PAKISTAN CENTRAL COTTON COMMITTEE, MULTAN

ANNUAL SUMMARY PROGRESS REPORT

CENTRAL COTTON RESEARCH INSTITUTE,

MULTAN

2015-2016

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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 2015-16" is being published on its 45th 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 772 kg per hectare during the current year. The continuous and untiring research endeavors of the scientists have yielded 20 cotton varieties (17 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.

Salient features of five new varieties viz. CIM-612, Cyto-124, Bt.CIM-600, Bt.CIM-616 and Bt.Cyto-177 were presented in the 71st Meeting of the Expert Sub Committee held at Ayub Agricultural Research Institute, Faisalabad on 09.03.2015. Apart from having up to the standard fibre quality traits, Bt.CIM-600 is tolerant to heat stress whereas Bt.CIM-616, CIM-612 and Bt.Cyto-177 are highly CLCuV tolerant with promising yield potential.

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.

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.

The country has suffered huge financial losses due to yield reduction in cotton crop caused by the wide scale infestation of cotton leaf curl virus (CLCuV) disease. Accepting this hard challenge, the scientists at the Institute were able to evolve varieties through introgression that have a high degree of tolerance to CLCuV. A variety Cyto-124, which is recently recommended by Expert Sub Committee, has shown its stability towards virus tolerance in early as well as late sowing (March to June planting). A couple of more promising genotypes (Cyto-120 & Cyto-122) are in pipeline. The contribution in the development of disease resistance is the outcome of continuous involvement by the Pathology Section for quantification and transformation of resistant character and its build up in the new genetic material.

The development of new varieties is based on the maintenance of high fibre quality traits to cope with the standards of the textile industry. The varieties released by the Institute are stable and maintain their fibre quality under various ecological zones. The Institute is at advanced level in developing transgenic cotton through classical breeding along with biotechnological tools. Results of the data gathered from the experiments and surveys cannot be deduced or inferred without the statistical analysis. The mass scale statistical analysis of data has made success to bring out this 44th Progress Report of the Institute. The results are not confined in the four-walls of the Institute. Message dissemination measures through print and electronic media, personal communication, training of farmers, field staff of seed, fertilizer and NGOs remained a regular phenomenon throughout the year. Various programs are televised through TV channels based at Multan.

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

AGRONOMY

Cotton agronomy is the management of utilization of natural resources in an efficient way to achieve the potential production in 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 CIM-620 produced higher yield over CIM-608 and Cyto-120. 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 the highest yield as compared to other planting dates i.e. 15th March, 1st April, 15th April, 1st May and 15th May. Genotype *Bt*.Cyto-179 produced significantly higher seed cotton yield as compared to *Bt*.CIM-622,*Bt.*Cyto-178 *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 (4393 kg ha^{-1}) than fallow land early planting (3773 kg ha^{-1}). Planting of cotton under modified technique (Relay crop 75 cm apart rows) produced 16.4, 93.5 and 107.9% higher cotton yield over fallow land, cotton planting after wheat and wide row (150 cm), respectively.

Potassium application @ 200 Kg K_2O in four equal splits (sowing, 30, 45 and 60 DAP) produced the highest seed cotton yield (3017 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 5.4% more seed cotton yield over split application of 200 kg K_2O ha^{-1} alone. The cost of production for the year 2015-16 was Rs. 74716 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. One *Bt*. variety CIM-600 has been recommended for approval by Expert Sub-Committee while two *Bt.* varieties viz. *Bt.*CIM-616, *Bt.*CIM-622 and one non Bt. variety CIM-620 completed two years NCVT and their spot examination has been done. While one Bt variety *Bt*.CIM-602 is also approved by Sindh Seed Council for general cultivation in Sindh Province in 32nd meeting. Sixteen advanced *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 41.7 with the staple length of 28.8 mm and micronaire of 4.2 µg $inch^{-1}$. The fibre strength of the strain is very good upto 100.7 tppsi. Seven advanced non-*Bt*. strains were also evaluated at Multan and Khanewal locations. The new strain CIM-620 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 and to study inter and intra-genomic relationships in the genus Gossypium. The research work of Cytogenetics Section encompass 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 F_7 of [{2(*G.hirs.*x *G.anom.*) x ^{3}G.*hirs*.} x {2 (*G.arbo.* x *G.anom.*) x ^{2}G.*hirs.*}] x *G. hirs.* were sown in single lines.Out of the 286 families 90 families remained free from virus under field conditions throughout the entire cotton season. Conversion of CLCuD tolerant lines in transgenic lines using back cross method is under observation in different filial generations i.e. F_1, F_2, F_3 , $F_4$and F_5.

Different shades of brown cotton were observed in F_2. Grey colour is also found in this material. All these shades have suitable fibre length. Search for aneuploids especially haploids remained in steps forward. Cyto material developed through multiple species hybridization was tested in progeny row trials, micro-varietal trials, Micro varietal trials and ZVT to observe their economic and fibre characteristics.

Bt Cyto-177 and Cyto-124 (non *Bt*), varieties developed through introgression has been sent for recommendation to Expert Sub Committee on 9th March 2015. Both lines have completed two years in NCVT, PCCT, ZVT and DGR trials for its wider adaptability in different ecological zones. Cyto-179 will be tested in NCVT, PCCT and ZVT trials for its wider adoptability in different ecological zones.

ENTOMOLOGY

Plant protection strategy and activities have significant importance in the overall crop production programmes for sustainable agriculture. Variation of Bt gene expression in different cultivars over time and efficacy to bollworms are the main concern now a days, studies undertaken on Earias spp proved the concerned. Similarly the efficacy of Bt cotton in the field is losing efficacy against the Pink bollworm, survey conducted revealed high infestations in green bolls. Monitoring of lepidopterous pest population viz sex pheromone and light traps was carried out and forecast the increasing trend in all bollworms population. Studies on red and dusky cotton bugs continued and efforts are made to find bio agents for long term solutions. Seed treatment effect and development of natural on early and normal planting studies revealed that the population of jassid was more on early sown field than normal sowing also the natural fauna was recorded higher in the early sown. The distinct efforts of researchers of the section have proved meaningful in devising pest management strategies against common and new emerging insect pests through application of IPM. Studies are continued on host plant tolerance of CCRI, Multan and National Coordinated *Bt.* & non-*Bt.* Strains. The section also studied effect of different IPM strategies on insect pest for transgenic cotton. Screening of new insecticides was also conducted against major insect pests of cotton.

PLANT PATHOLOGY

Mutual confederation and association provided by this section to Plant Breeding & Genetics and Cytogenetics disciplines has considerable role in the progress of virus tolerance varieties. The survey during the corp season showed that virus was prevented across the cotton belt. Due to sudden fluctuation in weather conditions CLCuD ranged from 0-100%. The incidence of stunting is minimal and boll rot was 1-2%. The material tested under VT, MVT, NCVT (Bt and Non Bt), PCCT (Bt and Non Bt) and SVT were found susceptible at various intensity to CLCuD. Except a few lines in MVT-1, VT-1 and VT-3 showed tolerance. Three hundred fifty five strains US germplasm tested under field conditions. None of any accessions showed resistance against CLCuD. The cultivation of Bt cotton in March and non-Bt in mid-April escaped from virus to some extent while the crop sown after May severely attacked by CLCuD. Early and late planting have a strong impact on appearance and progression of CLCuD during the crop season. The low incidence of disease was due to planting of CIM-620. The fortnightly incidence of disease when compared with weather parameter i.e. average maximum temperature from 33.6-34.7C minimum temperature 28.4-29.4C and relative humidity in the range of 74.5-84.4% at peak of CLCuD during the mid-July to mid-August. Even whiteflies were more virulent when collected during this period and released on healthy plants. Rotted bolls of cotton sprayed with different fungicides. Combine fungicides gave better performance than individual.

PLANT PHYSIOLOGY / CHEMISTRY

Integrated nutrient management is of utmost importance to increase nutrient use efficiency and economized crop production. Among the major inputs, fertilizers play a key role in enhancing yields and determining the cost of production of agricultural crops. 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 to evaluate the appropriate nutrient requirement of Bt cotton as well as traditional non-Bt cotton in Multan Division. The studies revealed that the response of cotton genotypes to incremental levels of fertilizers is more in Bt cotton as compared to non-Bt cotton. Exploring the alternate sources of fertilizers like FYM, humic acid; seed inoculants and growth regulators can help in improving yield.

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. While Gibberellic acid can change plant growth and development in varied ways, suggesting its agricultural uses. Glycine also has a chelating effect on micronutrients, the absorption and transportation of micronutrients inside the plant is easier due to the effect of cell membrane permeability. The studies carried out by the section revealed that both seed priming and/or foliar sprays of these bio-chemicals not only improved the seed cotton yield but also seed health and quality. Seed priming and subsequent foliar sprays of proline demonstrated its advantage over other treatments by improving the seed cotton production per unit area and also the seed health and quality parameters of cotton seed.

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 6 varieties were tested under normal irrigation and artificially imposed water stress conditions in the field. The genotype CIM-616 of the Institute surpassed the other varieties in yield performance both under non-water stress and water stressed conditions. Among the 12 genotypes investigated for thermal stress tolerance, genotypes NIAB-878, NIAB-414 and GH-Mubarik surpassed the other genotypes by maintaining highest 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 78,653 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.

Syed Sajid Masood Shah
Director
Central Cotton Research Institute
Multan

March, 2016

ANNUAL PROGRESS REPORT OF CENTRAL COTTON RESEARCH INSTITUTE, MULTAN FOR THE YEAR 2015-16

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 and Statistics. To unravel the production problems faced by the farmers and to increase production by evolving high yielding cotton varieties, the Institute expanded its horizonto cover applied research 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, 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 from cotton growing countries on “cotton research and development”

II. WEATHER AND COTTON CROP CONDITION

1. Weather

The pattern of maximum temperatures during cotton crop season 2015-16 remained lower from third week of May to end August while minimum temperatures remained higher during April-May and lower from June-August. The annual average maximum temperature during 2015/16 remained 32.3°C while it was 32.5°C during last year. Similarly the annual average minimum temperature during current year remained at 23.3°C while it was 22.0°C during last year. The average relative humidity remained 77.5% during current season while it was 77.0% during last season. A total of 373 mm rainfall was recorded during whole year (Jan-Dec) while it was 143 mm during last year.

The meteorological data for the year 2014 vis-à-vis 2015 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 2014 and 2015 are given in Appendix-I.

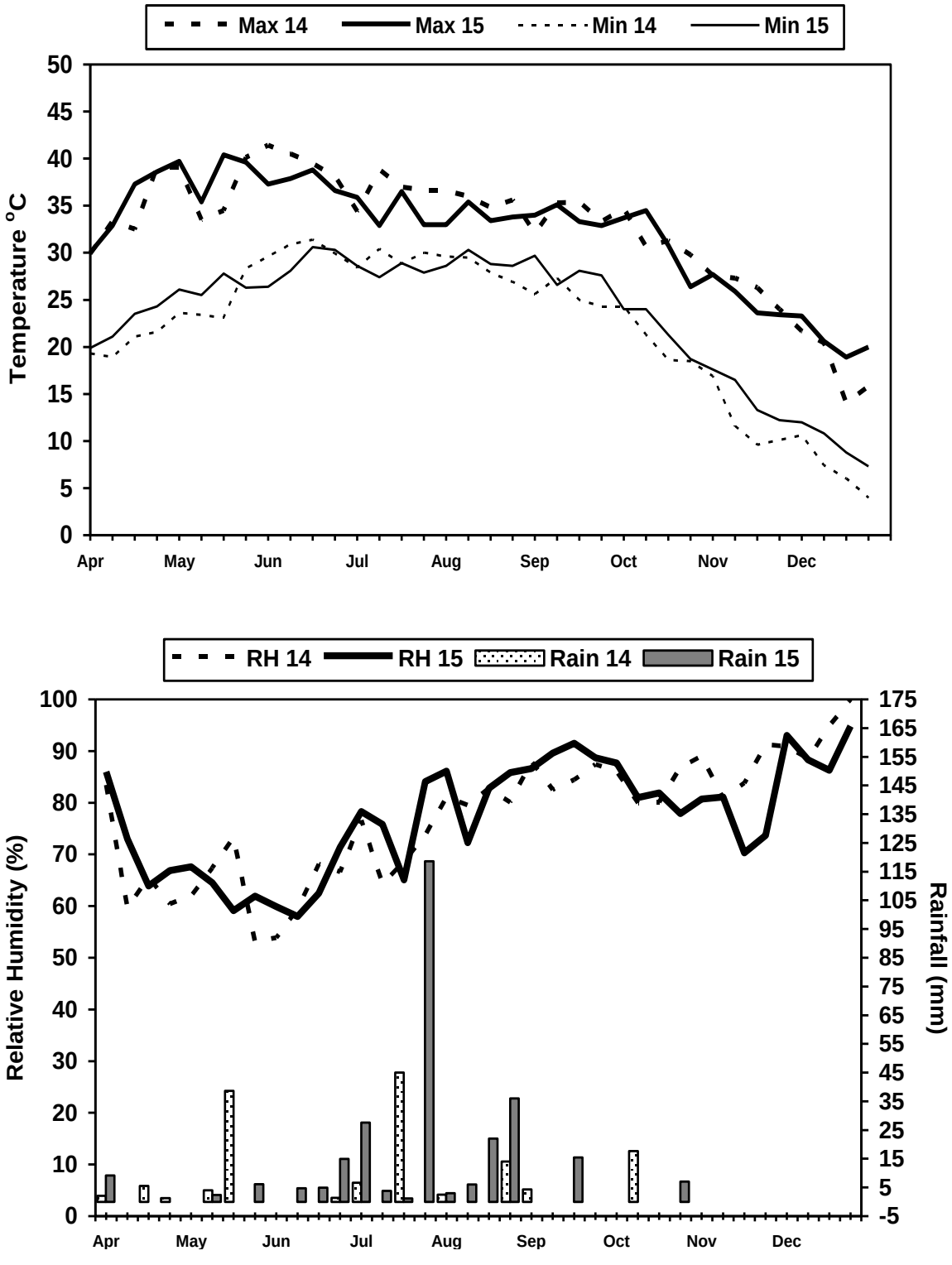


Fig. 1 Weekly Average Temperature, Relative Humidity and Total Rainfall during 2014 and 2015.

2. Cotton Crop Situation

2.1 Cotton Sowing

The Federal Committee on Cotton (FCC) of the Ministry of Textile Industry, Government of Pakistan fixed target for cotton area of 2.428 million hectares with a production of 10.5 million bales for the Punjab province, in its meeting held on 19th February 2015. However, cotton crop was planted on 2.258 million hectares which was 93 percent of the target and 2.70 percent less area sown than last year while cotton production was estimated at 7.4 million bales for the province which was around 30% short than the target.

Target		Achievements	
Area (Mil. ha)	**Production (Mil. bales)**	**Area (Mil. ha)**	**Production (Mil. bales)**
2.428	10.500	2.258	7.400

Cotton crop suffered a heavy loss by 40% due to torrential and prolonged rains in the Punjab province. The worst affected areas were Mianwali, Rajanpur, Rahim Yar Khan, Lodhran, DG Khan, Layyah, Sahiwal, Bahawalpur, Bahawalnagar, Muzafargarh, Khushab. During the year 2015-16, Multan area received 373 mm rainfall during January to October i.e., five-times increase in intensity of rains during June and three-times jump during July and August. There are estimates that cotton crop in the Punjab province has suffered an economic loss of Rs. 100 billion due to abnormal rains in the province. The continuous rains affected pollination (100mm to 373mm), 128 mm for 28 days during 3rd week of July upto 3rd week of August 2015 as compared to only 13 mm during same period last year. Heavy rains resulted in high humidity which favored flare up of Whitefly, Jassid and other pests. This phenomena resulted in limited application of inputs, growth of crop restricted and pest complex established. Damages due to rains coupled with prevailing lower cotton prices & high rates of inputs, farmers lost interest in spending more on already damaged crop.

2.2 Supply of Inputs

The overall certified seed availability in the Punjab province remained at 25,093 metric tons against 19,033 metric tons during last year which was 81% of the total seed requirement (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 throught out the cropping season as previous and cotton sowing was also delayed in some areas due to delayed water availability.

The availability of nitrogenous and phophatic fertilizers remained satisfactory and no shortage was reported.

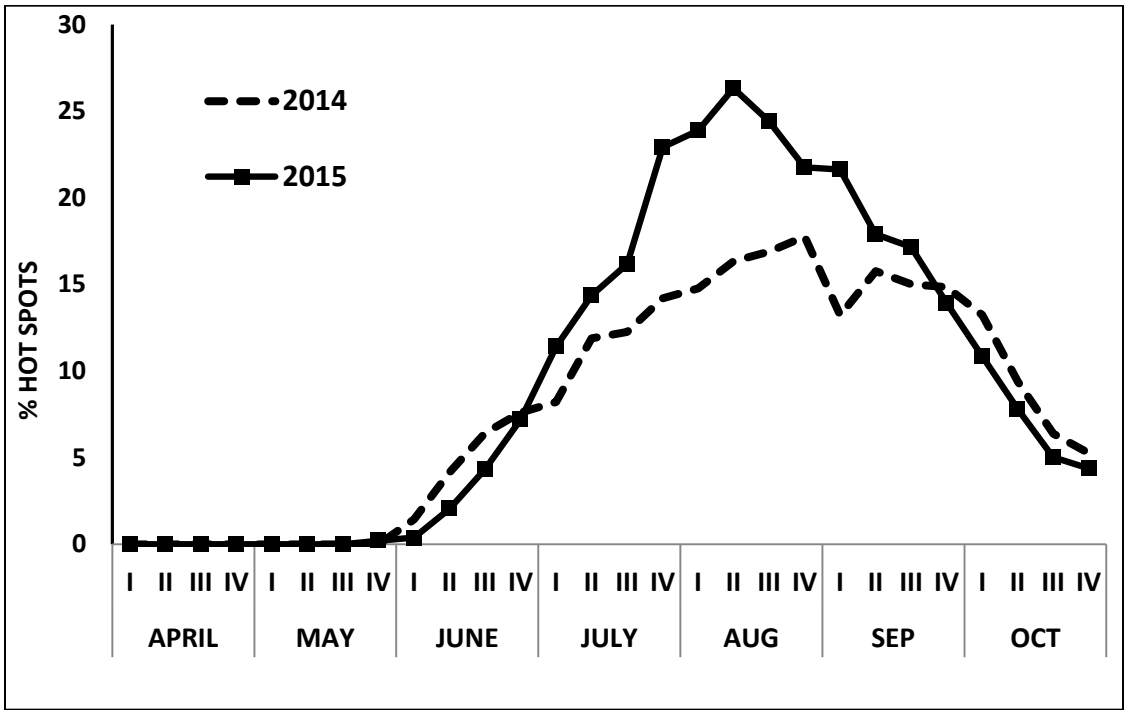
The availability of cotton pests-specific pesticides remained satisfactory during the season. However, due to heavy rains and sudden flare up of Pink bollworm, Armyworm and other pests; farmers could not spray crop which damages cotton crop substantially.

2.3 Cotton Pests and Disease Situation

2.4.1 Cotton Pests Situation

a) Whitefly Population

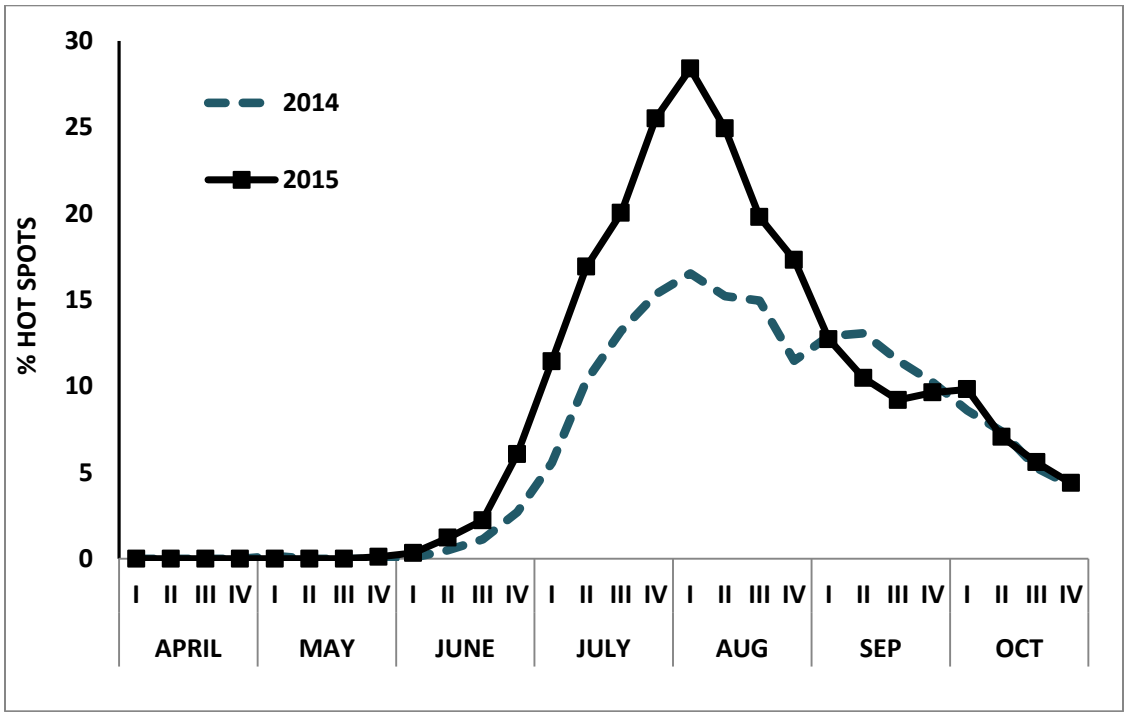
The population of whitefly was substantially high during the year in comparison with 2014-15. Maximum population was recorded during August and then declined gradually.



Source: Pest Warning & Quality Control of Pesticides, Punjab

b) Jassid Population

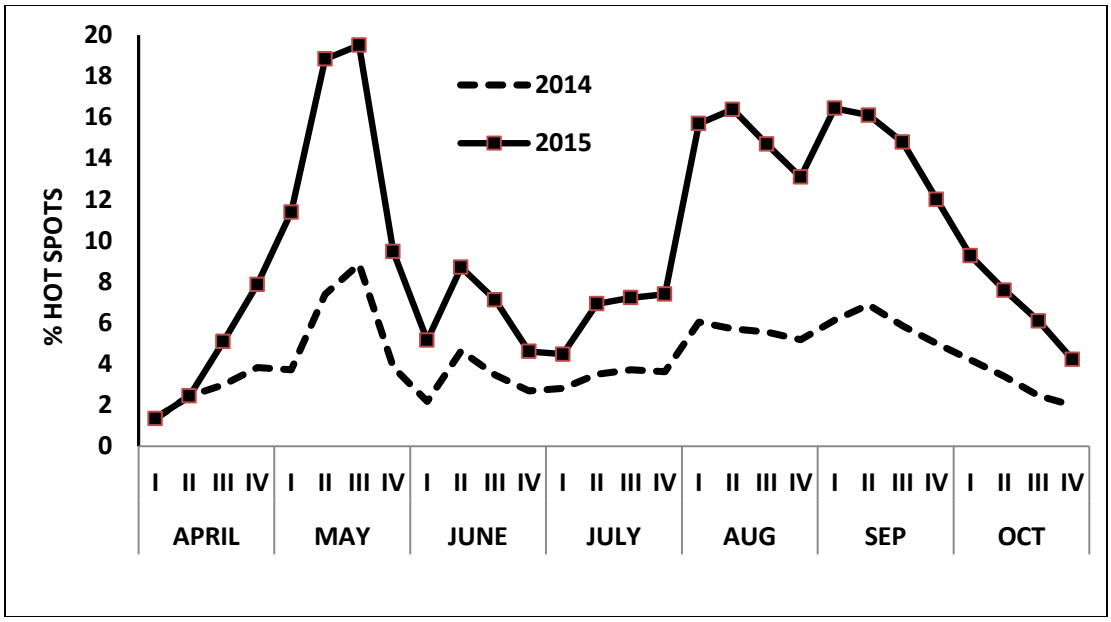
The population of Jassid was quite high during the year 2015-16 compared to 2014-15. Maximum population was reported during the month of July and August, and then declined over the period.



Source: Pest Warning & Quality Control of Pesticides, Punjab

c) Armyworm

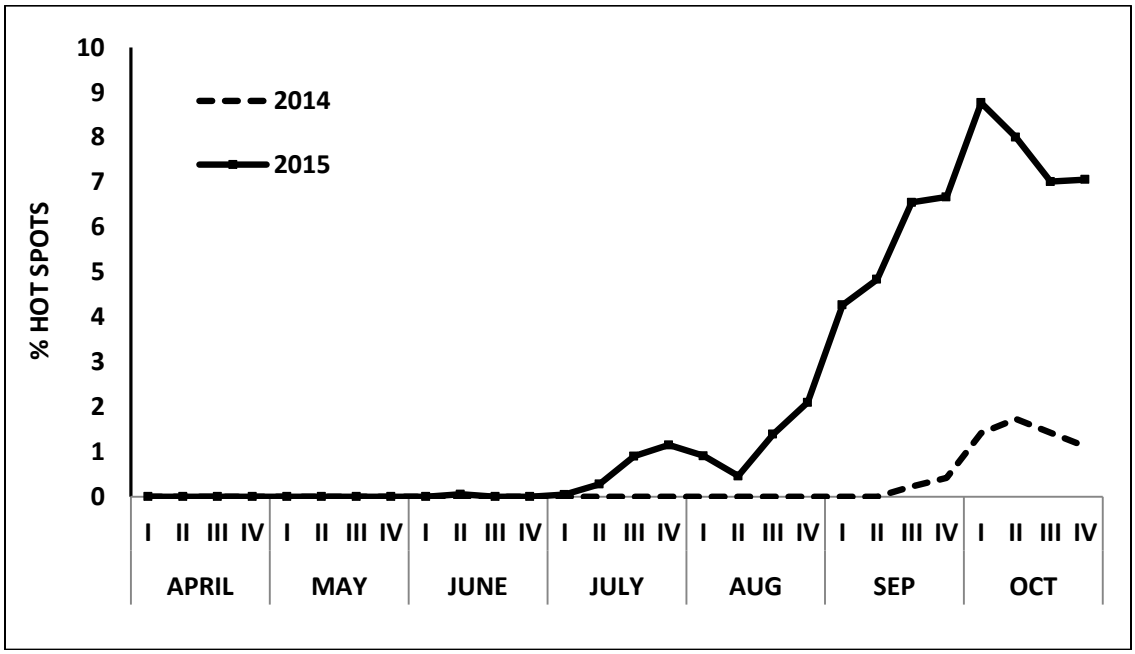
The population of Armyworm reached at the highest level during the year 2015-16 compared to the year 2014-15. Maximum population was recorded during the months of April and May, declined during June and July and then again rose during the reproductive period (August-September months).



Source: Pest Warning & Quality Control of Pesticides, Punjab

d) Pink bollworm

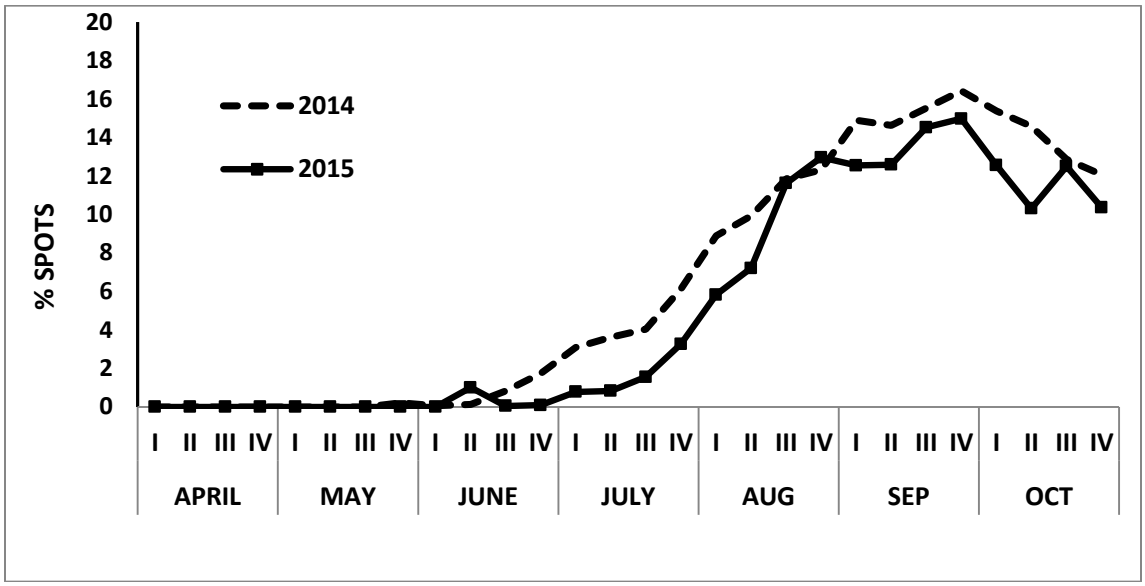
The population of Pink bollworm started to rise during month of July, continued to rise till September and then declined later on. The infestation of Pink bollworm was also substantially high during 2015-16 compared to 2014-15.



Source: Pest Warning & Quality Control of Pesticides, Punjab

iv) Infestation of Cotton Leaf Curl Virus (CLCuV)

The infestation of cotton leaf curl virus (CLCuV) was low during the year 2015-16 compared to the previous season 2014-15. The prevalence rate followed the similar pattern during the both years. The infestation started to rise from last week of May and reached to its maximum in September and then slowed down.



Source: Pest Warning & Quality Control of Pesticides, Punjab

2.6 Cotton Market Situation

2.6.1 Cotton Prices

The market prices of seedcotton on overall season basis remained at Rs.2547 per 40 kgs as compared to Rs.2417 during last year. Similar trend was also seen in case of lint prices which averaged at Rs.5611 against Rs.5645 during last year. The seedcotton prices were Rs.1800-2150 during end July and first week of August while it increased upto Rs. 2750 by the end of December.

Month	Seedcotton		Lint	
	2015	**2014**	**2015**	**2014**
August	2332	2615	5543	5795
September	2352	2546	5610	5884
October	2785	2345	5582	5521
November	2737	2216	5623	5309
December	2666	2359	5698	5098
Average	**2574**	**2417**	**5611**	**5645**

2.6.2 Cotton Arrival Position

The cotton arrival position into ginning factories upto 15th February, 2016, as reported by Pakitan Cotton Ginners Assocaition, showed a shortage of 33.62% in the country than that of last year whereas Punjab province faced a huge slump as arrival shrinked to 5.9 million bales as against 10.6 showing 44% shortage in the province due to heavy rains.

District	Arrival 2015	Arrival 2014	% Change
Multan	129,309	492,861	-73.76
Lodhran	97,437	363,237	-73.18
Khanewal	402,920	968,664	-58.40
Muzafargarh	263,448	487,032	-45.91
DG Khan	291,145	492,247	-40.85
Rajanpur	405,037	567,093	-28.58
Layyah	251,948	394,177	-36.08
Vehari	308,908	788,930	-60.84
Sahiwal	254,494	585,318	-56.52
Pak Patten	66,478	173,332	-61.65
Okara	22,148	52,028	-57.43
Qasur	11,376	22,400	-49.21
TT Singh	135,522	321,995	-57.91
Faisalabad	52,523	97,033	-45.87
Jhang	42,680	74,084	-42.39
Mian Wali	339,571	446,685	-23.98
Bhakkar	82,459	193,750	-57.44
Sargodha	11,600	26,582	-56.36
RY Khan	1,112,641	1,394,631	-20.22
Bahawalpur	734,060	1,311,738	-44.04
Bahawalnagar	911,676	1,385,503	-34.20
PUNJAB	**5,927,380**	**10,639,320**	**-44.29**
Hyderabad	250,607	266,031	-5.80
Mirpur Khas	274,145	403,461	-32.05
Sanghar	1,342,409	1,503,741	-10.73
Nawab Shah	312,622	313,761	-0.36
Nousero Feroz	283,084	258,265	9.61
Khair Pur	270,431	250,548	7.94
Ghotki	320,362	222,749	43.82
Sukkur	448,068	413,864	8.26
Dadu	38,328	44,664	-14.19
Jamshoro	133,000	148,800	-10.62
Badin	31,645	54,700	-42.15
BALOCHISTAN	**57,045**	**77,002**	**-25.92**
SINDH	**3,759,746**	**3,954,576**	**-4.93**
PAKISTAN	**9,687,116**	**14,593,896**	**-33.62**

Source: Pakistan Cotton Ginners Association

III. STAFF POSITION

A total of 167 staff members including 43 officersand 124 other staff membersremained at the Institute during the period under report. The position of technical staff during the year 2015-16 is given in **Appendix-II**.

IV. BUDGET

The sanctioned budget from the year 2012-13 to 2015-16 is given below:

(Rs. Million)

Sr. #	Detail	2012-13	2013-14	2014-15	2015-16
1.	Pay & Allowances	47.072	47.072	66.464	68.470
2.	Medical	2.607	2.607	3.465	2.00
3.	Traveling Allowance	0.149	0.179	0.500	1.500
4.	Group Insurance	0.167	0.167	0.641	0.987
5.	Utility Bills*	3.936	4.723	6.610	6.750
6.	Contingencies	4.232	5.750	11.755	21.22
	Total	**58.163**	**60.498**	**89.435**	**103.928**

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

V. INCOME

The income of the Institute from the year 2012-13 to 2015-16 is given below:

(Rs. Million)

Sr. #	Head	2012-13*	2013-14	2014-15	2015-16
1.	Farm Produce	2.033	5.634	1.871	1.783
2.	Non-Farm Produce	0.150	0.018	0.000	0.000
	Total	**2.183**	**5.652**	**1.871**	**1.783**

* Period from 1st July to 29th February

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

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1. AGRONOMY

Agronomic research comprises of appropriate sowing date and optimum fertilizer requirement for development of profitable cotton production technology for advanced genotypes (open pollinated & GMO) evolved by CCRI, Multan and included in National Coordinated Varietal Trial for the process of approval for general cultivation. In addition, the most profitable wheat-cotton cropping system, sowing of cotton as relay crop under minimum tillage technology for cultural management of CLCuD and increasing the profitability of small farmers were conducted during the year under report. The impact of potassium application strategies on seed cotton yield was also evaluated. The results get holds are given as under.

1.1 Effect of time of sowing on productivity of advanced genotypes

Three new genotypes i.e. CIM-620, Cyto-120 and CIM-608 (std) 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 spray of Stomp 455CS @ 2.5 L ha^{-1}. 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) recorded are given in Table 1.1.

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

Sowing dates	Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence %age 105 DAS
April 15	CIM-620	133.3	31	2.55	2992	2.4
	Cyto-120	122.0	32	2.51	3016	2.0
	CIM-608	112.5	30	2.52	2973	6.0
May 01	CIM-620	120.2	30	2.57	2908	23.4
	Cyto-120	113.4	30	2.52	2896	4.0
	CIM-608	107.0	29	2.52	2889	16.3
May 15	CIM-620	114.3	27	2.59	2687	44.2
	Cyto-120	103.9	26	2.56	2563	48.4
	CIM-608	103.3	24	2.58	2296	77.7
June 01	CIM-620	99.0	22	2.59	1984	56.0
	Cyto-120	93.0	21	2.57	1944	66.0
	CIM-608	87.0	20	2.58	1926	100.0
June 15	CIM-620	80.0	16	2.60	1572	95.7
	Cyto-120	68.0	15	2.58	1512	100.0
	CIM-608	73.0	15	2.58	1492	100.0

DAS* = Days After Sowing

Sub-effects

Sowing dates	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence %age
April 15	122.6	31	2.53	2994	3.46
May 01	113.5	30	2.54	2898	14.57
May 15	107.2	26	2.58	2515	56.77
June 01	93.0	21	2.58	1951	74.00
June 15	73.7	15	2.59	1525	98.57

Genotypes	Plant height (cm)	Number of Bolls plant^{-1}	Boll Weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence %age
CIM-620	109.4	25	2.58	2429	44.34
Cyto-120	100.1	25	2.55	2386	44.08
CIM-608	96.6	24	2.56	2315	60.0

C.D 5%

Sowing date (SD)	2.625	1.917	0.027	78.972	2.1825
Genotype (G)	1.420	1.026	0.018	87.260	1.8087
SD x G	9.841	2.294	0.041	195.12	4.0444

The data presented in Table 1.1 indicated that on overall average basis of sowing dates, CIM-620 produced higher seed cotton yield as compared to Cyto-120 and CIM-608. The genotype CIM-620 produced 1.8 and 4.9% higher seed cotton yield than Cyto-120 and CIM-608, respectively. Averaged across the genotypes, plant height, bolls per plant and seed cotton yield decreased as the 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 (2.59) produced from 15th June sown crop. The maximum bolls per plant (31) and seed cotton yield (2994 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 74.0% in June 01 and 98.6% in June 15 sown crops. Whereas, April 15, May 01 and May 15 showed 3.5%, 14.6% and 56.8%, respectively. On the average basis of sowing dates, genotype Cyto-120 showed 0.3% and 15.9% less CLCuD incidence than CIM-620 and CIM-608, respectively (Fig. 6). The interaction between sowing dates and genotypes is illustrated in Fig. 7.

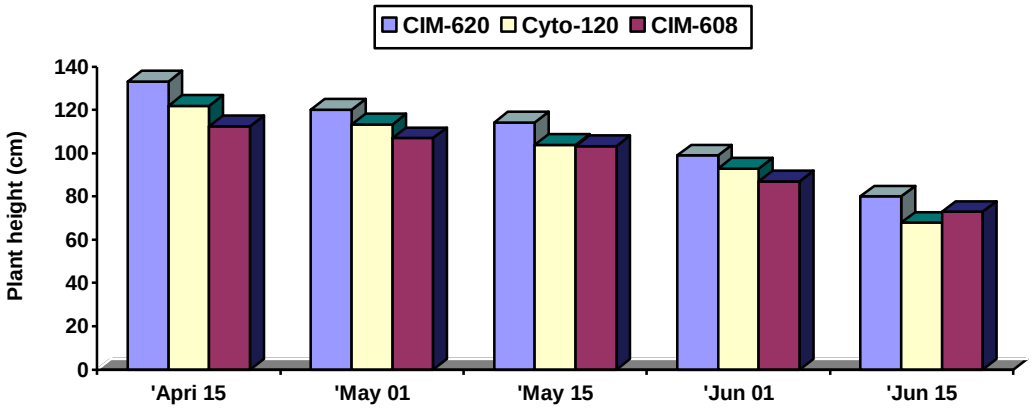

Fig 1 Sowing dates x Genotypes interaction on plant height

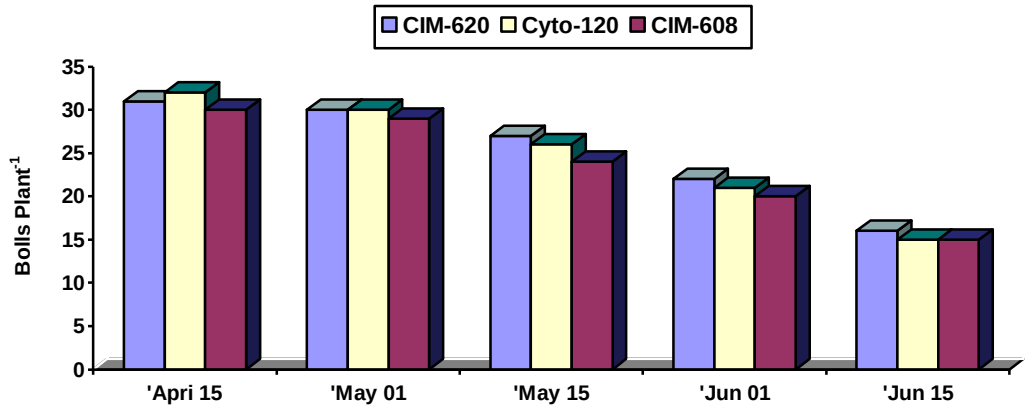

Fig 2 Sowing dates x Genotypes interaction on bolls plant^{-1}

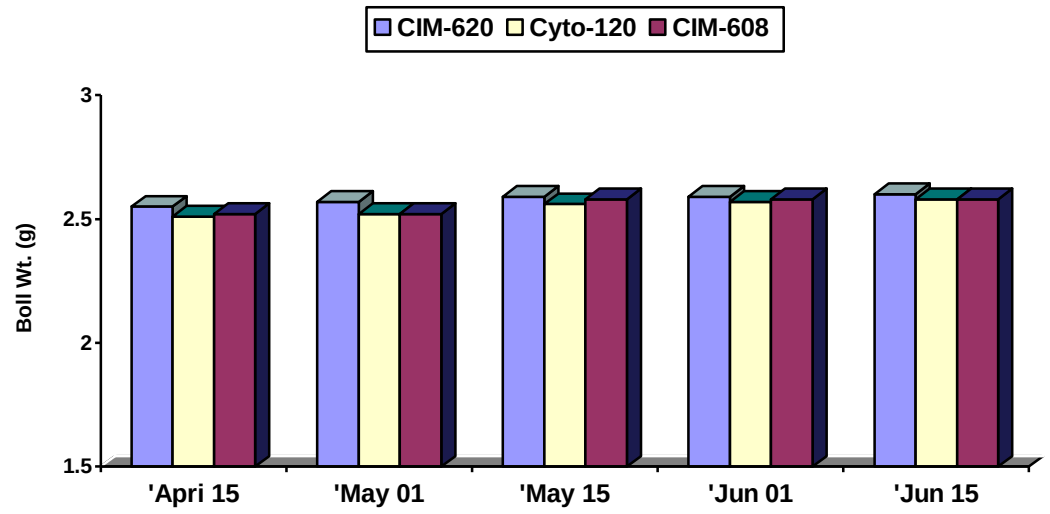

Fig 3 Sowing dates x Genotypes interaction on boll weight

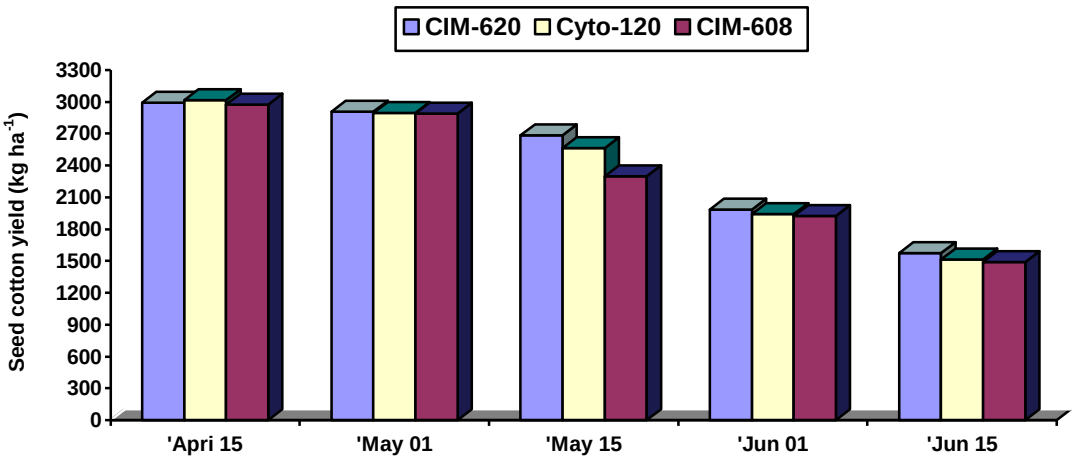

Fig 4 Sowing dates x Genotypes interaction on seed cotton yield

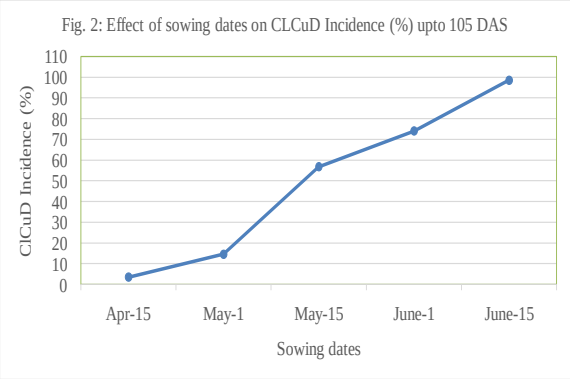

Fig 5. Sowing dates effect on virus infestation at 105 DAS

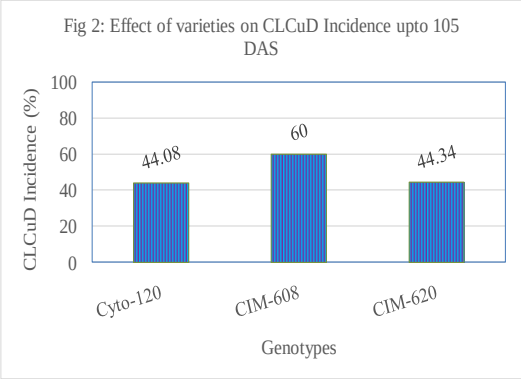

Fig 6. CLCuD Incidence in different genotypes

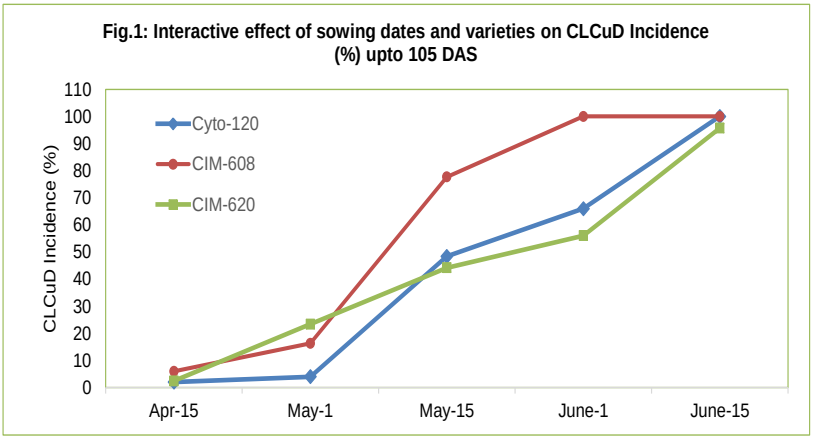

Fig 7. Sowing dates x Genotypes interaction for CLCuD incidence (%) at 105 DAS

1.2 Effect of time of sowing on production of transgenic cotton

Four transgenic cotton varieties i.e. *Bt.*CIM-622, *Bt.*Cyto-178, *Bt.*Cyto-179 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 application of Stomp 455CS @ 2.5 L ha^{-1}. 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.

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

Sowing dates	Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton (kg ha^{-1})	CLCuD incidence %age 120 DAS
March 01	*Bt.*CIM-622	135.4	33	2.56	3340	0.0
	*Bt.*Cyto-178	127.8	32	2.71	3327	0.0
	*Bt.*Cyto-179	129.7	35	2.73	3685	0.0
	*Bt.*CIM-602	134.3	35	2.34	3335	0.0
March 15	*Bt.*CIM-622	132.9	30	2.56	2995	1.62
	*Bt.*Cyto-178	125.2	29	2.74	2979	2.55
	*Bt.*Cyto-179	126.2	33	2.76	3442	1.51
	*Bt.*CIM-602	130.9	32	2.36	2997	5.22
April 01	*Bt.*CIM-622	130.8	28	2.57	2829	3.03
	*Bt.*Cyto-178	124.0	27	2.76	2792	10.76
	*Bt.*Cyto-179	125.5	29	2.78	3049	18.60
	*Bt.*CIM-602	130.0	29	2.36	2778	9.34
April 15	*Bt.*CIM-622	130.0	26	2.58	2614	32.00
	*Bt.*Cyto-178	116.0	25	2.74	2668	33.50
	*Bt.*Cyto-179	119.5	25	2.79	2699	30.60
	*Bt.*CIM-602	126.8	28	2.37	2607	33.80
May 01	*Bt.*CIM-622	116.7	22	2.62	2193	82.69
	*Bt.*Cyto-178	94.5	20	2.74	2085	98.36
	*Bt.*Cyto-179	96.2	22	2.78	2264	94.35
	*Bt.*CIM-602	99.1	23	2.36	2025	86.62
May 15	*Bt.*CIM-622	98.6	18	2.66	1798	100.0
	*Bt.*Cyto-178	75.0	16	2.76	1654	100.0
	*Bt.*Cyto-179	81.0	16	2.79	1704	100.0
	*Bt.*CIM-602	97.5	17	2.36	1590	100.0

DAS* =Days after sowing

Sub-effects

Sowing dates	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})	CLCuD incidence %age
March 01	131.8	34	2.59	3422	0.0
March 15	128.8	31	2.61	3103	2.73
April 01	127.6	28	2.62	2862	10.43
April 15	123.1	26	2.62	2647	32.48
May 01	101.6	22	2.63	2142	90.51
May 15	88.0	17	2.64	1687	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-622	124.1	26	2.59	2628	36.56
Bt.Cyto-178	110.4	25	2.74	2584	40.87
Bt.Cyto-179	113.0	27	2.77	2807	40.84
Bt.CIM-602	119.8	27	2.35	2555	39.16

C.D 5%

Sowing date (SD)	4.577	1.881	0.021	84.912	0.890
Genotype (G)	3.472	1.612	0.019	57.141	0.654
SD x G	8.668	3.949	0.047	139.97	1.603

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 (131.8 cm), bolls plant^{-1} (34) and seed cotton yield (3422 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*.Cyto-179 produced 6.8%, 8.6% and 9.9% more seed cotton yield than *Bt*.CIM-622, *Bt*.Cyto-178 and *Bt*.CIM-602, respectively.

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 90.51% in May 01 and 100% in May 15 sown crop while, March 01, March 15, April 01 and April 15 sown crops showed 0.0%, 2.73%, 10.43% and 32.48%, respectively. On the average basis of sowing dates, genotype *Bt.*CIM-622 showed 2.61%, 4.29% and 4.32% less incidence of CLCuD than *Bt*.CIM-602, *Bt*.Cyto-179 and *Bt*.Cyto-178, respectively (Fig. 13). The interaction between sowing dates and genotypes is illustrated in Fig. 14.

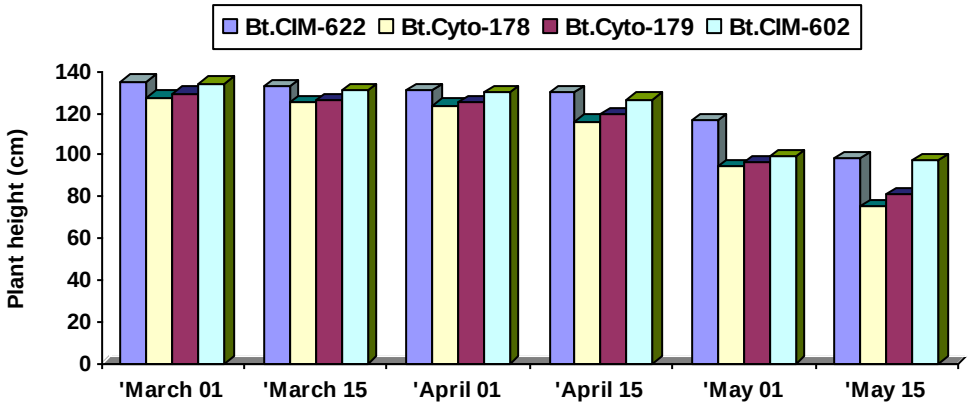

Fig 8 Sowing dates x Genotypes interaction on plant height

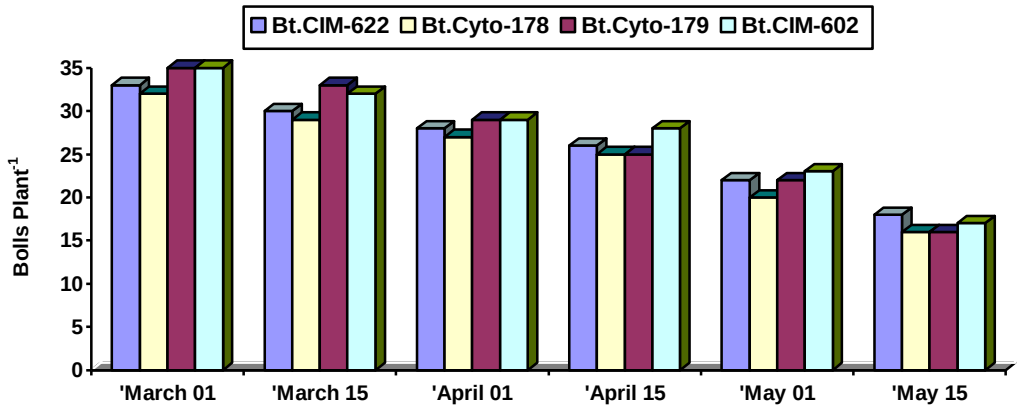

Fig 9 Sowing dates x Genotypes interaction on bolls plant^{-1}

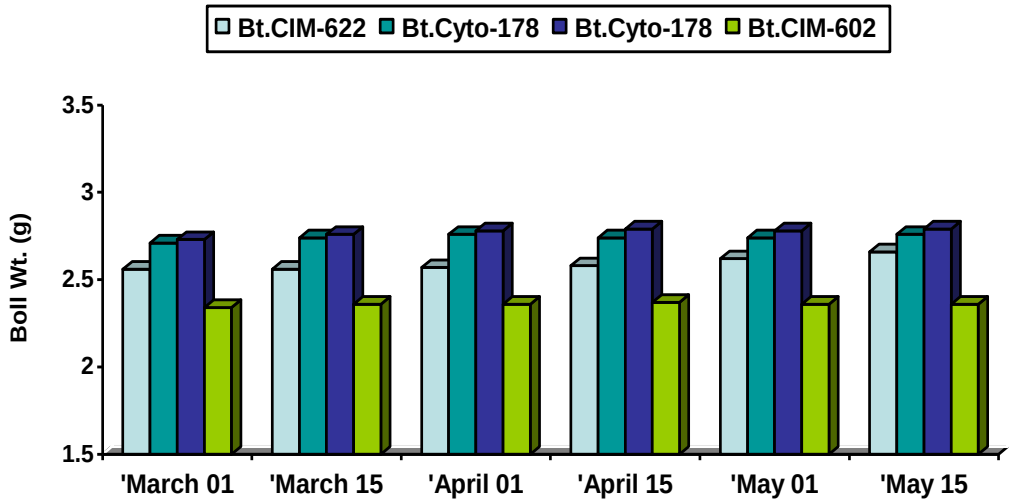

Fig 10 Sowing dates x Genotypes interaction on boll weight

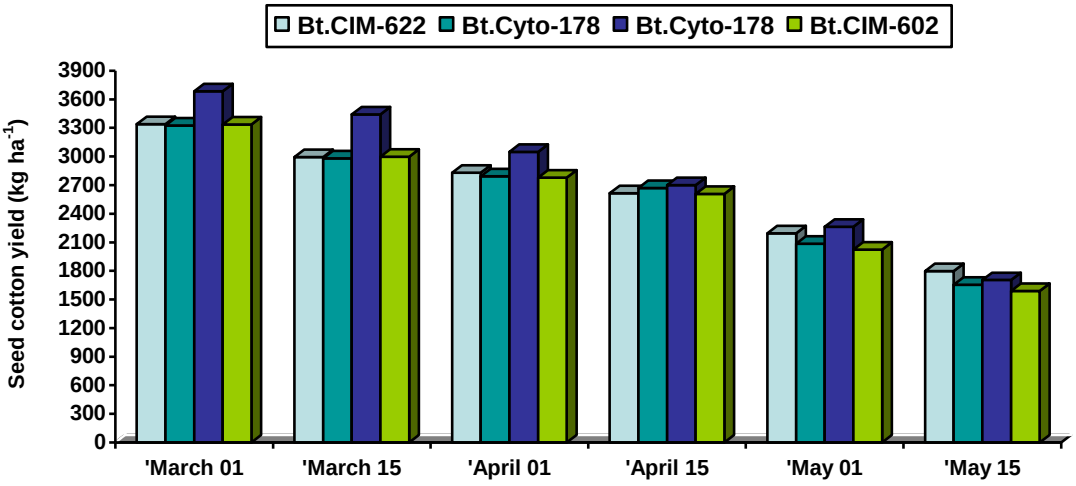

Fig 11 Sowing dates x Genotypes interaction on seed cotton yield

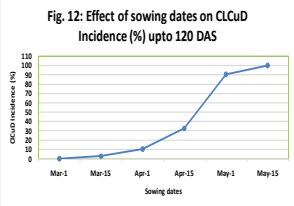

Fig 12. Virus Infestation at 120 DAS

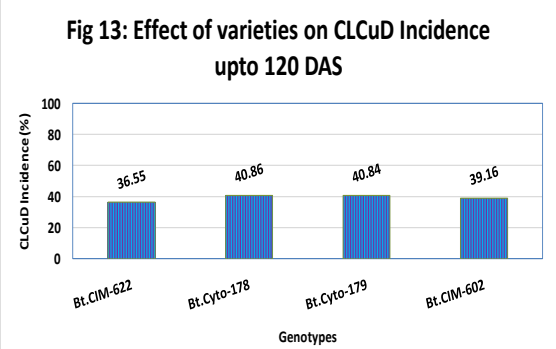

Fig 13. CLCuD Incidence (%) in Different Genotypes

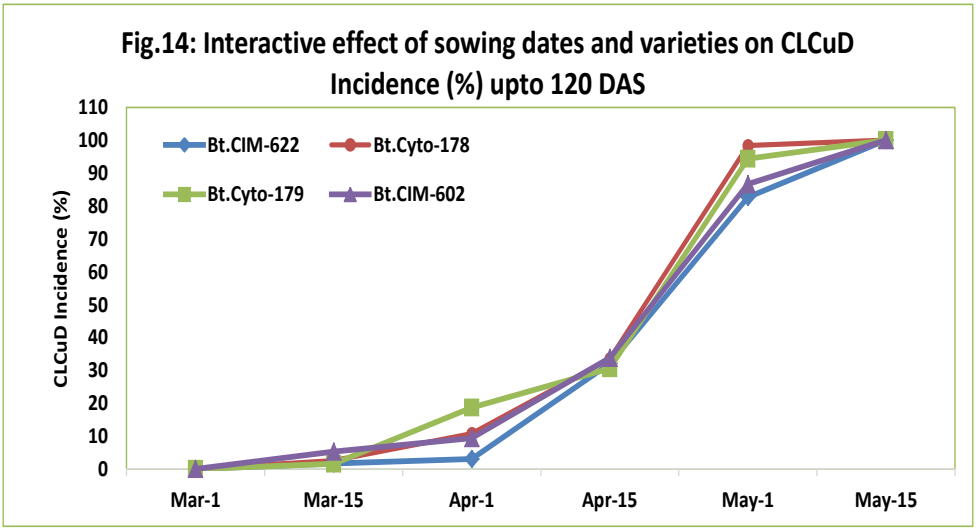

Fig 14. Sowing Dates x Bt. Genotypes Interaction for CLCuD Incidence (%) at 120 DAS

1.3 Evaluation of new genotypes at different levels of nitrogen fertilizer

Three new genotypes i.e. CIM-620, Cyto-120 and CIM-608 (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. 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 20.5.2015 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 their respective treatments. 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.

Data presented in Table 1.3 indicated that application of 150 kg N ha^{-1} produced significant increase in seed cotton yield. The difference in seed cotton yield between 150 and 200 kg N ha^{-1} was non-significant. Averaged across the genotypes, the nitrogen doses @150 and 200 kg N ha^{-1} resulted in significant increase in plant height, boll plant,$^{-1}$ boll weight and seed cotton yield than 0, 50 and 100 kg N ha^{-1} (Fig. 15, 16, 17 & 18). Averaged across the nitrogen doses, genotype Cyto-122 produced higher seed cotton yield than CIM-620 and CIM-608.

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 ant^{-1}	Boll Weight (g)	Seed cotton yield (kg ha^{-1})
0	CIM-620	90.4	17	2.30	1433
	Cyto-122	75.0	16	2.27	1361
	CIM-608	88.2	16	2.28	1372
50	CIM-620	99.0	21	2.33	1885
	Cyto-122	80.0	21	2.29	1853
	CIM-608	93.0	20	2.32	1775
100	CIM-620	104.0	24	2.37	2193
	Cyto-122	86.1	25	2.32	2185
	CIM-608	100.0	23	2.35	2080
150	CIM-620	111.0	27	2.40	2496
	Cyto-122	92.0	29	2.34	2584
	CIM-608	107.5	26	2.39	2356
200	CIM-620	112.0	28	2.42	2519
	Cyto-122	93.5	29	2.35	2598
	CIM-608	108.0	28	2.39	2485

Sub-effects

Nitrogen (kg ha^{-1})	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
0	84.5	16	2.28	1389
50	90.7	21	2.31	1838
100	96.7	24	2.34	2153
150	103.5	27	2.38	2479
200	104.5	28	2.39	2534

Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
CIM-620	103.3	23	2.36	2105
Cyto-122	85.3	24	2.31	2116
CIM-608	99.3	23	2.35	2014

C.D 5%

Nitrogen (N)	8.201	1.764	0.022	112.88
Genotype (G)	4.555	1.306	0.016	40.478
N x G	10.185	2.920	0.036	90.511

1.4 Evaluation of transgenic cotton at different levels of nitrogen fertilizer

Four genotypes i.e *Bt.*CIM-622, *Bt.*Cyto-178, *Bt.*Cyto-179 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. 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 22.5.15 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 treatments. 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.

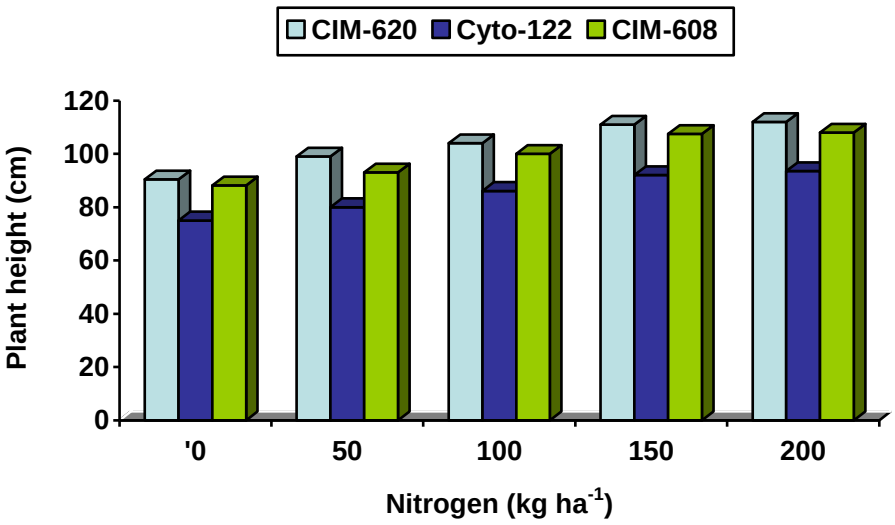

Fig 15 Nitrogen levels X genotypes interaction on plant height

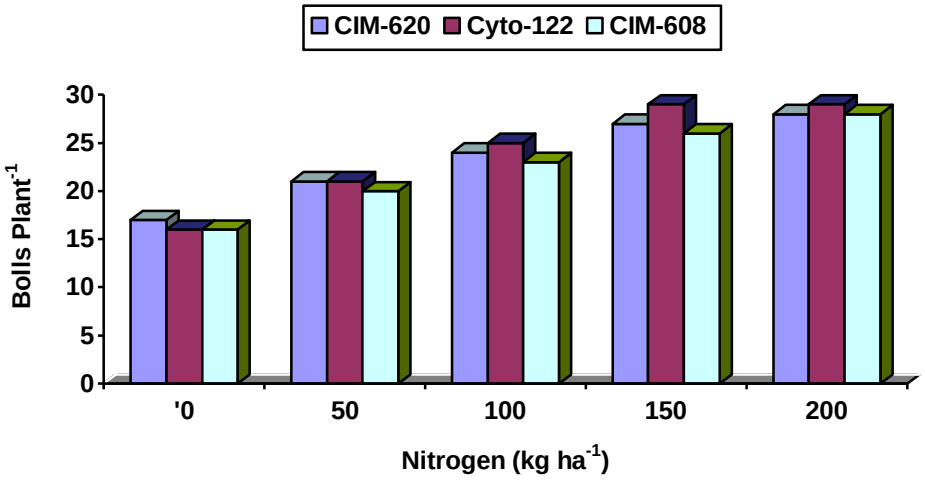

Fig 16 Nitrogen levels X genotypes interaction on bolls plant^{-1}

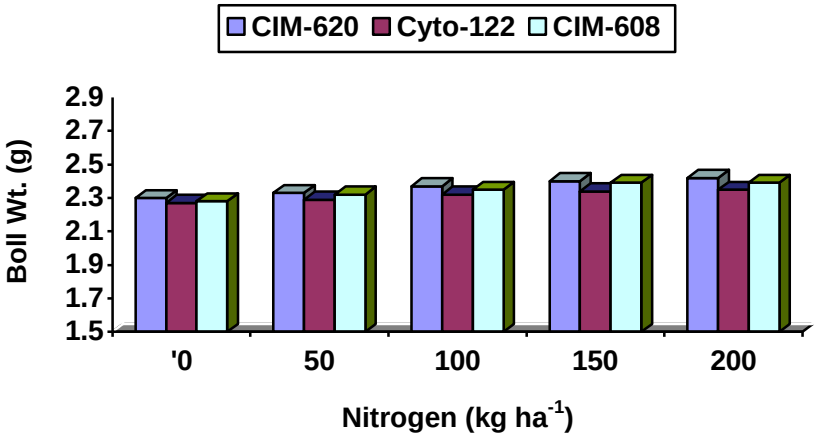

Fig 17 Nitrogen levels X genotypes interaction on boll weight

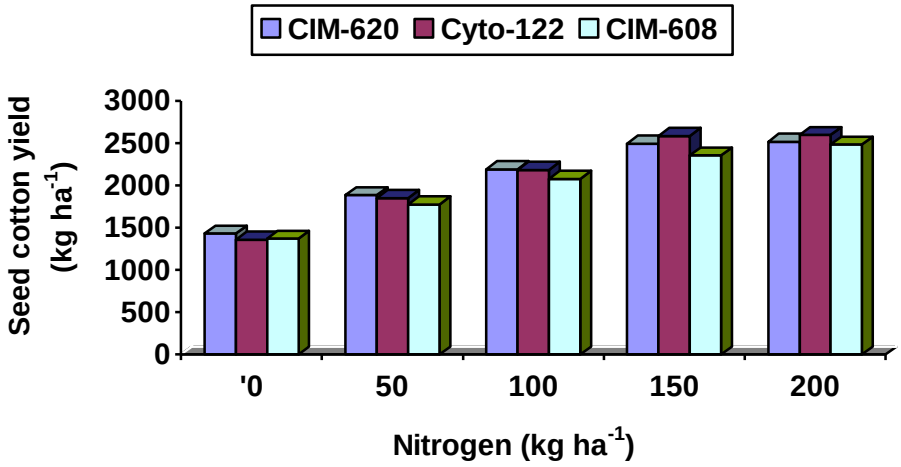

Fig 18 Nitrogen levels X genotypes interaction on seed cotton yield

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-622	93.3	18	2.64	1546
	Bt.Cyto-178	81.5	17	2.63	1493
	Bt.Cyto-179	87.2	19	2.71	1554
	Bt.CIM-602	92.6	17	2.59	1463
100	*Bt*. CIM-622	102.4	25	2.70	2372
	Bt.Cyto-178	92.6	24	2.68	2285
	Bt.Cyto-179	96.4	25	2.75	2395
	Bt.CIM-602	99.9	23	2.65	2233
200	*Bt*. CIM-622	105.8	27	2.73	2642
	Bt.Cyto-178	99.2	27	2.71	2612
	Bt.Cyto-179	101.6	28	2.76	2663
	Bt.CIM-602	103.7	26	2.67	2585
300	*Bt*. CIM-622	110.2	30	2.77	3029
	Bt.Cyto-178	102.6	31	2.76	3050
	Bt.Cyto-179	104.7	31	2.80	3055
	Bt.CIM-602	108.4	29	2.72	2863
400	*Bt*. CIM-622	113.5	31	2.80	3140
	Bt.Cyto-178	107.8	32	2.78	3195
	Bt.Cyto-179	110.3	32	2.82	3245
	Bt.CIM-602	112.0	31	2.71	3084

Sub-effects

Nitrogen (kg ha^{-1})	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
0	88.7	18	2.64	1514
100	97.8	24	2.70	2321
200	102.6	27	2.72	2626
300	106.5	30	2.76	2999
400	110.9	32	2.78	3166

Genotypes	Plant height (cm)	Number of bolls plant^{-1}	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Bt. CIM-622	105.0	26	2.73	2546
Bt.Cyto-178	96.7	26	2.71	2527
Bt.Cyto-179	100.0	27	2.77	2582
Bt.CIM-602	103.3	25	2.67	2446

C.D 5%

Nitrogen (N)	5.125	1.854	0.024	57.286
Genotype (G)	6.288	1.594	0.025	63.173
N x G	14.060	3.565	0.026	141.26

Average across the genotypes, the increase in nitrogen doses resulted in significant increase in plant height, bolls per plant, boll weight and seed cotton yield (Table 1.4). Nitrogen application at the rate of 400 kg ha^{-1} gave significant increase in seed cotton yield over 300 kg N ha^{-1}. Whereas each level of nitrogen gave increase in plant height and boll weight (Fig. 19 & 21). Averaged across the nitrogen doses, genotype *Bt.*Cyto-179 produced 1.4%, 2.2% and 5.6% higher seed cotton yield over *Bt.*CIM-622, *Bt.*Cyto-178 and *Bt.*CIM-602.

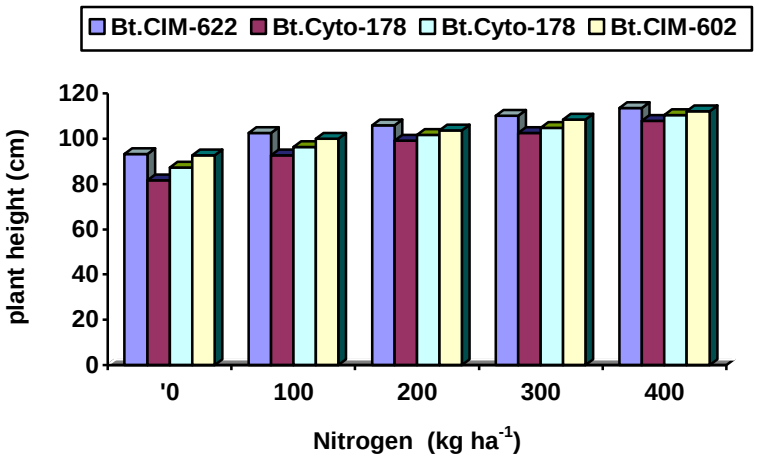

Fig 19 Nitrogen levels X genotypes interaction on plant height

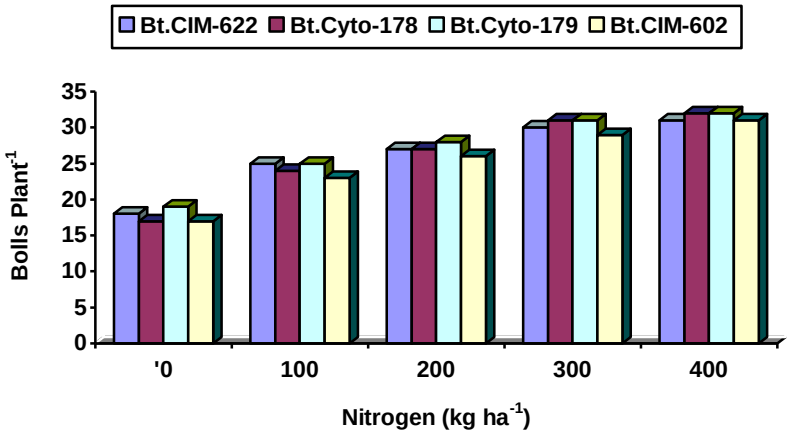

Fig 20 Nitrogen levels X genotypes interaction on bolls plant^{-1}

1.5 Response of cotton to potassium fertilizer

Studies were conducted to determine potassium requirement of transgenic cotton with different potassium doses in combination with foliar application. In set-I, three potassium doses i.e. 0, 100 and 200 kg ha^{-1} were applied to soil either as full dose at pre-plant or two and four equal splits (pre-plant, 30, 45 and 60 DAS). In set-II, the potassium doses i.e. 0, 100 and 200 kg ha^{-1} were applied to soil at pre-plant and four foliar sprays of K_2O at 30, 45, 60 and 75 DAS. Experimental design was Randomized Complete Block Design (RCBD) with four replications. Bed-furrow prepared after land preparation in dry condition followed by bed shaping and application of Pendimethalin 33% EC @2.5 lit ha^{-1}. Cotton Cultivar Bt.CIM-616 was dibbled on 18-04-2015. Sowing was done by dibbling seeds at 25cm plant to plant distance followed by

irrigation. Data on plant height (cm), boll weight (g), number of bolls per plant and seed cotton yield was recorded which is given in Table 1.5.1.

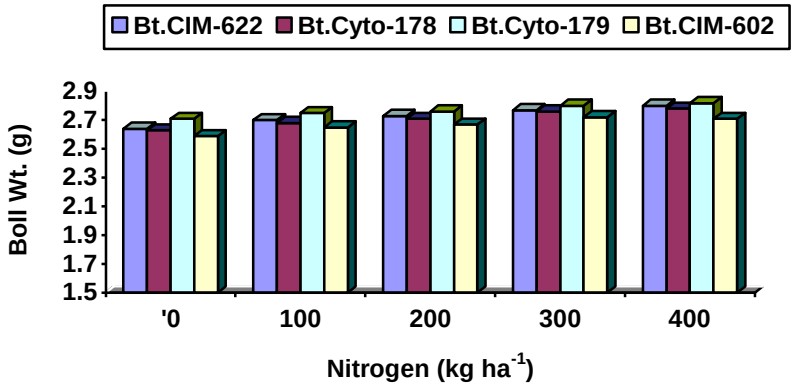

Fig 21 Nitrogen levels X genotypes interaction on boll weight

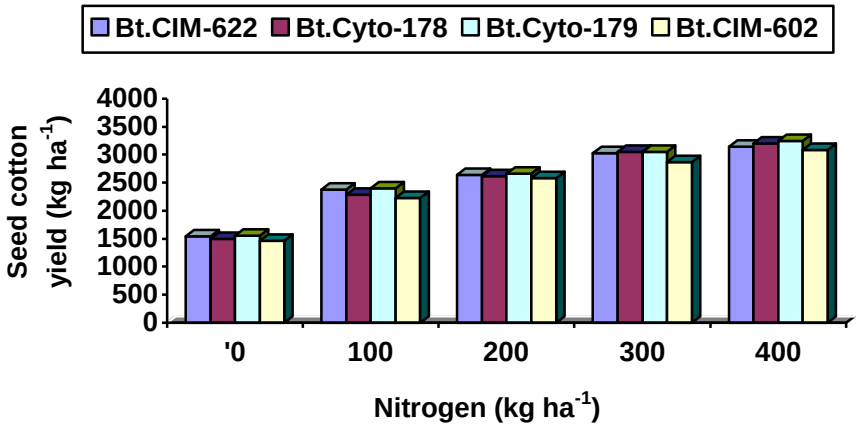

Fig 22 Nitrogen levels X genotypes interaction on seed cotton yield

Table 1.5.1: Interactive effects of doses of potassium fertilizer and its top dressing soil application on Plant structure

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	96.0	22.0	2.48	2290
100	Full at sowing	104.0	27.8	2.57	2756
	Two splits	107.2	28.6	2.62	2884
200	Full at sowing	108.0	28.4	2.59	2890
	Four splits	112.1	29.8	2.62	3017
CD 5%		8.7174	3.1411	0.0314	154.49

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 with K-fertilization. Soil application of K either as full dose or in splits increased the above parameters over control. Main stem height increased from 96.0 to 112.1 cm as the K dose was increased from 0 to 200 kg K_2O ha^{-1}.The no. of bolls per plant, boll weight and seed cotton yield was improved from 22 to 29.8, 2.48 to 2.62 (g) and 2290 to 3017 kg ha^{-1}, respectively, with the increase in potassium application from 0 to 200 kg K_2O ha^{-1}.

Table 1.5.2: Enhancing efficiency of soil applied potassium fertilizer through exogenous applied potassium sulphate for improving quality and quantity of cotton crop

Potassium Fertilizer (kg K_2O ha^{-1})	Foliar application of (2% K_2So_4)	Plant height (cm)	Number of bolls $plant^{-1}$	Boll weight (g)	Seed cotton yield (kg ha^{-1})
0	Four foliar spray of water	99.8	23.0	2.48	2427
	Four foliar spray of K_2So_4	123.4	24.7	2.49	2547
100	Four foliar sprays of K_2So_4	130.3	29.8	2.58	3050
200	Four foliar sprays of K_2So_4	132.2	30.9	2.61	3180
CD 5%		14.57	4.9546	0.0331	175.61

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 increase. Main stem height increased from 99.8 to 132.2 cm as the K dose was increased from 0 to 200 kg K_2O ha^{-1} with foliar spray of 2% K_2SO_4. The bolls per plant, boll weight and seed cotton yield was improved from 23 to 30.9, 2.48 to 2.61 (g) and 2427 to 3180 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% K_2SO_4.

1.6 Cotton as Relay Cropping

Cotton cultivar *Bt.* CIM-616 was sown in all treatment of the experiments. The crop was sown on 18-04-2015 as sole crop on fallow land (T_1). While, sowing in standing wheat was done on 25-04-2015 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 done on 04-06-2015 (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 G/L @ 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)	56000	124.5	269	2.78	3773
Cotton sowing in standing wheat (row to row distance 75cm)	82000	129.4	320	2.74	4393
Cotton sowing in standing wheat (row to row distance 150cm)	38000	116.2	203	2.73	2113
Cotton planting after wheat harvesting	45000	90.50	206	2.75	2270
C.D 5%	1959.6	10.88	23.77	ns	168.89

The result showed that cotton sowing in standing wheat (75 cm apart rows) produced maximum plant height (129.4 cm), bolls (320 m^{-2}) and seed cotton yield (4393 kg ha^{-1}). While minimum bolls (203 m^{-2}) and seed cotton yield (2113 kg ha^{-1}) were produced from cotton sown in standing wheat (150 apart rows) Maximum boll weight (2.78 g) produced by the cotton crop sown as sole. Planting of cotton under modified technique (Relay crop 75 cm apart rows) produced 16.4, 93.5 and 107.9% higher seed cotton yield over fallow land, after wheat harvesting and wide row (150 cm), respectively.

1.7 Internship

Agronomy Section provided research facilities to four Ph.D. scholars of Agriculture College Bahauddin Zakariya University in addition to twenty two students of B.Sc (Hons) Agri (Agronomy) of different Agricultural Colleges/Universities throughout the country. They are facilitated in Research activities and internship training under the supervision of experts.

1.8 Cost of Production of One Acre Cotton for the Year 2015-16

Sr. No.	Operations and Inputs	Number/ Quantity	Rate (Rs)	Amount (Rs.)
1.	Land Preparation			**2560.00**
	a) Leveling	1	400/leveling	400.00
	b) Cultivation	3	700/cultivation	2100.00
	c) Bund making	1	60/acre	60.00
2.	Seedbed Preparation			**4180.00**
	a. Rambar	1	300/acre	300.00
	b. Ploughing + planking	4	700/cultivation	2800.00
	c. Pre-emergence Herbicide	1.2 litre	1080/1.2litre	1080.00
3.	Seed			**1077.00**
	a. Cost	8 kg.	5000/40 kg	1000.00
	b. Transportation	-	25/bag	5.00
	c. Delinting	-	360/40 kg	72.00
4.	Sowing by drill	1	700/acre	**700.00**
5.	Thinning	2	380/acre	**760.00**
6.	Interculturing and earthing up	4	700/acre	**2400.00**
7.	Irrigation			**10853.00**
	a. Land preparation (3 hours)	1/3 canal		
	b. *Rouni* (4 hours)	2/3 tubewell	500/hour of tubewell	9333.00
	c. Post planting irrigation (21hours)			
	d. Cleaning of water channel and labour charges for irrigation	4 man day	380/man day	1520.00
8.	*Abiana* (Water rates)	-	85/acre	**85.00**
9.	Fertilizer			**9940.00**
	a. DAP (Di-Amonium Phosphate)	1 bag	3850/bag	3850.00
	b. Urea	3.0 bags	1870/bag	5610.00
	c. Transportation	4.0 bags	25/bag	100.00
	d. Fertilizer Application Charges	1man day	380/day	380.00
10.	Plant Protection			**9575.00**
	a. Sucking	8	775/spray	6200.00
	b. Bollworm	5	675/spray	3375.00
11.	Harvesting (Picking charges)	800 Kg	8.0/kg	**6400.00**
12	Stick Cutting	2 man day	380/man day	+760.00
12a	Value of cotton sticks			-760.00
13.	Managerial Charges For 1 acre	8 month	18000/month/100 acre	**1440.00**
14.	Ushar	-	120/acre	**120.00**
15.	Land Rent	8 months	25,000/acre/annum	**16667.00**
16.	Unforeseen Expenses	-	2000/acre	**2000.00**
17.	Production Expenditure	-	-	
	a. Including Land Rent			**68757.00**
	b. Excluding Land Rent			**52090.00**
18.	Mark-up on Investment	8 month	13% for one year	
	a. Including Land Rent			**5958.88**
	b. Excluding Land Rent			**4514.40**
19.	Total Expenditure	--		
	a. Including Land Rent			**74715.88**
	b. Excluding Land Rent			**56604.40**
20.	Income of Seed Cotton	800 kg	2600/40 kg	**52000. 00**
21.	Market expenses	800 kg	100/40 kg	**2000. 00**
22.	Cost of Production at Farm level	-		
	a. Including Land Rent		Per 40 kg	**3735.60**
	b. Excluding Land Rent			**2830.00**
23.	Cost of production at Market	-		**3835.60**
	a. Including land rent.		Per 40 kg	**2930.00**
	b. Excluding land rent.			

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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-506, 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 5765 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

Nine medium long staple promising *Bt*. strains viz., *Bt*.CIM-616, *Bt*.CIM-622, *Bt*.CIM-625, *Bt*.CIM-627, *Bt*-CIM-629, *Bt*.CIM-630, *Bt*.CIM-631, *Bt*.CIM-632 *a*nd *Bt*.CIM-633 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 seedcotton yield and other parameters are given in **Tables 2.1, 2.2** and **2.3**.

Averaged across locations, the strain *Bt*.CIM-632 produced the highest seedcotton yield of 2689 kg ha^{-1} followed by *Bt*.CIM-629 having yield 2453 kg ha^{-1} while the standard varieties FH-142 and *Bt*.CIM-602 yielded 1798 and 1704 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 (30/4)*	Khanewal (26/5)*	Average			
Bt.CIM-616	2698	2071	2385	935	3.5	43896
Bt.CIM-622	2416	2062	2239	860	3.1	42017
Bt.CIM-625	1308	1480	1394	542	2.9	42871
*Bt.*CIM-627	2115	1641	1878	768	3.1	41675
*Bt.*CIM-629	2888	2018	2453	927	3.0	30317
*Bt.*CIM-630	2281	1480	1881	720	3.4	42956
*Bt.*CIM-631	1045	1004	1025	393	2.8	25449
*Bt.*CIM-632	3226	2152	2689	1121	3.0	36893
*Bt.*CIM-633	1833	1722	1778	725	2.9	34160
FH-142	2008	1587	1798	698	3.1	42871
*Bt.*CIM-602	1883	1524	1704	654	2.9	42871

* = Sowing date

CD (5%) for seedcotton: Locations (L) = 43.03; Varieties (V) = 100.90; L x V = 142.70

The new strain *Bt*.CIM-632 produced the highest lint percentage of 41.7, followed by *Bt*.CIM-627 and *Bt*.CIM-633 having lint percentage values of 40.9 and 40.8, respectively

(**Table 2.2**). The new strain *Bt.*CIM-632 produced the longest staple of 28.8 mm, followed by *Bt*.CIM-622 and *Bt*.CIM-625 with 28.5 mm while the standards FH-142 and *Bt*.CIM-602 produced 26.5 and 28.5 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
Bt.CIM-616	39.4	39.0	39.2	28.1	28.4	28.3
Bt.CIM-622	38.5	38.2	38.4	28.3	28.7	28.5
Bt.CIM-625	39.0	38.7	38.9	28.2	28.7	28.5
*Bt.*CIM-627	41.2	40.5	40.9	28.2	28.6	28.4
*Bt.*CIM-629	37.8	37.7	37.8	28.0	28.4	28.2
*Bt.*CIM-630	38.5	38.1	38.3	27.1	27.8	27.5
*Bt.*CIM-631	38.4	38.2	38.3	26.9	27.1	27.0
*Bt.*CIM-632	41.8	41.5	41.7	28.5	29.0	28.8
*Bt.*CIM-633	41.3	40.2	40.8	28.0	28.4	28.2
FH-142	39.0	38.6	38.8	26.2	26.7	26.5
*Bt.*CIM-602	38.5	38.2	38.4	28.3	28.6	28.5

All the new strains possess desirable micronaire values ranging from 4.0 to 4.6 μg inch^{-1} in comparison to FH-142 with 4.6 μg inch^{-1} and *Bt*.CIM-602 with 4.2 μg inch^{-1}. The fibre strength of all the new strains and standards is in the desirable range, i.e., 92.2 to 102.3 tppsi **(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 (tppsi)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
Bt.CIM-616	4.8	4.4	4.6	100.9	100.4	100.7
Bt.CIM-622	4.1	4.0	4.1	92.6	92.8	92.7
Bt.CIM-625	3.9	4.0	4.0	92.0	92.3	92.2
*Bt.*CIM-627	4.3	4.0	4.2	96.9	97.7	97.3
*Bt.*CIM-629	4.1	4.1	4.1	102.3	102.1	102.2
*Bt.*CIM-630	4.7	4.3	4.5	93.9	93.3	93.6
*Bt.*CIM-631	4.4	3.9	4.2	93.8	93.7	93.8
*Bt.*CIM-632	4.3	4.0	4.2	100.9	100.5	100.7
*Bt.*CIM-633	4.4	4.2	4.3	100.0	99.3	99.7
FH-142	4.7	4.4	4.6	102.6	101.9	102.3
*Bt.*CIM-602	4.2	4.1	4.2	96.5	96.0	96.3

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-620, CIM-716, CIM-717, CIM-718, CIM-719 and CIM-720 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-620, averaged across locations, produced the highest seedcotton yield of 2216 kg ha^{-1}, followed by CIM-720 with 2106 kg ha^{-1} and CIM-717 with 1945 kg ha^{-1} while the standard variety CIM-573 produced 1408 kg ha^{-1}.

The strain CIM-610 had the highest lint percentage of 39.8, followed by 39.5% of CIM-620 and CIM-720 with 38.6% in comparison to the commercial variety CIM-573 which produced 38.8 lint percentage. The strain CIM-717 produced the longest staple of 29.2 mm followed by CIM-573 having 29.1 mm and 28.6mm of CIM-610 and CIM-620. **(Table 2.5).**

All the strains possess desirable micronaire values ranging from 4.0 to 4.5 μg inch^{-1}**.** The fibre strength of the strains ranged from 92.7 to 105.6 tppsi **(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 (19/5)*	Khanewal (26/5)*	Average			
CIM-610	1803	1960	1882	749	3.3	30994
CIM-620	2339	2092	2216	875	2.9	30276
CIM-716	960	1351	1156	428	2.8	28840
CIM-717	1954	1936	1945	737	3.0	35421
CIM-718	1275	1434	1355	515	3.1	25968
CIM-719	1738	2032	1885	720	2.9	30794
CIM-720	2132	2080	2106	813	3.0	33148
CIM-573	1429	1387	1408	546	2.8	32908

* = Sowing date

CD (5%) for seedcotton: Locations (L) = 53.59; Varieties (V) = 107.18; L x V = 151.58

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	40.5	39.1	39.8	28.4	28.8	28.6
CIM-620	39.6	39.3	39.5	28.4	28.7	28.6
CIM-716	37.2	36.8	37.0	28.2	28.8	28.5
CIM-717	38.5	37.3	37.9	29.0	29.4	29.2
CIM-718	38.1	37.9	38.0	26.9	26.2	26.6
CIM-719	38.5	37.8	38.2	28.1	28.4	28.3
CIM-720	39.1	38.1	38.6	28.3	27.5	27.9
CIM-573	39.1	38.5	38.8	28.9	29.2	29.1

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 (tppsi)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
CIM-610	4.3	4.1	4.2	102.6	103.0	102.8
CIM-620	4.6	4.3	4.5	92.6	92.8	92.7
CIM-716	4.4	4.3	4.4	101.6	102.4	102.0
CIM-717	4.4	4.2	4.3	102.7	100.1	101.4
CIM-718	4.1	3.9	4.0	106.6	104.6	105.6
CIM-719	4.4	4.1	4.3	96.8	95.2	96.0
CIM-720	4.6	4.2	4.4	97.7	99.1	98.4
CIM-573	4.3	4.0	4.2	95.5	96.9	96.1

2.1.2 Varietal Trial-3

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

Seven medium staple promising *Bt*. strains viz., *Bt*.CIM-634 to *Bt*.CIM-640, were evaluated against *Bt*. commercial variety FH-142 at CCRI, Multan and Punjab Seed Corporation Farm, Khanewal. Data on seedcotton yield and other parameters are given in **Tables 2.7, 2.8** and **2.9**.

Averaged across locations, the strain *Bt*.CIM-638 produced the highest seedcotton yield of 2229 kg ha^{-1} followed by *Bt*.CIM-636 having yield of 2072 kg ha^{-1} while the standard variety FH-142 yielded 1265 kg ha^{-1} **(Table 2.7).**

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

Strains	Seedcotton yield (kg ha^{-1})			Lint Yield (kg ha^{-1})	Av. Boll weight (g)	Plant Pop. (ha^{-1})
	Multan (23/5)*	Khanewal (26/5)*	Average			
Bt.CIM-634	1524	1593	1559	583	2.8	30386
Bt.CIM-635	1422	1256	1339	542	2.9	28782
Bt.CIM-636	2153	1991	2072	804	3.4	33028
*Bt.*CIM-637	2025	1758	1892	726	2.9	28876
*Bt.*CIM-638	2458	2000	2229	859	3.2	34538
*Bt.*CIM-639	1645	1444	1545	514	2.8	36237
*Bt.*CIM-640	1517	1880	1699	634	3.0	35010
FH-142	1239	1290	1265	497	3.0	23403

* = Sowing date

CD (5%) for seedcotton: Locations (L) = 40.14; Varieties (V) = 80.27; L x V = 113.52

The new strain *Bt*.CIM-635 produced the highest lint percentage of 40.5, followed by *Bt*.CIM-636 and *Bt*.CIM-638 having lint percentage values of 38.8 and 38.5, respectively **(Table 2.8).** The new strain *Bt.*CIM-638 produced the longest staple of 28.7 mm, followed by *Bt*.CIM-637 and *Bt*.CIM-636 with 28.4 mm and 28.3 mm respectively while the standards FH-142 produced 26.7mm in 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
Bt.CIM-634	37.5	37.2	37.4	27.8	28.1	28.0
Bt.CIM-635	40.7	40.3	40.5	26.8	27.0	26.9
Bt.CIM-636	38.9	38.6	38.8	28.0	28.6	28.3
*Bt.*CIM-637	38.5	38.3	38.4	28.1	28.7	28.4
*Bt.*CIM-638	38.6	38.3	38.5	28.5	28.9	28.7
*Bt.*CIM-639	33.5	33.0	33.3	28.0	28.2	28.1
*Bt.*CIM-640	36.6	36.7	36.7	27.5	28.1	27.8
FH-142	39.7	38.9	39.3	26.6	26.9	26.8

All the new strains possess desirable micronaire values ranging from 3.9 to 4.8 μg inch^{-1} in comparison to FH-142 with 4.2 μg inch^{-1}. 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 (tppsi)		
	Multan	Khanewal	Average	Multan	Khanewal	Average
Bt.CIM-634	4.5	4.1	4.3	92.3	93.0	92.7
Bt.CIM-635	4.8	4.8	4.8	95.4	95.1	95.3
Bt.CIM-636	4.0	3.9	4.0	100.1	98.6	99.4
*Bt.*CIM-637	4.5	4.3	4.4	99.4	95.2	97.3
*Bt.*CIM-638	4.6	4.0	4.3	96.4	98.8	97.6
*Bt.*CIM-639	3.9	3.8	3.9	101.4	100.0	100.7
*Bt.*CIM-640	4.5	4.1	4.3	100.0	99.5	99.8
FH-142	4.3	4.1	4.2	100.7	97.1	98.9

2.1.3 Micro Varietal Trial-1

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

Ten newly bulked medium long staple *Bt.* strains from 2704/15 to 2713/15 were tested against a commercial variety *Bt*.CIM-602 at CCRI, Multan. Data presented in **Table 2.10** showed that the new strain 2712 produced the highest seedcotton yield of 3327 kg ha^{-1} followed by strains 2707/15 and 2705/15 with seedcotton yield of 3023 and 3021 kg ha^{-1}, respectively compared to yield of 2361 kg ha^{-1} of variety *Bt*.CIM-602.

The new strain 2705/15 produced the highest lint percentage of 42.1, followed by 2708/15 having 41.5 and 2707/15 with 41.3 lint %age compared with the variety *Bt*.CIM-602 which produced 38.2% lint. The strain 2712/15 produced the longest staple of 28.8 mm, followed by 2707/15 having 28.7 mm staple length against the commercial variety *Bt*.CIM-602 having 28.1 mm staple length.

All the strains have desirable micronaire values ranging from 3.8 to 4.7 μg $inch^{-1}$ except 2713. All the new strains had the desirable fibre strength ranging from 93.5 to 106.0 tppsi where as *Bt*.CIM-602 has 96.8 tppsi fibre strength.

Table 2.10 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 (tppsi)	Av. boll wt. (g)	Plant Pop. (ha^{-1})
2704/15	2398	971	40.5	26.4	4.0	104.4	2.8	41340
2705/15	3021	1272	42.1	26.1	4.7	100.8	2.9	40962
2706/15	2191	859	39.2	28.0	3.8	102.6	2.8	41151
2707/15	3023	1249	41.3	28.7	4.3	100.4	3.0	40396
2708/15	2432	1009	41.5	26.4	4.0	106.0	2.8	40396
2709/15	2148	821	38.2	26.4	4.4	100.1	2.9	40774
2710/15	3008	1191	39.6	28.1	4.4	93.5	3.1	41529
2711/15	2796	1018	36.4	28.0	4.1	95.2	2.8	38320
2712/15	3327	1341	40.3	28.8	4.4	93.5	2.9	40774
2713/15	2397	918	38.3	27.3	5.1	94.0	2.8	41529
*Bt.*CIM-602	2361	902	38.2	28.1	4.1	96.8	2.8	41906

Sowing date = 30.04.2015; CD (5%) for seedcotton: Strains = 245.65 ; CV % = 5.45

2.1.4 Micro Varietal Trial-2

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

Ten newly bulked strains numbering from 2714/15 to 2723/15 were tested against commercial variety *Bt*.CIM-602 at CCRI, Multan. The new strain 2722/15 surpassed all the strains and standard variety in seedcotton yield by producing 2928 kg ha^{-1}, followed by 2723/15 with 2840 kg ha^{-1} and 2716/15 having 2748 kg ha^{-1} compared with 2127 yield of *Bt.*CIM-602 **(Table 2.11).**

The strain 2719/15 produced the highest lint percentage of 42.0, followed by 41.9 percent lint in 2715/15 while the commercial variety *Bt*.CIM-602 produced the lint percentage of 38.1. The strain 2715 produced the longest staple of 29.3 mm, followed by 29.2 mm in 2722/15 compared with the fibre length of 28.0 mm in commercial variety *Bt*.CIM-602. All the strains have desirable micronaire values ranging from 3.8 to 4.7 μg $inch^{-1}$. The strain 2723/15 maintained the maximum fibre strength of 103.7 tppsi, followed by 102.0 tppsi in 2716/15 while standard *Bt.*CIM-602 had 95.5 tppsi.

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

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micro-naire value (µg inch^{-1})	Fibre Strength (tppsi)	Av. boll wt. (g)	Plant Pop. (ha^{-1})
2714/15	2088	787	37.7	27.5	4.7	98.6	2.7	40019
2715/15	1968	825	41.9	29.3	4.0	99.4	2.9	40774
2716/15	2748	1069	38.9	26.2	4.2	102.0	2.8	42095
2717/15	1760	648	36.8	28.6	4.1	98.6	3.0	37942
2718/15	1730	621	35.9	27.8	3.9	100.8	2.7	40207
2719/15	2147	902	42.0	27.9	3.9	99.3	2.9	41717
2720/15	2055	859	41.8	27.2	3.8	101.8	3.0	40207
2721/15	2156	850	39.4	26.8	4.3	97.6	2.7	43605
2722/15	2928	1165	39.8	29.2	4.2	100.4	2.9	41340
2723/15	2840	1091	38.4	28.2	4.5	103.7	3.0	40774
*Bt.*CIM-602	2127	810	38.1	28.0	4.0	95.5	2.9	42095

Sowing date = 30.04.2015; CD (5%) for seedcotton =254.50; CV. % = 6.70

2.1.5 Micro Varietal Trial-3

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

Six newly bulked strains numbering from 939/15 to 944/15 were tested against commercial variety CIM-573 at CCRI, Multan. Data presented in **Table 2.12** indicated that the new strain 939/15 surpassed all the new strains yielding 2370 kg ha^{-1}, followed by strains 940/15 and 942/15 which produced 2090 and 2033 kg ha^{-1} seedcotton respectively while the standard CIM-573 yielding 1479 kg ha^{-1}. The new strain 941/15 produced the highest lint percentage of 38.2 followed by 37.5% in 940/15 and 944/15 in comparison to CIM-573 having 38.9 lint percentage. The strains 941/15 and 943/15 produced the longest staple of 30.3 mm followed by 29.9 mm in 940/15 compared with the staple length of 28.8 mm in standard variety CIM-573. The genotypes 941/15 and 942/15 have undesirable micronaire value while all other have desirable micronaire value. All these strains show desirable fibre strength.

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

Strains	Seed cotton yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micronaire value (µg inch^{-1})	Fibre strength (tppsi)	Av. boll weight (g)	Plant Pop. (ha^{-1})
939/15	2370	827	34.9	29.8	4.0	92.4	3.2	34430
940/15	2090	784	37.5	29.9	3.9	98.0	3.1	26779
941/15	1498	572	38.2	30.3	3.4	100.9	2.9	27257
942/15	2033	736	36.2	29.8	3.5	98.3	2.9	34909
943/15	1795	628	35.0	30.3	3.9	104.0	3.0	27736
944/15	1620	608	37.5	28.1	3.8	100.4	2.8	19606
CIM-573	1479	575	38.9	28.8	4.0	94.7	2.9	35148

Sowing date = 21.05.2015; CD (5%) for seedcotton = 185.03; CV. % = 5.65

2.1.6 Micro-Varietal Trial-4

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

Eight newly bulked elite *Bt*. strains from 3775/15 to 3782/15 were tested against commercial variety *Bt.*CIM-602 at CCRI, Multan. Data on yield and other parameters are presented in **Table 2.13**.

The strain 3777/15 out-yielded all the strains and standard variety by producing 1531 kg ha^{-1} seedcotton, followed by 3779/15 and 3781/15 having seedcotton yields of 1518 and 1456 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 1078 kg ha^{-1} seedcotton. The strains 3778/15 and 3782/15 produced the higher lint percentage values of 40.8 and 40.5, respectively compared with that of 37.9% by *Bt.*CIM-602.

The strain 3776/15 produced the longest staple of 30.7 mm, followed by the 28.9 mm of strain 3781/15 compared with the 28.1 mm of *Bt.*CIM-602. All the strains have desirable micronaire values ranging from 3.9 to 4.4 μg $inch^{-1}$. The fibre strength of all the new strains is observed within the desirable range.

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

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micronaire value (μg $inch^{-1}$)	Fibre Strength (tppsi)	Av. boll weight (g)	Plant pop. (ha^{-1})
3775/15	1306	512	39.2	28.7	4.2	93.7	2.9	35653
3776/15	1433	549	38.3	30.7	4.0	97.6	2.9	40084
3777/15	1531	602	39.3	27.9	4.2	96.8	2.8	41771
3778/15	986	402	40.8	28.0	4.4	99.3	2.9	41139
3779/15	1518	584	38.5	28.2	4.1	97.0	2.8	39451
3780/15	1345	529	39.3	28.2	4.2	95.3	2.9	39240
3781/15	1456	556	38.2	28.9	3.9	97.1	2.8	36286
3782/15	1203	487	40.5	28.3	4.2	95.4	2.7	36286
*Bt.*CIM-602	1078	409	37.9	28.1	4.3	93.6	2.8	38607

Sowing date = 27.05.2015; CD (5%) for seedcotton = 312.71; CV. % = 13.71

2.1.7 Micro-Varietal Trial-5

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

Eleven newly bulked elite strains 3973/15 to 3983/15 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 3975/15 out-yielded all the strains and standard variety by producing 2390 kg ha^{-1} seedcotton, followed by 3982/15 and 3978/15 having seedcotton yields of 2381 and 2376 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 1632 kg ha^{-1} seedcotton. The strains 3979/15 and 3974/15 produced the higher lint percentage values of 44.0 and 42.6 respectively compared with that of 37.4% by *Bt.*CIM-602.

The strain 3976/15 produced the longest staple of 28.8 mm, followed by 28.5 mm in 3973/15 compared with the fibre length of 28.0 mm in commercial variety *Bt.*CIM-602. All strains have desirable micronaire values ranging from 3.8 to 4.9 μg $inch^{-1}$ except 3980/15 and 3983/15. The strain 3976/15 maintained the maximum fibre strength of 107.5 tppsi, followed by 3975 tppsi in 106.3 while standard *Bt.*CIM-602 had 94.7 tppsi fibre strength.

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

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micronaire value (µg inch^{-1})	Fibre Strength (tppsi)	Av. boll weight (g)	Plant pop. (ha^{-1})
3973/15	2309	951	41.2	28.5	4.6	101.4	3.7	39530
3974/15	1721	733	42.6	26.4	4.5	93.2	4.0	41430
3975/15	2390	839	35.1	25.9	3.8	106.3	2.8	40230
3976/15	2034	683	33.6	28.8	3.9	107.5	3.3	22350
3977/15	2122	821	38.7	24.9	4.7	92.6	3.0	41877
3978/15	2376	979	41.2	27.6	4.3	96.5	3.2	40230
3979/15	2048	901	44.0	24.5	4.9	92.5	2.8	36533
3980/15	1970	786	39.9	25.6	5.0	100.8	3.1	42546
3981/15	2373	921	38.8	27.6	4.3	99.7	3.2	42440
3982/15	2381	876	36.8	27.7	4.1	94.6	3.2	42525
3983/15	1946	716	36.8	27.9	3.7	101.6	2.9	38235
*Bt.*CIM-602	1632	610	37.4	28.0	3.9	94.7	3.1	41762

Sowing date = 06.06.2015; CD (5%) for seedcotton =104.17; CV. % = 2.92

2.1.8 Micro-Varietal Trial-6

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

Nine newly bulked elite strains 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 4086/15 out-yielded all the strains and standard variety by producing 1941 kg ha^{-1} seedcotton, followed by 4088/15 and 4084/15 having seedcotton yields of 1755 and 1701 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 1277 kg ha^{-1} seedcotton. The strains 4080/15 and 4086/15 produced the higher lint percentage values of 40.2 and 39.5, respectively compared with that of 38.4% by *Bt.*CIM-602.

The strain 4082/15 produced the longest staple of 30.6 mm, followed by 28.8 mm in 4088/15 compared with the fibre length of 28.0 mm in commercial variety *Bt*.CIM-602. All strains have desirable micronaire values raging from 4.0 mm to 4.7 mm. The fibre strength of all the strains was observed to be in the desirable range.

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

Strains	Seed Cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple Length (mm)	Micronaire value (µg inch^{-1})	Fibre Strength (tppsi)	Av. boll weight (g)	Plant pop. (ha^{-1})
4080/15	1228	494	40.2	27.6	4.1	98.0	2.8	38736
4081/15	926	349	37.7	27.9	4.3	94.6	2.9	39274
4082/15	1203	446	37.1	30.6	4.1	100.5	3.4	35687
4083/15	1531	547	35.7	28.0	4.7	94.5	2.9	38198
4084/15	1701	641	37.7	27.4	4.7	92.7	2.8	40709
4085/15	1030	387	37.6	28.7	4.0	98.5	3.0	31742
4086/15	1941	767	39.5	27.9	4.0	92.4	3.0	34432
4087/15	1565	601	38.4	28.6	4.0	100.4	3.0	38557
4088/15	1755	676	38.5	28.8	4.2	102.1	2.8	36405
*Bt.*CIM-602	1277	490	38.4	28.0	4.0	95.4	2.9	38736

Sowing date: 04.06.2015 CD (5%) for seedcotton: Strains = 165.87, CV% = 6.83

2.1.9 Micro-Varietal Trial-7

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

Nine newly bulked elite strains (4210/15 to 4218/15) 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 4211/15 out-yielded all the strains and standard variety by producing 2476 kg ha^{-1} seedcotton, followed by 4216/15 and 4213/15 having seedcotton yields of 1794 and 1522 kg ha^{-1}, respectively against commercial variety *Bt.*CIM-602 which produced 1320 kg ha^{-1} seedcotton. The strains 4213/15 produced the maximum lint percentage values of 40.8 followed by 4217/15 which produced 40.0% lint and 38.7% by *Bt.*CIM-602.

The strain 4215/15 produced the longest staple of 29.3 mm, followed by 28.9 mm in 4210/15 compared with the fibre length of 27.5 mm in commercial variety *Bt*.CIM-602. All strains have desirable micronaire values ranging from 4.0 to 4.8. The strain 4218/15 maintained the maximum fibre strength of 101.3 tppsi, followed by 99.4 tppsi in 4213/15 while standard *Bt.*CIM-602 had 94.3 tppsi fibre strength.

Table 2.16 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 (tppsi)	Av. boll weight (g)	Plant pop. (ha^{-1})
4210/15	1459	553	37.9	28.9	4.6	92.8	2.7	39453
4211/15	2476	953	38.5	28.3	4.8	93.0	2.9	40888
4212/15	805	320	39.7	27.5	4.0	98.4	2.8	43040
4213/15	1522	609	40.8	28.0	4.1	99.4	3.0	37481
4214/15	1007	395	39.2	27.8	4.3	97.6	2.9	40171
4215/15	1125	430	38.2	29.3	4.1	96.7	3.0	38915
4216/15	1794	696	38.8	28.7	4.3	93.9	3.1	40529
4217/15	1242	497	40.0	28.4	4.2	95.2	3.0	41247
4218/15	1246	492	39.5	27.8	4.5	101.3	3.3	38557
*Bt.*CIM-602	1320	511	38.7	27.5	4.1	94.3	2.8	36405

Sowing date: 04.06.2015; CD (5%) for seedcotton: Strains = 150.70; CV% = 6.28

2.1.10 Testing of advance strains at farmers' fields

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

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

Two medium-long staple *Bt.* strains viz., *Bt*.CIM-616 and *Bt*.CIM-622 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-616 produced the highest seedcotton yield of 3046 kg ha^{-1} compared with the yield of 2694 kg ha^{-1} of *Bt*.CIM-602 **(Table 2.17).**

Data presented in **Table 2.18** show that the strain *Bt*.CIM-616 produced the highest lint percentage of 39.7 and the longest staple of 28.9 mm of *Bt.*CIM-622 **(Table-2.19).**

Table-2.17 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	Seedcotton (kg ha^{-1})		
		***Bt*.CIM-616**	***Bt*.CIM-622**	***Bt*.CIM-602**
1	Mian Muhammad Amjid Zia, Khanewal	2816	2745	2679
2	Mr. Nazar Muhammad, Lodhran	3122	2961	2812
3	Ch. Rehmat Ali, 88/10-R, Khanewal	3073	2878	2800
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	3147	2751	2595
5	Ch. Muhammad Hanif 108/7R, Sahiwal	3555	3194	2722
6	Haji Allah Ditta, Kukar Hatta, Khanewal	2712	2578	2675
7	Mr. Iftikhar Shah, D. G. Khan	2961	2812	2607
8	Haji Zulfiqar Ali Haroonabad	3310	3050	2870
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	3040	2710	2666
10	Ch. Ramzan Ahmad, Hasilpur	3566	3121	2868
11	Ch. Zia-ur-Rehman, Liaquat Pur	2911	2833	2721
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	2756	2420	2530
13	Ch. Khuda Bux, 19 Kasi, Multan	2683	2539	2676
14	Ch. Hafeez, Rajan Pur	2995	2816	2500
	Average	**3046**	**2815**	**2694**

Table-2.18 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-616**	***Bt*.CIM-622**	***Bt*.CIM-602**
1	Mian Muhammad Amjid Zia, Khanewal	40.7	39.6	38.3
2	Mr. Nazar Muhammad, Lodhran	40.0	38.4	39.1
3	Ch. Rehmat Ali, 88/10-R, Khanewal	40.5	38.0	38.7
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	40.4	38.7	38.6
5	Ch. Muhammad Hanif 108/7R, Sahiwal	39.9	39.2	39.0
6	Haji Allah Ditta, Kukar Hatta, Khanewal	40.1	38.6	37.9
7	Mr. Iftikhar Shah, D. G. Khan	39.0	38.6	37.7
8	Haji Zulfiqar Ali Haroonabad	39.7	38.9	38.4
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	39.8	38.6	38.7
10	Ch. Ramzan Ahmad, Hasilpur	38.9	38.0	38.0
11	Ch. Zia-ur-Rehman, Liaquat Pur	39.3	38.7	39.1
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	39.4	38.2	38.0
13	Ch. Khuda Bux, 19 Kasi, Multan	38.9	38.7	38.3
14	Ch. Hafeez, Rajan Pur	38.7	38.0	38.5
	Average	**39.7**	**38.6**	**38.5**

Table-2.19 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-616**	***Bt*.CIM-622**	***Bt*.CIM-602**
1	Mian Muhammad Amjid Zia, Khanewal	28.3	29.0	28.7
2	Mr. Nazar Muhammad, Lodhran	28.1	28.9	28.0
3	Ch. Rehmat Ali, 88/10-R, Khanewal	28.7	29.2	28.5
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	28.3	28.9	28.1
5	Ch. Muhammad Hanif 108/7R, Sahiwal	28.0	28.8	27.9
6	Haji Allah Ditta, Kukar Hatta, Khanewal	28.7	29.3	28.5
7	Mr. Iftikhar Shah, D. G. Khan	28.0	28.5	28.2
8	Haji Zulfiqar Ali Haroonabad	28.3	28.6	28.2
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	27.9	29.0	28.7
10	Ch. Ramzan Ahmad, Hasilpur	28.3	29.3	28.3
11	Ch. Zia-ur-Rehman, Liaquat Pur	28.1	29.0	28.4
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	28.6	28.7	28.1
13	Ch. Khuda Bux, 19 Kasi, Multan	27.8	28.8	28.3
14	Ch. Hafeez, Rajan Pur	28.4	28.4	28.6
	Average	**28.3**	**28.9**	**28.3**

2.1.12 Zonal Varietal Trial-2

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

One medium-long staple strain viz., CIM-620 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-620 produced the highest seedcotton yield of 2781 kg ha^{-1} compared with 2435 kg ha^{-1} of CIM-573 **(Table 2.20).**

Data presented in **Table 2.21** showed that the strain CIM-620 had the lint percentage of 39.6 as compared with 38.6 percent lint of CIM-573. Moreover, the new strain CIM-620 produced the staple length of 28.6 mm, compared with the staple length of 29.0 mm in CIM-573 **(Table 2.22).**

Table-2.20 Yield performance of advanced strains in Zonal Varietal Trial-2 at farmers' fields

Sr. No.	Name of cotton grower and Location	Seedcotton (kg ha^{-1})	
		CIM-620	**CIM-573**
1	Mian Muhammad Amjid Zia, Khanewal	2678	2500
2	Mr. Nazar Muhammad, Lodhran	2794	2630
3	Ch. Rehmat Ali, 88/10-R, Khanewal	2717	2265
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	2820	2470
5	Ch. Muhammad Hanif 108/7R, Sahiwal	2970	2640
6	Haji Allah Ditta, Kukar Hatta, Khanewal	2630	2378
7	Mr. Iftikhar Shah, D. G. Khan	2750	2515
8	Haji Zulfiqar Ali Haroonabad	2825	2400
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	2710	2590
10	Ch. Ramzan Ahmad, Hasilpur	2850	2435
11	Ch. Zia-ur-Rehman, Liaquat Pur	2970	2300
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	3014	2433
13	Ch. Khuda Bux, 19 Kasi, Multan	2577	2150
14	Ch. Hafeez, Rajan Pur	2630	2380
	Average	**2781**	**2435**

Table-2.21 Lint percentage of advanced strains in Zonal Varietal Trial-2 at farmers' fields

Sr. No.	Name of cotton grower and Location	Lint (%)	
		CIM-620	CIM-573
1	Mian Muhammad Amjid Zia, Khanewal	39.9	38.8
2	Mr. Nazar Muhammad, Lodhran	39.8	38.9
3	Ch. Rehmat Ali, 88/10-R, Khanewal	39.5	38.4
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	39.6	38.6
5	Ch. Muhammad Hanif 108/7R, Sahiwal	39.2	38.4
6	Haji Allah Ditta, Kukar Hatta, Khanewal	39.8	38.6
7	Mr. Iftikhar Shah, D. G. Khan	39.7	38.7
8	Haji Zulfiqar Ali Haroonabad	38.9	38.7
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	40.3	39.5
10	Ch. Ramzan Ahmad, Hasilpur	39.6	38.5
11	Ch. Zia-ur-Rehman, Liaquat Pur	38.8	38.0
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	39.6	38.1
13	Ch. Khuda Bux, 19 Kasi, Multan	39.7	38.6
14	Ch. Hafeez, Rajan Pur	39.8	38.9
	Average	**39.6**	**38.6**

Table-2.22 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-620	CIM-573
1	Mian Muhammad Amjid Zia, Khanewal	28.4	29.0
2	Mr. Nazar Muhammad, Lodhran	28.5	28.8
3	Ch. Rehmat Ali, 88/10-R, Khanewal	28.7	28.9
4	Mr. Dawood Sarwar, Chak 14/8AR, Mian Channu	28.4	28.3
5	Ch. Muhammad Hanif 108/7R, Sahiwal	28.8	28.7
6	Haji Allah Ditta, Kukar Hatta, Khanewal	28.9	29.7
7	Mr. Iftikhar Shah, D. G. Khan	28.5	29.0
8	Haji Zulfiqar Ali Haroonabad	28.6	29.2
9	Mr. Ghulam Mustafa Chatta, Uch Sharif	28.7	28.9
10	Ch. Ramzan Ahmad, Hasilpur	29.0	29.0
11	Ch. Zia-ur-Rehman, Liaquat Pur	28.4	28.8
12	Mian Muhammad Iqbal Shah, Makhdum Wali, Lodhran	28.8	29.3
13	Ch. Khuda Bux, 19 Kasi, Multan	28.3	28.9
14	Ch. Hafeez, Rajan Pur	28.6	28.9
	Average	**28.6**	**29.0**

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 seedcotton production and other parameters are presented in **Table 2.23**.

The results indicated that the strain A-10 produced maximum yield 1867 kg ha^{-1} followed by A-15 having 1855 kg ha^{-1} of seed cotton yield while A-4 produced lowest yield that is 761 kg ha^{-1}.

The strain A-9 produced the highest lint percentage of 39.9%, followed by A-15 with 39.8%. The strains A-5 and A-8 produced the highest value of staple length 28.7 mm, followed by A-15 which has staple length of 28.6 mm. All the strains have desirable micronaire value except A-9 (5.1 µg $inch^{-1}$). All values of fibre strength were within the range.

Table 2.23 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 (tppsi)	Plant Pop. (ha^{-1})
A-1	698	267	38.3	25.3	4.2	93.0	34605
A-2	1157	411	35.5	25.7	4.4	97.9	36936
A-3	801	292	36.5	26.1	4.0	94.8	34784
A-4	761	269	35.4	24.6	3.8	95.5	40074
A-5	1093	400	36.6	28.7	4.0	100.6	37743
A-6	1333	519	38.9	26.3	4.6	98.0	28060
A-7	965	359	37.2	26.0	4.5	98.2	38281
A-8	1108	428	38.6	28.7	4.0	93.3	37653
A-9	974	389	39.9	24.6	5.1	100.1	33439
A-10	1867	730	39.1	28.2	4.4	92.9	36039
A-11	806	303	37.6	26.1	4.2	98.2	35143
A-12	1352	499	36.9	26.7	4.3	99.0	32543
A-13	1492	516	34.6	25.3	4.0	93.3	39894
A-14	1295	465	35.9	26.3	4.5	96.4	35591
A-15	1855	738	39.8	28.6	4.0	92.1	35322
A-16	1189	461	38.8	26.2	4.7	99.6	31736

Sowing date = 21.05.2015

2.2.2 National Coordinated Varietal Trials (Set-B)

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

Twenty 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 2.24** showed that the B-14 produced the highest seedcotton yield of 3195 kg ha^{-1}, followed by B-9 having 2724 kg ha^{-1} seedcotton yield while B-12 produced lowest yield 718 kg ha^{-1}.

Data also revealed that the strain B-16 produced the highest lint percentage of 42.3, followed by B-4 with 39.9%. The strain B-2 and B-9 produced the longest staple with 28.1 mm length, followed by B-18 with 27.8 mm.

All the strains had the micronaire value ranging from 3.5- 5.2 μg inch^{-1}. Maximum fibre strength was maintained by B-5 having 110.3 tppsi, followed by B-7 with 109.7 tppsi fibre strength. All the strains have fibre strength above the required limit.

Table 2.24 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 (tppsi)	Plant Pop. (ha^{-1})
B-1	1336	496	37.1	25.7	5.0	104.3	22233
B-2	1671	627	37.5	28.1	4.4	102.4	34157
B-3	1989	746	37.5	26.7	4.7	107.6	41867
B-4	1928	769	39.9	26.1	4.7	108.5	40881
B-5	1299	517	39.8	25.2	4.4	110.3	37653
B-6	1734	633	36.5	24.0	4.5	106.4	38998
B-7	2199	871	39.6	25.8	4.8	109.7	40432
B-8	2039	779	38.2	27.0	4.8	107.0	39984
B-9	2724	1046	38.4	28.1	4.3	96.9	41687
B-10	1052	398	37.8	25.5	5.0	105.0	33081
B-11	1735	663	38.2	25.9	4.5	103.9	37922
B-12	718	264	36.7	25.7	3.5	100.1	40522
B-13	1356	522	38.5	26.6	4.6	101.1	40343
B-14	3195	1096	34.3	27.4	4.5	101.7	42315
B-15	1232	450	36.5	27.4	5.0	105.6	32633
B-16	1626	688	42.3	25.4	4.5	93.3	39536
B-17	1505	573	38.1	25.8	5.2	97.0	37922
B-18	1547	589	38.1	27.8	4.1	98.0	42136
B-19	1434	564	39.3	26.4	4.8	105.4	34246
B-20	1673	647	38.7	25.9	4.6	102.9	39446
B-21	2258	874	38.7	27.1	4.7	100.6	40881
B-22	1066	375	35.2	25.9	4.8	102.1	37025

Sowing date = 30.04.2015

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 cottonseed of twenty candidate varieties (under coded number) 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 2.25** showed that the variety C-10 produced the highest seedcotton yield of 3353 kg ha^{-1}, followed by C-8 with 2170 kg ha^{-1} seedcotton yield while C-21 was at bottom position in respect of seed cotton yield.

Data presented in **Table 2.25** revealed that C-14 produced the highest lint percentage 41.2 followed by the C-17 with 39.6%.

The staple length of all the genotypes was less than minimum standard i.e. 28.0 mm. Micronaire value of two genotypes C-17 and C-12 was not within desirable limits. Fibre strength of all the strains was upto the required standard except C-13 and C-14.

Table 2.25 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 (µg inch^{-1})	Fibre strength (tppsi)	Plant Pop. (ha^{-1})
C-1	1659	629	37.9	26.1	4.7	101.9	37743
C-2	1443	540	37.4	25.3	4.8	99.6	39536
C-3	1919	737	38.4	26.8	4.3	102.3	41060
C-4	1578	604	38.3	27.8	4.0	96.4	42136
C-5	1479	583	39.4	25.6	4.5	104.3	37743
C-6	1004	387	38.5	26.9	4.2	95.3	40343
C-7	1838	720	39.2	25.8	4.4	101.0	40343
C-8	2170	851	39.2	25.8	4.8	102.8	42046
C-9	1757	685	39.0	25.9	4.8	101.7	41239
C-10	3353	1237	36.9	26.7	4.6	96.2	40611
C-11	2044	807	39.5	26.3	4.5	98.4	41867
C-12	1721	654	38.0	25.4	5.0	99.9	41060
C-13	1076	414	38.5	27.5	4.5	90.6	41508
C-14	1847	761	41.2	26.6	4.4	91.1	41956
C-15	879	316	35.9	27.0	4.3	101.9	17482
C-16	1650	597	36.2	27.6	4.6	99.5	40253
C-17	1363	540	39.6	25.3	5.1	103.3	42046
C-18	1587	624	39.3	26.1	4.7	102.4	39625
C-19	1605	618	38.5	26.4	4.4	101.3	40880
C-20	780	296	37.9	25.2	4.0	103.8	40970
C-21	466	166	35.7	24.9	3.9	93.9	36757
C-22	726	257	35.4	24.9	4.6	92.9	40253

Sowing date = 01.05.2015

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 seedcotton production and other parameters are presented in **Table 2.26**. The data showed that D-18 produced the highest seedcotton yield of 2649 kg ha^{-1}, followed by D-7 with 2316 kg ha^{-1} while D-6 produced lowest yield among these strains under the trial.

The strain D-12 produced the highest lint percentage of 41.4, followed by D-16 which had 40.3%.

The D-18 produced the longest staple of 28.9 mm, followed by D-17 with 28.8 mm. Micronaire values of D-1, D-7, D-10 and D-16 was higher above the limit. Fibre strength of all strains were up to standard except D-6.

Table 2.26 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 (tppsi)	Plant Pop. (ha^{-1})
D-1	1547	602	38.9	25.5	5.0	99.5	43122
D-2	2238	846	37.8	26.0	4.7	102.2	42136
D-3	1852	693	37.4	23.1	4.8	104.2	42942
D-4	1889	750	39.7	25.3	4.8	100.2	42315
D-5	1823	695	38.1	25.8	4.9	104.7	43032
D-6	144	500	34.9	25.0	3.7	87.5	42763
D-7	2316	880	38.0	25.8	5.0	98.2	43032
D-8	1158	450	38.9	25.9	4.7	99.3	41598
D-9	2203	817	37.1	26.1	4.7	102.7	41956
D-10	1972	789	40.0	26.1	5.0	105.8	39805
D-11	950	381	40.1	24.5	4.7	100.2	40074
D-12	1104	457	41.4	24.6	4.8	99.7	41060
D-13	2070	760	36.7	25.8	4.9	97.6	39715
D-14	1348	515	38.2	28.0	4.0	96.0	42942
D-15	1653	661	40.0	25.7	4.7	100.4	38460
D-16	503	203	40.3	25.5	5.0	101.4	22144
D-17	1746	642	36.8	28.8	4.8	98.0	40611
D-18	2649	1004	37.9	28.9	4.1	104.6	42315
D-19	2268	894	39.4	25.8	4.7	101.0	42046

Sowing dated = 01.05.2015

2.2.5 Provincial Coordinated Cotton Trials

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

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

Twenty two promising strains of different cotton breeders from the Punjab were evaluated along with two standards MNH-886 and FH-142 at CCRI, Multan. Data presented in **Table 2.27** revealed that PC-10 produced the maximum seedcotton yield of 1826 kg ha^{-1}, followed by PC-3 with 1667 kg ha^{-1} and PC-18 with 1622 kg ha^{-1} seed cotton production while PC-21 was at the bottom of the conducted trial.

The Strain PC-7 produced the highest lint percentage of 41.7 followed by PC-16 having 41.3 lint percentage.

The strain PC-10 produced the longest staple having 28.7 mm length, followed by the variety PC-3 with 28.4 mm and PC-11 which produced 28.1 mm staple length while all other strains have staple length below the required standard. Micronaire value of all the strains was up to standard except PC-12.All the strains have desirable fibre strength ranging from 93.2 to 108.4 tppsi.

Table 2.27 Performance of new *Bt.* strains in Provincial Coordinated Cotton Trial-I at CCRI, Multan

Strains	Seed cotton Yield (kg ha^{-1})	Lint Yield (kg ha^{-1})	Lint (% age)	Staple length (mm)	Micronaire value (µg inch^{-1})	Fibre strength (tppsi)	Plant Pop. (ha^{-1})
PC-1	780	219	36.5	26.9	4.0	101.9	33713
PC-2	839	231	38.9	25.6	4.1	95.7	43038
PC-3	1667	238	38.2	28.4	4.0	93.2	44951
PC-4	889	262	38.5	25.1	4.7	103.8	43994
PC-5	671	227	35.8	26.8	4.7	99.4	35387
PC-6	691	201	35.6	26.1	4.3	105.7	40647
PC-7	1088	277	41.7	24.7	4.3	99.3	45429
PC-8	812	212	38.4	25.3	4.7	106.0	38734
PC-9	738	182	39.6	26.9	4.2	108.4	34670
PC-10	1826	267	33.6	28.7	4.5	105.5	43994
PC-11	623	105	35.7	28.1	4.5	102.4	34430
PC-12	967	203	38.8	25.8	5.1	106.2	44951
PC-13	1061	183	41.0	26.2	4.3	99.9	44473
PC-14	346	167	38.9	26.6	4.3	96.3	45668
PC-15	784	150	39.8	25.5	4.7	100.6	43277
PC-16	924	182	41.3	26.5	4.3	96.9	44234
PC-17	728	141	34.4	26.5	4.4	99.2	40886
PC-18	1622	172	38.4	24.4	4.7	100.4	43755
PC-19	857	174	38.5	25.9	4.5	107.2	40647
PC-20	654	166	37.4	25.3	4.7	107.4	44234
PC-21	325	137	37.7	24.6	4.9	104.4	45429
PC-22	1224	223	36.8	26.9	4.6	100.2	42321
PC-23	533	133	36.8	25.2	4.1	96.3	45668
PC-24	762	164	36.3	24.9	4.6	99.4	44234

Sowing date = 23.05.2015; C.D. (5%) for seedcotton = 131.68; CV% = 8.98

2.2.6 Provincial Coordinated Cotton Trial-II

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

Nineteen promising strains of different cotton breeders from the Punjab and two standard varieties MNH-886 and FH-142 were evaluated at CCRI, Multan. Data presented in **Table 2.28** revealed that PC-8 produced the maximum seedcotton yield of 1417 kg ha^{-1}, followed by PC-2 with 1308 kg ha^{-1} and PC-7 with 1296 kg ha^{-1} seed cotton production while PC-12 produced lowest yield.

The strain PC-9 and PC-6 produced the highest lint percentage of 40.4%, followed by the PC-7 with 40.3 lint percentage. All the strains have staple length below the required standard. Micronaire values of PC-14 and PC-15 was above the required limit. Fibre strength of all the genotypes was upto standard.

Table 2.28 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 (tppsi)	Plant Pop. (ha^{-1})
PC-1	708	278	39.2	25.5	4.5	96.3	38734
PC-2	1308	512	39.2	25.6	4.7	104.5	43038
PC-3	974	349	35.8	25.5	4.7	101.4	34430
PC-4	698	278	39.9	24.3	4.7	100.4	38734
PC-5	731	292	39.9	24.8	4.8	101.9	39451
PC-6	777	313	40.4	25.3	4.5	100.8	37299
PC-7	1296	522	40.3	25.6	4.9	106.3	41603
PC-8	1417	529	37.3	25.7	4.9	101.8	43038
PC-9	1176	475	40.4	25.2	4.9	104.1	39451
PC-10	1133	455	40.2	26.1	4.2	102.1	43038
PC-11	878	329	37.5	22.8	3.8	100.7	42320
PC-12	569	226	39.7	25.5	4.5	102.5	33713
PC-13	899	357	39.7	25.4	4.6	99.6	42320
PC-14	636	254	40.0	25.4	5.1	97.7	40168
PC-15	1188	474	39.9	25.8	5.0	99.3	40886
PC-16	1219	458	37.6	25.2	4.4	98.1	42320
PC-17	748	294	39.3	25.6	4.3	102.3	40168
PC-18	959	374	39.0	25.5	4.6	102.8	42320
PC-19	830	330	39.7	25.1	4.8	105.4	40886
PC-20	1066	396	37.1	25.3	4.9	101.4	43038
PC-21	890	326	36.6	22.5	4.0	103.7	43038

Sowing date = 23.05.2015; C.D. (5%) for seedcotton = 184.75; CV% = 11.70

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

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

Three promising strains of different cotton breeders from the Punjab along with one standard variety were evaluated at CCRI, Multan. Data presented in **Table 2.29** revealed that PC-4 produced the maximum seedcotton yield of 2117 kg ha^{-1}, followed by PC-2 with 1899 kg ha^{-1} seedcotton production. The strain PC-4 produced the highest lint %age 40.8 followed by the PC-1 with 38.6%.

The strain PC-3 produced the longest staple having 28.2 mm length, followed by the strains PC-2 and PC-4 with 27.7 mm fibre length. Micronaire value of all strains was upto the standard. Fibre strength of all the genotypes was in the desirable range.

Table 2.29 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 (tppsi)	Plant Pop. (ha^{-1})
PC-1	1059	409	38.6	26.2	4.0	97.4	40886
PC-2	1899	667	35.1	27.7	4.2	96.3	39930
PC-3	1801	675	37.5	28.2	3.9	98.9	39212
PC-4	2117	864	40.8	27.7	4.2	92.2	39930

Sowing date = 21.05.2015; C.D. (5%) for seedcotton =64.62; CV% = 1.88

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 two commercial varieties of the country were tested at CCRI, Multan. Data recorded on seedcotton yield and other parameters are presented in **Table 2.30**. The results indicated that variety CIM-573 excelled among all varieties by producing seedcotton yield 2026 kg ha^{-1} followed by the variety CIM-554 with 1974 kg ha^{-1} and Marvi with 1968 kg ha^{-1} seedcotton production. Variety CIM-496 had the highest lint percentage of 41.5, followed by varieties CIM-554 and CIM-482 having lint percentage of 40.4. The variety CIM-707 maintained the longest staple of 29.6 mm, followed by the variety the CIM-573 with 28.8 mm staple length.

Table 2.30 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 (tppsi)	Av. Boll wt. (g)	Plant Pop. (ha^{-1})
CIM-446	1530	591	38.6	27.2	3.9	98.8	3.0	39166
CIM-482	1480	598	40.4	28.3	4.1	96.9	3.1	37875
CIM-473	1901	749	39.4	28.1	3.9	96.0	2.9	37445
CIM-506	1755	683	38.9	26.8	4.4	97.6	3.0	32280
CIM-707	1350	518	38.4	29.6	4.0	103.9	2.8	37445
CIM-496	1725	716	41.5	28.0	4.5	96.8	3.0	41318
CIM-534	1308	508	38.4	26.7	4.1	92.7	2.8	31419
CIM-554	1974	797	40.4	27.7	4.6	99.3	3.0	38736
CIM-573	2026	784	38.7	28.8	4.2	94.4	2.8	39166
CIM-608	1801	719	39.9	28.1	4.1	95.2	2.8	40027
BH-160	1677	666	39.7	26.4	4.0	96.1	2.9	38306
FH-901	1549	587	37.9	26.8	4.2	97.4	3.0	39166
NIAB-111	1610	597	37.1	26.8	4.1	101.1	3.0	37875
NIAB-777	1567	617	37.0	25.6	4.9	94.5	3.0	44331
NIBGE-2	1675	621	37.1	26.9	4.2	95.4	2.9	28837
MNH-786	1431	544	38.0	26.2	4.7	97.8	3.0	36154
CRSM-38	1690	656	38.8	27.3	3.9	92.9	3.0	36584
CRIS-134	1420	513	36.1	25.8	4.2	93.1	2.6	38306
CRIS-342	1730	612	35.4	26.0	4.7	93.8	2.8	36154
Marvi	1968	687	34.9	26.4	4.1	101.9	2.9	40888
Malmal	1730	607	35.1	24.7	4.7	95.0	2.6	40458
Gomal-93	1370	495	36.1	26.1	4.3	95.4	2.8	38306

Sowing date: 20.05.2015; C.D. (5%) for seedcotton 111.69 CV% = 4011

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

Sixteen *Bt*. commercial varieties of the country were tested at CCRI, Multan. Data recorded on seedcotton yield and other parameters are presented in **Table 2.31**. The results indicated that variety *Bt.* CIM-602 excelled among all varieties by producing seedcotton yield of 1746 kg ha^{-1}, followed by the variety CEMB-33 with 1431 kg ha^{-1} and *Bt*. CIM-599 with 1413 kg ha^{-1} seedcotton production. Variety IR-3701 had the highest lint percentage of 42.2, followed by varieties CEMB-33 and *Bt*. CIM-599 having lint percentage of 39.8% and 39.6% respectively. The variety Bt. CIM-602 maintained the longest staple length of 28.4 mm, followed by the variety the *Bt.*CIM-599 with 28.2 mm staple length.

Table 2.31 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 (tppsi)	Av. Boll wt. (g)2	Plant Pop. (ha^{-1})
Bt.CIM-598	1206	472	39.2	27.5	3.9	100.3	2.8	33882
Bt.CIM-599	1413	559	39.6	28.2	4.0	95.5	2.9	42494
Bt.CIM-602	1746	668	38.3	28.4	4.1	93.0	3.0	43569
AA-703	576	211	36.7	27.9	4.3	97.1	2.7	35501
AA-802	792	300	38.0	25.6	4.2	104.0	2.8	34425
A-555	1179	461	39.1	25.8	4.9	98.9	3.0	40883
IR-3701	961	403	42.2	25.2	4.8	96.7	3.1	32887
CEMB-33	1431	569	39.8	26.1	4.4	103.2	3.0	44107
IUB-222	1324	501	37.9	27.3	4.3	103.1	3.2	41418
MNH-886	1285	489	38.1	27.1	4.4	96.3	3.2	25281
Sitara-008	854	320	37.5	26.0	4.8	96.6	3.0	39266
Bt.-121	535	208	39.0	26.5	3.9	100.3	2.8	22053
Bt.-141	723	260	36.0	26.6	4.7	99.0	2.7	38190
FH-113	753	269	35.8	25.7	4.0	101.1	2.7	30660
FH-114	848	314	37.1	25.8	4.5	98.6	2.8	40880
FH-142	1107	436	39.4	26.2	4.5	103.0	3.1	43569

Sowing date: 04.06.2015 C.D. (5%) for seedcotton 122.23, CV% = 7.01

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 2015-16 is given in **Table 2.32**.

Table 2.32 Detail of single plants selected from breeding material

Generation/Trial	No. of plants Selected	Range	
		Lint (%age)	Staple length (mm)
Progeny row trial	170	38.5 – 48.8	27.1 – 31.2
F_6 single lines	220	38.7 – 47.9	27.3 – 31.4
F_5 single lines	470	38.4 – 48.4	28.0 – 31.7
F_4 generation	430	38.5 – 49.0	27.2 – 31.5
F_3 generation	1400	38.4 – 48.2	27.0 – 31.3
F_2 generation	1950	38.7 – 48.5	27.1 – 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 seven hundred and sixty five 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 2.33. 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 2.34.**

Table 2.33 Detail of Genetic Stock of World Cotton Collection

Local genotypes	1064
Exotic genotypes	4701
Total	**5765**
Species-Wise Detail	
Gossypium herbaceum L.	556
Gossypium arboreum L.	1025
Gossypium hirsutum L.	4077
Gossypium barbadence L.	107

Table 2.34 List of scientists/researchers whom received the cotton germplasm 2015-16

Sr. #	Name of Institute / Research Scientists	No. of stock
1	Cotton Research Station, Dera Ismail Khan	06
2	Department of Entomology, FAST, BZU, Multan	03
3	Director, Cotton Research Institute, Faisalabad	03
4	Dr Tayyab Hussain, University of the Punjab, Lahore.	28
5	Dr. Abdul Quyyum, FAST, BZU, Multan	11
6	Dr. Amir Shakeel Assistant Professor, Department of PBG, University of Agriculture, Faisalabad.	10
7	Dr. Asif Saeed, Assistant Professor, Department of PBG, Uni. of Agri. Faisalabad.	17
8	Dr. Hayat Ullah, Office Incharge, CRS, D.I. Khan	25
9	Dr. Muhammad Babar Professor, IMBB, BZU, Multan	18
10	Dr. Muhammad Kamran Qureshi, Asstt. Professor, FAST, BZU, Multan	25
11	Dr. Rashida Attique, FAST, BZU, Multan	52
12	Dr. Syed Bilal Hussain, FAST, BZU, Multan	41
13	Dr. Ummad-ud-Din Umar, FAST, BZU, Multan	03
14	Dr. Waqas Malik, FAST, BZU, Multan	04
15	Khalid Mahmood, Director CRI, AARI, Faisalabad	04
16	Liaqat Seed Corporation, Bahawalpur	03
17	Nadeem Ahmed, Ph.D Scholar, Uni. of Agri. Faisalabad.	10
18	Nuclear Institute of Agriculture Tandojam-70060-Sindh, Pakistan	03
19	Officer Incharge, Cotton Research Station, Sahiwal	30
20	Syed Mohsin Raza,Manager Crop Breeding, Aurigi Group, Lahore.	15
21	The Cotton Botanist, Agr. Research Institute, Tandojam	200
22	The Officer Incharge, Central Cotton Res. Station, Near Iqbal Petrol Pump, Ring Road, Mirpurkhas.	05
23	The Plant Pathologist, Plant Pathology, Research Institute, Faisalabad	05
24	Waleed Ahmed (M.Sc Student) Department of PBG, University of Agri. Faisalabad	15

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 2.35**.

Table 2.35 Detail of pre-basic seed produced during 2015-16

Variety	Pre-basic seed produced (kg)
CIIM-496	40
CIIM-506	20
CIIM-554	50
CIIM-573	40
*Bt.*CIIM-598	36
*Bt.*CIIM-599	70
Bt.CIIM-602	148

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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 pest resistance, drought tolerance, heat tolerance and better fiber quality through introgression.

Cytological studies of a newly developed inter-specific hybrid were undertaken. Conversion of CLCuD 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 and F_5.

In iterspecific crosses, different shades of cotton were observed in F_1,F_2 and F_3 but Brown colour has suitable fibre length.

Search for aneuploids especially haploids remained in steps forward. Cyto material developed through multiple species hybridization was tested in single lines, varietal trial, and ZVTs to observe their economic and fibre characteristics.

Bt CYTO-177 and CYTO-124 (non *Bt*), varieties developed through introgression has been sent for approval in Punjab seed council. Cyto-179 and Cyto-301will be tested in ZVT, PCCT and NCVT trials for their wider adoptability in different ecological zones.

3.1 Maintenance of *Gossypium* germplasm

Thirty two species of *Gossypium* (cultivated and wild) are being maintained for exploitation in hybridization program. Species are *G. anomalum* B1, *G. barbosanum* B2, *G. capitis viridis* B3, *G. sturtianum* C1, *G. nandewarense* C?, *G. thurberi* D1, *G. harknessii* D2-2, *G. davidsonii* D3-d, *G. klotzschianum* D3-k, *G. aridum* D4, *G. raimondii* D-5, *G. gossypioides* D6, *G. lobatum* D7, *G.trilobum* D8, *G. laxum* D9, *G. schwendimanii* D-11, *G. stocksii* E1, *G. somalense* E2, *G. areysianum* E3, *G. incanum* E4, *G. longicalyx* F1, *G. bickii* G1, *G. australe* G2, *G. nelsonii* G3, & *G. costulatum* K?. All these are diploid wild species. While *G. tomentosum* 2(AD)3, *G. mustelinum* 2(AD)4 and *G. darwinii* 2(AD)5 are the tetraploid wild species. The species *G. herbaceum* A1 & *G. arboreum* A2, (diploid); *G. hirsutum* 2(AD) 1 and *G. barbadense* 2(AD) 2 (tetraploid) are the cultivated species.

Two *G. hirsutum* races viz. morrilli and palmeri; 14 diploid and 5 tetraploid hybrids; 5 triploid and 2 hexaploid hybrids; 3 pentaploids hybrids and 5 tri and 1 tetra species combinations are also maintained.

Fig-1

Fig-2

Fig-3

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 interspecific hybrids into transgenic lines was also carried out using back crossing during the cropping season. The detail of species hybridization is given in Table 3.1.

Table 3.1 Detail of Intra and Interspecific crosses attempted during 2015-16

Sr. No.	Cross No.	Parentage	No. of Pollinations	No. of Bolls picked
1	DD1	*G.hirs.* x *G.anomalum*	150	1
2	DD2	*G.hirs.* x *G.herkensii*	111	5
3	DD3	*G.hirs.* x *G.incanum*	245	1
4	DD4	*G arbo*. x*G.herbacium*	110	3
5	DD5	*G arbo*. x *G. anomalum*	107	3
6	DD6	*G arbo*. x *G.stocksii*	114	0
7	DD7	*G arbo*. x *G.incanum*	179	0
8	DD8	*G arbo*. x *G.areysianum*	180	0
9	DD9	*G.herkensii* x *G arbo*.	147	0
10	HT1/15	Cyto124 xCyto 179	205	12
11	HT2/15	Cyto124xCyto177	146	14
12	HT3/15	Cyto124xCyto305	304	11
13	HT4/15	Cyto124xEarly2	228	13
14	HT5/15	Cyto124xR46	114	13
15	HT6/15	Cyto124xR47	244	13
16	HT7/15	Cyto164 x Cyto179	201	10
17	HT8/15	Cyto164 x Early2	133	10
18	HT9/15	Cyto161 x Cyto179	179	14
19	HT10/15	Cyto161 x Cyto305	101	15
20	HT11/15	13-3/15 x R47	41	2
21	HT12/15	I1 x BB2	30	2
22	HT13/15	I1 x Mac-1	55	0
23	HT14/15	14-1/15 x Mac-1	75	0
24	Ht-15/15	26-1/15 x Mac-1	35	1
25	HT-16/15	29-1/15 x Mac-1	22	1
26	HT-17/15	H2P1 x R46	11	2
27	HT-18/15	H2P1 x R47	10	4
28	HT-19/15	Mac-1 x 29-1/15	17	1
29	HT-20/15	Mac-1 x R47	14	2
30	HT-21/15	Mac-1 x Cyto-305	13	0
31	HT-22/15	25-1/14 x Cyto179	17	1
32	HT-23/15	H2P10 x Early2	35	1
33	HT-24/15	H2P10 x R47	13	2
34	HT-25/15	H2P10 x R4	17	0
35	HT-26/15	H2P10 x R46	11	1
36	HT-27/15	H9P74 x Early2	20	3
37	HT-28/15	H9P74 x R47	11	0
38	HT-29/15	H2P20 x Cyto179	41	2
39	HT-30/15	H2P20 x Cyto305	21	2
40	HT-31/15	T1 x R47	33	2
41	HT-32/15	D1 x R46	26	1
42	HT-33/15	Z.No x R47	16	2
43	HT-34/15	T1 x Early-2	21	3
44	HT-37/15	1-3/15 x CG-5	14	5
45	HT-38/15	1-3/15 x R46	16	2
Total			**3833**	**180**

A total of 3833 pollinations were attempted in 45 combinations. The boll setting was obtained in 36 combinations whereas in other combinations boll setting could not be achieved either due to incompatibility among different species or sterility barriers existing

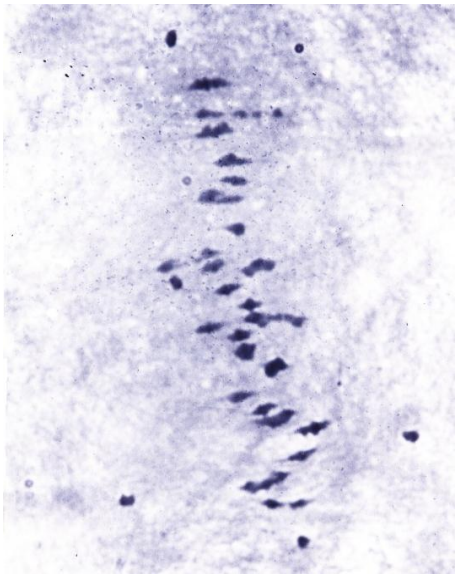
at pre and post fertilization stages of hybridization. The hormones viz., Gibberellic acid (GA) and Nephthalene acetic acid (NAA) were exogenously applied at the rates of 50 and 100 mg L^{-1} water, respectively, after 24 hours of pollination. The application continued till 72 hours to retain the crossed bolls.

3.3 Chromosomal Studies

Buds screening of {***G.hirsutum*** x **2(*G.arboreum*** x ***G.anomalum*****)} x ***.*^{4}*G.hirsutum*** was done cytologically. At Metaphase -1, 6 I's and 23II's were observed. The photographs of Metaphase-1 is given below .

Table-3.2. Chromosomal configurations

Hybrid	PMC No.	I's	II's	Total	Remarks
{***G.hirs.*** x **2(*G.arbo.*** x ***G.anom.*****)} x.^{4}***G.hirs.***	**1**	**6**	**23**	**52**	Plant is partially fertile



6 I's and 23 II's = 52

Fig-4 Chromosomal configurations of {*G.hirs.* x 2(*G.arbo.*x *G.anom.*)} x.^{4}*G.hirs.*

3.4. Performance of filial generations during 2015-16

i) **Interspecific Crosses**

F_1

Sixty cross combinations of single, double and three way crosses of interspecific crosses were sown under field conditions to check their performance. The crosses having desirable traits are given below.

Table-3.3 The economic and fibre characteristics of F1 (developed through introgression) during 2015-16

Family No	Yield/pl. (g)	GOT%	Staple length (mm)	Micro-naire (µg/inch)	Streng-th (g tex $^{-1}$)
	Range				
{***G.hirsutum*** x 2(***G.arboreum x G.anomalum***)} x .^{5}***G.hirsutum***					
1-1/15	25.4-55.5	36.6-41.0	25.8-26.2	3.6-4.5	27.9-31.0
5-1/15	10.6-63.5	37.0-40.6	28.2-28.6	4.1-4.8	28.4-30.7
6-1/15	37.6-77.8	38.6-41.2	25.4-26.6	4.1-4.5	27.1-28.3
12-1/15	35.9-135.9	36.6-40.9	25.3-27.1	3.9-4.8	24.0-29.2
14-1/15	21.7-87.2	39.0-42.3	25.2-26.6	3.8-4.7	25.0-28.0
18-1/15	30.3-89.4	36.9-39.9	26.3-28.3	3.2-4.3	27.7-31.3
23-1/15	31.6-165.2	32.5-42.0	24.1-26.9	3.8-4.9	22.1-29.5
24-1/15	19.0-170.5	35.2-42.0	24.0-27.8	4.0-4.8	24.3-29.8
26-1/15	16.1-88.2	34.7-44.1	24.4-25.4	4.0-4.8	23.0-29.6
30-1/15	21.5-88.4	36.2-40.0	24.9-26.7	3.6-4.4	28.3-30.2
36-1/15	30.1-108.2	36.0-41.9	24.2-26.8	4.1-4.8	25.7-30.6
38-1/15	15.9-102.8	37.1-41.1	25.8-28.1	3.7-4.5	26.8-32.4
41-1/15	20.9-64.1	38.0-42.5	24.1-26.7	4.1-4.9	27.3-31.8
42-1/15	54.1-91.3	34.7-49.7	26.9-28.1	3.9-4.3	28.9-29.9
43-1/15	27.6-70.4	39.4-41.1	26.4-27.4	4.1-4.8	28.7-30.6
45-1/15	17.1-63.1	38.5-42.9	25.3-26.7	4.4-4.9	26.3-31.8
47-1/15	40.4-105.6	41.7-54.2	25.1-27.7	4.0-4.5	25.1-30.8
53-1/15	30.0-179.9	29.2-34.1	25.9-28.0	3.4-4.6	24.6-22.1
55-1/15	55.0-116.1	36.9-40.0	24.2-26.3	3.8-4.6	24.5-29.0
{2(*hirs.x anom*) x *barba.*} x ^{5}*hirs.*					
9-1/16	83.2-133.5	34.8-36.	27.4-28.3	3.1-4.4	29.8-34.1
19-1/16	35.9-122.9	34.5-37.1	27.1-29.4	3.4-4.1	28.8-32.4
22-1/16	34.0-175.8	33.4-36.5	27.5-29.4	3.6-4.2	30.3-31.6
35-1/16	41.8-82.2	38.8-41.9	27.2-29.5	3.4-4.8	28.7-33.4
FH-142	**-**	**38.7**	**24.7**	**5.2**	**25.7**
CIM-602	**-**	**37.4**	**26.0**	**3.8**	**28.3**

F_2

Seventy six plants were selected from F_1 during 2014-15 crop season. These plants possessing a distinguished morphological character of coloured petals with petal spots were sown as F_2 in crop season 2015-16. layout was plant to progeny row trial. Different shades of brown cotton were observed in F_2.

Table 3.4 Performance of F_2 interspecific hybrids lines during 2015-2016

Family	Yield (g)	GOT%	Staple length (mm)	Micro-naire (µg/inch)	Streng-th (g tex $^{-1}$)
{***G.hirsutum*** x **2(*G.arboreum*** x ***G.anomalum***)} x **.^{4}*G.hirsutum***					
4-2/15	97.7-98.6	38.6-40.0	27.6-29.6	3.1-3.7	33.0-33.1
6-2/15	36.7-56.6	36.6-41.0	26.0-27.0	4.0-4.9	28.0-29.3
7-2/15	24.6-180.5	32.7-42.1	23.8-29.8	2.7-4.3	25.1-33.9
9-2/15	39.8-85.4	36.6-41.9	24.2-28.1	3.6-4.7	26.3-37.0
16-2/15	35.8-111.2	25.4-40.4	23.7-28.1	3.1-5.0	23.8-28.5
18-2/15	36.3-107.1	31.9-36.1	24.6-28.1	3.9-4.7	26.5-29.3
20-2/15	22.5-81.1	30.8-40.9	22.2-26.2	3.9-5.1	21.4-28.1
22-2/15	54.4-109.2	37.6-43.0	25.3-26.9	3.8-4.8	26.4-29.5
24-2/15	44.1-82.5	37.8-40.5	23.9-26.8	3.8-5.1	23.1-29.3
25-2/15	57.8-76.2	41.3-43.8	26.1-26.8	4.5-4.8	28.5-29.2
26-2/15	17.9-103.7	36.8-41.0	25.3-27.1	3.2-4.9	28.5-32.5
28-2/15	54.4-80.9	31.7-38.8	24.0-26.1	3.6-4.7	23.8-28.7
29-2/15	35.8-95.3	35.0-42.7	24.2-26.3	3.4-4.7	26.2-29.5
30-2/16	37.2-70.0	41.2-44.6	25.6-26.8	3.9-4.4	37.7-31.6
31-2/15	21.7-144.9	37.2-44.2	27.0-29.1	3.4-4.2	28.0-31.7

32-2/15	29.0-111.1	39.0-44.5	26.0-30.7	3.5-5.0	26.9-33.5
33-2/15	22.2-100.8	38.3-42.9	24.5-29.5	3.9-4.6	25.4-30.7
34-2/15	46.3-117.8	36.9-42.6	25.9-28.2	3.5-4.7	27.4-30.6
35-2/15	41.3-161.7	36.7-43.0	25.2-27.4	4.3-5.4	27.4-29.9
37-2/15	44.2-103.0	39.3-46.5	28.3-29.2	4.1-4.5	28.3-31.2
38-2/15	49.7-131.0	36.0-43.5	26.8-29.4	3.7-4.6	28.8-32.8
39-2/15	20.7-102.1	30.4-44.3	26.5-27.9	4.2-5.1	28.6-30.0
{2(*hirs.x anom*) x *barba*.} x ^{4}*hirs.*					
40-2/15	20.7-128.0	38.7-53.1	25.1-28.3	3.5-4.5	28.0-30.7
47-2/15	67.7-88.7	33.4-45.6	24.5-25.3	4.8-5.2	25.7-28.3
48-2/15	34.1-72.0	39.6-41.0	28.0-29.1	3.9-4.6	28.5-31.0
49-2/15	32.3-101.9	40.5-45.8	27.4-29.1	3.9-4.6	27.9-30.1
52-2/15	33.8-71.9	34.3-44.0	26.7-27.9	3.1-4.4	30.4-31.5
53-2/15	48.8-120.5	39.6-42.2	27.5-29.2	4.2-4.6	28.6-31.7
54-2/15	91.2-161.1	36.9-41.8	27.1-28.6	3.8-4.5	30.1-31.9
55-2/15	21.8-54.7	36.9-42.5	26.2-28.9	3.4-4.6	29.8-33.9
56-2/15	26.0-71.2	39.5-45.5	25.8-29.4	3.6-4.6	28.0-33.6
59-2/15	38.5-54.0	37.5-41.4	28.6-30.6	3.5-4.2	31.2-34.3
60-2/15	47.0-107.9	35.0-41.6	27.1-29.8	4.0-5.0	25.9-32.7
61-2/15	57.2-101.6	36.7-40.3	29.3-31.4	4.1-5.1	30.8-33.7
62-2/15	31.9-36.8	36.8-40.7	27.5-29.7	3.5-5.1	28.4-33.4
63-2/15	36.8-106.3	37.5-40.7	27.3-30.3	3.5-4.6	28.3-32.9
64-2/15	51.4-138.4	36.7-41.5	28.5-31.4	3.6-4.9	29.3-33.2
66-2/15	58.9-149.0	36.9-41.0	26.5-30.3	3.7-4.3	28.1-34.1
67-2/15	51.9-102.5	34.8-41.0	27.6-29.1	3.1-4.1	28.4-32.9
68-2/15	42.0-146.5	37.5-42.8	28.6-30.3	4.0-4.7	29.7-33.2
69-2/15	33.3-67.5	37.7-40.7	26.6-30.9	3.8-4.5	23.2-32.9
70-2/15	43.8-46.5	35.4-40.1	27.3-28.7	4.3-4.8	27.4-27.7
71-2/15	21.5-71.2	35.1-39.0	27.7-31.8	3.6-4.3	29.8-34.8
72-2/15	39.6-112.7	34.7-39.7	27.9-30.4	3.6-4.6	28.4-32.1
73-2/15	13.2-320.0	37.6-43.0	24.7-28.6	3.6-5.2	26.8-32.7
74-2/15	46.2-63.6	38.0-41.5	26.6-26.7	3.7-3.9	30.3-32.5
75-2/15	70.4-112.8	38.4-39.4	26.0-27.7	4.2-4.9	28.7-31.6
76-2/15	26.5-129.2	33.8-40.0	25.3-28.8	3.5-5.0	28.2-32.6
FH-142	**-**	**40.1**	**24.7**	**5.2**	**25.7**
CIM-602	**-**	**37.4**	**26.0**	**3.8**	**28.3**

The data revealed that the material in F_2 of interspecific crosses had excellent fibre traits as compared to standard FH-142 and CIM-602.

Fig-5

Fig-6

F_3

Table-3.5 The economic and fibre characteristics of F_3 progenies(developed through introgression) during 2015-16

Family	Yield (g/pl.)	GOT%	Staple length mm	Micro naire	Strength (g tex^{-1})
	Range				
{*G.hirsutum* x **2**(*G.arboreum* x *G.anomalum*)} x *.*^{3}*G.hirsutum*					
6-3/15	8.3-96.6	27.5-36.6	23.8-24.9	3.6-4.9	28.1-30.5
7-3/15	7.4-56	27.1-38.6	23-26	3.6-5.1	22-29
11A-3/15	16.7-119.8	31.2-41.7	23.8-27.4	3.9-5.0	26.5-30.3
14-3/15	24.6-130	25.7-37.2	26.7-29.3	2.6-4.2	30.4-32.8
17-3/15	30.2-82.1	31.2-38	28-31.3	3.6-4.2	28.5-32.6
18-3/15	35.1-114.7	31-38.3	28-31.3	2.9-3.7	26.2-34.2
24-3/15	45.5-59.4	35.8-44.3	25.6-26.1	3.5-4	27.4-29.4
31-3/15	24-75.7	33.5-45.4	23.9-26.3	5.0-5.3	25.2-29.4
35-3/15	15.5-34.3	39.6-42.6	24.9-26.0	4.9-5.6	25.9-27.9
37-3/15	31.8-52.7	36.4-42.1	23.4-25.5	4.1-4.8	24-28.0
39-3/15	43.1-105.5	33.6-44.8	23.0-25.1	4.8-5.5	24.9-27.9
40-3/15	38.5-121.6	38.4-43.5	24.9-26.3	4.0-5.4	25.3-29.1
41-3/15	22.5-105.7	37.9-46.9	23.1-26.5	3.5-4.5	25.2-29.4
43-3/15	43.2-84.4	32.1-42.6	22.6-26.2	2.6-5.5	23.6-28
46-3/15	28.2-91	36.2-41.8	23.3-29.1	4.4-5.8	26.2-31.2
48-3/15	38.2-97.7	31.3-40.7	22.8-27.8	4.4-5.5	21.7-28.0
{2(***hirs.*****x** ***anom*** **) x** ***barba.*****} x** ^{3}***hirs.***					
50-3/15	34.6-58.2	38.1-41.4	26.1-27.9	4.2-4.6	27.9-29.6
58-3/15	33.6-81.1	37.7-40.6	28.4-29. 2	3.5-3.9	29.3-32.4
60-3/15	32.6-96.8	36.7-43.1	25.2-27.3	3.8-4.8	25.3-27.8
65-3/15	29.7-108-7	37.7-42.6	26.3-30.8	3.3-4.7	28.8-31.8
73-3/15	53.3-83.2	40.5-41.7	24.7-28.7	3.8-5.0	27.7-31.1
77-3/15	36.7-119.2	37.6-41.4	29.7-31.	3.7-4.2	29.0-31.7
78-3/15	33.3-115.5	39.5-42.3	24.4-26.7	4.6-5.3	27.0-29.8
MNH-886	**-**	**38.1**	**24.3**	**5.3**	**26.0**

The data revealed that the material in F_2 of interspecific crosses had excellent fibre traits as compared to standard MNH-886.

ii). Interaspecific Crosses

F_2

Thirteen hybrids were selected from F_1 during 2014-15 crop season. These plants were sown as F_2 in crop season 2015-16. Lay out was plant to progeny row trial. Plants having resistance against Kanamycin were selected as *Bt* plant. Performance of F_2 is given in Table 3.6.

Table 3.6 Performance of F_2 during 2015-2016

Family No.	Yield plant^{-1}	G.O.T (%)	Staple length (mm)	Micro naire (µg inch^{-1})	Strength (g tex^{-1})
78-2/15	69.4-123.1	34.1-41.8	23.2-27.4	3.9-5.0	25.6-27.9
79-2/15	33.5-189.7	35.3-41.3	21.7-27.7	3.7-5.2	21.6-31.9
79-2-15	47.0-27.6	31.7-41.5	24.3-27.8	3.7-4.8	26.6-29.8
81-2/15	46.0-145.4	37.8-41.8	27.0-28.8	3.7-4.7	28.7-32.5
82-2/15	41.8-170.8	35.7-41.7	23.7-25.9	4.4-5.8	26.6-30.9
82-2/15	41.8-237.1	35.5-42.5	22.8-29.7	3.5-5.1	24.0-28.6
83-2/15	38.1-175.0	33.5-41.9	23.3-29.6	4.1-5.5	25.3-29.9
84-2/15	38.2-196.9	36.1-42.8	24.1-27.6	4.0-5.1	24.7-29.8
85-2/15	54.0-214.4	34.4-41.7	24.0-27.8	3.4-5.3	25.4-30.1
86-2/15	55.9-153.0	37.2-41.4	23.8-26.6	4.4-5.2	22.5-27.9
88-2/15	36.0-176.6	36.3-42.4	25.3-29.1	3.0-5.2	25.1-30.5
91-2/15	52.2-141.7	35.7-42.4	24.4-26.9	3.8-4.8	24.3-30.1
CIM-602	-	**37.6**	**27.4**	**3.7**	**28.9**

The Data revealed in Table-3 exhibited that F_2 had excellent lint percentage as compared to standard MNH-886.

iii) F_3

Three hundred and ninety-nine plants were selected from F_2 during 2014-15 crop season. These plants were sown as F_3 in crop season 2015-16. Lay out was plant to progeny row trial. Performance of F_3 converted into transgenic lines is given in Table 3.7.

Table-3.7 The economic and fibre characteristics of elite F3 during 2015-16

Family	Yield plant^{-1}	G.O.T (%)	Staple length (mm)	Micro naire (µg inch^{-1})	Strength (g tex^{-1})
	Range				
80-3/15	30.9-137.7	37.0-39.9	27.9-31.0	3.7-4.3	30.0-33.6
82-3/15	43.8-71.6	38.2-41.2	26.1-29.6	4.0-4.7	28.4-31.5
83-3/15	28.5-82.2	37.5-42.4	26.6-29.1	3.8-5.0	28.5-32.9
84-3/15	39.4-60.8	35.5-43.9	24.9-29.3	4.0-4.4	28.5-31.1
88-3/15	22.8-53.4	38.0-42.8	28.5-30.7	4.1-5.0	28.6-33.7
90-3/15	31.2-74.7	36.2-39.8	26.9-29.7	3.8-4.1	26.5-31.2
92-3/15	18.1-46.2	32.6-39.2	28.3-29.2	3.6-4.2	26.8-32.9
93-3/15	27.1-61.9	40.3-43.6	27.6-30.0	4.1-4.9	29.7-30.9
94-3/15	33.1-73.3	39.6-42.2	27.2-28.6	3.9-4.8	28.0-31.2
98-3/15	34.3-71.12	37.6-43.7	26.0-28.7	4.4-4.9	26.1-31.0
99-3/15	40.5-66.5	41.7-44.6	26.0-28.5	4.3-5.0	23.2-27.6
101-3/15	31.4-48.4	36.4-40.4	27.2-28.7	4.5-4.9	28.3-30.2
108-3/15	36.8-77.5	38.7-44.1	25.9-27.4	4.0-5.1	23.5-28.8
114-3/15	50.2-95.1	39.8-45.9	25.2-27.3	4.2-5.2	23.4-26.8
119-3/15	43.7-104.9	36.5-40.1	26.3-29.3	3.6-4.2	27.1-29.0
124-3/15	39.3-71.6	41.1-43.5	26.8-28.5	4.1-4.8	25.8-29.2
125-3/15	35.9-64.1	36.5-40.9	26.7-28.0	4.3-4.8	25.8-28.4
130-3/15	43.6-81.1	40.8-43.5	26.7-28.1	4.1-4.3	27.3-29.0
131-3/15	43.8-70.6	41.0-45.3	25.2-27.9	4.9-4.7	24.8-28.3
135-3/15	45.5-76.4	41.3-43.2	25.3-27.2	3.5-4.5	24.1-26.4
139-3/15	26.1-33.4	37.3-42.8	26.2-28.5	4.7-5.1	26.9-28.8
141-3/15	36.1-72.1	38.0-45.9	24.5-27.8	4.5-5.1	23.4-25.8
142-3/15	34.3-67.8	39.2-40.8	26.4-28.5	4.1-4.6	24.9-28.2
143-3/15	56.5-74.4	38.2-43.0	25.3-27.0	4.2-4.6	25.1-27.0
144-3/15	32.44-66.0	38.5-43.7	25.9-27.7	3.7-5.2	27.5-28.7
148-3/15	35.7-116.4	38.5-42.3	25.5-27.4	3.7-4.3	24.5-27.1
156-3/15	45.5-94.8	39.1-42.1	26.5-27.4	3.1-4.1	25.1-28.5
159-3/15	40.3-70.3	42.6-46.8	24.9-26.5	4.2-4.9	21.8-27.3
162-3/15	45.3-83.8	39.7-44.9	26.7-29.0	3.3-4.4	24.2-28.5
168-3/15	48.5-74.0	38.2-41.0	25.6-28.2	3.8-4.3	26.5-29.5
183-3/15	29.5-68.6	38.0-40.4	26.1-27.1	4.1-4.9	24.4-29.7
185-3/15	29.8-81.9	37.5-42.0	26.4-28.2	4.1-5.5	25.3-30.3
186-3/15	24.2-68.7	36.0-44.4	24.9-28.6	4.5-5.2	26.1-30.3
187-3/15	26.5-82.4	36.9-40.7	87.6-29.2	4.0-4.2	28.2-30.3
188-3/15	25.9-56.2	37.2-41.2	265.6-28.3	4.3-5.1	28.0-30.4
190-3/15	34.9-63.8	37.3-38.9	28.6-29.3	3.8-4.4	28.2-29.8
193-3/15	44.4-77.2	40.4-41.2	26.2-28.3	3.6-4.4	28.1-29.2
195-3/15	40.3-68.4	40.0-41.7	26.8-28.2	3.6-4.4	25.7-28.8
196-3/15	20.5-41.6	39.4-41.9	25.0-26.1	4.0-4.5	25.0-29.8
198-3/15	44.8-76.9	37.0-40.6	26.3-27.8	2.7-4.6	27.2-30.1
200-3/15	29.4-44.6	36.5-42.1	28.0-28.9	3.4-4.2	29.4-29.7
205-3/15	24.7-66.4	40.0-45.3	27.3-29.3	4.8-5.3	27.7-29.4
207-3/15	22.3-37.1	35.7-39.4	27.3-28.2	4.0-4.5	27.6-29.5
210-3/15	24.3-55.5	41.5-45.7	24.7-28.1	4.2-5.1	27.2-29.9
211-3/15	26.2-53.5	31.2-42.3	25.9-26.4	4.5-4.8	28.1-29.1
212-3/15	30.2-63.0	27.0-44.5	24.7-26.9	4.5-5.1	26.2-29.4
FH-142	-	**38.5**	**24.2**	**5.4**	**25.6**
CIM-602	-	**37.4**	**26.3**	**4.0**	**28.3**

The data revealed that the material in F_3 had excellent lint percentage as compared to standard FH-142 and CIM-602.

v) F_5

Forty eight plants were selected from F_4 during 2014-15 crop season. These plants were sown as F_5 in crop season 2015-16. Layout was plant to progeny row trial. Performance of F_5 lines is given below.

Table 3.8 Performance of F_5 single lines during 2015-2016

Family No.	Yield plant^{-1}	G.O.T (%)	Staple Length *(mm)*	Micro Naire (µg inch^{-1})	Strength (g tex^{-1})
1-5/15	20.9-26.6	43.0-46.2	26.0-27.9	3.7-4.4	26.4-28.8
4-5/15	23.2-43.5	41.6-45.7	25.5-26.9	4.3-5.1	
5-5/15	19.5-54.5	36.8-41.5	27.1-28.8	3.8-4.4	28.1-30.4
9-5/15	28.7-55.9	40.9-43.0	26.2-29.3	4.0-4.3	26.6-30.5
10-5/15	26.0-54.6	40.7-43.8	25.0-26.7	4.0-5.0	26.9-29.9
11-5/15	13.9-65.0	39.3-45.0	26.4-29.0	4.2-4.8	26.6-30.7
12-5/15	32.7-63.3	43.0-42.8	26.0-26.8	4.4-4.7	26.7-29.9
13-5/15	27.1-51.3	39.8-44.8	25.4-26.8	4.3-5.0	26.0-28.2
14-5/15	36.3-44.4	40.1-43.6	26.5-27.1	4.6-5.0	29.4-30.3
15-5/15	33.3-42.9	41.1-44.6	25.8-28.1	3.4-5.2	25.6-30.4
16-5/15	29.0-119.9	40.5-44.1	25.3-26.8	4.1-4.9	26.3-30.0
22-5/15	18.6-61.7	32.2-44.3	24.6-26.9	3.9-5.0	25.7-27.7
23-5/15	24.2-86.6	40.0-53.0	25.6-27.5	4.6-5.1	25.0-28.4
24-5/15	26.4-38.8	37.9-41.4	23.6-26.8	4.5-5.0	25.7-28.3
25-5/15	25.4-32.1	43.0-44.4	24.4-26.7	4.5-5.3	26.2-28.4
27-5/15	31.5-36.4	33.6-40.7	25.8-29.1	4.0-4.2	26.4-32.1
29-5/15	24.5-55.6	36.1-39.6	26.9-27.8	3.9-4.5	25.4-28.4
30-5/15	19.4-61.5	38.9-41.8	26.4-28.0	3.9-4.2	26.0-31.0
31-5/15	20.5-34.6	37.7-40.9	25.0-27.7	3.5-4.5	26.6-30.3
32-5/15	24.8-41.3	35.5-40.3	24.9-28.4	3.8-4.2	24.3-27.4
33-5/15	31.8-66.6	39.0-40.7	25.8-27.8	3.6-4.3	24.3-27.7
34-5/15	21.1-45.7	36.8-40.4	26.2-29.4	3.7-4.0	27.3-29.3
35-5/15	19.8-43.2	20.1-40.4	26.1-28.5	3.6-4.1	28.3-30.2
36-5/15	28.8-51.1	36.5-39.2	27.7-28.4	3.7-4.2	29.8-31.2
37-5/15	32.2-99.5	37.5-41.6	26.5-28.8	3.5-4.0	28.2-32.7
38-5/15	31.2-63.7	37.9-39.8	27.8-29.3	3.9-4.6	28.3-32.2
39-5/15	30.1-95.8	36.5-41.9	27.0-29.3	3.8-4.5	28.6-31.5
40-5/15	32.5-67.5	37.8-41.9	27.1-28.4	3.3-4.2	28.1-31.2
41-5/15	30.0-38.1	40.1-41.3	27.0-28.2	3.4-4.2	28.9-30.4
42-5/15	34.2-46.2	39.0-41.7	25.3-26.9	3.4-4.1	26.8-29.4
44-5/15	25.5-52.5	38.0-41.1	25.6-28.3	3.4-4.4	26.9-29.8
45-5/15	27.8-30.2	38.4-40.2	28.2-28.8	3.6-4.5	27.6-32.2
46-5/15	20.1-58.7	41.6-43.7	26.6-27.8	3.3-4.2	27.3-29.6
47-5/15	21.7-50.0	36.7-43.1	27.0-28.5	3.5-4.0	25.3-30.8
48-5/15	27.1-65.7	39.5-27.2	24.3-27.2	3.8-4.7	23.8-30.0
FH-142	-	**38.6**	**24.4**	**5.2**	**25.6**
CIM-602	-	**38.0**	**26.7**	**4.3**	**28.3**

The data revealed that the material in F_5 had excellent lint percentage as compared to standard FH-142 and CIM-616.

3.5 Search for aneuploids/ haploids

In the nature, there is spontaneous occurrence of aneuploids and haploids in *G. hirsutum* and *G. barbadense.* Therefore, the efforts continued to search for the monosomes in order to identify individual chromosomes and haploids for making homozygous lines of cotton, Six rogue plants apparently aneuploids on the basis of morphological characteristics were tagged from the Cytogenetic material and cytologically analysed for their chromosome numbers. All the tagged plants were Disomes with normal chromosome conjugations of 26 II's at M1.

3.6 Performance of Cyto-strains

3.6.1 Varietal trial-1

Six CLCuD tolerant Cyto-strains were evaluated in varietal trial-1 for their specific traits as well as yield, GOT (%age) and fibre characteristics against FH-142 as standards.

Table-3.9. Performance of Cyto-strains in VT during 2015-16

Strain No.	Yield (kg ha^{-1})	Plant popu lation (ha^{-1})	Pl. Height (cm)	Boll/ Pl.	Boll wt. (g)	Lint (%age)	Fiber Length (mm)	Micro-naire (µg/inch)	Stren-gth g/tex
Cyto-177	1232.89	41534	114.8	21	2.4	39.4	26.4	4.6	28.2
Cyto-178	1688.61	42538	104	18	2.8	39.4	25.5	4.9	25.9
Cyto-179	1633.45	42649	107.7	24	3.1	39.9	25.8	4.8	26.6
Cyto-300	1338.64	41964	106.4	23	2.6	39.9	25.3	4.7	28.2
Cyto-301	1586.94	42179	112.8	23	2.5	39.7	26.5	4.7	25.9
Cyto-305	2424.16	42681	118.4	21	3.3	37.9	27.1	4.3	26.6
FH-142	**1599.79**	**42322**	**104.0**	**22**	**2.8**	**40.1**	**24.5**	**5.0**	**25.7**

C.V = 2.07

Data in Table-3. revealed that three Cyto strains viz. *Bt*.Cyto-178 (1688.61kg ha^{-1}), *Bt*.Cyto-179 (1633.45kg ha^{-1}) and *Bt*.Cyto-305 (2424.16 kg ha^{-1}) produced better seed cotton yield as compared to standard FH-142 (**1599.79**kg ha^{-1}). All Cyto strains maintained better fibre traits than the standard (Table -.3.9).

3.7 Testing of *Bt*. Cyto-179 and *Bt*. Cyto-301 in NCVT:

Bt.Cyto-179 and *Bt.* Cyto -301 will be tested in NCVT for their adaptability in various ecological zones.

3.8 Internship Programme:

Two students from BZU Multan, two from UAF and four from UCA, DG Khan completed 3-months internship.

3.9 Collaboration

i) Within Institute

a) Agronomy
b) Plant Breeding & Genetics
c) Plant Pathology
d) Plant Physiology
e) Fibre Technology
f) Transfer Technology

ii) Other Institutes

a) NIBGE
b) NIAB
c) CEMB
d) CCRI Sakrand
e) NIA Tando Jam
f) CRS Tando Jam

iii) Universities

1) Dept. Of Plant Breeding & Genetics (UAF)
2) Dept. Of Plant Breeding & Genetics (UCA,IUB)
3) Dept. Of Plant Breeding & Genetics (UCA,SU)
4) Dept. Of Plant Breeding & Genetics (MNSUA)

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4. ENTOMOLOGY

The research carried out on various aspects under field conditions was focused on 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, screening of USDA and local accessions against sucking insects and CLCuD, *Earias* spp survival to transgenic Bt cotton strains having different protein levels, development of natural enemies of sucking pests on GM cotton at different planting dates, status of Pink bollworm & Red cotton bug Infestation in Punjab, impact of dusky and red cotton bugs on planting periods and fructification, development of different rearing techniques of red cotton bug and. screening of new insecticides. Natural enemies culture maintaining for laboratory studies and field releases.

The section participated in training programmes, organized by the Institute for farmers and staff of Agriculture Extension Department and Pesticide Companies. Section also provided internship facilities` to different Universities. Scientists also recorded IPM related programmes in electronic media.

4.1 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). Increasing of population trend was observed in *P. gossypiella* compared to last year at both the locations. Whereas the declining trend in moth catches of *E. insulana,* both *Spodoptera* species and *H.armigera* compared to last year was recorded. However, population of *E. vittella, H. armigera* decreased at CCRI, Multan and increased at farmer's field. Overall male moth catches of all the species were higher at farmer's field as compared with CCRI, Multan **(Table-4.1).** Weekly male moth catch activities are given in **Fig. 4.1 (a-f).**

Table-4.1 Comparison of male moth catches of lepidopterous pests in sex pheromone traps

Insect pest	CCRI, Multan			Farmer' field		
	2014	2015	+ %age	2014	2015	+ %age
P. gossypiella	177.5	385.5	**+ 117.2**	338.0	827.0	**+ 144.7**
E. vittella	140.0	117.5	**- 19.2**	289.5	293	**+ 01.2**
E. insulana	115.0	89.5	**- 28.5**	215.0	176.0	**- 22.2**
S. litura	197.5	115.5	**- 71.0**	423.0	191.0	**- 121.5**
S. exigua	339.0	108.0	**- 213.9**	791.5	247.0	**- 220.5**
H. armigera	138.0	123.0	**- 12.2**	335.0	343.0	**+ 02.4**

4.1.1 *Pectinophora gossypiella* (Pink bollworm)

Male moth catches remained zero upto mid-April and during last fortnight of December and were quite low upto 3rd week of July at both the locations. Moths' population increased from end July and fluctuated upto 1st week of December with its maximum catches in 1st and 2nd week of November both at farmer's field and CCRI, Multan respectively. Moth catches were 115% higher at farmer's field than at CCRI, Multan **(Fig. 4.1a)**. Overall male moth catches were 117.2% and 144.7% higher to that of last year at CCRI, Multan and at farmer's field respectively **(Table-4.1).**

4.1.2 *Earias vittella* (Spotted bollworm)

Male moths' activity remained zero upto 3rd week of May and during November and December and it remained negligible upto mid-July at both the locations. Afterwards moth activity increased with maximum catches from August to mid-October at both the locations. Moth catches at farmer's field were 149% higher than at Multan **(Fig. 4.1b).** Overall, male moth catches were 19.2% lower at Multan and 1.2% higher at farmer's field as compared to last year **(Table-4.1).**

4.1.3 *Earias insulana* (Spiny bollworm)

Male moth catches remained zero upto May and during November and December at both the locations. Moth activity remained negligible during June and July. Afterwards, population increased with its peak from August to mid-October.

Moth catches were 97% higher at farmer's field than at Multan. Comparatively moth catches of this species were lower as compared to *E. vittella* **(Fig. 4.1c).** Overall male moth catches were 28.5% and 22.2% lower at Multan and farmer's field respectively as compared with last year **(Table-4.1).**

4.1.4 *Spodoptera litura* (Armyworm)

Male moth catches were zero from January to 3rd week of March and from 2nd fortnight of November to December at both the locations. Moth activity started from end March and fluctuated at low level upto mid-July. From 2nd fortnight of July population increased and fluctuated upto mid-November with maximum catches during August. Moth catches at farmer's field were comparatively 65% higher than at Multan **(Fig. 4.1d)**. Overall male moth catches were 71% and 121.5% lower than that of last year at Multan and farmer's field respectively. **(Table-4.1).**

4.1.5 *Spodoptera exigua* (Beet armyworm)

The population of male moths was almost zero from January to 1st week of March, during last three weeks of June and from 2nd fortnight of October to December at both the locations. Moth activity started from 2nd week of March and its population fluctuated upto 1st week of June with the peak catches in 2nd week of April at farmer's field and 4th week at Multan. From July onwards, moth catches started and fluctuated upto mid-October. Catches were 129% higher at farmer's field than at Multan **(Fig. 4.1e)**. Overall male moth catches were 213.9% and 220.5% lower at Multan and farmer's field respectively as compared to last year **(Table-4.1).**

4.1.6 *Helicoverpa armigera*. (American bollworm)

Male moth activity was zero upto February which increased afterwards and fluctuated upto May with maximum catches during April at both the locations. Afterwards population declined and only a few moths were caught upto mid-September and then afterwards, there was no moth activity at both the locations. Moth catches were higher at farmer's field than at Multan **(Fig. 4.1f)**. Overall, male moth catches were about 12.2% lower at Multan and 2.4% higher at farmer's field as compared to last year **(Table-4.1).**

4.2 Monitoring of lepidopterous pests with light traps

Moth activity of *E. insulana*, *E. vittella*, *S. litura*, *S. exigua* and *H. armigera* was monitored throughout the year with inflorescent light traps at CCRI, Multan. 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* and *H. armigera* while decreasing trend in case of *E. insulana, S. litura* & *S. Exigua* **(Table-4.2).** Moth catches on weekly basis are given in **Fig. 4.2 (a-e).**

4.2.1 *Earias vittella* (Spotted bollworm)

Moth catches of this species were zero upto May and during November and December. Afterwards pest activity started at low level which increased from 4th week of July and fluctuated upto 3rd week of October. Maximum moth catches were recorded during 2nd fortnight of September and 1st fortnight of October **(Fig. 4.2a).** Overall number of moth catches was 3.4% higher than that of last year **(Table-4.2).**

4.2.2 *Earias insulana* (Spiny bollworm)

Moth activity was almost same as that of *E. vittella* and the pest was zero upto May and during November and December. Moths were caught at low level during June and July but afterwards their activity increased and fluctuated upto 3rd week of October.**(Fig. 4.2b).** Total number of moths was 4.5% lower than last year **(Table-4.2).**

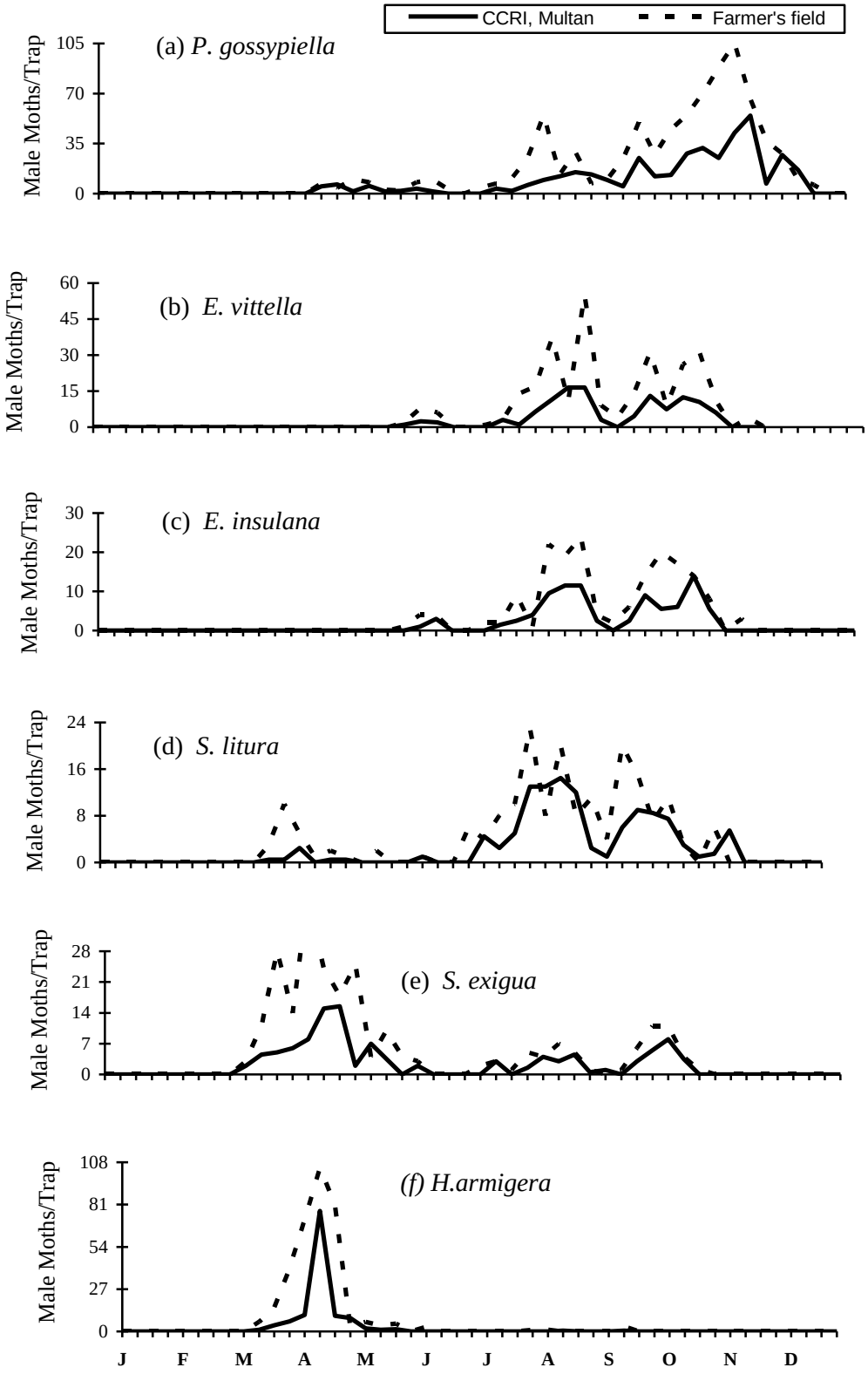

Fig.4.1 Weekly male moth catches of Lepidopterous pests in sex pheromone traps at CCRI, Multan and farmer's field (Khanewal).

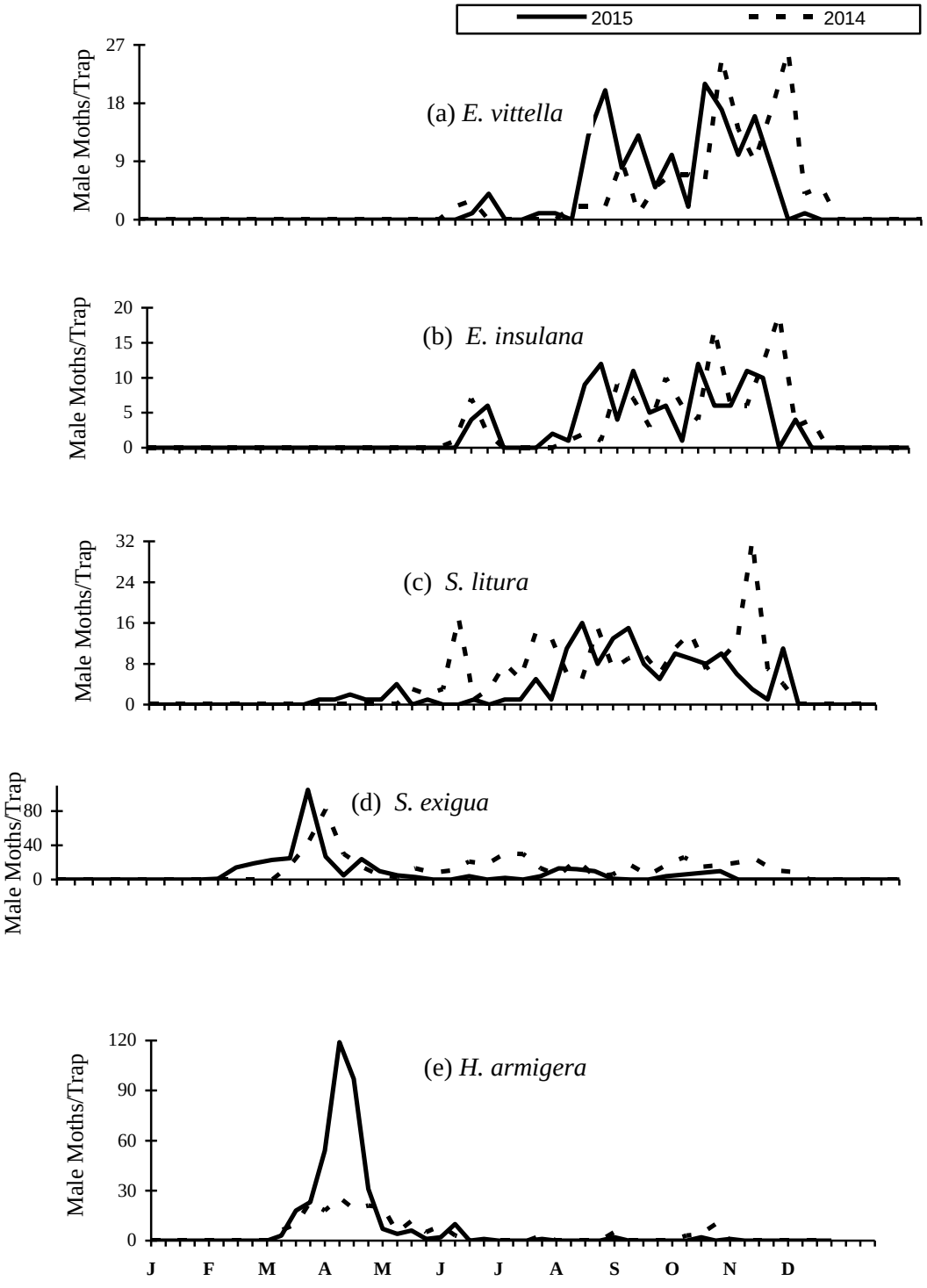

Fig. 4.2 Weekly moth catches of lepidopterous pests in light traps at CCRI, Multan

4.2.3 *Spodoptera litura* (Armyworm)

Moth catches were zero from January to 3rd week of Mach then the activity started and continued till 3rd week of July at low level. Afterwards, the activity increased and fluctuated upto mid- November and no moth activity was found after that. Maximum moth activity was observed from last week of July to mid-October **(Fig. 4.2c)**. Overall moth catches were 44.8% lower than the last year **(Table-4.2).**

4.2.4 *Spodoptera exigua* (Beet armyworm)

Moths' activity of *S. exigua* was zero upto 1st week of March. Afterwards population starts to increase and reached to its maximum during 3rd week of April before the normal cotton season. Population declined afterwards and fluctuated upto 1st fortnight of November with the maximum catches during August. No moth activity was recorded from last fortnight of October upto the end of year **(Fig. 4.2d)**. Overall moth catches were 59.6% lower than last year **(Table-4.2).**

4.2.5 *Helicoverpa armigera* (American bollworm)

Moth activity of *H. armigera* was recorded from 2nd week of March to 1st fortnight of June. Moth peak catches was recorded during 2nd week of April. Its activity was almost zero during maximum fruit setting phase of the crop except few moths were caught in last week of July, 1st week of September, 3rd week of October and 1st week of November **(Fig. 4.2e)**. Overall moth catches were 84.5% higher as compared to last year **(Table-4.2).**

Table-4.2 Comparison of moth catches of lepidopterous pests in light traps based on total catches during the year/trap

Insect pest	2014	2015	% change (±)
Earias vittella	146.0	151.0	**+ 03.4**
Earias insulana	115.0	110.0	**- 04.5**
Spodoptera litura	223.0	154.0	**- 44.8**
Spodoptera exigua	538.0	337.0	**- 59.6**
Helicoverpa armigera	207.0	382.0	**+ 84.5**

4.3 Host plant tolerance studies of CCRI strains

4.3.1 Studies on conventional strains

Two conventional promising strains viz. Cyto-122 and CIM-620 developed by CCRI, Multan were tested for their tolerance/susceptibility against major insect pests. Cultivar Cyto-124 was kept as standard. The trial was sown on May 21, 2015 using RCBD with three sets. Each set was replicated three times having plot size of 28'x20'. Set-I was kept unsprayed for sucking pests, whereas, bollworms were controlled with suitable insecticides. In Set-II, sucking pests were controlled and bollworms 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.

In Set-I, initially jassid was higher on Cyto-122 reaching economic threshold level (ETL) in 4th week of June while in on other strains ETL was observed in 1st week of July. Afterwards population remained above ETL upto 1st week of August with its peak in 2nd week of July on all the strains. Then population declined and fluctuated below ETL on all strains. Overall pest pressure was higher on Cyto-124 and lower on Cyto-122. Whitefly remained below ETL during June which increased afterwards and remained above ETL upto 3rd week of August and during 1st week of September on all tested strains. Afterwards population declined upto harvest. Its population was on its peak on Cyto-122 & 124 in 3rd while on CIM-620 in 4th week of July. Overall pest pressure was higher on CIM-620 and lower on Cyto-122 throughout the crop season. Thrips remained below ETL throughout the season except 2nd fortnight of July and was on peak during 3rd week of July on all the cultivars. Overall, Cyto-122 proved to be the least and CIM-620 most preferred cultivar for this pest **(Fig. 4.3 - 4.5)**.

In Set-II, spotted bollworm was the major pest and initially its infestation was higher on CIM-620. Its infestation was on its peak in Cyto-122 & 124 during 1st week and in CIM-620 3rd week of September which declined in October. Overall pest infestation was maximum on Cyto-122 and minimum on CIM-620 **(Fig. 4.6)**. **(Table-4.3)**.

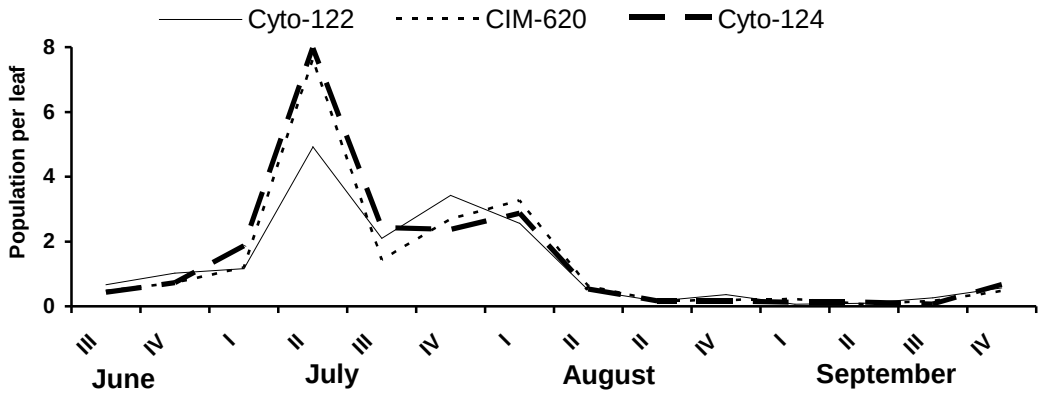

Fig. 4.3 Jassid population trend in non-*Bt* promising varieties

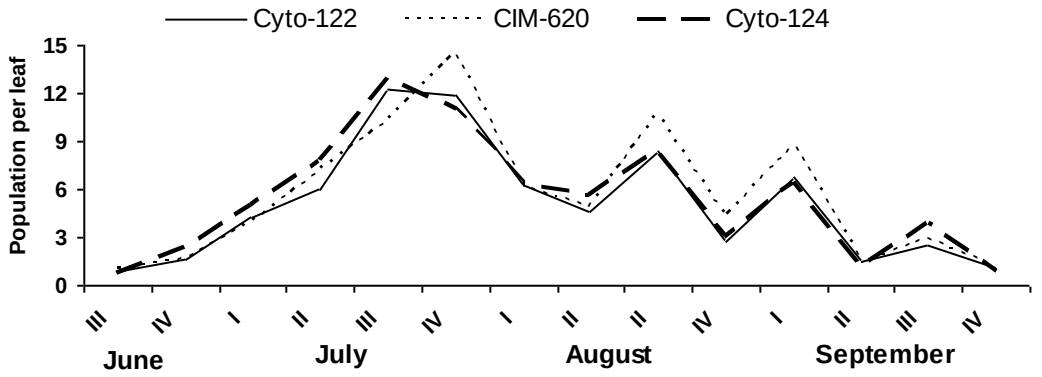

Fig. 4.4 Whitefly population trend in non-*Bt* promising varieties

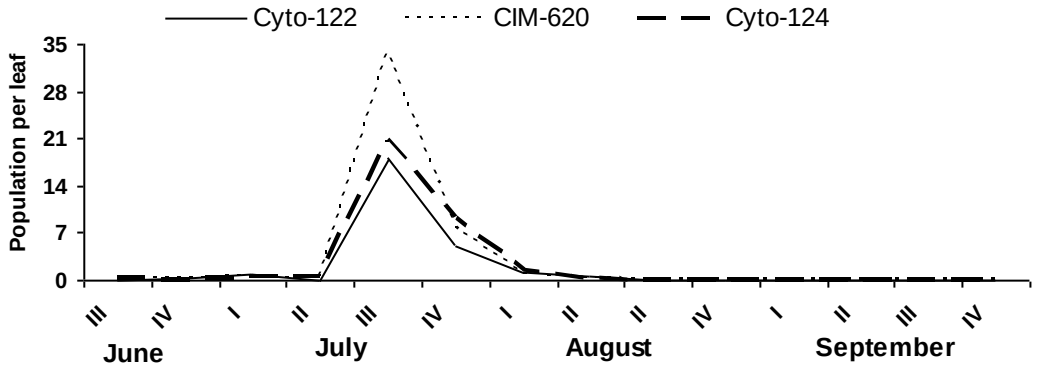

Fig. 4.5 Thrips population trend in non-*Bt* promising varieties

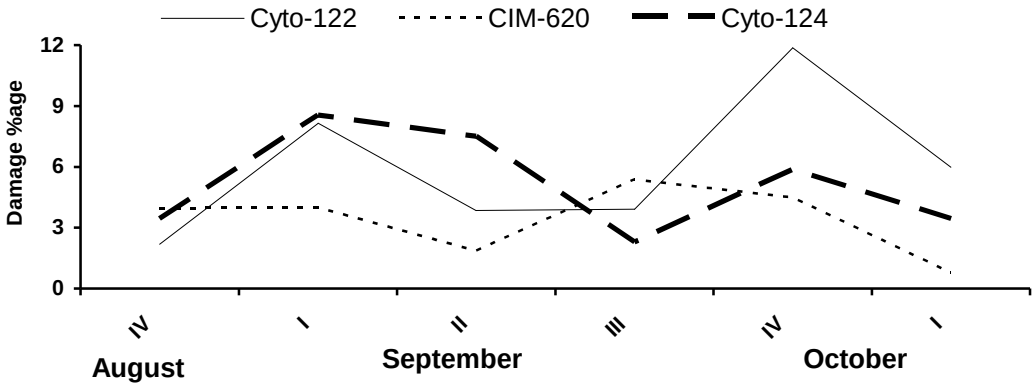

Fig. 4.6 Bollworms trend in non-*Bt* promising varieties

In Set-I, Cyto-122 produced maximum and CIM-620 minimum seed cotton yield, while in Set II, CIM-620 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-620 followed by Cyto-124 and Cyto-122 respectively. Reduction in seed cotton yield was higher due to the attack of bollworms compared to the sucking pests in both Cyto strains in Set-II while in CIM-620 in Set-I. **(Table-4.3)**.

Pink bollworm infestation was also observed in green bolls in mid-October from Set-II where bollworms were allowed to develop. Among the testing strains, all were highly susceptible to this pest and its damage/larval survival percentage ranged 80-100.

Table-4.3 Pink bollworm damage/larvae in green bolls and seed cotton yield in different sets

Strain	Seed cotton yield (kg ha^{-1})			% yield reduction over Set-III		% pink bollworm (Set-II)	
	Set-I	Set-II	Set-III	Set-I	Set-II	Damage	Larvae
Cyto-122	636	445	709	10.3	37.2	93.3	80.0
CIM-620	420	479	779	46.1	38.5	93.3	93.3
Cyto-124 (Std)	522	441	718	27.3	38.6	100.0	100.0
CD at 5%	**34.07**	**30.41**	**16.43**	**-**	**-**	**3.68**	**1.97**

4.3.2 Studies on *Bt* strains

Three *Bt* promising strains viz. Cyto-179, CIM-622 & CIM-625, developed by CCRI, Multan were tested for their tolerance/susceptibility against major insect pests. CIM-602 was kept as standard. The trial was sown on May 21, 2015 using RCBD with two sets. Each set was replicated three times having plot size of 40'x22.5'. Set-II was kept unsprayed for sucking pests, while in Set-I sucking pests controlled with insecticides. Data on population of sucking pests and percentage bollworms damage were recorded. Crop was harvested to quantify production potential.

In Set-II, jassid and whitefly were the major pests. Jassid reached on ETL on CIM-602 & CIM-625 in the 4th week of June, increased afterwards and was on its peak in the 2nd week of July on all the tested strains. Its population fluctuated above ETL upto 1st week of August and declined till harvest on all the strains. Overall its intensity was comparatively higher on Cyto-179 and lower on CIM-622. Whitefly remained below ETL from June to mid-July which increased afterwards and remained above ETL during 2nd fortnight of July and 1st week of September on all the strains. Its population declined afterwards. Overall CIM-622 proved most and CIM-625 least preferred strains for this pest. 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 July on all the cultivars. Overall Cyto-179 proved most and CIM-625 least preferred strain for this pest **(Fig. 4.7 - 4.9)**.

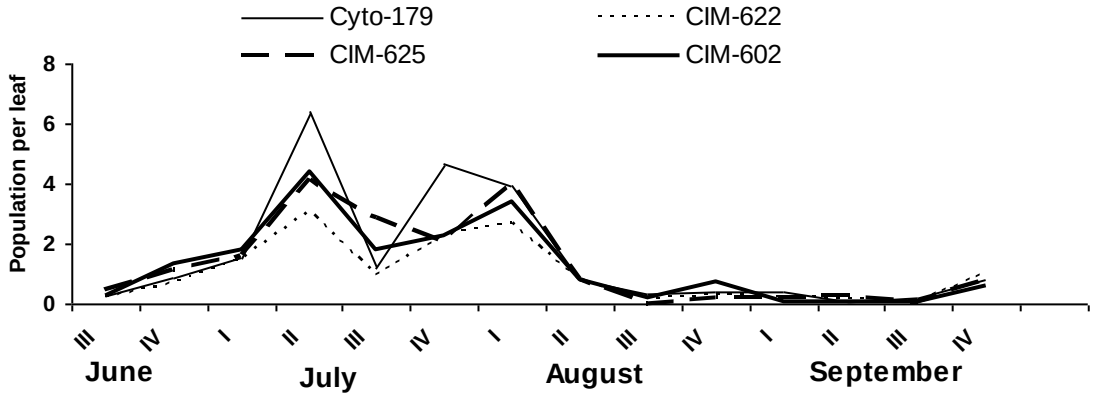

Fig. 4.7 Jassid population trend on promising *Bt* varieties

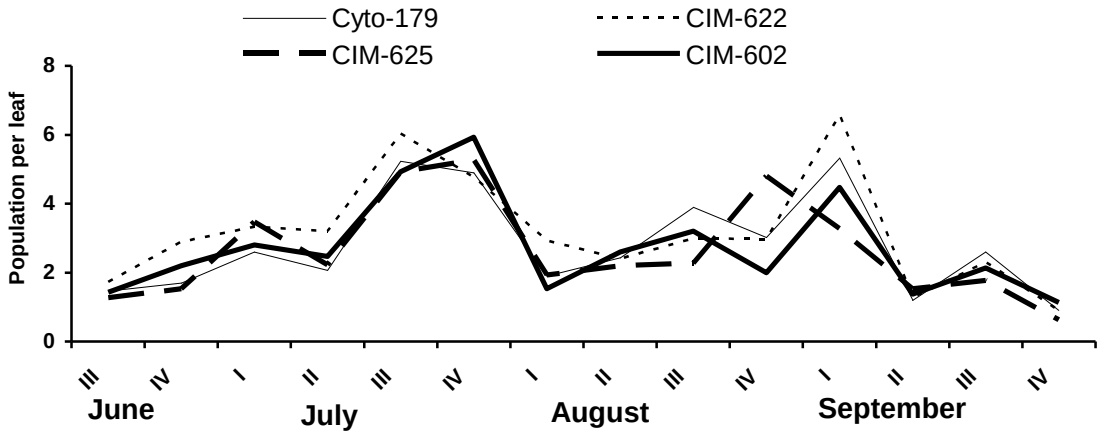

Fig. 4.8 Whitefly population trend on promising *Bt* varieties

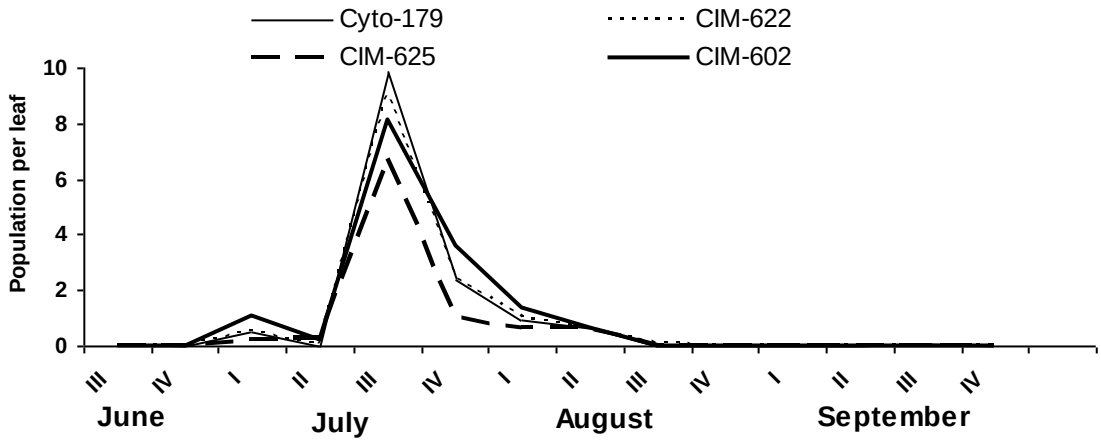

Fig. 4.9 Thrips population trend on promising *Bt* varieties

Pink bollworm was the major and only pest observed throughout the fruiting phase on 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-625 while lowest on Cyto-179 in both sets **(Table-4.4)**.

Table-4.4 Pink bollworm damage/larvae in green bolls

Strain	PBW damage %age		PBW larval %age	
	Set-I**	Set-II*	Set-I**	Set-II*
Cyto-179	60.0	40.0	60.0	20.0
CIM-622	66.7	66.7	53.3	46.7
CIM-625	80.0	66.7	66.7	46.7
CIM-602 (Std)	60.0	60.0	53.3	40.0
CD at 5%	**2.91**	**3.95**	**0.99**	**0.85**

* = 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-625 gave the lowest yield in both sets. Maximum reduction in seed cotton yield was observed also in CIM-625 (17.8%) and minimum (11.0%) in CIM-622 **(Table-4.5)**.

Table-4.5 Seed cotton yield in different sets

Strain	Seed cotton yield (kg ha^{-1})		% yield reduction over Set-II
	Set-I**	Set-II*	
Cyto-179	1161	998	14.0
CIM-622	953	848	11.0
CIM-625	428	352	17.8
CIM-602 (Std)	1005	870	13.4
CD at 5%	**77.50**	**24.13**	**-**

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

4.4 National Coordinated Varietal Trials (NCVT)

Fifty nine promising *Bt* and non-*Bt* strains developed by different institutions/ organizations were tested for their tolerance to sucking pests and bollworms in four sets. The experiment was conducted in a Randomized Complete Block Design (RCBD) with four replications of each set. Planting of Set-A was done on 21st May, Set-B on 30th April while the Set-C & D were planted on 1st May with the plot size of 30'x12'.

Population of sucking insect pests was recorded from June to August, whereas, the bollworms infestation was observed during August, September and October. Pink bollworm infestation in susceptible bolls was recorded in 3rd week of September and 4th week of October. Sucking insect pests were controlled at Economic Threshold Level (ETL) in all sets while bollworms were controlled with recommended insecticides only in set-A (non-*Bt*). Two consecutive sprays were given against pink bollworm on its appearance on all the sets.

4.4.1 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 A-1 followed by A-16, 6 & A-13 and lowest on A-15 and A-8 which remained below ETL in July and was above ETL on A-4, 5, 7, 12 & A-16 during August. Whitefly population remained below ETL during June except A-10, 14 & 16 which increased afterwards and found above ETL on all the testing strains during July and August. Its intensity was highest on A-10 followed by A-16 & A-5 while lowest on A-13, A-8 and A-6. Thrips remained below ETL throughout the season on all the strains while its population was comparatively higher on A-9, 3, 5 and A-6 while lower on A-4, 7 & A-8 **(Table-4.6)**.

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

Strains	Number of sucking insect pests per leaf								
	Jassid			Whitefly			Thrips		
	June	July	Aug	June	July	Aug	June	July	Aug
A-1	7.73	0.55	0.60	3.05	15.80	9.30	1.71	3.18	2.50
A-2	4.60	0.24	0.20	3.49	16.31	9.90	0.93	2.60	4.40
A-3	6.95	0.29	0.50	3.58	10.34	7.20	0.27	3.98	4.70
A-4	5.43	0.23	1.20	3.93	12.63	13.30	1.18	2.50	1.50
A-5	6.65	0.33	1.10	3.26	16.70	13.00	0.68	4.48	4.70
A-6	7.28	0.33	0.60	2.54	11.74	7.30	0.17	4.63	4.20
A-7	5.14	0.45	1.70	3.04	15.09	12.00	1.33	2.63	1.30
A-8	3.90	0.48	0.70	2.53	13.19	8.30	0.35	3.16	1.90
A-9	6.85	0.70	0.60	4.09	18.38	5.60	0.83	4.34	4.90
A-10	5.49	0.15	0.50	9.34	35.96	7.30	1.24	3.06	2.70
A-11	4.70	0.35	0.90	3.99	12.34	10.00	1.98	2.44	1.20
A-12	4.18	0.10	1.00	3.88	14.30	10.20	0.55	4.31	4.10
A-13	7.03	0.25	0.80	2.41	13.53	9.10	0.95	3.53	3.60
A-14	5.11	0.39	0.80	6.88	14.91	9.10	0.86	3.88	3.90
A-15	3.41	0.66	0.50	4.07	14.18	11.80	1.38	3.90	2.70
A-16	7.63	0.64	1.00	5.94	22.98	7.90	0.62	2.83	2.70

Table-4.7 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		October				
	Imm	Mat	Imm	Mat	Imm	Mat	Aug	Sep	Oct
A-1	0.00	0.00	2.09	5.52	0.00	4.76	0.00	1.25	2.50
A-2	0.00	0.00	1.13	1.56	0.00	0.00	0.00	2.50	2.50
A-3	1.96	0.00	1.57	3.64	0.00	2.13	0.00	1.25	0.00
A-4	2.44	0.00	1.71	1.02	0.00	0.00	0.00	2.50	1.25
A-5	0.00	0.00	1.72	1.26	0.00	0.00	0.00	1.25	1.25
A-6	0.00	2.38	3.57	0.68	2.86	0.00	0.00	0.00	1.25
A-7	0.00	2.33	3.52	2.16	0.00	0.00	0.00	5.00	3.75
A-8	2.38	3.64	2.48	4.02	1.28	0.00	0.00	1.25	2.50
A-9	0.00	0.00	1.43	1.93	0.33	1.67	0.00	1.25	1.25
A-10	0.00	0.00	1.61	0.85	4.26	2.94	0.00	0.00	0.00
A-11	1.54	0.00	3.11	2.74	7.14	8.57	0.00	0.00	1.25
A-12	1.75	2.44	3.42	2.00	0.00	0.00	0.00	3.75	1.25
A-13	2.17	0.00	4.30	1.14	2.86	3.23	0.00	5.00	3.75
A-14	6.25	4.76	5.37	2.37	3.13	0.00	0.00	3.75	0.00
A-15	2.13	0.00	2.05	1.14	3.23	1.72	0.00	1.25	2.50
A-16	0.00	5.00	2.36	4.35	2.67	0.00	0.00	1.25	1.25

Bollworm infestation in immature fruiting parts was higher in A-14 during August and September while in A-11 during October while in mature fruiting parts, maximum infestation was recorded in A-16 & A-14 during August, in A-1 & A-16 during September and in A-11 & A-1 during October. Larval population was higher in A-7 & A-13 and no larva found in A-10 throughout the season **(Table-4.7)**.

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 A-11 followed by A-2, 7 & 6 and lower in A-14, 1 and A-12 during September while it was higher in A-11, 7 & 5 and lower in A-14, 1 and A-12 during October. Maximum larvae were found in A-2, A-5 & 15 while minimum in A-11 & A-4 during September. In October population declined and was higher again in A-2, A-5 & 15 and lower in A-4, 7, 9, 11 and A-14 **(Table-4.8)**.

Table-4.8 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	October	September	October
A-1	12.5	16.0	8.3	8.0
A-2	50.0	20.0	25.0	16.0
A-3	29.2	12.0	25.0	12.0
A-4	37.5	8.0	25.0	4.0
A-5	37.5	20.0	29.2	20.0
A-6	41.7	12.0	29.2	8.0
A-7	45.8	12.0	33.3	4.0
A-8	25.0	12.0	16.7	12.0
A-9	25.0	12.0	12.5	4.0
A-10	33.3	8.0	25.0	8.0
A-11	54.2	4.0	37.5	4.0
A-12	16.7	8.0	8.3	8.0
A-13	29.2	16.0	12.5	8.0
A-14	8.3	12.0	8.3	4.0
A-15	25.0	20.0	16.7	16.0
A-16	33.3	16.0	29.2	12.0

4.4.2 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 & August on all the strains. Its maximum number was recorded on B-6 followed by B-3, 9 & 16 and minimum on B-15, 2, 21 and 13. Population of whitefly remained above ETL during June and July on all strains and declined afterwards. Its intensity was highest on B-15 followed by B-22 & 10 and lowest on B-1, 3 and B-13 during June. During July it was higher on B-14, 5 & 16 and lower on B-15, 4 and B-9. Thrips population was found below ETL during June and August while it was above ETL in July on all the testing strains. Its intensity was higher on B-14 followed by B-10 & B-17 and lower on B-22, 7 and B-15 **(Table-4.9)**. No bollworms damage/larva was found in immature and mature fruiting parts of any strain throughout the season but all the candidate strains proved susceptible to pink bollworm. Maximum infestation in susceptible bolls was recorded in B-9 followed by B-2, 12 & B-19 while minimum in B-13, 20 and B-3 in 3rd week of September. Whereas, during 4th week of October infestation was higher in B-6, 21 & 12 while zero in B-11 and B-20. Pink bollworm larval population was found in all strains except B-20 where no larval survival was observed throughout the season. Its larval population was highest in B-17 followed by B-19, 9 & B-18 and lowest in B-3, 13 and B-21 during September while its number were higher in B-21, 16, 8 & 1 and zero in B-2, 4, 11, 17 and B-19 during October **(Table-4.10)**.

4.4.3 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 C-11, 13 and 17 while minimum on C-3 and C-10 during study period. Population of whitefly found above ETL almost on all the strains during July and August which declined in September. Overall its intensity was highest on C-19 followed by C-9 & C-3 while lowest on C-22, 14 & 21. Thrips population was above ETL during July which remained below ETL during June and August on all the testing strains. Overall its population was highest on C-10 followed by C-8, 14 & 17 and lowest on C-12, 11 & 13 **(Table-4.11)**.

Spotted bollworm infestation and live larvae remained zero in most of the cases during the study period except negligible damage was observed in immature fruiting parts in C-3, 8 & 13 during August, in C-7, 9 & 15 during September and in C-2 during October. In mature fruits low level of infestation was observed in C-3 & 9 during September and in C-14 & 19 during October. Its larval population was

observed at low level in C-4 in August and in C-7, 9, 11 and C-15 in September while no larva was found during October **(Table-4.12)**. 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 C-14 & 15 followed by C-3 & 10 and lower in C-16, 20 and C-21 during end-September while it was higher in C-16 & 21 and zero in C-7, 9, 13, and C-15 during end-October. Maximum larvae were found in C-14 followed by C-2, 3, 15 & 18 while minimum population was in C-20 and C-8 during September. In October population declined and was maximum in C-21 & 16 and zero in C-7, 9, 10, 13 and C-15 **(Table-4.13)**.

Table-4.9 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
B-1	2.93	0.40	0.13	4.90	6.00	1.57	0.68	16.50	0.00
B-2	1.83	0.20	0.33	7.90	6.70	1.50	2.65	13.40	0.00
B-3	4.23	0.20	0.33	4.93	6.50	1.83	1.20	14.20	0.17
B-4	3.38	0.20	0.03	5.33	4.20	1.87	1.10	18.10	0.07
B-5	3.10	0.30	0.03	6.93	7.70	2.67	1.95	16.50	0.00
B-6	6.05	0.40	0.07	8.05	4.40	2.13	2.10	15.30	0.00
B-7	3.53	0.20	0.40	6.10	5.60	2.33	1.40	9.40	0.00
B-8	2.80	0.40	0.23	5.33	6.60	1.53	0.63	18.50	0.10
B-9	3.95	0.80	0.10	5.90	4.30	1.53	1.40	10.00	0.07
B-10	2.63	0.20	0.20	11.30	6.20	2.13	1.13	20.90	0.03
B-11	3.60	0.30	0.23	6.68	5.80	1.77	2.53	11.80	0.07
B-12	2.53	0.20	0.23	6.20	6.30	3.00	0.53	15.60	0.07
B-13	1.98	0.20	0.13	5.30	3.50	2.20	2.43	16.00	0.03
B-14	2.68	0.20	0.23	7.98	8.60	2.77	3.48	22.80	0.03
B-15	1.43	0.10	0.03	11.85	3.10	4.30	1.43	9.40	0.00
B-16	3.68	0.20	0.27	7.70	7.70	2.70	2.35	16.20	0.23
B-17	2.20	0.20	0.30	7.40	5.20	1.80	1.03	20.60	0.30
B-18	2.03	0.20	0.13	5.45	4.90	1.40	1.40	14.10	0.13
B-19	2.70	0.10	0.20	7.53	5.80	3.03	1.08	11.50	0.87
B-20	2.60	0.10	0.20	8.90	5.00	1.70	2.43	15.60	0.23
B-21	1.83	0.10	0.10	10.45	7.10	2.00	2.30	16.90	0.10
B-22	3.18	0.20	0.30	11.80	5.90	3.43	1.43	7.20	0.00

Table-4.10 Pink bollworms damage and larval population at different stages of crop development on different *Bt* strains

Strains	PBW damage %age		PBW larval %age	
	September	October	September	October
B-1	29.17	14.29	25.0	14.3
B-2	50.00	5.26	33.3	0.0
B-3	12.50	13.64	4.2	13.6
B-4	16.67	9.09	8.3	0.0
B-5	20.83	11.54	20.8	3.9
B-6	25.00	33.33	16.7	9.5
B-7	20.83	8.00	12.5	4.0
B-8	16.67	18.52	12.5	14.8
B-9	54.17	10.53	29.2	10.5
B-10	25.00	17.24	12.5	10.3
B-11	25.00	0.00	12.5	0.0
B-12	45.83	20.00	25.0	12.0
B-13	8.33	5.26	4.2	5.3
B-14	37.50	4.35	20.8	4.4
B-15	33.33	4.35	20.8	4.4
B-16	25.00	15.38	20.8	15.4
B-17	33.33	0.00	33.3	0.0
B-18	29.17	5.56	29.2	5.6
B-19	45.83	13.33	33.3	0.0
B-20	8.33	0.00	0.0	0.0
B-21	20.83	23.08	4.2	23.1
B-22	41.67	5.26	20.87	5.3

Table-4.11 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
C-1	1.8	0.3	0.20	6.90	5.20	2.10	1.4	13.7	0.00
C-2	3.1	0.2	0.00	3.30	10.30	2.37	2.0	13.2	0.08
C-3	1.3	0.3	0.18	7.40	6.00	4.53	2.0	15.5	0.00
C-4	2.1	0.3	0.25	4.70	5.60	1.80	1.3	12.6	0.03
C-5	3.7	0.4	0.63	6.60	8.20	2.83	1.5	16.1	0.00
C-6	3.4	0.0	0.38	5.20	8.00	1.68	1.7	11.6	0.03
C-7	2.3	0.5	0.15	4.70	8.70	3.53	1.3	11.3	0.00
C-8	2.8	0.7	0.13	4.90	13.00	2.37	0.8	17.2	0.00
C-9	2.6	0.2	0.38	5.40	11.00	2.70	1.5	12.1	0.00
C-10	1.7	0.2	0.30	7.80	4.70	3.33	1.1	17.7	0.00
C-11	4.7	0.4	0.33	4.20	10.50	2.78	1.5	6.8	0.00
C-12	3.7	0.1	0.20	5.80	3.80	2.70	0.6	6.1	0.00
C-13	4.2	0.7	0.58	4.40	6.00	1.85	1.5	7.7	0.00
C-14	2.6	0.7	0.20	4.10	4.50	2.63	1.4	16.7	0.00
C-15	3.0	0.5	0.48	5.20	4.60	2.03	1.2	8.0	0.00
C-16	2.2	0.6	0.25	5.30	4.70	2.25	0.6	9.9	0.00
C-17	4.1	0.5	0.18	7.20	4.30	4.80	0.5	16.4	0.00
C-18	2.4	0.4	0.28	5.20	4.50	3.15	0.8	14.6	0.00
C-19	2.5	0.3	0.23	8.20	9.90	2.43	1.1	11.1	0.03
C-20	2.8	0.0	0.40	5.70	3.90	2.33	1.6	12.4	0.00
C-21	1.8	0.2	0.55	4.50	4.70	2.22	0.9	8.8	0.00
C-22	2.7	0.2	0.38	3.20	3.60	1.93	1.1	8.8	0.03

Table-4.12 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
C-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-2	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
C-3	0.56	0.00	0.00	1.36	0.00	0.00	0.00	0.00	0.00
C-4	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00
C-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-7	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.66	0.00
C-8	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-9	0.00	0.00	1.85	0.43	0.00	0.00	0.00	1.26	0.00
C-10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00
C-12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-13	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-14	0.00	0.00	0.00	0.00	0.00	1.92	0.00	0.00	0.00
C-15	0.00	0.00	1.19	0.00	0.00	0.00	0.00	1.49	0.00
C-16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-19	0.00	0.00	0.00	0.00	0.00	3.06	0.00	0.00	0.00
C-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C-22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4.4.4 Pest situation in Set-D

In this set 17 Bt cotton strains and two standards (CIM-602 & FH-142) were tested for their tolerance/susceptibility to insect pest complex. Jassid population was above ETL on all the strains except D-9 during June and was higher on D-2 followed by D-15, 11 & 13 while lower on D-12 and D-18. During July it was above ETL on 13 of the testing strains except D-8, 9, 10, 11, 14 and D-19 while it remained below ETL during August except D-1. Whitefly remained above ETL on all the strains during June and also in July except D-1, 3, 5, 8, 12 and D-13 but declined in August except

D-3 where it was above ETL. Overall its intensity was highest on D-2 followed by D-19, 11 & D-15 and lowest on D-1, 7 and D-9. Thrips populations remained below ETL during June and August while it was above ETL on 10 of the testing strains during August. Overall its intensity was higher on D-18 followed by D-17 & 15 and lower on D-7, 6 and 8 **(Table-4.14)**. Low level of spotted bollworm infestation was observed in immature fruits of 4 strains during August & September and 7 strains during October. Whereas, low damage was recorded in mature fruits during August and September in D-4 and during October in D-14, 15 and D-18 while no larva was found in any of the testing strains throughout the study period **(Table-4.15).**

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	
	September	October	September	October
C-1	33.3	12.0	33.3	8.0
C-2	45.4	12.0	45.8	12.0
C-3	62.5	8.0	45.8	8.0
C-4	33.3	8.0	16.7	4.0
C-5	54.2	8.0	41.7	8.0
C-6	29.2	4.0	16.7	4.0
C-7	37.5	0.0	33.3	0.0
C-8	25.0	8.0	12.5	8.0
C-9	41.7	0.0	20.8	0.0
C-10	54.2	4.0	37.5	0.0
C-11	29.2	12.0	25.0	4.0
C-12	33.3	8.0	16.7	8.0
C-13	29.2	0.0	20.8	0.0
C-14	66.7	16.0	50.0	8.0
C-15	66.7	0.0	45.8	0.0
C-16	41.7	32.0	29.2	24.0
C-17	16.7	16.0	16.7	12.0
C-18	45.4	4.0	45.8	4.0
C-19	41.7	8.0	25.0	4.0
C-20	16.7	4.0	8.3	4.0
C-21	16.7	20.0	16.7	28.0
C-22	37.5	4.0	29.2	4.0

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
D-1	2.60	1.80	1.53	5.80	2.80	3.27	0.80	4.00	0.63
D-2	3.20	1.50	0.67	9.60	13.20	2.63	2.00	9.80	0.10
D-3	2.00	1.80	0.60	6.30	3.00	6.17	0.70	6.80	3.33
D-4	2.40	2.60	0.30	5.40	6.80	3.93	0.40	8.10	0.17
D-5	2.60	1.80	0.60	6.10	3.20	2.33	0.60	10.10	0.70
D-6	2.30	1.40	0.40	4.60	5.10	0.70	0.60	2.90	0.00
D-7	2.40	1.30	0.10	4.40	4.90	0.97	1.70	2.00	0.00
D-8	2.30	0.90	0.33	7.10	3.70	2.10	1.80	3.40	0.00
D-9	0.80	0.90	0.00	4.20	4.90	2.33	1.00	11.60	1.70
D-10	2.10	0.60	0.30	6.70	4.30	1.87	0.60	9.70	1.07
D-11	1.90	0.80	0.73	8.80	7.70	2.40	0.60	6.50	0.00
D-12	1.00	1.70	0.57	7.80	3.10	1.63	0.80	4.10	1.33
D-13	2.00	1.10	0.43	8.10	2.70	1.37	1.00	9.40	0.00
D-14	2.10	0.60	0.00	5.60	5.50	3.63	0.60	5.50	0.77
D-15	3.00	1.10	0.50	8.90	6.50	1.93	1.20	15.10	0.00
D-16	2.10	1.20	0.30	7.80	5.50	1.93	1.20	10.30	0.93
D-17	2.40	1.00	0.27	5.50	4.70	3.33	1.90	24.10	0.60
D-18	1.20	2.10	0.10	7.70	5.60	2.63	0.80	27.60	0.00
D-19	2.60	0.60	0.27	5.80	12.50	2.63	0.80	6.30	0.00

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
D-1	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
D-2	0.0	0.0	3.4	0.0	0.0	0.0	0.00	0.00	0.00
D-3	2.5	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
D-4	0.0	1.4	0.0	2.8	0.0	0.0	0.00	0.00	0.00
D-5	0.0	0.0	0.0	0.0	1.8	0.0	0.00	0.00	0.00
D-6	0.0	0.0	1.2	0.0	0.9	0.0	0.00	0.00	0.00
D-7	0.0	0.0	2.5	0.0	0.0	0.0	0.00	0.00	0.00
D-8	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
D-9	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
D-10	1.4	0.0	0.0	0.0	1.8	0.0	0.00	0.00	0.00
D-11	1.7	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
D-12	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
D-13	0.0	0.0	2.9	0.0	0.0	0.0	0.00	0.00	0.00
D-14	1.0	0.0	0.0	0.0	2.0	1.0	0.00	0.00	0.00
D-15	0.0	0.0	0.0	0.0	0.0	0.9	0.00	0.00	0.00
D-16	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
D-17	0.0	0.0	0.0	0.0	2.6	0.0	0.00	0.00	0.00
D-18	0.0	0.0	0.0	0.0	2.4	1.3	0.00	0.00	0.00
D-19	2.5	0.0	0.0	0.0	3.1	0.0	0.00	0.00	0.00

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/larval population was highest in D-8, 11 & 14 and lowest in D-5 and D-6 during end-September while it was higher in D-19, 7 & 14 and below ETL in eight of the testing strains during end-October **(Table-4.16)**.

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	
	September	October	September	October
D-1	16.7	0.0	16.7	0.0
D-2	25.0	4.0	25.0	4.0
D-3	25.0	8.0	25.0	8.0
D-4	25.0	8.0	16.7	8.0
D-5	4.2	8.0	4.2	8.0
D-6	4.2	12.0	4.2	12.0
D-7	25.0	16.0	20.8	16.0
D-8	41.7	0.0	33.3	0.0
D-9	8.3	8.0	8.3	8.0
D-10	29.2	4.0	20.8	4.0
D-11	41.7	8.0	33.3	8.0
D-12	25.0	4.0	20.8	0.0
D-13	12.5	0.0	12.5	0.0
D-14	45.8	16.0	33.3	12.0
D-15	20.8	4.0	20.8	4.0
D-16	33.3	0.0	25.0	0.0
D-17	29.2	8.0	25.0	4.0
D-18	28.2	8.0	29.2	8.0
D-19	29.2	20.0	16.7	20.0

4.5 Development of natural enemies of sucking pests on treated and untreated seed of GM cotton at different planting dates of cotton

A trial was conducted to determine the population dynamics of sucking insect pests & their predators and parasitoids in early and normal planting. Three seed dressing insecticides, Confidor 70WS @ 10g/kg, Guacho 70WS @ 10g/kg and Actara ST 70WS @ 5g/kg were evaluated for their efficacy against sucking insect pests and impact on predators. Treated seed of CIM-599 was dibbled on beds on 10th April (D1) and 11th May (D2) in three replicates with the plot size of 15' x 30' in split plot design. An untreated check was kept for comparison. Population of sucking insect pests and

their predators was recorded in the field at weekly interval starting from 3rd to 7th week of crop planting. To observe the parasitism, whitefly infested leaves were kept in perti dishes and allow the parasitoids to emerge.

Overall population of sucking pests remained low in insecticides seed treated plots as compared to untreated check. Population of jassid was below ETL in early sown crop throughout the season in all treatments. In normal planting jassid intensity was highest in untreated plots followed by Actara ST 70WS while lowest in Guacho 70WS treated plots. Its population reached at ETL in check plots in 5th week while in all other treatments in 6th week after sowing. Studies showed that early sown crop is tolerant against jassid as compared to normal planting. Whitefly remained almost below ETL in both planting dates but its intensity was comparatively higher in late sown plots of all treatments during the observation period. Overall whitefly population was also higher in untreated plots followed by Guacho 70WS and Actara ST 70WS treated plots of normal planting. Thrips remained below ETL throughout observation period in all treatments **(Table-4.17 -4.19)**.

Table-4.17 Population of jassid in plots treated with different seed dressing insecticides

Treatment	Dose /kg seed (g)	Population per leaf after sowing (weeks)					
		3	4	5	6	7	Av
Early planting (D1)							
Confidor 70 WS	10	0.0	0.00	0.00	0.07	0.10	0.41
Gaucho 70 WS	10	0.0	0.03	0.03	0.07	0.33	0.43
Actara ST 70 WS	5	0.0	0.03	0.00	0.10	0.30	0.43
Untreated		0.0	0.03	0.07	0.17	0.37	0.45
Normal planting (D2)							
Confidor 70 WS	10	0.50	0.00	0.10	1.23	5.03	1.37
Gaucho 70 WS	10	0.30	0.10	0.10	1.50	4.27	1.25
Actara ST 70 WS	5	0.30	0.10	0.40	1.77	6.33	1.78
Untreated	-	2.10	0.50	1.40	2.30	4.10	2.08
LSD							
D		0.68	0.03	0.06	0.12	0.13	0.11
ST		0.26	0.02	0.06	0.03	0.03	0.03
D*ST		0.37	0.03	0.08	0.05	0.05	0.04

D = sowing date, ST = seed treatment, D*ST = interaction between sowing date & seed treatment

Table-4.18 Population of whitefly in plots treated with different seed dressing insecticides

Treatment	Dose /kg seed (g)	Population per leaf after sowing (weeks)					
		3	4	5	6	7	Av
Early planting (D1)							
Confidor 70 WS	10	0	0.50	0.25	0.70	2.80	0.69
Gaucho 70 WS	10	0	0.40	0.10	0.60	2.50	0.62
Actara ST 70 WS	5	0	1.30	0.30	1.50	3.05	1.02
Untreated		0	1.33	0.37	2.10	3.60	1.16
Normal planting (D2)							
Confidor 70 WS	10	0.4	0.90	0.90	2.73	3.03	1.59
Gaucho 70 WS	10	0.4	2.00	1.20	2.77	3.87	2.05
Actara ST 70 WS	5	0.4	1.60	1.00	3.20	3.17	1.87
Untreated	-	0.7	3.50	1.10	3.60	4.70	2.72
LSD							
D		0.03	0.14	0.02	0.28	0.02	0.16
ST		0.04	0.12	0.05	0.09	0.15	0.06
D*ST		0.06	0.18	0.07	0.13	0.21	0.09

D = sowing date, ST = seed treatment, D*ST = interaction between sowing date & seed treatment

Overall population of predators was higher in early sown crop as compared to normal planting while seed treatment didn't show any negative impact on their numbers. Prevalence of predators was lower in the early season and gradually increased with the rise of sucking insect pests' population both in the treated and untreated plots of early and normal sowing blocks **(Table-4.20)**. Comparatively parasitism was higher in early sown crop than normal planting and maximum

parasitism was recorded from Guacho 70 WS treated plots of both early and normal sown crops **(Fig. 4.10).**

Table-4.19 Population of thrips in plots treated with different seed dressing insecticides

Treatment	Dose /kg seed (g)	Population per leaf after sowing (weeks)					
		3	4	5	6	7	Av
Early planting (D1)							
Confidor 70 WS	10	0	0.37	0.03	0.20	0.10	0.15
Gaucho 70 WS	10	0	0.17	0.03	0.23	0.10	0.11
Actara ST 70 WS	5	0	0.20	0.00	0.17	0.03	0.09
Untreated		0	0.67	0.10	0.40	0.13	0.29
Normal planting (D2)							
Confidor 70 WS	10	0	0.57	0.00	0.03	0.23	0.17
Gaucho 70 WS	10	0	0.23	0.03	0.17	0.27	0.14
Actara ST 70 WS	5	0	0.13	0.00	0.07	0.10	0.06
Untreated	-	0	0.40	0.10	0.20	0.20	0.18
LSD							
D		-	NS	NS	0.02	0.02	NS
ST		-	0.11	0.02	NS	NS	0.04
D*ST		-	NS	NS	NS	NS	NS

D = sowing date, ST = seed treatment, D*ST = interaction between sowing date & seed treatment

Table-4.20 Population of predators in plots treated with different seed dressing insecticides

Treatment	Dose /kg seed (g)	Population (000/acre)					
		3	4	5	6	7	Av
Early planting (D1)							
Confidor 70 WS	10	4.80	3.20	19.60	43.60	75.00	29.48
Gaucho 70 WS	10	4.80	6.40	25.73	42.60	91.20	34.44
Actara ST 70 WS	5	6.40	4.80	21.50	44.80	75.20	31.14
Untreated		4.80	4.80	24.00	41.60	58.40	26.72
Normal planting (D2)							
Confidor 70 WS	10	1.60	1.60	14.40	20.80	30.40	13.76
Gaucho 70 WS	10	1.60	6.40	33.63	17.60	20.80	16.01
Actara ST 70 WS	5	0.00	3.20	25.60	27.20	17.60	14.72
Untreated	-	3.20	1.60	9.20	20.80	14.40	9.84
LSD							
D		0.26	0.04	NS	0.61	2.54	NS
ST		0.23	0.15	1.40	0.43	0.69	0.04
D*ST		0.32	0.21	1.98	0.60	0.98	NS

D = sowing date, ST = seed treatment, D*ST = interaction between sowing date & seed treatment

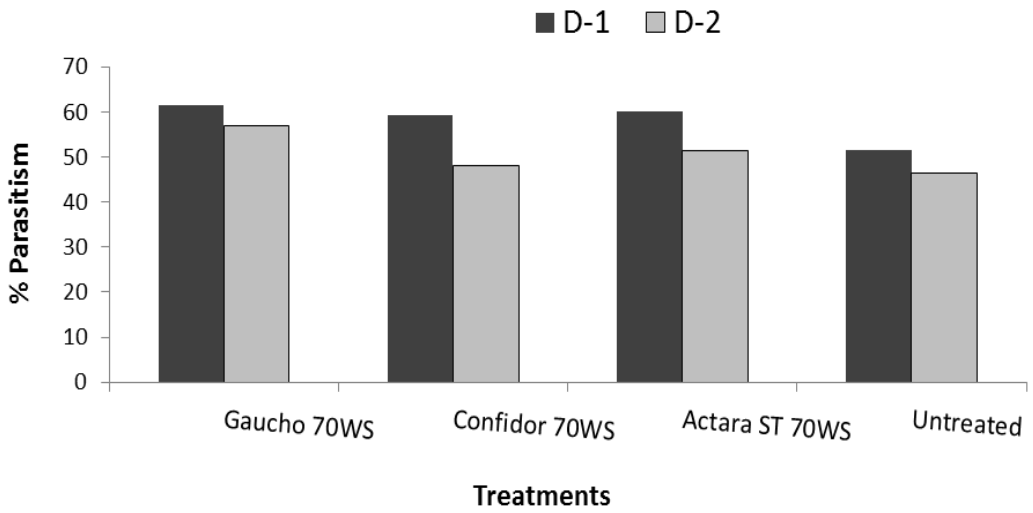

Fig. 4.10 Parasitism %age in treated and untreated plots of early & normal sown crop

4.6 Studies on Pink bollworm

4.6.1 Status of Pink bollworm infestation

A survey was conducted during October only in Muzaffar Garh district to estimate the Pink bollworm infestation in green bolls. Susceptible green bolls of different varieties were randomly collected from different locations and kept in the laboratory for 2-3 days before dissecting.

Pink bollworm damage and live larvae were recorded higher in Muzaffar Garh followed by Khan Garh, Rohilan Wali, Jatoi and Shah Jamal while its minimum intensity was found in Permit and Sehar Sultan areas. Overall 41.4% bolls were infested by pink bollworm and 39.2 % live larvae were present in collected bolls **(Table-4.21)**.

All Bt cotton varieties were found susceptible to pink bollworm. Its maximum infestation and live larvae were recorded in the bolls collected from FH-Lalazar followed by FH-142 and MNH-886 while its intensity was lowest in CIM-616 **(Table-4.22)**.

Table-4.21 Pink bollworm damage and live larvae in green bolls

Location	Total bolls	Damage (%)	Live Larvae (%)
Muzaffar Garh	200	100.0	100.0
Khan Garh	200	75.0	65.0
Rohilan Wali	400	35.0	34.0
Sehar Sultan	150	5.33	4.0
Permit	100	2.0	2.0
Jatoi	250	28.0	28.0
Shah Jamal	250	28.8	25.6
Overall	**1550**	**41.4**	**39.2**

Table-4.22 Varietal comparison of Pink bollworm damage and live larvae

Variety/strain	Total bolls	Damage (%)	Live Larvae (%)
FH-Lalazar	400	63.5	60.0
FH-142	400	56.5	56.5
MNH-886	500	25.6	23.6
CIM-616	250	16.0	12.8

4.6.2 Pink Bollworm management awareness campaign:

Pink bollworm again emerged as a major pest in cotton growing areas of Punjab. However, it was effectively controlled with the Bt-cotton which contains single gene (Cry 1Ac) till now. Unfortunately Bt cotton start losing its efficacy and PBW caused significant loses to the crop during 2015-16. Keeping in view the sensitivity of the issue, we promptly responded and organize a National Seminar on “Pink Bollworm Management” at CCRI, Multan on January, 11, 2016. The objective of holding the seminar was to have collective effectors to combat the impending risk due to the onslaught of Pink bollworm and to save the coming cotton crop from its damage. Haji Sikandar Hayat Khan Bosan, Federal Minister for National Food Security & Research chaired the seminar. Ms Rubina Wasti, Senior Joint Secretary, Ministry of Textile Industry, Dr. Khalid Abdullah, Cotton Commissioner, Ministry of Textile Industry/Vice President of PCCC also co-chaired the session. The seminar was attended by participants from KCA, PCGA, PCSI, NIAB, NIBGE, NIA (Tandojam) PW&QC, EDO, DO’s, WWF, pesticide & seed industries, and progressive growers from Punjab and Sindh.

Pink bollworm management awareness campaign during off season was also launched to educate the cotton farmers at their door step. Large numbers of farmers attended the farmers gathering organized in more than 20 places at different cotton growing areas.

4.7 Studies on red cotton bug

4.7.1 Efficacy, fecundity, survival and response of *Antilochus coqueberti* adults

A potential predator, *Antilochus coqueberti* was provided 3rd, 4th, 5th instars and adults of cotton stainer in laboratory to evaluate the level of its predation, fecundity and life duration to identify the best predacious stage of predator and most preferable stage of the host for biological control in field conditions. One pair of *A.*

coqueberti was released on 10 individuals of the respective stage in four replicates. Laboratory temperature and humidity were maintained at 25 ± 2°C and 70 ± 5% respectively. The observations were taken daily.

Predator and the host in each replication was contained in a glass jar of 5.5" diameter having 8.5" height, filled with 2 inches thick layer of soil with small quantity of sand. Two plastic petri-dishes of 5cm diameter, one for moisture and the other of cotton seed as a food for the cotton stainer were kept in each jar. To maintain moisture, surgical cotton was used in petri-dish covered with filter paper disc and 6ml water was sprinkled on filter paper daily. The other petri-dish contained 10 delinted and wet cotton seeds on filter paper disc.

Table-4.23 Percent predation, fecundity and life duration of *A. coqueberti* fed on cotton stainer

Host stage	Predation (%)	Fecundity			Life duration	
		No. of batches	Total eggs	Eggs/ batch	Male	Female
3rd instar	27.22	4.75	243.25	51.21	84.50	94.00
4th instar	12.21	1.75	102.50	14.64	99.00	58.25
5th instar	14.10	4.00	269.50	53.04	56.75	73.00
Adult	9.21	3.00	163.00	46.33	78.00	48.50

Maximum predation was recorded on 3rd instar of host (27.22%) followed by 5th, 4th instar and adult stage (14.10, 12.21 and 9.21%) respectively. The results revealed that *A. coqueberti* mostly preferred immature stages of host.

Highest number of egg batches of predator were obtained when it fed on 3rd instar of the cotton stainer (4.75) followed by 5th instar (4.00) while lowest on 4th instar (1.75) and adult stage (3.00). Overall maximum eggs were laid when it fed on 5th instar (269.50) and lowest on 4th instar (102.50). The results clearly indicate that predator responded well when it was fed on 4th instar of host. Longest life period of males was recorded when it fed on 4th instar of host (99 days) and shortest on 5th instar (56.75 days) while female longest life period was recorded when it fed on 3rd instar (94 days) and shortest on adult stage (48.50 days) **(Table-4.23)**.

4.8 Studies on dusky cotton bug

4.8.1 Impact of sowing dates and control measures on dusky cotton bugs infestation in the field condition

Dusky cotton bug is a serious pest of cotton causing both quantitative and qualitative losses by fruit shedding, reducing seed germination and seed weight.

The trial was conducted to record the pest impact on the seed cotton on early and normal sowing period. Cotton genotype CIM-599 was sown in mid-March and mid-May. The Spit plot design was used with sowing dates as main blocks and the sprayed and unsprayed as treatments replicated three times. Plot, block, and treatments sizes were 0.55, 0.28, 0.14 acres, respectively. Spraying was initiated on observing 5 pairs per immature fruit per plant in treated plots.

The seed cotton weight in sprayed plots (1019.0 kg ac^{-1}) of mid-March sowing was higher than in unsprayed plots (877.8 kg ac^{-1}) by 7.4% and of mid-May sprayed plots (753.5 kg ac^{-1}) was unsprayed plots (679.3 kg ac^{-1}) by 5.2%. The results further revealed that with of fuzzy seed after ginning of one kg of seed cotton was lower by 3.4 % by weight in sprayed plots of March sown crop and 1.7% of May sown crop as compared to unsprayed plots. Similarly percent germination was higher by 26 & 20 % in sprayed plots as compared in unsprayed plots, respectively of March and May sown crops (**Table 4.24**).

Table 4.24 Impact of dusky cotton bug infestation on different fruiting parts sown on different dates

Sowing period	Treatment	Seed cotton weight (kg ac^{-1})	Fuzzy seed wt from 1kg cotton seed	% germination
Mid-March	Sprayed	1019.0 (7.4%↑)	0.605 > 3.4 %	72
	Unsprayed	877.8	0.565	46
Mid-May	Sprayed	753.5 (5.2%↑)	0.595 > 1.7%	82
	Unsprayed	679.3	0.575	62

Note: % yield difference= $\frac{(Y_{(sprayed)} - Y_{(unsprayed)}) \times 100}{(Y_{(sprayed)} + Y_{(unsprayed)})}$

4.8.2 Qualitative and quantitative losses at different threshold levels of adult dusky cotton bugs under the field cage conditions

The trial was conducted to determine the level of damage by dusky cotton bug at various threshold levels in the field cage conditions. The pest infestation was observed on squares, small bolls and matures or partially opened bolls. Two plants with counted number of each fruiting part were covered in a cage replicated three times. The cage size was 1 ×1 ×5 m^3. Each cage contained frame of iron rod covered with net cloth from four sides having an outlet at one side for entrance. The cages were installed for the period from 13th October to 29th November for 47 days (the most favorable period of breeding and feeding for the bugs). Before releasing the dusky cotton bugs adults, the plants were ensured free of all other types of pests with insecticide applications. The releases were made one week after spray to eliminate the insecticidal residual effects. For each fruiting parts, three threshold levels were proposed with one control without releases. TL1 with five pairs of dusky cotton bugs per fruiting parts, TL2 with 10 pairs and TL3 with 20 pairs. TL4 was kept as a control with no dusky bug. In total 36 cages were used (i.e. for each square, small bolls and mature or partially opened boll, 12 cages). The mean of the total number of fruiting parts in the three cages of each category were adjusted as 50 fruiting parts and summarized in **(Table 4.25 & 4.26).**

In control cages (TL4) the shedding percentage was 32% in squares and 6% in small bolls. Whereas in dusky cotton bugs released caged (TL1, TL2 & TL3), shedding percentage in squares were 17.9, 39.6 and 45.8% respectively. Similarly shedding percentage in small bolls was 33.3, 57.1 & 70.0% respectively in released cages. (**Table-4.25**).

Dusky cotton bug reduces the weight of the seed cotton compared to control cages. Also percentage reduction in seed cotton weight 1.8, 8.5 & 11.6% was recorded in TL1, TL2, TL3 and TL4 respectively. Similarly dusky cotton also affected the seed germination and it was recorded 57, 49, 44 and 68% in TL1, TL2, TL3 & TL4 respectively **(Table-4.25 & Table-4.26).**

Table-4.25 Number of shed fruits from total of 50 each in squares and small bolls in the cage condition caused by Dusky cotton bugs

Treatments	Shedding in Squares	% shedding over control	Shedding in Small bolls	% shedding over control
TL1	23	17.9	6	33.3
TL2	37	39.6	11	57.1
TL3	43	45.8	17	70.0
TL4	16	-	3	-

Note: TL1 = 5 pairs; TL2 =10 pairs; TL3= 20 pairs; TL4= Control

Table-4.26 Impact of dusky cotton bugs infestation on seed weight and % germination based on 50 bolls per cage in the cage condition

Treatments	Weight (gm)		% reduction in cotton seed weight over control	% germination
	Seed cotton	Cotton seed (fuzzy seeds)		
TL1	180.0	111.5	1.8	57
TL2	177.0	97.5	8.5	49
TL3	162.8	91.6	11.6	44
TL4	186.3	115.6	-	68

Note: TL1 = 5 pairs; TL2 =10 pairs; TL3= 20 pairs; TL4= Control

4.9 Screening of insecticides

Eighteen insecticides of different groups were evaluated against dusky cotton bug at farmer's field on early sown cotton at peak squaring stage. Hand operated knack sap sprayer was used for insecticide application and untreated check kept for comparison. The pest mortality data were recorded from five randomly selected plants /replicate of each treatment. Data was recorded from whole of the plant including terminal buds, leaves and squares 72 hours and one week after the treatment.

After 72 hours of the spray, Rafree 5 SC, Telsta 20 SC, Coniflex 50 WP, K-2, Nurelle-D 505 EC, Lasenta 80 WG, Cedox 360 EC and mixture of Karate & Chlorpyrifos proved most effective and gave 95.5–99.4% pest mortality. While Vibrant 36 SC, Advantage 20 EC and Karate 2.5 EC proved less effective and gave less than 69% mortality. Rafree 5 SC, Telsta 20 SC, Pelegan 40 EC, Coniflex 50 WP, Boltan 31 EC, Cedox 360 EC, Momentum 50 WDG and mixture of Karate & Chlorpyrifos proved most effective and gave 90.7–97.6% pest mortality after one week of the treatment. Vibrant 36 SC, Denadim 40 EC, K-2, Nurelle-D 505 EC, Lasenta 80 WG and Polytrin-C 440 EC also found effective with more than 75% mortality. Pyramid 10 SL, Advantage 20 EC and Karate 2.5 EC proved weaker against the pest and gave less than 32.4 – 52.9% mortality **(Table-4.26)**.

4.9 Effect of seed dressing insecticides on sucking insect pest and their predators

One seed dressing insecticide, Hombre Excel 372.5FS was evaluated for its efficacy against sucking insect pests and impact on predators and Confidor 70 WS was kept as standard. Treated seed of *Bt* CIM-599 was dibbled on beds on 25th May in three replicates with the plot size of 30'x15'. An untreated check was kept for comparison. Data on sucking pests and predators' population was recorded at weekly interval from 3rd to 7th week of crop planting.

Overall population of sucking pests remained low in insecticides treated plots as compared to untreated check. Jassid was main pest and its population reached at ETL in untreated check plots in 3rd week after sowing. Whereas, in insecticide treated plots, it reached at ETL in 6th week after sowing. Overall jassid population remained low in plots treated with Hombre Excel 372.5 FS. Whitefly remained below ETL in treated plots throughout the observation period, while in untreated plot its population reached at ETL in 7th week after sowing. Thrips remained negligible in all the treated and untreated plots. The tested insecticides proved almost safe to the predators after third week of treatment **(Table-4.27)**.

Table-4.26 Efficacy of different insecticides against dusky cotton bug on square stage

Insecticide	Common name	Dose acre^{-1} (ml/g)	Percent Mortality	
			72 hrs	1-week
Rafree 5 SC	Fipronil	480	95.5	97.6
Telsta 20 SC	Clothiandin	200	99.0	93.0
Pelegan 40 EC	Triazophos	700	91.5	96.9
Vibrant 36 SC	Chlorfenapyr	200	55.8	81.1
Coniflex 50 WP	Imidacloprid	100	97.7	90.7
Pyramid 10 SL	Nitenpyram	200	67.4	32.4
Curacron 50 EC	Profenophos	500	74.4	66.5
Danadim 40 EC	Dimethoate	400	89.3	75.3
Polo 500 EC	Diafenthiuron	200	75.9	62.7
Advantage 20 EC	Carbosulfan	500	68.1	42.0
K-2		400	96.0	85.4
Nurelle-D 505 EC	Cyper. + Chlorpyrifos	500	95.8	86.8
Boltan 31 EC	Gamacyhalo+Chlorpyrifos	500	91.7	93.8
Lasenta 80 WG	Imidaclprid +Fipronil	60	96.3	86.4
Cedox 360 EC	Triazophos+Deltamethrin	600	98.7	95.5
Polytrin-C 440 EC	Cypermeth+Profenophos	600	81.3	75.7
Karate 2.5 EC	Lambdacyhalothrin	330	45.9	52.9
Momentum 50WDG	Chlorfenapyr+Nitenpyram	150	75.3	95.4
Karate +Chlorpyrifos	Lambda. + Chlorpyrifos	200+300	99.4	95.5
X-tall		750	88.7	69.0
Untreated Check			0.00	0.00
CD at 5%	**-**	**-**	**6.80**	**8.26**

Pretreatment data = 109.9/ plant

Table-4.27 Population of sucking pests and predators in plots treated with different seed dressing insecticides

a) Jassid

Treatment	Dose /kg seed	Population per leaf after sowing (weeks)				
		3	4	5	6	7
Hombre Excel 372.5FS	10ml	0.80	0.10	0.10	1.37	4.47
Confidor 70WS	10g	0.50	0.10	0.20	1.23	5.03
Untreated	-	2.10	0.50	1.40	2.30	4.10
C.D.5%		**0.34**	**0.07**	**0.22**	**0.10**	**0.07**

b) Whitefly

Treatment	Dose /kg seed	Population per leaf after sowing (weeks)				
		3	4	5	6	7
Hombre Excel 372.5FS	10ml	0.20	1.20	1.00	2.90	1.90
Confidor 70WS	10g	0.40	0.90	0.90	2.73	3.03
Untreated	-	0.70	3.50	1.10	3.60	4.70
C.D.5%		**NS**	**0.30**	**NS**	**0.32**	**0.43**

c) Thrips

Treatment	Dose /kg seed	Population per leaf after sowing (weeks)				
		3	4	5	6	7
Hombre Excel 372.5FS	10ml	0.00	0.13	0.00	0.07	0.00
Confidor 70WS	10g	0.00	0.40	0.00	0.07	0.23
Untreated	-	0.00	0.57	0.10	0.20	0.27
C.D.5%		**NS**	**0.04**	**0.02**	**0.03**	**0.06**

d) Predators

Treatment	Dose /kg seed	Population per leaf after sowing (weeks)				
		3	4	5	6	7
Hombre Excel 372.5FS	10ml	0.00	1.60	19.20	43.20	20.80
Confidor 70WS	10g	1.60	1.60	14.40	20.80	30.40
Untreated	-	3.20	1.60	9.20	20.80	14.40
C.D.5%		**1.70**	**NS**	**7.23**	**1.86**	**12.76**

4.10 Evaluation of Foliar Insecticides

4.10.1 Thrips *(Thrips tabaci)*

Nineteen insecticides of different groups were evaluated against thrips at farmer's field keeping untreated check for comparison. Tracer 240 SC, Polytrin-C 440 EC and Radiant 12 SC proved most effective after 72 hours of spray and gave more than 85.0% pest mortality. Pyrifox 60 WDG gave maximum pest mortality (88.8%) till one week after application followed by Radiant 12 SC, Tracer 240 SC, Momentum 50 WDG and Pelegan 40 EC those gave more than 80%. Other insecticides gave more than 59% mortality while Telsta 20 SC and Applaud 20 SC proved least effective against the pest **(Table-4.28).**

Table-4.28 Efficacy of different insecticides against thrips

Treatment	Common name	Dose acre^{-1} (ml/g)	Mortality %age	
			72 hours	1 week
Coniflex 50 WP	Imidacloprid	100	70.6	64.8
Foxal 36 SC	Chlorfenapyr	200	79.2	74.9
Lanolex 10.8 EC	Pyriproxyfen	250	69.4	76.0
Pyrifox 60 WDG	Chlorfena+ Nitenpyram	100	78.1	88.8
Vapco 40 WDG	Acetamiprid	60	65.8	68.5
Momentum 50WDG	Chlorfena+ Nitenpyram	150	77.0	82.2
Big Hope 5 SC	Fipronil	480	74.9	76.4
Tracer 240 SC	Spinosad	50	87.1	82.7
Telsta 20 SC	Clothiandin	200	28.7	41.4
Danadim 40 EC	Dimethoate	400	63.7	59.6
Pelegan 40 EC	Triazophos	700	85.7	80.6
Lasenta 80 WG	Imidaclopr + Fipronil	60	81.2	77.7
Coredor 75 SP	Acephate	250	70.1	73.4
Advantage 20 EC	Carbosulfan	500	61.1	68.6
Polo 500 EC	Diafenthiuron	200	52.1	66.1
Curacron 50 EC	Profenophos	500	72.0	79.4
Polytrin-C 440 EC	Cyper + Profenophos	600	85.0	78.9
Applaud 25 SC	Buprofezin	600	33.3	21.1
Radiant 12 SC	Spinetroram	50	85.4	86.8
Untreated Check	-	-	0.00	0.00
CD at 5%	**-**	**-**	**9.59**	**8.10**

Pretreatment data = 16.7/ leaf

4.10.2 Jassid *(Amrasca devastans)*

Efficacy of twenty three insecticides from different groups was evaluated against jassid at farmer's field keeping untreated check for comparison. Lasenta 80 WP and Pyrifox 60 WDG gave maximum pest mortality (92.0 & 90.5% respectively) while Foxal 36 Sc, Pirox Super 60 WDG, Momentum 50 WDG, Rafree 5 SC, Telsta 20 SC, Danadim 40 EC, Coredor 75 SP, Polo 500 SC and Oshin 20 SG proved also effective and gave more than 80% pest mortality till one week after application. Within other treatments, Coniflex 50 WP and Vapco 40 WDG proved moderately effective against the pest and gave more than 74% pest mortality. Curacron 500 EC, Priority10.8EC, Pelegan 40 EC, Applaud 25 SC, Tracer 240 SC, Polytrin-C 440 EC and Radiant 12 SC proved least effective against the pest **(Table-4.29)**.

Table-4.29 Efficacy of different insecticides against jassid

Treatment	Common name	Dose acre^{-1} (ml/g)	Mortality %age	
			72 hours	1 week
Coniflex 50 WP	Imidacloprid	100	76.5	79.9
Foxal 36 SC	Chlorfenapyr	200	82.0	85.8
Pirox Super 60 WDG	Nitenpyram	100	85.4	87.5
Pyrifox 60 WDG	Chlorfena + Nitenpyram	100	89.6	90.5
Vapco 40 WDG	Acetamiprid	60	77.0	74.1
Talstar 10 EC (NR)	Bifenthrin	250	47.6	57.5
Talstar 10 EC (Std)	Bifenthrin	250	51.7	53.2
Momentum 50 WDG	Chlorfena + Nitenpyram	150	88.9	87.4
Rafree 5 SC	Fipronil	480	85.0	88.7
Telsta 20 SC	Clothiandin	200	85.8	80.9
Danadim 40 EC	Dimethoate	400	93.8	89.7
Pelegan 40 EC	Triazophos	700	22.0	41.0
Lasenta 80 WG	Imidacloprid + Fibronil	60	95.3	92.0
Tracer 240 SC	Spinosad	50	30.5	41.7
Coredor 75 SP	Acephate	250	82.6	83.4
Advantage 20 EC	Carbosulfan	500	42.3	57.0
Polo 500 EC	Diafenthiuron	200	85.8	81.0
Curacron 50 EC	Profenophos	500	48.6	36.4
Polytrin-C 440 EC	Cyper + Profeno	600	52.5	42.1
Applaud 25 SC	Buprofezin	600	27.5	41.5
Priority 10.8 EC	Pyriproxyfen	500	22.1	38.7
Radiant 12 SC	Spinetroram	50	36.6	45.2
Oshin 20 SG	Dinotefuran	100	90.4	84.9
Untreated Check	-	-	0.00	0.00
CD at 5%	**-**	**-**	**8.16**	**9.33**

Pretreatment data = 7.37 / leaf

4.10.3 Whitefly *(Bemisia tabaci)*

A total of 21 insecticides from different groups and their mixtures were screened against whitefly at CCRI, Multan keeping untreated check for comparison. Movento 240 SC, Ulala 50 WG and Triazophos 40 EC proved most effective and gave more than 73% pest mortality after application. Pyrifox 60 WDG, Talstar 10 EC (old recipe), Movento 240 SC, Lanolex 30 WDG and Triazophos 40 EC proved effective and gave more than 70% mortality while Coniflex 50 WP, Vapco 40 WDG, Priority 10.8 EC, Ulala 50 WG and Lanolex 10.8 EC gave more than 67% mortality upto one week of application. Other insecticides proved less effective against this pest **(Table-4.30).**

4.10.4 Two spotted mites *(Tetranychus* sp.*)*

Efficacy of four candidate insecticides from different groups was evaluated against two spotted mites keeping Talstar 10 EC (OR) and Pirate 360 SC as standards and untreated check for comparison. Pirate 36 SC showed knockdown effect and gave 90.3% pest mortality followed by Pyrifox 60 WDG (85.3%) and Starfen 10 EW (82.5%) while Talstar 10 EC (OR) and Foxal 36 SC gave lowest mortality (77.6 & 78.4% respectively) after 72 hours of the spray. Pyrifox 60 WDG, Foxal 36 SC and Pirate 36 SC proved better and gave more than 96% mortality upto one week of application while Talstar 10 EC (NR & OR) gave less than 87% mortality **(Table-4.31).**

4.10.5 Spotted/spiny bollworm (*Earias* spp.)

Three candidate insecticides from different groups were tested against *Earias* species while Talstar 10 EC (OR), Pelegan 40 EC and Demeter 2.5 EC were kept as standards. Talstar 10 EC (NR) showed knockdown effect and gave 79.6% larval mortality followed by Starfen10 EW (78.1%) while Check Worm 5 EC gave lowest mortality (67.7%) after 72 hours of the spray. Demeter 2.5 EC and Pelegan 40 EC proved better and gave more than 79% larval mortality upto one week of application while Starfen10 EW and new & old Talstar recepies lost their efficacy gradually and

gave lowest mortality. All the insecticides were proved statistically almost equal to each other **(Table-4.32).**

Table-4.30 Efficacy of different insecticides against whitefly

Treatment	Common name	Dose acre^{-1} (ml/g)	Mortality %age	
			72 hrs	1 wk
Coniflex 50 WP	Imidacloprid	100	59.3	69.9
Foxal 36 SC	Chlorfenapyr	200	68.4	65.3
Lanolex 10.8 EC	Pyriproxyfen	250	62.7	67.6
Lanolex 30 WDG	Pyriproxyfen	100	69.3	72.1
Gladio 43 WP	Pyriproxyfen+Acetamip	150	60.8	65.3
Pyrifox 60 WDG	Chlorfenapyr+Nitenpyram	100	63.1	76.6
Talstar 10 EC (NR)	Bifenthrin	250	68.9	67.6
Vapco 40 WDG	Acetamiprid	60	67.6	69.1
Coredor 75 SP	Acephate	330	59.8	57.3
Pelegan 40 EC	Triazophos	700	73.1	70.6
Talstar 10 EC (Std)	Bifenthrin	250	68.1	68.4
Priority 10.8 EC	Pyriproxyfen	400	56.9	68.6
Applaud	Buprofezin	600	69.1	62.8
Polo 500 EC	Diafenthiuron	200	69.9	62.3
Momentum 50 WDG	Chlorfenapyr+Nitenpyram	150	60.8	55.5
Rafree 5 SC	Fipronil	480	48.0	33.3
Telsta 20 SC	Clothiandin	200	62.3	57.8
Polytrin-C 440 EC	Cyper + Profenophos	600	63.1	55.5
Movento 240 SC	Spirotetramat + Adjuvant	125+250	77.4	72.1
Ulala 50 WG	Flonicamid	80	74.8	68.4
Lancer Gold 51.8 SP	Aceph 50%+ imida 1.8%	500	66.6	62.3
Untreated Check	-	-	0.00	0.00
CD at 5%	**-**	**-**	**10.16**	**9.21**

Pretreatment data = 13.27 / leaf

Table-4.31 Efficacy of different insecticides against two spotted mites

Treatment	Common name	Dose acre^{-1} (ml/g)	Mortality %age	
			72 hours	1 week
Foxal 36 SC	Chlorfenapyr	200	83.1	96.4
Pyrifox 60 WDG	Chlorfenapyr + Nitenpyram	200	85.3	97.0
Talstar 10 EC (NR)	Bifenthrin	250	80.1	82.5
Starfen 10 EW	Bifenthrin	250	82.5	87.3
Talstar 10 EC (OR)	Bifenthrin	250	77.6	86.7
Pirate 36 SC	Chlorfenapyr	100	90.3	96.0
Untreated check	-	-	0.00	0.00
CD at 5%	-	-	**0.86**	**0.31**

Pretreatment population = 16.55 / leaf

Note:- • √ X + 0.5 transformation used for analysis.

Table-4.32 Efficacy of different insecticides against spotted bollworm

Treatment	Common name	Dose acre^{-1} (ml/g)	Mortality %age	
			72 hours	1 week
Check Worm 5 EC	Emamectin	75	67.7	72.2
Starfen10 EW	Bifenthrin	75	78.1	75.9
Talstar 10 EC (NR)	Bifenthrin	250	79.6	75.9
Talstar 10 EC (OR)	Bifenthrin	250	77.7	74.4
Pelegan 40 EC	Triazophos	1000	77.7	79.6
Demeter 2.5 EC	Deltamethrin	330	72.2	83.3
Untreated check	-	-	5.6	7.4
CD at 5%	-	-	**0.72**	**0.60**

Pretreatment population = 9 larvae / 25 plants

Note:- • √ X + 0.5 transformation used for analysis.

4.10.6 Pink bollworm *(Pectinophora gossypiella)*

Three candidate insecticides from different groups were tested against pink bollworm *(P. gossypiella)* while Talstar 10 EC (OR), Pelegan 40 EC and Demeter 2.5 EC were kept as standards. Talstar 10 EC (NR & OR) and Demeter 2.5 EC proved effective and gave more than 74% larval mortality while Check Worm 5 EC gave

lowest mortality (65.7%) after 72 hours of the spray. Demeter 2.5 EC, Pelegan 40 EC and Starfen10 EW proved better and gave more than 74% larval mortality upto one week of application while new & old Talstar recepies lost their efficacy gradually and gave lowest mortality. All the insecticides were statistically equal to each other **(Table-4.33).**

Table-4.33 Efficacy of different insecticides against pink bollworm

Treatment	Common name	Dose acre^{-1} (ml/g)	Mortality %age	
			72 hours	1 week
Check Worm 5 EC	Emamectin	75	65.7	68.6
Starfen10 EW	Bifenthrin	75	68.8	74.3
Talstar 10 EC (NR)	Bifenthrin	250	77.1	71.4
Talstar 10 EC (OR)	Bifenthrin	250	74.3	68.6
Pelegan 40 EC	Triazophos	1000	71.4	74.3
Demeter 2.5 EC	Deltamethrin	330	75.6	77.1
Untreated check	-	-	0.00	0.00
CD at 5%	-	-	**0.79**	**0.86**

Pretreatment population = 35 larvae / 100 bolls

Note:- • √ X + 0.5 transformation used for analysis.

4.10.7 Armyworm *(Spodoptera litura)*

Performance of seven candidate insecticides of different groups was observed against armyworm (*S. litura);* Pirate 36 SC, Match 50 EC and Belt 48 SC were kept as standards. Foxal 36 SC, Pyrifox 60 WDG, Latch 10 EC and Match 50 EC proved more effective and gave more than 90% larval mortality while Uniron 10 EC gave lowest mortality (57.9%) after 48 hours of the spray. Pyrifox 60 WDG, Foxal 36 SC, Match 50 EC, Latch 10 EC Pirate 36 SC and Stalker 10 WDG proved better and gave more than 96% larval mortality upto one week of application. Takumi 20 SC, Check Worm 5 EC and Belt 48 SC also proved effective and gave more than 91% mortality while Uniron 10 EC gave lowest mortality (77.1%). Efficacy of all the insecticides increased gradually with the span of time **(Table-4.34).**

Table-4.34 Efficacy of different insecticides against Armyworm

Treatment	Common name	Dose acre^{-1} (ml/g)	Pretreat. No. / 5 plants	Mortality %age	
				48 hrs	1 wk
Stalker 10 WDG	Chlorfenapyr	100	74	90.53	95.95
Takumi 20 SC	Flubendiamide	120	78	83.33	93.59
Foxal 36 SC	Chlorfenapyr	200	68	94.12	97.07
Check Worm 5 EC	Emamectin	75	81	82.73	91.37
Pyrifox 60 WDG	Chlorfenapyr + Nitenpyram	200	76	93.23	98.67
Latch 10 EC	Lufenuron	200	92	91.30	96.73
Uniron 10 EC	Novaluron	300	83	57.83	77.11
Pirate 36 SC (Std)	Chlorfenapyr	100	75	88.00	96.00
Match 50 EC (Std)	Lufenuron	200	88	90.90	97.73
Belt 48 SC (Std)	Flubendiamide	50	73	82.20	93.15
Untreated check	-	-	80	5.00	7.50
CD at 5%	**-**	**-**		**0.51**	**0.38**

Note:- • √ X + 0.5 transformation used for analysis.

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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 (CLCu) and other cotton diseases in different parts of the Punjab. The maximum CLCuD was recorded in Muzaffer Gur followed by Multan Districts. The average severity level of disease and natural incidence was less in Bahawalpur, 0.75 and 2.0 % respectively when compared to other districts. All the varieties showed symptoms of CLCuD in surveyed areas. The maximum incidence was recorded in MNH-456 (33%) with disease severity 2.7. 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. However early sown rain fed crop was affected by wilting syndrome, in some areas. The prevalence of bacterial blight and leaf spot of cotton was minimal. Blackening of leaves was observed in some spots.

5.2 Screening of Breeding Material against CLCuD

5.2.1 Screening under field conditions

The advanced strains/genotypes of this Institute included in varietal, micro varietal trials and various national coordinated varietal trials were screened for their reaction to CLCuD under field conditions. Two hundred sixty three families were screened during the year. Data present in **Table-5.1** show that all 263 families of breeding material, showed symptoms of the CLCuD under filed conditions. However a few lines in VT-1 (CM-5, 8.7%), VT-3 (CM-25, 5.4%) and MVT-1 (2713/15, 2.8%) 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 (1050) of *G. hirsutum* (Introgression material) of cotton was screened in Set-K to Set-N during the previous year under field conditions. Out of one hundred fourteen accessions (were found resistant against CLCuD) only one hundred two accessions were sprouted during this year. Screening was done during the season. All the resistant accessions which were sprouted this year did not show any symptoms of CLCuD during this season.

New Germplasm

Three hundred fifty five (355) strains of US-Germplasm were planted in three sets (Set-P = 100, Set-Q = 200 and Set-R = 55 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.

Data presented in Table-5.2 show that none of any accession showed resistance against CLCuD at day 120 after planting. Overall three hundred fifty three accessions out of three hundred fifty five showed susceptibility in Disease Rating Scale-4.

Table 5.1 Reaction of Genetic Resources to Cotton Leaf Curl Disease

Experiment	No. of Families Screened	No. of Families showing Resistance to CLCuD	Disease index Φ Range
VT-1	11	0	**8.7** ~ 74.8
VT-2	8	0	40.5 ~ 75.6
VT-3	8	0	**5.4** ~ 75.6
MVT-1	11	0	**2.8** ~ 57.3
MVT-2	11	0	57.8 ~ 72.4
MVT-3	7	0	45.2 ~ 68.7
MVT-4	9	0	52.0 ~ 76.2
MVT-5	12	0	54.8 ~ 83.5
MVT-6	10	0	72.2 ~ 78.7
MVT-7	10	0	64.8 ~80.1
NCVT A	16	0	69.8 ~ 81.3
NCVT B (Bt)	22	0	56.1 ~ 72.6
NCVT C (Bt)	22	0	59.8 ~ 77.3
NCVT D (Non-Bt)	19	0	57.7 ~ 73.1
PCCT-I	24	0	67.7 ~ 78.8
PCCT-II	21	0	70.2 ~ 79.0
PCCT-II (Non-Bt)	4	0	68.5 ~ 76.7
SVT-I	22	0	60.8 ~ 83.1
SVT-II	16	0	73.0 ~ 82.2
Total	**263**	**0**	

VT = Varietal Trial
MVT = Micro-Varietal Trial
SVT = Standard Varietal Trail
PCCT = Punjab Coordinated Cotton Trial
NCVT = National Coordinated Varietal Trial
NBCT= National Biosafety Committee Trial
Φ= Disease incidence x Severity/ maximum severity value (4)

Table-5.2. Screening of US Germplasm against CLCuD at day 30, 60, 90 and 120 after planting during 2015-2016

Set-#	Name of Sp	Total Accessions	Days after Planting	Missing /Not Germinated	Category of Resistance based upon Disease Rating				
					0	**1**	**2**	**3**	**4**
Set-P	*G.hirsutum*	100	30	-	100	0	0	0	0
			60	-	1	0	3	20	76
			90	-	0	0	0	1	99
			120	-	0	0	0	0	100
Set-Q	*G.hirsutum*	200	30	-	192	0	8	0	0
			60	-	43	0	59	57	41
			90	-	0	0	1	2	197
			120	-	0	0	0	1	199
Set-R	*G.hirsutum*	55	30	-	54	0	0	0	1
			60	-	4	0	21	16	14
			90	1	0	0	0	3	51
			120	1	0	0	0	0	54
	Total	**355**	**30**	**-**	**346**	**0**	**8**	**0**	**1**
			60	**-**	**48**	**0**	**83**	**93**	**131**
			90	**1**	**0**	**0**	**1**	**4**	**349**
			120	**1**	**0**	**0**	**0**	**1**	**353**

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, Set-C twenty two strains each (Bt-strains) 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 A-10. Maximum disease index was observed in A-2. Maximum boll rot was recorded in A-3 (3.2%) and minimum in A-15 (Table 5.3).

NCVT-Set-B

All the NCVT strains found highly susceptible to cotton leaf curl disease. Minimum disease incidence and disease index was recorded in B-17. Maximum CLCuD severity and disease index was observed in B-15. Incidence of boll rot was recorded in B-13 & B-17 (1.61%) whereas all others showed 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 C-9. Maximum disease severity and disease index was observed in C-22. Maximum boll rot incidence was recorded in C-18 (2.06%) (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 D-5. Minimum disease severity and disease index was observed in D-1. Boll rot incidence was recorded in D-6 (1.38%) where as other strains showed less than 1 % (Table-5.6).

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

NCVT Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
A1	0	100	3.12	77.88	0.89
A2	0	100	**3.26**	**81.39**	0.77
A3	0	100	3.13	78.17	3.27
A4	0	100	3.14	78.62	1.53
A5	0.41	100	3.09	77.22	0.44
A6	0	100	3.03	75.76	1.69
A7	0	100	3.25	81.33	2.23
A8	0.41	100	3.00	74.92	1.07
A9	0	100	3.16	78.98	2.85
A10	0	100	**2.79**	**69.82**	0.68
A11	0.43	100	3.19	79.76	1.36
A12	0	100	3.14	78.44	0.65
A13	0.41	100	3.08	77.03	1.70
A14	0	100	3.10	77.39	0.89
A15	0.45	100	2.84	70.95	0.37
A16	0	100	3.03	75.68	0.60

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 Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
B-1	0	100	2.54	63.41	1.00
B-2	0.87	100	2.70	67.46	1.14
B-3	0.41	100	2.47	61.82	1.01
B-4	0.43	100	2.34	58.39	1.45
B-5	0.84	100	2.57	64.34	1.38
B-6	0.42	100	2.74	68.58	1.32
B-7	0	100	2.39	59.82	0.75
B-8	0	100	2.62	65.56	1.43
B-9	0.43	100	2.61	65.29	063
B-10	0	100	2.73	68.16	0.63
B-11	0	100	2.65	66.17	0.99
B-12	0.43	100	2.64	65.98	1.50
B-13	0	100	2.78	69.53	1.61
B-14	0	100	2.64	65.92	0.72
B-15	**0**	**100**	**2.91**	**72.69**	1.12
B-16	0	100	2.87	71.79	0.84
B-17	**0**	**100**	**2.25**	**56.16**	1.61
B-18	0	100	2.64	66.06	1.32
B-19	0	100	2.69	67.23	0.80
B-20	0	100	2.49	62.18	0.87
B-21	0	100	2.83	70.74	0.79
B-22	0	100	2.78	69.54	1.15

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 Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
C-1	0	100	2.80	70.07	0.00
C-2	0	100	2.66	66.61	0.82
C-3	0	100	2.70	67.45	1.65
C-4	0	100	2.92	72.93	0.62
C-5	0	100	2.42	60.49	0.42
C-6	0	100	2.77	69.23	0.85
C-7	0	100	2.75	68.69	0.90
C-8	0	100	2.68	67.02	1.03
C-9	0	100	2.39	59.85	1.15
C-10	0	100	3.00	75.09	0.27
C-11	0	100	2.73	68.19	0.22
C-12	0	100	2.70	67.52	0.44
C-13	0	100	3.01	75.21	0.91
C-14	0	100	2.92	73.00	0.79
C-15	0	100	2.47	61.71	1.38
C-16	0	100	2.46	61.47	1.46
C-17	0	100	2.43	60.81	1.39
C-18	0	100	2.41	60.36	2.06
C-19	0	100	2.86	71.44	0.77
C-20	0	100	2.82	70.51	0.94
C-21	0	100	2.96	74.10	1.05
C-22	0	100	3.09	77.37	1.25

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 Strain	Stunting %age	Cotton Leaf Curl Disease			Boll Rot (%)
		Disease % age	Disease Severity	Disease Index	
D-1	0	100	2.31	57.74	0.72
D-2	0	100	2.35	58.81	1.02
D-3	**0**	**100**	**2.40**	59.97	0.96
D-4	0	100	2.63	65.76	1.12
D-5	0	100	2.90	72.50	0.18
D-6	0	100	2.41	60.29	1.38
D-7	0	100	2.93	73.19	0.00
D-8	0	100	2.90	72.45	0.71
D-9	0	100	2.81	70.34	0.00
D-10	0	100	2.57	64.17	0.21
D-11	0	100	2.46	61.62	0.21
D-12	0	100	2.67	66.76	0.46
D-13	0	100	2.47	61.78	0.98
D-14	0	100	2.79	69.70	0.40
D-15	**0**	**100**	**2.70**	**67.53**	0.20
D-16	0	100	2.53	63.14	0.00
D-17	**0**	**100**	**2.64**	**65.91**	0.56
D-18	0	100	2.58	64.47	0.47
D-19	0	100	2.80	70.10	0.60

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

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 20 days after graft transmission. The strain A-5, A-6, A-7 and A-10 took more days to produce the symptoms and less severity of the disease. Similarly A-1 to A-3 and A-9 took less days to produced the symptoms and showed more susceptibility than others. Overall data indicated that none of the above material is completely resistant against CLCuD.

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*
A1	12 ~ 15	6
A2	12 ~ 14	6
A3	13 ~ 15	6
A4	14 ~ 18	5
A5	27 ~ 35	2
A6	25 ~ 35	3
A7	25 ~ 30	3
A8	15 ~ 20	5
A9	15 ~ 20	5
A10	28 ~ 35	2
A11	13 ~ 15	6
A12	14 ~ 18	6
A13	15 ~ 20	6
A14	15 ~ 20	6
A15	14 ~ 20	6
A16	14 ~ 18	5

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

Three advanced genotypes i.e. Cyto-178, Cyto-179, CIM-622 and 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 level remained minimum on crop planted from 1st March to 1st April. The disease incidence remained low up to end of July (0.71 %) and reached maximum level (22.14%) on 30th September in 1st March planting. Where as in 15th March planting CLCuD started to appear during the mid of May (0.15 %) and gradually attained maximum level (28.15%) during the end of September.

In 1st April planting, disease incidence was 1.03 to 5.96% from 30th June to mid of July respectively. Whereas in 15th April planting disease incidence was 0.48 % at the mid of June, 32.50% during mid of August and reached 53.21 % at the end of September,

In 1st May planting incidence started within 45 DAP (mid-July) then increased sharply i.e. 64.89 to 100% during end of August to end of September whereas in 15th May planting disease symptoms appeared only 0.13% at end of July 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 1st March to 15th April. The cultivar Cyto-179 showed minimum level of disease when planted during the month of March to 1st April when compared to others. Al the varieties which were planted during 15th April shows 25% incidence during the end of July and reached upto 50% at the end of the season. Whereas in 1st May and 15th May planting all the cultivars showing highly susceptibility (64 to 100 %) at the end of August (Fig-5.1).

Averages across planting dates the cultivar Cyto-178 showed less disease incidence as compared to others during mid-August to mid-September (Fig-5.2).

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 1st April which ranged from 22.1 to 29.9% respectively. The disease index increased with the delay in sowing and it reached up to 53.2 and 100 % in crop sown on 15th April to 15th May respectively (Table-5.8). The strain Cyto-178 and CIM-602 on an average showed less disease as compared to CIM-622 and Cyto-179.

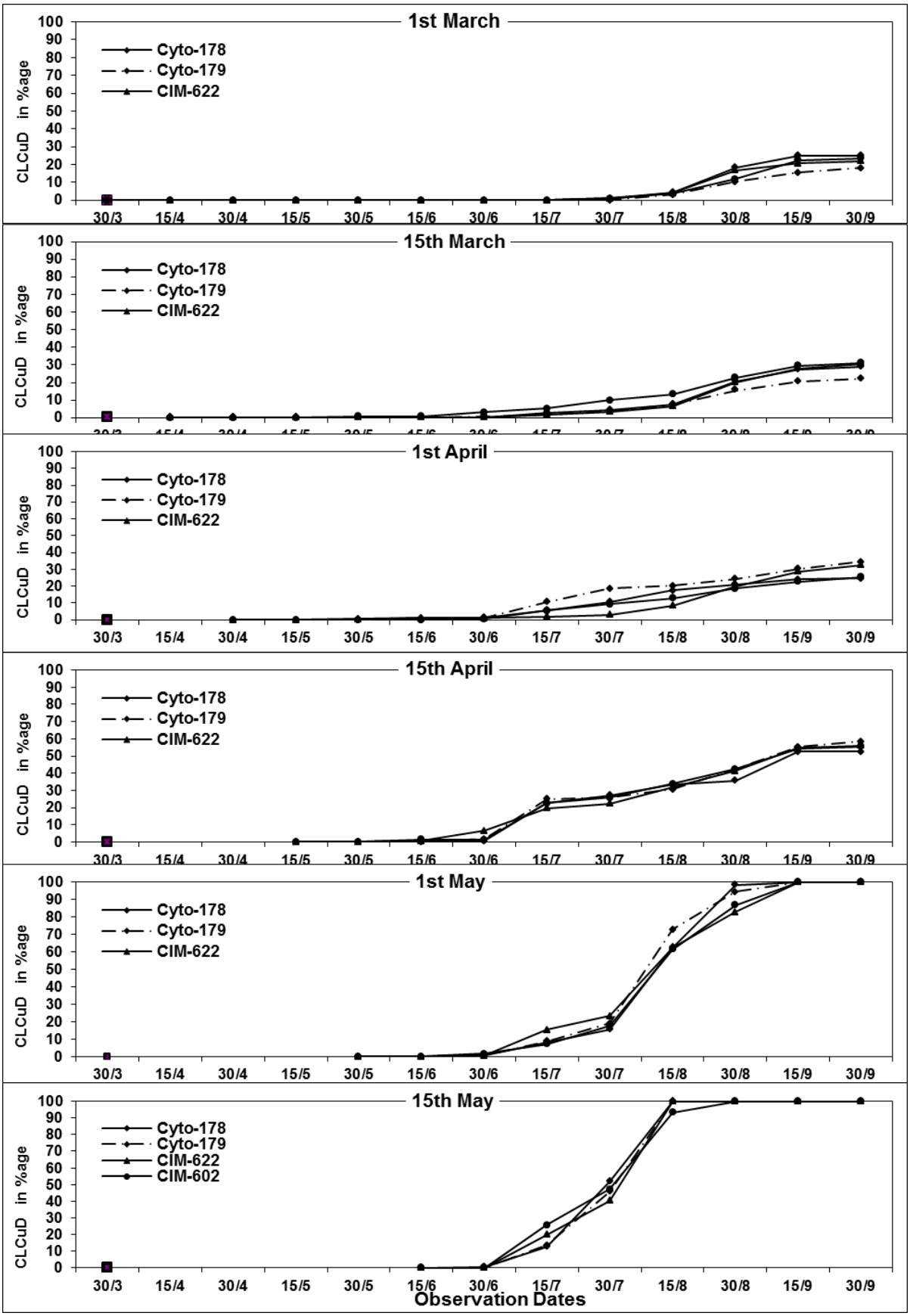

Fig-5.1 **Incidence of CLCuD as influenced by planting Dates and strain on Bt-cotton.**

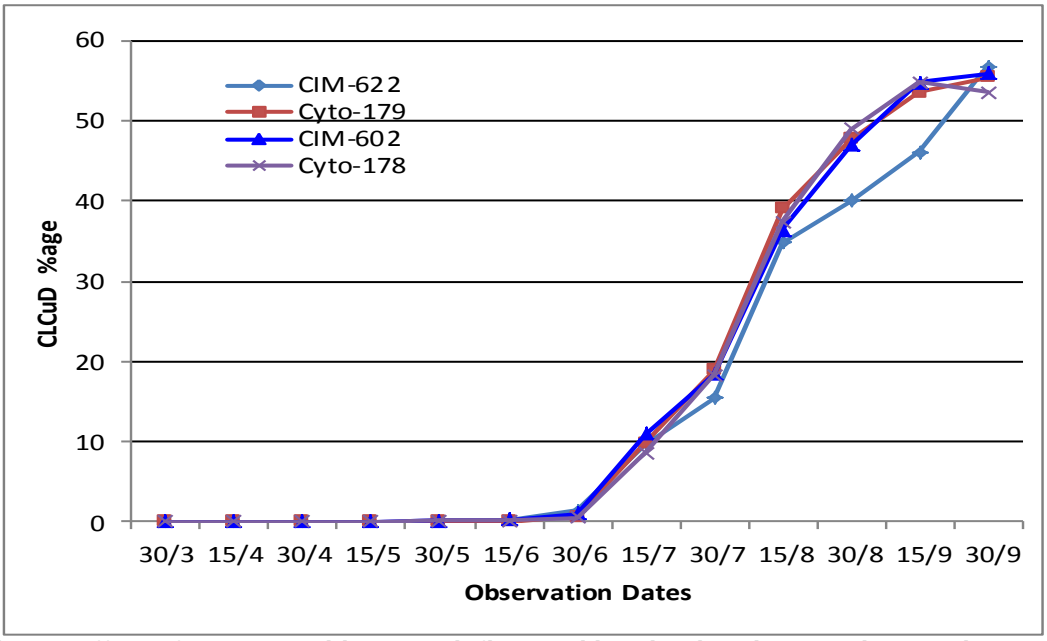

Fig-5.2 Effect of CLCuD Incidence as influenced by planting dates and Bt-strain

On an average basis of sowing dates, maximum level of fortnightly increase of disease was recorded from July to end of August. Among environmental parameters the maximum temperature range was 33.6 ~ 34.7°C, minimum temperature, 28.4 ~ 29.4°C with relative humidity 74.5 ~ 84.4% 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 5.8 Disease index of Cotton Leaf Curl on cultivars planted at different times

Cultivars	Planting Dates						Average
	1st March	15th March	1st April	15th April	1st May	15th May	
Cyto-178	25.1	28.9	25.7	43.1	100	100	53.8
Cyto-179	18.1	22.1	34.5	58.4	100	100	55.3
CIM-622	21.8	30.6	32.5	55.9	100	100	56.8
CIM-602	23.5	31.1	27.2	55.5	100	100	53.2
Average	22.1	28.2	29.9	53.2	100	100	

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

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	0	0	0	0	0.71	2.93	10.63	6.68	1.19
March 15th		0	0	0	0.15	0	0.79	1.78	2.52	3.29	11.14	6.62	1.86
April 1st			0	0	0.21	0.46	0.36	4.93	4.49	7.35	3.38	5.31	2.77
April 15th				0	0	0.48	2.06	19.86	2.9	7.2	7.91	11.39	1.41
May 1st					0	0	0.75	9.06	9.05	46.03	25.61	9.5	0
May 15th						0	0.13	17.77	28.36	52.04	0.7	1	0
Average	0	0	0	0	0.07	0.16	0.68	**8.90**	**8.01**	**19.81**	**9.90**	6.75	1.21
Max. C	28.4	31.4	37.9	37.5	40	37.2	37.7	34.4	34.7	34.2	33.6	35.2	33
Min. C	19	20.5	23.9	25.8	27.2	27.3	30.5	28.6	28.4	29.4	28.4	28.2	27.8
Difference	9.4	10.9	14	11.7	12.8	9.9	7.2	5.8	6.3	4.8	5.2	7	5.2
RH%	78.8	79.5	65.4	61	61	58.2	66.9	76.5	74.5	79.7	84.4	88.1	90.1

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-120 and CIM-620 along with one standard variety CIM-608 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 given in Fig-5.3.

Effect of appearance of cotton leaf curl disease and its progression different significantly with sowing dates. Minimum CLCuD infestation was observed in 15thApril Planting on mid June data i.e. 0.2%. With the advancement of age the infestation level reached 17.51% during the end of September.

A gradual increase in CLCuD incidence was observed in 1st May planting date. The disease started on end June with minimum level of incidence of 1.3% which increased moderately and reached to 34.2% at the end of September.

Similarly in case of 15thMay planting CLCuD incidence was 0.8% at the end of June and got its maximum level 69.3% on end of September (135DAP).

In 1stJune and 15thJune planting the disease started on mid July (9.1% and 0.6%) and reached up to 77.7% and 98.3% respectively at the end of September.

The level of disease incidence in Cyto-120 and CIM-620 showed less in 15th April and 1st May planting as compare to CIM-608. 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).

Average across planting period, comparison among the varieties revealed that CIM-620 and Cyto-120 were the least affected with CLCuD, at all sowing dates even when planted during the month of June followed by CIM-608 (**Fig-5.4**).

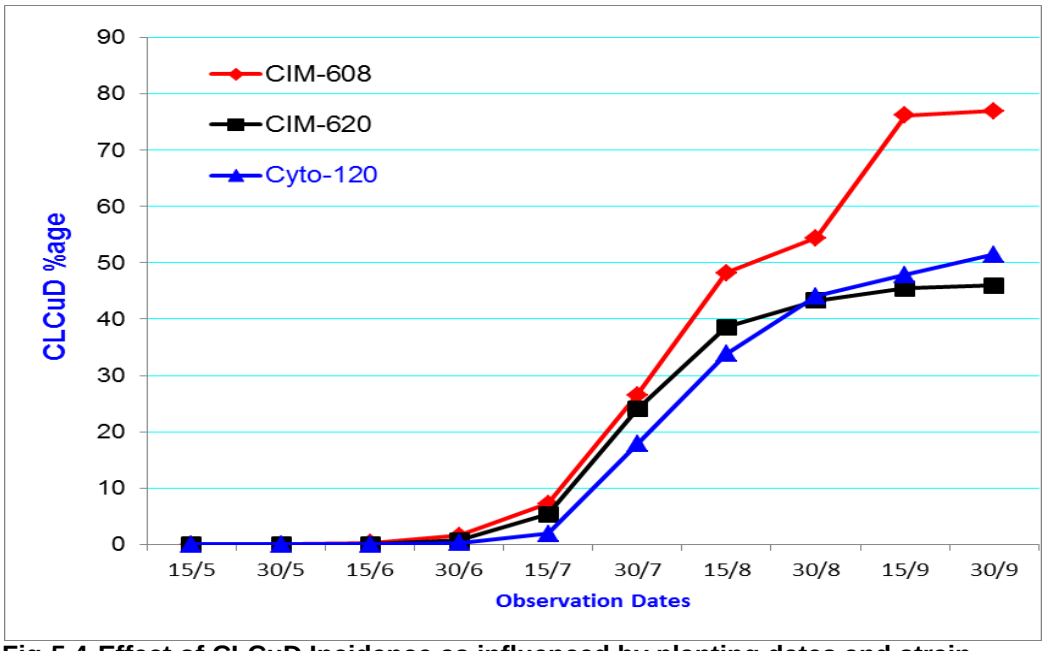

Fig-5.4 Effect of CLCuD Incidence as influenced by planting dates and strain

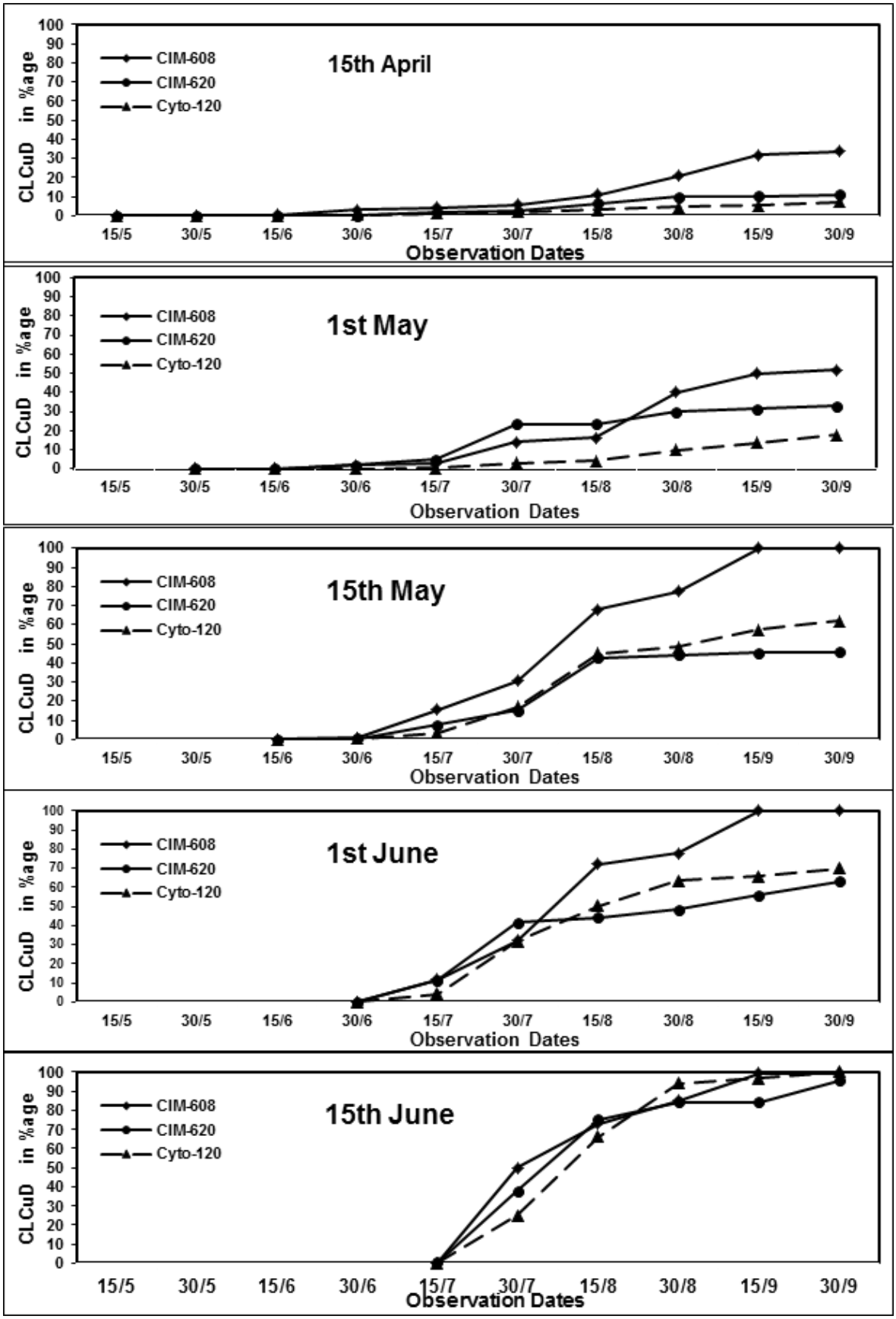

Fig-5.3 Incidence of CLCuD as influenced by planting Dates and strain on Non-Bt-cotton

Data on incidence and severity were recorded during the end of September from each treatment and computed for disease index. Average across cultivars, the minimum disease index 10.19% was recorded on crop planting on 15th April as compare to other planting dates. Average planting dates, minimum disease index level (33.74%) was recorded on genotype CIM-620 followed by Cyto-120 (Table-5.10).

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

Cultivars	Planting Dates					Average
	15th April	1st May	15th May	1st June	15th June	
Cyto-120	3.4	8.8	41.1	47.7	78.8	35.9
CIM-608	21.3	31.9	67.4	79.2	71.6	54.2
CIM-620	5.7	19.9	27.1	47.1	68.8	33.7
Average	10.1	20.2	45.2	58.0	73.0	

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 mid-July to end of August .Among environmental parameters the maximum temperature range was 33.6 ~ 34.7°C minimum temperature 28.4 ~ 29.4°C with the relative humidity 74.5 ~ 84.4% during the above mentioned period. Difference between maximum and minimum temperature was less 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 2015

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	0.22	1.07	1.31	0.83	3.60	4.82	4.02	1.63
1st May		0	0.00	1.27	1.40	10.79	1.11	12.01	5.10	2.50
15th May			0.20	0.78	8.20	11.97	31.54	9.69	5.50	1.69
1st June				0.00	9.08	26.13	20.60	3.30	14.88	3.71
15th June					0.60	36.98	33.92	19.08	2.75	5.00
Average	0	0	0.14	0.78	4.12	**17.34**	**18.16**	**9.78**	6.45	2.91
Max. °C	37.5	40	37.2	37.7	34.4	34.7	34.2	33.6	35.2	33
Min. °C	25.8	27.2	27.3	30.5	28.6	28.4	29.4	28.4	28.2	27.8
Difference	11.7	12.8	9.9	7.2	5.8	6.3	4.8	5.2	7	5.2
RH%	61	61	58.2	66.9	76.5	74.5	79.7	84.4	88.1	90.1

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.

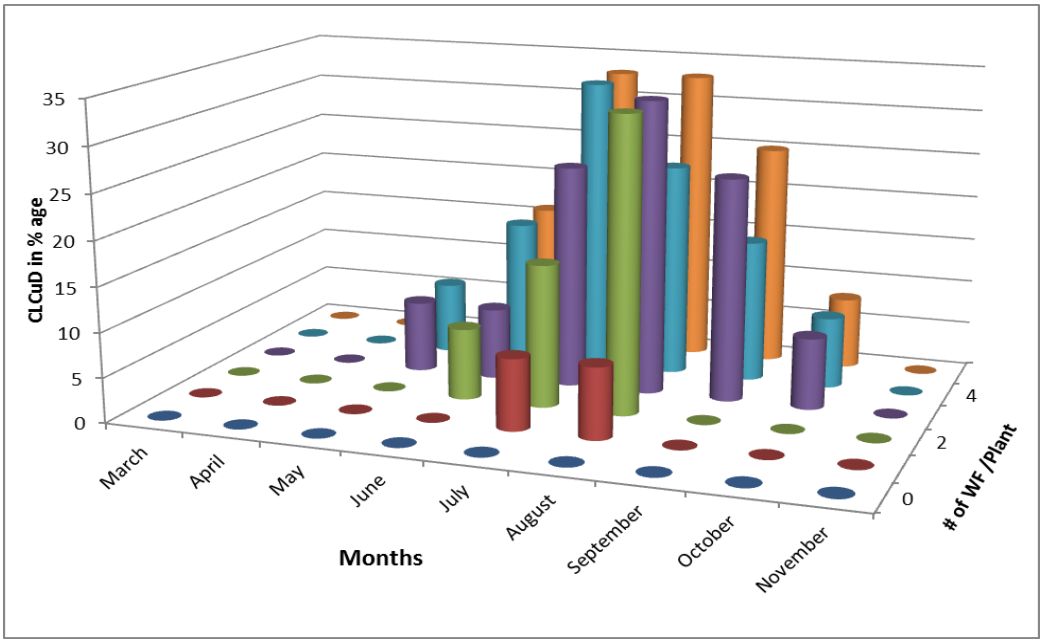

Fig 5.5 Effect of whitefly virulence on the incidence (%age) of CLCuD

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. 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 hypothezed that whiteflies being more virulent during the month of July and August.

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 in 1st April planting showed more disease was recorded as compared to others. Averaged across sowing dates, the variety Cyto-178 showed comparatively less boll rot as compared to others. The boll rot disease ranged from 0.38 to 1.10% in all sowing dates on an average basis (Table 5.12).

(b) Effect on Non-*Bt*-Strains

Another experiment (non *Bt* varieties) was conducted to quantify the boll rot disease in different strains planted during 15th April to 15th June with fortnightly interval. The boll rot disease was recorded and results are given in Table 5.13.

Averaged across sowing dates, 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 0.1 to 1.7% 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
Cyto-178	0.00	0.27	1.40	0.59	0.00	0.00	**0.38**
Cyto-179	0.67	1.64	1.70	1.35	1.26	0.00	**1.10**
CIM-622	0.48	1.32	1.42	0.00	1.08	0.58	**0.81**
CIM-602	1.17	0.54	0.55	0.44	0.00	0.00	**0.45**
Average	**0.58**	**0.94**	**1.27**	**0.60**	**0.59**	**0.15**	

* = 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
CIM-620	0.4	0.7	0.9	0.3	0.4	**0.54**
Cyto-120	0.0	0.8	2.8	3.1	3.2	**1.98**
CIM-608	0.0	0.0	0.7	1.6	1.5	**0.76**
Average	**0.1**	**0.5**	**1.5**	**1.7**	**1.7**	

* = Sowing Dates

5.6.2 Chemical Control of Boll Rot of Cotton

An experiment was conducted in Randomized Complete Block Design (RCBD) with three replications to control the boll rot of cotton. The spray of two fungicides i.e Corex (Cosugamycin & Tricyclazol) and Kocide (Copper hydroxide) was applied on rotted bolls of cotton under field conditions. After fifteen days of spray the incidence was recorded and is given in Table-5.14.

Table: 5.14 Chemical Control of Boll Rot of Cotton

Treatments	Dose per 100 lit of water	Boll rot %age
Corex	500g	2.43
Kocide	250g	2.24
Corex + Kocide	500g+250g	2.13
Control	Water only	3.51

Results shows that none of the fungicide tested is affected against boll rot of cotton, However Kocide with combination of Corex showed better performance when compared with the control.

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6. PLANT PHYSIOLOGY /CHEMISTRY SECTION

Studies were carried out on plant nutrition, seed physiology, soil-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} (Farmer's practice)
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

**In treatment T6 cotton seed was sown after treatment with Biozote @ 500g $acre^{-1}$*
Boron and Zinc were applied as foliar sprays @ 0.05% solution three times during the cropping season

Field trials were conducted for the second 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 2015.

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	8.15	8.82	8.52	8.54
EC_e (µS cm^{-1})	300	176	240	224
Organic matter (%)	0.84	0.89	0.67	0.64
Total-N (%)	0.010	0.099	0.094	0.088
$NaHCO_3$ -P	13.0	11.9	10.2	12.3
NH_4OAC-K	146	178	263	206
DTPA-B	2.01	1.93	2.11	2.23
DTPA-Zn	1.13	1.17	1.10	1.18
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 96.7 to 106.5 cm and nodes on main stem from 32.0 to 34.0 cm in Bt cotton. While in non-Bt cotton main stem height and nodes on main stem remained in the range of 84.6 to 93.9 cm and 29.2 to 32.0, respectively. Moreover, this location also produced the highest inter-nodal length than the other locations that ranged from 2.98 to 3.13 cm in Bt and from 2.82 to 2.93 cm in non-Bt cotton. Among the fertilizer treatments, on overall basis, the treatment T2 produced the maximum main stem height and nodes on main stem both in Bt (97.9cm; 33.7) and non-Bt cotton (89.8cm; 31.7) varieties (Table 6.2).

Data regarding seed cotton yield and its components at all locations are presented in Table 6.3. The data 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 (2329 kg ha^{-1}) but it did not vary significantly from other treatments (T3-T6). However, all the treatments, in Bt cotton, produced significantly ($p<0.05\%$) higher seed cotton yield over farmers practice (T1). The increase in yield over T1 ranged from 10 to 16% in different treatments in Bt cotton while it ranged from 4 to 8% 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 21 to 24, boll weight from 2.98 to 3.16g and seed cotton yield from 2215 to 2465 kg ha^{-1} whereas in non-Bt cotton number of bolls ranged from 20 to 22, boll weight from 2.89 to 3.02g and seed cotton yield from 2012 to 2272 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 2275 to 2554 kg ha^{-1} in Bt cotton while in non-Bt cotton seed cotton yield varied from 2097 to 2420 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.

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. This location produced comparatively more yield than the other locations. On average basis in different treatments, the seed cotton yield varied from 2340 to 2610 kg ha^{-1} in Bt cotton while in non-Bt cotton seed cotton yield varied from 2100 to 2426 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. Here the number of bolls per plant and boll weight varied from 23 to 25 and 2.93 to 3.03g, respectively in different treatments.

Table 6.2 Effect of organic and inorganic fertilizers on vegetative and reproductive 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)
	B			Non-Bt		
	CCRI, Multan					
T1	89.2	30.4	2.93	82.3	29.4	2.80
T2	99.9	34.0	2.94	91.4	32.0	2.86
T3	99.0	33.6	2.95	89.7	30.9	2.90
T4	102.0	33.9	3.01	91.5	31.6	2.90
T5	99.2	33.0	3.01	90.3	31.2	2.89
T6	98.4	33.4	2.95	89.3	30.7	2.91
LSD	*4.65**	*1.71**	*0.07**	*4.42**	*1.45**	*0.08**
	6-MR, Vehari Rd					
T1	96.7	32.0	3.02	84.6	29.2	2.90
T2	106.5	34.0	3.13	93.9	32.0	2.93
T3	99.6	33.4	2.98	86.3	30.6	2.82
T4	101.5	33.8	3.00	91.4	31.3	2.92
T5	99.0	32.6	3.04	85.8	30.0	2.86
T6	97.9	32.0	3.06	86.7	30.0	2.89
LSD	*4.12**	*1.40**	*0.08**	*5.21**	*1.32**	*0.07**
	Naseer Pur, Shujabad					
T1	89.4	31.4	2.85	85.3	30.6	2.79
T2	95.3	33.7	2.83	92.4	32.3	2.86
T3	94.7	33.2	2.85	91.4	32.0	2.86
T4	95.1	33.5	2.84	92.0	32.2	2.86
T5	95.0	32.4	2.93	92.0	31.5	2.92
T6	93.5	32.7	2.86	90.6	31.4	2.89
LSD	*5.10**	*1.42**	*ns*	*4.93**	*1.36**	*0.07**
	Chak 5-Faiz, Lodhran Rd					
T1	80.6	30.0	2.69	76.4	28.4	2.69
T2	89.7	33.0	2.72	81.5	30.6	2.66
T3	83.4	31.3	2.66	79.3	28.9	2.74
T4	90.6	32.8	2.76	82.4	30.2	2.73
T5	86.3	31.9	2.71	80.6	29.8	2.70
T6	85.6	31.4	2.73	79.4	29.7	2.67
LSD	*5.21**	*2.09**	*0.06**	*4.68**	*2.04**	*ns*

Data on nutrient uptake by whole cotton plant under different treatments and across four locations are presented in Table 6.4. In general the nutrient uptake remained higher in Bt cotton than the non-Bt cotton. The trend was similar at all locations. A comparison of the treatments 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. Considering all the locations, the uptake of nutrients in CIM-616 (Bt cotton) ranged from 110-170 kg ha^{-1} (N), 20-36 kg ha^{-1} (P), 108-191 kg ha^{-1} (K), 116-196 g ha^{-1} (B) and 117-190 g ha^{-1} (Zn) while in Cyto-124 (non-Bt cotton), the uptake ranged from 108-159 kg N ha^{-1}, 18-31 kg P ha^{-1}, 102-179 kg K ha^{-1}, 101-178 g B ha^{-1} and 114-164 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	19.6	2.96	2016	18.8	2.91	1958
T2	23.0	3.11	2329	21.0	2.98	2116
T3	22.4	3.04	2300	20.2	2.97	2074
T4	22.0	2.99	2282	19.6	2.96	2082
T5	21.3	2.96	2236	19.4	2.94	2055
T6	21.0	2.95	2215	19.2	2.94	2045
LSD	*1.75**	*0.04**	*120.4**	*1.64**	*0.05**	*115.6**
			6-MR, Makhdum Rasheed			
T1	21.1	2.98	2215	19.8	2.89	2012
T2	24.0	3.13	2465	21.9	3.02	2272
T3	23.5	3.09	2398	21.6	2.94	2243
T4	23.8	3.10	2402	21.4	2.98	2234
T5	23.0	3.13	2356	21.4	2.90	2220
T6	23.3	3.16	2374	21.0	2.91	2219
LSD	*2.01**	*0.06**	*125.4**	*1.16**	*0.07**	*112.5**
			Naseer Pur, Shujabad			
T1	21.4	3.04	2275	19.8	2.87	2097
T2	24.3	3.08	2554	22.7	2.95	2420
T3	23.4	3.11	2446	22.3	3.03	2367
T4	24.3	3.06	2489	22.8	2.98	2394
T5	24.2	3.09	2500	23.2	3.10	2402
T6	23.0	3.07	2476	23.3	3.04	2400
LSD	*2.16**	*0.04**	*157.8**	*2.21**	*0.07**	*124.4**
			Chak 5-Faiz, Lodhran Road			
T1	23.0	2.94	2340	20.3	2.86	2100
T2	25.3	3.01	2610	23.6	2.91	2426
T3	25.0	2.97	2520	23.9	2.86	2380
T4	24.0	3.03	2500	22.5	2.97	2365
T5	24.7	2.94	2510	23.0	2.90	2320
T6	24.0	2.93	2498	23.3	2.86	2330
LSD	*2.03**	*0.05**	*153.8**	*1.86**	*0.05**	*145.8**

6.2 Seed physiology

6.2.1 Investigating the role of amino acids and growth regulator on seed health and cotton production

Naturally occurring and synthetic regulators have an important role in the growth and developmental processes leading to enhanced production. Gibberellic acid, a product of Asian fungus, is a chemical which can change plant growth and development in varied ways, suggesting its agricultural uses. Plants experimentally treated with gibberellic acid have shown increased growth and flowering, produced more abundant foliage or more seeds, overcome dwarfism even roused from dormancy to start growth in unusual times and conditions. It has the unique ability among plant hormones to stimulate extensive growth of intact plant and may enhance the cotton seed yield and seed quality.

Exogenous application of proline is known to induce abiotic stress tolerance in various plant species. It acts mainly on the hydric balance of the plant strengthening the cellular walls in such a way that they attain resistance to unfavorable climatic conditions. 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. Amino acids could down regulate nitrate uptake and excessive accumulation within the plant. Glycine is the fundamental metabolite in the process of formation of vegetative tissue and chlorophyll synthesis imparting lush green colour to the plants and ensuring higher degree of photosynthesis. Glycine also has a chelating effect on micronutrients, the absorption and transportation of micronutrients inside the plant is easier due to the effect of cell membrane permeability.

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	110	20	108	148	118	108	18	102	122	114
T2	146	29	124	151	117	126	25	117	124	114
T3	149	29	122	174	148	128	24	114	152	138
T4	155	32	123	184	153	128	27	115	162	144
T5	136	30	119	183	149	120	22	111	155	130
T6	139	29	116	195	150	122	22	110	160	132
LSD	*7.1***	*2.3**	*6.4**	*10.4**	*8.5**	*6.5**	*3.4**	*6.6**	*7.0**	*8.2**
	6-MR, Makhdum Rasheed									
T1	125	22	122	145	129	118	20	119	130	125
T2	156	28	141	150	133	143	27	134	136	131
T3	159	27	139	183	154	145	26	135	164	146
T4	170	32	153	187	163	159	29	139	178	159
T5	152	26	140	175	145	143	25	133	159	141
T6	159	29	140	179	150	149	26	136	173	148
LSD	*10.1**	*3.4**	*7.2**	*9.4**	*9.2**	*11.1**	*3.2**	*6.6**	*8.7**	*8.2**
	Naseer Pur, Shujabad									
T1	128	24	143	135	126	122	22	133	128	116
T2	155	36	186	140	129	147	29	170	130	120
T3	153	30	182	182	175	142	28	165	159	152
T4	161	34	191	196	190	154	31	179	165	164
T5	147	28	180	176	172	140	28	166	150	153
T6	152	30	181	181	178	144	28	174	155	158
LSD	*8.6**	*2.8**	*10.5**	*11.3**	*9.8**	*7.9**	*3.0**	*12.2**	*12.0**	*9.6**
	Chak 5-Faiz, Lodhran Road									
T1	130	22	126	116	120	126	20	116	101	118
T2	152	28	152	120	121	149	28	141	106	120
T3	150	26	144	148	160	141	25	137	134	152
T4	162	28	162	152	167	151	29	142	138	159
T5	153	25	146	144	154	140	24	134	130	146
T6	154	25	150	147	158	142	24	136	133	148
LSD	*10.3**	*2.5**	*13.6**	*12.4**	*12.9**	*8.3**	*3.8**	*6.8**	*7.6**	*8.8**

The aim of this investigation was to study the response of cotton to seed priming and seed priming plus foliar application with Gibberellic acid and amino acids (glycine and proline) on yield and quality parameters of cotton seed. Following treatments were implemented. Seed priming with proposed bio-chemicals 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.

Plant structure development in different treatments was recorded at maturity. The results indicated that main stem height, nodes on main stem and inter-nodal length varied among different treatments. Main stem height varied from 104.2 to 120.5 cm, number of nodes on main stem from 33 to 37 and inter-nodal length from 3.16 to 3.30 cm in different treatments. The maximum height and

inter-nodal length were produced in treatment that received recommended dose of fertilizers along with seed priming plus foliar application of gibberellic acid (Table 6.5).

Following treatments were used for the trial:

Bio-chemicals	Application method
Control	Seed Priming (water)
	Foliar Spray (water)
L-Proline	Seed priming
	Seed Priming + Foliar Spray
L-Glycine	Seed priming
	Seed Priming + Foliar Spray
Gibberellic acid	Seed priming
	Seed Priming + Foliar Spray

*Recommended fertilizer doses (N, P, K, B & Zn) were applied in all plots

*Proline and glycine were used @0.1% while Gibberellic acid was used @0.01% both for seed priming and foliar sprays

Seed cotton yield differed significantly ($p<0.05$) among various treatments. The seed cotton yield varied from 838 to 1266 kg ha^{-1} in different treatments. The maximum seed cotton yield (1155 kg ha^{-1}) was observed in treatment that received recommended fertilizers along with seed priming and foliar spray of proline. The ginning outturn although, varied from 38.0 to 41.1% in different treatments, however the differences were not significant (Table 6.6).

Table 6.5 Effect of recommended fertilizers and seed priming on vegetative and reproductive of cotton plant at maturity

Bio-chemicals	Application method	Main stem height (cm)	Nodes on main stem	Inter-nodal length (cm)
Control	SP (Water)	104.2	33	3.16
	FS (water)	106.4	34	3.13
L-Proline	SP	114.4	35	3.27
	SP+FS	117.3	36	3.26
L-Glycine	SP	113.6	35	3.25
	SP+FS	115.2	36	3.20
Gibberellic acid	SP	118.7	36	3.30
	SP+FS	120.5	37	3.26
Main effects (bio-chemicals)				
Control		105.3	33.5	3.15
L-Proline		115.9	35.5	3.27
L-Glycine		114.4	35.5	3.23
Gibberellic Acid		119.6	36.5	3.28
Sub effects (application method)				
Seed priming		112.7	35	3.25
SP+FS		114.9	36	3.21
LSD Bio-chemicals		8.36*	2.4*	0.23^{ns}
Application method		7.45^{ns}	2.0^{ns}	0.18^{ns}
Interaction		9.61*	2.5*	0.08*

RF= Recommended fertilizers; SP= seed priming; FS= foliar spray

The assessment of seed quality parameters was done from the mature seed. Results indicated that recommended fertilizers along with seed priming alone or in combination with foliar sprays of different bio-chemicals improved parameters such as seed germination, seed index, oil and crude protein content and maintained free fatty acids within safe limits. Seed germination varied from 52- 62%, seed index from 6.3–7.40 g, oil content from 14 to 18 % and crude protein from 20.5 to 25.9 % in different treatments (Table 6.7).

Table 6.6 Effect of recommended fertilizers and seed priming on seed cotton yield at 150 DAP

Bio-chemicals	Application method	Seed cotton yield (kg ha^{-1})	GOT (%)
Control	SP (Water)	838	38.0
	FS (water)	844	38.2
L-Proline	SP	1002	40.1
	SP+FS	1266	40.3
L-Glycine	SP	1097	39.2
	SP+FS	1213	39.5
Gibberellic acid	SP	889	39.0
	SP+FS	1055	39.3
Main effects (bio-chemicals)			
Control		956	38.6
L-Proline		1155	40.2
L-Glycine		1055	39.4
Gibberellic Acid		972	39.2
Sub effects (application method)			
Seed priming		906	39.1
SP+FS		1095	39.3
LSD Bio-chemicals		102.6*	2.6^{ns}
Application method		88.4*	2.0^{ns}
Interaction		93.8*	3.5^{ns}

Table 6.7 Effect of recommended fertilizers and seed priming on biochemical parameters in different treatments

Treatments	Seed priming	EC (µS cm^{-1})	Na (%)	K (%)	pH	Seed index (g)	Germi-nation (%)	Oil (%)	Free fatty acid (%)	Crude protein (%)
Control	SP (Water)	132	0.49	0.56	7.2	6.3	52	16	0.95	20.5
	FS (water)	144	0.51	0.69	7.6	6.5	64	17	0.86	21.4
L-Proline	SP	161	0.38	0.51	7.5	7.0	54	14	0.66	23.6
	SP+FS	120	0.49	0.58	7.7	7.4	62	18	0.46	25.9
L-Glycine	SP	132	0.37	0.49	7.4	6.8	56	14	0.75	23.0
	SP+FS	118	0.50	0.62	7.6	7.1	61	16	0.48	24.8
Gibberellic acid	SP	152	0.38	0.52	6.8	6.6	56	14	0.55	22.8
	SP+FS	139	0.41	0.57	7.9	6.7	58	15	0.48	24.5

6.4 Soil-Plant-Water Relationships

6.4.1 Screening of advanced genotypes for drought tolerance

Water is the most precious and indispensable input for crop production. Under the changing climate scenario, irrigation water is becoming a limited commodity. High temperatures during the fruiting phase and irregular rains may 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. Since, cultivars differ in their acclimation to water stress environment because of 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 for the breeders to develop varieties which may perform efficiently under water stress conditions.

Therefore, a field experiment was conducted at the experimental area of Central Cotton Research Institute, Multan during the cotton cropping season 2015-16. A total of six cotton genotypes viz. CIM-622, CIM-616, Cyto-179, MNS-992, PB-896 and CRIS-543 were evaluated

for their performance under normal irrigation viz. -1.6 ± 0.2 MPa leaf water potential (ψ_w) and water stress (-2.4 ± 0.2 MPa ψ_w) conditions.

The treatments were laid out in RCBD with split-plot arrangement (water stress main plots; genotypes: sub-plots). Crop was sown on May 27, 2014. 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 3045 m^3 in no stress and 2530 m^3 in water stress treatments. A total precipitation of 222.5 mm (April-October) was received during the crop season.

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 seed cotton yield varied from 924 to1420 kg ha^{-1}, number of bolls per plant from 8 to 13 and boll weight from 2.72 to 3.18g 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 1303 to 1130 kg ha^{-1}, bolls per plant from 11.7 to 9.80 and boll weight from 3.04 to 2.82g irrespective of the genotypes. The decrease, due to water stress, was 13% in seed cotton yield, 16% in bolls per plant and 7.0% in boll weight. Averaged across the water stress treatments, the seed cotton yield varied from 1005 to 1344 kg ha^{-1}, bolls per plant from 8.5 to 12.5 and boll weight from 2.79 to 3.05g in different genotypes. The genotype CIM-616 produced the maximum seed cotton yield and number of bolls per plant while MNS-992 had the highest boll weight, irrespective of water stress levels (Table 6.8).

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 71.3 cm to 98.6 cm, nodes on main stem from 24 to 30 and inter-nodal length from 2.88 to 3.29 cm in different genotypes. Imposition of water stress caused a decrease of 12% in main stem height, 9% in nodes on main stem and 4% in inter-nodal length. Averaged across the water stress treatment, main stem height varied from 74.9cm to 91.5cm, nodes on main stem from 25.0 to 29.0 and inter-nodal length from 2.98 cm to 3.21 cm in different genotypes. The genotype CIM-622 maintained maximum height and intermodal length while MNS-992 maintained the maximum number of nodes on main stem (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 6.86 to 8.53 m mol CO_2 $m^{-2}s^{-1}$**,** *E* from 2.40 to 3.30 µ mole H_2O $m^{-2}s^{-1}$ and P_N from 7.52 to 12.7 m mol CO_2 $m^{-2}s^{-1}$. Imposition of water stress caused 20% decrease in g_s, 27% decrease in *E* and 41% decrease in P_N. Among the genotypes, g_s varied from 6.95 to 8.69 mmol CO_2 $m^{-2}s^{-1}$, *E* from 2.78 to 2.93 µmol H_2O $m^{-2}s^{-1}$, P_N from 8.09 to 11.7 m mol CO_2 $m^{-2}s^{-1}$, irrespective of water stress treatments. Averaged across the water stress treatments, the genotype CIM-616 maintained the highest values of gas exchange characteristics and photosynthetic water use efficiency (P_N/E) in comparison to other genotypes. The P_N/E varied from 2.90 to 3.94 m mol CO_2/ µ mole H_2O in different genotypes and decreased from 3.84 to 3.13 m mol CO_2/ µ mole H_2O with the imposition of water stress (Table 6.10).

6.5 Heat Tolerance

6.5.1 Adaptability of genotypes to temperature stress

Increased temperatures as a result of global climate change are projected to cause substantial losses in crop productivity by the end of the twenty-first century. High temperature is predominant among the cardinal ecological factors that determine crop growth and productivity. In cotton, temperature is a primary controller of the rate of plant growth, developmental events and fruit maturation. 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 effects of high temperature on germination, seedling growth, vegetative growth and crop development have been well documented. Although adverse temperatures can affect all stages of development, the crop seems to be particularly sensitive to adverse temperatures during reproductive development. Cultivars differ in their adaptation to heat

stress environments. 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. Twelve genotypes were planted for screening under heat stress conditions.

Table 6.8 Impact of water stress on seed cotton yield and its components

Water stress treatments	Genotypes						Mean
	CIM-622	CIM-616	Cyto-179	MNS-992	PB-896	CRIS-543	
	Seed cotton yield (kg ha^{-1})						
No stress	1348	1420	1380	1390	1195	1086	**1303**
Water stress	1140	1268	1206	1210	1030	924	**1130**
Mean	**1244**	**1344**	**1293**	**1300**	**1113**	**1005**	
LSD	*Genotypes: 89.6**		*Water stress treatment: 70.6**			*Interaction: ns*	
	Bolls per plant						
No stress	12	13	13	12	11	9	**11.7**
Water stress	10	12	10	10	9	8	**9.80**
Mean	**11.0**	**12.5**	**11.0**	**11.0**	**10.0**	**8.5**	
LSD	*Genotypes: 1.45**		*Water stress treatment: 1.21**			*Interaction: ns*	
	Boll weight (g)						
No stress	3.08	3.18	3.10	3.17	2.89	2.84	**3.04**
Water stress	2.82	2.90	2.89	2.92	2.72	2.73	**2.83**
Mean	**2.95**	**3.04**	**3.04**	**3.05**	**2.81**	**2.79**	
LSD	*Genotypes: 0.21**		*Water stress treatment: 0.18**			*Interaction: ns*	

* Significant at 5% level; ns: non-significant

Table 6.9 Impact of water stress on plant structure development of genotypes at maturity

Water stress treatments	Genotypes						Mean
	CIM-622	CIM-616	Cyto-179	MNS-992	PB-896	CRIS-543	
	Main stem height (cm)						
No stress	98.6	90.4	78.4	92.2	82.3	87.6	**88.3**
Water stress	84.4	82.4	71.3	80.6	72.4	76.8	**78.0**
Mean	**91.5**	**86.4**	**74.9**	**86.4**	**77.4**	**82.2**	
LSD	*Genotypes: 6.02**		*Water stress treatment: 7.14**			*Interaction: 7.03**	
	Nodes on main stem						
No stress	30	29	26	30	27	27	**28.2**
Water stress	27	27	24	28	24	25	**25.8**
Mean	**28.5**	**28.0**	**25.0**	**29.0**	**25.5**	**26.0**	
LSD	*Genotypes: 3.2**	*Water stress treatment: 2.1**			*Interaction: ns*		
	Inter-nodal length (cm)						
No stress	3.29	3.12	3.02	3.07	3.05	3.24	**3.13**
Water stress	3.13	3.05	2.97	2.88	3.02	3.07	**3.02**
Mean	**3.21**	**3.08**	**2.99**	**2.98**	**3.03**	**3.16**	
LSD	*Genotypes: 0.11**		*Water stress treatment: 0.09**			*Interaction: 0.06**	

Genotypes showed wide variation in various physiological parameters conferring to heat tolerance in cotton. Genotype NIAB-414 excelled in heat tolerance considering each trait compared with the other genotypes. Genotype CRIS-543 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=0.927), percent boll set on first (r=0.543) and second (r=0.402) positions along sympodia with seed cotton yield. There were negative correlations of cell injury (r = - 0.896) and electrical conductivity (r = -0.916) with the seed cotton yield. It is suggested that these traits may be taken into account while selecting future genotypes to overcome heat stress problems (Table 6.12).

Table 6.10 Impact of water stress on gas exchange characteristics and water use efficiency

Water stress treatments	Genotypes						Mean
	CIM-622	CIM-616	Cyto-179	MNS-992	PB-896	CRIS-543	
	g_s (m mol CO_2 $m^{-2}s^{-1}$)						
No stress	8.16	9.56	8.54	8.82	8.32	7.78	**8.53**
Water stress	6.41	7.81	6.86	7.32	6.64	6.12	**6.86**
Mean	**7.29**	**8.69**	**7.70**	**8.07**	**7.48**	**6.95**	
LSD	*Genotypes:1.12**		*Water stress treatment:1.22*;*		*Interaction:1.16**		
	E (µ mole H_2O $m^{-2}S^{-1}$)						
No stress	3.33	3.36	3.31	3.35	3.24	3.19	**3.30**
Water stress	2.30	2.49	2.41	2.47	2.38	2.36	**2.40**
Mean	**2.82**	**2.93**	**2.86**	**2.91**	**2.81**	**2.78**	
LSD	*Genotypes:0.23*;*		*Water stress treatment:0..16**;*		*Interaction:0.20**		
	P_N (m mol CO_2 $m^{-2}S^{-1}$)						
No stress	12.8	14.5	13.3	13.9	12.0	9.45	**12.7**
Water stress	6.54	8.87	7.69	7.81	7.46	6.72	**7.52**
Mean	**9.67**	**11.7**	**10.5**	**10.9**	**9.73**	**8.09**	
LSD	*Genotypes:0..86**^{s};*		*Water stress treatment:0.48**;*		*Interaction:0.68^{ns}*		
	P_N/E (m mol CO_2/ µ mole H_2O)						
No stress	3.84	4.32	4.02	4.15	3.70	2.96	3.84
Water stress	2.84	3.56	3.19	3.16	3.13	2.85	3.13
Mean	**3.34**	**3.94**	**3.60**	**3.66**	**3.42**	**2.90**	
LSD	*Genotypes:0.47*;*		*Water stress treatment:0.32*;*		*Interaction:0.41**		

Table 6.11 Physiological traits for determining heat tolerance in different genotypes

Physiological traits	NIAB-878	NIAB-414	GH-Mub.	CIM-622	CYTO-179	GH-Bagh dadi	NIAB-Bt-2	NIAB-874	PB-896	GH-HAM MAD	CIM-625	CRIS-543
Fully dehiscent anther (%)	93	87	83	77	75	72	68	65	63	62	57	55
Pollen viability (%)	97	95	92	88	85	77	71	69	62	59	48	47
First symodial node number	6	7	7	6	8	7	6	6	7	7	5	7
First sympodial node height (cm)	12	13	14	12	11	12	13	11	10	12	11	11
Sympodial node number bearing first effective boll	8	8	8	8	9	8	8	8	8	8	7	8
Sympodial node height (cm) bearing first effective boll	29	29	30	29	28	30	30	28	29	29	26	29
Sympodial node number bearing last effective boll	36	33	29	31	33	33	31	34	32	30	29	24
Sympodial node height (cm) bearing last effective boll	94	83	77	92	92	96	78	89	97	79	84	64
Percent boll set on first position along sympodia	48	45	47	42	39	40	38	34	29	33	31	44
Percent boll set on second position along sympodia	35	30	34	33	26	29	23	28	22	29	26	28
Cell injury (%)	39	46	48	51	56	58	67	67	69	70	75	77
Electrical conductivity (µS cm^{-1})	188	201	244	270	276	293	298	327	328	329	331	380

Although genotype NAIB-414 did not maintain the highest anther dehiscence compared to NIAB-878 but it produced the highest seed cotton yield due to having highest boll weight of 3.32g and number of bolls up to 26 per plant. In general the dehiscence of anthers was the lowest during 1st week of July and 1st week of August due to change in temperature values. The anther dehiscence increased gradually in 2nd 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-414 produced the highest seed cotton yield than the other genotypes tested. Seed cotton yield of different genotypes ranged from 717 to 2071 kg ha^{-1} (Table 6.13).

Table 6.12 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 =20.44 -171.4	y = 29.90x + 175.2	y = 30.02x + 485.7	y = -27.46x + 3008.0	y = -6.46x + 3215.0
Correlation co-efficient (*r*)	0.927**	0.543*	0.402*	-0.896*	-0.916 **

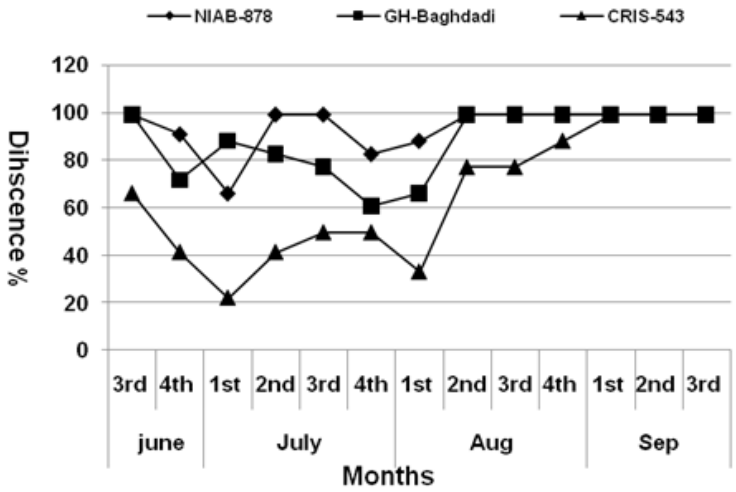

Fig. 6.1 Dehiscence of anthers during the season for three genotypes

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)
NIAB-414	1971	26	3.32
NIAB-878	1784	24	3.00
GH-Mubarak	1774	25	2.88
CIM-622	1540	20	2.63
CYTO-179	1482	17	2.71
GH-Baghdadi	1435	15	3.06
NIAB-Bt-2	1324	18	2.50
NIAB-874	1267	14	2.54
PB-896	1219	14	2.52
GH-HAMMAD	884	15	2.35
CIM-625	789	13	2.33
CRIS-543	717	12	1.94
LSD	292.6*	2.21**	0.16**

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7 TRANSFER OF TECHNOLOGY SECTION

Transfer of Technology Section continued its activities to disseminate the research findings/ practices for the development of profitable 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 crop season:

i) Profitable cotton production technology
ii) Agronomic practices to sustain the production in climatic change
iii) Breeding methods for better traits
iv) Seed production technology
v) Causes of low yield & its possible measures
vi) Introduction ,mode of damage & carry over sources of Pink bollworm
vii) Cotton pests and strategies for its management
viii) Contamination free cotton picking and its proper storage
ix) Proper management of Pink Bollworm
x) Pink Bollworm management & planning for the crop 2016-17
xi) Impact of cotton fiber properties on textile processing & yarn quality
xii) The trends in Pakistan's cotton marketing system & opportunities for cotton selectors

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

Date	Organized/ Coordinated by	Venue	Resource Person	Participants
04.03.2015	PCSI, Multan	CCRI, Multan	Dr. Dilbaugh Muhammad	**Total=27** Cotton Selectors
19.03.2015	FFC	Lodhran	i)Dr. Khalid Abdullah, VP, PCCC ii) Syed Sajid Masood Shah iii) Dr. Dilbaugh Muhammad	**Total= 153** Farmers = 137 FA = 04 AO = 02 FFC = 10 Officials
08.05.2015	Agri.Ext.Deptt. Punjab	Multan (Mango Research)	Dr. Dilbaugh Muhammad	**Total= 73** Master Trainees Agri.Ext.Deptt. Punjab
13.10.2015	PCSI, Multan	CCRI, Multan	Dr. Dilbaugh Muhammad	**Total=20** Cotton Selectors
26.01.2016	CCRI, Multan	i)Kot Lal Shah Karor Pakka) ii) Super Chowk (Lodhran) iii)Batool Farm (Lodhran)	i) Syed Sajid Masood Shah iii) Mr. Muhammad Rafiq iii) Dr. Muhammad Naveed	**Total=103** Farmers= 41 Farmers= 43 Farmers= 19
27.01.2016	-do-	i) Sikandar Abad (Shuja Abad) ii)Pul Khara (Shuja Abad) iii) Kund Rhim Bux (JPW)	-do-	**Total= 95** Farmers= 40 Farmers= 37 Farmers= 18
28.01.2016	-do-	i)Chak Jhedoo (Luddin, Vehari) ii) Chak 30/KB (Vehari) iii)Chak 27/W-B (Mian Chunnoo)	-do-	**Total= 98** Farmers= 36 Farmers= 43 Farmers= 19

01.02.2016	Pakistan Farmers Forum NGO,s	Khanewal	i) Dr. Dilbaugh Muhammad ii)Dr. Muhammad Naveed	**Total= 1116** Progressive Farmers =103 NGO's Staff =13
08.03.2016	PCSI, Multan	PCSI, Multan	i) Mr. M. Ilyas Sarwar ii) Mr. Danish Iqbal	**Total=25** Cotton Selectors

7.1.2 Cotton Survey Programs

The following Cotton Survey Programs & farmer meetings and interaction were conducted during the season:

Date	Venue	Resource Person
04.09.2015	Mian Channu	Dr. Dilbaugh Muhammad
06.09.2015	Khan Pur Kattora	i)Syed Sajid Masood Shah, ii)Dr. Dilbaugh Muhammad
15.09.2015	Khanewal	i)Mr. Muhammad Afzal, ii)Mr. Zahid Iqbal Anjum
16.09.2015	Kot Addu	Mr. M.Afzal & other SSO's PBG

7.1.3 TV & Radio Programs/TV Tellips

a) TV Programs

The following TV programs were conducted during the season:

Date	TV Channel	Topic	Resource Person	Remarks
14.04.2015	PTV, Multan	i)Cotton production and seed production technology ii)Agronomic practices for better cotton yield	Dr. Dilbaugh Mohammad	Recorded
17.04.2015	PTV, Multan	Land Preparation, Bed & Furrow method, sowing methods	Dr. Dilbaugh Mohammad	Recorded
08.05.2015	PTV, Multan	Wheat Harvesting & Cotton Cultivation	i)Dr. Dilbaugh Mohammad ii)Mr. Sajid Mahmood	Recorded
04.08.2015	Dunya, Multan	Impact of Rain fall on Cotton Crop	Syed Sajid Masood Shah Director, CCRI, Multan	Recorded
18.01.2016	Waseb, Multan (Zumindara)	Land preparation & Planning for better cotton production	i)Dr. Dilbaugh Mohammad ii)Dr. Muhammad Naveed Afzal	Recorded

b) Radio Programs

The following Radio programs were recorded during the season:

Date	Radio Programs	Topic	Resource Person	Remarks
05.05.2015	Radio Pakistan, Multan	Talk on 'Management of Late Cotton Sowing"	Dr. Dilbaugh Mohammad	Recorded
-do-	-do-	Interview on "Management of sucking insect pests especially related to Dusky Bug'	Mr. Muhammad Rafiq	-do-
05.08.2015	Radio Pakistan Multan	Talk on "Management of Cotton Crop in August"	Mr. Muhammad Rafiq	05.08.2015
-do-	-do-	Talk on "Sucking Insect Pest Management"	Mr. Muhammad Rafiq	-do-

c) TV Tellips

The following TV Tellips were conducted during the season

Date	TV Channel	Topic	Resource Person	Remarks/Timing
16.04.2015	PTV, Multan	Land preparation for cotton cultivation"	Dr. Dilbaugh Mohammad	Recorded/3minutes
08.08.2015	Dunya, Multan	Impacts of rainfall on cotton crop	Syed Sajid Masood Shah	Recorded/5minutes
11.01.2016	Express, Multan	"Government Policies about enhancement of Agriculture Sector in Pakistan"	Haji Sikandar Hayat Khan Bosan, Federal Minister for National Foos Security & Research, Islamabad	Recorded/6minutes

7.1.4 Press Releases

Thirty Two (32) press releases throughout the season were sent to the press time to time for publication.

7.1.5 Articles

Twelve (12) 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 Conferences

Three (03) press conferences were conducted for important dignitaries throughout the season.

7.1.7 TV/Press Coverage

Five (05) TV/ Press Coverage were conducted for meetings/seminars/workshops throughout the season.

7.1.8 Preparation of Leaflets

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

Varieties/Potash Leaflet	No. of Copies
CIM-599	1000
CIM-608	1000
CIM-602	1000
Kapaas mein Potash ki Ahmiyat	1000

7.1.9 Distribution of Printed Material

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

- 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-496
- 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*

7.2 Meetings

7.2.1 Agriculture Research Sub-Committee (ARSC)

Three days annual meeting of Agriculture Research Sub-Committee (ARSC) of Pakistan Central Cotton Committee (PCCC) was held at Central Cotton Research Institute (CCRI), Multan on April 6-8, 2015 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 2014-15 and the approval of Annual Program of Research Work for the year 2015-16. The meeting was attended by all members of the subcommittee PCCC offices, other public stakeholders, private seed sector and progressive farmers. The section provided all type of technical facilities to organize the meeting.

7.2.2 Cotton Crop Assessment Committee Meeting

Three meetings of Cotton Crop Assessment Committee (CCAC) were held at Islamabad under the chairmanship of Federal Secretary, MinTex on 1st Sep. 2015, Sep. 9, 2015 & November 11, 2015 respectively. Syed Sajid Masood Shah, Director, CCRI, Multan attended the meeting with other participants.

7.2.3 Cotton Expert Sub-Committee

71st Meeting of "Cotton Expert Sub-Committee" of "Punjab Seed Council" for the Year 2015 was held at Ayub Agricultural Reserach Institute (AARI), Faisalabad on March 9, 2015 under the Chairmanship of Director General Agricultural Research, Punjab. Performance of candidate Cotton varieties was reviewed and recommendations were forwarded to "Punjab Seed Council" for their formal approval. All public and private sector breeders attended the event to present and defend their best performing varieties for their approval by the Punjab government. Syed Sajid Massod Shah, Director CCRI, Multan, Ch. Muhammad Afzal, Head, PBG, Dr. Dilbaugh Muhammad, Head, Agronomy, Mr. Muhammad Tariq, Head, Pathology, Mr. Zahid Iqbal Anjum, Head, Cytogenetics also attended this meeting with other attendees.

7.2.4 Cotton Seed Production Plan (2015)

To evaluate progress on Cotton Seed Production Plan-2015 and preparation of Cotton Seed Production Plan 2015-16, a significant meeting was held at CCRI Multan on 23rd January, 2015. The meeting was jointly chaired by Dr. Khalid Abdullah, Cotton Commissioner, Ministry of Textile Industry / Vice President, Pakistan Central Cotton Committee and Dr. Shakeel Ahmad Khan, Director General, Federal Seed Certification & Registration Department, Ministry of National Food Security & Research. The meeting was held at CCRI Multan on Jan 23, 2015 and attended by representatives from public and private sector cotton breeders.

7.2.5 Germination of Cotton Seed

A meeting regarding “Germination of Cotton Seed” was held at the institute on 3rd July, 2015 under the chairman ship of Dr. Shakeel Ahmad Khan, Director General, Federal Seed Certification & Registration Department, Ministry of National Food Security & Research. The meeting was attended by representatives from public and private sector seed companies and cotton breeders. The section provided technical facilities for conducting this significant meeting.

7.2.6 Availability of Certified Cotton Seed

A meeting on "Availability of Certified Cotton Seed" was held at CCRI Multan on 24th March, 2015 jointly chaired by Dr. Khalid Abdullah, Cotton Commissioner, Ministry of Textile Industry / Vice President, Pakistan Central Cotton Committee and Dr. Shakeel Ahmad Khan, Director General, Federal Seed Certification & Registration Department / Food Security Commissioner, Ministry of National Food Security & Research. The meeting was attended by representatives from public and private sector seed companies and cotton breeders.

7.2.7 Cotton Production Plan for 2016-17

A meeting of Cotton Production Plan for 2016-17 was held at Faisalabad on January 20, 2016 under the chairmanship of Director Adaptive Research, Lahore. Dr. Dilbaugh Muhammad, Agronomist of the Institute participated in this meeting with other participants.

7.2.8 Federal Seed Certification & RD Department

Three significant meetings of Federal Seed Certification & RD department were held at the institute on 13th April 2015, August 10, 2015 & November 21, 2015 respectively. The section made arrangements of the meeting and provided technical assistance in this respect.

7.2.9 ICARDA Cotton Project

Three significant meetings of ICARDA cotton project were conducted at Faisalabad, Islamabad & Multan on July 29, 2015, August 18, 2015 & January 13, 2016 respectively. 2014. Director, CCRI, Multan, Syed Sajid Masood Shah, Dr. Dilbaugh Muhammad, Head, Agronomy, Mr. Muhammad Afzal, Head, PBG, Mr. Tariq Mehmood, Haed, Pathology sections and Mr. Muhammad Idrees Khan, Scientific Officer, PBG of the institute participated in the meeting along with other cotton experts.

7.2.10 Low Production of Cotton

A very significant meeting regarding cause of low cotton production meeting was held at Faisalabad on November 12-15, 2015. Syed Sajid Masood Shah, Director, CCRI, Multan & Dr. Dilbaugh Muhammad, Head Agrnomy/TTS attended this meeting.

7.3 Seminars

7.3.1 Seminar on Profitable Cotton Production Technology & other related issues

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

Date	Organized by	Venue	Resource Persons	Participants
19.03.2015	FFC	Lodhran	i) Dr. Khalid Abdullah, VP,PCCC ii) Syed Sajid Masood Shah, Director, CCRI, Multan ii) Dr. Dilbaugh Mohammad	**Total = 103** Farmers = 83 DO = 01 AO = 01 FA = 05 Pesticide Dealers = 08 FFC Officials = 05
09.04.2015	FFC	Burewala	Syed Sajid Masood Shah, Director, CCRI, Multan	**Total = 209** Farmers = 190 AO = 02 FA = 04 Pesticide Dealers = 05 FFC = 08 Officials
11.05.2015	NIBGE	Faisalabad	Syed Sajid Masood Shah, Director, CCRI, Multan	**Total =77** Technical Participants
21.05.2015	FFC	Bhakkar	i)Syed Sajid Masood Shah ii)Dr. Dilbaugh Mohammad iii) Mr. Muhammad Rafiq	**Total=235** Farmers = 203 FA = 15 DO = 01 DDO = 01 AO = 02 FFC staff = 13

01.12.2015	Agri. Extension .Dept. Punjab & CCRI Multan	CCRI, Multan	i)Syed Sajid Masood Shah ii)Dr. Dilbaugh Mohammad & other staff members	**Total=16** Farmers = 09 FA = 03 DO = 01 DDO = 01 AO = 02
09.12.2015	Federal Seed Certification &RD , Islamabad	UAF Faisalabad	i)Syed Sajid Masood Shah ii)Dr. Dilbaugh Mohammad	**Total= 77** Technical Participants = 23 Participants of academia = 35 Progressive Growers = 09 Private Seed Sectors & other stakeholders = 10

7.3.2 National Seminar on Profitable Cotton Production Technology

Following national seminars on cotton production technology and related issues were held during the season:

Date	Organized by & Venue	Topic	Chaired by	Participants
11.01.2016	CCRI, Multan	Pink Bollworm Management	i) Haji Sikandar Hayat Khan Bosan, Federal Minister for National Food Security & Research ii) Ms. Rubina Wasti, Senior Joint Secretary, MInTex & Dr. Khlaid Abdullah, VP,PCC/Cotton Commissioner, MinTex (co-chaired)	**Total = 107** Technical = 37 Farmers = 23 Private Seed Sectors & other stakeholders = 47
18.02.2016	CCRI, Multan	Challenges & Prospective of Potassium use in Cotton	Dr, Khalid Abdullah, Cotton Commissioner MinTex/ Vice President, PCCC	**Total = 73** Technical = 43 Farmers = 14 Private Seed Sectors & other stakeholders = 16
07.03.2016	CCRI Multan and M/s Evyol Group Pvt Ltd at CCRI,Multan	Seminar on "Cotton Genetic Manipulation Need for 21st Century	Dr, Khalid Abdullah, Cotton Commissioner MinTex/ Vice President, PCCC	**Total = 72** Technical = 31 Academia = 14 Growers = 10 Private Seed Sectors & other stakeholders = 17
11.03.2016	PCCC & M/s Evyol Group at Islamabad	Cotton Biotech Future & Current Trends in Breeding	Dr, Khalid Abdullah, Cotton Commissioner MinTex/ Vice President, PCCC	**Total = 41** Technical = 22 Academia = 07 Private Seed Sectors & other stakeholders = 04 NGO's Staff = 08

7.4 Participation in Workshop/Conference

Date	Workshop/Conference	Venue	Organized by	Participants
10th March, 2015	workshop on "Balanced use of fertilizers and food security"	Islamabad	FAO	Dr.Fiaz Ahmed
02.04.2015	workshop on CLCV management practices through adopting FFS approach	Multan	NARC, Islamabad	i)Dr. Muhammad Naveed Afzal ii)Mr. Muhammad Tariq
June 12, 2015	National Conference on Agricultural Development	CCRI, Multan	Pakistan Chambers of Agriculture & Livestock	All heads of the sections with Director
June 12-14, 2015	5th International & 12th National Weed Science Conference	SBBU, Dir, KPK	Weed Science Society of Pakistan & SBBU, Dir, KPK	Dr. Dilbaugh Mohammad
October 10, 2015	workshop on Implementation of Seed(Amendment) Act 2015 & Strategies for Improvement of Seed Sector	CCRI, Multan	Ministry of National Food Security & Research with FAO	i)All heads of the sections with Director ii) High officials of Ministry of National Food Security
November 4, 2015	Workshop on "Resilient cotton production under changing climate phenomenon"	CCRI, Multan	Ministry of Textile Industry, Islamabad	i)All heads of the sections with Directors of CCRI Multan & Sakrand ii) Farmers from all provinces

7.5 Visitors

a)

Dignitaries/Delegation	Dated
Two member Japanese delegation, Mr.Kiyotaka Masuda and Mr. Kazuhiro Sakashita, representative of Summit Agro International Limited, Tokyo, Japan	04.03.2015
Dr. Muhammad Shafiq-ur-Rehman, Agriculture Specialist, US Embassy	24.04.2015
2- member Chinese Agri. Scientists delegation	29.04.2015
3-member-Chinese agri. scientists	18.05.2015
Four-member Malaysian delegation	12.06.2015
Dr Abdul Wakeel, Assistant Professor, Institute of Soil & Environmental Sciences UAF	14.09.2015
Dr. Muhammad Ishtiaq Rajwana, In change, MNSUA, Multan	31.09.2015
Mr. Muhammad Arshad, Consultant , ICARDA	31.09.2015
Mr. Sikandar Hayat Khan Bosan Federal Minister for National Food Security and Research	12.10.2015
Mr. Tim Ekin, FAO International Consultant on Seed Sector	12.10.2015
Dr. Shakeel Ahmad, Director General, FSCR&D	12.10.2015
Mr. Mumtaz Khan Manais, Ex-Minister Punjab	12.10.2015
a Chinese Cotton Expert accompanied by Mr Shabir Khan G.M. Bio Century Pakistan	13.10.2015
Two member delegations of Chinese Agri Scientists	03.11.2015
Associate Prof. Dr. M. Iqbal Bandeshah , Chairman Plant Breeding and Genetics Section, Islamia University Bahawalpur	12.11.2015
Mr. Arif Nadeem,Chief Executive Officer, Pakistan Agricultural Coalition	18.11.2015
SANIFA.,Dr Neil Forrester ,Dr Don Keim & Dr. Albert Agri. Scientists	18.11.2015

Dr. Muhammad Rafiq Chaudhry , Head Information, Technology, ICARDA, Washington DC, USA	12.12.2015
Dr. Khalid Abdullah, Vice President , PCCC, Multan	12.12.2015
Ch. Muhammad Arshad, Consultant, ICARDA	12.12.2015
Haji Sikandar Hayat Khan Bosan, Federal Minister for National Foos Security & Research	11.01.2016
Ms Rubina Wasti Senior Joint Secretary, Min.Tex	11.01.2016
Dr, Khalid Abdullah, Cotton Commissioner MinTex/ Vice President, PCCC	11.01.2016
Prof. Dr. Asif Ali, Vice Chancellor, Muhammad Nawaz Shareef University of Agriculture (MNSUA), Multan	20.01.2016
Haji Sikandar Hayat Khan Bosan, Federal Minister for National Foos Security & Research	11.01.2016
Ms Rubina Wasti, Senior Joint Secretary , Mintex	11.01.2016
Mr. Jose Setti, Executive Director, ICAC , Washington DC, USA	26.02.2016
Ms Rubina Wasti, Senior Joint Secretary , Mintex	26.02.2016
A 3-member delegation from Engineering Council of Pakistan along with VC, Muhammad Nawaz Shareef University of Agriculture, Multan (MNSUA)	15.03.2015
Dr Aslam Bhatti, Cotton Breeder, USA	07.03.2016
CEO of Australian Center for International Agricultural Research (ACIAR)	03.03.2016

b) Student Study Tour

Name of University/Institution	No. of Participants
University of Agriculture, Faisalabad	194
University College of Agriculture, BZU, Multan	103
Muhammad Nawaz Sharif University of Agri. Multan(MNSUA)	137
Islamia University, Bahawalpur	43

c) Participants of 19th & 20th Career Management Course (MCMC)

Two groups of 19 & 20 participants of 19th Mid Career Management Course (MCMC) from the National Institute of Management (NIM), Lahore visited CCRI, Multan on 17th March, 2015 & October 27, 2015 respectively Director of the institute briefed them about the achievements and ongoing research activities of the institute. Later they visited experimental fields, glass house and wild specie block of the institute. They appreciated the research work conducted by the scientists if the institute.

7.6 Traveling Seminar

The scientists of traveling seminar visited the Institute on August 31, 2015. Mr.Muhammad Azam, Farm Officer & Mr. Khalid Hussain, SO, Plant Breeding Section of the Institute participated in the seminar. Dr. Khalid Abdullah, VP, PCCC delivered welcome address to the participants of Pakistan Central Cotton Committee Cotton Traveling Seminar at the Institute. Dr. Muhammad Ishtiaq Rajwana, In change, MNSUA, Multan, Mr. Muhammad Arshad, Consultant , ICARDA, Dr. Tassawar Hussain Malik, Director Res. PCCC, Mr. Gul Muhammad, Sec. PCCC, Syed Sajid Masood Shah, Director, CCRI, Multan, Dr, Muhammad Ali Talpur Director Marketing & Eco. Dr. M.Naveed, SSO. /Seminar Coordinator, Dr. Saghir Ahmad, In charge, CRS, Multan and other Agri. Scientists were also attended the seminar.

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 CRS Ghotki, CRS D.I.Khan, CRS Mirpur Khas, NIA Tandojam and to other relevant government and private parties as well. Research activities were focused to study the effects of environment & cotton leaf curl virus disease incidence on different fibre traits. 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 analysed at Fibre Technology Section to publish a comprehensive report entitled "Quality Survey of Pakistan Cottons" which reflect a true picture of commercially grown cotton at different locations and 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	13839	13608	13274	448			41169
Cytogenetics, CCRI Multan	7757	7609	7339	05			22710
Fibre Technology, CCRI, Multan	189	189	189		189		756
Entomology, CCRI, Multan	181	181	181				543
Agronomy, CCRI, Multan	102	102	102				306
Plant Physiology, CCRI, Multan	100	199	100				399
CCRI, M.P. Khas	150	150	150				450
CRS, Ghotki	802	802	802				2406
CRS, D.I.Khan	468	468	468				1404
CRS, Multan	04						04
NIA, Tandojam	164	164	164				492
Students (BZU & UAF)	1851	1851	1851				5553
Quality Survey	602	602	602		602		2408
Private Sector	11	11	11		8	12	53
Total	**26220**	**25936**	**25233**	**453**	**799**	**12**	**78653**

Five samples provided from Cytogenetics Section were processed to investigate the spinning potential on Miniature Spinning Plant.

8.2 Effects of Environment on Fibre Characteristics of Different Commercial Cotton Genotypes from Different Sowing Dates

The objective of the experiment was to study the effects of environment on fibre characteristics produced from the cotton bolls set at different growth periods. Two cotton genotypes were selected, viz., *Bt.*CIM-602 and Cyto-179 sown at two sowing dates viz., 15th April 2015 and 1st May 2015. In each genotype of both sowing dates, 200 cotton flowers were tagged after every 7 days' interval in three replications. The flower tagging was started from 29th July, 2015 and it continued up to 23rd September, 2015. Cotton bolls were picked at maturity. The seed cotton was ginned. The lint samples were tested for various fibre characteristics. The results are presented in Tables 8.2 to 8.5.

The results revealed that the fibre length, lint percentage and degree of reflectance increased, micronaire and degree of yellowness decreased with delay in date of flowering in all genotypes of both sowing dates. Fibre strength increased at middle flowering period then decreased in all genotypes.

The fibre length, degree of reflectance and lint percentage of all genotypes increasing with delaying flowering dates was probably attributed to sufficient thermal units and high mean daily temperature in boll maturation period.

Among the genotypes the longest fibre length 27.9 mm was obtained from *Bt.*CIM-602 of 15th April 2015 sowing in 16th of September flowering date and the shortest fibre length 23.9 mm was obtained from Cyto-179 of 1st May 2015 sowing in 05th August flowering date.

Table 8.2 Fibre characteristics of genotype *Bt.* CIM-602 of 15th April sowing as affected by boll setting dates

Date of flower tagging	Lint (%age)	Seed Index (g)	Fibre length (mm)	Uni-formity Index (%age)	Micronaire (µg inch^{-1})	Strength (g tex^{-1})	Color grade		
							Rd%	+b	C-G
29th July, 2015	37.5	5.9	27.5	79.7	3.5	29.5	65.4	8.3	51-4
05th Aug, 2015	40.7	5.7	27.5	80.4	3.7	29.7	65.2	8.1	51-4
11th Aug, 2015	38.3	6.3	27.5	79.6	3.6	29.8	66.5	8.1	51-3
19th Aug, 2015	37.1	6.2	28.1	80.1	3.5	30.4	67.4	8.2	51-3
26th Aug, 2015	37.6	5.4	27.8	78.3	3.1	31.1	66.9	8.3	51-4
02nd Sep, 2015	40.0	6.4	27.9	78.3	3.5	28.8	68.1	8.7	51-3
09th Sep, 2015	39.9	6.7	28.3	79.2	3.6	29.2	69.9	8.8	41-4
16th Sep, 2015	37.9	6.6	28.9	79.9	3.5	30.3	73.0	9.4	42-1
23th Sep, 2015	36.3	5.8	28.1	79.0	3.0	29.2	73.6	9.4	31-4

Table 8.3 Fibre characteristics of genotype *Bt.* CIM-602 of 1st May sowing as affected by boll setting dates

Date of flower tagging	Lint (%age)	Seed Index (g)	Fibre length (mm)	Uni-formity Index (%age)	Micronaire (µg inch^{-1})	Strength (g tex^{-1})	Color grade		
							Rd%	+b	C-G
29th July, 2015	36.7	5.8	27.0	79.2	3.8	28.1	65.0	9.4	52-1
05th Aug, 2015	37.0	6.0	27.6	79.2	3.8	29.6	66.0	8.7	52-1
11th Aug, 2015	37.0	6.5	27.9	79.6	3.7	30.2	66.4	8.5	51-3
19th Aug, 2015	39.5	6.5	28.5	80.4	3.6	30.6	66.3	8.5	52-1
26th Aug, 2015	37.7	6.4	28.1	79.8	3.6	29.9	66.4	8.7	52-1
02nd Sep, 2015	40.1	5.6	28.0	79.1	3.7	28.9	66.8	8.8	52-1
09th Sep, 2015	40.6	5.9	28.1	79.3	3.8	29.2	70.1	9.0	42-2
16th Sep, 2015	38.4	6.3	28.7	79.3	3.5	29.7	72.6	9.3	41-3
23th Sep, 2015	36.7	5.9	27.2	78.0	3.1	28.3	71.4	9.2	41-3

Table 8.4 Fibre characteristics of genotype Cyto-179 of 15th April sowing as affected by boll setting dates

Date of flower tagging	Lint (%age)	Seed Index (g)	Fibre length (mm)	Uni-formity Index (%age)	Micronaire (µg inch^{-1})	Strength (g tex^{-1})	Color grade		
							Rd%	+b	C-G
29th July, 2015	41.1	5.5	25.8	81.5	4.0	27.9	68.8	10.0	42-1
05th Aug, 2015	39.7	6.3	26.0	81.5	4.2	29.1	65.6	9.6	52-1
11th Aug, 2015	39.1	6.3	25.8	81.1	4.1	28.3	67.7	8.5	51-3
19th Aug, 2015	38.7	6.3	25.9	81.2	4.0	29.2	68.0	8.7	51-3
26th Aug, 2015	38.4	6.0	26.7	80.9	3.8	29.8	68.2	8.8	52-1
02nd Sep, 2015	39.6	5.9	25.7	80.0	4.1	27.6	70.7	8.8	41-4
09th Sep, 2015	40.0	6.1	25.7	80.0	3.8	28.7	70.8	8.9	41-4
16th Sep, 2015	40.0	7.0	26.0	80.4	3.9	27.8	70.2	9.0	41-4
23th Sep, 2015	41.0	5.9	25.7	80.6	3.6	29.4	74.3	9.3	31-4

Table 8.5 Fibre characteristics of genotype Cyto-179 of 1st May sowing as affected by boll setting dates

Date of flower tagging	Lint (%age)	Seed Index (g)	Fibre length (mm)	Uni-formity Index (%age)	Micronaire (µg inch^{-1})	Strength (g tex^{-1})	Color grade		
							Rd%	+b	C-G
29th July, 2015	37.0	5.4	25.6	80.7	4.2	26.5	66.5	8.9	52-1
05th Aug, 2015	39.0	6.5	24.9	81.0	4.9	27.3	66.2	8.1	51-4
11th Aug, 2015	39.0	6.5	25.1	81.2	4.7	27.2	66.9	8.8	52-1
19th Aug, 2015	38.2	6.2	25.7	80.7	4.5	27.2	68.0	8.6	52-1
26th Aug, 2015	40.1	6.3	26.4	79.9	4.2	28.5	65.9	9.0	52-1
02nd Sep, 2015	43.3	5.7	25.8	80.8	4.3	28.1	68.2	8.7	51-3
09th Sep, 2015	41.9	6.0	25.2	79.3	4.2	26.7	70.8	8.5	41-4
16th Sep, 2015	41.8	7.0	25.3	80.1	4.1	27.5	70.4	9.1	42-2
23th Sep, 2015	40.1	5.3	25.1	79.2	3.7	26.3	73.8	9.1	31-4

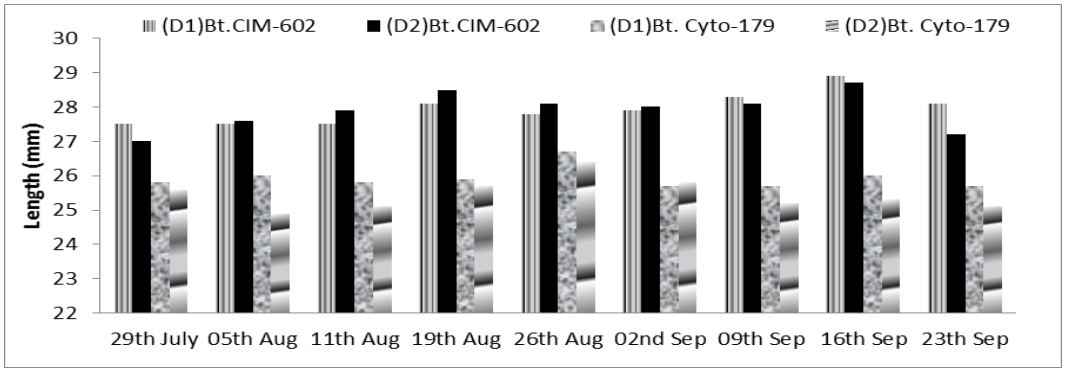

Fig 1 Interactive effect of flower tagging dates and genotypes on fibre length

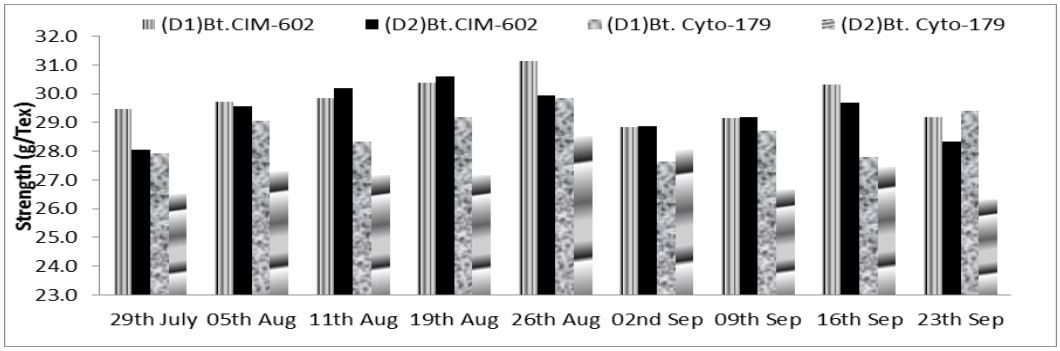

Fig 2 Interactive effect of flower tagging dates and genotypes on fibre strength

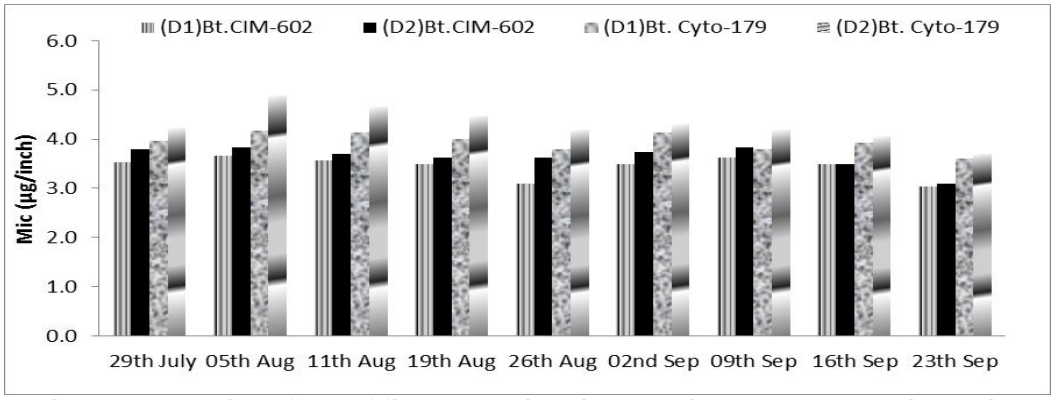

Fig 3 Interactive effect of flower tagging dates and genotypes on micronaire

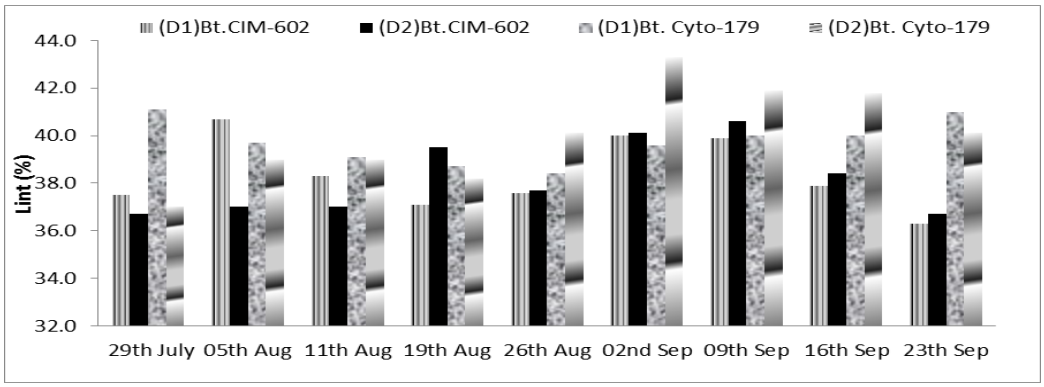

Fig 4 Interactive effect of flower tagging dates and genotypes on lint (%)

8.3 Effects of Cotton Leaf Curl Virus (CLCV) Disease Incidence on Fibre Characteristics of Some Cotton Cultivars

The objective of the experiment was to study the effects of cotton leaf curl virus disease incidence on different fibre characteristics of cotton cultivars. Two cotton genotypes were selected, viz., *Bt.*CIM-602 and Cyto-179 sown at four different sowing dates viz., 15th March 2015, 1st April 2015, 15th April 2015 and 1st May 2015. To identify the severity level of virus the technical support was provided by Plant Pathology Section of the Institute. Five healthy & five virus affected 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 presented in Tables 8.6 to 8.7 showed that cotton leaf curl virus disease significantly affected fibre characteristics.

Lint %age was influenced significantly by the virus disease incidence for both genotypes. In genotype *Bt*.CIM-602 the virus disease incidence affected significantly on 2nd, 3rd & 4th sowing dates. The maximum influence on 4th sowing date as lint %age decreased from 40.6% in healthy plants to 37.9% in severely affected plants. In genotype Cyto-179 the virus disease incidence affected significantly on 1st and 4th sowing dates. The maximum influence was on 1st sowing date as lint %age decreased from 42.6% in healthy plants to 37.9% in case of mild incidence of virus disease.

Fibre length was influenced significantly by the virus disease incidence for both genotypes. In genotype *Bt*.CIM-602 the virus disease incidence affected significantly on 2nd & 3rd sowing dates. The maximum influence was on 3rd sowing date as fibre length decreased from 27.3mm in healthy plants to 26.0mm in severely affected plants. In genotype Cyto-179 the virus disease incidence affected significantly on 2nd sowing date as fibre length decreased from 25.5mm in healthy plants to 24.4mm in severely affected plants.

Micronaire was significantly affected by the virus disease incidence for both genotypes. In genotype *Bt*.CIM-602 the virus disease incidence had significant effect on all four sowing dates. The maximum effect was on 4th sowing date as micronaire decreased from 4.27 $\mu g\ inch^{-1}$ in mild severity plant to 3.47 $\mu g\ inch^{-1}$ in severely affected plants. In genotype Cyto-179 the virus disease incidence affected significantly on 1st, 2nd and 3rd sowing dates. The maximum effect was on 1st sowing date as micronaire decreased from 4.07 for healthy plant to 3.77 for medium incidence of virus disease. Fibre strength was influenced significantly by the virus disease incidence for both genotypes. In genotype *Bt*.CIM-602 the virus disease incidence effect significantly on all four sowing dates. The maximum influence on 2nd sowing date as strength decreased from 30.8g/tex in healthy plants to 28.5g/tex in medium affected plants. In genotype Cyto-179 the virus disease incidence effect significantly on 1st, 3rd and 4th sowing dates. The maximum influence was on 3rd sowing date as strength decreased from 28.7g/tex in healthy plant to 25.1g/tex in mild affected plants.

In a study, Singh (2006) observed that CLCuD decreased 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

Table 8.6 Fibre characteristics of genotype *Bt*.CIM-602 of affected by different virus severity levels

Date of Sowing	Virus Severity Levels	Lint (%age)	Seed Index (g)	Fibre length (mm)	Uni-formity Index (%age)	Micronaire (µg inch^{-1})	Strength (g tex^{-1})	Color grade	
								Rd%	+b
15th March 2015	Healthy	39.1 a	6.0 a	26.2 a	81.8 a	3.50 b	30.4 ab	70.1 a	8.3 a
	Mild	38.9 a	5.8 ab	26.2 a	80.8 a	3.61 b	30.6 a	66.1 b	8.5 a
	Medium	39.3 a	5.4 b	25.8 a	80.1 a	4.30 a	28.3 b	65.8 b	8.2 a
1st April 2015	Healthy	37.6 b	6.8 a	27.3 a	79.0 a	3.21 c	30.8 a	70.1 a	8.8 b
	Mild	38.4 a	6.1 b	26.3 b	79.9 a	3.62 a	29.7 ab	67.6 b	9.3 a
	Medium	37.6 b	6.3 b	26.5 ab	79.2 a	3.31 b	28.5 b	66.5 c	9.5 a
15th April 2015	Healthy	40.0 ab	6.7 a	27.3 a	79.2 a	3.60 a	29.2 ab	69.6 a	8.8 a
	Mild	38.9 b	6.3 a	26.9 ab	78.5 a	3.63 ab	30.1 ab	66.2 b	8.1 c
	Medium	40.7 a	6.0 ab	26.7 ab	78.8 a	3.50 b	31.0 a	63.3 c	8.3 bc
	Severe	40.0 ab	5.3 b	26.0 b	78.8 a	3.70 a	28.8 b	66.6 b	8.6 ab
1st May 2015	Healthy	40.6 b	5.6 a	27.1 a	79.3 bc	3.83 b	29.2 b	70.1 a	9.0 b
	Mild	41.9 a	5.6 a	27.1 a	81.2 a	4.27 a	28.9 b	63.5 c	10.2 a
	Medium	39.8 c	5.6 a	26.1 b	80.5 ab	3.67 c	29.2 b	66.7 b	8.5 c
	Severe	37.9 d	5.8 a	27.3 a	78.9 c	3.47 d	31.5 a	66.4 b	8.6 bc

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

Table 8.7 Fibre characteristics of genotype Cyto-179 of affected by different virus severity levels

Date of Sowing	Virus Severity Levels	Lint (%age)	Seed Index (g)	Fibre length (mm)	Uni-formity Index (%age)	Micronaire (µg inch^{-1})	Strength (g tex^{-1})	Color grade	
								Rd%	+b
15th March 2015	Healthy	42.6 a	5.9 b	24.2 a	79.6 a	4.07 a	25.5 b	68.9 a	8.9 b
	Mild	37.9 c	6.3 a	24.9 a	80.4 a	3.60 b	27.8 a	66.0 b	8.8 b
	Medium	40.1 b	5.4 c	25.7 a	78.5 b	3.77 b	26.8 ab	68.6 a	10.7 a
1st April 2015	Healthy	40.5 a	6.2 b	24.6 b	79.0 b	3.83 b	27.4 a	68.8 a	8.4 c
	Mild	39.8 a	6.3 b	25.5 a	81.4 a	4.03 a	28.4 a	67.2 a	8.8 b
	Medium	40.1 a	7.1 a	24.4 b	79.4 b	3.80 b	27.7 a	67.2 a	9.8 a
15th April 2015	Healthy	40.0 a	6.1 a	24.7 a	79.9 a	3.80 b	28.7 a	70.8 a	8.9 a
	Mild	40.4 a	5.8 a	24.5 a	79.1 a	4.17 a	25.1 b	65.9 c	8.4 c
	Medium	39.6 a	6.1 a	24.6 a	80.2 a	4.07 ab	27.6 a	67.7 b	8.7 b
1st May 2015	Healthy	43.3 a	7.0 a	24.8 a	80.8 a	4.30 a	28.1 a	70.8 a	8.5 b
	Mild	40.9 c	6.2 b	24.9 a	78.8 b	4.30 a	26.1 b	67.9 b	8.6 b
	Medium	42.1 b	6.2 b	25.0 a	80.5 a	4.43 a	27.2 a	66.9 b	8.6 b
	Severe	40.7 c	6.1 b	24.9 a	80.4 a	4.33 a	27.6 a	67.6 b	8.8 a

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

8.4 International Cotton Check Out Program

The Fibre Technology Section participated in the International Check Out Program under the Faser Institute, Germany to keep the fibre testing equipment in calibrated form. Two lint samples were received during the year 2015. The lint samples were tested for different fibre characteristics. The results were submitted to the Faser Institute, Germany and fibre analysis met with other testing laboratories in the world.

The results of the Institute's Laboratory and the average results of the other participating laboratories are presented in Table 8.8.

Table 8.8 International Cotton Check Out 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)
10.03.15	**2015/1**	**Conventional Instruments**			
		Micronaire	3.97	4.10	-0.13
		Pressley Index (0")	8.49	8.45	0.04
		G / tex (1/8")	22.4	22.4	0.00
		Elongation (%)	5.60	5.40	0.20
		HVI-900A			
		U.H.M.L. (mm)	30.3	29.6	0.70
		Uniformity Index (%)	84.6	83.4	1.20
		Micronaire	4.10	4.10	0.00
		G/tex (1/8")	28.9	30.0	-1.10
		Elongation (%)	4.70	5.85	-1.15
		Rd (Reflectance)	70.9	72.0	-1.10
		+b (Yellowness)	13.9	13.2	0.70
11.09.15	**2015/3**	**Conventional Instruments**			
		Micronaire	4.40	4.34	0.06
		Pressley Index (0")	8.20	7.93	0.27
		G / tex (1/8")	21.3	22.8	-1.50
		Elongation (%)	5.60	6.53	-0.93
		HVI-900A			
		U.H.M.L. (mm)	29.5	29.6	-0.10
		Uniformity Index (%)	83.1	83.1	0.00
		Micronaire	4.30	4.43	-0.13
		G/tex (1/8")	27.4	30.2	-2.80
		Elongation (%)	5.20	7.10	-1.90
		SFI (%)	6.20	7.67	-1.47
		Rd (Reflectance)	73.0	76.3	-3.30
		+b (Yellowness)	13.5	12.9	0.60

8.5 International training on "Cochran Fellowship Program on Pakistan Cotton Grading and Standards in 2015" which was sponsored by the United States Department of Agriculture, attended by Scientific Officer of Fibre Technology Section Muhammad Ilyas Sarwar.

8.6 Lecture was delivered at Pakistan Standard Cotton Institute, Multan to the participants of Cotton Selector Course on the topic "Impact of Cotton Fibre Properties on Textile Processing and Yarn Quality" by Scientific Officer of Fibre Technology Section Muhammad Ilyas Sarwar.

8.7 Lecture was delivered at Pakistan Standard Cotton Institute, Multan to the participants of Cotton Selector Course on the topic "The Trends in Pakistan's Cotton Marketing System & Opportunities for Cotton Selectors" by Scientific Officer of Fibre Technology Section Danish Iqbal.

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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 sction performed analysis of 229 set of experimental data during 2015-16. (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			10				10					**20**
Cytogenetics		1										**1**
Pathology												
Entomology		96	1		3	6	1	5				**112**
Fiber												
Directotrate												
Directorate of Marketing						1	1					**2**
NCVT		94										**94**
Total		**191**	**11**		**3**	**7**	**12**	**5**				**229**

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 and 2015-16 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**.

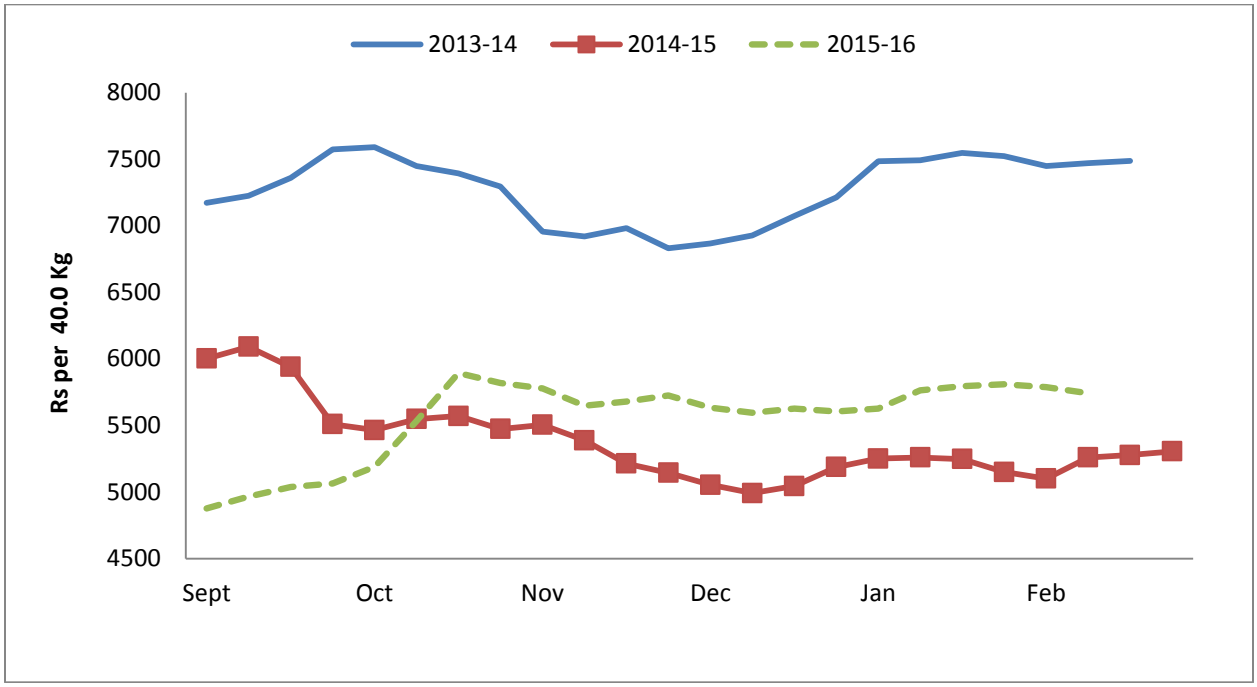
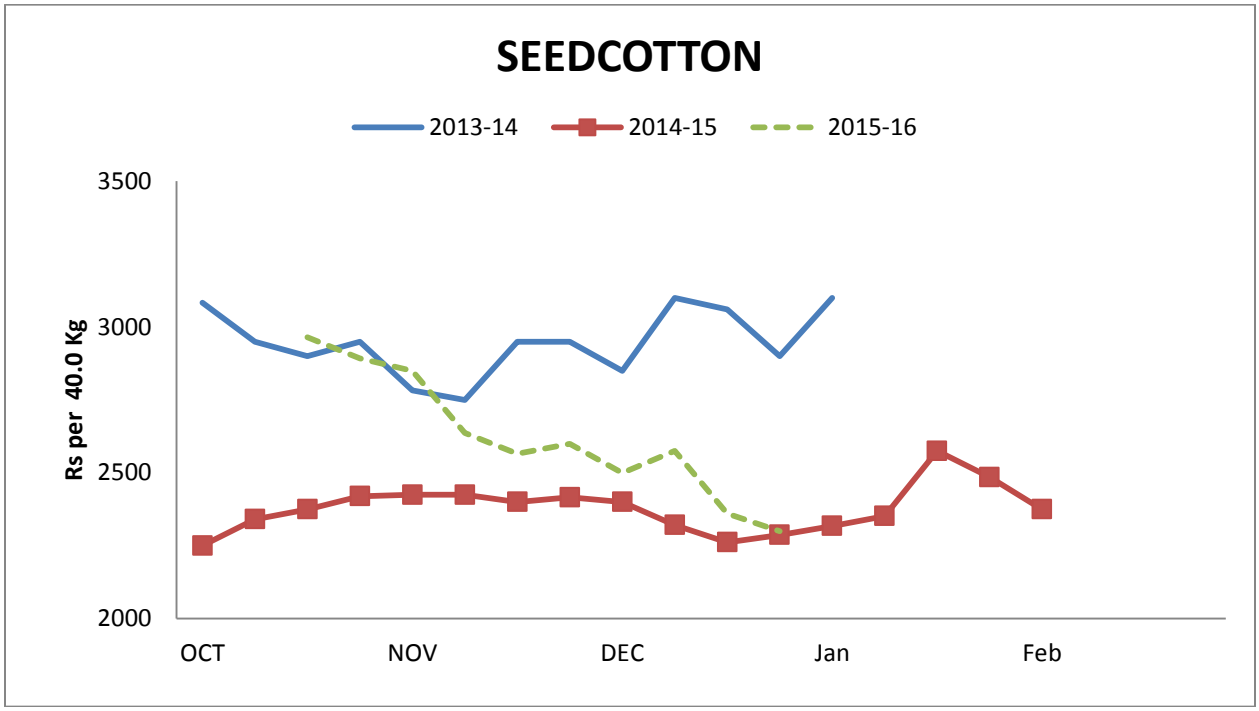
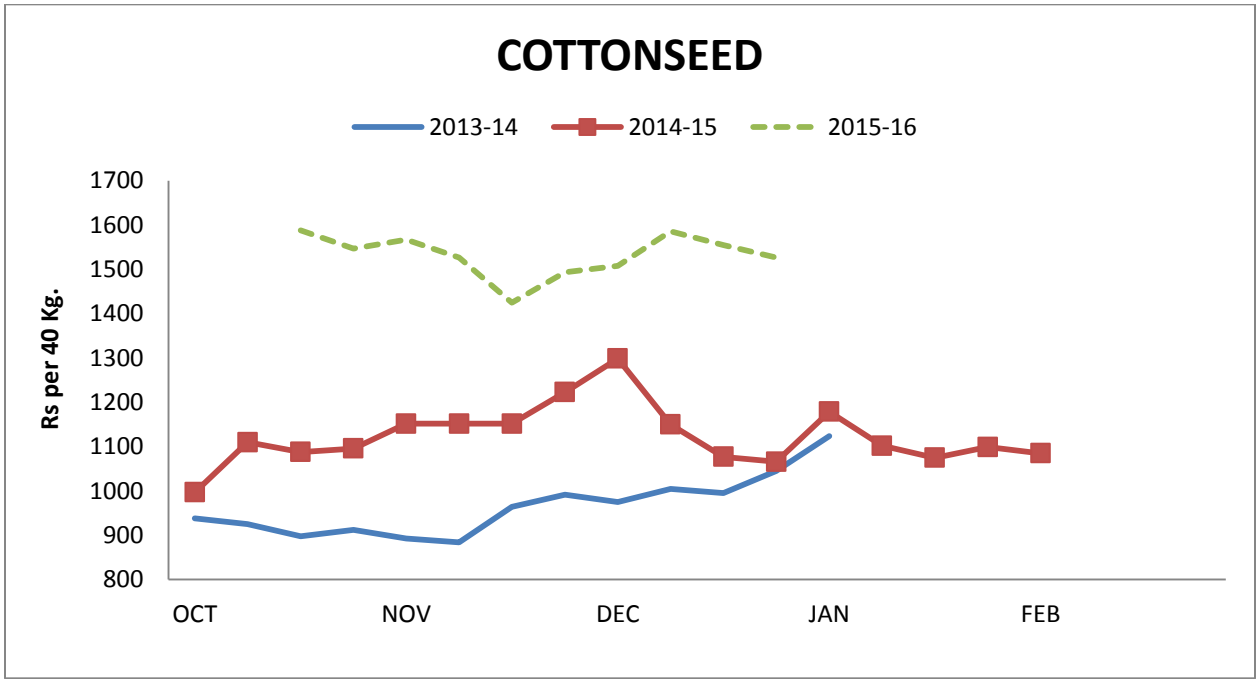
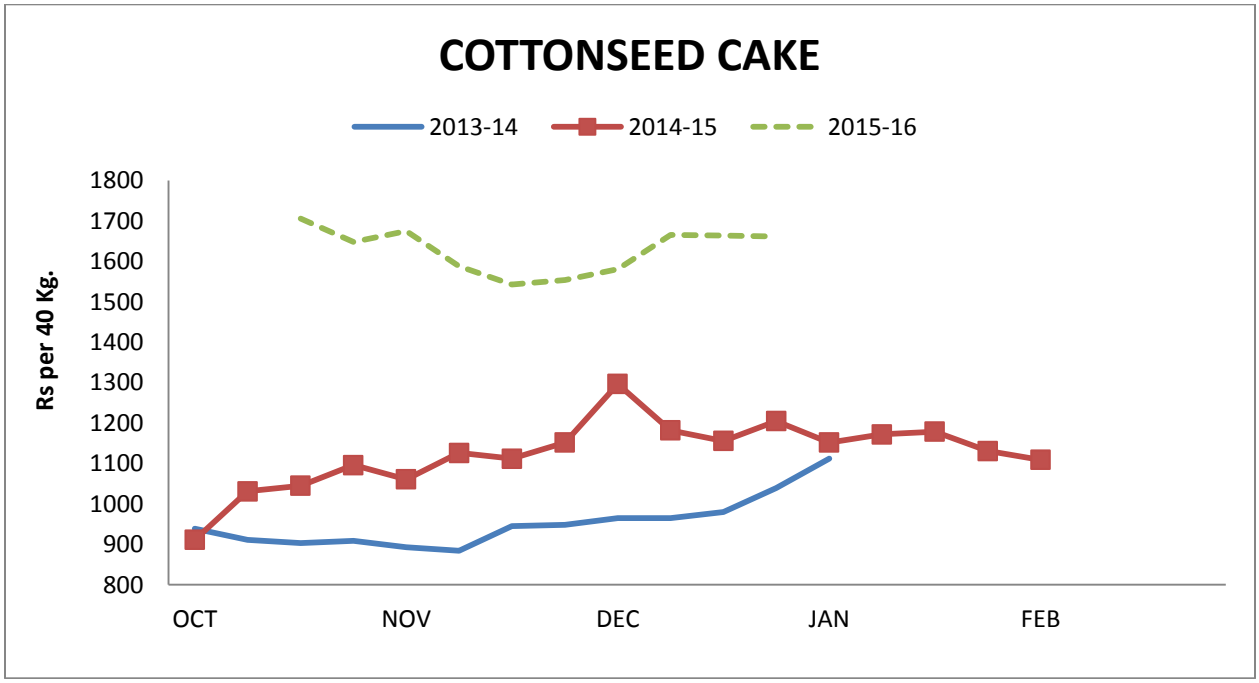
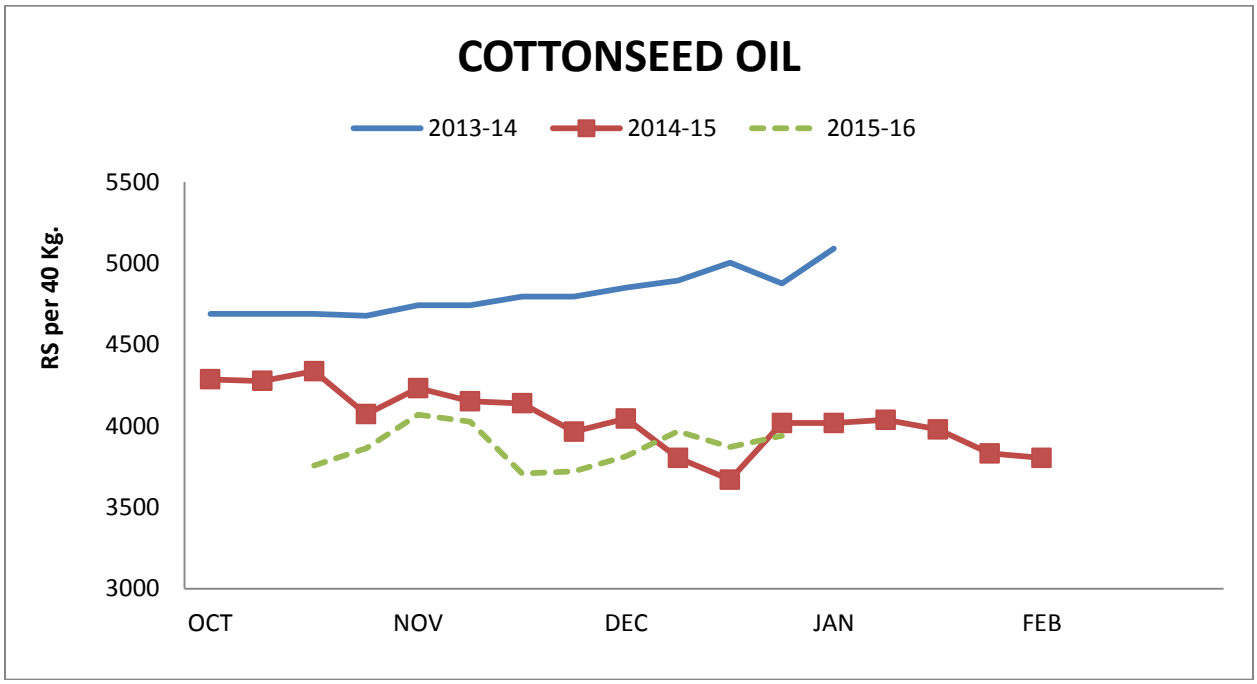


Figure 9.1: Weekly Average Spot Rates of Lint announced by Karachi Cotton Association during Cotton Seasons 2013-14, 2014-15 and 2015-16.




COTTONSEED
2013-14
2014-15
2015-16
Rs per 40 Kg.
1700
1600
1500
1400
1300
1200
1100
1000
900
800
OCT
NOV
DEC
JAN
FEB


COTTONSEED CAKE
2013-14
2014-15
2015-16
Rs per 40 Kg.
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
OCT
NOV
DEC
JAN
FEB



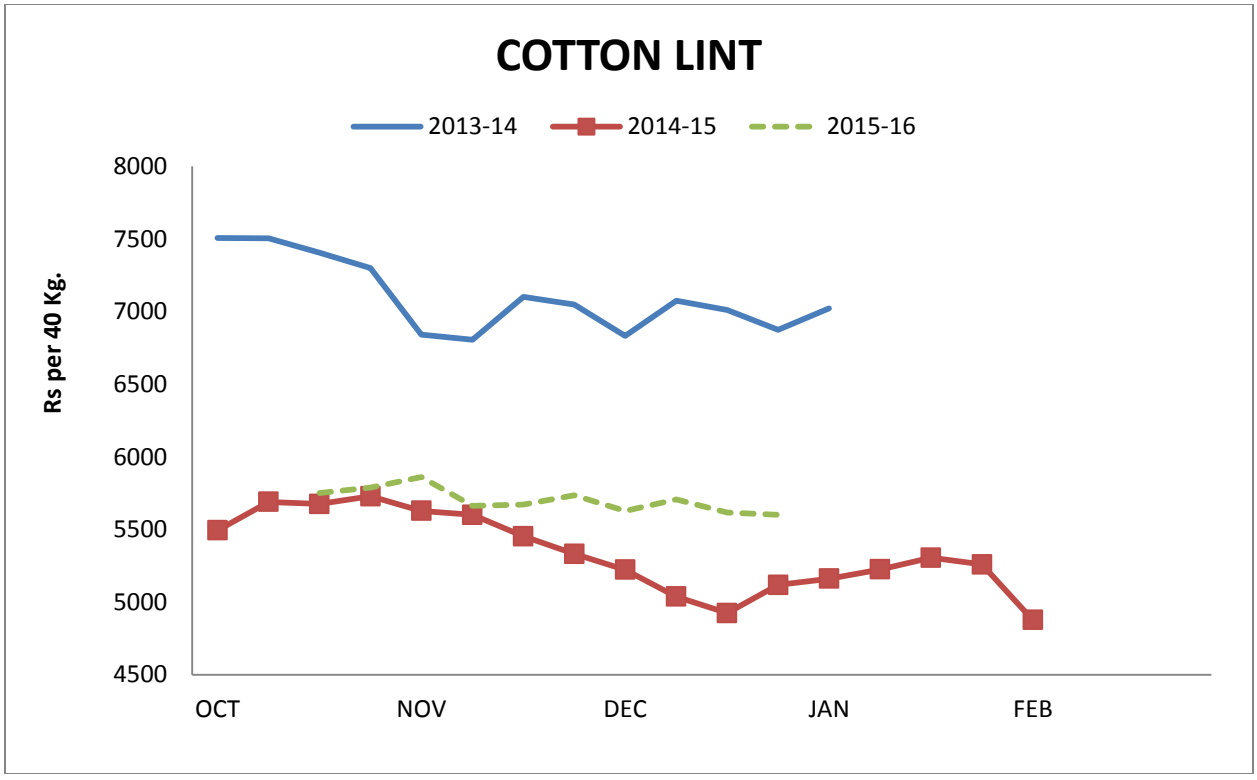


Figure 9.2: **Weekly Average Rates (Rs /40Kg.) of Seed Cotton, Cotton Seed, Cotton Seed Cake, Cotton Seed Oil and Cotton Lint of Multan Market during 2013-14, 2014-15 and 2015-16.**

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VI. 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.
- 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 of the 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. Do not keep farmyard manure in heaps in the open sky.
- Reclamation of saline-sodic soils 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-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.
- In case of early planting of *Bt* varieties, i.e. in the month of March, the minimum soil temperature (night temperature) at seed depth should be above 18ºC to avoid seed decay.
- For early planting of *Bt* varieties, the delinted seed should be treated with fungicides to avoid seed damage due to fungus.

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 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 saves the crop from early weed infestation when the crop does not permit mechanical hoeing operations.
- S-Metalacholar 960EC 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.
- 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 within 24 hours of sowing when the furrows are in wet condition.
- Glyphosate 490 G/L @ 4.7 lit ha^{-} 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 last week 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.

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

- ✪ 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.

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.

VII. PUBLICATIONS

a) International

1. Muhammad Tahir Jan, Naeem Abbas, Sarfraz Ali Shad, Muhammad Rafiq & Mushtaq Ahmad Saleem. (2015). Baseline susceptibility and resistance stability of *Earias vittella* fabricius (Lepidoptera: Noctuidae) to cypermethrin, deltamethrin and spinosad. Phytoparasitica 43: 577-582.
2. Muhammad Tahir Jan, Naeem Abbas, Sarfraz Ali Shad, Mushtaq Ahmad Saleem. (2015). Resistance to organophosphate, pyrethroid and biorational insecticides in populations of spotted bollworm, *Earias vittella* (Fabricius) (Lepidoptera: Noctuidae), in Pakistan. Crop Protection. 78:247-252.

b) National

1. Rabia Saeed, Muhammad Razaq, Muhammad Rafiq and Muhammad Naveed (2015). Evaluating Insecticide Spray Regimes to Manage Cotton Leafhopper, *Amrasca devastans* (Distant): Their Impact on Natural Enemies, Yield and Fiber Characteristics of Transgenic *Bt* Cotton. Pakistan J. Zool., Vol. 48(2),
2. Tariq Mahmood, Sabahat Hussain, Muhammad Tahir, Hafiz T. Mahmood, Dil Baugh Muhammad. (2015). Influence of Weather Variables and Age of Plant on Cotton Leaf Curl Disease (CLCuD). Pak. J. Phytopathol., Vol. 27 (01) 2015. 41-53.
3. Mahmood T., Tahir M., Hussain S., Afzal M. 2015. Behaviour of Advance Cultivars of Cotton (Gossypium hirsutum L.) against Cotton Leaf Curl Disease (CLCuD). The Pak. Cottons 57(1-2): (Impressed)

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Annexure-I

Comparative Monthly Meteorological Data Recorded at CCRI, Multan During 2014 and 2015

Month	Air Temperature (ºC)				Relative Humidity				Average Wind Speed (Km h^{-1})		Rainfall (mm)		Evapo-transpiration (cm day)		Soil Temperature (ºC)	
	Minimum		Maximum		Minimum		Maximum								5 cm	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
January	6.2	6.7	19.7	17.3	61	80	97	95	2.8	3.9	1.5	0.8	0.27	0.24	10.7	11.6
February	8.6	10.9	21.2	21.7	69	66	94	83	4.1	5.1	18.0	4.0	0.25	0.33	13.2	14.9
March	14.2	15.3	25.4	25.2	62	65	86	81	4.9	4.9	33.4	92.9	0.39	0.47	18.1	18.1
April	20.2	22.2	33.6	34.7	44	58	67	72	5.6	4.7	8.9	9.2	0.73	0.70	25.7	27.0
May	24.6	26.4	36.7	38.7	44	45	64	61	6.7	6.4	42.6	8.5	0.93	0.84	30.8	31.2
June	30.5	28.9	39.9	37.7	42	49	62	63	7.8	6.9	1.4	24.5	1.17	0.71	36.2	33.7
July	29.4	28.2	36.8	34.5	52	67	71	76	7.4	6.5	51.6	151.2	1.22	0.76	35.1	33.1
August	28.4	29.1	35.7	33.9	62	74	81	82	6.7	5.1	16.5	6.7	1.35	0.71	34.3	31.8
September	25.6	28.0	34.1	33.8	66	81	85	90	4.2	3.6	4.3	15.4	0.81	0.72	31.0	30.4
October	20.5	22.0	31.5	31.3	63	65	83	82	2.7	3.0	17.7	7.0	0.51	0.51	26.6	25.6
November	12.0.	14.9	26.3	25.1	68	53	86	76	2.1	2.3	0.0	0.0	0.28	0.30	18.2	19.1
December	6.9	9.7	17.8	20.6	75	59	94	90	2.6	2.1	0.0	0.0	0.18	0.18	13.0	12.9

Annexure-II

List of Officers at Central Cotton Research Institute, Multan (2015-16)

Discipline/ Designation	Incumbent	Qualification	Effective Date
DIRECTORATE			
Director	Mr. Sajid Masood Shah	M.Sc. (Hons.) Agri.	27.03.14
Farm Officer	Mr. Muhammad Azam Mian	M.Sc. (Hons.) Agri.	17.03.10
Administrative Officer	Mr. Zakirullah Khalidi	B.A.	20.05.14
Accountant	Mr. Nazir Ahmad	B. Com.	11.12.00
Assistant Private Secretary	Mr. Zahid Khan	M.A. (Economics)	21.02.13
AGRONOMY			
PSO	Dr. Dil Baugh Muhammad	M.Sc. (Hons.) Agri., Ph.D.(China)	27.03.14
SSO	Dr. Muhammad Naveed Afzal	M.Sc. (Hons.) Agri., Ph.D.	20.05.14
SO	Mr. Muhammad Tariq	M.Sc. (Hons.) Agri.	29.05.14
BREEDING AND GENETICS			
PSO	Mr. Muhammad Afzal*	M.Sc. (Hons.) Agri.	27.03.14
SSO	Dr. Muhammad Idrees Khan	M.Sc.(Hons). Agri. , Ph.D	20.05.14
SO	Mr. Muhammad Akbar	M.Sc. (Hons.) Agri.	17.03.10
SO	Mr. Khadim Hussain	M.Sc. (Hons.) Agri.	17.03.10
SO	Hafiz Abdul Haq	M.Sc. (Hons.) Agri.	14.05.14
SO	Mr. Saeed Muhammad	M.Sc. (Hons.) Agri.	16.05.14
SO	Dr. Fazal-i-Dayam Shehzad	M.Sc. (Hons.) Agri., Ph.D	15.05.14
CYTOGENETICS			
PSO	Mr. Zahid Iqbal Anjum	B.Sc. (Hons.) Agri.	27.03.14
SO	Mrs. Farzana Ashraf	M.Sc. (Hons.) Agri.	22.03.10
SO	Mr. Khezir Hayat	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

* Retired on April 5, 2016

Discipline/ Designation	Incumbent	Qualification	Effective Date
ENTOMOLOGY			
PSO	Mr. Muhammad Rafiq*	M.Sc.(Hons.) Agri.	27.03.14
SSO	Dr. Muhammad Naveed	M.Sc.(Hons.) Agri., M.Sc.(UK) D.I.C. (London)	20.05.14
SSO	Mr. Muhammad Tahir Jan	M.Sc.(Hons.) Agri.	20.05.14
SO	Mrs. Rabia Saeed	M.Sc. (Hons.) Agri.	17.03.10
SO	Syed Ishfaq Ali Shah	M.Sc. (Hons.) Agri.	22.03.10
SO	Mrs. Shabana Wazir	M.Sc. (Hons.) Agri.	14.05.14
Stenographer	Mr. Musawar Ali Shahid	F.A.	25.06.12
PATHOLOGY			
PSO	Mr. Tariq Mehmood	M.Sc. (Hons.) Agri.	27.03.14
SSO	Mr. Muhammad Tahir	M.Sc. (Hons.) Agri.	20.05.14
SSO	Mr. Hafiz Tariq Mahmood	M.Sc. (Hons.) Agri.	20.05.14
SSO	Mrs. Sabahat Hussain	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	M.Sc. (Hons.) Agri.	15.05.14
FIBRE TECHNOLOGY			
SO	Mr. Muhammad Ilyas Sarwar	M.Sc. Fibre Technology	14.05.14
SO	Mr. Danish Iqbal	M.Sc. Fibre Technology	19.05.14
TRANSFER OF TECHNOLOGY			
SO	Mr. Sajid Mahmood	M.A. (Mass Comm.)	11.12.06
PRO	Mr. Masood Shafi	M.A. (Mass Comm.)	16.01.10
Network Administrator	Mr. Muhammad Naveed Arshad	MS (Computer Science)	11.08.14
STATISTICS			
SO (Marketing)	Mr. Mubashir Islam Gill	M.B.A.	08.12.06

* Retired on 01.03.2016

PSO : Principal Scientific Officer **SSO :** Senior Scientific Officer
SO : Scientific Officer **PRO :** Public Relations Officer

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