.6	37.1-43.8	27.3-30.1	4.3-5.8	29.3-30.3
451-4/16	25.7-92.8	38.8-39.3	27.5-29.1	4.1-4.7	28.5-29.8
452-4/16	45.0-159.4	33.3-38.6	27.9-30.2	4.5-4.7	27.9-31.9
453-4/16	43.1-63.6	37.6-39.6	27.3-29.5	4.5-5.0	27.4-30.2
454-4/16	66.5-111.5	33.5-40.9	27.5-27.9	4.4-4.8	27.3-29.6
455-4/16	79.1-174.3	38.1-39.7	27.9-29.6	3.9-4.3	29.0-30.0
456-4/16	41.3-146.1	34.4-40.8	27.1-29.1	3.8-4.6	27.1-29.2
462-4/16	53.-122.4	37.0-38.9	27.8-28.8	3.8-4.7	28.0-29.9
463-4/16	72.5-158.9	38.5-42.1	28.4-30.3	3.5-4.7	26.3-32.3
465-4/16	41.0-123.9	37.5-38.8	24.2-27.2	4.0-5.4	25.7-29.1
477-4/16	81.3-116.7	37.4-40.3	28.3-30.3	3.4-4.1	28.2-30.5
479-4/16	62.9-94.3	38.9-40.1	28.4-30.5	3.3-4.4	30.4-31.3
489-4/16	56.4-167.7	35.9-39.8	29.0-30.7	3.4-4.3	30.0-32.4
501-4/16	57.5-117.2	37.2-9.8	31.2-32.0	3.8-4.5	33.5-34.8
503-4/16	69.1-155.6	37.4-39.5	30.1-32.0	4.0-4.3	32.6-34.0
512-4/16	79.7-163.6	25.4-38.7	26.7-26.9	4.6-4.9	28.0-30.0
514-4/16	76.0-145.9	32.1-37.2	26.3-30.3	3.7-4.9	28.3-32.7
515-4/16	98.9-166.1	32.5-36.1	27.7-30.4	3.4-4.4	29.4-33.8
516-4/16	80.3-125.6	33.2-37.5	29.3-30.3	3.9-4.6	31.5-32.4
520-4/16	86.3-142.3	34.4-41.3	28.2-31.2	3.7-4.9	30.7-33.8
522-4/16	68.8-164.5	37.1-41.7	28.4-30.4	3.7-4.4	31.0-32.9
523-4/16	109.2-181.8	33.9-38.6	29.6-31.5	4.0-5.0	31.0-33.3
525-4/16	76.6-126.9	34.4-40.3	28.0-31.1	3.7-5.0	30.5-33.4
527-4/16	85.3-187.7	36.7-40.7	30.7-32.2	3.9-4.5	32.1-34.4
528-4/16	55.2-144.8	33.6-37.6	29.7-31.5	3.7-4.6	31.2-33.9
529-4/16	63.4-133.7	32.9-37.1	27.8-29.5	3.3-3.8	29.0-33.5
530-4/16	88.2-239.4	38.4-40.6	25.9-30.6	3.8-4.5	27.6-32.9
534-4/16	159.1-309.6	37.7-42.9	28.7-30.5	3.5-4.4	30.3-32.5
535-4/16	101.6-233.2	31.2-39.9	29.5-31.5	3.9-4.5	31.5-33.9
541-4/16	71.4-86.6	37.6-40.6	29.9-32.1	3.3-4.3	31.7-34.7
545-4/16	73.2-146.1	35.4-38.1	28.2-29.9	3.7-4.4	30.0-31.9
546-4/16	86.6-182.2	36.1-39.4	28.1-29.2	4.5-4.9	30.3-31.0
547-4/16	56.9-160.0	31.2-36.7	27.5-29.4	3.7-4.7	29.4-31.6
575 -4/16	47.4-122.8	40.7-43.5	29.3-30.4	3.8-4.7	31.2-32.9
576-4/16	44.1-173.2	38.4-41.7	29.3-30.0	4.3-4.5	31.1-32.7
578-4/16	73.5-140.5	35.6-38.7	30.0-32.4	3.9-4.8	32.2-34.0
585-4/16	83.3-234.0	38.0-41.4	30.4-31.4	3.9-4.4	31.0-32.4
587-4/16	99.2-135.7	34.9-40.5	30.1-30.7	3.8-4.5	32.0-32.8
588-4/16	134.1-183.2	34.4-41.5	28.5-30.6	3.7-5.1	30.5-32.3
589-4/16	82.0-175.3	36.2-38.4	29.0-30.9	4.3-4.5	30.1-32.9
590-4/16	77.0-224.5	37.1-40.2	29.2-32.5	4.0-4.6	31.1-34.5
603-4/16	77.7-122.5	39.6-42.7	27.8-29.8	4.1-4.7	29.1-31.9
604-4/16	86.4-137.9	39.4-42.2	28.6-30.3	3.8-4.8	30.5-32.5
626-4/16	111.6-189.7	38.1-41.0	26.6-28.9	4.3-5.0	28.1-30.4
627-4/16	79.0-121.7	36.1-39.5	28.7-30.3	4.3-4.6	31.0-32.3
630-4/16	94.8-126.1	34.7-46.1	28.6-29.7	4.0-4.3	30.3-31.6
637-4/16	53.0-79.8	37.8-41.47	29.0-29.8	3.6-4.5	31.0-31.9
639-4/16	81.1-175.6	33.8-37.46	28.1-30.4	3.8-4.7	30.3-32.1
641-4/16	57.0-94.5	38.3-41.6	28.5-30.1	3.5-4.2	29.0-32.0
645-4/16	45.7-135.9	37.7-42.0	26.1-29.9	3.9-5.1	29.9-31.4
646-4/16	66.6-105.4	37.0-42.3	28.4-30.3	4.2-5.1	30.7-32.3
647-4/16	60.7-112.8	40.2-43.1	28.1-29.0	4.6-5.0	29.9-30.4
648-4/16	34.5-158.5	32.8-41.5	28.8-31.2	3.9-4.6	30.4-31.8
649-4/16	53.7-161.6	36.9-41.1	28.5-30.7	3.8-4.6	30.2-32.1
651-4/16	87.8-188.2	39.6-42.5	28.8-30.3	3.8-4.5	30.2-32.9
653-4/16	54.2-269.7	36.5-43.4	27.9-29.9	4.4-4.6	29.0-31.7

654-4/16	52.0-150.0	37.5-40.8	29.3-30.5	4.1-4.7	31.1-32.8
655-4/16	77.3-127.5	38.7-42.9	27.3-28.6	3.0-4.9	29.0-30.6
656-4/16	18.2-157.7	39.0-42.9	27.6-28.9	4.5-4.8	29..2-30.7
659-4/16	87.4-207.4	36.2-39.9	27.8-29.8	3.1-5.2	29.6-31.9
FH-142	**-**	**39.5**	**28.0**	**5.2**	**25.7**
CIM-602	**-**	**38.2**	**27.9**	**3.8**	**28.3**

The data revealed that the material in F_4 generation had excellent lint %, longer staple, desirable micronaire and fibre strength as compared to both standards FH-142 and CIM-602.

v) F_5 Generation

One hundred & ninty plants were selected from F_4 during 2015-16 crop season. These plants were sown as F_5 in crop season 2016-17. Lay out was plant to progeny row trial. Performance of F_5 lines is given below.

Table 3.10 Performance of F_5 single lines during 2016-2017

Sr. No.	Family	Yield (g)	GOT%	*Staple Length* (mm)	Micronaire (µg/inch)	Strength (g tex^{-1})
1	6-5/16	67.3-104.3	39.0-40.7	28.8-30.4	3.9-4.1	27.6-31.4
2	7-5/16	61.6-164.6	40.3-42.0	28.4-29.0	4.3-4.6	27.4-30.3
3	14-5/16	54.0-101.6	37.7-40.0	27.4-29.8	3.6-4.1	27.0-30.7
4	28-5/16	69.4-111.9	35.9-38.2	28.4-28.8	3.9-4.5	26.2-29.4
5	36-5-/16	74.7-158.2	38.8-42.4	27.2-28.2	4.6-5.0	27.0-28.8
6	50-5/16	113.5-381.8	38.3-41.8	28.4-29.0	4.0-4.6	28.1-30.0
7	63-5/16	91.7-191.8	38.7-40.8	28.3-29.2	4.0-4.3	28.1-29.6
8	64-5/16	63.2-144.7	40.1-44.7	29.0-31.0	3.5-4.5	27.0-32.6
9	80-5/16	113.6-236.7	33.1-36.9	26.8-29.8	3.8-4.5	27.3-29.6
10	81-5/16	92.4-25.4	36.2-39.0	28.3-29.4	3.6-4.1	28.4-30.0
11	82-5/16	74.6-180.8	33.2-37.2	27.8-29.5	3.3-4.1	27.3-29.8
12	83-5/16	48.3-136.0	37.1-39.2	27.8-29.5	3.6-4.7	27.3-30.6
13	87-5/16	70.3-151.5	37.9-43.1	27.0-28.9	3.6-4.4	27.1-29.5
14	93-5/16	73.8-173.0	40.2-43.2	28.7-30.9	4.1-4.8	30.4-32.1
15	95-5/16	66.2-205.9	40.7-43.6	27.2-29.8	3.8-4.8	28.3-30.9
16	97-5/16	53.5-207.6	34.3-38.6	27.6-30.3	3.9-5.0	28.3-31.7
17	113-5/16	58.5-125.7	38.0-40.3	25.9-28.6	4.5-5.1	26.4-28.9
18	114-5/16	70.7-130.9	38.5-40.9	26.8-28.3	4.8-5.3	26.0-28.8
19	116-5/16	94.3-200.0	34.7-40.3	29.0-31.0	3.4-3.8	28.5-32.0
20	128-5/16	54.5-227.9	34.8-39.6	28.1-30.1	3.9-4.5	28.4-31.9
21	145-5/16	42.5-207.7	38.0-43.0	27.5-28.9	3.9-4.9	27.2-29.8
22	149-5/16	117.0-220.3	35.4-39.0	27.5-29.6	2.8-4.6	27.1-31.5
23	158-5/16	78.2-164.3	38.0-40.3	27.4-30.4	3.6-4.2	27.8-31.2
24	162-5/16	78.5-149.6	35.5-41.2	28.7-30.0	3.7-4.5	28.5-31.1
25	172-5/16	38.5-144.5	37.2-41.3	27.5-29.9	4.1-4.8	28.1-31.2
26	174-5/16	78.7-169.9	40.0-43.8	27.8-29.9	4.0-4.9	27.3-30.4
27	178-5/16	69.0-133.3	39.0-41.5	28.5-29.8	4.5-5.2	28.2-28.8
28	187-5/16	43.2-193.3	37.2-40.9	26.5-29.7	3.2-4.0	27.1-30.2
29	189-5/16	74.7-179.3	40.9-44.1	27.8-29.4	3.7-4.5	25.9-29.4
	FH-142	**-**	**39.1**	**28.1**	**5.2**	**25.7**
	CIM-602	**-**	**38.0**	**27.8**	**3.8**	**28.3**

The data revealed that the material in F_5 generation had excellent lint %, longer staple, desirable micronaire and fibre strength as compared to both standards FH-142 and CIM-602.

v) F_6 Generation

Sixty plants were selected from F_5 generation and planted as F_6 in 2016-17crop season. Promising lines will be bulked and included in MVT in crop season 2017-18. Lay out was plant to progeny row trial. Performance of F_6 lines is given below.

Table 3.11 Performance of F_6 single lines during 2016-2017

Sr.	Family	Yield pl.	GOT%	*Staple length*	Micronaire	Strength

No.		(g)		(mm)	(µg/inch)	(g tex $^{-1}$)
1	15-6/16	67.2-172.2	40.3-44.6	25.9-28.9	4.0-4.9	25.1-28.9
2	16-6/16	41.8-110.0	35.9-39.8	27.9-29.8	3.5-4.9	28.7-30.3
3	27-6/16	46.7-121.4	40.2-43.4	26.7-27.9	3.9-5.1	25.3-29.0
4	28-6/16	48.1-112.3	41.4-42.0	26.4-28.7	4.5-4.9	25.6-27.6
5	29-6/16	79.5-173.7	41.2-42.1	27.9-28.7	4.2-5.0	26.6-28.1
6	53-6/16	59.7-168.5	36.5-40.2	26.2-28.5	4.1-5.1	26.0-29.2
7	**FH-142(Std)**	**-**	**38.7**	**28.1**	**5.2**	**25.7**
8	**CIM-602(Std)**	**-**	**38.1**	**27.9**	**3.8**	**28.3**

3.6 Search for aneuploids/ haploids

Search for aneuploids especially monosomes to identify individual chromosomes and haploid to make homozygous lines in cotton was done. Four rogue plants suspected to be aneuploids were studied cytologically. There were 26 bivalents at metaphase-1 in 3 plants, hence these were disomes. A branch of one plant showed haploidy having 26 chromosomes at metaphase-1.

3.7 Performance of Cyto-strains

3.7.1 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-179, Cyto-300, Cyto-305, Cyto-307 and Cyto-313 were evaluated for their specific traits as well as yield, GOT (%) and fibre characteristics against FH-142 & CIM-602 as standards.

Table-3.12. Performance of Cyto-strains in VT-1during 2016-17

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-179	3078	41633	3.1	40.7	28.2	4.3	26.6
Cyto-300	2242	40005	2.6	38.7	27.4	4.2	27.4
Cyto-305	3410	41785	3.8	38.3	28.0	4.4	27.9
Cyto-307	2399	40440	2.6	40.2	28.1	4.0	29.4
Cyto-313	2811	40529	2.9	38.9	28.3	4.0	31.3
FH-142 (Std.)	2742	41157	2.8	38.6	28.0	4.4	26.0
CIM-602(Std.)	2577	40171	2.7	38.1	27.9	4.1	26.8

C.D. (5%) for seed cotton Yield = 111.48 CV% = 2.27

Data presented in Table-3.13 exhibited that maximum seed cotton yield was produced by Cyto-305 (3410 kg ha^{-1}) followed by Cyto-179 (3078 kg ha^{-1}) and Cyto-313 (2811kg ha^{-1}) compared with standards FH-142 (2742 kg ha^{-1}) and CIM-602 (2577 kg ha^{-1}). Maximum lint % produced by Cyto-179 (40.7%) at par to Cyto-307 (40.2%) compared with standards FH-142 (38.6%) and CIM-602 (38.1%).

The strain Cyto-313 produced the medium long staple of 28.3mm, followed by 28.2 mm of Cyto-179 compared with 28.0 mm of FH-142 and 27.9 mm of CIM-602. All the strains have desirable micronaire values ranging from 4.0 to 4.4 µg inch^{-1}. The fibre strength of all the new strains is observed within the desirable range.

3.7.2 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* Cyto-strains viz.,Cyto-120, Cyto-122, Cyto-161and Cyto-164 were evaluated in varietal trial-2 for their specific traits as well as yield, GOT (%) and fibre characteristics against Cyto-124 & CIM-608 as standards.

Data presented in Table-3.14 exhibited that maximum seed cotton yield was produced by Cyto-161 (3340 kg ha^{-1}) followed by Cyto-120 (3111kg ha^{-1}) and Cyto-122 (2860 kg ha^{-1}) compared with standards Cyto-124 (2843 kg ha^{-1}) and Cyto-608 (2516 kg ha^{-1}). Maximum lint % produced by Cyto-164 (40.8%) followed by Cyto-161 (39.8%) compared with standards Cyto-124 (39.6%) and Cyto-608 (39.1%).

The strain Cyto-120 produced longest staple of 29.5 mm followed by Cyto-164 (28.9 mm) compared with 28.6 mm Cyto-124 and Cyto-608 (28.2mm). All the strains have desirable micronaire values ranging from 4.2 to 4.3 μg inch^{-1}. The fibre strength of all the new strains is observed within the desirable range.

Table-3.13. Performance of Cyto-strains in VT-2 during 2016-17

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	3111	40075	3.0	39.2	29.5	4.3	30.4
Cyto-122	2860	40563	2.9	39.7	28.8	4.3	28.2
Cyto-161	3340	41328	3.2	39.8	28.8	4.3	28.0
Cyto-164	3044	40189	2.9	40.8	28.9	4.2	26.7
Cyto-124 (Std.)	2843	40084	2.8	39.6	28.6	4.5	29.6
Cyto-608(Std.)	2516	40989	2.7	39.1	28.2	4.6	27.4

C.D. (5%) for seed cotton = 112.65 CV% = 2.10

3.8 Testing of Cyto strains in NCVT 2016

Bt. Cyto-179 and *Bt.* Cyto-313 were tested in NCBT Trials 2016-17. *Bt*. Cyto-179 and *Bt*. Cyto-313 secured 5th and 6th positions in overall Pakistan, respectively. *Bt*. Cyto-179 has been completed its two years of testing in NCVT and has been approved from Punjab seed Council. Cyto-313 will be tested for 2nd year during 2017-18.

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4. ENTOMOLOGY

Pink bollworm remained the hot topic of research during the study period. Sowing period impact on the development of pink bollworm, evaluation of new chemistry, survey conducted at major cotton growing districts, section also attempted to develop rearing technique on artificial diet. Studies were also conducted to see the impact of first spray on the 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, development of natural enemies of sucking pests on treated and untreated seed of GM cotton at different planting dates of cotton. Rearing and maintaining natural enemies for the use in the lab and for release in the field.

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.

4.1 Studies on Pink Bollworm

4.1.1 Impact of sowing period on the PBW infestation

The trial was conducted with the objective to evaluate the level of pink bollworm damage at different planting time.

First sowing was plan to be planted in Mid-March, but unfortunately unusual rain during that period delayed our planting. So the set 1 was planted in 30th March, and Set II on 4th May. Three Bt varieties (CIM-616, MNH-886 & CIM-178) And two non Bt varieties (CIM-620 & CIM-620) and also one strains from CEMB was also planted in Set II in RCBD with three replicates.

In Set I, maximum pink bollworm damage percentage in bolls were recorded in CIM-616 during September and October. In November in CIM-178 and MNH-886. Surprisingly in both non Bt varieties the PBW infestation was recorded lowest

(Table 4.1). Similarly percentage number of live larvae are more in CIM-616 compared with other varieties in September and October **(Table 4.2).**

In Set II, comparatively the pink bollworm damage percentage were recorded lower to Set I during September and October. Maximum bollworm damage was in MNH-886 in September and October period and higher in CIM-616 followed by CIM-178. Percentage live larvae were recorded higher in MNH-886 compared to other varieties **(Table 4.2)**

Overall, pink bollworm infestation and percentage of live larvae were higher in early planting in Set I compared with May planting, Set II. So the farmers are advised to avoid planting cotton before May.

Table. 4.1 Percentage PBW bollworm damage recorded in 3 Bt and 2 non Bt during 30th March (Set I) and 4th May (Set II) planting period.

Varieties	% bolls damage						Seasonal Average	
	September		October		November			
	Set I	Set II	Set I	Set II	Set I	Set II	Set I	Set II
CIM-616	48.0	2.0	51.4	22.8	66.7	80.0	55.0	35.0
MNH-886	14.7	16.0	20.0	28.6	70.0	66.7	35.0	37.0
CIM-178	13.3	4.0	25.7	14.3	72.7	71.4	37.0	30.0
Cyto-124 (Non Bt)	8.0	2.0	45.7	8.6	45.4	20.0	33.0	10.0
CIM-620 (Non Bt)	6.7	8.0	31.4	17.1	60.0	66.7	33.0	31.0
CEMB33	-	2.0	-	20.0	-	60.0	-	27.0

Table. 4.2 Percentage PBW live larvae recorded in 3 Bt and 2 non Bt during 30th March (Set I) and 4th May (Set II) planting period.

Varieties	% Live Larvae						Seasonal average	
	September		October		November			
	Set I	Set II	Set I	Set II	Set I	Set II	Set I	Set II
CIM-616	8.0	2.0	25.7	11.4	58.3	50.0	31.0	21.0
MNH-886	6.7	4.0	8.6	17.1	70.0	50.0	28.0	24.0
CIM-178	6.7	2.0	17.1	5.7	45.4	43.0	23.0	17.0
Cyto-124 (Non Bt)	5.3	0.0	25.7	8.6	58.3	0.0	30.0	3.0
CIM-620 (Non Bt)	5.3	4.0	20.0	5.7	60.0	50.0	28.0	20.0
CEMB33	-	0.0	-	10.0	-	50.0		20.0

4.1.2 Evaluation of insecticide against Pink bollworm

Efficacy of thirteen insecticides of different group belonging to new and old chemistry were evaluated against Pink bollworm at CCRI, Multan. Spray was initiated when pink bollworm reached above threshold level (> 5.0 % bollworm damage). Pretreatment data was recorded on 16th September, fifty susceptible bolls were collected from each plot and were kept in the lab for 2 days before dissecting. PBW damage percentage ranged between 16-18%. First spray was applied on 21th September and bolls were collected I-week after spray. The second spray of the same treatment on the same plot were applied on the 29th September and again the bolls were collected 1-week after 2nd spray.

Maximum efficacy percentage was observed in Coragen (37.5 %), & Radiant 120 SC (31.3 %) followed by Tracer (25.0 %) & Belt + Decis super treated plots 1-week after first spray. In the second spray, the maximum efficacy percentage was observed in Radiant 120 SC (68.8 %), Tracer (50.0 %), Coragen (50.0 %) followed by Gamma cyhalothrin (44.4 %) and Belt + decis super (43.8 %) **(Table 4.3)**.

Table 4.3 Efficacy of different group of insecticides against pink bollworm

Sr. No	Treatment	Dose/acre (ml/gm)	% bollworm damage Pretreatment	Efficacy % age, 1-week after sprays	
				Ist spray	2nd spray
1	Tracer 240 SC	50 ml	16.0	25.0	50.0
2	Radiant 120 SC	100 ml	16.0	31.3	68.8
3	Belt	50 ml	17.0	11.8	41.2
4	Coragen	80 ml	16.0	37.5	50.0
5	Triazophos	1000 ml	18.0	16.7	33.3
6	Triazophos + Decis super	1000 ml + 100 ml	16.0	12.5	31.3
7	Decis super 10EC	100 ml	17.0	5.9	11.8
8	Bifenthrin 10EC	300 ml	16.0	6.3	18.8
9	Gamma cyhalothirn	300 ml	18.0	16.7	44.4
10	Belt + Decis super	50 + 80	16.0	25.0	43.8
11	Novaluron	300 ml	17.0	11.8	29.4
12	X-tall	1000 ml	16.0	6.3	25.0
13	DPX-HGW86 + Codacide	300 ml+1000 ml	16.0	18.8	37.5
	Control		16.0	-	-

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

Fortnightly survey was conducted at major cotton growing districts for crop development and for population dynamic of insect pest of cotton. Here we are presenting the pink bollworm infestation recorded in the bolls collected from the surveyed area during July, August and October.

Pink bollworm infestation and live larvae percentage was recorded lower in all the districts during July and it gradually increase and recorded maximum during August and October. Overall maximum boll infestation was observed in district Khanewal followed by Bahawalpur and Multan **(Table 4.4)**.

Maximum percentage pink bollworm damage was recorded in CIM-616 & IUB-2013 varieties/strains in July, and in August the bollworm infestation was higher in IUB-2013, followed by MNH-886 and others. During October, maximum infestation was observed in CIM-616 and MNH-992 and minimum in FH-142. **(Table 4.5).**

Overall maximum boll infestation was observed in districts Khanewal followed by Bahawalpur and Multan. Comparatively varieties CIM-616 and IUB-2013 seems more vulnerable to pink bollworm infestation.

Table 4.4 Pink bollworm damage percentage in bolls and live larvae recorded during different months from major cotton growing districts

District	July		August		October		Average	
	% Boll damage	% Larvae	% Boll damage	% Larvae	% Boll damage	% Larvae	% Boll damage	% Larvae
Multan	4.0	4.0	18.0	32.0	22.0	36.0	13.3	22.7
Vehari	4.0	6.0	19.0	33.0	10.0	34.0	11.0	24.3
Bahawalpur	6.0	4.0	18.0	34.0	10.0	38.0	14.0	36.0
Lodhran	5.0	4.0	7.0	30.0	15.0	30.0	7.0	30.0
Khanewal	8.0	5.0	25.0	38.0	30.0	36.0	16.5	21.5

Table 4.5 Pink bollworm damage percentage in bolls recorded in different varieties recorded during survey from major cotton growing districts

Varieties	% Bolls damage			Average % Boll damage
	July	August	October	

CIM-616	40.0	7.0	31.0	26.0
IUB-2013	35.0	32.0	9.0	25.3
MNH-992	0.0	7.0	20.0	9.0
MNH-886	0.0	13.0	4.0	5.7
FH-142	0.0	7.0	3.0	3.3
IUB-2015	0.0	0.0	6.0	2.0
Others	0.0	13.0	8.0	7.0

4.1.4 Rearing of pink bollworm

Attempts are continue to rear the pink bollworm with artificial diets under lab conditions. Left over bolls were collected from the field and kept under lab conditions at temperature 28 $\pm$ 2 C with relative humidity 65-67%. Larvae in the bolls were forced for early emergence. Adult emerged from the bolls were collected and allow to lay eggs on the cotton twigs. Twigs alongwith the eggs were shifted to glass jars for hatching. First instar larvae were provided natural food (Okra) to develop to 2nd instar. 2nd instar larvae were reared on the artificial diets having different ingredients. So far we have successfully reared the pink bollworm larvae till adult, however, the success rate is not at par for rearing the pink bollworm at large scale. Efforts are continued to improve the rearing techniques.

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 EC @ 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 10th June when population of jassid reached at ETL and same insecticide was repeated on the same plots on 24th June.

Population of jassid was lower in dimethoate and acephate plots compared to other treatments however it was non-significant with other treatments except IGR's 72-hrs after 1st spray. After 72-hrs after 2nd spray, the jassid was recorded lower in Oshin followed by others.

Population of whitefly remained below ETL 72-hrs after 1st spray in all treatment including untreated check plots, however, after 2nd spray it showed increasing trend and recorded above ETL at Dimethoate and Acephate plots. Population of thrips remained below ETL in all the treatment during the study period **(Table 4.6)**.

Apparently, the early spray with organophosphate enhances the population of whitefly and it is recommended that the use of OP's should be avoided at the early season of the crop.

Table 4.6 Efficacy of different groups of insecticides against sucking insect pest of cotton

Treatments	Group	Dose /acre (ml/acre)	Population per leaf 72-hrs after spray					
			Jassid		Whitefly		Thrips	
			1st	2nd	1st	2nd	1st	2nd
Imidacloprid 50 WP	Neonicotinoid	100	0.9	2.0	2.1	3.4	1.0	0.8
Acetamiprid 40 WDG		60	0.8	1.2	0.7	2.6	0.0	0.6
Oshin 20SG		100	0.7	0.6	2.5	4.1	0.3	0.6
Nitenpyrem 60WDG		100	1.0	2.8	1.6	2.5	0.0	4.0
Polo 500EC	Thiourea	200	0.5	0.8	0.6	3.3	0.0	0.4
Acephate 75SP	Organophosphate	250	0.5	1.8	2.3	6.5	0.0	5.7
Dimethoate 40EC		400	0.2	0.8	3.9	6.1	0.0	3.4
Pyriproxyfen 10.8 EC	IGR	500	1.2	2.5	2.7	2.5	0.0	3.2
Buprofezin 25 SP		600	1.7	2.7	0.3	2.6	0.0	2.5
Control	-		2.5	3.0	0.7	0.8	0.0	1.1
CD 5 %			**0.82**	**1.25**	**1.64**	**1.60**	**NS**	**2.56**

4.3 Monitoring of lepidopterous pests with sex pheromone traps

Male moth activity of *Pectinophora gossypiella*, *Earias insulana, Earias vittella, Helicoverpa armigera, Spodoptera litura* and *Spodoptera exigua* was monitored with sex pheromone baited traps throughout the year at CCRI, Multan and farmer's field at Chak 116/10R (Khanewal). Comparatively the declining population trend was recorded in both *P. gossypiella,* both *Earias* spp., *S. exigua* and *H. armigera* while increasing trend in *S. litura* was seen compared to last year at both the locations. Overall male moth catches of all the species were higher at farmer's field as compared with CCRI, Multan **(Table-4.7).** Weekly male moth catch activities are given in **Fig. 4.3 (a-f).**

4.3.1 *Pectinophora gossypiella* (Pink bollworm)

Male moth catches remained zero upto 1st week of February and during last fortnight of December, while occurrence of moths was earlier during 2016 as compared to the last year 2015. Moths' population was not consistent and showed fluctuating trend throughout the season, with its maximum catches in 3rd week of September at CCRI, Multan and 2nd week of October at farmer's field. Comparatively, the moth catches were 40% higher at farmer's field than at Multan **(Fig. 4.3a)**. Overall male moth catches were

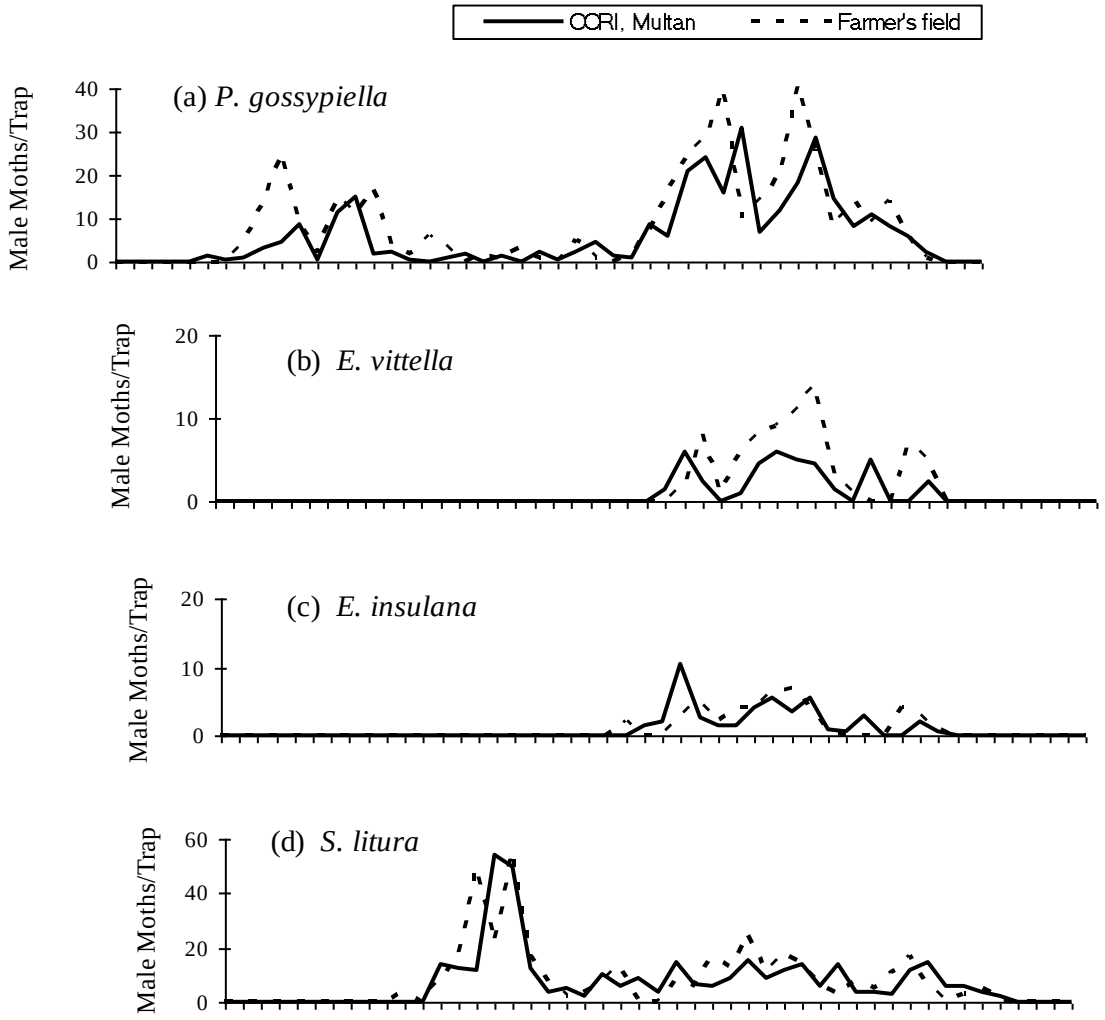
32.9% and 103.4% lower to that of last year at Multan and farmer's field, respectively **(Table-4.7).**

4.3.2 *Earias vittella* (Spotted bollworm)

Male moths' activity remained zero upto July and during November and December at both the locations. Afterwards moth activity increased with maximum catches in 3rd week of August at CCRI, Multan and 1st week of September at farmer's field. Moth catches at farmer's field were 88% higher than at Multan **(Fig. 4.3b).** Overall, male moth catches were 193.8% and 290.7% lower at Multan and farmer's field respectively as compared to last year **(Table-4.7).**

4.3.3 *Earias insulana* (Spiny bollworm)

Male moth catches remained zero upto end-June and during November and December at both the locations. Afterwards population increased with its peak in 2nd week of July at CCRI, Multan and 4th week of August at farmer's field. Moth activity remained negligible during September and October. Moth catches were 2% higher at farmer's field than at Multan. Comparatively moth catches of this species were lower as compared to *E. vittella* **(Fig. 4.3c).** Overall male moth catches were 98.9% and 282.6% lower at Multan and farmer's field respectively as compared with last year **(Table-4.7).**



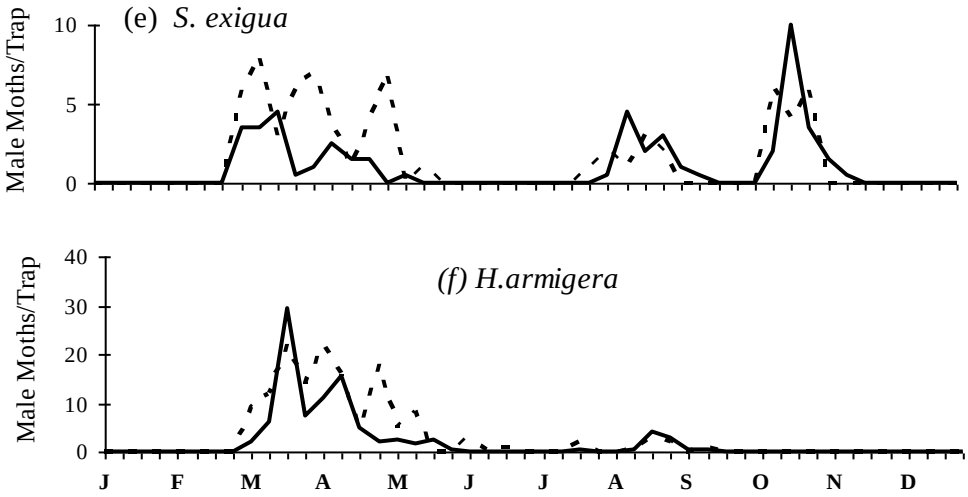


Fig.4.3 Weekly male moth catches of Lepidopterous pests in sex pheromone traps at CCRI, Multan and farmer's field (Khanewal).

4.3.4 *Spodoptera litura* (Armyworm)

Male moth catches were zero from January to end March and December at both the locations. Moth activity started from 1st week of April and reached at peak in 4th week of April at CCRI, Multan and 1st week of May at farmer's field with fluctuated trend afterwards. Moth catches at farmer's field were comparatively 9% higher than at Multan **(Fig. 4.3d)**. Overall male moth catches were 67.2% and 50.3% higher than that of last year at Multan and farmer's field respectively **(Table-4.7).**

4.3.5 *Spodoptera exigua* (Beet armyworm)

The population of male moths was almost zero in January, February, June and December at both the locations. Moth activity started from 1st week of March with fluctuating trend afterward uptil end May. Again from last week of July moth catches started and fluctuated upto mid-November. Catches were 50% higher at farmer's field than at Multan **(Fig. 4.3e)**. Overall male moth catches were 125.0% and 243.1% lower at Multan and farmer's field respectively as compared to last year **(Table-4.7).**

4.3.6 *Helicoverpa armigera*. (American bollworm)

Male moth activity was zero upto February which increased afterwards with maximum catches during March-April at both the locations. Afterwards population declined and only few moths were caught upto mid-September then moth activity finished at both the locations. Moth catches were comparatively 52% higher at farmer's field than Multan **(Fig. 4.3f)**. Overall, male moth catches were about 30.2% and 138.2% lower at Multan farmer's field respectively as compared to last year **(Table-4.7).**

Table-4.7 Comparison of male moth catches of lepidopterous pests in sex pheromone traps

Insect pest	CCRI, Multan			Farmer' field		
	2015	2016	±	2015	2016	±
P.	385.5	290.1	**- 32.9**	827.0	406.5	**- 103.4**

gossypiella						
E. vittella	117.5	40.0	**- 193.8**	293	75.0	**- 290.7**
E. insulana	89.5	45.0	**- 98.9**	176.0	46.0	**- 282.6**
S. litura	115.5	352.0	**+ 67.2**	191.0	384.5	**+ 50.3**
S. exigua	108.0	48.0	**- 125.0**	247.0	72.0	**- 243.1**
H. armigera	123.0	94.5	**- 30.2**	343.0	144.0	**- 138.2**

4.4 Monitoring of lepidopterous pests with light traps

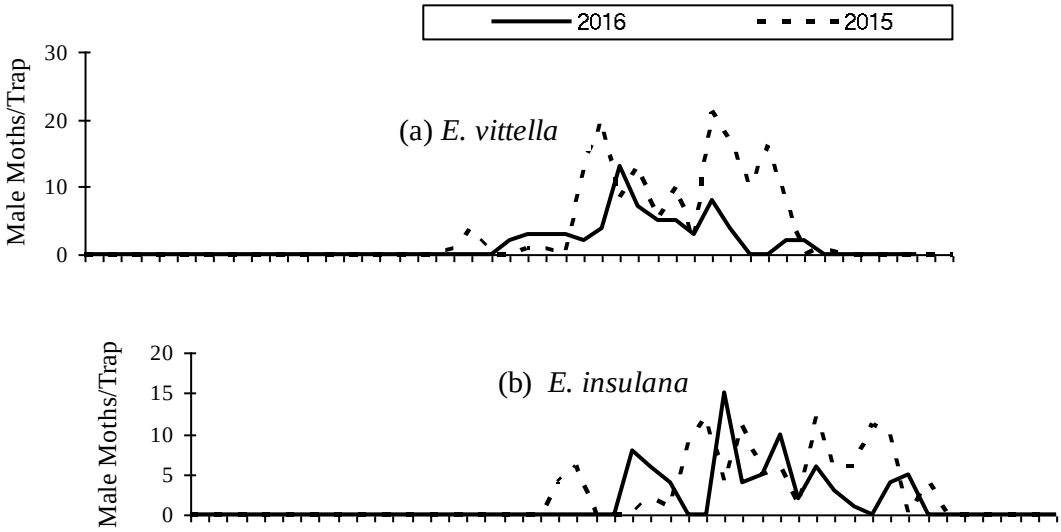
Moth activity of *E. insulana*, *E. vittella*, *S. litura*, *S. exigua* and *H. armigera* was monitored throughout the year with inflorescent light traps at CCRI, Multan. Population trend of all the pests was almost same as monitored in sex pheromone baited traps at CCRI, Multan. Increasing population trend was observed in case of *E. vittella* while decreasing trend in case of *E. insulana, H. armigera, S. litura* & *S. Exigua* **(Table-4.8).** 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 last week of June and during November and December. Afterwards pest activity started at low level with its peak in 2nd week of August and fluctuated upto end-October **(Fig. 4.4a).** Overall number of moth catches was 128.8 % lower than that of last year **(Table-4.8).**

4.4.2 *Earias insulana* (Spiny bollworm)

Male moth catches remained zero during January-June and November-December. Afterwards population increased with fluctuating trend upto end- October and its peak was observed in 2nd week of August **(Fig. 4.4b).** Total number of moths was 50.7% lower than last year **(Table-4.8).**



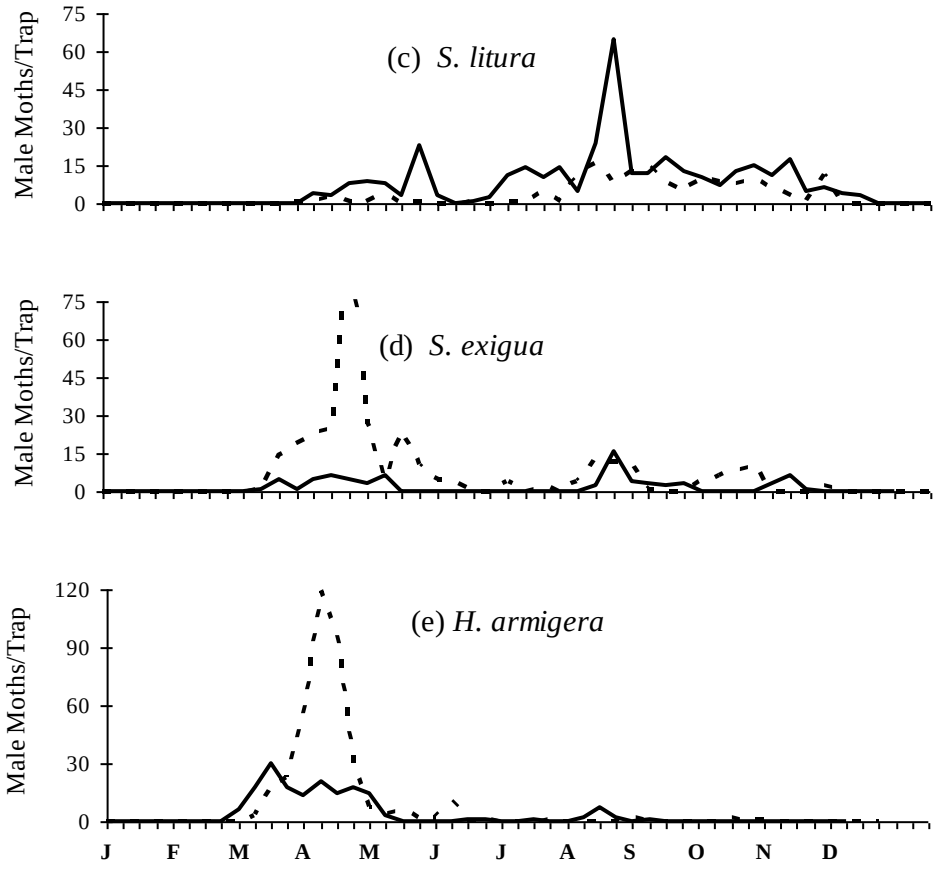


Fig. 4.2 Weekly moth catches of lepidopterous pests in light traps at CCRI, Multan

4.4.3 *Spodoptera litura* (Armyworm)

Moths' activity of *S. exigua* was zero upto end-March. Afterwards population starts to increase and reached to its maximum during 2nd week of August. Population declined afterwards with fluctuating trend upto last week of November. No moth activity was recorded in December **(Fig. 4.4c)**. Overall moth catches were 56.4% higher than last year **(Table-4.8).**

4.4.4 *Spodoptera exigua* (Beet armyworm)

Moth catches were zero from January to 1st week of Mach then the activity started and continued till 1st week of May at low level. Afterwards, the moth catches were zero until last week of July then moth activity again started in 1st week of August and fluctuated upto 1st week of November and no moth activity was found after that. Maximum moth activity was observed in 2nd week of August **(Fig. 4.4d)**. Overall moth catches were 370.0% lower than the last year **(Table-4.8).**

4.4.5 *Helicoverpa armigera* (American bollworm)

Moth activity of *H. armigera* was recorded from 1st week of March to 1st week of September with peak catches during 3rd week of March. Moth catches were zero from 2nd week of September to December **(Fig. 4.4e)**. Overall moth catches were 124.7% lower as compared to last year **(Table-4.8).**

Table-4.8 Comparison of moth catches of lepidopterous pests in light traps based on total catches during the year/trap

Insect pest	2015	2016	% change (±)
Earias vittella	151.0	66.0	**- 128.8**
Earias insulana	110.0	73.0	**- 50.7**
Spodoptera litura	154.0	353.0	**+ 56.4**
Spodoptera exigua	337.0	71.7	**- 370.0**
Helicoverpa armigera	382.0	170	**- 124.7**

4.5 National Coordinated Varietal Trials (NCVT)

4.5.1 Pest situation in set-A

In this set fifteen non-*Bt* strains and one standard (CIM-573) were tested for their tolerance/susceptibility to insect pest complex. Jassid and whitefly remained dominant among sucking pests. Jassid population was above ETL on all the strains during June and its intensity was highest on CRIS-543 followed by CIM-573 & Tahafuz-7 and lowest on PB-896 and GS-Ali-5 which remained below ETL in July and was above ETL on TH-20, TH-17, Tipu-2, NIAB-444, MPS-61 & GS-Hammad during August. Whitefly population remained below ETL during growing season on all the testing strains. Its intensity was highest on CIM-573 followed by GS-Ali-5 & NIAB-444 in August while lowest on NIAB-444, GS-Ali-5 and CRIS-543 in June. Thrips remained below ETL throughout the season on all the strains while its population was comparatively higher on PB-896, GS-Ali-1, MPS-61, GS-Ali-5 and Tahafuz-7 while lower on GS-Hammad, CIM-610 & NIAB-444 in August **(Table-4.9)**.

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

Strains	Number of sucking insect pests per leaf								
	Jassid			Whitefly			Thrips		
	June	July	Aug	June	July	Aug	June	July	Aug
CIM-573 (S)	6.43	0.30	0.60	0.91	1.50	3.10	0.00	0.40	1.30
Tipu-2	4.10	0.50	1.20	0.25	0.70	1.70	0.00	0.20	1.80
Thakkar-214	5.35	0.10	1.00	0.80	1.20	2.30	0.10	0.10	1.30
TH-20	3.29	0.50	1.30	0.10	0.60	1.70	0.00	0.20	1.50
TH-17	5.19	0.00	0.20	0.23	0.50	2.00	0.25	0.40	1.90
Tahafuz-7	6.03	0.30	0.40	0.95	1.20	2.70	0.00	0.00	1.80
RH-667	4.04	0.20	0.90	0.50	0.90	2.30	0.00	0.10	2.10
PB-896	2.15	0.40	0.70	0.89	1.30	2.40	0.00	0.20	2.40
NIAB-444	5.60	0.40	1.00	0.00	0.30	2.70	0.00	0.30	1.90
MPS-61	3.34	0.30	1.00	1.05	2.00	1.60	0.00	0.00	2.20
MPS-29	4.10	0.60	0.70	0.75	1.10	1.80	0.00	0.00	0.90
GS-Ali-5	2.98	0.60	0.40	0.10	0.50	3.00	0.10	0.20	2.20
GS-Ali-1	5.60	0.40	0.90	1.15	1.40	3.10	0.00	0.00	2.40
GS-Hammad	3.86	0.40	1.00	0.80	1.90	2.30	0.20	0.10	1.00
CIM-610	3.07	0.40	0.80	0.32	1.00	2.00	0.00	0.40	1.20
CRIS-543	6.83	0.60	0.80	0.18	0.90	2.10	0.00	0.10	2.00

Bollworm infestation in immature fruiting parts was higher in GS-Ali-5 during August and during September high infestation was observed on TH-20. Larval population was higher on RH-667during August & during September maximum larval infestation was observed on TH-20 **(Table-4.10)**.

Pink bollworm infestation was observed in susceptible bolls and its larval population was higher during September which declined after applying two consecutive insecticidal sprays. Its infestation was highest in TH-20followed by Tipu-2, TH-17, Tahafuz-7, RH-667, PB-896, NIAB-444 & MPS-61 and lower in CIM-573, Thakkar-214 MPS-29, GS-Ali-5, GS-Ali-1, GS-Hammad, CIM-610 and CRIS-543 during September **(Table-4.11)**.

Table-4.10 Spotted/American bollworms damage and larval population at different stages of crop development on different non-*Bt* strains

Strains	Bollworm damage % age				SBW larvae/ 25 plants	
	August		September		August	September
	Imm	Mat	Imm	Mat		
CIM-573 (S)	0.00	0.00	0.00	0.00	0.00	0.00
Tipu-2	0.00	0.00	0.00	0.00	0.00	0.00
Thakkar-214	0.00	0.00	0.00	0.00	0.00	0.00
TH-20	0.00	0.00	20.00	0.00	0.00	20.00
TH-17	0.00	0.00	0.00	0.00	0.00	0.00
Tahafuz-7	0.00	0.00	0.00	0.00	0.00	0.00
RH-667	2.74	0.00	0.00	0.00	2.74	0.00
PB-896	0.00	0.00	0.00	0.00	0.00	0.00
NIAB-444	3.13	0.00	0.00	0.00	3.13	0.00
MPS-61	0.00	0.00	0.00	0.00	0.00	0.00
MPS-29	0.00	0.00	0.00	0.00	0.00	0.00
GS-Ali-5	4.84	0.00	11.11	0.00	1.61	0.00
GS-Ali-1	1.28	0.00	0.00	0.00	2.56	0.00
GS-Hammad	1.61	0.00	5.26	0.00	0.00	0.00
CIM-610	0.00	0.00	10.00	0.00	0.00	0.00
CRIS-543	0.00	0.00	0.00	0.00	0.00	0.00

Table-4.11 Pink bollworms damage and larval population at different stages of crop development on different non-*Bt* strains

Strains	PBW damage %age	PBW larval %age
	September	September
CIM-573 (S)	0.00	0
Tipu-2	4.00	0
Thakkar-214	0.00	0
TH-20	8.00	0
TH-17	4.00	0
Tahafuz-7	4.00	4
RH-667	4.00	0
PB-896	4.00	0
NIAB-444	4.00	0
MPS-61	4.00	0
MPS-29	0.00	0
GS-Ali-5	0.00	0
GS-Ali-1	0.00	0
GS-Hammad	0.00	0
CIM-610	0.00	0
CRIS-543	0.00	0

4.5.2 Pest situation in Set-B

In this set 20 Bt cotton strains and two standards (CIM-602 & FH-142) were tested for their tolerance/susceptibility to insect pest complex. Jassid, whitefly and thrips remained dominant among sucking insect pests. Jassid population was above ETL in June and below in July on all the strains except BS-15**.** Jassid population again reached ETL on FH-152, Cyto-313, Cyto-179, Crystal-12, CEMB-88*, CEMB-55-S and CIM-632 in August Its maximum number was recorded on Deebal followed by FH-326, FH-152, Crystal-12 and

BPC-11 and minimum on CIM-602, Bakhtawar-1, BH-201 and CEMB-55-S respectively during June.

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

Strains	Number of sucking insect pests per leaf								
	Jassid			Whitefly			Thrips		
	June	July	Aug	June	July	Aug	June	July	Aug
FH-142 (S-2)	1.93	0.80	0.50	3.09	0.50	1.20	0.86	0.00	3.70
CIM-602 (S-1)	0.83	0.70	0.90	6.90	1.00	2.40	1.56	0.10	0.50
FH-326	3.32	0.30	0.70	3.39	0.90	2.10	0.02	1.50	2.10
FH-152	2.98	0.40	1.60	4.33	1.20	1.40	1.10	0.00	2.50
Eagle-2	2.10	0.40	0.50	5.39	1.60	1.90	1.59	1.70	0.50
Deebal	5.50	0.30	0.90	7.50	2.00	2.20	1.01	0.00	2.30
Cyto-313	2.35	0.20	1.00	5.01	1.20	2.30	0.40	0.10	4.50
Cyto-179	2.08	0.40	1.00	3.03	1.40	2.10	0.36	0.20	2.50
Crystal-12	2.59	0.30	1.00	4.09	2.00	1.20	1.04	0.40	2.10
CIM-625	1.36	0.90	0.80	10.03	1.00	1.60	0.93	0.30	1.40
CEMB-88*	2.06	0.30	1.40	5.86	1.40	1.60	1.35	1.70	1.50
CEMB-55-S	1.35	0.30	1.30	5.02	1.30	1.40	0.35	0.00	3.10
CRIS-600	1.89	0.70	0.80	4.03	0.50	2.80	1.34	0.20	2.30
CIM-632	1.86	0.60	1.10	6.89	1.60	1.50	2.84	0.00	3.70
BS-15	1.34	1.10	0.70	10.58	2.00	2.50	0.34	0.00	1.50
BPC-11	2.86	0.70	0.80	6.07	2.00	2.90	1.35	0.00	1.70
BPC-10	2.02	0.20	0.50	6.04	1.60	4.00	0.30	0.00	1.00
BH-201	1.30	0.60	0.80	4.54	1.30	1.90	0.40	0.20	0.90
Bakhtawar-1	1.07	0.60	1.30	6.35	1.10	1.60	0.80	0.20	1.60
Bahar-07	1.60	0.10	0.70	7.09	1.10	1.50	1.85	0.00	1.10

Table-4.13 Pink bollworms damage and larval population at different stages of crop development on different *Bt* strains

Strains	PBW damage %age	PBW larval %age
FH-142 (S-2)	0.00	0.00
CIM-602 (S-1)	0.00	0.00
FH-326	0.00	0.00
FH-152	0.00	0.00
Eagle-2	0.00	0.00
Deebal	8.00	4.00
Cyto-313	0.00	0.00
Cyto-179	4.00	0.00
Crystal-12	0.00	0.00
CIM-625	0.00	0.00
CEMB-88*	0.00	0.00
CEMB-55-S	0.00	0.00
CRIS-600	0.00	0.00
CIM-632	0.00	0.00
BS-15	0.00	0.00
BPC-11	0.00	0.00
BPC-10	0.00	0.00
BH-201	0.00	0.00
Bakhtawar-1	0.00	0.00
Bahar-07	0.00	0.00

Population of whitefly remained above ETL during June on and declined afterwards. Its intensity was highest on BS-15 followed by CIM-625 & Deebal and lowest on FH-142, FH-326 and Cyto-179 during June. During July and August it was below ETL on all strains Thrips population was found below ETL during June, July and August on all the

testing strains. Its intensity was higher on Cyto-313 followed by FH-142 & CIM-632 and lower on CIM-602, Cyto-313 and BH-201 in August **(Table-4.12)**. Bollworms damage/larva was found in Deebal and Cyto-179 but all other the candidate strains proved resistant to pink bollworm. Maximum infestation in susceptible bolls was recorded in Deebal while minimum in Cyto-179 in September. No pink bollworm larval population was found in all strains except Deebal **(Table-4.13)**.

4.5.3 Pest situation in Set-C

In this set 20 Bt cotton strains and two standards (CIM-602 & FH-142) were evaluated for their tolerance/susceptibility to insect pest complex. Population of jassid remained above ETL during June but its intensity decreased in July & August due to insecticidal sprays. Its population was highest on FH-142(S-2) & GH-Mubarak while minimum on Saim-32 & QM-IUB-65 during study period. Population of whitefly found below ETL almost on all the strains during July and August which declined in September. Overall its intensity was highest on NS-181 followed by FH-142(S-2) & NIAB-Bt-2 while lowest on QM-IUB-65 & NIAB-545. Thrips population remained below ETL on all the testing strains. Overall its population was highest on NIAB-Bt-2 and lowest on QM-IUB-65 & Saim-32 **(Table-4.14)**.

Table-4.14 Seasonal population of sucking insect pests on different *Bt* strains

Strains	Number of sucking insect pests per leaf								
	Jassid			Whitefly			Thrips		
	June	July	Aug	June	July	Aug	June	July	Aug
FH-142(S-2)	2.04	0.4	1.00	2.43	2.22	2.10	0.95	1.28	1.20
CIM-602 (S-1)	1.73	0.28	0.20	2.60	2.06	0.80	0.86	1.39	1.10
SAU-1	1.40	0.73	0.70	2.11	2.19	1.40	0.87	1.38	1.00
Saim-32	1.01	0.45	0.10	2.49	1.33	1.40	0.67	1.15	0.40
Sahara-Buraq	1.53	0.28	0.30	1.61	2.24	1.40	0.97	1.42	1.50
RH-668	1.01	0.43	0.40	1.60	1.92	1.90	0.56	1.07	1.00
RH-662	1.66	0.38	0.90	1.96	2.00	0.90	0.16	0.54	0.60
QM-IUB-65	1.03	0.38	0.10	2.13	1.57	0.70	0.21	0.95	0.40
NS-181	1.40	0.48	0.30	2.58	2.32	2.50	0.26	1.46	0.90
NIAB-Bt-2	1.28	0.11	0.60	1.61	2.72	2.20	1.02	2.14	2.20
NIAB-878-B	1.28	0.15	0.60	2.07	1.65	1.00	0.27	0.63	0.80
NIAB-545	1.34	0.68	0.30	2.03	1.56	0.70	0.10	1.76	0.80
NIAB-1048	1.79	0.88	0.30	2.57	1.88	1.60	0.54	1.80	0.60
NIA-86	2.01	0.56	0.40	2.45	2.27	1.10	0.96	1.71	0.90
MNS-992	1.52	0.61	0.30	2.11	2.96	1.60	0.43	1.81	1.00
MNH-1016	1.20	0.08	0.60	1.98	1.97	1.00	0.50	1.48	1.10
IR-NIBGE-9	1.61	0.49	0.30	1.84	1.89	1.90	0.21	0.89	0.50
IR-NIBGE-8	1.84	0.82	0.30	1.92	1.75	0.80	0.80	1.44	1.30
GH-Mubarak	2.02	0.77	1.00	2.22	1.29	1.00	0.85	1.12	1.00
FH-Kehashan	1.01	0.55	0.20	1.04	1.53	2.00	0.71	1.34	0.70

Spotted bollworm infestation and live larvae remained zero on all tested strains during the study period **(Table-4.15)**. Pink bollworm infestation was observed in susceptible bolls and its infestation was highest in Saim-32 and lower in GH-Mubarak, NIAB-545, IR-NIBGE-8 & GH-Mubarak while it remained zero in all other strains **(Table-4.16)**.

Table-4.15 Spotted bollworm damage and larval population at different stages of crop development on different *Bt* strains

Strains	Bollworm damage % age						SBW larvae/ 25 plants		
	August		September		October				
	Imm	Mat	Imm	Mat	Imm	Mat	Aug	Sep	Oct
FH-142(S-2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CIM-602 (S-1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SAU-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Saim-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sahara-Buraq	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RH-668	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RH-662	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
QM-IUB-65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NS-181	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIAB-Bt-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIAB-878-B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIAB-545	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIAB-1048	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIA-86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MNS-992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MNH-1016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IR-NIBGE-9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IR-NIBGE-8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GH-Mubarak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FH-Kehashan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table-4.16 Pink bollworms damage and larval population at different stages of crop development on different *Bt* strains

Strains	PBW damage %age	PBW larval %age
FH-142(S-2)	0	0
CIM-602 (S-1)	0	0
SAU-1	0	0
Saim-32	8	0
Sahara-Buraq	0	0
RH-668	0	0
RH-662	0	0
QM-IUB-65	0	0
NS-181	4	0
NIAB-Bt-2	0	0
NIAB-878-B	0	0
NIAB-545	4	0
NIAB-1048	0	0
NIA-86	0	0
MNS-992	0	0
MNH-1016	0	0
IR-NIBGE-9	0	0
IR-NIBGE-8	4	0
GH-Mubarak	4	4
FH-Kehashan	0	0

4.5.4 Pest situation in Set-D

In this set 19 Bt cotton strains and two standards (CIM-602 & FH-142) were tested for their tolerance/susceptibility to insect pest complex. During June, jassid population was above ETL on all the strains except SLH-12, Tahafuz-5, Sitara-15 & Shahkar, while it remained below ETL on all the tested strains during July. It was below ETL during August except Tarzan-5 & FH-142. Overall, its population was highest on Tarzan-5 & FH-142 while minimum on Sitara-14 and SLH-12 during study period. Whitefly remained below ETL on all the strains during study period. Overall its intensity was highest on Zakariya-1 &

Tarzan-5 and lowest on VH-Gulzar & Sitara-15. Thrips populations remained negligible during the study period **(Table-4.17)**.

Spotted bollworm infestation and live larvae remained zero on all tested strains during the study period **(Table-4.18)**. Pink bollworm infestation was observed in susceptible bolls and its infestation was highest in Zakariya-1 and lower in Shahkar & Weal-AG-Gold **(Table-4.19)**.

Table-4.17 Seasonal population of sucking insect pests on different *Bt* strains

Strains	Number of sucking insect pests per leaf								
	Jassid			Whitefly			Thrips		
	June	July	Aug	June	July	Aug	June	July	Aug
Thakkar-808	1.26	0.71	0.60	1.25	1.04	0.50	0.88	1.93	0.10
Shaheen-1	1.65	0.26	0.30	2.20	1.35	0.60	0.60	1.54	0.00
Tipu-1	1.38	0.33	0.60	1.01	0.96	0.60	0.55	1.47	0.30
Sitara-14	1.65	0.81	0.20	2.78	1.75	0.40	0.48	1.13	0.10
VH-363	1.40	0.04	0.40	1.10	1.57	0.60	0.98	1.29	0.20
Sitara-15	0.90	0.55	0.20	0.80	1.25	0.30	0.88	2.42	1.10
VH-Gulzar	1.20	0.08	0.20	0.99	1.05	0.20	0.78	2.45	1.20
SLH-12	0.80	0.55	0.20	0.67	1.13	0.60	0.59	1.85	1.40
Weal-AG-1606	1.00	0.83	0.80	1.10	1.56	0.30	0.49	2.08	0.50
Suncrop-4	1.61	0.61	0.30	2.53	0.89	0.60	0.20	1.64	0.20
Weal-AG-Gold	1.22	0.25	0.20	1.01	1.35	0.70	0.47	1.58	0.50
Suncrop-Hybrid-1	1.65	0.68	0.40	2.00	1.63	0.80	0.30	1.42	0.60
Weal-AG-Shahkar	0.95	0.55	0.60	2.11	0.89	0.40	0.90	1.68	0.10
Tahafuz-5	0.88	0.63	0.30	1.35	1.25	0.10	0.75	1.95	0.10
Zakariya-1	1.75	0.04	0.60	2.37	1.17	1.10	0.63	2.09	0.20
Tarzan-5	1.25	0.55	1.10	2.58	0.96	1.30	0.53	1.35	0.10
CIM-602 (S-1)	1.13	0.53	0.30	0.25	1.98	0.40	0.60	1.52	0.30
Tassco-1000	1.53	0.58	0.40	1.74	0.96	0.60	0.80	1.82	1.10
FH-142 (S-2)	1.65	0.22	1.20	1.50	0.69	0.50	0.90	1.40	0.10

Table-4.18 Spotted bollworm damage and larval population at different stages of crop development on different *Bt* strains

Strains	Bollworm damage % age						SBW larvae/ 25 plants		
	August		September		October				
	Imm	Mat	Imm	Mat	Imm	Mat	Aug	Sep	Oct
Thakkar-808	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shaheen-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tipu-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sitara-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VH-363	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sitara-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VH-Gulzar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SLH-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weal-AG-1606	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Suncrop-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weal-AG-Gold	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Suncrop-Hybrid-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weal-AG-Shahkar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tahafuz-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zakariya-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tarzan-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CIM-602 (S-1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tassco-1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FH-142 (S-2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table-4.19 Pink bollworms damage and larval population at different stages of crop development on different *Bt* strains

Strains	PBW damage %age	PBW larval %age
Thakkar-808	0.0	0.0
Shaheen-1	0.0	0.0
Tipu-1	0.0	0.0
Sitara-14	0.0	0.0
VH-363	0.0	0.0
Sitara-15	0.0	0.0
VH-Gulzar	0.0	0.0
SLH-12	0.0	0.0
Weal-AG-1606	0.0	0.0
Suncrop-4	0.0	0.0
Weal-AG-Gold	4.0	0.0
Suncrop-Hybrid-1	0.0	0.0
Weal-AG-Shahkar	4.0	0.0
Tahafuz-5	0.0	0.0
Zakariya-1	8.0	0.0
Tarzan-5	0.0	0.0
CIM-602 (S-1)	0.0	0.0
Tassco-1000	0.0	0.0
FH-142 (S-2)	0.0	0.0

4.6 Host plant tolerance studies of CCRI strains

4.6.1 Studies on conventional strains

Two conventional promising strains viz. Cyto-122 and CIM-610 developed by CCRI, Multan were tested for their tolerance/susceptibility against major insect pests. Cultivar CIM-554 was kept as standard. The trial was sown on May 20, 2016 using RCBD with three sets. Each set was replicated three times having plot size of 32.5'x16.5'. 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-4.20 Jassid Population per leaf in Non-Bt Varieties (Set-II)

Observation Dates	Jassid Population per leaf		
	CIM-554	CIM-610	Cyto-122
09-06-2016	0.53	0.66	0.43
21-6-2016	0.46	0.90	1.01
29-6-2016	2.56	2.13	2.13
14-7-2016	1.30	1.12	1.26
18-7-2016	0.60	0.43	0.33
22-7-2016	0.73	0.83	0.76
01-08-2016	0.86	1.06	0.90
17-08-2016	1.53	1.83	1.53
Average			
June	**1.18**	**1.23**	**1.19**
July	**0.88**	**0.78**	**0.78**
August	**1.20**	**1.45**	**1.20**

In Set-II, in 4th week of June all three strains attained economic threshold level (ETL) with relatively higher population on CIM-554. Afterwards all stains again reached economic threshold level (ETL) in 3rd week of August with relatively higher population on CIM-610. The population remained fluctuating during the 3rd week of july and 1st week of

August on all strains. Over all pest pressure was higher on CIM-610 and Cyto-122 (Table-4.20). Whitefly remained below economic threshold level (ETL) during June which increased afterward and in the 1st week of august reached above economic threshold level (ETL) on CIM-610 while remained below on other tested verities. Over all pest pressure was higher on CIM-610 and lower on CIM-554 **(Table-4.21)**.

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

Observation Dates	Whitefly Population per leaf		
	CIM-554	CIM-610	Cyto-122
09-6-2016	1.13	0.5	0.76
21-6-2016	0.53	0.7	0.66
29-6-2016	3	2.2	2.9
14-7-2016	1.5	2.1	1.96
18-7-2016	1.46	1.3	1.1
22-7-2016	1.67	1.83	1.23
01-8-2016	1.66	6.13	1.66
17-8-2016	0.83	1.43	1.3
Average			
June	1.55	1.13	1.44
July	1.54	1.74	1.43
August	1.25	3.78	1.48

Thrips remained below economic threshold level (ETL) thorough out the season on all tested cultivars **(Table-4.22)**.

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

Observation Dates	Thrips Population per leaf		
	CIM-554	CIM-610	Cyto-122
09-6-2016	0.23	0.00	0.00
21-6-2016	0.56	0.13	0.36
29-6-2016	0.66	0.56	0.66
14-7-2016	0.46	0.53	0.63
18-7-2016	0.00	0.00	0.00
22-7-2016	0.03	0.40	0.07
01-8-2016	4.43	4.00	4.96
17-8-2016	4.16	3.70	4.36
Average			
June	**0.48**	**0.23**	**0.34**
July	**0.16**	**0.31**	**0.23**
August	**4.30**	**3.85**	**4.66**

In Set-I, spotted bollworm was the major pest and initially its infestation was higher on CIM-554.and its infestation was on its peak in CIM-610 during 1st week of October. During month of October, its infestation was high on CIM-610 and declined on Cyto-122. Overall pest infestation was maximum on CIM-610 and minimum on CIM-554. **(Fig. 4.6).**

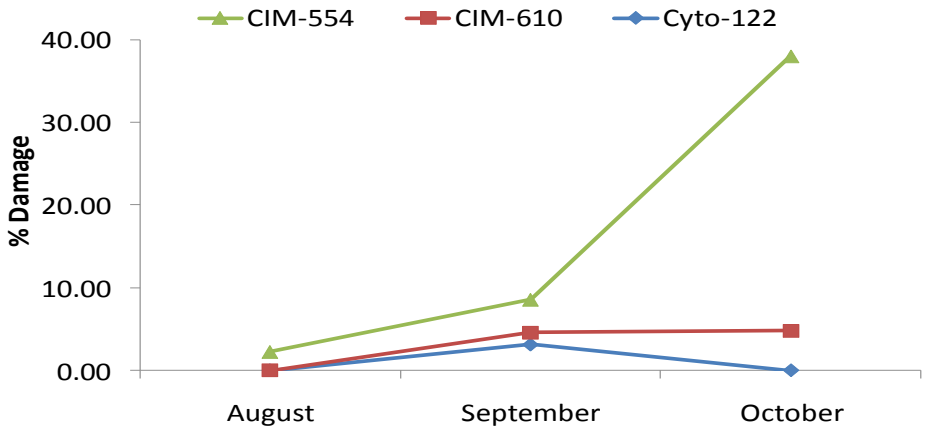


Fig 4.6 Bollworms trend in Non-Bt Promising Varieties

In Set-I, Cyto-122 produced maximum and CIM-610 minimum seed cotton yield, while in Set II, CIM-554 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 CIM-554 followed by Cyto-122 and CIM-610 respectively. Reduction in seed cotton yield was higher due to the attack of bollworms compared to the sucking pests in Set-I **(Table-4.23)**.

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 80-90.

Table-4.23 Pink bollworm damage/larvae in green bollsand 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-122	2030	2609	2706	22.22	11.11	77.78	66.67
CIM-610	1546	1256	1836	38.89	16.67	66.67	55.56
CIM-554 (Std)	1932	2706	2802	38.89	38.89	88.89	88.89
CD at 5%	**1994.22**	**796.24**	**1420.31**	**33.79**	**33.80**	**86.19**	**97.59**

4.6.2 Studies on *Bt* strains

Three *Bt* promising strains viz.CIM-632, Cyto-313, & Cyto-179, developed by CCRI, Multan were tested for their tolerance/susceptibility against major insect pests. CIM-600 was kept as standard. The trial was sown on May 20, 2015 using RCBD with two sets. Each set was replicated three times having plot size of 40'x20'. Set-II was kept un sprayed 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 on ETL on all tested strains in the 4th week of June, increased afterwards and was on its peak in the 1st week of July on all the tested strains. Its population fluctuated above ETL upto 2st week of July and declined till end of July on all the strains. Second peak of jassid was observed in ist week and 3rd week of August Overall its intensity was comparatively higher on CIM-632 and lower on Cyto-313.9 (Table-4.24)

Table-4.7 Jassid Population per leaf in Bt Varieties (Set-II)

Observation Dates	Jassid Population per leaf			
	CIM-632	CYTO-313	CIM-600	CYTO-179
09-6-2016	0.1	0.13	0.1	0.2
21-6-2016	0.63	0.7	0.73	0.83
29-6-2016	2.1	1.66	1.7	1.72
14-7-2016	1.33	1.63	1.5	1.46
18-7-2016	0.96	0.73	0.47	0.73
22-7-2016	0.47	0.7	0.67	0.87
01-8-2016	1.63	1.16	1.53	1.06
17-8-2016	1.2	1.27	1.2	1.3
Average				
June	**0.94**	**0.83**	**0.84**	**0.92**
July	**0.92**	**1.02**	**0.88**	**1.02**
August	**1.42**	**1.22**	**1.37**	**1.18**

Whitefly remained below ETL from June to mid-July which increased afterwards during 3rd week of July on all the strains except CIM-600. Its population declined afterwards. Overall CIM-632 proved most and CIM-600 least preferred strains for this pest (Table-4.25)

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

Observation Dates	Whitefly Population per leaf			
	CIM-632	CYTO-313	CIM-600	CYTO-179
09-6-2016	0.76	0.56	0.53	0.46
21-6-2016	0.6	0.46	0.43	0.63
29-6-2016	1.76	3.1	1.53	2
14-7-2016	3.73	3.8	2.83	3.43
18-7-2016	1.87	1.3	1.67	1.17
22-7-2016	0.87	1.83	0.67	0.63
01-8-2016	1.8	1.5	2.33	2.9
17-8-2016	1.067	0.93	0.867	0.7
Average				
June	**1.04**	**1.37**	**0.83**	**1.03**
July	**2.16**	**2.31**	**1.72**	**1.74**
August	**1.43**	**1.22**	**1.60**	**1.80**

Thrips population remained almost zero during June and from 2nd fortnight of August onwards upto crop termination while it was on its peak in 3rd week of August on all the cultivars. Overall Cyto-179 proved most and CIM-600 least preferred strain for this pest **(Table-4.26)**.

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

Observation Dates	Thrips Population per leaf			
	CIM-632	CYTO-313	CIM-600	CYTO-179
09-6-2016	0.0	0.0	0.0	0.0
21-6-2016	0.2	0.13	0.13	0.03
29-6-2016	0.4	0.63	0.33	0.73
14-7-2016	0.5	0.26	0.46	0.4
18-7-2016	0.13	0	0.2	0.1
22-7-2016	0.03	0.5	0	0.03
01-8-2016	2.76	4.43	2.7	3.96
17-8-2016	5.23	4.73	5.6	5.43
June	**0.20**	**0.25**	**0.15**	**0.25**
July	**0.22**	**0.25**	**0.22**	**0.18**
August	**4.00**	**4.58**	**4.15**	**4.70**

Pink bollworm was the major and only pest observed throughout the fruiting season all the tested strains. Its infestation and larval survival were observed in green bolls. It was above 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 CIM-600 and Cyto-179 in October while lowest on Cyto-313 and CIM-632 in both sets **(Table-4.27)**.

Table-4.27 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*
CIM-632	33.33	5.56	5.56	11.11	94.44	77.78	55.56	44.44
Cyto-313	16.67	38.89	38.89	16.67	77.78	83.33	83.33	61.11
CIM-600 (Std)	5.56	5.56	0.00	5.56	100.00	88.89	83.33	66.67
Cyto-179	27.78	16.67	16.67	16.67	100.00	94.44	100.00	66.67
CD at 5%	**32.28**	**27.95**	**19.10**	**16.14**	**19.10**	**29.76**	**54.49**	**52.05**

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

In Set-I, seed cotton yield was comparatively higher where sucking insect pests were controlled than set-II where they were allowed to develop. Among the cultivars, Cyto-179 produced maximum seed cotton yield, whereas, CIM-632 gave the lowest yield in sets-II **(Table-4.28)**.

Table-4.28 Seed cotton yield in different sets

Strain	Seed cotton yield (kg ha^{-1})	
	Set-I**	Set-II*
CIM-632	1256	875
Cyto-313	1973	1704
CIM-600 (Std)	1076	942
Cyto-179	1570	1659
CD at 5%	**653.41**	**511.31**

* = 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 of Multan and Vehari were exposed to five insecticides viz. acetamiprid, lambda-cyhalothrin, deltamethrin, emamcetin benzoate and tracer using seed dip method. Third instar of red cotton bugs were exposed and observations on mortality were taken 48 h after treatment.

LC^{50} of acetamiprid was generally high as compared to other insecticides, indicating a resistance to this insecticide in both locations. While LC^{50} of Pyrethroids (lambdacyhalothrin and deltamethrin) was very low, representing no resistance to these insecticides. Among the locations, Multan population showed higher LC^{50} values for acetamiprid and emamectin benzoate compared to Vehari population.

Table-4.29 Response of *Dysdercus koenigii* (Red cotton bug) to different insecticides collected from cotton in 2016

Insecticide	Location	Slope ± SE	LC50 (ppm)	95% fiducial limits
Acetamiprid	Vehari	1.37 ± 0.25	38.15	22.17 – 65.31
	Multan	1.52 ± 0.28	171.65	106.22 – 296.00
Lambda-cyhalothrin	Vehari	1.16 ± 0.21	0.03	0.01 – 0.047
	Multan	0.98 ± 0.19	0.01	0.002 – 0.01
Deltamethrin	Vehari	0.87 ± 0.16	0.04	0.02– 0.08
	Multan	0.89 ± 0.19	0.003	0.001 – 0.008
Tracer	Vehari	1.61 ± 0.40	35.47	21.90 – 86.77
	Multan	1.32 ± 0.11	5.45	0.78 – 13.83
Emamectin benzoate	Vehari	1.20 ± 0.30	14.24	7.67 – 30.81
	Multan	0.77 ± 0.27	19.25	12.40 – 33.11

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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. 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 crop season to record the prevalence of cotton leaf curl disease (CLCuD) and other cotton diseases in different parts of the Punjab. The maximum CLCuD was recorded in Bahawalpur, 71%. The average severity level of disease and natural incidence was less in D.G. Khan 16.8 when compared to other districts. All the varieties showed symptoms of CLCuD in surveyed areas. The maximum incidence was recorded in IUB-2015 (54%) with disease severity 2.0. 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 some spots However early sown rain fed crop was affected by wilting syndrome, in most of the cotton growing areas.

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. Two hundred ninety five families were

screened during the year. Data present in **Table-5.1** revealed that. Two hundred eighty two families of breeding material, showed symptoms of the CLCuD under filed conditions. However thirteen families showed resistance against CLCuD Ten lines in MVT-3 three line in MVT-4 Where as in VT-1(CM-1,), VT-2 (CM-15,), VT-4 (CM-29) MVT-2 (681/16,) MVT-8 and MVT-1-3405 showed tolerance against the disease.

5.2.2 Screening of U.S Germplasm material against CLCuD under field conditions

Ratoon Crop

The U.S Germplasm Ratoon crop (355) of *G. hirsutum* (Introgression material) of cotton was screened in three sets (Set-P = 100, Set-Q = 200 and Set-R = 55 accessions) during the previous year under field conditions. Three hundred fifty three accessions out of three hundred fifty five showed susceptibility in Disease Rating Scale-4. Screening was done during the season. All the accessions which were sprouted this year showed symptoms of CLCuD during this season.

New Germplasm

One hundred thirty two (132) strains of US-Germplasm were planted in two sets (Set-S = 60 and Set-T =72 accessions) during the 1st week of June at CCRI, Multan by Breeding Section. These lines were planted for screening against Cotton Leaf Curl Disease (CLCuD) under field conditions. Screening against CLCuD was done at day 30, 60, 90 and 120 days after planting. The results are given in **Table-5.2.**

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-	8	0	9.3	CM-
VT-	8	0	.8	CM-
VT-	8	0	6.8	*
VT-	11	0	0.1	CM-
MV	10	0	3.3	
MV	8	0	7.9	681
MV	13	10	.1	**
MV	10	3	.7	***
MV	10	0	0.0	

MV	9	0	9.9	
MV	12	0	1.4	
MV	10	0	7.7	^
MV	11	0	2.8	
MV	10	0	3.9	340
SVT-I	24	0	27.0 ~ 73.1	
SVT-II	18	0	53.7 ~ 79.3	
NCVT-A	16	0	64.5 ~ 83.0	
NCVT-B	20	0	71.5 ~ 75.5	
NCVT-C	20	0	69.5 ~ 76.7	
NCVT-D	19	0	57.7 ~ 73.1	
PCCC-I	33	0	68.4 ~ 76.7	
PCCC-II	3	0	61.9 ~ 67.8	
PCCC-III	4	0	65.8 ~ 71.3	
Total	**295**	**13**		

*=CM-21(1.5), CM-19(2.6), CM-20(4.8), CM-17 &CM-18(5.7)
**=1120, 1121, 1123~1130(0), 1119(0.45), 1122(1.3), 1132(2.3), 1138(3.3)
***= 1133, 1135, 1139(0), 1137(1.3), 1136(1.6), 1134(1.7), 1132(2.3), 1138(3.3)
^ = 2393(16.3), 2391 (19.5)
VT = Varietal Trial
MVT = Micro-Varietal Trial
SVT = Standard Varietal Trail
PCCT = Punjab Coordinated Cotton Trial
NCVT = National Coordinated Varietal Trial

Table-5.2. Screening of US Germplasm against CLCuD at day 30, 60, 90 and 120 after planting during 2016-2017

Status of US Germplasm against CLCuD

Set No	Total Access.	Days after planting	Category of Resistance Disease Rating Scales				
			0	**1**	**2**	**3**	**4**
Set-S	60	30	48	0	11	1	0
		60	0	0	1	6	53
		90	0	0	0	0	60
		120	0	0	0	0	60
Set-T	72	30	53	0	19	0	0
		60	0	0	4	1	67
		90	0	0	3	1	68
		120	0	0	3	1	68
Total	132	30	101	0	30	1	0
		60	0	0	5	7	120
		90	0	0	3	1	128
		120	0	0	3	1	128

Data presented in Table-5.2 show that only three accessions were tolerant and one susceptible. Where as other 128 accessions were highly susceptible against CLCuD at day 120 after planting. Overall one hundred twenty eight accessions out of One hundred thirty two showed susceptibility in Disease Rating Scale-4.

Summary of Screening of US Germplasm Events

Thirty four events of CEMB with four standards were screened against CLCuD at day 30, 60, 90 and 120 after planting. None of them showed resistance against the disease. The detail is given below.

Set No	Total Access.	Days after planting	Category of Resistance Disease Rating Scales				
			0	1	2	3	4
Events	34	30	34	0	0	0	0
		60	0	0	0	0	34
		90	0	0	0	0	34
		120	0	0	0	0	34

5.3 Evaluation of National Coordinated Varietal Trial against Different Diseases

National coordinated Varietal Trial were planted in four sets, Set-A sixteen strains (non-Bt), Set-B and Set-C twenty Bt strains/lines and in Set-D nineteen strains (Bt-hybrid) 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-610. Maximum disease index was observed in TH-17. Maximum boll rot was recorded in NIAB-444 (1.02%) and minimum in Tipu-2 and PB-896 (Table 5.3). Maximum stunting was recorded in RH-667 (1.66%) whereas all others showed stunting in traces.

NCVT-Set-B

All the NCVT strains found highly susceptible to cotton leaf curl disease. Minimum disease incidence and disease index was recorded in BPC-10. Maximum CLCuD severity and disease index was observed in CIM-602 and CRIS-600. Incidence of boll rot was recorded in FH-142 (1.12%). Maximum stunting was recorded in FH-152 and CRIS 600. (1.12% & 1.07%) whereas all others showed stunting in traces **(Table-5.4).**

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NCVT-Set-C

All the NCVT strains observed highly susceptibility to cotton leaf curl disease. Minimum disease severity and disease index was recorded in IR-NIBGE-9. Maximum stunting, disease severity and disease index was observed in GH-Mubarak. Maximum boll rot incidence was recorded in MNS-992(1.16%) **(Table-5.5).**

NCVT-Set-D

All the NCVT strains showed highly susceptibility to cotton leaf curl disease. Maximum CLCuD severity and disease index was recorded in Sitara-15. Minimum disease severity and disease index was observed in Sitara-14 Maximum boll rot incidence was recorded in VH-363(1.33%) where as other strains showed less than 1 % (Table-5.6). Maximum stunting was recorded in Tassco-1000 (2.23%) followed by Sitara-15 (2.21%)

The material included in NCVT Set A was also tested under greenhouse conditions. The material was grafted (petiole-graft technique) with cotton leaf curl virus infected leaves of cv. CIM-496. The observations were taken daily starting from one week after grafting. The material was graded according to a scale and given in Table-5.7.

The results presented in **Table 5.7** showed that that all the NCVT strains showed symptoms of CLCuV within 12 to 28 days after graft transmission. The strain A-7, A-12 and A-15 took more days to produce the symptoms and less severity of the disease.

Similarly A-3 to A-11and A-2 took minimum days to produce the symptoms and showed more susceptibility than others. Overall data indicated that none of the above material is completely resistant against CLCuD.

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	
CIM-573 (S)	0.71	100.00	2.86	71.53	0.98
Tipu-2	0.00	100.00	2.85	71.18	0.54
Thakkar-214	0.61	100.00	3.03	75.63	0.00
TH-20	0.00	100.00	2.87	71.65	0.35
TH-17	0.13	100.00	**3.32**	**83.04**	0.00
Tahafuz-7	0.00	100.00	2.95	73.80	0.28
RH-667	**1.66**	100.00	2.94	73.57	0.94
PB-896	0.00	100.00	2.87	71.86	0.84
NIAB-444	0.00	100.00	2.91	72.76	0.00
MTS-61	0.00	100.00	2.85	71.20	**1.02**
MTS-29	0.00	100.00	2.92	73.06	0.66
GS-Ali-5	1.10	100.00	2.88	72.08	0.26
GS-Ali-1	1.14	100.00	2.92	72.89	0.66
GS-Hammad	1.11	100.00	2.82	70.51	0.66
CIM-610	0.00	*100.00*	*2.58*	*64.53*	0.32
CRIS-546	0.66	100.00	2.90	72.57	0.28

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	
FH-142 (S2)	0.53	100.00	2.98	74.56	**1.12**
CIM-602 (S1)	0.66	100.00	**3.02**	**75.49**	0.31
FH-326	0.00	100.00	2.97	74.14	0.86
FH-152	1.12	100.00	2.94	73.59	0.85
Eagle-2	**2.51**	100.00	2.98	74.52	0.30
Deebal	0.00	100.00	2.97	74.29	1.05
Cyto-313	0.65	100.00	2.98	74.61	0.00
Cyto-179	0.54	100.00	2.89	72.33	0.60
Crystal-12	0.00	100.00	3.01	75.28	0.33
CIM-625	0.89	100.00	2.87	71.84	0.94
CEMB-88	0.00	100.00	2.90	72.61	0.00
CEMB-55-S	0.62	100.00	3.01	75.25	0.32
CRIS-600	1.07	100.00	**3.02**	**75.47**	0.89
CIM-632	0.00	100.00	2.92	72.99	0.53
BS-15	0.00	99.44	2.98	74.13	0.59
BPC-11	0.52	100.00	2.92	72.94	0.32
BPC-10	0.57	100.00	2.86	71.50	0.00
BH-201	0.75	100.00	2.93	73.16	0.31

Bakhtawar-1	0.00	100.00	2.94	73.40	0.36
Bahar-07	0.00	100.00	2.92	72.98	0.33

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	
FH-142 (S2)	0.00	100.00	2.99	74.75	0.00
CIM-602 (S1)	0.00	99.44	2.95	73.42	0.33
SAU-1	0.55	100.00	2.92	72.90	0.00
Saim-32	0.00	98.36	3.02	74.14	0.00
Sahara-buraq	0.00	100.00	2.90	72.59	0.00
RH-668	1.11	100.00	2.93	73.20	0.55
RH-662	0.59	100.00	2.94	73.39	0.00
QM-IUB-65	0.00	100.00	2.94	73.54	0.00
NS-181	0.00	100.00	2.97	74.18	0.26
NIAB-Bt-2	0.00	100.00	2.98	74.47	0.30
NIAB-878-B	0.54	100.00	2.87	71.64	0.00
|NIAB-545	0.00	100.00	2.97	74.28	0.00
NIAB-1048	0.00	100.00	2.88	72.01	0.00
NIAN-86	0.00	100.00	2.95	73.63	0.00
MNS-992	0.00	100.00	2.95	73.85	**1.16**
MNS-1016	0.00	100.00	2.90	72.40	0.00
IR-NIBGE-9	0.00	97.08	2.86	69.52	0.25
NIBGE-8	0.00	100.00	2.93	73.29	0.28
GH-Mubarak	**2.49**	100.00	**3.07**	**76.74**	0.00
FH-Kehashan	2.33	100.00	2.92	72.91	0.00

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

Table-5.6 Stunting, Cotton Leaf Curl Disease Incidence, Severity, Disease Index and Boll Rot of Cotton on NCVT Set-D

NCVT Set D Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
Thakar-808	0.00	100.00	2.94	73.51	0.62
Shaheen-1	0.00	100.00	2.98	74.60	0.37
Tipu-1	0.00	100.00	3.02	75.55	0.28
Sitra-14	0.00	94.95	2.92	69.33	0.66
VH-363	0.00	100.00	2.99	74.67	**1.33**
Sitra-15	2.21	100.00	**3.06**	**76.44**	0.28
VH-Gulzar	0.55	100.00	2.96	73.90	0.00
SLH-13	0.00	100.00	2.99	74.72	0.92
Weal-AG-1606	1.65	100.00	3.00	75.00	0.29
Suncrop-4	0.00	100.00	2.95	73.72	0.00
Veal-AG-Gold	0.00	100.00	2.99	74.87	0.00
Suncrop-Hybrid-1	0.00	100.00	2.94	73.44	0.37
Weal-AG-Shahkar	0.00	100.00	2.93	73.25	0.31
Tahafuz-5	0.00	100.00	2.95	73.73	0.64
Zakariya-1	0.00	100.00	2.99	74.86	0.00
Tarzan-5	0.00	100.00	2.91	72.66	0.00
CIM-602 (S1)	1.05	100.00	2.97	74.29	0.32

Tassco-1000	**2.23**	100.00	3.04	76.10	0.00
FH-142(S2)	0.00	100.00	3.03	75.83	0.00

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

Table-5.7 Screening of NCVT Strains Against CLCuD Through Petiole-graft Transmission Technique.

Variety/ strain	No. of days taken to appear the symptoms (after grafting)	Intensity* 0-4*
CIM-573 (S)	12 ~ 16	3
Tipu-2	10 ~ 12	4
Thakkar-214	8 ~ 14	4
TH-20	18 ~ 20	2
TH-17	14 ~ 18	3
Tahafuz-7	17 ~ 20	3
RH-667	22 ~ 24	2
PB-896	12 ~ 16	3
NIAB-444	14 ~ 18	3
MTS-29	8 ~ 14	4
GS-Ali-5	22 ~ 24	2
GS-Ali-1	10 ~ 15	4
GS-Hammad	10 ~ 15	4
CIM-610	24 ~ 28	2
CRIS-546	12 ~ 16	4

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

5.4 Epidemiological Studies on CLCuD

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

Effect of sowing dates on *Bt*-Strains

Two advanced genotypes i.e. CIM-632 and Cyto-313 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 1st April with in 60 DAP The disease incidence remained low up to end of June (0.89 %) and reached maximum level (45.9%) on 30th September in 1st March planting. Where as in 15th March planting CLCuD started to appear during the end of June (0.68 %) and gradually attained maximum level (28.36%) during the end of September.

In 1st April planting, disease incidence was 2.55 to 6.01% from mid of June to 30th June respectively. Whereas in 15th April planting disease incidence was 2.75 % at the mid of June, 84.49% during mid of August and reached 96.2 % at the end of September,

In 1st May planting incidence started within 60 DAP (end of June) then increased sharply i.e. 96.05 to 100% during end of August to end of September whereas in 15th May

planting disease symptoms appeared only 0.77% at end of June and disease incidence recorded 100% during the month of September (within 65 DAP)

Those crops which were planted earlier showed less disease incidence. All the cultivars showed minimum 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 80% 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 June and July 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 remained low on the crop planted on 1st March to 15th March which ranged from 19.01 to 29.02% respectively. The disease index increased with the delay in sowing and it reached up to 48.94 and 76.39 % in crop sown on 15th April to 15th May respectively (Table-5.8). There is no varietal difference in all sowing dates.

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-632	20.40	8.82	70.12	70.79	74.30	78.13	53.76
CIM-313	41.90	22.70	32.85	64.53	75.03	75.19	52.03
CIM-602	24.75	25.50	43.84	72.29	73.42	75.85	52.61
Average	**29.02**	**19.01**	**48.94**	**69.20**	**74.25**	**76.39**	

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 34.5~ 36.3°C minimum temperature 27.6 ~ 30°C with the relative humidity 71.9~ 86.6% during the above mentioned period. It's indicated that during that period the late sown crop was more affected as earlier (Table-5.9).

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

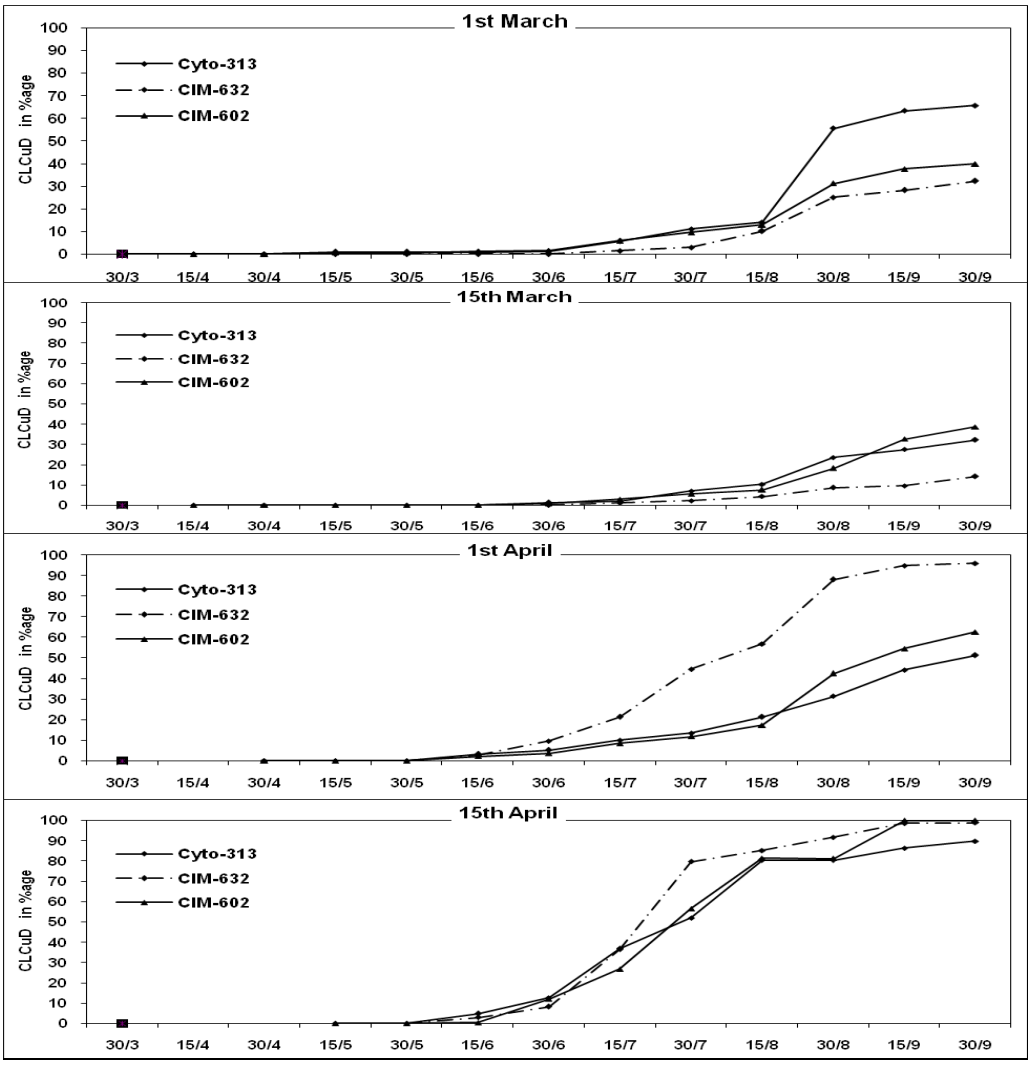
Sowing Date	**Fortnightly increase of CLCuD on**												
	16-31/3	1-15/4	16-30/4	1-15/5	16-31/5	1-15/6	16-30/6	1-15/7	**16-31/7**	**1-15/8**	**16-31/8**	1-15/9	16-30/9
March 1st	0	0	0	0.44	0	0.17	0.27	2.39	4.52	4.52	24.99	5.73	2.86
March 15th		0	0	0	0	0	0.86	1.36	2.94	2.41	9.38	6.43	5.16
April 1st			0	0	0	2.55	3.46	7.12	10.04	8.57	22.15	10.58	5.43
April 15th				0	0	2.75	8.29	22.37	29.36	19.61	2.17	10.37	1.28
May 1st					0	0	3.34	17.14	16.12	20.39	38.36	4.65	0
May 15th						0	0.77	17.15	38.69	39.44	3.96	0	0
Average	0	0	0	0.07	0	0.91	2.83	11.25	**16.94**	**15.82**	**16.83**	6.29	2.45
Max. C	27.4	32.0	37.1	39.3	41	40.2	39.4	36.8	36.3	34.5	35.7	33.8	35.6
Min. C	18.3	20.7	24.3	27.5	29.3	30.6	31.4	29.2	30	28.6	27.6	26.1	26.3

Difference	9.1	11.3	12.8	11.8	11.7	9.6	8.0	7.6	6.3	5.9	8.1	7.7	9.3
RH%	82.5	85.7	86.5	86.4	64.3	68.8	72.1	71.9	77.6	85.1	86.6	88.8	72.2

5.4.2 Effect of Sowing Time on Non Bt. Trial

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 Cyto-124 and Cyto-122 along with one standard variety FH-942 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.



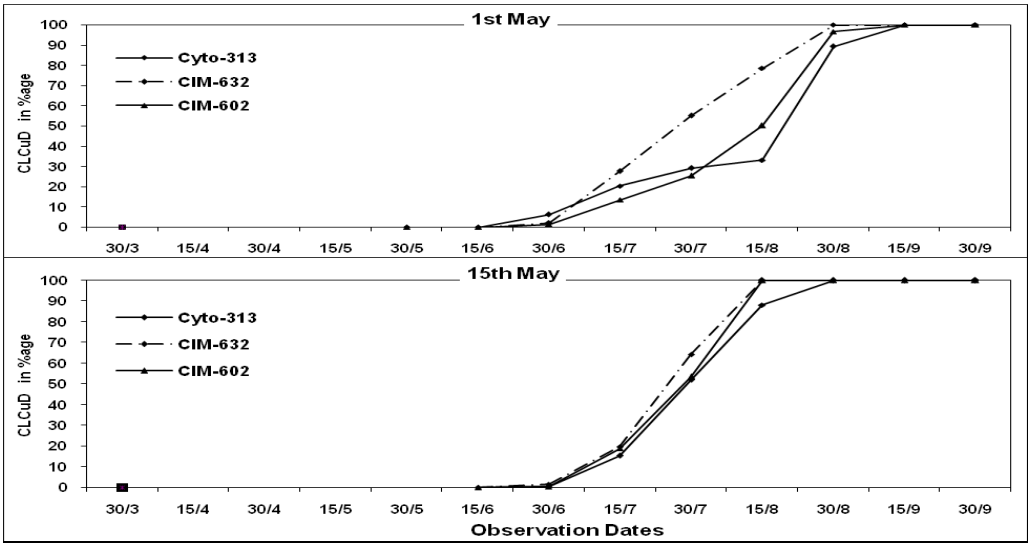


Fig-5.1 Incidence of CLCuD as influenced by planting Dates and strains on Bt-cotton

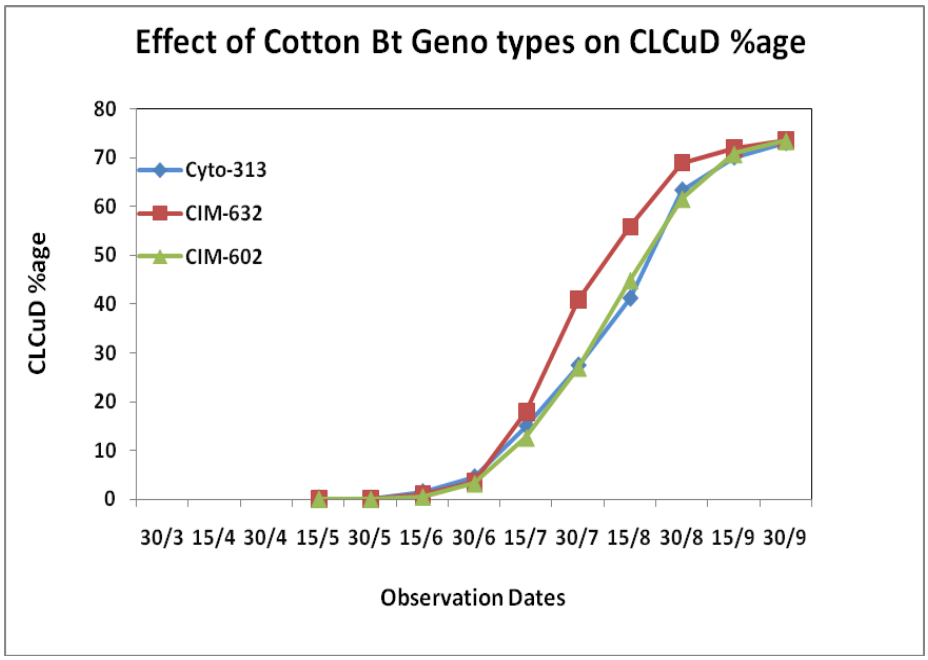


Fig-5.2 Effect of CLCuD Incidence as influenced by planting dates and Bt-strain

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. 2.5%. With the advancement of age the infestation level reached 36.20% during the end 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 1.3% which increased moderately and reached to 36.8% at the end of September.

Similarly in case of 15thMay planting CLCuD incidence was 1.3% in the first week of July and got its maximum level 51.1% on end of September (135DAP).

In 1stJune and 15thJune planting the disease started on mid July (2.9% and 0.8%) and reached up to 55.1% and 80.2% respectively at the end of September.

The level of disease incidence in Cyto-124 and Cyto-122 showed less in 15th April and 1st May planting as compare to FH-942. There is a great varietal difference in June sowing. FH-942 showed Maximum CLCuD infestation in early planting and late planting (Fig-5.3).

Average across planting period, comparison among the varieties revealed that Cyto-124 and Cyto-122 were the least affected with CLCuD, at all sowing dates even when planted during the month of June followed by FH-942 (**Fig-5.4**).

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 21.55% was recorded on crop planting on 15th April as compare to other planting dates. Average planting dates, minimum disease index level (16.52%) was recorded on genotype Cyto-124 followed by Cyto-122 (19.78%) Table-5.10

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

Cultivars	*15th April*	1st May	15th May	1st June	15th June	Average
Cyto-122	3.20	6.22	10.95	24.20	54.35	19.78
Cyto-124	2.02	3. 10	24.21	16.43	36.85	16.52
FH-942	63.87	55.33	65.00	62.10	70.05	63.27
Average	23.03	21.55	33.39	34.25	53.75	

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 August to end of August .Among environmental parameters the maximum temperature range was 34.5 ~ 36.3°C minimum temperature 27.6 ~ 30.0°C with the relative humidity 71.9%~ 86.6% 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 2016

Planting Time	Fortnightly increase of CLCuD on									
	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	16-30/9
15th April	0	0	0	2.5	5.6	7.4	2.5	13.60	4.2	0.4
1st May		0	0	1.3	8.4	3.6	2.8	19.2	1.2	0.3
15th May			0	1.0	3.10	10.9	6.1	19.1	8. 7	2.6
1st June				0	2.9	11.7	20.3	10.5	3.8	5.9
15th June					0.8	5.3	28.2	28.6	3.6	13.6
Average	0	0	0	0.96	4.2	7.8	**11.98**	**18.20**	4.30	4.56
Max. °C	39.3	41	40.2	39.4	36.8	36.3	34.5	35.7	33.8	35.6
Min. °C	27.5	29.3	30.6	31.4	29.2	30	28.6	27.6	26.1	26.3
Difference	11.8	11.7	9.6	8.0	7.6	6.3	5.9	8.1	7.7	9.3
RH%	86.4	64.3	68.8	72.1	71.9	77.6	85.1	86.6	88.8	72.2

5.5 Effect of whitefly virulence to healthy plants

An experiment was conducted to evaluate whitefly virulence throughout cotton growing season. The cultivar CIM-496 was sown in pots and covered them with net, in every month. Whiteflies were collected from fields of CCRI and kept them in refrigerator (half an hour) for fasting. One to five whiteflies per plant (first true leaf) was transferred to healthy plants. One pot kept as control (free from whitefly). The observations were taken daily (appearance of symptoms of CLCuD) starting from one week after releasing of whiteflies. The results are given in Fig-5.5.

The data indicate that maximum disease incidence was recorded on those plants where whiteflies were collected and released during the month of July and August and September. No CLCuD symptoms were observed in those pots on which whiteflies were released during the month of March, April and November. Whereas those pots showed comparatively less symptoms of CLCuD which were inoculated during the month of May, June, September and October. So it might be concluded that whiteflies being more virulent during the month of July and August and September.

5.6 Boll Rot of Cotton

5.6.1 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-602 showed comparatively less boll rot as compared to others. The boll rot disease ranged from 0.07 to 0.25% in all sowing dates on an average basis (Table 5.12).

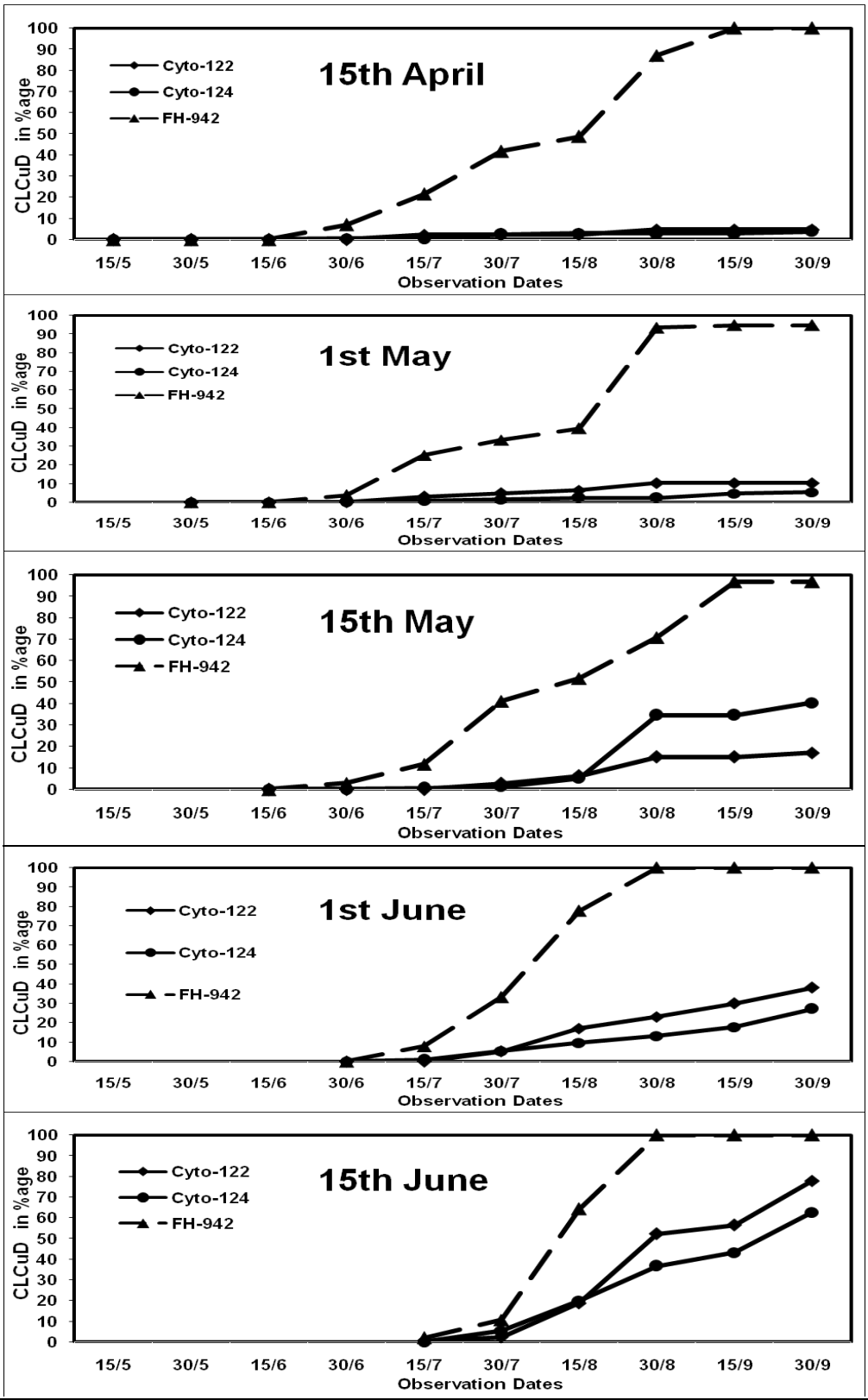

15th April
1st May
15th May
1st June
15th June
Cyto-122
Cyto-124
FH-942
CLCuD in %age
Observation Dates
15/5
30/5
15/6
30/6
15/7
30/7
15/8
30/8
15/9
30/9

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

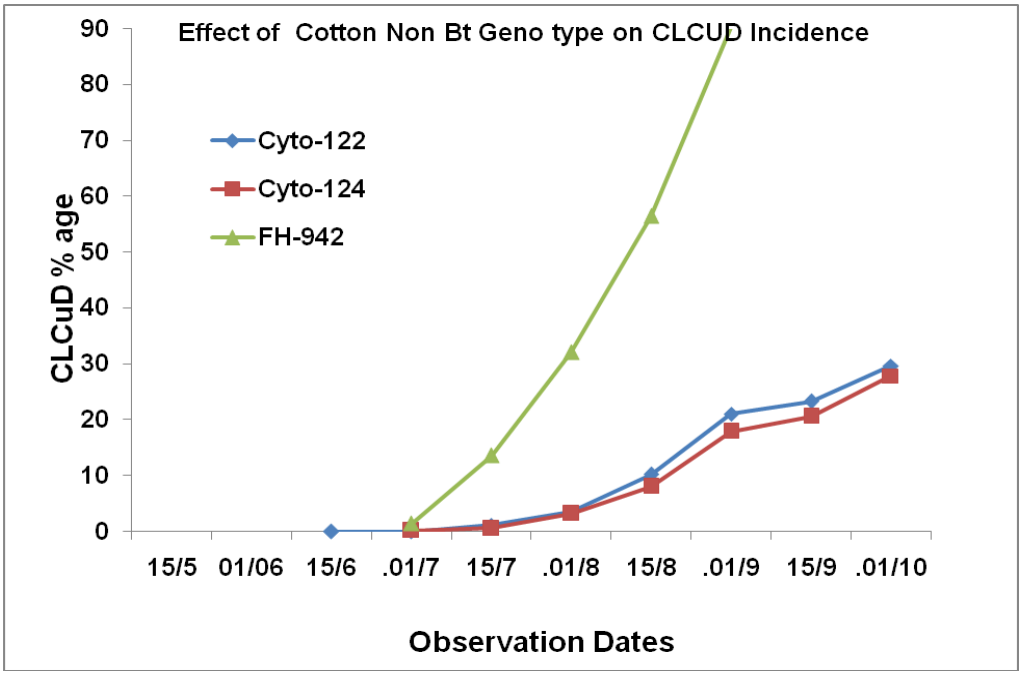


Fig-5.4 Incidence of CLCuD as influenced by planting Dates and strain on Non-Bt-cotton

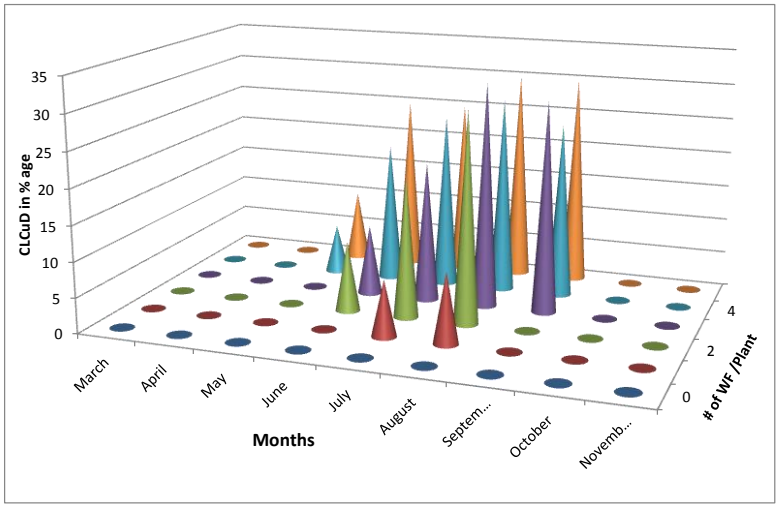


Fig 5.5 Effect of whitefly virulence on the incidence (%age) of CLCuD

(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, cultivars showed little difference regarding boll rot of cotton. On an average basis, the crop planted during mid-June was more affected by boll rot as compared to early planting. On an average basis, boll rot disease ranged from 0.2 to 0.65% 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-632	0.19	0.16	0.57	0.27	0.00	0.00	**0.19**
CIM-313	0.53	0.39	0.00	0.23	1.33	0.23	**0.45**
CIM-602	0.00	0.20	0.00	0.00	0.00	0.00	**0.03**
Average	**0.24**	**0.25**	**0.19**	**0.16**	**0.44**	**0.07**	

* = Sowing Dates

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
Cyto-122	0.4	0.7	0.76	0.4	0.4	**0.45**
Cyto-124	0.20	0.0	0.27	0.3	0.3	**0.21**
FH-942	0.0	0.8	0.90	1.25	1.21	**0.83**
Average	**0.2**	**0.5**	**0.64**	**0.65**	**0.63**	

* = Sowing Date

5.6.2 Wilt of Cotton

Sudden drying (New wilt) Symptoms are noticed in some fields after drought followed by rains or irrigation Cotton 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.

Isolation and microscopic studies revealed that fungus *Botryodiplodia sp*. infested the internal stem portion as a secondary pathogen.

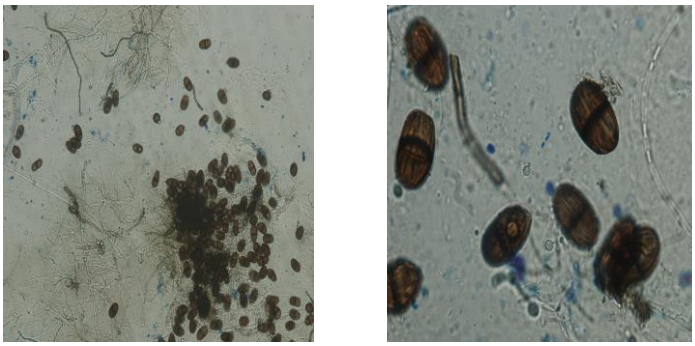


Fig.5.5 *Botryodiplodia*

Spray with Nativo 75 WG, a formulation containing both fungicides (trifloxystrobin 250 **+** tebuconazole 500 g) @10mg/liter (10ppm) on affected plants within few hours of onset of symptoms gave an effective control against this fungus.

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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 Nutrient management for cotton productivity by conjoint use of organic and inorganic fertilizers under extended cultivation regimes

Cotton crop is vulnerable to abiotic and abiotic stresses, more than any other crop, during the cropping season. The abiotic stresses that include temperature, rainfall, salinity, irrigation water, soil health and nutrient fertilizers etc. may exert more than 70% losses to cotton productivity. The crop yield is dependent upon the environment in which it is grown and the management practices of the cropping system. In the recent past, two major factors had a significant impact on the economics of cotton production. These are extensive use of agrochemicals and yield stagnation. Among all agrochemicals, fertilizers and insecticides are of utmost importance. There are no efficient alternatives to synthetic fertilizers and cotton production has to bear the use of nutrient supplements in the form of inorganic fertilizers. Currently, there is a greater need for new developments in production research but more and more researchers are confronted with maintaining the current status of yields. The cost of production has increased to such a level that it is threatening the economics of cotton production. The crop sowing trend, in the recent past (about 10-15% of the total cotton area) shifted from conventional to early sowing (long duration) of cotton. Apart from getting the benefit of extra yields due to prolonged cotton crop season, the cost of production as well as the production technology changed remarkably. Among the major inputs like irrigation water supply and application of insecticides, the fertilizer application observed a non-judicial increase, thereby threatening the production economics and environmental safety.

To cope with the growing needs of the ever increasing population, agricultural production needs to be increased at equal rate on sustained basis. Under the limited land and squeezing water resources, these goals can be achieved by replenishing all the nutrient needs of the crop in an optimized and integrated manner using alternate nutrient resources without compromising the soil health. Thus, there is a need to break the yield stagnation barriers by improving soil health and nutrient use efficiency through incorporation of different sources (inorganic and/or organic) in judicial manner to achieve desired yield goals.

Therefore, a multi-location field trial was conducted to evaluate the appropriate nutrient requirement of Bt cotton as well as traditional non-Bt cotton in Multan Division using organic and inorganic sources. Following different treatments were implemented.

Treatments

T1: 200 N + 50 P_2O_5 (kg ha^{-1})
T2: 400 N + 150 P_2O_5 + 125 K_2O (kg ha^{-1})
T3: 300 N + 110 P_2O_5 + 90 K_2O (kg ha^{-1}) + Zn, B*
T4: 225 N (170 kg from Urea + 56 kg from FYM) + 80 P_2O_5 + 70 K_2O (kg ha^{-1}) + Zn, B
T5: 225 N + 80 P_2O_5 + 70 K_2O + 50 HA, (kg ha^{-1}) + Zn, B
T6: 225 N + 80 P_2O_5 + 70 K_2O, (kg ha^{-1}) + Zn, B#

**Boron and Zinc were applied as foliar sprays @ 0.05% solution three times during the cropping season*

#In treatment T6 cotton seed was sown after treatment with Biozote @ 500g $acre^{-1}$

Field trials were conducted for the third and final year on already selected four sites viz. CCRI, Multan, Chak 5 Faiz, Moza Naseer Pur, Shujabad and 6-MR, Vehari road with Bt and non-Bt cotton varieties. Cotton crop was sown in the month of April 2016.

Composite soil samples from plough layer were collected from all the experimental sites before planting. Physical and chemical analyses of the soil samples revealed that the soils at all the locations are alkaline in reaction with moderate salinity, having medium to adequate organic matter content, medium to adequate extractable-P, adequate extractable-K, boron and zinc content. The textural class of the samples varied from silt loam to silty clay loam (Table 6.1)

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

Soil parameter	Location			
	CCRI, Multan	Chak 5-Faiz	Moza Naseer Pur, Shujabad	6-MR,Vehari Road
pH	8.13	8.81	8.53	8.55
EC_e (µS cm^{-1})	310	189	244	220
Organic matter (%)	0.80	0.84	0.65	0.65
Total-N (%)	0.010	0.097	0.091	0.089
$NaHCO_3$ -P	13.4	12.2	10.1	12.2
NH_4OAC-K	140	170	258	203
DTPA-B	2.00	1.85	2.00	2.18
DTPA-Zn	1.11	1.14	1.03	1.15
Textural class	silt loam	silty clay loam	silty clay loam	silt loam

Data on plant structure development were recorded at maturity. The results indicated that the plant structure in Bt and non-Bt cotton varied among different treatments as well as the locations. Generally, the Bt cotton responded more efficiently to the same fertilizer doses and developed better plant structure in comparison to non-Bt cotton. Among the locations, maximum plant structure (height, nodes) was observed in trial planted at 6-MR Makhdum Rasheed. At that location, the main stem height varied from 102.6 to 115.3 cm and nodes on main stem from 33.0 to 35.7 cm in Bt cotton. While in non-Bt cotton main stem height and nodes on main stem remained in the range of 94.2 to 110.3 cm and 31.3 to 33.6, respectively. Moreover, this location also produced the highest inter-nodal length than the other locations that ranged from 3.11 to 3.23 cm in Bt and from 3.01 to 3.28 cm in non-Bt cotton. Among the fertilizer treatments, on overall basis, the treatment T4 produced the maximum main stem height and nodes on main stem both in Bt and non-Bt cotton varieties (Table 6.2).

Data regarding seed cotton yield and its components at all locations are presented in Table 6.3. The results of trial at CCRI, Multan indicated that seed cotton yield and its components varied significantly among different treatments both in Bt and non-Bt cotton varieties. The treatment T2 produced the highest seed cotton per hectare both in Bt (3120 kg ha^{-1}) and non-Bt (3070 kg ha^{-1}) cotton. However, the treatments T3 & T4 remained at par with T2 in terms of seed cotton production. All the treatments, both in Bt and non-Bt cotton, produced significantly ($p<0.05\%$) higher seed cotton yield over T1. The increase in yield over T1 ranged from 12 to 19% in different treatments in Bt cotton while it ranged from 17 to 26% in non-Bt cotton.

Seed cotton yield and its components from trial at 6-MR, Vehari Road, Multan also varied significantly among different treatments. In Bt cotton, number of bolls per plant varied from 31 to 35, boll weight from 3.07 to 3.21g and seed cotton yield from 2965 to 3430 kg ha^{-1} whereas in non-Bt cotton number of bolls ranged from 28 to 32, boll weight from 3.02 to 3.20 g and seed cotton yield from 2700 to 3160 kg ha^{-1} in different treatments.

Among the different treatments at Naseer Pur Shujabad, seed cotton yield and its components varied significantly both in Bt and non-Bt cotton. On average basis in

different treatments, the seed cotton yield varied from 2945 to 3570 kg ha^{-1} in Bt cotton while in non-Bt cotton seed cotton yield varied from 2860 to 3330 kg ha^{-1}. Although, the maximum seed cotton yield, both in Bt and non-Bt cotton, was observed in treatment T2 (400 N + 150 P_2O_5 + 125 K_2O kg ha^{-1}), however it did not vary significantly from T3 and T4 treatments.

The trial at Chak 5-Faiz Lodhran Road also showed the similar trend as seed cotton production remained higher in Bt cotton as compared to non-Bt cotton. On average basis in different treatments, the seed cotton yield varied from 2945 to 3570 kg ha^{-1} in Bt cotton while in non-Bt cotton seed cotton yield varied from 2860 to 3330 kg ha^{-1}. The maximum seed cotton yield was observed in treatment T2 (both in Bt and non-Bt) that received fertilizer dose of 400 N + 150 P_2O_5 + 125 K_2O kg ha^{-1} compared to other treatments.

Table 6.2 Effect of chemical fertilizers with or without organic manures on vegetative development of cotton plant

Treatments	Main stem height (cm)	Nodes on main stem	Inter-nodal length (cm)	Main stem height (cm)	Nodes on main stem	Inter-nodal length (cm)
	Bt			Non-Bt		
	CCRI, Multan					
T1	92.4	31.4	2.94	89.4	30.5	2.93
T2	105.3	34.8	3.03	99.5	32.7	3.04
T3	101.0	34.1	2.96	92.5	31.4	2.95
T4	107.2	34.0	3.15	97.8	32.0	3.06
T5	100.2	33.6	2.98	93.5	31.6	2.96
T6	99.7	33.5	2.98	92.4	31.1	2.97
LSD	*4.87**	*1.52**	*0.05**	*5.64**	*1.54**	*0.09**
	6-MR, Vehari Rd					
T1	106.5	34.2	3.11	94.2	31.3	3.01
T2	112.3	35.4	3.17	103.4	33.2	3.11
T3	108.5	34.5	3.14	101.2	33.0	3.07
T4	115.3	35.7	3.23	110.3	33.6	3.28
T5	104.5	33.3	3.14	102.6	33.3	3.08
T6	102.6	33.0	3.11	101.5	32.9	3.09
LSD	*4.31**	*1.44**	*0.07**	*4.22**	*1.34**	*0.06**
	Naseer Pur, Shujabad					
T1	98.3	32.8	3.00	91.2	32.0	2.85
T2	106.2	33.6	3.16	98.7	33.3	2.96
T3	102.5	33.2	3.09	96.4	33.0	2.92
T4	109.3	34.0	3.21	101.6	33.9	3.00
T5	99.4	33.4	2.98	95.5	32.9	2.90
T6	98.4	33.2	2.96	94.3	32.4	2.91
LSD	*5.06**	*1.41**	*0.08**	*5.33**	*1.34**	*0.08**
	Chak 5-Faiz, Lodhran Rd					
T1	90.6	31.2	2.90	94.6	30.5	3.10
T2	98.6	32.8	3.01	95.1	31.3	3.04
T3	94.3	32.4	2.91	93.4	30.9	3.02
T4	104.2	33.3	3.13	99.8	31.8	3.14
T5	96.3	32.6	2.95	92.6	30.6	3.03
T6	90.7	32.6	2.78	93.4	30.8	3.03
LSD	*5.18**	*1.79**	*0.09**	*4.22**	*ns*	*0.05**

Data on nutrient uptake by whole cotton plant under different treatments and for all four locations are presented in Table 6.4. In general, the uptake of nutrients remained higher in Bt cotton than the non-Bt cotton. The trend was similar at all locations. However,

a comparison of the treatments of trial at CCRI, Multan indicated that the uptake of N, P, K, B and Zn nutrients varied significantly in different treatments. The treatment T4 where chemical fertilizers (N, P, K, B and Zn) were applied in conjunction with FYM surpassed the rest of the treatments in terms of nutrient uptake by cotton plant. The uptake of nutrients in CIM-616 (Bt cotton) ranged from 121-158 kg ha^{-1} (N), 22-34 kg ha^{-1} (P), 114-135 kg ha^{-1} (K), 136-183 g ha^{-1} (B) and 114-158 g ha^{-1} (Zn) while in Cyto-124 (non-Bt cotton), the uptake ranged from 116-136 kg N ha^{-1}, 20-28 kg P ha^{-1}, 108-130 kg K ha^{-1}, 128-160 g B ha^{-1} and 108-148 g Zn ha^{-1}.

Table 6.3 Effect of conjoint use of organic and inorganic fertilizers on seed cotton yield and its parameters

Treatments	Bolls per plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})	Bolls per plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})
	Bt			Non-Bt		
			CCRI, Multan			
T1	27	3.02	2620	26	2.99	2442
T2	32	3.14	3120	32	3.05	3070
T3	31	3.04	2996	30	3.06	2945
T4	30	3.12	2972	30	3.14	2930
T5	31	3.02	2940	30	3.04	2845
T6	31	3.03	2943	30	3.08	2860
Mean	30	3.06	2932	30	3.06	2849
LSD	*1.82**	*0.05**	*162.3**	*1.71**	*0.08**	*155.8**
			6-MR, Makhdum Rasheed			
T1	31	3.07	2965	28	3.02	2700
T2	35	3.11	3430	32	3.12	3160
T3	34	3.12	3366	31	3.15	3070
T4	33	3.21	3330	30	3.20	3055
T5	32	3.15	3200	31	3.12	3044
T6	32	3.16	3208	31	3.10	3037
Mean	33	3.14	3250	31	3.12	3011
LSD	*2.11**	*0.07**	*145.6**	*1.35**	*0.06**	*142.8**
			Naseer Pur, Shujabad			
T1	30	3.16	2945	30	3.02	2860
T2	35	3.18	3570	35	3.08	3330
T3	33	3.21	3420	31	3.12	3165
T4	32	3.32	3390	32	3.02	3167
T5	33	3.18	3260	31	3.04	3080
T6	32	3.23	3278	31	3.02	3066
Mean	33	3.21	3311	32	3.05	3111
LSD	*2.13**	*0.06**	*185.6**	*2.24**	*0.08**	*180.5**
			Chak 5-Faiz, Lodhran Road			
T1	30	3.15	2940	27	3.06	2745
T2	35	3.16	3453	35	3.12	3300
T3	34	3.18	3330	32	3.13	3160
T4	34	3.16	3320	31	3.18	3145
T5	32	3.28	3270	32	3.06	3110
T6	31	3.32	3230	31	3.16	3080
Mean	33	3.21	3257	31	3.12	3090
LSD	*2.10**	*0.07**	*153.4**	*1.95**	*0.06**	*155.4**

Table 6.4 Effect of organic and inorganic fertilizers on nutrient uptake by cotton plant

Treatments	N	P	K	B	Zn	N	P	K	B	ZN
	kg ha^{-1}			g ha^{-1}		kg ha^{-1}			g ha^{-1}	
	Bt					Non-Bt				
	CCRI, Multan									
T1	121	22	114	136	114	116	20	108	128	108
T2	156	31	133	145	115	138	28	129	132	112
T3	148	30	128	177	154	134	26	126	157	141
T4	158	34	135	183	158	136	28	130	160	148
T5	149	30	128	179	150	128	25	124	157	140
T6	151	30	127	182	148	129	26	125	160	142
Mean	147	30	128	167	140	130	26	124	149	132
LSD	*9.8***	*3.0**	*9.3**	*14.1**	*10.3**	*7.0**	*3.5**	*6.3**	*7.6**	*9.3**
	6-MR, Makhdum Rasheed									
T1	132	23	124	141	122	122	21	116	133	120
T2	160	29	146	145	130	151	28	130	135	124
T3	155	27	141	180	140	144	27	128	161	136
T4	162	33	158	186	153	160	30	136	175	141
T5	154	27	144	180	138	150	27	131	160	138
T6	158	27	142	179	136	149	27	132	162	137
Mean	154	28	143	169	137	146	27	129	154	133
LSD	*10.3**	*3.9**	*8.4**	*8.6**	*8.5**	*10.7**	*3.4**	*7.7**	*7.9**	*8.0**
	Naseer Pur, Shujabad									
T1	132	26	146	133	127	127	23	130	132	122
T2	158	39	188	136	131	137	28	166	133	124
T3	155	34	178	166	181	134	28	160	165	159
T4	164	37	190	176	189	141	32	176	170	166
T5	150	33	184	164	176	138	29	160	166	155
T6	153	31	182	166	177	139	29	167	164	157
Mean	152	33	178	157	164	136	28	160	155	147
LSD	*9.4**	*2.9**	*12.4**	*11.4**	*10.6**	*8.4**	*3.3**	*12.8**	*13.2**	*9.9**
	Chak 5-Faiz, Lodhran Road									
T1	133	24	132	119	124	127	21	114	107	116
T2	158	30	158	121	126	145	27	142	112	118
T3	154	28	152	148	168	137	24	135	138	156
T4	164	31	166	152	176	148	29	146	148	163
T5	155	28	151	144	164	141	26	135	136	159
T6	155	28	149	147	168	143	26	134	137	159
Mean	153	28	151	139	154	140	26	134	130	145
LSD	*11.0**	*2.4**	*13.9**	*12.8**	*13.4**	*8.8**	*4.2**	*7.6**	*8.2**	*9.2**

6.2 Seed physiology

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

Abiotic stresses (Drought and heat) are the major causes of decline in agricultural production world-wide. 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 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 was as given below:

T1	No Foliar application Foliar application (B &Zn)
T2	No Foliar application Foliar application (0.05% proline with B &Zn)
T3	No Foliar application Foliar application (0.1 % proline with B &Zn)
T4	No Foliar application Foliar application (0.15% proline with B &Zn)
T5	No Foliar application Foliar application (0.2 % proline with B &Zn)

Plant structure development in different treatments was recorded at maturity. Main stem height, nodes on main stem and inter-nodal length varied significantly ($p<0.05$) among different treatments. Main stem height varied from 95 to 112 cm, number of nodes on main stem from 35 to 38 and inter-nodal length from 2.66 to 2.89 cm in different treatments (Table 6.5).

Seed cotton yield differed significantly ($p<0.05$) among various treatments. The seed cotton yield varied from 2322 to 2700 kg ha^{-1} in different treatments. The maximum seed cotton yield was observed in treatment that received seed priming along with foliar application of 0.1 % proline with added B & Zn micronutrients. The ginning outturn varied from 38.0 to 41.0% in different treatments (Table 6.6).

Table 6.5 Effect of seed priming alone or in conjunction with exogenously applied proline with and without micronutrients on vegetative and reproductive development at maturity

Treatments	Main stem height (cm)	Nodes on main stem	Inter-nodal length (cm)
No Foliar application	109	38	2.87
Foliar application (B &Zn)	96	35	2.74
No Foliar application	109	38	2.87
Foliar application (0.05% proline with B &Zn)	99	36	2.75
No Foliar application	110	38	2.89
Foliar application (0.1 % proline with B &Zn)	106	38	2.79
No Foliar application	104	38	2.74
Foliar application (0.15% proline with B &Zn)	101	37	2.73
No Foliar application	100	37	2.76
Foliar application (0.2 % proline with B &Zn)	95	35	2.66
LSD	6.32*	1.21*	0.08*

Table 6.6 Effect of seed priming alone or in conjunction with exogenously applied proline with and without micronutrients on seed cotton yield

Seed priming	Seed cotton yield (kg ha^{-1})	GOT%
No Foliar application	2322	38.0
Foliar application (B & Zn)	2452	39.4
No Foliar application	2340	38.2
Foliar application (0.05% proline with B &Zn)	2596	40.6
No Foliar application	2348	38.3
Foliar application (0.1 % proline with B &Zn)	2700	41.0
No Foliar application	2352	38.0
Foliar application (0.15%proline with B &Zn)	2680	40.6
No Foliar application	2360	38.0
Foliar application (0.2 % proline with B &Zn)	2654	40.3
LSD	115.6*	2.06*

The assessment of seed quality parameters was done from the mature cotton seeds. Results indicated that seed priming alone or in combination with foliar sprays of 0.1% proline with and without added B & Zn micronutrients improved parameters such as seed germination, seed index, oil and crude protein content. Biochemical analysis of the oil revealed that the free fatty acids were within safe limits. Seed germination varied from 46-70%, seed index from 6.9-7.6 g, oil content from 16.6 to 20.2 % and crude protein from 20.5 to 26.8 % in different treatments (Table 6.7).

Data on fibre characteristics indicated that seed priming in combination with foliar sprays of 0.1% proline with added B & Zn micronutrients improved staple length, fibre strength, fibre fineness and uniformity index % among different treatments. Staple length ranged from 25.9 to 26.9mm, fibre strength from 26.9 to 27.4 G/Tex, uniformity index from 81.9 to 83.5 and fibre fineness from 4.6 to 4.9 µg inch^{-1} (Table 6.8).

Table 6.7 Effect of seed priming alone or in conjunction with exogenously applied proline with and without added micronutrients on seed quality parameters

Treatments	EC ($\mu S\ cm^{-1}$)	Na (%)	K (%)	pH	Seed index (g)	Germi-nation (%)	Oil (%)	Free fatty acid (%)	Crude protein (%)
No Foliar application	288	0.47	0.60	7.0	6.9	46	16.6	0.93	20.5
Foliar application (B & Zn)	327	0.49	0.65	7.5	7.2	56	17.8	0.84	22.0
No Foliar application	282	0.44	0.64	6.9	6.9	48	16.8	0.91	20.4
Foliar application (0.05% proline with B & Zn)	333	0.55	0.70	7.3	7.6	59	19.2	0.79	23.7
No Foliar application	278	0.56	0.67	6.9	7.0	47	16.9	0.90	24.8
Foliar application @ 0.1 % proline with B & Zn	302	0.58	0.74	7.4	7.6	70	20.2	0.63	26.8
No Foliar application	294	0.49	0.62	7.2	7.1	45	16.7	0.92	23.6
Foliar application @ 0.15% proline with B & Zn	318	0.52	0.69	7.3	7.5	66	18.7	0.65	25.4
No Foliar application	293	0.50	0.61	7.3	7.0	44	17.0	0.90	24.5
Foliar application @ 0.2 % proline with B & Zn	298	0.52	0.65	7.4	7.4	68	19.4	0.69	24.2

6.3 Soil-Plant-Water Relationships

6.3.1 Screening of advanced genotypes for drought tolerance

Water is the most precious and indispensable input for agricultural production. With the rise in population, intensification of agriculture and changing climate scenario, irrigation water scarcity is on rise. 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 deficit stress conditions.

Therefore, a field experiment was conducted at the experimental area of Central Cotton Research Institute, Multan during the cotton cropping season 2016-17. A total of twelve cotton genotypes viz. CIM-632, Cyto-313, CIM-620, NIAB-444, NIAB-545, PB-896, NIAB-1089, NIAB-878, NIAB-1048, NIAB-1042, NIAB-BT-2 and NIAB-1064 were evaluated for their performance under normal irrigation (-1.6 $\pm$ 0.2 MPa leaf water potential; ψ_w) and water deficit stress (-2.4 $\pm$ 0.2 MPa ψ_w).

Table 6.8 Effect of seed priming alone or in conjunction with exogenously applied proline with and without added micronutrients on fiber characteristics in different treatments

Treatments	Staple length (mm)	Uniformity Index (%)	Micronaire (µg inch^{-1})	Strength G/Tex1/8"
No Foliar application	26.0	82.0	4.7	27.0
Foliar application (B & Zn)	26.6	83.1	4.8	27.2
No Foliar application	25.9	82.0	4.6	27.1
Foliar application (0.05% proline with B &Zn)	26.8	82.7	4.7	27.2
No Foliar application	26.1	82.1	4.8	26.9
Foliar application (0.1 % proline with B &Zn)	26.9	83.5	4.8	27.4
No Foliar application	26.0	81.9	4.8	27.1
Foliar application (0.15%proline with B &Zn)	26.6	82.6	4.9	27.4
No Foliar application	25.9	81.9	4.8	26.9
Foliar application (0.2 % proline with B &Zn)	26.5	82.8	4.9	27.3

The treatments were laid out in RCBD with split-plot arrangement (water stress main plots; genotypes: sub-plots). Crop was sown on May 17, 2016. 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 3024 m^3 in no stress and 2545 m^3 in water stress treatments. A total precipitation of 155.2 mm (May-November) was received during the crop season.

Main stem height, nodes on main stem and inter-nodal length varied significantly ($p<0.05$) with water stress and among the genotypes. Main stem height varied from 54.9 cm to 104.3 cm, nodes on main stem from 24 to 37 and inter-nodal length from 1.89 to 3.15 cm in different genotypes. Imposition of water stress caused a decrease of 15% in main stem height, 9% in nodes on main stem and 6% in inter-nodal length. Averaged across the water stress treatment, main stem height varied from 61.1cm to 95.3 cm, nodes on main stem from 27 to 35 and inter-nodal length from 2.00 cm to 3.08 cm in different genotypes. The genotype NIAB-878 maintained maximum height (95.3cm) while maximum nodes (37) on main stem were observed in NIAB-1042 (Table 6.9).

The results revealed that seed cotton yield, number of bolls per plant and boll weight varied significantly ($p<0.05$) with water stress and among genotypes. The number of bolls per plant varied from 15 to 34, boll weight from 2.61 to 3.13 g and seed cotton yield varied from 1320 to 3360 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 2489 to 2048 kg ha^{-1}, bolls per plant from 27 to 23 and boll weight from 2.78 to 2.61g irrespective of the genotypes. The decrease, due to water stress, was 18% in seed cotton yield, 15% in bolls

per plant and 5.0% in boll weight. Averaged across the water stress treatments, the seed cotton yield varied from 1710 to 2850 kg ha^{-1}, bolls per plant from 19 to 30 and boll weight from 2.67 to 3.08g in different genotypes. The genotype NIAB-878 produced the maximum seed cotton yield (2850 kg ha^{-1}) and number of bolls per plant while NIAB-1048 had the highest boll weight (3.08g), irrespective of water stress levels (Table 6.9).

The observations regarding gas exchange characteristics like stomatal conductance (g_s), transpiration rate *(E)* and net photosynthetic rate *(P_N)* varied significantly ($p<0.05$) with water stress and among the genotypes. Averaged across genotypes, g_s varied from 15.8 to 19.2 m mol CO_2 m^{-2} s^{-1}**,** *E* from 4.05 to 5.23 µ mole H_2O $m^{-2}s^{-1}$ and P_N from 24.2 to 33.0 m mol CO_2 $m^{-2}s^{-1}$. Imposition of water stress caused 18% decrease in g_s, 23% decrease in *E* and 27% decrease in P_N. Among the genotypes, g_s varied from 13.5 to 22.6 mmol CO_2 $m^{-2}s^{-1}$, *E* from 3.42 to 6.05 µmol H_2O $m^{-2}s^{-1}$, P_N from 17.1 to 36.6 m mol CO_2 $m^{-2}s^{-1}$, irrespective of water stress treatments. Averaged across the water stress treatments, the genotype NIAB-878 maintained the highest values of stomatal conductance and net photosynthetic rate in comparison to other genotypes. The P_N/E varied from 5.03 to 6.59 m mol CO_2/ µ mole H_2O in different genotypes and decreased from 6.27 to 5.94 m mol CO_2/ µ mole H_2O with the imposition of water stress (Table 6.10).

Table 6.9 Interactive effects of genotypes and water stress on plant structure and yield parameters

Water stress treatments	Genotypes	Vegetative development			Reproductive development		
		Main stem height (cm)	Nodes on main stem	Inter-nodal length (cm)	No of bolls per plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})
No water stress (-1.6 ± 0.2 MPa ψ_w)	CIM-632	96.6	35	2.76	20	2.85	1860
	Cyto-313	100.0	36	2.78	22	3.06	2160
	CIM-620	97.6	31	3.15	25	2.87	2280
	PB-896	92.3	33	2.80	24	3.13	2340
	NIAB-444	93.0	35	2.66	26	2.86	2340
	NIAB-545	81.0	30	2.70	30	2.98	2880
	NIAB-1089	82.3	29	2.84	30	2.81	2640
	NIAB-878	98.3	34	2.89	34	3.16	3360
	NIAB-1048	97.3	35	2.78	30	3.12	2930
	NIAB-1042	104.3	37	2.82	30	2.93	2820
	NIAB-BT-2	67.3	32	2.10	24	2.73	2100
	NIAB-1064	97.6	31	3.15	24	2.88	2160
	Mean	**92.3**	**33**	**2.78**	**27**	**2.95**	**2489**
Water stress (-2.0 ± 0.2 MPa ψ_w)	CIM-632	81.0	33	2.46	18	2.77	1680
	Cyto-313	86.6	30	2.89	21	2.96	2040
	CIM-620	73.9	28	2.65	24	2.78	2100
	PB-896	78.0	30	2.62	19	2.81	1740
	NIAB-444	72.0	33	2.19	25	2.81	2220
	NIAB-545	76.6	29	2.65	27	2.80	2460
	NIAB-1089	66.9	24	2.79	24	2.64	1980
	NIAB-878	92.3	30	3.10	25	2.88	2340
	NIAB-1048	88.4	33	2.68	24	3.03	2280
	NIAB-1042	82.4	32	2.58	26	2.88	2400
	NIAB-BT-2	54.9	29	1.89	15	2.61	1320
	NIAB-1064	86.6	29	2.99	23	2.75	2020
	Mean	**78.3**	**30**	**2.61**	**23**	**2.81**	**2048**
LSD	Water stress	1.30**	4.71**	0.43**	3.89**	0.04**	27.6**
	Genotypes	4.77**	10.2**	0.29**	3.33**	0.05**	78.7**
	Interaction	5.06*	3.09^{ns}	0.31^{ns}	3.53*	0.08**	111.3**

Table 6.10 Interactive effects of genotypes and water stress on gas exchange characteristics and physiological water use efficiency

		Gas exchange characteristics

Water stress treatments	Genotypes	Stomatal conductance (g_s) (mmol CO_2 $m^{-2}s^{-1}$)	Transpiration rate (E) (µmol H_2O $m^{-2}s^{-1}$)	Net photosynthetic rate (P_N) (mmol CO_2 $m^{-2}s^{-1}$)	Physiological water use efficiency (P_N/E) (mmol CO_2/µmol H_2O)
No water stress (-1.6 ± 0.2 MPa ψ_w)	CIM-632	14.7	4.06	26.4	6.49
	Cyto-313	16.3	4.41	28.2	6.40
	CIM-620	16.7	4.51	28.0	6.21
	PB-896	18.1	4.86	31.8	6.55
	NIAB-444	18.2	4.92	32.5	6.61
	NIAB-545	21.5	6.14	40.3	6.57
	NIAB-1089	20.4	5.67	36.7	6.47
	NIAB-878	25.4	6.83	44.7	6.54
	NIAB-1048	23.8	6.38	41.9	6.57
	NIAB-1042	24.0	6.67	41.4	6.21
	NIAB-BT-2	15.6	3.99	20.3	5.20
	NIAB-1064	16.2	4.26	23.3	5.48
	Mean	19.2	5.23	33.0	6.27
Water stress (-2.0 ± 0.2 MPa ψ_w)	CIM-632	12.4	3.10	18.8	6.08
	Cyto-313	15.3	3.97	24.3	6.13
	CIM-620	15.3	3.87	23.7	6.12
	PB-896	13.2	2.93	16.1	5.52
	NIAB-444	14.8	4.02	26.3	6.59
	NIAB-545	18.5	4.87	32.1	6.61
	NIAB-1089	16.4	3.81	23.5	6.18
	NIAB-878	19.8	5.10	28.5	5.58
	NIAB-1048	17.9	4.68	29.5	6.30
	NIAB-1042	20.3	5.43	32.9	6.07
	NIAB-BT-2	11.3	2.84	13.8	4.87
	NIAB-1064	14.9	3.92	20.6	5.24
	Mean	15.8	4.05	24.2	5.94
LSD	Water stress	0.41**	0.50**	3.45**	0.41**
	Genotypes	1.04**	0.36**	2.92**	0.76**
	Interaction	1.48**	0.51**	4.12**	0.81^{ns}

6.5 Heat Tolerance

6.5.1 Adaptability of genotypes to temperature stress

Climatic anomalies play an important role in increasing the uncertainties in cotton production. Productivity of Cotton genotypes falls markedly at high temperatures. Higher night temperatures have given 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. Current rise in temperature is likely to continue during this century and extreme events associated with rise are also expected to increase in frequency, intensity and persistence thus 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. 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 occasionally high temperature of about 50°C during the month of May and June, which is approximately 20°C higher than the optimum temperature required for its normal growth, thus retarding performance to higher extent. Plant growth such as shoot development, flowering and fiber quality traits are influenced largely due to high temperature. Although adverse temperatures can affect all stages of development, the crop seems to be particularly sensitive to adverse temperatures during reproductive development. 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. Twenty-one genotypes were planted for screening under heat stress conditions.

Genotypes showed wide variation in various physiological parameters conferring to heat tolerance in cotton. Genotype NIAB-878 excelled in heat tolerance considering each trait compared with the other genotypes. Genotype NIAB-BT-2 was found to be the most susceptible genotype to heat stress (Table 6.11).

Physiological traits having relevance to heat tolerance were recorded in the genotypes. Results showed that there were positive correlations of pollen viability (r=0.205), percent boll set on first (r=0.234) and second (r=0.1) positions along sympodia with seed cotton yield. There were negative correlations of cell injury (r= -0.632) and electrical conductivity (r= -0.694) with the seed cotton yield. These traits may be considered while selecting future genotypes to overcome heat stress problems (Table 6.12).

The genotype NAIB-878 maintain the highest anther dehiscence compared to other genotypes and produced the highest seed cotton yield due to having maximum boll weight of 3.36g and number of bolls up to 28 per plant. The dehiscence of anthers was the lowest during1st and 2nd week of July and increased gradually in 1st week of August and later it increased continuously until 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 NAIB-878 produced the highest seed cotton yield than the other genotypes tested. Seed cotton yield of different genotypes ranged from 1167 to 2880 kg ha^{-1} (Table 6.13).

Fibre characteristics like staple length, uniformity index, fibre strength and fibre fineness varied marginally among different genotypes. The genotype NIAB-878 maintained higher values of staple length and uniformity index whereas the values of fibre strength and fibre fineness remained higher in genotype NIAB-1064 (Table 6.14).

Table 6.11 Relationship between seed cotton yield and physiological traits determining heat tolerance

Relationship	Pollen viability (%)	% boll set on 1st position along sympodia	% boll set on 2nd position along sympodia	Cell injury (%)	Electrical conductivity (µS cm^{-1})
Regression Equation	y =7.863x -1530	y = 15.37x + 1722	y = 10.18x + 1931	y = -22.33x + 3665	y = -4.555x + 483
Correlation co-efficient (*r*)	0.205**	0.234*	0.1**	-0.632*	-0.694 **

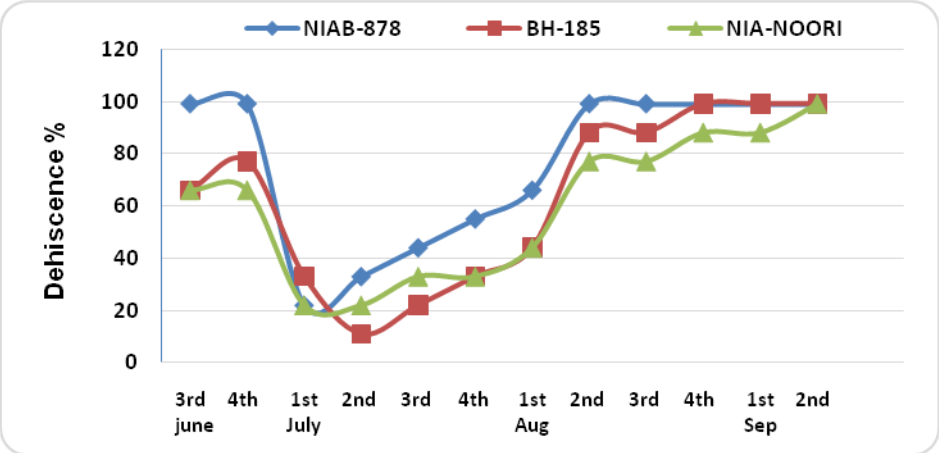

Fig. 6.1 Dehiscence of anthers during the season for three genotypes

6.12 Physiological traits determining heat tolerance in different genotypes

Physiological traits	NIAB -878	NIAB - 1064	Deebal	NIAB - 1042	NIAB -444	NIAB - 1048	Lala-zar	FH-142	NIAB -545	NIAB - 1089	DNH-57	GH-Mubarak	FH-Noor	MNH-992	BH-185	VH-363	PB-896	CIM-632	NIA-NOORI	Cyto -301	NIAB-Bt-2
Fully dehiscent anther (%)	82	78	78	74	73	73	72	67	66	64	63	63	61	61	61	60	60	59	57	55	53
Pollen viability (%)	97	95	92	88	85	81	78	77	69	67	66	65	64	64	63	68	69	62	59	60	55
First sympodial node number	10	12	11	9	10	11	9	11	9	10	8	9	10	11	12	9	11	10	12	11	11
First sympodial node height (cm)	20	19	21	21	19	23	20	23	18	19	19	17	21	23	24	17	18	21	22	20	21
Sympodial node number bearing first effective boll	24	21	22	11	20	27	21	19	17	19	14	18	17	15	19	21	18	17	33	19	21
Sympodial node height (cm) bearing first effective boll	53	52	57	44	39	55	53	32	29	41	47	58	31	37	46	49	41	39	75	44	35
Percent boll set on first position along sympodia	43	40	31	30	30	28	27	27	24	23	23	23	20	20	19	19	19	19	18	18	15
Percent boll set on second position along sympodia	26	22	22	21	21	21	19	19	18	18	17	17	17	15	13	13	12	11	11	10	10
Cell injury (%)	39	46	48	51	56	58	67	67	69	70	75	77	79	80	82	82	83	83	84	85	87
Electrical conductivity (μmhos cm^{-1})	168	175	172	186	181	185	199	243	266	279	295	301	327	331	334	342	365	359	367	380	403

Table 6.13 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)	GOT%
NIAB-878	2880	28	3.36	37
NIAB-1064	2516	28	2.80	44
Deebal	2497	25	3.30	40
NIAB-1042	2487	24	3.26	46
NIAB-444	2440	24	3.27	41
NIAB-1048	2334	24	3.14	44
Lalazar	2330	23	3.40	39
FH-142	2219	23	3.16	38
NIAB-545	2191	29	2.42	44
NIAB-1089	2191	17	4.10	45
DNH-57	2143	22	3.04	38
GH-Mubarak	2124	21	3.20	41
FH-Noor	2076	19	3.50	40
MNH-992	2009	22	2.92	39
BH-185	1904	24	2.52	43
VH-363	1894	26	2.28	47
PB-896	1885	19	3.12	39
CIM-632	1818	20	2.87	44
NIA-NOORI	1741	19	2.90	37
Cyto-301	1349	15	2.96	43
NIAB-Bt-2	1167	14	2.80	41
LSD(0.05)	**287.5**	**7.84**	**0.20**	

Table 6.14 Effect of heat stress on fiber characteristics in different genotypes

Genotypes	Staple length (mm)	U.I %	Micro naire (µg inch^{-1})	Strength G/Tex1/8"
NIAB-878	28.0	84.9	4.6	27.0
NIAB-1064	26.0	81.9	5.6	28.8
GH-Deebal	27.2	82.1	4.7	28.2
Lalazar	27.1	81.2	4.9	28.1
NIAB-1042	26.2	81.0	4.2	27.2
NIAB-444	25.7	78.2	4.4	25.7
NIAB-1048	26.4	82.8	4.4	27.8
FH-142	25.6	82.2	4.4	27.0
NIAB-545	27.0	82.0	4.5	28.4
NIAB-1089	27.8	81.0	4.6	26.8
DNH-57	24.4	80.3	4.6	27.3
GH-Mubarak	26.5	84.3	4.9	27.6
FH-Noor	28.0	84.1	5.4	27.6
MNH-992	27.6	84.8	4.6	28.7
BH-185	26.2	80.6	4.9	27.9
VH-363	25.0	82.1	4.9	27.8
PB-896	25.9	83.6	4.8	26.0
CIM-632	25.8	81.5	4.6	28.6
NIA-NOORI	24.5	81.5	5.2	26.4
Cyto-301	26.6	80.9	4.0	27.9
NIAB-Bt-2	26.4	82.0	4.9	27.7

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7. TRANSFER OF TECHNOLOGY SECTION

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

7.1 Human Resource Development

7.1.1 Training Program

The following training programs were arranged during the season:

i) Profitable cotton production technology
ii) Seed production technology
iii) Land preparation, selection of varieties & weed management
iv) Agronomic practices to sustain the production in climatic change
v) Importance of soil analysis
vi) Breeding methods for better traits
vii) Causes of low yield & its possible measures for better yield
viii) Pink Bollworm management & planning for the crop 2016-17
ix) Insect pest management on area-wide PBW management before & during cotton season
x) Management strategies against White fly & PBW
xi) Irrigation and water management
xii) Promising strains of the Institute especially to CIM-598
xiii) Insect Pest Management especially to White fly
xiv) Current cotton crop situation
xv) Clean cotton picking, storage and transportation
xvi) Contamination free cotton
xvii) Awareness Campaign regarding management of White fly
xviii) Relay Cropping
xix) Off-season campaign for Management of Pink Bollworm and Mealy bug

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

Date	Organized/ Coordinated by	Venue	Resource Person	Participants
07.04.2016	Agri. Extension Pinjab	JPP Wala	Dr. Muhammad Naveed	**Total =133** Farmers = 119 EDO = 01 DDO = 01 DO = 01 A.O = 03 F.A = 08
11.04.2016	Agri. Extension Pinjab	Laar, Multan	i)Dr. Dilbaugh Muhammad ii)Dr. Muhammad Naveed	**Total =147** Farmers = 133 EDO = 01 DDO = 01 DO = 01 A.O = 04 F.A = 07
13 .04.2016	FFC	Hasil Pur	i) Syed Sajid Masood Shah ii) Dr. Dilbaugh Muhammad iii) Dr. Muhammad Naveed	**Total = 287** Farmers = 247 Master Trainees = 13 FFC Staff = 19 Others = 08

14.04.2016	Agri. Extension Pinjab	Shuja Abad	Dr. Dilbaugh Muhammad	**Total =183** Farmers = 167 EDO = 01 DDO = 01 DO = 01 A.O = 02 F.A = 11
17.05.2016	Agri. Extension Balochistan	CCRI, Multan	i)Syed Sajid Masood Shah ii)Dr. Dilbaugh Muhammad iii) Dr. Muhammad Naveed	**Total = 24** Senior Instructor = 01 A.O =01 Progressive Farmers = 22
06.08.2016	Pakistan Farmers Forum (NGO)	Mian Chunnoo	Dr. Muhammad Nveed	**Total=52** Progressive=45 Farmers Staff=07
31.08.2016	Agri. Extension Deptt.Multan , Punjab	CCRI, Multan	Dr. Muhammad Naveed Afzal	**Total = 69** Farmers = 20 DO = 01 DDO = 01 A.O = 03 F.A = 44
01.09.2016	Agri. Extension Deptt. Balochistan	CCRI, Multan	Syed Sajid Masood Shah	**Total = 07** Deputy Directors of Agri.Extension Department of Balochistan
08.09.2016	PCSI, Multan	CCRI, Multan	i)Dr. Dilbaugh Muhammad ii)Dr. Muhammad Nveed iii)Mr. Sajid Mahmood	**Total=16** Cotton Selectors
17.09.2016	Agri. Extension Sindh & Shoaib Seed Corporation (Sindh)	Sindh	i)Syed Sajid Masood Shah ii)Dr. Muhammad Naveed iii)Dr. Muhammad Idrees Khan	**Total = 538** Farmers = 497 DO = 01 DDO = 01 A.O = 05 F.A = 11 Seed industries & others = 23
20.09.2016	Pakistan Kissan Forum (Lodhran)	CCRI, Multan	i)Syed Sajid Masood Shah ii)Mr. Zahid Iqbal Anjum ii)Dr. Muhammad Naveed iii)Dr. Muhammad Idrees Khan	**Total = 35** Progressive Farmers=27 Staff=08
21.09.2016	CCRI , Multan	Bahawal Pur Chak No 29-BC	i)Dr. Muhammad Naveed ii)Mr. Muhammad Ilyas Sarwar	**Total = 37** **(Farmers)**
-do-	CCRI , Multan	Basti Malook Moza Tinu Wala	i)Syed Sajid Masood Shah ii) Dr. Muhammad Naveed	**Total = 34** **(Farmers)**

22.09.2016	CCRI , Multan	Lodhran Dunya Pur Chak NO 364-WB (Makhdum Aali)	i)Syed Sajid Masood Shah ii) Dr. Muhammad Naveed	**Total = 40** (Farmers)
22.09.2016	Agri. Extension.Deptt. Vehari, Pujab	Vehari	Dr. Muhammad Naveed Afzal	**Total = 25** EDO = 01 DO = 01 DDO = 04 A.O = 19
23.09.2016	Agri. Extension.Deptt. Bahawal Pur, Pujab & CCRI,Multan	Bahawal Pur	Dr. Muhammad Naveed Afzal	**Total = 32** EDO = 01 DO = 01 DDO = 03 A.O = 13 F.A = 14
23.09.2016	CCRI,Multan	Super Chock,Lodhran	i)Syed Sajid Masood Shah ii) Dr. Muhammad Naveed	**Total = 49** (Farmers)
24.09.2016	-do-	Yazman, Bahawal Pur	-do-	**Total = 54** (Farmers)
25.09.2016	-do-	Goth Sha Muhammad (Col.Shoaib Farm)	-do-	**Total = 38** (Farmers)
-do-	-do-	Kher Pur Tame-wali (Dera M.Ameen Surpaul)	-do-	**Total = 73** (Farmers)
27.09.2016	-do-	Lala Wala/Juggu Wala ,JPW	-do-	**Total = 25** (Farmers)
29.09.2016	-do-	Kot Lal Shah, Karor Paka	-do-	**Total = 24** (Farmers)
01.10.2016	-do-	Chak NO 226/9-R Shahbaz Wala , Tehsil Fort Abbas, District Bahawal Nagar	-do-	**Total = 26** (Farmers)
-do-	-do-	Chak NO 283/H-R Shahbaz Wala , Tehsil Fort Abbas, District Bahawal Nagar	-do-	**Total = 12** (Farmers)
21.10.2016	-do-	CCRI,Multan	Dr.Muhammad Naveed Afzal	**Total = 30** (Farmers)

05.01.2017	PCCC & Agri. Extension KPK	D.I.Khan	i) Dr. Muhammad Naveed ii) Dr. Fiaz Ahmad iii)Dr. M.Idrees Khan iv)Dr. M. Naveed Afzal	**Total = 53** Farmers = 45 ADA = 02 F.A = 06
-do	-do-	-do-	-do-	**Total = 46** ADA = 03 A.O = 03 F.A = 40
16.01.2017	CCRI,Multan & Agri. Extension Punjab	Khanewal	Dr. Muhammad Naveed	**Total = 21** ADA = 02 A.O = 12 C.I = 07
-do	CCRI,Multan & Agri. Extension Punjab	Sahiwal	-do-	**Total = 20** DDA =01 ADA =01 AO =07 FA =05 CI =06
17.01.2017	CCRI,Multan & Agri. Extension Punjab	Vehari	-do-	**Total = 82** DDA = 01 ADA = 02 A.O = 20 F.A = 54 C.1 = 05
-do-	-do-	Bahawalnagar	-do-	**Total = 106** DDA = 01 ADA = 01 A.O = 12 F.A = 80 C.1 = 12
18.01.2017	-do-	Bahawalpur	-do-	**Total = 24** DDA = 01 A.O = 19 C.1 = 04
-do-	-do-	Lodhran	-do-	**Total = 39** DDA = 01 A.O = 06 FA. = 29 C.1 = 03
19.01.2017	-do-	Multan	-do-	**Total = 17** DDA = 01 ADA =02 A.O = 07 F.A =04 C.1 = 03
21.01.2017	-do	Bhakkar	i.Dr. Muhammad Naveed ii.Mr.Sajid Mahmood	**Total = 46** ADA = 02 A.O = 05 F.A =34 C.1 = 05
-do-	-do-	Layyah	-do-	**Total = 44** ADA = 01 AO = 06 F.A =34 C.1 = 03

23.01.2017	-do-	Muzaffar Garh	-do-	**Total = 40** DDA =01 ADA = 04 A.O = 11 F.A =20 C.1 = 04
-do-	-do-	D.G.Khan	-do-	**Total = 48** DDA =01 ADA = 03 A.O = 11 F.A =29 C.1 =04

7.1.2 TV Tellips/Sorts

The following TV Tellips/Sorts were conducted during the season:

Date	TV Channel	Topic	Resource Person	Remarks/Timing
05.05.2016	Channel 24, Multan	Causes of Low production of the last year & strategy for better cotton production in next year	Dr. Khalid Abdullah	Recorded/4Minutes
05.05.2016	Channel 24, Multan	Achievements of CCRI ,Multan	Syed Sajid Masood Shah	Recorded/2Minutes
05.05.2016	Channel 24, Multan	Approval of Non Bt Cyto 124 for general cultivation in Punjab	Mr. Zahid Qureshi	Recorded/2Minutes
05.05.2016	Channel 24, Multan	Approval of Six Varieties of the Institute for general cultivation in Punjab	Mr. Muhammad Idrees Khan	Recorded/3Minutes
27.05.2016	PTV, Multan	Agriculture policies of Punjab Government to enhance agriculture sector in the province	Dr. Farrukh Javed, Minister , Agriculture , Punjab	Recorded/4Minutes
27.05.2016	Express TV, Multan	The strategy for better cotton yield for next year 2016-17	Dr. Khalid Abdullah	Recorded/5Minutes
15.08.2016	Dunya News, Multan	Management for Cotton fruit-shedding	Dr. Dilbaugh Muhammad	Recorded/ 3Minutes
19.08.2016	Channel 24, Multan	Insect pests of cotton and their impact on yield	Mrs. Shabana Wazir	Recorded/ 4Minutes
31.10.2016	PTV, Islamabad	Objectives of 75th Plenary meeting of ICAC	Dr. Khalid Abdullah	Recorded/2minutes
2.11.2016	-do-	Strategy against Pink Bollworm Management	D. Muhammad Naveed	Recorded/5minutes
20.02.2017	Channel 24,Multan	Approval of Bt- 179 in expert sub-committee meeting	Dr. Zahid Mahmood	Recorded/2Minutes
-do-	-do-	Varietal character of Bt-179	Mr. Sajid Mahmood	Recorded/2Minutes

7.1.3 Radio Programs

The following Radio programs were recorded during the season:

Date	Radio	Topic	Resource Person	Remarks
17.01.2017	Super FM-90 Bahawalnagar	Talk on " Off-season campaign for Management of Pink Bollworm and Mealy bug"	Dr. Muhammad Naveed	Recorded & on air 15-minutes
19.01.2017	FM-Solo 88, Multan	Talk on "Activities of SMS Tele Cotton Service at the Institute"	Dr. Muhammad Naveed	Recorded & on air 5-minutes
-do-	-do	Talk on "Seed storage and ongoing research activities of Cytogenetics Section"	Ms.Rehana Anjum	Recorded & on air 5-minutes
-do-	-do	Talk on "Biological Control of Cotton Insects"	Ms.Rabia Saeed	Recorded & on air 5-minutes
22.02.2017	FM Solo-88 Multan	Talk on " Why Govt.of Punjab banned cotton cultivation before 15th April and management of Pink Bollworm	Dr. Muhammad Naveed	Recorded & on air 10-Minutes

7.1.4 Press Releases

Forty Four (44) press releases throughout the season were sent to the press time to time for publication.

7.1.5 Articles

Seven (07) Urdu articles with up to date recommendations were composed and sent to the press for the guidance of cotton growers during the season.

7.1.6 Press Reports

Following two press reports by Mr. Sajid Mahmood, SO, TTS were sent to the press and published during the season:

1. 75th Plenary Meeting of International Cotton Advisory Committee (ICAC) published in Daily Pakistan, Multan on November 13, 2016.
2. SMS Tele-Cotton Service at CCRI, Multan published in Daily Nawa-e-Waqt, Multan on 16.01.2017

7.1.7 Press Conferences

Three (03) press conferences were conducted for Cotton Crop Management Group (CCMG) Meeting throughout the season.

7.1.8 Media Coverage

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

Date	Media Coverage
05.05.2016	Agriculture Research Sub-Committee (ARSC) Meeting
27.05.2016	Cotton Crop Management Group (CCMG) Meeting
16.06.2016	Cotton Crop Management Group (CCMG) Meeting
16.07.2016	Khadim-e-Pinjab Kissan Package Awareness Seminar
04.08.2016	Cotton Crop Management Group (CCMG) Meeting
10.10.2016	Cotton Crop Management Group (CCMG) Meeting

7.1.9 Preparation of video clip messages

Following video clip messages were prepared for the visitors/farmers during the season:

Date	Topic
11.08.2016	Impact of rainfall on cotton crop and precautionary measures
01.09.2016	Red cotton bug, mode of damage & recommendations
22.11.2016	Cotton production technology film
02.12.2016	Importance of grazing in empty fields of cotton

7.1.10 Preparation of a documentary film

A documentary film on "Cotton Production Technology" was prepared by the section for the exhibition stall planted in 75th plenary meeting of ICAC held at Islamabad. Delegates visited the stall and appreciated.

7.1.11 Preparation of Handouts

The section composed and published following Urdu handouts during the season:

Sr.#	Handouts	No's
1.	CIM-573	1000
2.	CIM-608	1000
3.	Bt.CIM-598	1000
4.	Bt.CIM-599	1000
5.	Bt.CIM-602	1000
6.	Cyto-124	1000
7.	کپاس کے بیج کو محفوظ کرنے کے لیے سفارشات	2000

7.1.12 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 Departments for their information and guidance:

- Recommendations of Cotton Variety CIM-496
- Recommendations of Cotton Variety CIM-534
- Recommendations of Cotton Variety CIM-573
- Recommendations of Cotton Variety CIM-598
- Recommendations of Cotton Variety CIM-599
- Recommendations of Cotton Variety CIM-602
- Recommendations of Cotton Variety CIM-608
- Management of Pink Bollworm
- *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*

7.1.13 Posts for Social Media

Posts regarding "Recommendations for better cotton production technology "were prepared and uploaded on official FB Page of the Institute.

7.1.14 Tele-Cotton SMS Service

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

a. Fifteen (15) Tele-Cotton Advertisements were sent to press and published in various national newspapers for registration of cotton growers, extension workers and other stakeholders during the season.

b. Fifty Six (56) Tele-Cotton SMS were sent to cotton growers, extension workers and other stakeholders during the season.

c. Almost Two thousand (2000) clients of Tele-Cotton were registered on data – base during the season.

7.1.5 Agricultural Shows/Mela

The section planted the cotton stalls in following agricultural exhibitions held during the season:

Date	Organized by	Venue	Remarks
October 30 to November 4, 2016	PCCC	Serena Hotel, Islamabad	No. of foreign and local delegations visited the stall and appreciated the research work conducted by the scientists of PCCC
December 23, 2016	MNSUA	CCRI, Multan	got 1st prize and very well appreciated by the visitors and the organizing committee of exhibition
1st January,2017	-do-	-do-	The visitors appreciated the research work conducted by the scientists of the Institute
March 3, 2017	PCCC	MinTex, Islamabad	Members of National Standing Committee on Textile Industry visited the stall and were very pleased about activities of the PCCC in cotton promotion in the country

7.2 Meetings

7.2.1 Agriculture Research Sub-Committee (ARSC)

Three days consecutive annual meeting of Agriculture Research Sub-Committee (ARSC) of Pakistan Central Cotton Committee (PCCC) was held at Central Cotton Research Institute (CCRI), Multan on May 3-5, 2016 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 sectors and progressive farmers. The section provided technical facilities to organize the meeting.

7.2.2 Cotton Crop Management Group (CCMG)

Following four Cotton Crop Management Group (CCMG) Meetings were held at Central Cotton Research Institute, Multan during the season:

Date	Chaired by/Special guests
27.05.2016	i. Dr. Farrukh Javed, Agri., Minister for Agriculture, Government of the Punjab ii. Dr. Khalid Abdullah, Cotton Commissioner, Mintex was the Special guest of the meeting.
16.06.2016	i. Mr. Muhammad Mahmood, Secretary Agriculture, Punjab ii. Co-chaired by Mr. Hussain Sardar Additional Secretary,Task Force, Agriculture, Punjab & Dr. Khalid Abdullah,Cotton Commissioner, Mintex was the special guest of the meeting
04.08.2016	i. Mr. Muhammad Mahmood, Secretary Agriculture, Punjab ii. Syed Fakhar Imam, Ex. Speaker National Assembly, Rana Ejaz

	Ahmed Noon, Parliamentary Secretary, Punjab Assembly and Dr. Khalid Abdullah, Cotton Commissioner, Mintex were the special guests of the meeting.
19.10.2016	i. Mr. Muhammad Mahmood, Secretary Agriculture, Punjab ii. Syed Fakhar Imam, Ex. Speaker National Assembly was the special guest of the meeting.

Dr. Asif Ali, Vice Chancellor, MNSUA, Multan; Dr. Anjum Ali Butter, Director General Agri Ext., Dr. Abid Mahmood, Director General Agri Research, Dr. General Pest Warning & Quality Control, Syed Sajid Masood Shah, Director CCRI Multan, Chief engineers of irrigation department, representative of MEPCO, Multan, progressive farmers and stakeholders of public & private sectors attended the meetings .The section provided technical facilities to the meetings.

7.2.3 Cotton Crop Assessment Committee

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

Date	Chaired by
06.09.2016	Mr. Ameer Muhammad Marwat , Secretary, Ministry of Textile Industry, Islamabad
07.10.2016	Mr. Hassan Iqbal, Secretary, Ministry of Textile Industry, Islamabad
05.12.2016	Mr. Hassan Iqbal, Secretary, Ministry of Textile Industry, Islamabad

7.2.4 75th Plenary Meeting of ICAC

75th meeting of International Cotton Advisory Committee (ICAC) organized by Pakistan Central Cotton Committee Multan was held at Serena Hotel, Islamabad on 30th October to November 4, 2016.The theme was "Emerging Dynamics in Cotton: Enhancing Sustainability in the Cotton Value Chain". The proposed agenda encompassed a broad range of topics, including: climate change; measures and methodologies to reduce the water footprint of cotton; enhancing the attractiveness of cotton production as a business proposition to farmers; sustainable production practices; challenges facing cotton in the textile industry; modern approaches to preservation of quality and reduction of contamination; state-of-the-art ginning and instrument testing practices; inter-fiber competition; and the role of the public sector in the production and trade of cotton. Almost 150 delegates of 30 countries participated in this significant meeting. Research scientific staff of Cotton Research Institutes, Multan & Sakrand and other scientific staff of all cotton research stations of Pakistan Central Cotton Committee Multan participated in the meeting as well. Dr. Muhammad Naveed presented a paper titled “New Pests New Challenges” during technical session and Muhammad Ilyas Sarwar also presented a paper titled “Co-existence of cotton fiber among competitors fibers with future prospects”.

7.2.5 48th Meeting of Punjab Seed Council

48th Meeting of Punjab Seed Council was held on March 6, 2017 at Lahore under the chairmanship of Minister of agriculture, Punjab, Muhammad Naeem Akhtar Khan Bhaba.In the meeting three varieties of CCRI, Multan i.e Bt.Cyto-179, Bt.Cyto-177 and Bt.CIM-600 were approved for general cultivation for the year, 2017. Dr. Khalid Abdullah, Vice President, PCCC appraised the Director and scientists of CCRI, Multan on this great achievement. Dr. Zahid Mahmood, Director & Dr. Muhammad Idrees Khan, Head, PBG Section of the Institute attended the meeting with other participants.

7.2.6 Cotton Production Plan 2016-17

A meeting on Cotton Seed Production Plan 2017 was held at the institute on May 30, 2016 under the chairmanship of Dr. Shakeel Ahmad Khan, Director General, Federal Seed Certification & Registration Department, Islamabad to review the availability of

cotton seed during Kharif 2016. Syed Sajid Masood Shah, Director CCRI Multan; Regional Directors of FSC&RD; representatives of seed companies and other stakeholders attended the meeting.

7.2.7 PCCC Budget Meeting 2016-17

A meeting on "PCCC budget 2016-17" was held at the institute on 1st June 2016 under the chairmanship of Dr. Khalid Abdullah, Vice President, PCCC. Mr. Gull Muhammad, Secretary , PCCC; Dr. Tassawar Hussain Malik, Director Research, PCCC; Dr Muhammad Ali Talpur, Director, Marketing & economic research, PCCC , Directors of CCRI ,Multan & Sakrand , and in charge of all stations of PCCC participated in this session. The section provided technical facilities to the meeting.

7.2.8 Formulation of Agriculture Policy

A consultative meeting of Formulation of Agriculture Policy, organized by MNSUA Multan was held on 14th November, 2016 at the Institute. The meeting was chaired by Haji Sikandar Hayyath Khan Bosan, Federal Minister for National Food Security. Large numbers of growers and scientists participated and added their inputs to be incorporated in policy. The section provided technical assistance to organize the meeting.

7.2.9 Klean Cotton Herbicide Resistance

A meeting on "Klean Cotton Herbicide Resistance Meeting" was held at the institute on 1st December, 2016.Mr. Tariq Mahmood Director CCRI, Multan & Scientists of the Institute discussed with Dr Idrees Nasir & Muhammad Siddique of CEMB Lahore on Screening of Clean Cotton Herbicide Resistance at CCRI, Multan during 2016-17

7.2.10 Off-season Training Program

A meeting regarding off-season training programs was held at the institute on December 27, 2016. Dr. Khalid Abdullah, Vice-President, PCCC presided over the meeting to chalk out growers training programs for cotton crop season 2017 with special emphasis on off-season pest management, with coordinating of provincial agriculture department in order to complement resources and give a unified message to cotton growers of Punjab. Mr. Tariq Mahmood, Director of the institute, Dr. Sagheer Ahmad, Director (Cotton), Ayub Agriculture Research Institute, Faisalabad, Haji Naseer Ahmad, District Officer Agriculture (Extension), Multan, Mr. Khalid Bhutta, Deputy Director Pest Warning and Quality Control of Pesticides Multan, Dr. Muhammad Naveed, Head Entomology & TOT, Mr. Zahid Iqbal Anjum, Head Cytogenetics , Mr. Muhammad Tariq SO, Agronomy CCRI, Multan participated the meeting.

7.2.11 Development of prediction model for pink bollworm

A meeting regarding the development of prediction model for Pink bollworm was held at Agriculture Secretariat, Director General (PQ&QC), PITB office, Lahore on Feb, 17, 2017. Dr. Muhammad Naveed Entomologist of the institute provided technical assistance to Fahad Ali, Program Manager Punjab Public Reforms Management Project (PPRMP) and others attendees.

7.3 Seminars

a. Following seminars on cotton production technology and other related issues were held during the season:

i. Cotton planting in standing Wheat
ii. Khadim-e-Pinjab Kissan Package Awareness Seminar
iii. Cotton Diseases & their Control
iv. Development finance for non -farm sector of agriculture today
v. International Seminar on Water Resource Management

Date	Organized by	Venue	Resource Persons	Participants
April22,2016	CCRI, Multan in collaboration with ICARDA	CCRI, Multan	i. Dr. Abdul Majeed Country Manager, ICARDA ii. Mr. Muhammad Arshad, Consultant, ICARDA	**Total = 72** Farmers = 34 EDO = 01 DO = 01 AO = 02 FA = 11 Technical participants = 17 Academia = 06
July 16,2016	-do-	CCRI, Multan	i.Dr Khalid Abdullah ii.Director CCRI,Multan iii.And other scientific staff of the institute	**More than 150** growers
October 7,2016	B.Z.U.Multan	B.Z.U.Multan	Mr. Tariq Mahmood	**Total = 47** Students
December 23,2016	Muhammad Nawaz Sharif University of Agri. Multan (MNSUA)	CCRI, Multan	Director CCRI,Multan and other scientific staff of the institute	**More than 200** Farmers, academia, representatives of public and private sectors
January 20 , 2016	-do-	CCRI, Multan	-do-	**More than 200** Farmers, academia, representatives of public and private sectors

b. Internal Seminar for Scientific Staff Members

Upon the decision made in the Agricultural Research Sub Committee (ARSC) meeting 2015-16 of the PCCC, Ten (10) internal seminars of the Institute for scientific staff members to improve their skill to represent the research activities were held during the season. Madam Sabahat SSO/Head Plant Pathology coordinated the events and the section provided technical facilities to organize the seminars.

c. Traveling Seminar

The scientists of traveling seminar visited the Institute on September 29, 2016. Dr. Muhammad Idrees Khan, Head ,PBG ,Mr. Muhammad Akbar, SO, PBG & Mr. Muhammad Imran, SO, Cytogenetics, Sections of the Institute participated in the seminar as coordinator, Dr. Saghir Ahmad, In charge, CRS, Multan and other agri. scientists were also attended the seminar. Dr. Tassawar Husain Malik. Director Research PCCC was the organizer of this traveling seminar.

7.4 MoU between MNSUA & PCCC

Memorandum of Understanding (MoU) for mutual cooperation in academic and R&D of cotton between Muhammad Nawaz Sharif University of Agriculture (MNSUA), Multan and Pakistan Central Cotton Committee (PCCC), Multan was signed on 1st June 2016. Prof. Dr. Asif Ali, Vice Chancellor, MNSUAM and Dr Khalid Abdullah, Vice President, PCCC signed the MoU. Mr. Gull Muhammad, Secretary; Dr.Tassawar Hussain Malik, Director Research; Dr Muhammad Ali Talpur, Director (Marketing); Syed Sajid Masood Shah, Director CCRI were also present in this occasion

7.5 Participation in Workshop/Conference

Date	Workshop/Conference	Venue	Organized by	Participants

April 27, 2016	Workshop on Information & Communication Technologies (ICT's) for Agricultural Technology Transfer	MNS-UAM	MNSUAM & UAF , Faisalabad	Mr. Sajid Mahmood
May 2-6,2016	World Cotton Research Conference-6(WCRC)	Brazil	ICAC	i) Dr. Dilbaugh Muhammad ii) Ms.Asia Perveen
June 8,2016	Workshop on "installation of pheromones & light traps at PCCC substations"	CCRI,Multan	PCCC	Dr. Muhammad Naveed & other scientists of PCCC sub-stations
August 12-13, 2016	Workshop on Data Analysis using *SPSS	Islamabad	Trading & Development Net Work (TDN)	i) Mr. Mubashir Islam Gill ii)Mrs. Asia Perveen
August 29-31, 2016	Conference on " SAARC Regional Co-coordinated Cotton Technology Exchange Program"	India (Nagpur)	SAARC	Dr. Dilbaugh Muhammad
December 16-18,2016	Conference on "International Entomological Congress"	Faisalabad	Pakistan Entomological Society	Dr.Muhammad Naveed presented "Forecasting of pink bollworm model based on pheromone trap catches"
February 23,2017	Conference on "recent advances and strategies for management of cotton whitefly in Pakistan" at AARI, Faisalabad".	Faisalabad	AARI Faisalabad	Dr Muhammad Naveed presented "Role of alternate host plants for the conservation of natural enemies of whitefly" i)Dr. Zahid Mahmood iii)Dr.Fiaz Ahmed iv)Dr.M.Idrees Khan v)Dr.M.N.Afzal vi) Ms.Rehana Anjum vii)Mr.Sajid Mahmood viii)Mr.Khadim Hussain ix)Hafiz.M.Imran x)Ms.Asia Perveen

7.6 Visitors

a)

Dignitaries/Delegation	Dated
Visit of Cap. (Retd.) Mr. Arif Nadeem, CEO, Pakistan Agriculture Coalition, Lahore	24.03.2016
5-members Malaysian Delegation	26.05.2016
Dr. Farrukh Javed, Agri., Minister for Agriculture, Government of the Punjab	27.05.2016
Mr. Hussain Sardar, Additional Secretary, Task Force, Agriculture, Punjab. Secretary Agriculture, Punjab	27.05.2016
Dr. Asif Ali, Vice Chancellor, MNSUA, Multan	27.05.2016
Dr. Anjum Ali Butter, Director General Agri Ext	27.05.2016
Dr. Abid Mahmood, Director General Agri Research	27.05.2016
5-members Malaysian Delegation	26.05.2016
Mr. Abdul Rahman, Deputy Secretary (Admn-1), and Syed Iftikhar Hussain Naqvi, Deputy	02.06.2016

Secretary (PC), Ministry of Textile Industry	
Prof. Dr. Jalal Arif, Chairman, Department of Entomology, UAF, Faisalabad	02.11.2016
Mr. Ikram Ahmad, Assistant Controller, Food Department, Multan	02.11.2016
Ch. Asif Ali, Chairman, Seed Association of Pakistan (SAP)	22.11.2016
Mr. Hassan Iqbal, Federal Secretary, Ministry of Textile Industry, Islamabad	10.11.2016
Mr. Muhammad Jamil, Ex. MPA from Bahawalpur	07.12.2016
Five member delegations of agriculture scientists from Mozambique and Nigeria	13.12.2016
3-member Chinese delegation from AGVEN Pvt Ltd., Karachi	12.01.2017

b) Student Study Tour

Name of University/Institution	No. of Participants
University of Agriculture, Faisalabad	151
University College of Agriculture, BZU, Multan	79
Muhammad Nawaz Sharif University of Agri. Multan(MNSUA)	101
Islamia University, Bahawalpur	191
The University of Poonch Rawlakot, Azad Kashmir	89

7.7 Face book Page CCRI, Multan

A page on Face book www.facebook.com/CCRI.MTN 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

The Fibre Technology Section provided the fibre testing and spinning services to the various sections of the Institute and particularly to the Plant Breeding & Genetics and Cyto-Genetics sections. 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 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 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. The lint samples collected by PICR&T during the Quality Survey of Ginning factories from Punjab & Sindh were analysis 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 is fruitful for cotton breeders, 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		Color grade	Trash	Total
			g tex^{-1}	Tppsi			
Breeding, CCRI, Multan	10091	9864	9864	601			30420
Cytogenetics, CCRI Multan	7791	7711	7711	13			23226
Agronomy, CCRI, Multan	123	123	123				369
Entomology, CCRI, Multan	102	102	102				306
CCRI, Sakrand	391	391	391				1173
CRS, Lasbella	40	40	40				120
CRS, Ghotki	909	909	909				2727
CRS, M.P. Khas	124	124	124				372
CRS, D.I.Khan	1000	1000	1000				3000
Ayub Agriculture Res. Inst. FSD	27	27	27	14			95
Punjab Seed Corp. Khanewal	124	124	124	2			374
Federal Seed Cert. Khanewal	71	71	71				213
Students	510	492	492				1494
Quality Survey	1103	1103	1103		1103		4412
Private Sector	14	14	14				42
Total	**22420**	**22095**	**22095**	**630**	**1103**	**0**	**68343**

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-602 and *Bt.*CIM-632 sown at five different sowing dates viz., 1st March 2016, 15th March 2016, 1st April 2016, 15th April 2016 and 1st May 2016. To identify the severity levels of virus the technical support is provided by Plant Pathology Section of the Institute. 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 cotton leaf curl virus disease significantly effect on fibre characteristics.

Table 8.2 Fibre characteristics of variety *Bt*.CIM-602 of affected by different virus severity levels

Characteristics	1st March 2016				15th March 2016				1st April 2016				15th March 2016					1st May 2016				
	Healthy	Mild	Medium	%DOH	Healthy	Mild	Medium	%DOH	Healthy	Mild	Medium	%DOH	Healthy	Mild	Medium	Severe	%DOH	Healthy	Mild	Medium	Severe	%DOH
GOT %	39.2 a	37.1 b	36.9 c	**5.87**	38.9 a	37.8 b	37.5 c	**3.60**	37.6 a	37.0 b	36.8 c	**2.13**	37.0 a	36.2 b	35.9 c	35.1 d	**5.14**	35.3 a	34.2 b	33.9 c	32.4 d	**8.22**
Seed Index	6.05 c	6.66 b	7.23 a	**-19.50**	6.35 c	6.50 b	6.70 a	**-5.51**	6.60 b	6.50 c	6.80 a	**-3.03**	6.30 d	7.50 c	8.20 b	8.56 a	**-35.87**	8.00 d	8.50 c	8.90 b	9.20 a	**-15.00**
Length (mm)	29.3 a	27.9 b	27.7 c	**5.46**	28.4 a	27.6 b	27.3 c	**3.87**	28.0 a	27.2 b	26.6 c	**5.00**	27.2 a	26.6 b	26.1 c	26.0 d	**4.41**	26.9 a	26.6 b	25.9 c	24.4 d	**9.29**
Unif. Index %	81.9 a	81.5 b	81.5 b	**0.49**	83.5 a	82.7 b	82.4 c	**1.32**	80.6 a	79.9 b	79.4 c	**1.49**	81.9 a	81.5 b	81.5 b	81.0 c	**1.10**	80.1 a	79.6 b	79.4 c	79.0 d	**1.37**
Micronaire	3.8 c	4.2 b	4.3 a	**-13.16**	3.6 c	4.0 b	4.1 a	**-13.89**	3.4 c	3.7 b	4.1 a	**-20.59**	3.8 d	4.4 c	4.7 b	4.8 a	**-26.32**	3.7 c	4.1 b	4.1 b	4.4 a	**-18.92**
Strength (G tex^{-1})	30.5 a	28.8 b	28.6 c	**6.23**	29.7 a	28.9 b	28.5 c	**4.04**	28.8 a	28.6 b	27.5 c	**4.51**	27.5 a	-	27.3 b	27.2 c	**1.09**	28.4 a	28.0 b	27.1 c	-	**4.58**
Short Fibre Ind.	8.5 c	8.7 b	8.8 a	**-3.53**	6.7 c	7.8 a	7.4 b	**-16.42**	10.0 c	10.5 b	11.1 a	**-11.00**	8.9 a	-	8.4 b	8.0 c	**10.11**	10.0 c	10.4 b	10.6 a	-	**-6.00**
Elongation %	5.7 a	5.4 b	5.0 c	**12.28**	5.8 a	5.2 b	4.9 c	**15.52**	5.7 a	5.6 b	5.4 c	**5.26**	5.4 a	-	5.3 b	5.1 c	**5.56**	5.9 a	5.9 a	5.7 b	-	**3.39**

Values with different letters in each column of every date of sowing are statistically significant at p<0.05.

%DOH= percentage decrease over healthy

Table 8.3 Fibre characteristics of variety *Bt.* CIM-632 as affected by different virus severity levels.

Characteristics	1st March 2016			15th March 2016				1st April 2016					15th March 2016					1st May 2016		
	Healthy	Mild	%DOH	Healthy	Mild	Medium	%DOH	Healthy	Mild	Medium	Severe	%DOH	Healthy	Mild	Medium	Severe	%DOH	Healthy	Severe	%DOH
GOT %	41.9 a	40.6 b	**3.10**	40.1 a	39.3 b	38.7 c	**3.49**	38.8 a	37.5 b	36.9 c	36.4 d	**6.19**	37.3 a	36.4 b	35.8 c	35.6 d	**4.56**	36.1 a	34.6 b	**4.16**
Seed Index	5.07 b	5.45 a	**-7.50**	5.60 c	6.20 b	7.00 a	**-25.00**	7.10 d	7.15 c	7.50 b	7.55 a	**-6.34**	6.80 d	7.51 c	8.20 b	8.35 a	**-22.79**	7.90 b	8.56 a	**-8.35**
Length (mm)	29.0 a	27.0 b	**6.90**	28.9 a	27.4 b	27.2 c	**5.88**	26.1 a	25.4 b	24.7 c	24.1 d	**7.66**	25.2 a	24.2 b	24.1 c	23.4 d	**7.14**	24.5 a	23.9 b	**2.45**
Unif. Index %	84.7 a	81.1 b	**4.25**	83.8 a	80.4 b	80.3 b	**4.18**	82.7 a	81.9 b	80.1 c	78.6 d	**4.96**	81.0 a	79.3 b	79.0 c	77.3 d	**4.57**	80.0 a	79.1 b	**1.13**
Micronaire	3.8 b	4.0 a	**-5.26**	4.1 c	4.3 b	4.9 a	**-19.51**	4.4 c	4.8 b	4.9 a	4.9 a	**-11.36**	4.2 d	4.6 c	4.8 b	4.9 a	**-16.67**	4.4 b	4.9 a	**-11.36**
Strength (G tex^{-1})	30.5 a	29.9 b	**1.97**	-	-	28.0		29.0 a	-	27.7 b	-	**4.48**	28.7 a	27.9 b	-	25.9 c	**9.76**	27.5 a	26.8 b	**2.55**
Short Fibre Ind.	4.6 b	8.9 a	**-93.48**	-	-	9.7		8.9 b	-	9.1 a	-	**-2.25**	9.0 c	9.9 b	-	12.7 a	**-41.11**	9.5 b	11.2 a	**-17.89**
Elongation %	5.2 b	5.6 a	**-7.69**	-	-	5.3		5.3 a	-	5.2 b	-	**1.89**	5.3 a	5.1 b	-	5.0 c	**5.66**	5.2 a	5.1 b	**1.92**

Values with different letters in each column of every date of sowing are statistically significant at p<0.5

There were significant differences between healthy and diseased cotton plants of both varieties, for ginning out turn, seed index, fibre length, micronaire, strength, short fibre index and elongation (Table 8.2 & 8.3). Ginning out turn % was negatively affected by CLCuD of both test varieties. The maximum decrease in GOT % was found in variety *Bt*.CIM-602 (8.22%) at 1st May, 2016 sowing date and minimum decrease in variety *Bt*.CIM-602 (2.13%) at 1st April, 2016 sowing date as compared to healthy plants. Seed Index was positively affected by CLCuD of both varieties. The maximum increase in seed index was found in variety *Bt*.CIM-602 (-35.87%) at 15th March, 2016 sowing date and minimum increase in variety *Bt*.CIM-602 (-3.03%) at 1st April, 2016 sowing date as compared to healthy plants.

Fibre length was influenced negatively by the virus disease incidence for both varieties. The maximum decrease in length was found in variety *Bt*.CIM-602 (9.29%) at 1st May, 2016 sowing date and minimum decrease in variety *Bt*.CIM-632 (2.45%) at 1st May, 2016 sowing date as compared to healthy plants. Uniformity index was influenced negatively by the virus disease incidence for both varieties. The maximum decrease in uniformity was found in variety *Bt*.CIM-632 (4.96%) at 1st April, 2016 sowing date and minimum decrease in variety *Bt*.CIM-602 (0.49%) at 1st March, 2016 sowing date as compared to healthy plants. Micronaire value was positively affected by CLCuD of both varieties. The maximum increase in micronaire was found in variety *Bt*.CIM-602 (-26.32%) at 15th March, 2016 sowing date and minimum increase in variety *Bt*.CIM-632 (-5.26%) at 1st March, 2016 sowing date as compared to healthy plants. Fibre strength was influenced negatively by the virus disease incidence for both varieties. The maximum decrease in strength was found in variety *Bt*.CIM-632 (9.76%) at 15th March, 2016 sowing date and minimum decrease in variety *Bt*.CIM-602 (1.09%) at 15th March, 2016 sowing date as compared to healthy plants. Short fibre index was positively affected by CLCuD of both varieties. The maximum increase in short fibre index was found in variety *Bt*.CIM-632 (-93.48%) at 1st March, 2016 sowing date and minimum increase in variety *Bt*.CIM-632 (-2.25%) at 1st April, 2016 sowing date as compared to healthy plants. Elongation % was negatively affected by CLCuD of both varieties. The maximum decrease in elongation was found in variety *Bt*.CIM-602 (15.52%) at 15th March, 2016 sowing date and minimum decrease in variety *Bt*.CIM-632 (1.89%) at 1st April, 2016 sowing date as compared to healthy plants.

Previous studies have documented the impacts of CLCV disease incidents on fibre properties. Singh (2006) observed that CLCuD reduced the fibre length by 5.2 %, strength by 5.4 %, elongation by 10.0 %, uniformity by 2.2 % and miconaire value by 4.1 % in diseased plants over the healthy plants. Akhtar *et al.,* concluded that the disease CLCuD has a significant effect on GOT and other cotton fibre quality traits.

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

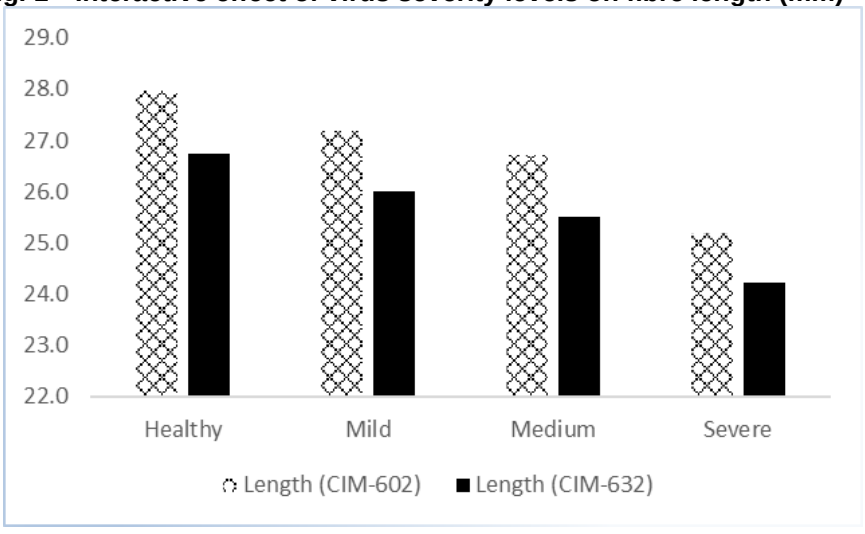


Fig. 2 Interactive effect of virus severity levels on fibre strength (g tex^{-1})

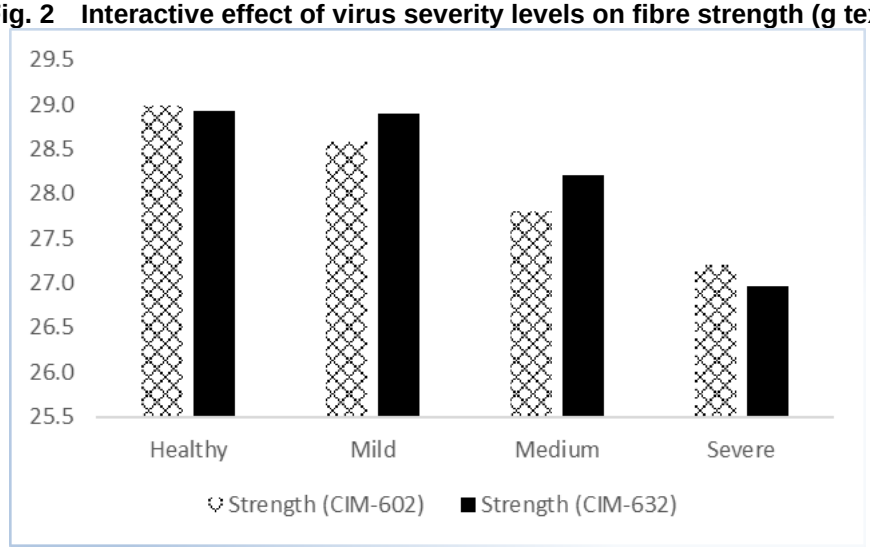


Fig. 3 Interactive effect of virus severity levels on micronaire value

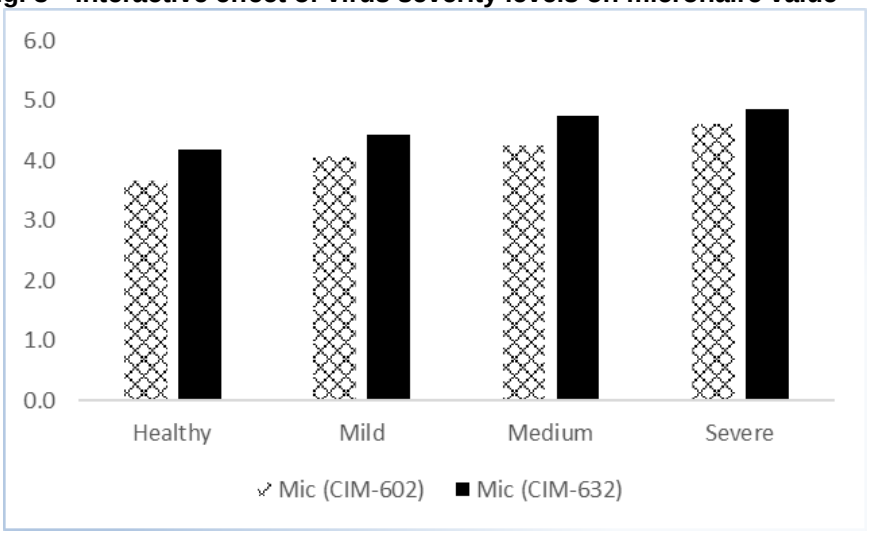
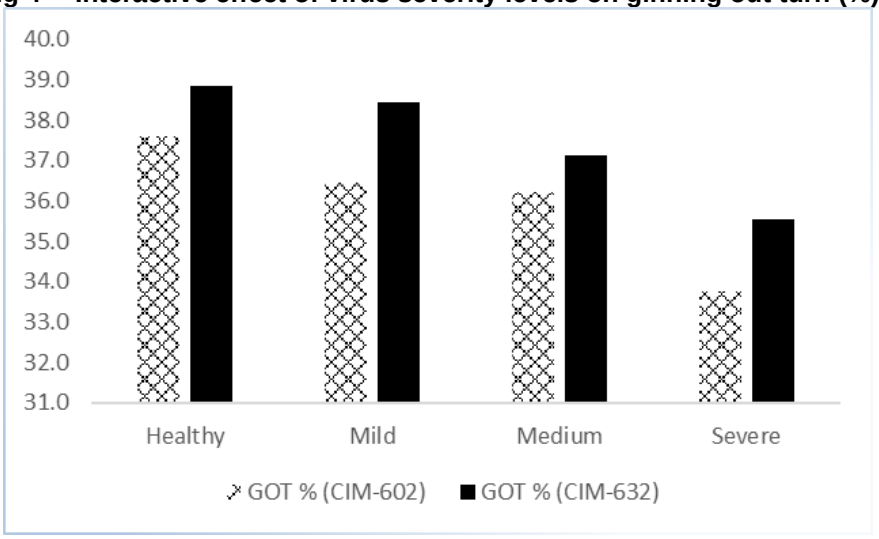


Fig 4 Interactive effect of virus severity levels on ginning out turn (%)



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

The objective of the experiment was to study the effect of different moisture content 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 when testing cotton fibre. The cotton variety *Bt.*CIM-616 was selected for the experiment. The seed cotton was ginned. The 50 lint samples of each moisture level viz., 6%, 8.5%, 10% and 12% were prepared and tested for various fibre characteristics. The results are presented in Table 8.4.

Table 8.4 Fibre characteristics as affected by different moisture content levels.

Moisture Level %	Fibre Length (mm)	Fibre Strength (g/tex)	Micronaire value	Uniformity Index %	Short Fibre Index %	Elongation %
6%	26.3 d	27.7 d	4.7 c	82.8 c	8.1 a	4.4 a
8.5%	27.4 c	30.8 c	4.8 b	84.8 b	5.3 b	3.8 b
10%	27.6 b	31.9 b	4.8 b	85.0 a	5.1 b	3.6 c
12%	27.8 a	32.4 a	5.1 a	85.2 a	4.8 c	3.3 d

Values with different letters in each column of every date of sowing are statistically significant at p<0.5

The findings from different moisture content levels are presented in table 8.4 revealed that there were significant differences between different moisture content levels, for fibre length, fibre strength, micronaire value, uniformity index, short fibre index and elongation. The fibre length, fibre strength, micronaire value and uniformity increased, short fibre index and elongation decreased with increase in moisture content level.

Fig. 5 Interactive effect of different moisture content levels on fibre length (mm)

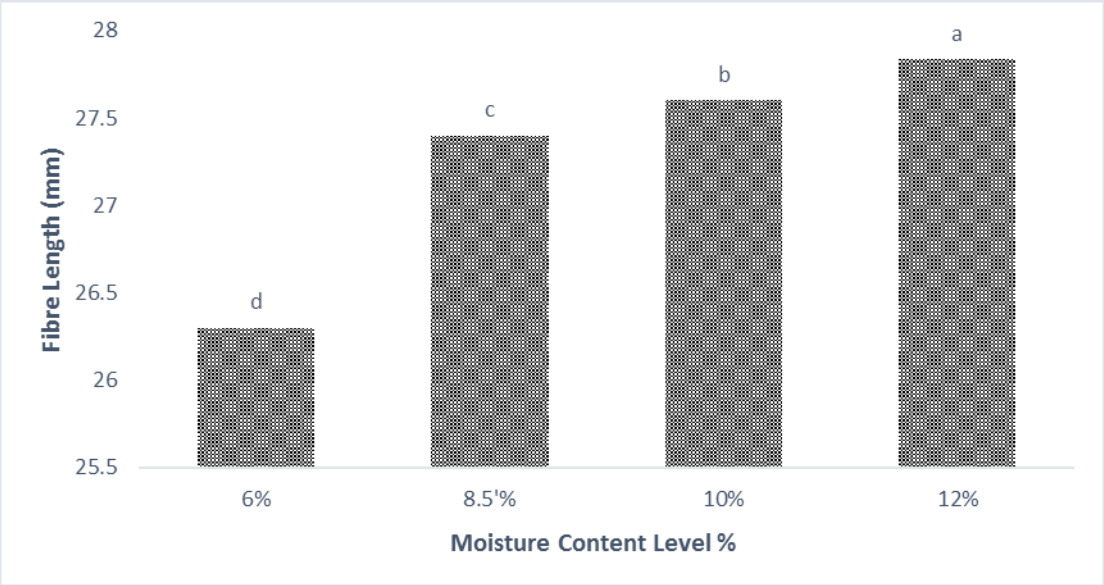


Fig. 6 Interactive effect of different moisture content levels on fibre strength (g/tex)

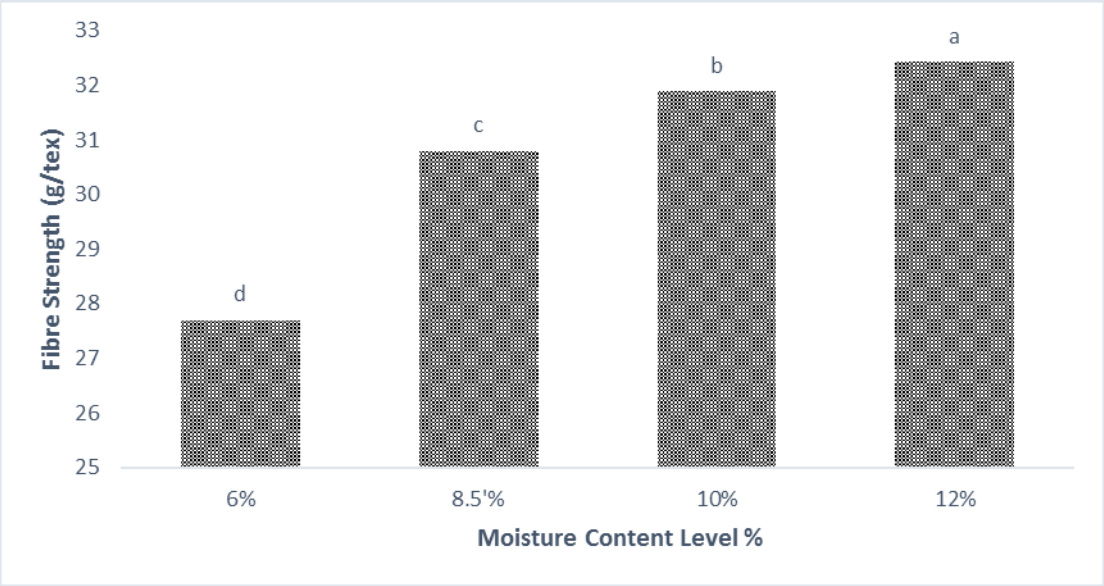
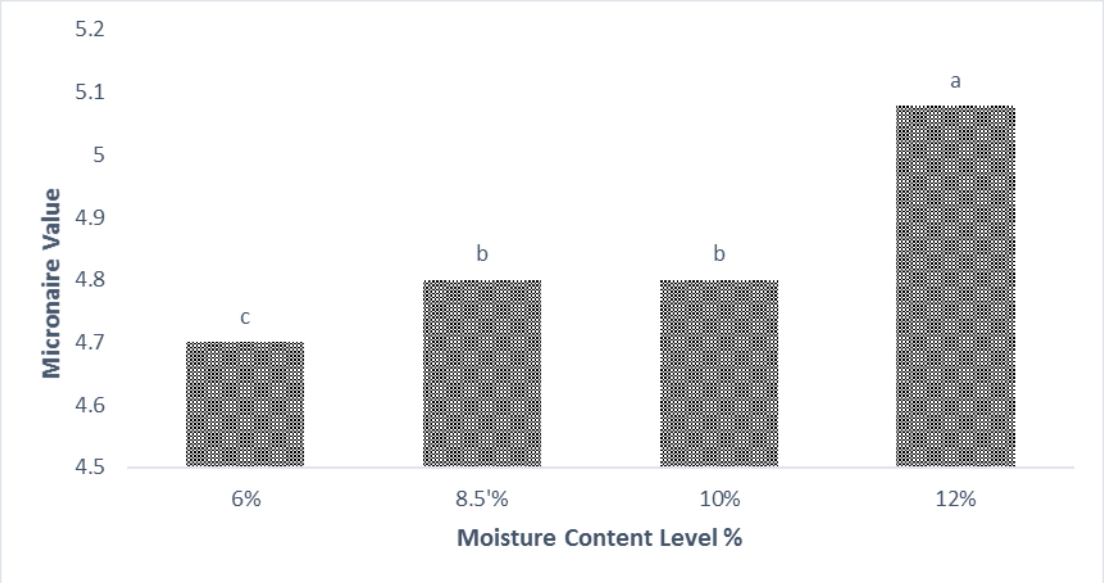


Fig. 7 Interactive effect of different moisture content levels on micronaire value



8.4 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 2016. 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 8.5.

Table 8.5 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)
16.03.16	**2016/1**	**Conventional Instruments**			
		Micronaire	4.15	4.17	-0.02
		Pressley Index (0")	7.81	7.30	0.51
		G / tex (1/8")	19.1	20.57	-1.47
		Elongation (%)	5.80	6.68	-0.88
		HVI-900A			
		U.H.M.L. (mm)	28.8	28.29	0.51
		Uniformity Index (%)	82.5	81.7	0.80
		Micronaire	4.20	4.22	-0.02
		G/tex (1/8")	27.9	28.3	-0.40
		Elongation (%)	5.20	7.20	-2.00
		SFI (%)	7.30	9.65	-2.35
		Rd (Reflectance)	75.4	76.7	-1.30
		+b (Yellowness)	11.2	11.0	0.20
11.07.16	**2016/2**	**Conventional Instruments**			
		Micronaire	4.40	4.50	-0.10
		Pressley Index (0")	7.40	7.44	-0.04
		G / tex (1/8")	20.9	22.5	-1.60
		Elongation (%)	5.40	6.40	-1.00
		HVI-900A			
		U.H.M.L. (mm)	28.8	28.6	0.20
		Uniformity Index (%)	83.5	82.7	0.80
		Micronaire	4.30	4.50	-0.20
		G/tex (1/8")	28.0	28.8	-0.80
		Elongation (%)	6.00	6.70	-0.70
		SFI (%)	6.50	8.50	-2.00
		Rd (Reflectance)	74.0	74.0	0.00
		+b (Yellowness)	9.30	8.90	0.40
18.10.16	**2016/3**	**Conventional Instruments**			
		Micronaire	4.40	4.50	-0.10
		Pressley Index (0")	8.70	8.70	0.00
		G / tex (1/8")	21.6	22.9	-1.35
		Elongation (%)	5.20	6.13	-0.93
		HVI-900A			
		U.H.M.L. (mm)	28.7	28.2	0.50
		Uniformity Index (%)	83.1	82.3	0.80
		Micronaire	4.40	4.51	-0.11
		G/tex (1/8")	32.4	30.4	-2.00
		Elongation (%)	4.30	6.70	-2.40
		SFI (%)	6.60	8.87	-2.27
		+b (Yellowness)	10.4	10.6	-0.20

8.5 Presentation was delivered in 75th International Cotton Advisory Committee (ICAC) meeting held at Islamabad, Pakistan on the topic “The Co-Existence of Cotton Fibre among Competitor Fibres with Future Prospects.” by Head of Fibre Technology Section Muhammad Ilyas Sarwar.

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9. STATISTICS

Statistics Section helps other sections of the institute in designing layout of experiments and analysis of the research data. National coordinated varietal trial data were statistically analyzed for Director Research, Pakistan Central Cotton Committee, Multan. Daily documentation of market rates of cotton commodities. Summary of PCGA Cotton Arrival were prepared for Head Office PCCC, Multan.

9.1 Statistical Analysis

Statistics section performed analysis of 143 set of experimental data during 2016-17. (Table 9.1)

Table 9.1 Detail of Statistical Analyses.

Sections	CRD	RCBD	Split	Split-Split	F-Pool	Regression	Correlation	Graphical Rep.	Covariance	PCA	Descriptive Summaries	Total
Agronomy												
Physiology												
Breeding		12			18							**30**
Cytogenetics												
Pathology												
Entomology												
Fiber												
Directotrate												
CRS Bahawalpur		17	1									**18**
NCVT		95										**95**
Total		**124**	**1**		**18**							**143**

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 37.32 kg for the three cotton seasons i.e. 2013-14, 2014-15, 2015-16, and 2016-17 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 three years on weekly basis is illustrated in **Fig. 9.2**.

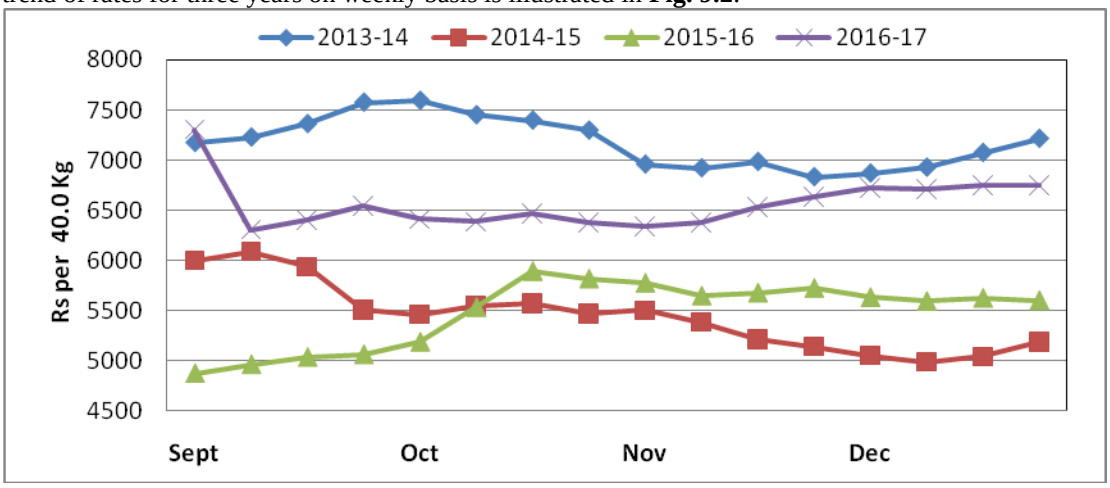
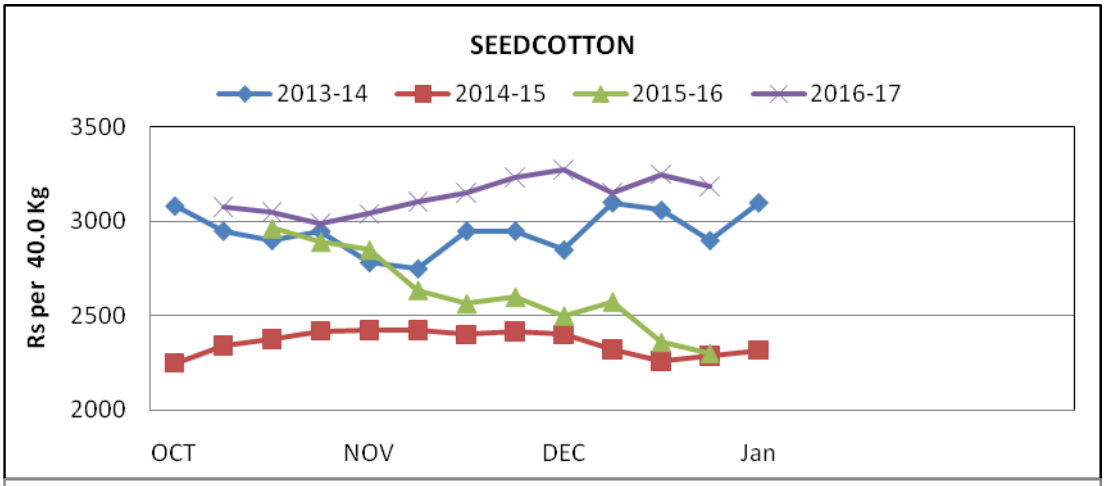
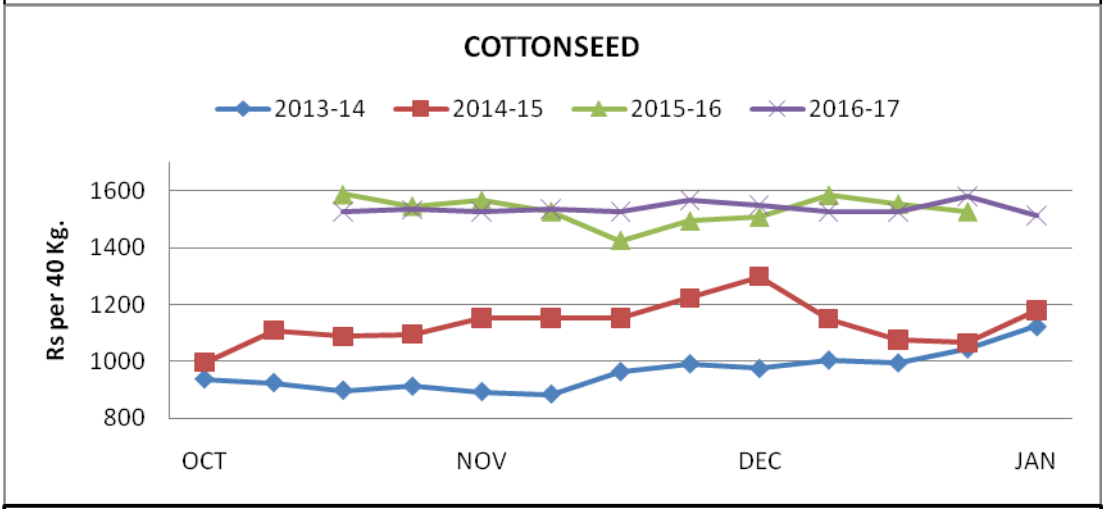
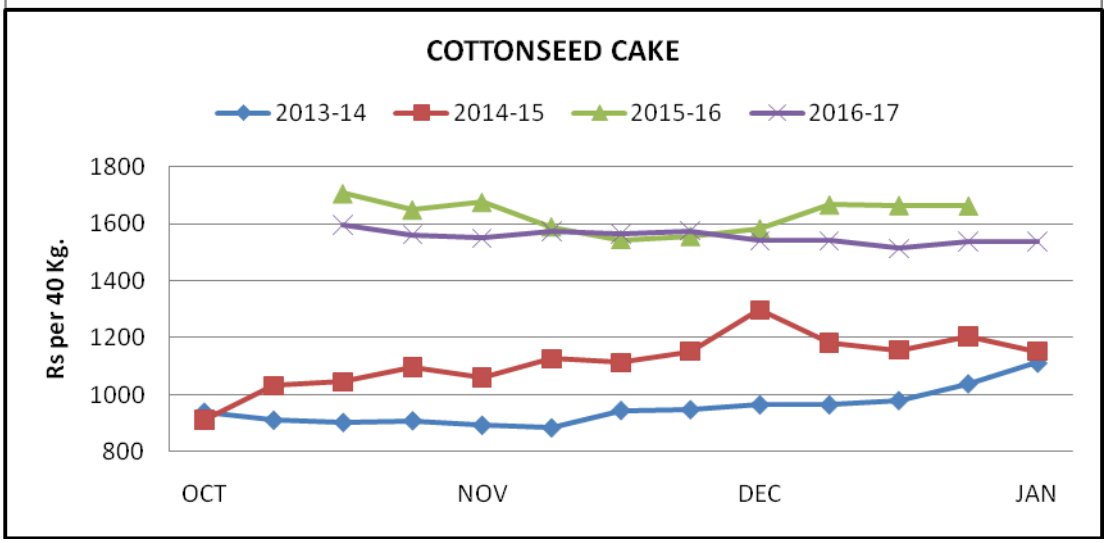


Figure 9.1: Weekly Average Spot Rates of Lint announced by Karachi Cotton Association during Cotton Seasons 2013-14, 2014-15 , 2015-16 and 2016-17.


SEEDCOTTON
2013-14
2014-15
2015-16
2016-17
Rs per 40.0 Kg
3500
3000
2500
2000
OCT
NOV
DEC
Jan


COTTONSEED
2013-14
2014-15
2015-16
2016-17
Rs per 40 Kg.
1600
1400
1200
1000
800
OCT
NOV
DEC
JAN


COTTONSEED CAKE
2013-14
2014-15
2015-16
2016-17
Rs per 40 Kg.
1800
1600
1400
1200
1000
800
OCT
NOV
DEC
JAN

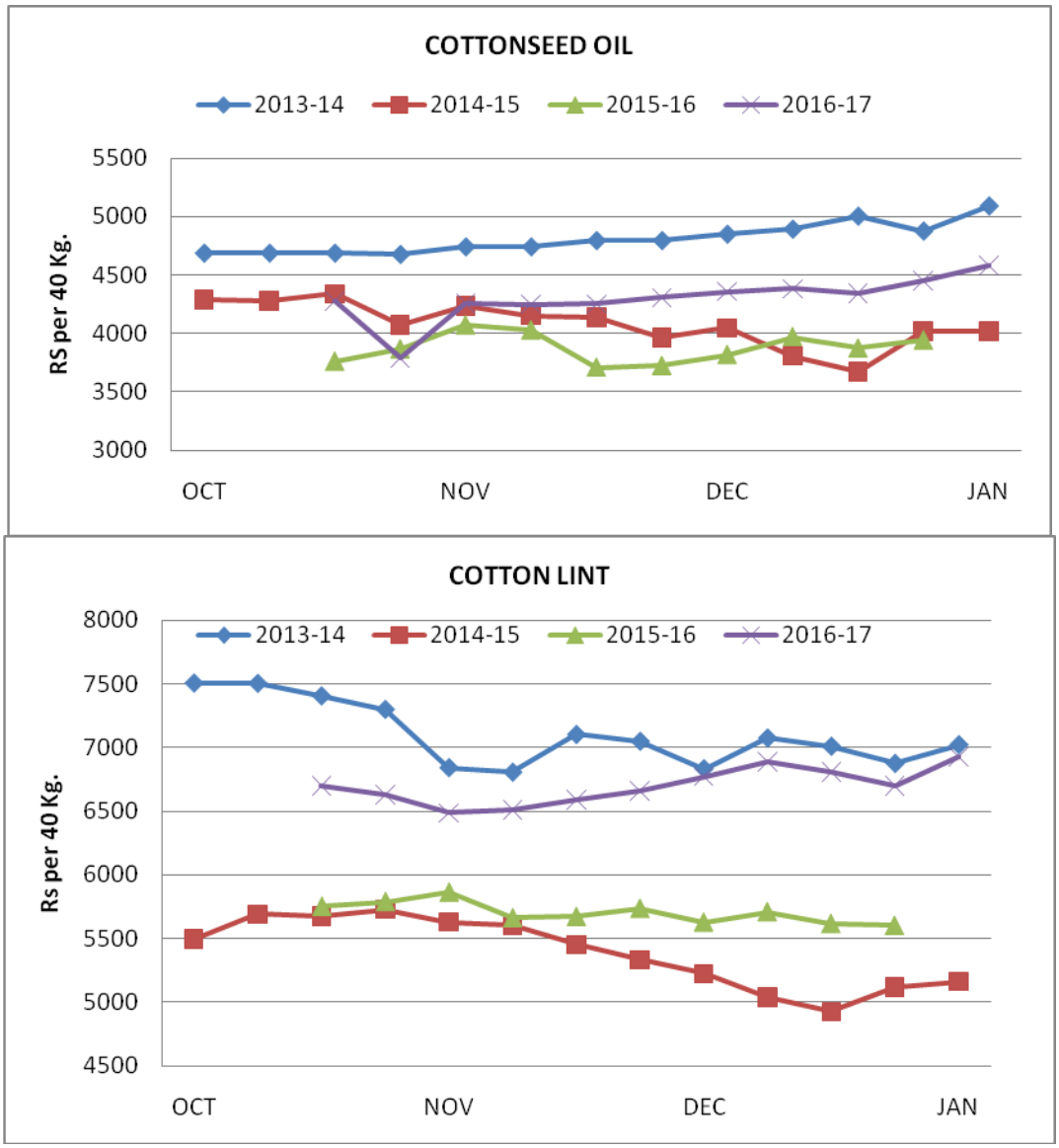


Figure 9.2: **Weekly Average Rates (Rs /40Kg.) of Seed Cotton, Cotton Seed, Cotton Seed Cake, Cotton Seed Oil and Cotton Lint of Multan Market during 2013-14, 2014-15 ,2015-16 and 2016-17.**

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VII. RECOMMENDATIONS

Presently, cotton crop is facing multifaceted problems such as climate change, diseases, emerging pests, development of resistance, cost of production and lint prices. Apart from the Cotton leaf curl virus (CLCuD) that has been invariably a considerable natural constraint in sustainable cotton production, unusual weather condition (high temperature, frequent rains) coupled with unexpected resurgence of Pink Boll worm later in the copping season caused huge losses to the cotton production. Moreover, highly priced inputs, shortage of canal irrigation water, high salt contents in underground water, insufficient/irregular availability of electricity, imbalance use of fertilizers and failure to adopt advance technology are also pushing down the potential yield of commercial varieties. The pest population scenario has changed with prevalence of Bt cotton. Consequently, the minor pests like Dusky and Red Cotton bugs have become a serious threat to cotton production and fibre quality. All stakeholders are struggling to overcome crucial problems for economic returns. Based on the research work done at CCRI, Multan, the recommendations for cotton growers to enhance yield are illustrated below:

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 to improve the physical condition of the soil. Among green 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.

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.

SELECTION OF VARIETY AND SEED PREPARATION

- Grow recommended cotton varieties as given below:

Bt Varieties	Non-Bt Varieties
Bt.CIM-598, Bt.CIM-599, Bt.CIM-602, IR-3701, IR-1524, IR-NIAB-824, FH-118, FH-142, MNH-886, VH-259, IUB-222, BH-178, Ali Akbar-703, NS-121, Ali Akbar-802, Tarzan-1, Tarzan-2, MG-6, Sitara-008, Sitara-11M, A-555, Saiban-201, KZ-181, BN-2085 (Hybrid),	CIM-620, Cyto-124, CIM-496, CIM-506, CIM-554, CIM-573, CIM-608, NIAB-777, NIAB-Kiran, NIAB-112, FH-942, MNH-786, CRSM-38, SLH-317, BH-187, NIBGE-115, NIAB-852, NIAB-846, GS-1, Alseemi-151 (Hybrid),

- 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.

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 ferigation of phosphorus in splits is more efficient than the broadcast at time of sowing.

- In case of early *Bt* planting, the nitrogen dose should be adjusted according to the crop requirement. Up to 400 kg N ha^{-1} may be applied to the early planted *Bt* cotton crop in less fertile fields for optimum yield.
- The crop showing deficiency of nitrogen late in the season can be sprayed 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.

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 mid of 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

INTERNATIONAL

1. Khan, M.I., Haq, H.A., Ullah, K., Arshad, M. and Majid, A. (2017) Genetic Diversity and Correlation Studies for Cotton Leaf Curl Disease (CLCuD), Fiber & Yield Related Attributes in Exotic Lines of *Gossypium arboreum L*. American .Journal of Plant Sciences , 8, 615-624

2. Muhammad, D.B., M. N. Afzal, M. Tariq and A. Wakeel. 2016. Impact of potassium fertilizer on plant biomass and seed cotton yield under arid environments. World cotton research conference-6. Convention Center Goiânia - Goiás, Brazil. 02-05-2016 to 06-05-2016.

3. Saeed, R., Razaq, M. and Hardy, I.C.W., 2016. Impact of neonicotinoid seed treatment of cotton on the cotton leaf hopper, *Amrasca devastans* (Hemiptera: Cicadellidae), and its natural enemies. *Pest Management Science*. 72: 1260-1267.

4. Saeed, R., Razaq, M., Abbas, N., Jan, M. and Naveed, M., 2017. Toxicity and resistance of the cotton leaf hopper, *Amrasca devastans* (Distant) to neonicotinoid insecticides in Punjab, Pakistan. *Crop Protection*. 93: 143-147.

NATIONAL

1. Khan, M.I., Hussain, K., Akbar, M. and Haq, H.A. (2017) Evolution of cotton (*Gossypium Hirsutum L*) variety Bt. CIM-598 equipped with wider adoptability traits, CLCuV tolerant and desirable fiber traits. Journal of Agricultural and Basic Sciences, 2(1): 28-36.
2. Muhammad, D. B., M. Tariq, M. N. Afzal, A. Wakeel, M. Ahmed, A. N. Shehzad, A.A. Wahab, Z. Ali and S. Ahmed. 2016. Foliar application of KNO3 in combination with basal dose boost up seed cotton yield and potassium concentrations in plant organs**.** International conference on "significance of potash use in Pakistani agriculture" Institute of agricultural Sciences, University of Punjab, Lahore, Pakistan**.** 24-11-2016 to 25-11-2016.
3. Muhammad, D.B., M.N. Afzal, M. Tariq and A. Wakeel. 2016. Impact of Potassium Fertilization Dose, Regime, and Application Methods on Cotton Development and Seed-Cotton Yield under an Arid Environment. e-ifc No. 45, June 2016.
4. Muhammad, D.B., M.N. Afzal, M. Tariq, M. Ahmed, A. Anwar and M. Azam. 2016. Comparative performance of pre and post emergence herbicides for weed control in cotton. 13th national conference of weed sciences. Shaheed Benanizir University Sheringal, Dir Upper. 19-08-2016 to 21-08-2016.

5. Saeed, R., Razaq, M., Rafiq, M. and Naveed, M., 2016. Evaluating insecticide spray regimes to manage cotton leafhopper, *Amrasca devastans* (Distant): their impact on natural enemies, yield and fiber characteristics of transgenic *Bt* cotton. *Pak Journal of Zoology*. 48: 703-711.

6. Shah, S.I.A., Rafiq, M., Malik, T.H., Khan, I.R., Shah, SAS and Hussain, Z. 2016. Comparison of the newly introduced rearing methods of cotton stainer, Dysdercus koenigii (Hemiptera: Pyrrhocoridae) with classical methods. *Pakistan Journal of Zoology*, 48: 781-787.

7. Tariq, M., M. N. Afzal, D.B. Muhammad and M. Ahmed. 2016. sustaining productivity of wheat-cotton cropping system through relay cropping technology. International conference on "sustainable agriculture in Pakistan" U.S-Pakistan Center for Advanced Studies in Agriculture and Food Science, University of Agri, Faisalabad, Pakistan. 17-11-2016 to 19-11-2016.

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Annexure-I

Comparative Monthly Meteorological Data Recorded at CCRI, Multan During 2015 and 2016

Month	Air Temperature (ºC)				Relative Humidity				Average Wind Speed (Km h^{-1})		Rainfall (mm)		Evapo-transpiration (cm day)		Soil Te
	Minimum		Maximum		Minimum		Maximum								5
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015
January	6.7	9.9	17.3	16.4	80	76	95	96	3.9	2.6	0.8	0.9	0.24	0.18	11.6
February	10.9	10.7	21.7	23.2	66	58	83	90	5.1	2.5	4.0	0.1	0.33	0.31	14.9
March	15.3	17.8	25.2	26.1	65	70	81	84	4.9	4.8	92.9	20.1	0.47	0.36	18.1
April	22.2	22.5	34.7	34.5	58	85	72	86	4.7	5.0	9.2	13.1	0.70	0.73	27.0
May	26.4	28.5	38.7	40.2	45	73	61	75	6.4	6.5	8.5	2.0	0.84	1.17	31.2
June	28.9	31.1	37.7	39.8	49	67	63	70	6.9	6.8	24.5	4.0	0.71	1.11	33.7
July	28.2	29.5	34.5	36.5	67	70	76	75	6.5	6.3	151.2	36.2	0.76	1.02	33.1
August	29.1	28.1	33.9	35.1	74	82	82	86	5.1	4.6	6.7	109.0	0.71	1.07	31.8
September	28.0	26.2	33.8	34.8	81	80	90	84	3.6	3.9	15.4	4.0	0.72	1.17	30.4
October	22.0	20.8	31.3	33.0	65	62	82	75	3.0	2.7	7.0	0.0	0.51	1.16	25.6
November	14.9	13.5	25.1	26.4	53	55	76	83	2.3	2.1	0.0	0.0	0.30	0.28	19.1
December	9.7	10.7	20.6	22.2	59	62	90	94	2.1	1.8	0.0	0.0	0.18	0.16	12.9

Annexure-II

List of Officers at Central Cotton Research Institute, Multan (2016-17)

Discipline/ Designation	Incumbent	Qualification	Effective Date
DIRECTORATE			
Director	Dr. Zahid Mahmood	M.Sc. (Hons.) Agri., Ph.D	01.02.17
	Syed Sajid Masood Shah[1]	M.Sc. (Hons.) Agri.	01.10.13
Farm Officer	Mr. Muhammad Azam Mian	M.Sc. (Hons.) Agri.	17.03.10
Administrative Officer	Mr. Zakirullah Khalidi	B.A.	20.05.14
Network Administrator	Mr. Muhammad Naveed Arshad	M.S (Computer Science)	11.08.14
Accountant	Mr. Nazir Ahmad[2]	B. Com.	11.12.00
APS	Mr. Zahid Khan	B.Com., M.A. (Economics)	02.02.16
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
PSO	Dr. Dil Baugh Muhammad[3]	M.Sc. (Hons.) Agri., Ph.D.(China)	27.03.14
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
PSO	Mr. Muhammad Afzal[4]	M.Sc. (Hons.) Agri.	27.03.14
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
PSO	Mr. Zahid Iqbal Anjum[5]	B.Sc. (Hons.) Agri.	27.03.14
SO	Mrs. Farzana Ashraf	M.Sc. (Hons.) Agri.	22.03.10
SO	Mr. Khezir Hayat[6]	M.Sc. (Hons.) Agri.	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] retired on 09.11.2016, [2] On ex-Pakistan leave from 20.01.16, [3] retired on 09.09.16,
[4] retired on 05.04.16, [5] retired on 01.01.17, [6] Study Leave from 10.02.14

Discipline/ Designation	Incumbent	Qualification	Effective Date
ENTOMOLOGY			
SSO	Dr. Muhammad Naveed	M.Sc.(Hons.) Agri., M.Sc.(UK) D.I.C. (London)	20.05.14
PSO	Mr. Muhammad Rafiq[7]	M.Sc.(Hons.) Agri.	27.03.14
SO	Mrs. Rabia Saeed	M.Sc. (Hons.) Agri.	17.03.10
SO	Syed Ishfaq Ali Shah[8]	M.Sc. (Hons.) Agri.	22.03.10
SO	Mrs. Shabana Wazir	M.Sc. (Hons.) Agri.	14.05.14
APS	Mr. Musawar Ali Shahid	F.A.	02.02.16
PATHOLOGY			
SSO	Mrs. Sabahat Hussain	M.Sc. (Hons.) Agri.	20.05.14
PSO	Mr. Tariq Mehmood[9]	M.Sc. (Hons.) Agri.	27.03.14
SSO	Mr. Muhammad Tahir[10]	M.Sc. (Hons.) Agri.	20.05.14
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[11]	M.Sc. (Hons.) Agri.	15.05.14
Librarian	Ms Shahida Hameed	M.Sc. (Physics)	01.04.16
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
PRO	Mr. Masood Shafi[12]	M.A. (Mass Comm.)	16.01.10
STATISTICS			
SO (Marketing)	Mr. Mubashir Islam Gill	M.B.A.	08.12.06

[7] retired on 01.03.16, [8] Study Leave from 01.09.15, [9] retired on 18.01.17, [10] retired on 22.01.17
[11] Study Leave from 15.09.14, [12] retired on 09.03.17

PSO : Principal Scientific Officer
SO : Scientific Officer
APS: Assistant Private Secretary
SSO : Senior Scientific Officer
PRO : Public Relations Officer

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